E/CONF.77/3/Add.1

THIRD UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR THE AMERICAS

New York, 19 February – 1 March 1985

Volume II. Technical papers

TROISIÈME CONFÉRENCE CARTOGRAPHIQUE RÉGIONALE DES NATIONS UNIES POUR L'AMÉRIQUE

New York, 19 février – 1er mars 1985

Volume II. Communications techniques

TERCERA CONFERENCIA CARTOGRAFICA REGIONAL DE LAS NACIONES UNIDAS PARA AMERICA

Nueva York, 19 de febrero – 1° de marzo de 1985

Volumen II. Documentos técnicos

UNITED NATIONS/NATIONS UNIES/NACIONES UNIDAS

Department of Technical Co-operation for Development
Département de la coopération technique pour le développement
Departamento de Cooperación Técnica para el Desarrollo

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New York/Nueva York, 1989

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The term "country" as used in this publication also refers, as appropriate, to territories or areas.

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E/CONF.77/3/Add.1

UNITED NATIONS PUBLICATION
Sales No. E/F/S.88.I.19

04200
ISBN 92-1-002051-0

PREFACE

The official records of the Third United Nations Cartographic Conference for the Americas, held at New York from 19 February to 1 March 1985, are issued in two volumes: volume I, *Report of the Conference*,[1] and the present publication, volume II, *Technical papers*, which contains the texts of the technical background papers submitted to the Conference by the participating Governments.

These technical papers are grouped according to the agenda item to which they relate.[2] They are reproduced in the language in which they were received (English, French or Spanish) and many are preceded by a summary in the two other languages. They have been edited in accordance with United Nations practice and requirements.

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

The official records of the Second United Nations Regional Cartographic Conference for the Americas have been published as E/CONF.71/3 (Sales Nos. E.81.I.4, F.81.I.4 and S.81.I.4 and E/CONF.71/3/Add.1 (Sales No. E/F/S.82.I.14)

[1] *Third United Nations Regional Cartographic Conference for the Americas*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.85.I.14).

[2] The agenda is reproduced in the annex.

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PRÉFACE

Les documents officiels de la troisième Conférence cartographique régionale des Nations Unies pour l'Amérique, qui s'est tenue à New York du 19 février au 1er mars 1985 sont publiés en deux volumes : le volume I, *Compte rendu de la Conférence*[1], et le présent volume II, *Communications techniques*, qui contient les documents techniques d'information présentés à la Conférence par les gouvernements participants.

Ces communications techniques sont groupées par points de l'ordre du jour de la Conférence[2]. Elles sont reproduites dans la langue dans laquelle elles ont été présentées (anglais, espagnol ou français) et précédées d'un résumé dans les deux autres langues. Elles ont été mises en forme suivant les usages en vigueur aux Nations Unies.

Les appellations employées dans cette publication ainsi que la présentation des données n'impliquent de la part du Secrétariat de l'Organisation des Nations Unies aucune prise de position quant au statut juridique des pays, territoires, villes ou zones, ou de leurs autorités, ni quant au tracé de leurs frontières ou limites.

Les documents officiels de la deuxième Conférence cartographique régionale des Nations Unies pour l'Amérique ont été publiés sous les cotes E/CONF.71/3 (numéros de vente : E.81.I.4, F.81.I.4 et S.81.I.4) et E/CONF.71/3/Add.1 (numéro de vente : E/F/S.82.I.14).

[1] *Troisième Conférence cartographique régionale des Nations Unies pour l'Amérique*, vol. I : *Compte rendu de la Conférence* (publication des Nations Unies, numéro de vente : F.85.I.14).

[2] L'ordre du jour est reproduit à l'annexe.

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* *

PREFACIO

Los documentos oficiales de la Tercera Conferencia Cartográfica Regional de las Naciones Unidas para América, celebrada en Nueva York del 19 de febrero al 1º de marzo de 1985, se publican en dos volúmenes: el volumen I, *Informe de la Conferencia*[1], y la presente publicación, volumen II, *Documentos técnicos*, en que figuran los textos de los documentos técnicos presentados a la Conferencia por los gobiernos participantes.

Estos documentos técnicos se han agrupado según el tema del programa a que se refieren[2]. Se reproducen en el idioma en que se recibieron (inglés, francés o español) y muchos de ellos van precedidos por un resumen en los otros idiomas. Se han preparado con arreglo a las prácticas y requisitos de las Naciones Unidas.

Las denominaciones empleadas en esta publicación y la forma en que aparecen presentados los datos que contiene no implican, de parte de la Secretaría de las Naciones Unidas, juicio alguno sobre la condición jurídica de países, territorios, ciudades o zonas, o de sus autoridades, ni respecto de la delimitación de sus fronteras o límites.

Los documentos oficiales de la Segunda Conferencia Cartográfica Regional de las Naciones Unidas para América se han publicado con las signaturas E/CONF.71/3 (Nos. de venta: E.81.I.4, F.81.I.4 y S.81.I.4) y E/CONF.71/3/Add.1 (No. de venta: E/F/S.82.8.I.14).

[1] *Tercera Conferencia Cartográfica Regional de las Naciones Unidas para América*, vol. I, *Informe de la Conferencia* (publicación de las Naciones Unidas, No. de venta: S.85.I.14).

[2] El programa se reproduce en el anexo.

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The surveyor and human settlements, submitted by the International Federation of Surveyors 241

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AGENDA ITEM 4

Country reports and progress made since the Second Conference

NATIONAL REPORT: CARTOGRAPHY, PHOTOGRAMMETRY AND REMOTE SENSING, 1979-1984*

Paper submitted by Brazil

COMMISSION OF CARTOGRAPHY OF BRAZIL

The Commission of Cartography (COCAR) was created by law on 28 February 1967, with authority to co-ordinate national cartographic policy. COCAR is responsible for the leadership of the National Cartographic System, as well as for enactment and enforcement of cartographic standards and norms. Its secretariat provides administrative and technical support.

COCAR is composed of representative members from the following bodies:

Major staff of the Armed Forces (EMFA)
Navy (DHN)
Army (DSG)
Air Force (ICA)
Agriculture (MA)
Mines and Energy (MME)
Interior (MINTER)
National Program of Land Tenure Regularization (MEAF)
Brazilian Institute of Geography and Statistics (IBGE)
National Association of Aerosurvey Enterprises (ANEA)
Private sector

COCAR meets regularly at the Ministry of Planning, in the Federal capital, Brasília. The secretariat is located at Edifício Venâncio II, 2nd floor, SDS, CEP 70302, Brasília, DF.

COCAR's resolutions and deliberations are held at its plenary assemblies, while the several themes and standards are set forth, to be submitted to the Plenary Assembly, with support from the secretariat by the subcommissions:

Plans and programs (SPP): IBGE, DHN, DSG, ICA, MINTER
Budget (SOR): MME, EMFA, MA, MINTER, ANEA
Legislation and standards (SLN): DSG, DHN, ICA, EMFA, IBGE
Studies and conference (SER): ANEA, IBGE, MA, MME, MEAF

NATIONAL CARTOGRAPHIC SYSTEM

The National Cartographic System (SCN) is legally "composed of national entities, both public and private, having the main attribution of performing cartographic work or correlated activities".

The Brazilian Society of Cartography (SBC) draws membership from all Brazilian professionals in the cartographic field. The President of SBC is a cartographer.

During this inter-conference period cartography has developed steadily. Photogrammetry was applied not only for cartography but in other fields of activity. Photogrammetric methods are being used intensively to complete the detailing and recycling of cartographic mapping of the entire territory. Terrestrial photogrammetry is being applied to control earthworks, dams and other engineering projects.

Brazil is the greatest continuous area with complete radargrammetric coverage; taking advantage of LANDSAT coverage of the entire country, a variety of studies and research projects are being pursued in the remote sensing area.

RADAMBRASIL, with side-looking airborne radar images, acquired during the sixties, provides a time-fixed horizon, while LANDSAT images provide a dynamic picture of the changing features of the terrain.

Tuition and research in the fields of cartography, photogrammetry, geodesy, geophysics, geology, remote sensing and related areas, are under development through the universities of Rio de Janiero, Paraná, Pernambuco, and São Paulo, and the Military Institute of Engineering.

Students of geodetic science at Master's and Doctor's level at the Federal University of Paraná are being graduated yearly with a high level of quality.

Remote sensing is being taught at almost all universities besides the aforementioned, among others, the federal universities of Rio de Janeiro, Paraíba and Santa Maria and the Space Research Institute (INPE), with post-graduate courses at university level.

Post-graduation at Master's level in INPE is being continued uninterruptedly and with increasing quality. Accumulated experience, as well as theory and practice, in the use of remote sensing data, entitles the Institute to transfer its acquired knowledge.

CONGRESSES, SYMPOSIA, AND WORKSHOPS

1980

Cycle of conferences on cartographic activities, Brazilian Society of Cartography; Brasília (April)
Geologic and Geotectonic Aspects of São Paulo Sedimentary Basin, Brazilian Society of Geology (May)
Seminar on Geological Contribution to Search and Utilization of Conventional and non-Conventional Energy Sources, Brazilian Society of Geology; São Paulo (June)
Operation Rio de Janeiro II, DHN-IPqM; Rio de Janeiro (June)
XXXII Annual Meeting, Brazilian Society for the Progress of Science (SBPC); Rio de Janeiro (July)
Mapping of Superficial Formations in the Marília Region, University of São Paulo/University of Caln-França; Marília (July)

*The original text of this paper, prepared by Fernando Rodrigues De Carvalho, Executive Secretary, Commission of Cartography, appeared as document E/CONF 77/L 69

Meeting of the Permanent Group on Tuna and Similar Fishes, SUDEPE; Rio de Janeiro (August)

Ecologic Studies Week, University of São Paulo; Rio Claro (September)

XXXI Brazilian Congress of Geology, Brazilian Society of Geology; Camboriú (October)

I Biology Week, Centro de Ciências Biológicas e da Saúde de da Universidade de Taubaté; Taubaté (October)

Cycle of conferences, Brazilian Society of Geology; São Paulo (November)

Seminar on Remote Sensing as Applied to Forestry Science, IBDF; Brasília (November)

Workshops and meetings (about 35) conducted by the Space Research Institute

1981

XXXIII Annual Meeting, Brazilian Society for the Progress of Science; Salvador (July)

XI Brazilian Congress of Agriculture Engineering; Brasília (July)

II Brazilian Congress of Agrometeorology; Pelotas (July)

XVIII Brazilian Congress of Soil Science; Salvador (July/August)

Latin American Satellite Remote Sensing Users' Meeting; São José dos Campos (November)

COGEODATA IAMG for South America; Rio de Janeiro (December)

X Brazilian Congress of Cartography; Brasília

Workshops, meetings and lectures (about 13) on LANDSAT image uses, conducted by the Space Research Institute

1982

I Naval Symposium of SONAR; Arraial do Cabo (April)

II Brazilian Symposium on Remote Sensing; Brazilia (May)

I Brazilian Meeting on Hydric Resources and Sanitation Research; Porto Alegre (May)

Technical Meeting on Environmental Cartography, CETESB; São Paulo (July)

I Brazilian-Peruvian Meeting on Remote Sensing; Acre (July)

Latin-American Regional Conference of International Geographic Union; Rio Claro (August)

National Congress on Native Tree Species; Campos do Jordão (September)

XXXII Brazilian Congress of Geology; Salvador (September)

International Symposium on Coastal Ecosystems: Utilization: Planning/Pollution and Productivity; Rio Grande (November)

Seminar on Image Interpretation of Vegetation, Directorate of the Army Geographic Service; Rio de Janeiro (July)

Seminar on Application of Remote Sensing in the Study of Areas with Rice Cultures, IRGA; Porto Alegre (August)

Lectures and conferences on LANDSAT image uses for about 16 Brazilian organizations, conducted by the Space Research Institute

1983

United Nations Regional Seminar on Space Applications in Consideration of the Implementation of the results of UNISPACE '82; Space Research Institute, São José dos Campos (May)

National Week of Environment, IBGE; Rio de Janeiro (July)

Meeting on environment, UFMT; Cuiabá, MT (June)

II Cubatão Meeting: Valley of Life, SBPC; São Paulo (August)

IV Paulista Congress of Agronomy, CATI; Campinas (August)

I Brazilian Congress of Geosciences and Technology as Applied to Environment Studies, GEOTEC I; University of Rio de Janeiro (November)

XI Brazilian Congress of Cartography; Rio de Janeiro

Workshops and meetings for about 12 Brazilian organizations, conducted by the Space Research Institute

1984

ACSM-ASP Annual Meeting; Washington, D.C., United States of America (March)

IV Brazilian Congress of Engineering Geology; Belo Horizonte, MG (April)

XV Congress of the International Society of Photogrammetry and Remote Sensing; Rio de Janeiro (June)

Post-Congress Symposium of Photogrammetry and Remote Sensing; Curitiba, PR (July)

XII Conference of the International Cartographic Association; Perth, Australia (August)

ACSM-ASP Fall meeting; Houston, Texas, United States of America (September/October)

XXXIII Brazilian Congress of Geology; Rio de Janeiro (October/November)

III Brazilian Symposium of Remote Sensing; Rio de Janeiro (November)

Seminar on Geodetic Base and the Cartographic System of the Federal District; Brasília (December)

International Workshop on Land Tenure Administration; Salvador (September)

CARTOGRAPHIC APPLICATIONS

Systematic mapping

The Cartographic Dynamization Program (DINCART) began operations at the end of 1978, co-ordinated by COCAR. The results from 1977 through 1984 are listed in table 1. Systematic terrestrial topographic mapping is performed by the Brazilian Institute of Geography and Statistics (IBGE) and by the Directorate of the Army Geographic Service (DSG). Work is shared between both organizations in order to ensure efficiency and to avoid expensive overlaps.

TABLE 1. DINCART: SYSTEMATIC TERRESTRIAL MAPPING

(In square kilometres. Brazilian territory 8,511,965 km², 30' × 30' modules: 3,049)

Year	Year		Total	
	Mapped area	%	Mapped area	National territory (%)
1977	—	—	4,050,000	44 42
1978	349,500	3 83	4,399,500	48 25
1979	183,000	2 01	4,585,500	50 26
1980	591 750	6 49	5,174,250	56 75
1981	486,000	5 33	5,660,250	62 08
1982	894,000	9 81	6,554,250	71 89
1983	441,000	4.84	6,995,250	76 73
1984	318,000	3.49	7,313,250	80.22

[a] Not including revisions and reprints.

Figure 1. Brazil: Cartographic Dynamization Program; area mapped through 1977 (DINCART-77)

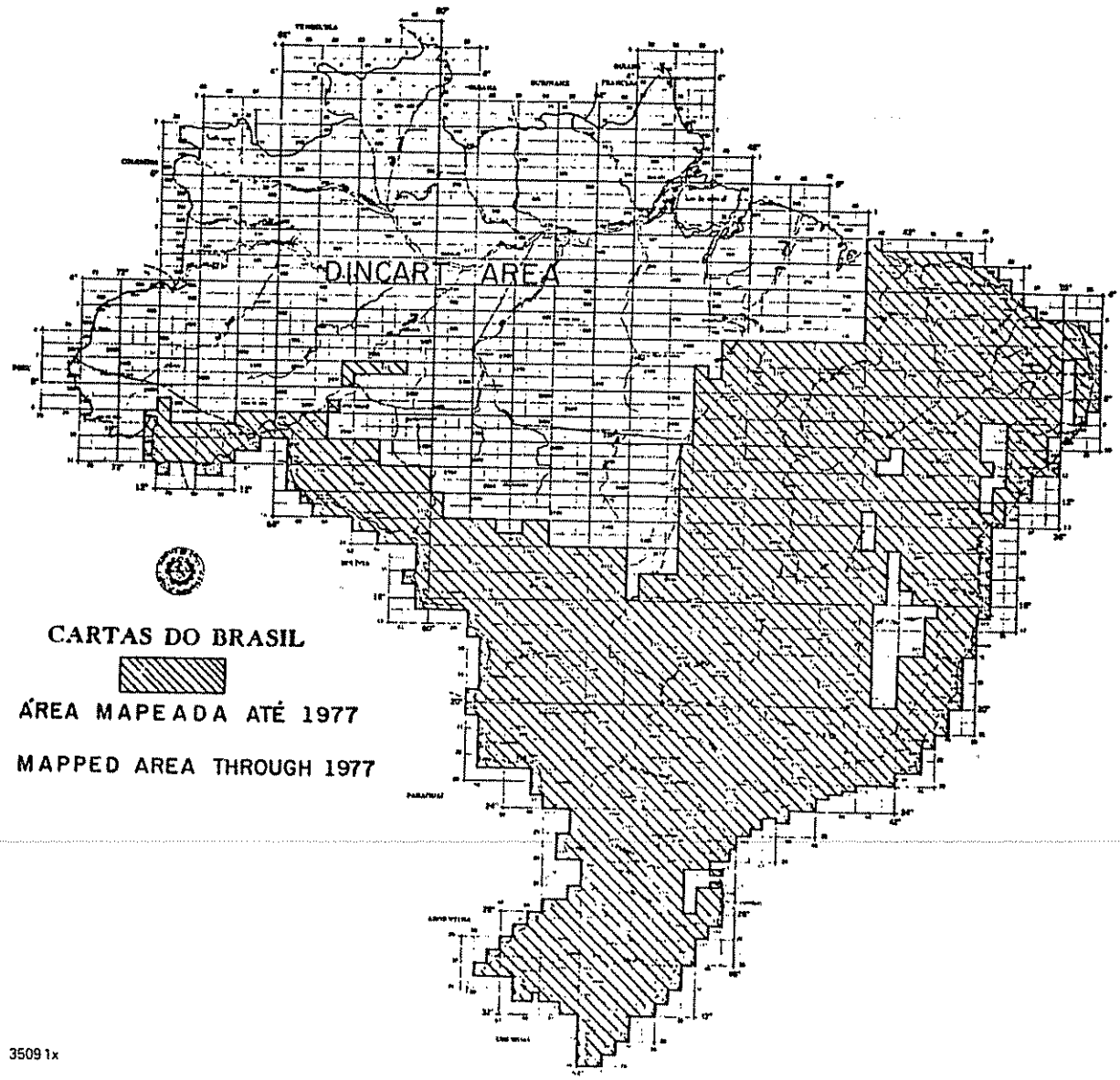


Figure 2. Brazil: the Cartographic Dynamization Program; work accomplished by 1984 (DINCART-84)

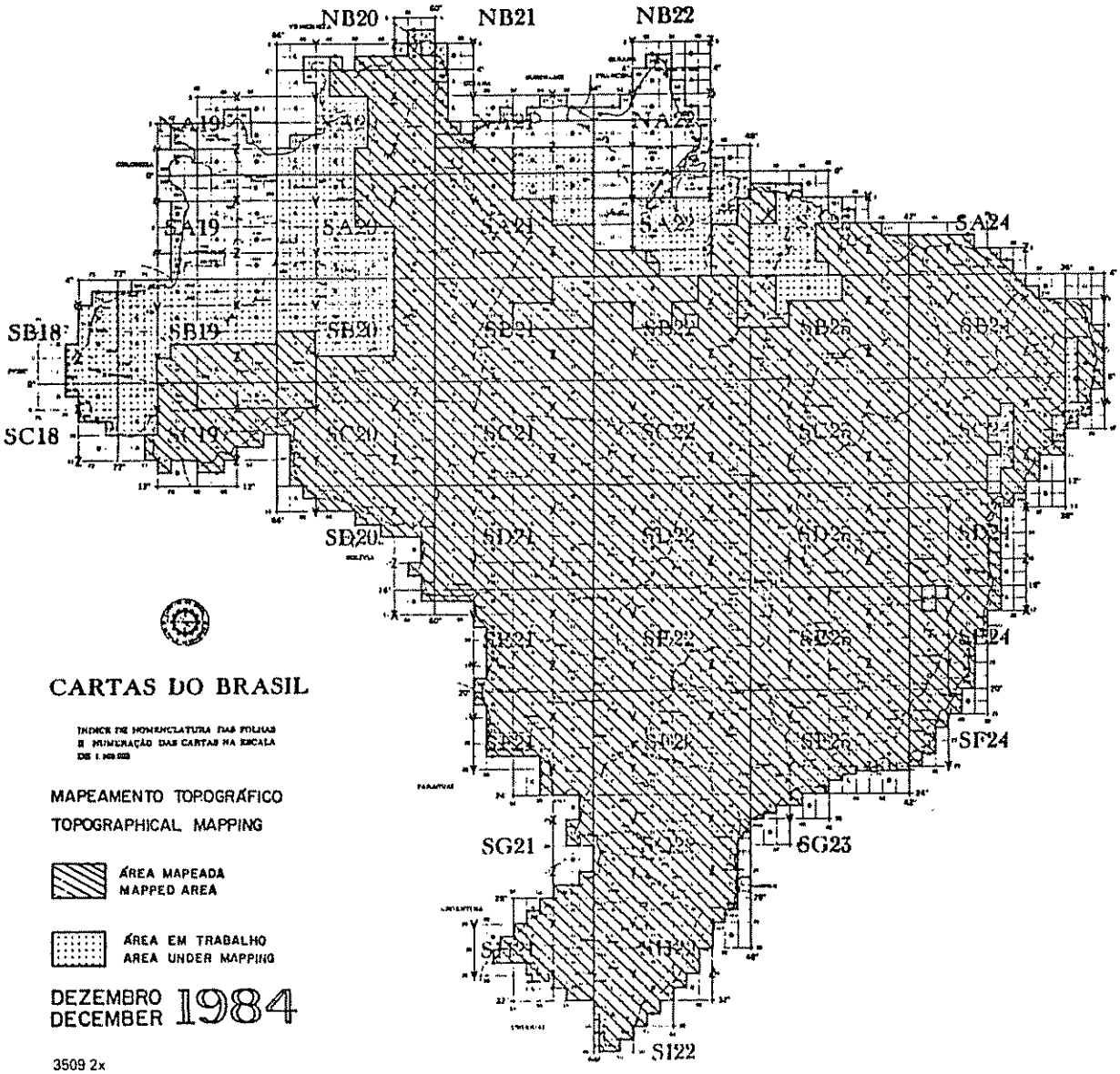


TABLE 2 AIR PHOTOGRAPHY, 1980-1984*
(square kilometres)

Scale	1980	1981	1982	1983	Total area	National territory (%)
1:4.000	42		5		47	
1:5.000	460	900	530	201	2.091	0 02
1:6,000	5		324		329	
1:8,000	2.899	4.132	2.070	3.209	12,310	0 14
1:10.000	1.183	1.707	671	920	4,481	
1:15,000	4.065	2.110	760	13.600	20,535	0 24
1:20,000	17,778	675	4.931	2.534	25.918	0 30
1:25,000	202.200	1.400	64.324	17,238	285.162	3 35
1:30.000	660	3.000	102,309	63.640	169,609	1 99
1:35.000	17,200			36.537	53.737	0 63
1:40.000	5,462	24.000	3.707	59.010	92.179	1 08
1:50,000	600	3.000	1.500	10.560	15.660	0.18
1:60,000		9.207	75,660		84,867	0 99
1:70,000	24.000		60.000		84,000	0 98
1:100,000	778.000	186,983	221,280	150.762	1.337.025	15 70
TOTAL	1.054.554	237.114	538.071	358,211	2.187,950	25 70
Geophysics	390,000	221,637	385,132	143,100	39,869	14 73

* Data for 1984 under updating process

Aerophotography and Aerogeophysics

Aerophotography and aerogeophysic coverage in the period are displayed in table 2

Additional cartographic performance

In addition to the aforesaid activities, the following production by IBGE, DSG and other State agencies should be mentioned:

International Map of the World (IMW): 27 sheets (re-editions)

Map of Brazil 1:5,000,000: 2 editions

Combined RADAR image plus topographic charts at 1:250,000 scale CIRC — charts: 74 sheets

Combined RADAR image plus planimetric charts at 1:250,000 scale CIRP — charts: 118 sheets

Combined LANDSAT image plus topographic charts at 1:250,000 scale CILC — charts: 9 sheets

Combined LANDSAT image plus planimetric charts at 1:250,000 scale CILP — charts: 29 sheets

State maps: 9 sheets

State atlases: 4 each

Regional atlas: 2 each

Municipal maps: 502 sheets

Magnetic variation chart of Brazil: 1 sheet

Geoidal chart of Brazil: 1 sheet

Geodetic System

In geodesy, expansion of the fundamental geodetic network was accomplished by IBGE as follows:

First-order triangulation stations: 602 benchmarks

First-order traversing stations: 325 benchmarks

First-order Doppler satellite stations: 672 benchmarks

First-order geometric levelling (56.536 km): 17,038 benchmarks

Laplace stations:

Latitudes: 91
Longitudes: 96
Azimuths: 116

First-order bases (2,461 km): 111

Gravimetric stations: 3,604

Non-systematic mapping

Non-systematic mapping at scales greater than 1:50,000 is performed mainly by private enterprises, hired generally by governmental organizations and, to a lesser extent, by private users. The results are presented in table 3.

TABLE 3 NON-SYSTEMATIC MAPPING
(Square kilometres)

Scale	1980	1981	1982	1983	Total	Brazilian territory (%)
1:500	24		5	2	31	
1:1.000	36	18	6	501	561	
1:2.000	3.893	2.716	891	3.214	10.714	
1:2.500	3				3	0 13
1:4.000	30	24			54	
1:5,000	8.079	6.174	9.980	3.400	27.633	0 32
1:8,000				260	260	
1:10,000	15.505	5.915	6.389	5.996	33.805	0 40
1:15,000	200				200	
1:20.000	5.339	1.158	9.125	1.739	17.361	0 20
1:25.000	520	10.882	44.380	39.675	95.457	1 12
Orthophotomapping						
1:2.500		54			54	
1:5,000	1.850			96	1.946	0 02
1:10.000			21.000	33.789	54.789	0 64
TOTAL	35,479	26,941	91,776	88,672	242,868	2 85

The data for 1984 are under updating process

Local and regional plans

Large-scale cartography at systematic mode is recent in Brazil. In metropolitan regions it is used as the starting point for the implementation of city plans (Cartographic City Systems).

At state level, the State of São Paulo Cartographic Plan covers more than 30 per cent of the state (247,320 km²) by 1:10,000-scale charts; about 68 cities (out of 571) of medium size are mapped at 1:2,000 scale. As a total, out of 120 medium-sized towns in Brazil, about 100 have cartographic plans (medium-sized towns are considered to be those with 100,000 inhabitants).

Soil mapping

Soil survey activities made good use of the photogrammetric method and image interpretation from aerial photographs, LANDSAT and RADAM, which was at this time extended to the entire country. RADAM is the acronym of RADar of AMazonia: its name now became RADAMBRASIL).

Ground truth and data evaluation techniques are added to the final job.

Among other bodies involved were the National Soil Survey and Conservation Service (SNLCS), RADAMBRASIL, Superintendence of Central-West Development (SUDECO), INPE and the Centre for Technology of the State of Minas Gerais (CETEC).

The accomplishments were as follows:

Scale	*Area covered (km²)*	*National territory (%)*	*Body*
1:10,000	36		SNLCS
1:25,000	14,915	0.17	CETEC + OTHERS
1:50,000	23,460	0.27	SNLCS + CETEC
1:100,000	27,711	0.32	SNLCS + OTHERS
1:200,000	19,800	0.23	SNLCS
1:250,000	171,823	2.01	SNLCS + OTHERS
1:500,000	1,432,639	16.08	SNLCS + INPE + CETEC
1:600,000	402,576	4.72	SNLCS
1:750,000	248,420	2.91	SNLCS + RADAM
1:1,000,000	7,440,000	133.96	OTHERS
1:1,000,000	3,970,000	46.64	SNLCS + RADAM
1:5,000,000	8,511,965	100.00	SNLCS
1:5,000,000	1,879,455	22.08	SUDECO
TOTAL	24,135,744	283.55	

Geological mapping

In the field of geology, several government organizations joined their efforts to shape the "facies" of the Brazilian territory, almost all of them by hiring private companies to do the data-collection: among others, the National Department of Mineral Production, RADAMBRASIL, and various regional and state organizations.

Intense use was made of the photogrammetric method and image interpretation from RADAM and LANDSAT images, as well as ground truth.

The results were:

Scale	*Area covered (km²)*	
1:20,000	772	
1:25,000	2,510	
1:50,000	76,517	
1:100,000	6,000	
1:250,000	22,758	
1:500,000	673,764	
1:1,000,000	5,723,002	
1:2,500,000	8,511,965	(area of Brazil)
TOTAL AREA	15,294,885	(179.6%)

Vegetation mapping

Vegetation and forest cover monitoring studies were done mainly by the Brazilian Institute of Forest Development (IBDF) as well as by INPE, RADAM, SUDECO and others.

Their accomplishments resulted from intensive use of the photogrammetric method and photo and image interpretation from RADAM and LANDSAT sources, averaging:

Scale	*Area covered (km²)*	*National territory (%)*
1:100,000	11,621	0.13
1:250,000	1,548,423	18.19
1:300,000	150,000	1.76
1:500,000	682,933	8.02
1:600,000	77,000	0.09
1:1,000,000	4,011,814	47.13
1:5,000,000	1,879,455	22.08
TOTAL	8,361,246	98.23%

Aeronautical cartography

Performed by the Institute of Aeronautical Cartography, aeronautical charting, besides increasing production by means of acquired equipment, went forward with the updating of the World Aeronautical Chart (WAC) produced at the beginning of the eighties; collecting data for the Aeronautical Pilotage Chart; and cadastral mapping of aerodromes, which was started in order to support the infrastructure of airports and protect flights.

76 sheets of the Aeronautical Pilotage Chart were produced at scale 1:250,000, by compilation from topographic terrestrial charts and intense use of RADAM and LANDSAT information; 45 topographic sets of charts of aerodromes by photogrammetric methods at scales ranging from 1:10,000 to 1:2,000; 16 editions of the Air Navigation Set, each set containing 12 charts at 1:3,000,000 scale, terminal area charts, 415 standard instrument departure charts and 10,508 instrument approach and landing charts.

The following publications were issued: Aeronautical Information Publication (half-yearly); aeronautical information circulars (as needed); and *Notice to Airmen* (NOTAM) (daily).

Nautical cartography

Performed by the Directorate of Hydrography and Navigation, nautical cartography increases its operations continuously, thanks to renewal of hydrographic equipment, issuing 110 new charts; 87 new editions; 332 reprints; 193 amendments; hydrographic surveys of 15 rivers; hydrographic reconnaissance of 13 rivers as well as an updating survey of previously surveyed rivers; 47 navigation *croquis* of Japurá River; all charts of Paraná, Paraguay, Amazon, Trombetas and Tapajós rivers, all of them important supply and exportation corridors. All charts of Rio Pará deemed important to the launching of the project "Port of Vila do Conde–Barcarena for Aluminium Export" were produced.

Hydrological resources

Hydrologic research has been developed mainly by RADAM, the Department of Mineral Production, the Superintendency of the North-east (SUDENE) and CETEC.

The results produced charts at several scales such as;

Scale	*Area covered (km²)*	*National territory (%)*
1:500,000	3,163,213	37.16
1:1,000,000	2,587,818	30.40
1:2,500,000	8,511,965	100.00
TOTAL	14,263,006	167.56

Remote sensing

Information on remote sensing is supplied by the Space Research Institute (INPE). Since the sixties INPE has concentrated its efforts on this activity. In 1967 a co-operative programme with NASA was started and a group of specialists received special training in the United States. From the seventies on, taking into account the development of activities in space applications of remote sensing, INPE became entitled to own and operate a station for reception and processing of LANDSAT images.

By mid-1973 the reception and recording station at Cuiabá (MT) was in operational status. Since late 1974, INPE has supplied operationally national and international users with LANDSAT imagery, through its laboratory in Cachoeira Paulista (SP).

During the last 15 years, INPE, through a special programme, developed a team of technicians specializing in the development of remote sensing methodologies, as applied to monitoring the Earth's surface.

Besides short-duration courses, INPE maintains a programme of graduation at Master's degree level on remote sensing. INPE's cadre is today composed of 8 professionals at Doctorate level and 27 at Master's level.

Main emphasis on the agricultural area has been applied to develop and test systems of harvest estimation, concerning cultures of economic expression for the country, based on remote sensing techniques.

Vegetation

The main effort has been directed toward developing a methodology for forest cover monitoring in a joint work of INPE and the Brazilian Institute of Forest Development (IBDF). For the first time, it is possible to regularly evaluate the deforested area of all legal Amazonia.

Soils

Generalized knowledge of soil and its potential is becoming more and more important in making possible programmes of agricultural development, as well as soil classification. Mapping affords information necessary to the rational exploitation of land and consequent increase of productivity. In the field of soils, two basic lines of work have been developed: the first aims at soil mapping, based on spatial parameters of small-scale images; the second is aimed at characterizing the spectral behaviour of soils as indicator of physical and chemical properties. In this research work, it is attempted to relate the different spectral parameters measured in the field and in laboratories with those observed on LANDSAT orbital images.

Geology

During 1979-1984 research was concentrated on the study and evaluation of techniques of spectral discrimination of mineralized areas, rocks discrimination and alteration products.

At the same time, owing to lack of current data on the national territory, an effort was developed towards making good use of the potential of LANDSAT orbital data for geological mapping purposes.

Environmental analysis

Remote sensing research, as applied to environment analysis, is aimed at the development and evaluation of techniques of environment monitoring, through data collected by airborne and spaceborne sensors.

From 1980 to 1984 several activities in this field were developed, such as methodology for utilization of remote sensing data; MSS-LANDSAT digital data analysis; use of remote sensing techniques to characterize soil erosion; identification of areas where there have been alterations in soil uses; use of decision-making techniques of MSS-LANDSAT channels to identify areas where carbon mining rejects are occurring; urban soil-use mapping; methodology of remote sensing sequential data use to study the lapse of reaction of fluvial systems to anthropogenic activity; methodology of the temporal attributes of LANDSAT images for change detection.

Oceanography

During the period 1979-1984, the following contributions related to ocean studies: methods to estimate the content of chlorophyll in the waters of Guanabara Bay, arising from MSS-LANDSAT digital data; model of fishing charts from remote sensing oceanographic data; determination of sea surface through GEOS and TIROS-N satellite data.

Hydrological resources

The 1979-1984 period presented several activities applying remote sensing to hydrological resource studies, such as a proposal for a method to evaluate areas subject to floodings by means of MSS-LANDSAT digital data processing; multi-temporal analysis of rivers by means of detection and mapping of water bodies at different seasons of the year; and mapping of areas subject to flooding risks.

Methodology transfer in remote sensing

Methodology transfer in remote sensing is aimed at the diffusion of techniques and methods to users, reaching indirect customers (executive and entrepreneurial class) as well as direct customers (technicians, educators, researchers etc.).

To reach the proposed objective it is necessary to disseminate and transfer the remote sensing techniques by means of training courses and intensive training; participation in symposia, congresses and seminars; conferences on remote sensing; technical meetings; participation in remote sensing courses at Master's degree level; customer assistance and other activities.

Training courses and intensive training

The goal is to develop manual skills and to familiarize the trainee with techniques and basic problems in applying remote sensing data to a study of natural resources, in agronomics, environment analysis, forestry, geology, oceanography and hydrological resources.

During 1980-1983, 352 participants were trained; they belong to national and international government organizations, as well as private enterprises. Seven training courses are now in effect, with about one hundred participants.

RESEÑA DE LAS ACTIVIDADES CARTOGRAFICAS*

Documento presentado por Chile

I. Reseña de las actividades cartográficas más importantes realizadas por el Instituto Geográfico Militar desde el año 1979 hasta 1984

Actividades geodésicas

Trabajos geodésicos en el territorio chileno continental

Con el objeto de completar la cubierta cartográfica regular del territorio austral del país, se estableció una red básica de 161 vértices geodésicos utilizando el sistema de posicionamiento con instrumentos georreceptores de señales satelitarias, única alternativa a utilizar en esta parte del continente por sus características geomorfológicas y climáticas (desde los 43°30′ al sur).

Estos valores de la red de vértices geodésicos sirvieron para establecer el ajuste de la red geodésica nacional clásica, con las poligonales telurométricas de precisión que se habían calculado anteriormente a los 52°30′ S y las redes de triangulación y poligonales electrónicas correspondientes a los levantamientos cartográficos en el sector limítrofe internacional.

En forma paralela a lo anterior, se continúa densificando y recuperando la red geodésica nacional para la cartografía a escala 1:25 000 en aquellas zonas de interés económico.

Por otra parte, se han revisado y renivelado las líneas de nivelación de precisión en la zona central, las cuales se ven constantemente afectadas por el carácter sísmico del país y por las constantes actividades de construcción de obras que se operan.

Todos los trabajos geodésicos señalados anteriormente se efectuaron con origen en el Datum y Elipsoide Sudamericano del año 1969.

Trabajos geodésicos en el territorio antártico

Con miras a proceder al levantamiento de la cartografía regular de esta parte del territorio, concurrió a este continente una Comisión Técnica que realizó un reconocimiento del área de trabajo, a objeto de estudiar los antecedentes y definir los métodos más convenientes del trabajo, como asimismo, necesidades de personal, implementos, equipos y apoyo logístico que permitan elaborar la cartografía regular a partir de los 63° S.

Para cumplir este objetivo se continuará con el establecimiento de una red geodésica básica, mediante el empleo de georreceptores que permitan el ajuste analítico de los bloques de modelos fotogramétricos.

Actividades cartográficas

Carta regular, escala 1:25.000

La necesidad de disponer de cartografía con un nivel de detalle que permita identificar con precisión los lugares de interés de aquellos sectores con mayor desarrollo socioeconómico, ha motivado un significativo impulso a la ejecución de esta carta.

De esta forma se ha materializado una producción anual promedio de 130 cartas, lo que ha significado hasta hoy cubrir las áreas de especial importancia económica de la zona central del país, cuyo detalle se indica en la figura 3.

Carta regular, escala 1:50.000

Tal como se señala en la figura 4, el Instituto Geográfico Militar de Chile ha dedicado especial interés en la completación de la cubierta cartográfica a esta escala, a partir de los 43°30′ S y hasta los 56°00′ S.

Carta regular, escala 1:250.000

Durante el año 1984 se realizaron los trabajos para la publicación de 26 hojas en versión uso público, las cuales corresponden a la primera prioridad de un Plan Nacional de Cubierta Cartográfica a esta escala.

El detalle de las hojas publicadas se indica en la figura 5.

Otra cartografía

Durante el período 1983-1984, se procedió a obtener las primeras hojas de cartografía del Territorio Antártico (Tierra de O'Higgins) a escala 1:500.000, a través de imágenes Landsat.

En el transcurso del año 1985 se continuó efectuando el levantamiento cartográfico por intermedio de este procedimiento, hasta completar la cobertura total de este sector de la península antártica.

Ortofotocartas

El Instituto Geográfico Militar de Chile ha estado trabajando en la producción de ortofotos desde el año 1979, fecha de instalación de los equipos adquiridos para el efecto. Después de un período de preparación y experimentación, se han obtenido importantes resultados que permiten ofrecer este producto para su aplicación en el área de recursos naturales, planificación, catastro rural, fotointerpretación, minería, etc.

Esta imagen fotográfica, cuya proyección central ha sido transformada a una proyección ortogonal, eliminando así las distorsiones de la fotografía aérea convencional, se ha convertido en un valioso instrumento de análisis en las áreas ya señaladas.

A pedido del usuario esta ortofoto puede completarse con información altimétrica (curvas de nivel y otros) y toponimia, obteniéndose entonces una ortofotocarta.

En la figura 6, se indican los sectores cubiertos con ortofotos.

Plan piloto de cartografía automatizada y banco de datos

Cartografía automatizada

Los trabajos en este campo tienen como objetivo esencial la ejecución de planos, cartas a distintas escalas. La información se puede dividir en distintos niveles y permite su almacenamiento en medios magnéticos. La salida de información puede ser gráfica, mediante el plotter o terminal gráfico, y no gráfica, por pantalla no gráfica e impresora.

Se han ejecutado a la fecha planos a diferentes escalas, símbolos y gráficos para diversas obras editadas por el Instituto y programas de colocación de símbolos mediante coordenadas o para unir puntos mediante coordenadas.

Banco de nombres geográficos

Tiene por finalidad almacenar y actualizar la totalidad de los nombres geográficos o topónimos que existen en nuestro territorio.

La base de datos se ha estructurado de la siguiente forma: número de identificación del topónimo, topónimo o nombre

* The original text of this paper appeared as document E/CONF 77/L 70

Figura 3. Chile: Carta regular, escala 1:25.000

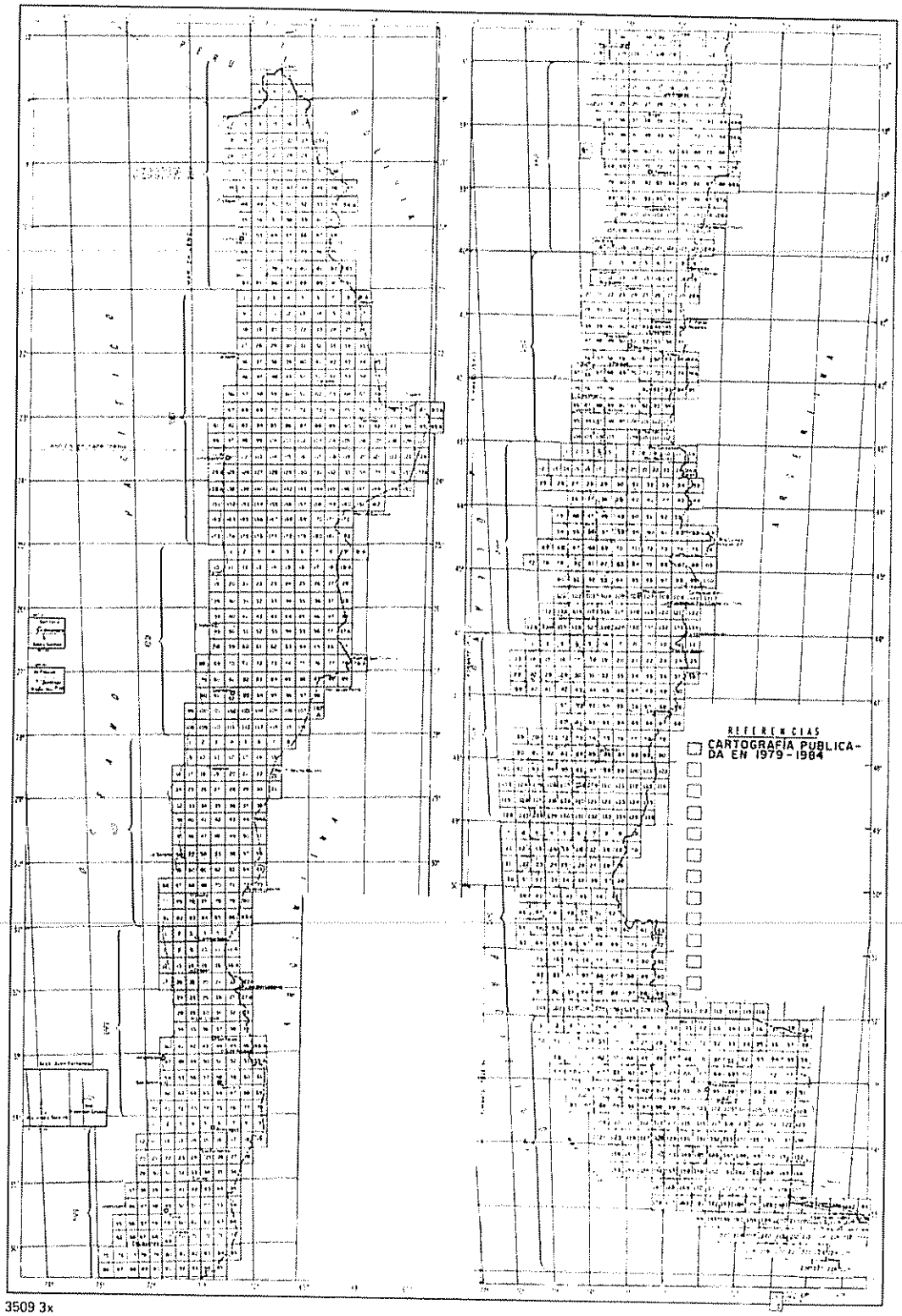
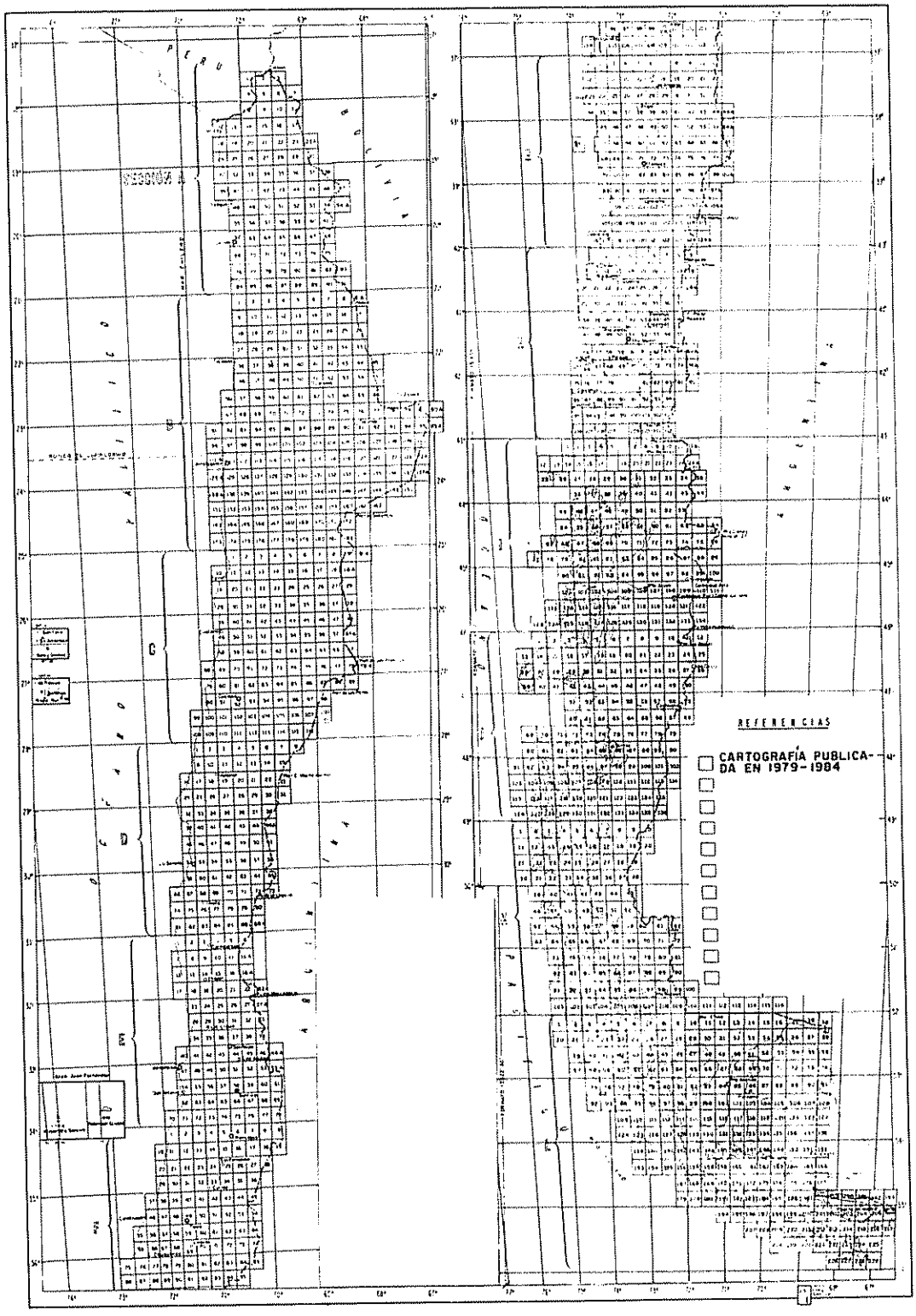


Figura 4. Chile: Carta regular, escala 1:50.000



3509 4x

Figura 5. Chile: Carta regular, escala 1:250.000

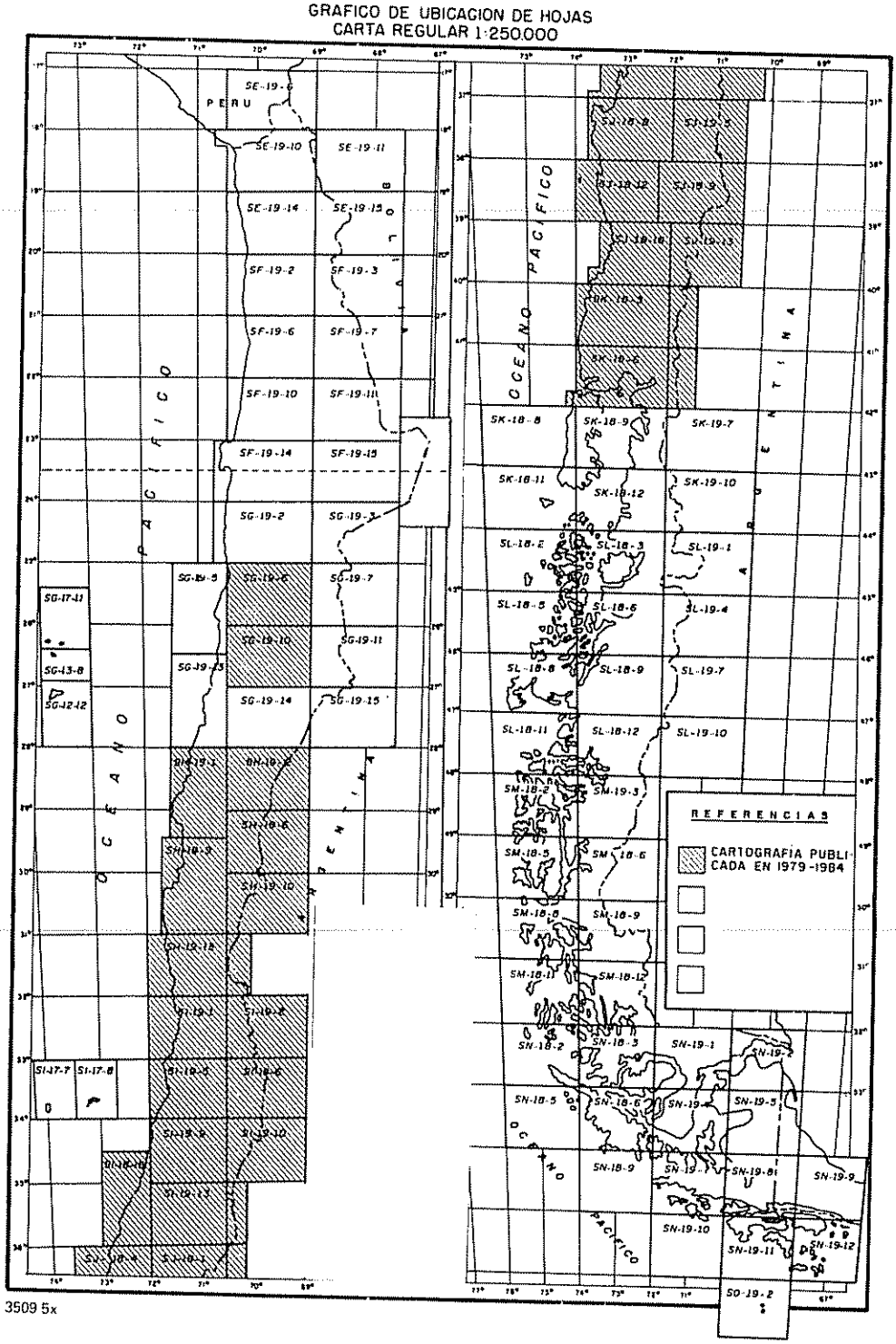
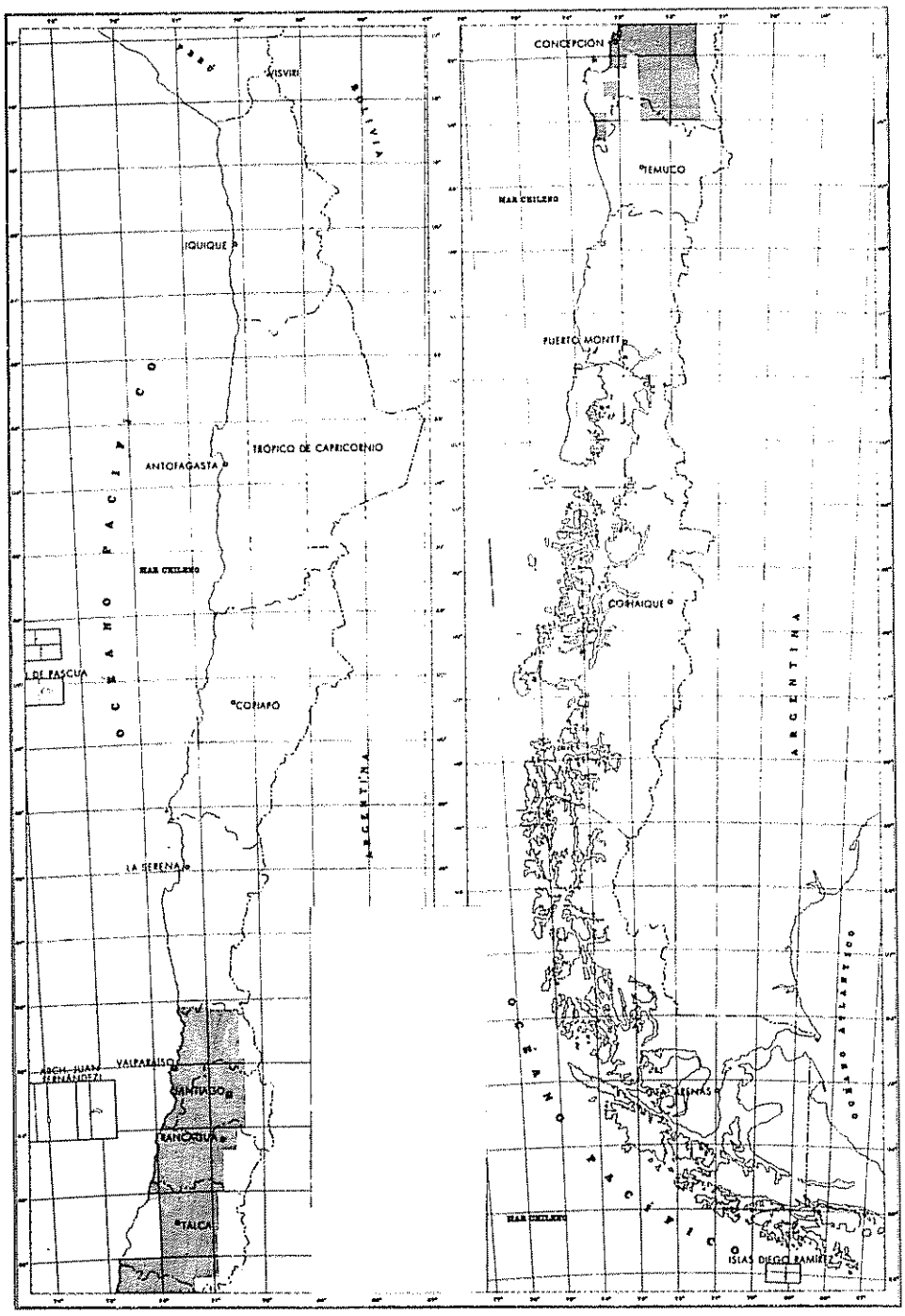


Figura 6. Chile: Area cubierta por ortofotos



3509.6x

geográfico, tipo de accidente, latitud aproximada, longitud aproximada, altura, carta del Instituto Geográfico Militar donde se ubica el topónimo, región donde se encuentra el topónimo y, finalmente, datos breves de referencia

En este campo se ha ejecutado el listado de nombres geográficos y además se ha procedido a la actualización de la base de datos ingresados

Banco de datos geodésicos

A través de este banco de datos se mantendrá y conformará una base de todos los puntos geodésicos del territorio, que estará sometida a una constante actualización.

Este banco estructura su archivo tomando como referencia, entre otros, la sección donde se ubica el punto, clase de punto (doppler, trigonométrico, etc.), orden, datum y elipsoide, nombre, hasta llegar a un código que lo identifica.

Se han elaborado a la fecha, básicamente, los programas de conformación y ocupación de la base de datos, como asimismo, las búsquedas primarias e ingreso periódico de los mismos.

Banco de nivelación

Este banco tiene por objeto almacenar y manejar la información de todos los pilares de nivelación medidos por el Instituto Geográfico Militar.

La estructura del archivo de esta base de datos contiene, entre otros, el nombre del pilar, cota, precisión, latitud y longitud aproximada, descripción de la línea. El almacenamiento de esta base de datos se encuentra disponible en disco o cinta.

En este banco se han ingresado cinco líneas de nivelación y se han conformado los programas correspondientes

Levantamientos catastrales

Durante el año 1984 se formó una Comisión Interinstitucional en la cual el Instituto ha tenido una activa participación.

Esta Comisión, en las etapas desarrolladas, concluyó el "Estudio de prefactibilidad del Catastro Nacional", cuyos resultados indican una iniciativa de amplio beneficio en la consolidación de un Sistema de Registro e Información sobre los Bienes Raíces. Este permitirá disponer de datos confiables y actualizados sobre las características físicas y económicas de la propiedad inmueble. Para lograr este registro se requerirá de la conciliación entre los registros legales y catastrales.

Para el año 1985, el Instituto se ha fijado como meta la completación y profundización de los costos y beneficios intangibles del catastro, mediante la realización de un proyecto piloto en una comuna de la región metropolitana de Santiago.

Este proyecto persigue evaluar la relación costo-beneficio del proyecto y además experimentar y probar los procedimientos técnico-jurídicos más adecuados para la ejecución de los levantamientos catastrales, los cuales ya han sido puestos en práctica en pequeñas áreas del gran Santiago, a través de proyectos pilotos.

Cartografía a escala pequeña

El Instituto Geográfico Militar, consciente de la gran utilidad que presta este tipo de cartografía, ha publicado los siguientes mapas y planisferios, orientados al campo de la educación.

Mapa de América del Sur

Este mapa contiene antecedentes físicos y políticos del continente sudamericano. Ejecutado en Proyección Cónica Oblicua Bipolar Conforme, a escala 1:8.000.000, contiene, además, un recuadro con el Territorio Antártico, a escala 1:23.000.000. Se complementa con la ilustración de banderas de los países, su capital, superficie y población, además de un perfil longitudinal con las principales alturas

Planisferio

Contiene la división política del mundo, incluyendo la ilustración de las banderas de los países y sus idiomas. Ejecutado en una Proyección de Van der Grinten, a escala 1:32.000.000, contiene, además de las capitales nacionales, las cuidades de mayor importancia de cada país.

Plan Nacional de Cartografía y Fotogrametría

A través de este Plan se han renovado y completado los medios tecnológicos para la ejecución de los trabajos cartográficos. Se ha implementado de un moderno instrumental de restitución fotogramétrico y de información de cartas, además de helicópteros, vehículos, instrumentos y equipos accesorios. Junto a esta implementación instrumental, se ha llevado a cabo un programa de perfeccionamiento del personal, con cursos de capacitación en el país y en el extranjero.

Esta alta capacidad técnico-profesional del Instituto le ha permitido levantar anualmente 144.000 km^2 de cartografía a escalas 1:50.000 y 1:25.000.

Informe general de Chile con los progresos alcanzados desde la Segunda Conferencia

Atlas nacionales y regionales

Atlas de la República de Chile. El Instituto Geográfico Militar de Chile, en su calidad de autoridad oficial en todo lo referido a la geografía y levantamiento del territorio nacional, publicó la primera edición de este Atlas el año 1966. Posteriormente se imprimieron dos nuevas ediciones, los años 1970 y 1972.

Consciente de la necesidad de actualizar esta obra, se reeditó el año 1983, ampliada y completamente renovada, acorde con las recientes técnicas de trabajo cartográfico y sobre la base de la nueva División Político-Administrativa, vigente en el país

Atlas escolar de Chile. A partir del año 1976 se realizaron cuatro ediciones de este atlas, orientado a la educación media y básica, con un tratamiento de las materias a nivel nacional y regional. Estas ediciones se encuentran totalmente agotadas.

Atlas geográfico de Chile para la educación. En el año 1984, adecuándose a los nuevos programas de educación, se publicó este atlas, orientado básicamente a la educación media. Este documento se elaboró sobre la base de datos censales y estadísticos completamente actualizados, en una línea de presentación didáctica, ágil y moderna

Este atlas se desarrolla con un tratamiento a nivel nacional y regional, agregándose como complemento a los materias, numerosos bloques de diagramas y anaglifos.

Atlas cartográfico del Reino de Chile. En el campo de la cartografía histórica, se editó en el año 1981 este atlas, obra en la que se reprodujeron importantes piezas cartográficas de los siglos XVII a XIX, mantenidas en bibliotecas del país y del extranjero.

Colección Geografía de Chile

El Instituto Geográfico Militar de Chile está llevando a cabo este proyecto, que se compone de 13 tomos regionales. 20 tomos nacionales y un tomo glosario de términos, que tratarán los aspectos físicos, económicos y humanos del territorio.

Durante el año 1983 se editaron los tomos correspondientes a "Fundamentos Geográficos del Territorio Nacional", "Geomorfología", "Biogeografía" y "Población y Sistema Nacional de Asentamientos Urbanos". A su vez, el año 1984 se editaron otros cuatro tomos correspondientes a "Geografía de los suelos", "Geografía de los fondos marinos", "Geografía industrial" e "Hidrografía".

Durante el año 1985 se ha previsto la edición de ocho tomos.

Normalización de nombres geográficos

Durante el año 1984 se editó el Listado de Nombres Geográficos, obra que se compone de dos tomos y que comprende 65.000 topónimos, que cubren desde los 17°35′ S a los 42°55′ S, en los cuales se ha recopilado la totalidad de la toponimia contenida en la cartografía a escala 1:50.000 y 1:250.000 publicada por el Instituto Geográfico Militar.

II. Informe de las actividades hidrográficas y de cartografía náutica realizadas por el Instituto Hidrográfico de la Armada de Chile

Misión

En conformidad a lo establecido por el D.F L. No. 2090 del 30 de julio de 1930; la ley No. 16.771 del 16 de marzo de 1968 y el Decreto Supremo No. 192 del 6 de marzo de 1969, el Instituto Hidrográfico de la Armada tiene por misión principal proporcionar los elementos técnicos y las informaciones y asistencia técnica destinada a dar seguridad a la navegación en las vías fluviales y lacustres, dentro de sus aguas interiores, mar territorial chileno y en la alta mar contigua al litoral de Chile.

Del mismo modo constituye el servicio oficial, técnico y permanente del Estado, en todo lo que se refiere a hidrografía; levantamiento hidrográfico marítimo, fluvial y lacustre; cartografía náutica, confección y publicación de cartas de navegación de aguas nacionales; oceanografía, planificación y coordinación de todas las actividades oceanográficas nacionales relacionadas con investigaciones físico-químicas, mareas, maremotos; geografía náutica, navegación, astronomía, señales horarias oficiales; aerofotogrametría aplicada a la carta náutica y señalización marítima.

Corresponde también al IHA, contribuir mediante la investigación al desarrollo y fomento de otras actividades nacionales e internacionales afines que sean de interés para el país.

Levantamiento hidrográfico

Un levantamiento hidrográfico tiene como propósito principal la determinación de aquellos datos, dentro de un área marítima, fluvial o lacustre junto a la porción de tierra litoránea adyacente o circundante, que posibiliten la elaboración o actualización de una carta náutica.

Las operaciones de geodesia constituyen, en un levantamiento hidrográfico, el armazón básico e imprescindible sobre el cual se apoyarán posteriormente las sucesivas etapas de elaboración de la carta náutica. Las actividades de geodesia comprenden mediciones en el terreno empleando instrumental óptico y distanciómetros electrónicos. Con el empleo de estos últimos se utiliza principalmente el método de poligonales, que ha reemplazado las antiguas y lentas mediciones de base y triangulaciones, adquiriendo así una mayor rapidez sin alterar las normas de exactitud requeridas. Posteriormente, en el trabajo de gabinete se efectúan los cómputos que, en combinación con las observaciones de coordenadas geográficas, conducen a la determinación de las coordenadas de los vértices establecidos en el terreno.

Apoyándose en las mediciones geodésicas ya efectuadas, viene a continuación el aspecto más importante de un levantamiento hidrográfico y de vital importancia para la navegación, y es lo que se denomina "operaciones de sondaje". Estas tienen por finalidad obtener un conocimiento completo y detallado de las profundidades marinas y la ubicación de los bajos fondos, los que constituyen el mayor peligro para una navegación segura y expedita. Estas operaciones son realizadas por medio de buques y embarcaciones hidrográficas convenientemente equipados con instrumentos de gran precisión.

Simultáneamente con las operaciones de sondaje se efectúan observaciones de mareas y corrientes, las que permiten determinar el comportamiento dinámico de las aguas, de modo de poder conocer y pronosticar su régimen cíclico permanente.

El Instituto Hidrográfico, consciente de la importancia que tienen las actividades antes descritas, se ha esforzado en proporcionar a su personal instrumental moderno. Es así como se dispone de teodolitos WILD T-2, T-3 y T-16 para mediciones angulares; niveles automáticos WILD NAK-2; giróscopos WILD GAK-1 para determinar orientaciones; distanciómetros electrónicos MRA-6 para la medición de distancias en geodesia; equipos de posicionamiento por satélite Magnavox modelo MX-1502 para la determinación de coordenadas geográficas; posicionadores Mini Range III y ecosondas portátiles Elac LAZ modelos 100-01 y AW-50 para trabajos de sondaje, conjuntamente con un sonar de rebusca lateral EGG, modelo 259-4, que imprime la configuración y los obstáculos submarinos; mareógrafos portátiles Metercraft y correntómetros Interocean modelo 135-A.

El lento y fatigoso trabajo de antaño — muchas veces en condiciones meteorológicas adversas — de ocupación de los vértices, traslado de observadores, instrumental y materiales, ha sido facilitado y agilizado con el intenso empleo y apoyo de los helicópteros embarcados de la aviación naval.

En la actualidad, las actividades de levantamiento hidrográfico se vienen realizando — principalmente — por medio del buque hidrográfico "Piloto Pardo", con oficiales especialistas y técnicos del Instituto. Este buque lleva el nombre del distinguido oficial de la Armada de Chile que el año 1916 rescató de la Isla Elefante del Territorio Antártico a los miembros de la expedición polar británica de Sir Ernest Shackleton.

Las amplias y bien distribuidas acomodaciones del "Piloto Pardo", como asimismo el adecuado instrumental y medios que posee, permiten efectuar una eficiente labor hidrográfica. Su cubierta especial para el despegue y aterrizaje de helicópteros facilita y acelera enormemente la actividad total de levantamiento. En ese sentido, la participación de la aviación naval ha sido de inapreciable valor y la experiencia y habilidad de sus pilotos han hecho posible el cumplimiento de difíciles comisiones hidrográficas en zonas riesgosas, como son la región austral y antártica de nuestro litoral, donde imperan frecuentemente condiciones meteorológicas adversas.

Aerofotogrametría

Los métodos actuales difieren esencialmente de los antiguos, en los que el contorno de la costa y el detalle topográfico se obtenía tras largo y fatigoso trabajo de terreno. Hoy en día esto se logra por medio de fotografías aéreas

verticales empleando técnicas de aerofotogrametría. Utilizando las imprescindibles mediciones efectuadas en geodesia en el terreno, se obtiene básicamente la escala, la orientación y las coordenadas geográficas de las fotografías aéreas.

El objetivo de la aerofotogrametría es la confección de modelos geométricamente semejantes al terreno, empleando fotografías aéreas verticales del mismo. Este trabajo es realizado en el Instituto Hidrográfico por medio de procesos ópticos u óptico-mecánicos con instrumental y equipos especiales.

Los trabajos fotogramétricos se inician con la toma de fotografías aéreas verticales de la zona que interesa levantar, de acuerdo a un plan de vuelo establecido de antemano que se proporciona al avión. Para este objeto el Instituto Hidrográfico cuenta con cámaras aéreas que son instaladas en un avión de la Armada especialmente acondicionado para estas actividades.

Obtenidos los fotogramas aéreos, éstos son procesados en un laboratorio con que cuenta el Instituto para estos fines específicos, que se encuentra equipado con sala de revelado, ampliadora, rectificador de fotografías aéreas Zeiss SEG-V y otros instrumentos menores.

Para los procesos de aerotriangulación, fotointerpretación y restitución, se dispone de una sección especializada con instrumentos tales como aerotriangulador analítico Wild BC-1, aviógrafos Wild B-8 automatizados con microcomputadores y mesas Aviotab TA y equipos de transferencia de puntos Wild Puig-4 de gran precisión, los cuales permiten que las cartas de navegación se elaboren con el detalle topográfico exacto, lo que es de valiosa ayuda para el navegante.

En los últimos años la labor aerofotogramétrica, en su etapa de aerotriangulación, ha logrado una mayor exactitud en los resultados, con el diseño de programas especiales y uso de sistemas computacionales.

También se cuenta con una completa fototeca con fotogramas aéreos de gran parte del litoral, los que se han utilizado en la producción de la cartografía náutica moderna.

Cartografía

Desde su fundación, el Instituto Hidrográfico de la Armada ha dedicado, con especial esfuerzo, su atención a la publicación de planos y cartas para ser usados por las naves que surcan nuestras aguas. La carta náutica, considerada hoy en día una de las más completas y significativas expresiones gráficas de la Tierra, contiene un sinnúmero de informaciones necesarias para brindar seguridad a la navegación marítima, fluvial y lacustre. La exactitud en el detalle topográfico es tan importante como los datos de las profundidades y la precisa ubicación de todos los accidentes geográficos. Un pequeño error de orientación en un canal, por ejemplo, puede producir un grave accidente marítimo, con la consiguiente pérdida de vidas, materiales y el desastroso efecto de la contaminación marina.

Desde su primera carta, publicada oficialmente el año 1874, hasta nuestros días, el IHA ha editado centenares de cartas de nuestras aguas jurisdiccionales. La actual producción comprende cerca de 250 cartas de diferentes escalas, las que cubren la totalidad de nuestro extenso litoral.

El Archivo Hidrográfico contiene antecedentes y trabajos ejecutados por la Armada desde aquel lejano diciembre de 1834 en que el bergantín de guerra "Aquiles", al mando del Capitán de Fragata don Roberto Simpson, procediera al reconocimiento y levantamiento de la desembocadura del Río Bueno. Todos estos antecedentes, debidamente catalogados, han servido de base en la construcción de las cartas de navegación.

El nivel técnico-profesional alcanzado por el personal y el empleo de modernos equipos como la cámara cartográfica de reproducción Klimsch Commodore, la incorporación de la fotocomposición y los nuevos equipos offset son una garantía en la exactitud y fidelidad en la reproducción cartográfica.

La constante preocupación por acelerar los métodos de producción y, a su vez, evitar la deformación que a lo largo del proceso de reproducción originan los cambios de temperatura y humedad, ha conducido al uso de materiales más estables, como son las hojas plásticas y el plástico stabilene empleados en la construcción de los originales de las cartas náuticas, adoptándose, como consecuencia de ello, el método de grabado por "separación de colores".

En la construcción de la carta náutica, las informaciones que contienen los diversos antecedentes hidrográficos se someten a un proceso científico de evaluación y selección cartográfica, según normas internacionales y de acuerdo al propósito de la carta, generalmente señalado por las necesidades de los usuarios. La representación gráfica de los datos estudiados, ubicados en su posición exacta en varias hojas seleccionadas por materias, conforma lo que se conoce como "manuscrito de compilación", antecedente base para la preparación del original de la carta.

Los títulos, nombres geográficos, sondas y demás indicaciones son impresos fotográficamente sobre trozos de papel transparente especial, los que posteriormente son adheridos al dibujo original, obteniéndose con ello una mayor rapidez de trabajo y mejor presentación. Los datos e informaciones contenidos en las cartas hacen que éstas no sólo tengan utilidad para fines de navegación, sino que también sean empleadas para otros propósitos tales como: faenas de pesca, estudios de anteproyectos de construcción de obras portuarias, ubicación de la línea de más alta marea para concesiones marítimas, dragados, prospecciones petroleras y otros.

El Instituto Hidrográfico, además de editar cartas de uso para la navegación, edita otras especiales para ser empleadas en ciertos tipos de investigaciones, como son las cartas de variación magnética, de fuerza horizontal y fuerza vertical del magnetismo terrestre, de zonas horarias, pesqueras, etc.

El antiguo sistema de reproducción cartográfica por medio de grabado en cobre y su posterior impresión litográfica ha sido reemplazado, hace ya años, por el más práctico y rápido método del proceso fotomecánico e impresión offset. Para este objeto se emplea película cartográfica especial muy estable. El original de la carta, constituido por las hojas plásticas grabadas y película, es transferido a una plancha offset para proceder a su reproducción.

Los originales son cuidadosamente clasificados, constituyendo un valioso y permanente registro de las cartas editadas por el Instituto. Siempre que no hayan ocurrido grandes y fundamentales cambios desde la construcción de la carta, se podrá utilizar el mismo original para una nueva edición de ella.

Finalizado el largo y laborioso proceso de confección de la carta náutica, todos los variados y múltiples antecedentes que fueron empleados son depositados, debidamente clasificados, en el Archivo Hidrográfico del Instituto. El Archivo Hidrográfico es hoy en día una de las fuentes históricas y científicas más valiosas y completas que tiene la Armada sobre el mar litoral chileno. En él se guardan importantes piezas cartográficas — chilenas y extranjeras — que se han

constituido, con el pasar de los años, en verdaderas obras de arte y piezas de museo, entre las que se mencionan:

La carta levantada en el Estrecho de Magallanes en 1680 por Guillermo Blaeu, la carta de Valparaíso de Merburen Und Hafen en 1744 y, naturalmente, los originales de los primeros trabajos realizados por la Marina y por la Oficina Hidrográfica algunos años más tarde.

Dada la gran cantidad de documentos depositados en el Archivo Hidrográfico, se encuentra muy avanzado el proceso de microfilmación y catalogamiento de todos ellos, con lo cual se evitará el deterioro de los originales, haciéndose posible la búsqueda, observación y obtención de copias de cualquier documento original mediante el uso de un lector de microfilm y de una reproductora.

Otra de las actividades ligadas a la producción de cartografía náutica es aquella destinada a la impresión de múltiples publicaciones que contienen informaciones complementarias a la carta náutica, publicaciones que permiten al navegante disponer en cualquier instante de todos los datos que aseguren una navegación segura y expedita.

Para lo anterior, el IHA dispone de completos talleres destinados a la producción de publicaciones, libros, folletos, boletines y otros, contando para ello con equipos de plegado, de dorado al fuego y de costura. Para su preparación, dispone de modernos equipos de fotocomposición, fotomecánica e impresión offset.

Progresos logrados desde el año 1979

Desde el año 1979 a la fecha, la actividad hidrográfica se ha visto implementada con modernos equipos de posicionamiento y registro batimétrico, lo que, junto a un fuerte progreso en el procesamiento automatizado, ha permitido generar un mayor volumen de información, permitiendo con ello entregar al navegante cartas náuticas confiables, en especial de los puertos y rutas de canales.

Cartografía náutica editada durante el período 1979-1984

IHA No	*Título*	*Escala*
1	Símbolos Convencionales y Abreviatura	—
9	Carta de Variación Magnética	1:15 000 000
10	Carta Intensidad Horizontal de la Fuerza Magnética Terrestre	1:15 000 000
11	Carta Intensidad Vertical de la Fuerza Magnética Terrestre	1:15 000 000
14	Carta Mundial	1:40.000 000
17	Límite Internacional en el Canal Beagle	1:80 000
17-A	Acceso Oceánico Oriental al Canal Beagle	1:1.000 000
CP-500	Carta Pesquera Bahía Valparaíso—Golfo de Arauco	1:500 000
CP-600	Carta Pesquera Golfo de Arauco a Bahía Corral	1:500 000
CP-800	Carta Pesquera Isla Guafo a Golfo de Penas	1:500 000
CP-1000	Carta Pesquera Canal Trinidad a Estrecho de Magallanes	1:500 000
113	Puertos en la Costa de Chile (Pisagua—Buena—Junín—Mejillones del Norte)	Varias
131	Puerto Tocopilla	1:10 000
133	Bahía Mejillones del Sur	1:50 000
212	Rada de Antofagasta	1:10 000
400	Bahía Coquimbo a Bahía Valparaíso	1:500 000
424	Bahía Quintero	1:10 000
500	Bahía Valparaíso a Golfo de Arauco	1:500 000
513	Rada El Algarrobo	1:10 000
514	Puerto San Antonio	1:10 000
600	Talcahuano a Corral	1:500 000
612	Puertos Lirquén, Penco y Talcahuano	1:10 000
613	Bahía San Vicente	1:10 000
623	Bahía y Puerto de Corral	1:20 000
734	Canal Calbuco	1:20 000
801	Canal Moraleda—Islas Guaitecas a Puerto Lagunas	1:250 000
841	Puerto Yates—Italiano y Lagunas	Varias
904	Canal Trinidad	1:100 000
941	Angostura Inglesa y Paso del Indio	Varias
1008	Canal Smyth de Isla Cutler a Isla Richards	1:30 000
1009	Canal Smyth de Roca Bert a Faro Fairway	1:30 000
1062	Canal y Angostura Kirke	1:20 000
1160	Estrecho de Magallanes Primera Angostura a Punta Dungeness	1:100 000
1251	Paso O'Brien—Paso Timbales	1:40 000
1307	Canal Beagle de Puerto Williams al Paso Murray	1:80 000
1316	Islas Wollaston y Hermite	1:100 000
1322	Pta Tasbani a Cabo Webley	1:50 000
1340	Isla Nueva a Isla de los Estados	1:200 000
1410	Caletas en Bahía Fildes (Territorio Antártico)	1:10 000

Otras Actividades

Por resolución del Instituto Panamericano de Geografía e Historia, el Instituto Hidrográfico de la Armada efectuó la traducción e impresión de los siguientes textos:

a) Especificaciones Cartográficas de la Oficina Hidrográfica Internacional;

b) Reglamentos de la Oficina Hidrográfica Internacional para la Carta Internacional (INT);

c) Especificaciones de la Oficina Hidrográfica Internacional para la Carta a Escala Pequeña;

d) Repertorio de Resoluciones Técnicas de la Oficina Hidrográfica Internacional;

e) Repertorio de Resoluciones Administrativas de la Oficina Hidrográfica Internacional.

Todo lo cual ha significado un importante aporte para los países de habla hispana.

SURVEYING AND MAPPING ACTIVITIES*

Paper submitted by China

RÉSUMÉ

Le rapport donne un aperçu des réalisations effectuées au cours des dernières années par les services topographiques et cartographiques chinois, notamment dans les domaines

RESUMEN

En el informe se exponen los logros de los departamentos de levantamiento topográfico y cartográfico de China en los últimos años, entre ellos, geodesia y geodesia mediante satélites, fotogrametría, cartografía topográfica, cartografía y enseñanza. China cuenta con una gran variedad de equipo y numerosos ingenieros y técnicos calificados. Por lo tanto,

* The original text of this paper appeared as document E/CONF 77/L 43

de la géodésie, de la géodésie par satellite, de la photogrammétrie, de l'établissement de cartes topographiques, de la cartographie et de l'éducation. La Chine dispose d'un matériel extrêmement varié et d'un grand nombre d'ingénieurs et de techniciens qualifiés. Elle peut donc non seulement mener à bien de façon autonome ses propres activités cartographiques, mais encore coopérer avec des pays étrangers dans le domaine technologique. Aujourd'hui, la Chine participe activement aux activités internationales qui sont menées dans ce domaine et coopère avec un grand nombre de pays. Elle a pour objectif de promouvoir le développement des activités topographiques et cartographiques mondiales.

no sólo puede poner en práctica sus propios programas de levantamiento cartográfico, sino también cooperar con los demás países en materia de tecnología. En la actualidad, China participa en actividades internacionales en colaboración con muchos países con el objetivo de fomentar el desarrollo de las actividades de levantamiento topográfico y cartográfico a nivel mundial.

Chinese surveying facilities are threefold: the National Bureau of Surveying and Mapping; survey teams attached to other departments of government; and the military survey services. In recent years, economic construction of the country has been fast developing, owing to the Government's "open door policy", and demands for maps and survey products are urgent. Surveying and mapping organizations have done much to meet the demands. Besides basic scale mapping, large-scale mapping was conducted mainly for agriculture, the energy industry, transportation and town planning. Meanwhile, substantial achievements were obtained in compiling and publishing small-scale maps and atlases, in addition to geographic base maps and large atlases. Research work in the fields of geodesy, photogrammetry and remote sensing has been intensified and expanded. New fields of surveying and mapping are opened continuously and there is increased co-operation and exchange between China and some foreign countries. China sent a large number of scientists and engineers to attend various international scientific activities, contributing to mutual understanding and friendship between nations.

Geodesy

As the basis for all the country's surveying control, a complete astro-geodetic network and levelling network had been established within China. The main emphasis in recent years has been to strengthen and upgrade the accuracy and density of the control network. Satellite geodesy was put into practice.

Overall adjustment of the astro-geodetic network

From 1978, an overall adjustment plan was drawn out, with a view to adjusting almost 50,000 first-order and secondary points of triangulation. The computation was accomplished in 1982. The difference between planimetric co-ordinates of the same point adjusted in two versions, was only 4-5 cm.

First-order levelling network

More than 90,000-km first-order levelling network have been set up on the mainland of China: field-work was completed in 1981. Adjustment computation will be started after partial checking and remeasurements in 1983; an adjustment technology is under investigation. A secondary levelling network was set up from 1982. The network totals more than 130,000 km in length and will be accomplished in 1990.

Reform of secondary network

The secondary filling-in network, established in 1950, cannot meet the demands of large-scale mapping. Now the investigation continues to compare methods for improving accuracies, such as adding extra order traverses, Doppler's points and networks, initial sides, etc. A reasonable reform plan will be chosen after comparison.

Satellite geodetic network

A satellite Doppler geodetic network, consisting of 37 points, has been established over the country with an average separation between points of more than 800 km. A purpose of the network is to strengthen and reform the classical astro-geodetic network by satellite geodesy.

Moreover, the Xisha Islands of the South China Sea were connected to the mainland by Doppler satellite. An experimental station for satellite observation is under preparation in order to study the further application of space technology to geodesy and geodynamics.

Gravimetry

Average gravity measurement of patches 1° × 1° was completed over the country. The average accuracy of the measurement of gravity anomaly is better than 3-5 m Gal.

For reduction of elevations gravity measurements were conducted along the first-order levelling routes of the country. The same measurements will also be conducted along the secondary levelling routes.

The 11 absolute gravity points were measured in co-operation with Italy.

The strength and reform of the country's gravity network was completed. Data processing is under way. The relative gravity measurements between China and some other countries and regions were accomplished.

Survey signals

In order to improve the preservation of survey signals, organized survey and repair of the survey signals has developed in China.

Photogrammetry and topographic mapping

Aerophotogrammetry is a major method of topographic mapping in China. The theory and technology of photogrammetry has developed considerably. Topographic mapping is evolving in the direction of large-scale maps of wide variety in order to meet the growing needs of national construction.

Basic scale series mapping

Topomaps and photoplans at scale 1:10,000 are the main products at present, for use in agricultural construction, natural resources surveys, city and town planning, etc. During 1980-1983, topomapping at scale 1:10.000 of a total of

804,000 km² were completed. In the meantime, topomaps at scale 1:25,000 are being mapped for resources exploitation and construction. In the period 1980-1983, second generation topomaps comprising 4,154 sheets at scale 1:50,000 and 823 sheets at 1:100,000 were produced.

Large-scale engineering mapping

In accordance with the development of cities and towns, industrial enterprises and civil engineering, there is a greater demand for large-scale topomaps (1:2,000-1:500). Besides survey teams of other departments, the National Bureau of Surveying and Mapping has devoted 6 to 8 per cent of its survey forces to carrying out this kind of work. By the gradual application of aerophotogrammetry, large-scale mapping for engineering purposes has been speeded up.

Revision of topomaps at scale 1:50,000

The geographic landscape of the country changes rapidly owing to the fast development of economic construction. Therefore, well-planned revision of topomaps at scale 1:50,000, keeping their modernity, is an important task. In the revision, a method of combined interpretation of aerophotographs in field and office is applied. It reduces a great deal of field-work and speeds up map production.

Non-topographic photogrammetry

Non-topographic photogrammetry is widely used in many branches of engineering survey. Some work has been done in the areas of ancient architecture, dam deformation, determination of volume of large constructions, harbour deformation, trajectory measurement of flying objects, etc. An ancient Buddha was mapped by photogrammetry recently. The method has an important role in the preserving and repairing of very many ancient buildings. Close-range photogrammetry of a tooth model, which is under way, guides it into the field of medicine.

Research and development

Analytical aerotriangulation is widely used in photogrammetric production. A new technology of map production, e.g. "small map scale and large photo format" has been put into production gradually. It speeds up map production considerably.

China has developed some instruments and equipment such as a precision point-marking device, an autorecording stereo-comparator, a co-ordinatograph and precision stereoplotter.

Research institutes and high learning institutes are making every effort to study digital photogrammetry and automation. Development of the computer-controlled mapping system has made some progress. The China-made orthoprojector has been put into trial production. A more complicated full digital automatic mapping system has also gained some results. A photomap with contour lines, drawn by digital correlation, was produced. Several theoretical aspects on digital correlation have been discussed. Preparatory work for the development of a geographic information system is in progress.

Remote sensing

Remote sensing techniques have made a rapid progress and development in China in the last decade. Increasingly, remote sensed data are being applied to natural resources survey and land-use classification. Dealing with these kinds of work, the surveying and mapping organizations gradually adopt remote sensing techniques. Many of them have set up remote sensing sections and have purchased the necessary equipment.

In recent years, surveying and mapping organizations have made good progress in providing data, processing images, making maps by remote sensing data, etc. Satellite photomaps at scale 1:20,000,000 of China and its provinces were compiled. Various geoscience analyses were commenced using LANDSAT-MSS images imported since 1974. A number of new concepts and increased understanding of certain macrostructural scientific problems on a nation-wide scale have been embraced.

As a result, *The Atlas of Geoscience Analyses of LANDSAT Imagery in China* was published. It includes maps of land cover and land use, hydrological dynamic phenomena, regional land-formations, lineaments of geological structures and reference maps for interpretation.

Cartography

Besides a national series of topomaps, other departments have compiled and published small-scale topomaps and thematic maps, education maps and atlases. A large combined atlas is under compilation.

Small-scale maps

Nation-wide topomaps at scales 1:200,000, 1:500,000 and 1:1,000,000, new eidition, were compiled. Thus the basic data can be provided to economic departments.

Thematic maps

In recent years, a large number of thematic maps, such as maps devoted to tourists, forests, land use and hydrography have been issued. Geological maps were produced at scale 1:1,000,000 for China in general and scale 1:200,000 for most regions of the country. Regional maps for agriculture planning are completed for some provinces and countries. Environment mapping is a rapidly developing area of thematic mapping. In 1983, the Map Publishing House produced 46 types of tourist maps.

Other atlases

Many provinces have produced their own atlases of general purpose reflecting the natural geographic conditions, socio-economic development and their achievements. The atlases serve as reference for the institutions concerned.

A population atlas of China is being compiled based on the census data of 1983. The atlas will contain more than 100 maps, which will be produced mainly by computer-assisted cartography. The *Atlas of China History* was published, which depicts basic facts on the boundaries of Chinese societies, administrative areas and nationalities during the various historical periods before 1840. It is an important reference for studying the history of China.

The National Atlas

The *National Atlas of the People's Republic of China* is being compiled. It consists of five volumes: general purpose, nature, agriculture, energy and history. These will vividly depict the development and achievements in physical geography, social structure, history, culture and economy of China. The *Atlas* will provide important basic material for overall planning, programmes of industrial and agricultural development, natural resources exploitation and management of nature, and will be a basic work for economic studies and geoscience researches.

Research and development

Efforts are being concentrated on computer-assisted cartography. Some institutions have already applied this technique to production. As far as theoretical research is concerned, Chinese cartographers are interested in cartographic

communication and map perception and have started some research projects. Several theories of modern cartographic systems have been put forward.

Education

The institutions specialized in surveying and mapping are the Wuhan Technical University of Surveying and Mapping and the Zheng Zhou College of Surveying and Mapping; some other universities and colleges of engineering sciences have surveying departments or special courses also. Wuhan is one of the key institutes of higher learning in the country. The main task of the university is the education of high-level survey specialists. It has the disciplines and specialities to conduct Master's or Doctor's degree programmes. Starting from 1956, more than 70,000 students have been graduated. At the moment, there are more than 2,000 students registered at Wuhan.

The survey colleges mainly train specialists of middle level and provide other industrial departments with technicians.

Currently, survey education is undergoing reform. Education programmes are being revised and teaching media modernized. A series of new teaching and reference books have already been published.

Conclusion

In recent years surveying and mapping in China have made great progress in meeting the basic needs of economic development. In the meantime, for economy's sake, it relies on standard instruments and methods and makes full use of the existing equipment. Of course, where the new technologies and equipment are concerned, there is a certain difference measured against the advanced level of other countries. Therefore, insisting on independence and self-reliance, China follows the "open door" policy. While acquiring experiences and advanced techniques from abroad, every effort is being made, together with colleagues from all over the world, to develop the survey sciences for the benefit of mankind.

COUNTRY REPORT*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

En République fédérale d'Allemagne, les travaux de recherche scientifique dans toutes les branches de la cartographie, y compris la géodésie, la photogrammétrie et l'établissement des cartes, sont essentiellement coordonnés par la Commission allemande de géodésie Deutsche Geodätische Kommission (DGK). Les activités de coordination comprennent l'élaboration et l'appui de projets de recherche visant à faire appliquer en République fédérale d'Allemagne les recommandations de l'Association internationale de géodésie (AIG) et d'assurer la participation de la République fédérale aux projets internationaux. Dans l'accomplissement de ces tâches, la Commission allemande de géodésie est assistée par l'Institut allemand de recherche géodésique Deutsches Geodätisches Forschungs-Institut (DGFI).

Le service géographique fédéral des Länder et plusieurs instituts nationaux sont officiellement chargés des levés topographiques et de l'établissement des cartes. Ils ont créé la Commission de travail du service géographique des Länder de la République fédérale d'Allemagne (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) en vue de coordonner leurs tâches, leurs méthodes et leurs résultats. Des groupes de travail relevant de la Commission mènent des travaux de recherche-développement en vue de réaliser des applications pratiques dans leurs domaines d'activité respectifs. Il en est de même pour les bureaux de conservation, d'amélioration, de mise en valeur et de remembrement des terres des Länder et pour leur commission de travail.

Tous ces organismes fédéraux ainsi que leurs bureaux locaux sont officiellement chargés des travaux topographiques nationaux, de l'établissement de cartes et du cadastre. Ils sont assistés par des experts géomètres (géomètres agréés) qui travaillent à leur compte mais doivent cependant

*The original text of this paper, compiled by the Institut für Angewandte Geodäsie, appeared as document E/CONF 77/L 5

RESUMEN

En la República Federal de Alemania, la investigación científica en todas las esferas de la cartografía, incluidas la geodesia, la fotogrametría y la elaboración de mapas, es coordinada principalmente por la Comisión Geodésica Alemana (Deutsche Geodätische Kommission (DGK)). Esa coordinación comprende: la iniciación y el apoyo de proyectos de investigación que vayan a realizar las recomendaciones de la Asociación Internacional de Geodesia (AIG), y la aportación de la colaboración a proyectos internacionales. Para realizar esas tareas, la DGK se vale del Instituto Alemán de Investigación Geodésica (Deutsches Geodätisches Forschungs-Institut (DGFI)).

Los organismos de agrimensura de los "Laender" y varias instituciones nacionales se encargan oficialmente de la agrimensura y la elaboración de mapas. Esos organismos fundaron el Comité de Trabajo de los Organismos de Agrimensura de los Laender de la República Federal de Alemania (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV)) a fin de coordinar sus tareas, métodos y resultados. Los grupos de trabajo del AdV realizan labores de investigación y desarrollo encaminadas a la utilización práctica en sus respectivas esferas de trabajo. Lo mismo puede decirse de las oficinas de preservación, mejoramiento, recuperación y consolidación de tierras de los Laender y de su comité de trabajo.

Todos esos organismos públicos centrales y sus oficinas locales realizan las actividades de agrimensura nacional, cartografía oficial y catastro de propiedades. Su labor es complementada por agrimensores colegiados (agrimensores oficialmente inscritos) que trabajan independientemente, pero que deben cumplir las leyes y decretos pertinentes. Esos profesionales ejecutan también toda clase de trabajos técnicos de agrimensura.

La investigación y la enseñanza técnica son realizadas en universidades técnicas y escuelas profesionales, que también

respecter les lois et décrets en vigueur dans ce domaine Ils exécutent également différents levés d'études.

L'enseignement technique et la formation en matière de recherche sont dispensés dans les instituts universitaires techniques et les écoles professionnelles, qui assurent également une formation poussée avec des activités professionnelles sous forme de colloques scientifiques, de conférences sur les matières enseignées et de cours Ces rencontres sont fréquemment organisées en collaboration avec des associations scientifiques et techniques soucieuses d'assurer une formation spécialisée à leurs membres

imparten la capacitación superior que se requiere para la labor profesional en forma de coloquios científicos, series de conferencias sobre temas de actualidad y cursos prácticos Con frecuencia, esas reuniones se celebran conjuntamente con asociaciones científicas y técnicas, con objeto de fomentar la capacitación técnica superior de sus miembros.

In the Federal Republic of Germany scientific research in all fields of cartography, comprising geodesy, photogrammetry and mapping, is primarily co-ordinated by the Geodetic Commission (Deutsche Geodätische Kommission (DGK)). This co-ordination comprises (a) initiating and supporting research projects to carry out the recommendations of the International Association for Geodesy (IAG), and (b) contributing to international projects. In order to accomplish these tasks, DGK works through the Geodetic Research Institute (Deutsches Geodätisches Forschungsinstitut (DGFI)).

The survey administrations of the Länder and several national institutions are responsible for official surveying and mapping They have founded the Working Committee of the Survey Administrations of the Länder of the Federal Republic of Germany (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV)) in order to co-ordinate their tasks, methods and results Working groups of the AdV carry on research and development directed to practical use in their respective fields of work. The same applies to the offices of preservation, improvement, reclamation and consolidation of land of the *Länder* and their working committee.

All these central public authorities and their lower local offices perform the activities of national surveying, official cartography and property cadastre. They are supported by chartered surveyors (registered land surveyors), working on a freelance basis, who must nevertheless observe the relevant laws and decrees They also execute all kinds of engineering surveying.

Research and technical education is carried on at technical universities and professional schools. Advanced training accompanies professional work in the form of scientific colloquiums, lecture series on current subjects and contact study courses. Such meetings are frequently held together with scientific and technical associations, aiming at the advanced technical training of their members.

Scientific research

In the fields of geodesy, photogrammetry and cartography the following main research works were carried out during this reporting period:

Geodesy

The work focused on the use of earth satellites for geodetic purposes. The development of the Satellite Observation Station at Wettzell in the south-eastern part of the Federal Republic of Germany proceeded at an intensified level with the objective of making it a fundamental geodetic reference station. These efforts, within the scope of the research group for satellite geodesy (''Forschungsgruppe Satellitengeodäsie''), were initiated as a contribution to the international requirement for establishing a world-wide network of well equipped and routinely operating observatories. Activities have been concentrated on including a 20-m radiotelescope and a modular transportable laser ranging system (MTLRS) Observations with the telescope participating in world-wide programmes of very long baseline interferometry (VLBI) began routinely in early 1984. Verification and testing of the MTLRS are ongoing now, and field-work in the eastern Mediterranean will begin in 1985. General maintenance of the Station Wettzell is the responsibility of IfAG

The main facilities routinely working at Wettzell are:

(*a*) Neodimium-YAG laser ranging system of the third generation, tracking automatically to existing and planned satellites. Plans are now finished to replace this equipment by a new one capable also of measurements to the moon;

(*b*) 20-m radiotelescope equipped with a Mk-III system and hydrogen masers, routinely in operation every five days for 24 hours;

(*c*) Modular transportable laser ranging system (MTLRS 1) being verified and tested;

(*d*) Doppler measuring system CMA-722 B for the satellites of the United States Navy Navigation Satellite System (NNSS);

(*e*) TRANET-2 system, tracking automatically the NNSS-satellites and contributing to the determination of the ephemeris;

(*f*) Precise timing equipment consisting of several atomic clocks and two hydrogen masers;

(*g*) Several terrestrial services, as earth tide and seismic registrations, precise horizontal and vertical monitoring of files movement, etc.

German institutes, as well as the Station Wettzell, took part in several international Doppler campaigns, such as:

CIDOC. In this project of technical co-operation a primary network of 17 points covering the entire area of Côte d'Ivoire has been established.

ALGEDOP. A grid of points is being determined with Doppler for the purpose of measuring geoid profiles across the Alps. Each station is connected by means of levelling to the national levelling network.

RETDOC. Simultaneous Doppler measurements have been performed at selected sites of the European triangulation network in order to combine terrestrial and satellite data for the RETrig final adjustment.

ANTARCTIC CAMPAIGNS. Doppler measurements have been performed to determine the absolute movement of the shelf ice and its seasonal variation.

Geodynamic networks have been installed and measured in order to determine tectonic movements, as, e.g., in the high Andes of South America produced by the production of aseismic ocean ridges underneath the South American plate.

As a consequence of the refinements and new measuring techniques of the terrestrial measurements (such as inertial geodesy) and the precise results of space methods, new evaluation techniques, for example operational geodesy, have been introduced. The goal of these techniques may be defined as the determination of points on the surface of the earth as well as the determination of an approximation of the earth's gravity field on the surface and outside derived from heterogeneous geodetic observations with different precision.

The gravimeter-calibration-system-Hanover has been established for the determination of calibration functions with microgal accuracy. For monitoring local seasonal and secular vertical crustal movements highly precise gravity and height control networks have been established and measured (e.g. Wettzell and Transalpine line). Instrumental capabilities of LCR-gravimeters have been investigated and improved. The results with the new type of superconducting gravimeter (GWR) show a considerable improvement of precision (better than 0.1 μGal for 1 hour mean value) also in long-term registration. Evaluations are ongoing, analysing geodynamic effects like polar motion also.

Cartography

Research work has been performed mainly in the field of automatization. At the Institut für Nachrichtentechnik of the Technical University of Braunschweig, a low-cost video-scanner named "Video-Scan" was constructed for cartographic material up to 60 × 90 cm² in size and at the Forschungsinstitut für Informations-verarbeitung und Mustererkennung (FIM), in Karlsruhe, the method of semi-automatic extraction of features from scanned maps or air photos with mixed content has been enhanced by a technique of co-operative line extraction from different graphic sources.

The land survey office Niedersachsen in Hanover produces contour line foils of the 1:5,000-scale official topographic base map of the Federal Republic of Germany (*Deutsche Grundkarte*) using a computer-assisted method (TOPSY) at a rate of 150 sheets per year. A method of tagging scanned contour lines was developed by IfAG which avoids vectorization, using merely digital raster data-processing techniques. The basic idea of the procedure is the successive digital colouring of the hypsometric layers in upward direction, starting out from interactively marked low terrain points. This process works in a hierarchical manner, thus saving a lot of computer time.

IfAG also has implemented a hardware configuration with special characteristics for digital raster data transformation and editing, centred around a PDP 11/34 A computer. Special software for the data exchange between the different components of the system ensures equilibrium between speed of data transfer and data processing in the array processor. On the average, processing speed is 50 times faster using cartographic raster applications compared to conventional computers. Also, a procedure for automation-assisted updating of the official map series 1:200,000 (TÜK 200) in digital raster mode is being implemented on the SCITEX system. In this context the different point-, line-, and areal symbols of this map series were defined digitally in raster mode in strict accordance with the official symbol definitions. Also the applicability of digital raster methods for automatic colour separation and digital screening on raster-plotters for high quality topographic maps has been studied—especially for the TÜK-200 series.

By late 1983 the *Bildschirmtext* system of the post administration of the Federal Republic of Germany became generally operable. With this system users may access centralized digital data bases by telephone and have selected information displayed on their television screens. The transfer of digital thematic maps is also planned, although the display capacity is rather limited. The whole map is limited to a maximum of 880 signs, each of which may show one of a set of 64 different graphic signs, and alphanumerics. Seven colours are available in two brightnesses each.

The Wiener-Kolmogorof theory of optimal statistical filtering was applied to the task of simplifying line networks given in vector format for cartographic generalization purposes. The results can be planned and predicted with a high degree of reliability—avoiding the trial-and-error procedure that was usual in automatic line smoothing up to now.

The *Gazetteer Federal Republic of Germany* was published by IfAG in 1981 in accordance with the recommendations of the United Nations, with the co-operation of the Permanent Committee on Geographical Names and the survey administrations of the Länder of the Federal Republic of Germany.

Photogrammetry

The state survey offices continue to utilize standard mapping techniques for the preparation of the topographic base map 1:5,000 and for the revision of the map 1:25,000. Some *Länder*, where progress in preparing the 1:5,000 map is still insufficient or where many changes in urban areas occur, produce orthophotomaps 1:5,000 in addition to the standard line map series (Rhineland-Palatinate, Northrhine-Westphalia). Most compilation centres use digital recording and automatic drafting. There is increased use of analytical photogrammetric instruments for aerial triangulation. These are also equipped with efficient aerial triangulation adjustment packages by bundles or models originating from universities in the Federal Republic of Germany (Hanover, Stuttgart); other programmes concern the acquisition and processing of digital terrain models (Munich).

In research there is experimentation with newly designed correlators (raster-epipolar correlator at Hanover, area correlator at Stuttgart). Considerable research effort is carried out in the area of digital image processing for cartographic purposes: e.g., at the Universities of Berlin, Hanover, Karlsruhe, Munich and Stuttgart and at IfAG at Frankfurt. Of particular interest was the successful photogrammetric camera mission of Spacelab-1 conducted on Shuttle STS-9 from 28 November to 7 December 1983. Cartographic evaluation of this imagery is currently carried out at 18 institutions in the Federal Republic of Germany.

Practical Work in Cadastre, Cartography, Photogrammetry and Surveying

Surveying

Activities concern primarily the supersession of the networks of horizontal and vertical control survey stations. Owing to modern survey techniques using electronic measuring systems and to the evaluation of a lot of measuring values by means of electronic computer, such a supersession has become possible within a reasonable time-frame. As far

as the network of horizontal control survey stations is concerned the work is already in process, starting from a scientific diagnosis of the network. As to the network of vertical control survey a complete resurvey of the precise levelling network (DHHN) is being carried out by the State survey authorities. Each line of the Unified European Levelling Network (UELN) was renewed during the period under report. This resurvey has made obvious that some automatic levels are dependent on magnetic field. Further research was aimed at the scale factor of levelling rods and on vertical refraction, among others. In addition the conventional measurements for the densification of the national networks are continuously performed. For all projects, the automatic data flow is planned from the field survey up to the data file for the control survey stations. After the establishment of the primary gravity network of the Federal Republic of Germany, the network of gravity control survey stations is being densified up to one station per 4 km^2.

Photogrammetry

Topographic national surveying by means of aerial photogrammetry and—as far as necessary—tacheometric procedures refer to the topographic basic maps 1:5,000 (in the south of the Federal Republic of Germany partly 1:2,500). At present, two thirds of this map series are produced as final or provisional editions. Depending on the large scale and the detailed representation of planimetry and heights, this map series serves as a basis for various purposes of application. Some of the *Länder* produce orthophotomaps 1:5,000 as a supplement to the basic maps 1:5,000. In Northrhine-Westphalia the whole series of orthophotomaps has been completed and is being renewed in a 6-year cycle.

Topography

Until this map series is completed, the topographic map 1:25,000 is being used for the capture of topographic changes and thus constitutes the basis for the preparation and revision of the derived scales; this map series is completely available.

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

Topographic Map, 1:25,000: 2,095 sheets
Topographic Map, 1:50,000: 560 sheets
Topographic Map, 1:100,000: 151 sheets

Of the sheets, at present, 70% are available in final edition, the rest in provisional edition. Newly prepared each year are about:

15 sheets, 1:25,000;
5 sheets, 1:100,000.

Updated each year are about:

360 sheets, 1:25,000,
100 sheets, 1:50,000,
17 sheets, 1:100,000.

By order of the federal administration and corresponding to an agreement with the Survey Administration of the respective *Länder*, the IfAG publishes

Topographic General Map, 1:200,000: 44 sheets
General Map, 1:500,000: 4 sheets
International Map of the World on the Millionth Scale: 2 sheets
Maps for air traffic control and military purposes

From these map series, special maps (combined sheets, maps of towns with environment, district maps, etc.) are prepared and thematic maps of most different kinds derived, depending on the demand. The compilation and reproduction of regular topographic map series and of thematic mapping are carried out by using modern techniques and materials.

Geology

The Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)) prepares and publishes geoscientific maps of the Federal Republic of Germany, international maps, and maps containing the results of its work abroad. Some of these maps are published jointly by the BGR and other organizations, e.g., the provincial geological surveys and UNESCO. The BGR works within the commissions of the International Geological Congress (IGC) and the International Union of Geological Sciences (IUGS) on the following projects:

International Geological Map of Europe and the Mediterranean Regions, 1:1,500,000
International Hydrogeological Map of Europe, 1:1,500,000
Metallogenic Map of Europe, 1:2,500,000
Mineral Atlas of Europe, and the *International Metallogenic Lexicon*

Since 1982, the activities, in the field of graphical data processing, including hardware and software, were concentrated in a new unit called Centralized Computer Graphics combined with interactive digitizing stations (graphic representations and integration of graphic and alphanumeric data files).

Cadastre

For the automation of the property cadastre the survey administrations decided upon a nominal concept for the tax roll and for the property map. Since 1977 they have carried on automation of the property map aiming at storing the property boundaries and all important planimetric information of the parcels no longer graphically but digitally in EDP-systems. Thus, data files will be established for planimetry, co-ordinates, and measuring elements. For the future course of work, it is planned to store these data files in an integrated manner with the appertaining data of the tax roll (descriptions of the parcels) and those of the property register (legal conditions of the parcel). In the individual *Länder*, the work has been started and advanced to a different extent.

FURTHER ACTIVITIES

Apart from institutions of scientific research and public administration, scientific-technical associations in the Federal Republic of Germany pursue their fields in science and technology and maintain international co-operation. Special purposes are

(*a*) Publication of technical journals;

(*b*) Organization of annual congresses, each one on a certain topic and devoted to bringing together personnel from science, technology and the public;

(*c*) Realization of technical events (courses, symposiums);

(*d*) Exchange of knowledge and experience among working groups, often executing independently certain investigations;

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

Universities, professional schools, and associations organize courses for advanced training on certain interrelated subjects

In the Federal Republic of Germany, advanced training of foreign specialists and top executives, especially from developing countries, is carried on with intensity. Possibilities are permanently available to obtain individual advanced training at practically all scientific institutions and public authorities. Sometimes, courses have been held covering a longer period of time for a larger number of participants with remarkable success.

Detailed information is given on the development and progress made in surveying and mapping in the Federal Republic of Germany in numerous published series regularly issued by scientific organizations, public authorities and associations.

Through IfAG a special booklet can be ordered describing the responsibilities and activities in surveying and mapping in the Federal Republic of Germany and co-operation with other countries.

MAPPING ACTIVITIES*

Paper submitted by Finland

RÉSUMÉ

Ce rapport donne un aperçu général des activités cartographiques entreprises en Finlande et se concentre surtout sur la cartographie nationale

RESUMEN

Este documento presenta una reseña de las actividades cartográficas realizadas en Finlandia, con especial referencia al levantamiento de mapas en el plano nacional.

The report provides a general summary of mapping activities in Finland. Emphasis is on national mapping. A previous, corresponding report, presented to the Sixth United Nations Regional Cartographic Conference for Asia and the Far East more than ten years ago, is updated.

Education and scientific research

Higher education in geodesy, photogrammetry and cartography is provided at the Surveying Department of Helsinki University of Technology. An average of 40 master degree surveyors graduate annually, but a large number of these eventually move into legal or cadastral surveying. Survey technicians are educated at four technical schools, where they undergo three years of instruction in surveying. The average number of graduates a year is 70. One- and two-year programmes in surveying and draughting are offered at vocational schools, and about 150 persons are graduated annually.

The main scientific organization for geodesy in Finland is the Geodetic Institute (GI) which, at the moment, employs about 15 researchers. Photogrammetric research was permanently included in the programme of the Geodetic Institute in 1978. Besides research work the Geodetic Institute has carried out the high precision horizontal and vertical control used as a base for the national mapping of the country. Helsinki University of Technology is also engaged in extensive research work. The main fields at the moment are digital methods in photogrammetry and cartography. The Land Use Laboratory of the Technical Research Centre does specialized work in remote sensing, employing a staff of about 10 experts

In addition to this organized research work, most of the actual mapping agencies carry out their own development projects, aimed at bringing new products or production technology into practical use.

Mapping organizations

The main government organization for mapping is the National Board of Survey. It is also responsible for cadastral surveys. Employees number about 2,300, of which 600 are engaged in mapping operations proper. The main responsibilities of the Board in the field of mapping are as follows:

(*a*) To produce, densify and maintain the national horizontal and vertical control networks;

(*b*) To carry out photogrammetric and remote sensing operations;

(*c*) To produce basic topographic maps and thematic maps;

(*d*) To take care of the printing and sale of maps;

(*e*) To carry out mapping work to special order

The annual total expenditure amounts to about $US 14 million, the corresponding revenue to $6 million.

Two other government agencies are involved in national general mapping: the Geodetic Institute and the Topographic Service of the Finnish Defence Forces. The former has completed the high precision geodetic control and the latter, in co-operation with the National Board of Survey, has participated in the basic mapping. The Topographic Service has concentrated its operations in the northern part of the country.

Many other government organizations have special units that carry out mapping work relevant to their main line of activity. The most prominent among these are the National Board of Navigation, the National Board of Roads and Waterways, the National Board of Forestry and the Geological Survey. In most cases these agencies use the national control network as the base for their mapping. They also often have resort to facilities provided by the National Board of Survey or by private companies

Municipal maps are customarily prepared at scales ranging from 1:500 to 1:2,000. Though originally made for planning purposes, the maps usually serve as base material for all local large-scale maps as well. The municipalities are themselves responsible for this activity. Cities have their

* The original text of this paper appeared as document E/CONF.77/L.53

own survey departments and typically carry out the mapping process independently, except for photogrammetric operations, which are awarded out to private companies. The rural municipalities, on the other hand, very seldom have a professional survey unit and all of the mapping is done by private firms or by the National Board of Survey. The technical inspection and the official acceptance of the surveys and maps are looked after for the rural municipalities by the National Board of Survey.

There are several private surveying firms which are able to provide complete survey and mapping services to government authorities, cities and rural municipalities as well as to industry. They also engage in exporting. In Finland the main province of the private firms has been large-scale mapping, of scales varying from 1:500 to 1:5,000. The export has mainly involved topographic mapping projects with related operations. Maps have usually been multicoloured, with scales varying from 1:10,000 to 1:250,000, most possessing an orthophoto background.

Control survey

The measurements of the national triangulation have been carried out by the Geodetic Institute and the National Board of Survey. The aim has been to establish a network accurate enough to meet the requirements of both small and large-scale mapping, as well as of special surveys. The density varies from five stations per 100 km² in southern Finland to two stations per 100 km² in northern Finland.

The primary control, where the stations are an average of 30 km apart, covers the whole country. The completion of the secondary control will require another ten years or so. All angles and distances in the nets have been measured, except for the first-order chains where angle observations and baselines determine the co-ordinates.

The following table shows the present status of triangulation:

	Number of stations	*Accuracy ± (ppm)*	*Carried out*	
			(agency)	*(years)*
Primary				
I	331[a]	1.5	GI	1920-
Ib	157	2	NBS	1963-75
Secondary				
II	2157	2-3	NBS	1963-
III	7714	3-8	NBS	1963-

GI: Geodetic Institute; NBS: National Board of Survey.
[a] 291 of the points belong to the first-order chains (1920-1965); the rest form areal nets (after 1967)

The network described above forms the basis for local control surveys carried out by other government organizations, municipalities, cadastral offices and private firms. The standards and specifications for those surveys have been defined by the National Board of Survey.

The density of the national levelling is such that the levelled lines are about 5 km apart in southern Finland and about 10 km apart in northern Finland. The bench-marks have been spaced from 1 to 2 km apart along the line. The basic vertical network is now almost complete, and maintenance of the net is the main task. The following table gives the important details of the vertical control.

	Lines (km)	*Accuracy ($\pm$ mm $\sqrt{km}$)*	*Carried out*	
			(agency)	*(years)*
Precise	8,200	0.6	GI	1936-55
Primary	11,800	1.0	NBS	1948-
Secondary	21,100	5.0	NBS	1948

Photogrammetric operations

Map production in Finland is to a large extent based on aerial photography and photogrammetric methods. New photography is carried out every summer to meet the requirements of new large-scale mapping projects and to bring the topographic maps up to date. The *Basic Map 1:20,000* today covers the whole country and the typical mapping work is map revision. The photoscale normally used for this purpose is 1:30,000. The interval of revision is from 5 to 20 years depending on the area in question. In densely built-up areas where the map scales are from 1:500 to 1:5,000, the scales of photographs vary from 1:3,000 to 1:15,000. In 1979 the National Board of Survey started production of the *Cadastral Photomap 1:5,000*. This map consists of an orthophotomap and of boundary data, which is primarily produced in digital form. The aerial photography is carried out at a scale of 1:16,000. This map will form a homogeneous base for cadastral surveys and in rural areas will also serve as a base for activities, such as planning, fiscal needs, forestry and agriculture. In one year, some 20,000 aerial photographs may be taken for cartographic purposes.

The main part (90 per cent) of the materials used in aerial photography have been black-and-white films. The use of colour emulsions for mapping and interpretation promises, however, to increase markedly in the near future.

The methods of aerotriangulation have been applied in small-scale mapping for over 40 years. At the moment aerotriangulation is most often carried out with block adjustment of independent models or of bundles of rays. The control point network for the *Basic Map 1:20,000* was densified photogrammetrically. Today, however, the main application for aerotriangulation is the large-scale mapping 1:500-1:2,000 and the boundary co-ordinate measurements for the *Cadastral Photomap 1:5,000*. Annually about 150,000-200,000 points are densified.

There is no centralized space organization in Finland, but the activities have been spread among different agencies. The Technical Research Centre takes care of the research work on remote sensing and the National Board of Survey takes care of the initial processing and distribution of the data. The main applications are in forestry, geology and cartography. The agreement signed between the European Space Agency and the National Board of Survey provides the framework for the supply of data.

Cartography

The National Board of Survey is responsible for the production of all topographic maps in Finland. The following series of maps are available:

Basic Map 1:10,000/1:20,000 and *Topographic Map 1:20,000*

Topographic Map 1:50,000

Topographic Map 1:100,000

General Map 1:400,000

The *Basic Map 1:10,000/1:20,000* is a topographic map covering southern and central Finland. The reconnaissance of the terrain and fair drawings are done at 1:10,000 (planimetry, contours and cadastral boundaries). After photographic reduction to 1:20,000 scale the map is printed in five colours. Currently, the main task in the basic mapping work is updating of existing maps. To make this more effective the field-work has been decentralized by dividing the country into four topographic mapping units.

The *Topographic Map 1:20,000* covers northern Finland. The mapping work is carried out in co-operation with the

Topographic Service of the Finnish Defence Forces. The field-work is done at the same scale as the final printing. Compared with the *Basic Map*, the *Topographic Map 1:20,000* is more generalized and its cartographic representation is simpler. The *Topographic Map 1:20,000* is printed in three colours, whereas the *Basic Maps* are in five colours. Altogether the 1:20,000 map series consists of 3,712 map sheets covering the whole country. One 1:20,000 sheet shows an area 10 × 10 km.

The *Topographic Map 1:50,000* is a direct photographic reproduction from the *Basic Map 1:20,000* or the *Topographic Map 1:20,000*. The whole country will be covered by this series in 1986, in a total of 647 map sheets. One 1:50,000 sheet covers an area of 20 × 30 km. The map is printed in five colours.

The *Topographic Map 1:100,000* is derived from updated 1:20,000 series map sheets. In December 1982 the whole country was covered by 342 sheets of this series. One sheet covers an area of 30 × 40 km. The map is printed in 7-9 colours.

The *General Map 1:400,000* was the first topographic map series to cover the whole of Finland. The first edition was produced in 1841-1873. The second edition, consisting of 31 sheets, was thoroughly revised, and completed in 1966. For the third edition the cartographic representation has been redesigned and the sheet size enlarged. The whole country is to be covered by six sheets. The map will be printed in six colours and the three first sheets covering southern Finland are scheduled to be published during 1985.

Besides general mapping, compilation of touring and special maps is another extensive cartographic activity of the National Board of Survey.

The *Road Map of Finland 1:200,000*—the so-called GT series—covers the country in 19 sheets. This map is revised at 3- to 5-year intervals. In addition to the usual touring and traffic network symbols, it provides representations of arable land, marshes and 20-metre contour lines. Besides its main use, the 1:200,000 road map serves as a base for numerous special and thematic maps.

The *Motoring Road Map 1:800,000* is revised every year. In addition to Finland it serves motorists in the whole North Calotte Area.

The *General Road Map 1:1,500,000* is mainly used in tourist information booklets and in advertising and is revised every second year.

Regional touring maps at scales of 1:400,000-1:200,000 are available for southern Finland.

The assortment of outdoor maps published by the National Board of Survey has been enlarged—especially for Lapland. Scales vary from 1:25,000 to 1:100,000.

The importance of thematic maps is continually increasing (see the brochure "Production of thematic maps in Finland" included with this volume). The main undertaking at this time is the production of the fifth edition of the *Atlas of Finland*, which is being published jointly by the Geographical Society of Finland and the National Board of Survey. The *Atlas* is to appear in the form of 26 separate folios, comprising text as well as maps. In all 54 different subject areas will be covered. At this writing, seven folios and eleven 1:1,000,000 separate wall maps have been completed.

Another important project in thematic cartography is the compiling of geological maps which are being produced jointly by the Geological Survey of Finland and the National Board of Survey. Soil and rock maps at 1:100,000 and 1:400,000 are to be published. In 1979 an agreement was signed for the production of 1:20,000-scale Quaternary Deposit Maps by the Geological Survey, the Agricultural Research Centre and the National Board of Survey. Since 1979 a total of 122 map sheets have been completed.

The *Aeronautical Chart 1:500,000* (ICAO) covering all of Finland on seven sheets has been revised at regular intervals. The most recent sheets were issued in 1980 and 1982. The *Aeronautical Chart 1:1,000,000* was revised in 1978.

The National Board of Navigation has continued with its programme to adopt automation of methods for the production of nautical charts. The production and drawing of the latest charts was about 50 per cent automated.

Changeover of the buoying system to comply with the IALA maritime specifications caused much work in the area of nautical charts in 1981 and 1982. In 1981 all charts for sea and sea-coast areas in Finland were corrected, and in 1982 the charts for all lakes. Old symbols were removed from originals and new ones added; in all, over 8,000 stick mark symbols were corrected.

In July 1984 the new uniform *Yachting Chart 1:50,000* was completed, covering the whole sea-coast area. The chart is published in folios.

COUNTRY REPORT ON SURVEYING AND MAPPING ACTIVITIES*

Paper submitted by India

Surveying and mapping activities in India are mostly done by the Survey of India, a central government organization, and to a relatively minor extent by the National Atlas and Thematic Mapping Organization which is also a government organization. The Survey of India was founded in 1767, that is, about 220 years ago.

The strength of technical personnel of the Survey of India consists of about 700 high-level supervisors and managers, about 1,500 middle-level supervisors and about 5,000 actual producers. There are 10 regional divisions and 6 specialized divisions. Each regional division undertakes all kinds of mapping activities in its regions. The specialized divisions are responsible for education and training, for research and development (R & D) activities, for printing policies and, partly, printing. In spite of its collaboration with universities and other mapping agencies, the Survey of India is a self-contained, continuously developing surveying and mapping unit for the country. Even the universities sometimes look to the Survey of India for state-of-the-art in mapping.

As a complete surveying and mapping unit, the Survey of India does basic high-precision geodetic surveys and control-work, topographical surveys on various scales by photogrammetry, mapping (by scribing to an increasing

* The original text of this paper appeared as document E/CONF.77/L.73.

extent), printing of maps etc. It does thematic cartography, although the National Atlas and Thematic Mapping Organization has this main function. The Survey of India trains its people from the basics and continuously educates them through organized courses. It does R & D through special agencies. Remarkably, it has no flying unit for aerial photography. The Survey of India has concerned itself with LANDSAT data for cartographic need.

Geodetic surveys

Geodetic triangulation and traverse, and precision levelling, are being carried out for strengthening the existing national framework for topographical survey, and for specific requirements of development projects. Preliminary adjustment of the second level net of India, including fresh mean sea level data and precision levelling data, is carried out. Study of tectonic and crustal movements across selected faults, thrusts, tear zones and seismic areas for the International Geodynamic Project and assessment of secular changes in heights of Himalayan peaks and deformation studies for major dams and archaeological monuments continue. Observations with Doppler satellite receivers for establishing control are taken, and computer program developed for their reduction. Preliminary values of the transformation parameters between the Indian Datum and the World Geodetic System 1972 have also been determined. Gravimetric, geomagnetic, astronomical and tidal observations continue for scientific investigations. The reduction system of geodetic and geophysical observations was modernized by developing programs for electronic computers.

Topographical surveys

Aerial photographs are used for all topographical surveys. Whereas photogrammetric plotting is done in most cases, for some large-scale surveys for specific development projects, simple rectification-cum-enlargement followed by contouring actually on the ground or later in the office on the basis of dense levelling spot-heights is resorted to in plain areas. When the contour interval is not too small, large-scale photographs, say on 1:5,000 scale, are flown; and maps on 1:2,000 scale or so are made photogrammetrically. The Survey of India does not need to make very large-scale maps, as on 1:500 scale; some large-scale maps are, however, made by enlargement at the printing stage.

Scales at 1:250,000, 1:50,000 and 1:25,000 are the main standard departmental scales for surveys. Updated versions must be made and brought out as the Survey's core liability is about 400 1:250,000-scale maps, about 5,000 1:50,000-scale maps and about 22,000 1:25,000-scale maps. So far as 1:250,000 and 1:50,000 scales are concerned, about 7 and 4 per cent, respectively, have yet to be published. Of course, their provisional versions mostly exist, and the unpublished maps are all in the cartography or printing stages. So far as 1:25,000 scale is concerned, about 8 per cent of them have been published. Many maps on this scale are yet to be photogrammetrically surveyed. Thus, the main thrust of surveying in India with regard to primary-scale mapping will be on 1:25,000 scale. For example, in 1983/84 (one year), topographical surveys on 1:25,000 scale were done of an area of about 30,000 km^2.

Topographical and engineering surveys for the development projects connected with coalfields, irrigation, power, communication, flood control, water supply, forestry, built-up sites, landing and approach charts for air liners, command area development and canal area management are being carried out. Some of the important surveys carried out during the year 1983/84 are listed below:

Surveys	*Scale*	*Area/Length (km^2/km)*
Guide maps	1:5,000 to 1:20,000	1,900
Command area development	1:2,500	1,100
Canal area surveys	1:10,000 to 1:25,000	8,000
Other projects	Various	8,000
Forest surveys	1:25,000	7,100
Flood control surveys	1:15,000 to 1:25,000	14,000
Built-up areas	1:2,000 to 1:5,000	50
Aeronautical and approach charts	1:500,000 1:250,000	0.5 million
Landing charts	1:50,000	700
Control work for future surveys	—	78,000
Spirit-levelling	—	11,700 km

Printing

Topographical maps

As mentioned earlier, the entire country has been covered by 1:50,000-scale mapping; and maps are now printed for most of the area.

The following maps were printed during the year 1983/84:

Topographical	
1:50,000 or so	642
1:25,000	370
1:250,000 or so	41
Guide maps	11
Geographical and index maps	
State Map, 1:1,000,000	
Miscellaneous maps, indexes etc.	152

Special-purpose maps

Many projects were undertaken connected with development activities and other user requirements. The following maps were published in 1983/84:

Project maps	980
Forest maps	105
Miscellaneous	110

Many special maps on larger scales are being increasingly printed in India by the small-budget printing system, called silk-screen printing. This system not only has decentralized map-printing in the country, but also has increased the unitary characteristics of the regional divisions. All users can get two-colour specially-requisitioned maps relatively more quickly with this system.

In 1983/84, the Survey supplied 3.5 million maps to various personalities and agencies. With the increased map-mindedness of the people and the ever-increasing demands of various agencies, the burden of printing will increase—happily, however.

Thematic cartography

The preparation of quality thematic maps showing physical, social and economic conditions of the country is comparatively recent in India. Thematic cartography in India greatly increased after independence, especially after the National Atlas and Thematic Mapping Organization was set

up in 1956. The organization has since issued many thematic maps and atlases.

The Indian Meteorological Department publishes weather charts. The Geological Survey of India has been publishing geological and mineral maps at scales 1:1,000,000 and 1:2,250,000. Osmania University has brought out a planning atlas of a state in collaboration with the Survey of India. The atlas, which was produced using the latest colour-control system, comprises 96 multicoloured map sheets covering physical, economic, social, demographic and developmental characteristics of the State of Andhra Pradesh. More such maps are in the offing. The Central Ground Water Board carries out surveys and prepares maps showing hydrogeological conditions in the subsurface horizons. The Naval Hydrographic Department is the national authority responsible for undertaking hydrographic surveys of Indian coasts and harbours and for the production of nautical charts and documents required for navigational and other purposes.

Training and Education

In India, the surveyors (except cadastral surveyors) and cartographers are usually first trained in the profession in the Survey of India. The Survey recruits men for its various cadres on the basis of their merit in general education in science, mathematics or engineering, depending upon the cadre. It gives an initial training of two years to all, in different tailor-made courses for surveyors, cartographers etc. Many of them later receive specialized training for up to one year. This somewhat unique feature is of advantage to the Survey as staff have been given a common background in their profession.

The Centre for Survey Training and Map Production was formed in Hyderabad in 1967, funded extensively by the United Nations Development Programme (UNDP). The Survey Training Institute, which is part of this Centre, provides academic, education and practical training, not only to impart job-oriented training-cum-education, but also to produce prospective candidates for research, development and teaching activities. Students from foreign countries are also accepted, as also are private candidates and employees of government departments.

The Centre runs about 50 courses of four types:

(*a*) Basic training-cum-education at various levels, i.e. survey technician, middle-level supervisors and the professional surveyors;

(*b*) Specialized and advanced training-cum-education to cater for various survey specializations and new technology;

(*c*) Refresher training-cum-education for all levels;

(*d*) User-oriented courses.

The Institute conducts advanced courses in geodesy, photogrammetry and cartography. So far, the Centre does not administer degrees or diplomas on the completion of courses. Steps are, however, in hand to get the various courses recognized by universities. It is hoped that the basic survey engineering course will be recognized at par with a Bachelor of Technology course in surveying, and the advanced course, after some modification, as equivalent to the Master of Technology course. The International Institute for Aerial Survey and Earth Sciences (ITC) considers the advanced photogrammetric course at par with their B.Sc. and Ph.E. course.

During 1980/84, 131 trainees from Afghanistan, Bhutan, Fiji, Iraq, Jordan, Nepal, Sri Lanka and Zimbabwe were trained at the Institute, in addition to about 1,850 Indians.

Noticeably, about 10 senior-level technologists received training in 1983/84 in advanced photogrammetry, advanced geodesy etc. at ITC (Netherlands), Ohio State University (United States of America), and the Imperial College of Science and Technology (London). About five more senior-level technologists got training in Indian universities in advanced photogrammetry and in computer science.

Research and Development

Geodesy

A project study of secular variation anomalies of magnetic elements, viz. HF, VF in India, is in progress in collaboration with the Indian Institute of Geomagnetism.

Crustal movement studies across faults, thrusts or tear zones and earthquake-prone areas continue.

Efforts towards development of an indigenous model of short-range EDM instruments, metallic staves (for levelling), Invar staff, autoset level, centring device etc. continue.

A number of large-scale surveys (such as SHAR, Western Coalfields Ltd., A P. Irrigation Project, Nhawa Sheva Project) have been conducted to form the data base for R & D projects.

Cartography

Automated cartography

The computer-based automated cartographic cell has completed its work on the experimental project for preparing a topographical map at 1:25,000 scale, using a dedicated software developed by Systemhouse Ltd., Ottawa, in close association with Indian experts. Experimental maps on other scales have been brought out. The problem of generalization on reduction has been solved in a pragmatic manner.

Map conversion (from one projection to another)

In this project, digitization of the external boundaries, coastline and island territories of India at 1:4,000,000 scale, on Lambert's Conical Orthomorphic projection with two standard parallels, has commenced. The digitized data will be transformed into the Mercator projection.

Aeronautical mapping

The project has been taken up in the automated cartography cell. Fine-tuning and development of aeronautical symbols etc. are in progress.

Special urban map

A project on urban utility map around Hyderabad city area has been undertaken and is nearing completion.

Topographic map, new design

A project on redesigning the topographic map with new symbology, contents etc. has been undertaken.

Photogrammetry

Survey of Lion Capital

Fair mapping of the photogrammetrically (close-range) plotted first face of the Lion Capital has been completed and is ready for publication. Work on other faces continue.

Stecometer-C

To make the instrument operational some trial observations were made, and these are in process.

Nagarjunsagar Dam, spillway survey

Precise survey of spillway of the prestigious Nagarjunsagar Dam is under way. The first phase of the work comprising field survey/photography and computation/processing of the data has been completed, and the second phase of the work has commenced.

Instrumentation

Photogrammetric maintenance cover

Maintenance cover is provided for various types of photogrammetric instruments.

Instrument repair cover

Repairs of optical, mechanical and electronic field instruments continue in R & D workshop.

Printing

Orthophoto reproduction

Trials are being made by conventional half-tone process, on reproduction of the orthophoto map of the twin cities Hyderabad and Secunderabad, with encouraging results. Further work to improve the process is in hand.

Four-colour printing

Trials have been made in taking out plastic proof of a portion of a topo-sheet, using basic four-colour process (i.e. yellow, magenta, cyan and black), and it was possible to get normal six-colour effect in good registration of details. Further work towards preparing a full-size topo-sheet is in hand.

Computer applications

The PDP 11/34 computer available in the automated cartography cell is being run in double shifts, partly to cater to the needs of geodetic research.

The Cyber Computer NIC and IBM 145/155/370 are used on a hire basis for the large photogrammetric adjustment problems etc. All survey computations and smaller adjustments are done by in-house computers.

Satellite imageries and remote sensing

An experimental project to find out how LANDSAT imagery could be utilized to identify flood-prone areas on the Gangetic plains has been undertaken with the following participating agencies: the Indian Space Research Organization; the Ganges Flood Control Commission; and the Survey of India.

A project on combined aerial photography and scanner survey has been undertaken in the Gandak basin area to assess the feasibility of applying remotely sensed data for diverse physical and socio-economic planning problems.

An experimental project has been undertaken for hydrographic survey of waterways (Ganges) from Allahabad to Farakka, in order to identify and assess a suitable channel based on colour photography of suitable scale followed by ground investigations in limited initial areas.

Data base and other activity

The Survey of India is participating in National Natural Resources Management System activities, and has contributed to the same. It is taking on a project for creation of a data base of a geographic information system (GIS) on a selected basis as a pilot task.

An All India Project "Seismicity and Seismotectonics of the Himalayan Region" has been taken up. The scheme is a multi-institutional one with the Survey of India, Wadia Institute of Himalayan Geology, the Department of Earth Sciences (Roorkee University) and the National Geophysical Research Institute as participants for the period 1982-1985.

NATIONAL SYMPOSIA

An international seminar on computer-assisted cartography was held, in collaboration with ICA, at Delhi in November 1983. About 130 delegates, including an ICA team, participated in the seminar. It was followed up by a workshop at Delhi in September 1984, in which delegates from the United Kingdom also participated.

In order to continuously understand each other's problems, to disseminate trends and thoughts and to equip the surveyors and cartographers with more and more information and expertise, many more internal and multilateral symposia were held in the country in recent years.

REPRESENTATION IN NATIONAL AND INTERNATIONAL FORUMS

The Survey of India is an active participant in the activities of the Indian National Cartographic Association, the Institution of Surveyors, the Computer Society of India and so on. The Survey of India is represented in three Commissions of the International Association of Geodesy. It is also represented in the Working Group of Commission IV of the International Society for Photogrammetry and Remote Sensing (ISPRS).

India was represented by delegates to various international conferences and symposia: XVII Congress of the International Federation of Surveyors (FIG) in 1983 at Sofia; the Commonwealth Survey Officers' Conference in 1983 at Cambridge; meetings of the International Gravity Commission and International Union of Geodesy and Geophysics (IUGG) in 1983 Hamburg; the International Symposium on Crustal Movement in the Pacific Region, in 1984 in New Zealand; conferences of ICA in 1983 and 1984 at Warsaw and Perth, Australia, respectively; and others.

CONCLUSION

As a large developing nation, India has been carrying a heavy burden in surveying and mapping successfully. It has always tried to keep pace with new technology to the extent that the technology is compatible with the country's needs and characteristics. India will always look forward to learning from the problems and solutions of other regions and will be ever ready to co-operate with any task set by the United Nations.

PERFIL DEL INSTITUTO DE ESTUDIO GEOGRAFICO*

Documento presentado por el Japón

SUMMARY

The Geographical Survey Institute (GSI) is the national governmental agency responsible for surveying and map-

* The original text of this paper appeared as document E/CONF 77/L 68

RÉSUMÉ

L'Institut de levés géographiques [Geographical Survey Institute (GSI)] est l'organisme national chargé d'exécuter des levés topographiques et des cartes du territoire japonais. Il entreprend des travaux géodésiques, topographiques et des études géographiques, fournit des services d'information

ping the land areas of Japan. It carries out geodetic, cartographic and geographic work, provides information services and conducts research at Tsukuba Science City

GSI makes its technology, personnel and facilities available to other countries through the Japan International Cooperation Agency. It provides them with expertise and assistance in mapping and related activities.

et effectue des travaux de recherche à Tsukuba Science City.

Par l'intermédiaire de l'Agence japonaise de coopération internationale, l'Institut met à la disposition d'autres pays sa technologie, son personnel et ses services. Il leur fournit des services d'expert et leur apporte une aide en matière de cartographie et activités connexes

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El Instituto de Estudio Geográfico (GSI), dependiente del Ministerio de Construcción, es una agencia nacional del Gobierno del Japón, responsable de agrimensura y confección de mapas, y, como tal, ejecuta la agrimensura de terrenos del país y produce mapas de todo tipo.

Existen aproximadamente 130.000 puntos de control, incluyendo casi 87.000 puntos de triangulación y 26.000 puntos de referencia de cota conocida cubriendo todo el país. La ubicación de esos puntos precisamente se identifica mediante sus coordenadas. El levantamiento básico que realiza el GSI incluye levantamientos astronómicos, levantamientos geomagnéticos y levantamientos gravimétricos. El levantamiento de los puntos de control se repite regularmente para la vigilancia de los movimientos de capa del globo y los resultados de los levantamientos se utilizan como datos básicos para la predicción de terremotos.

Las áreas enteras del territorio del Japón, que se totaliza aproximadamente en 377.000 km^2, están cubiertas por los mapas topográficos a escala de 1:25 000 o más y fotografías aéreas de color a escala de 1:8 000 hasta 1:15 000.

Además de los mapas básicos a las escalas de 1:2.500, 1:5.000, 1:10.000, 1:25.000, 1:50 000, 1:200.000, 1:500.000, 1:1.000.000, 1:3.000.000, se incluyen en las actividades de GSI preparación de mapa para usos de tierra, mapa de condiciones de tierra, carta de lagos, mapa topográfico de área costera de mar, mapa de la condición de tierra en el área costera de mar y otros mapas temáticos, lo mismo que el atlas nacional.

Para sostener estas actividades hay que trabajar extensivamente en los campos de geodesia, geofísica, fotogrametría, remisión remota, cartografía, geomorfología, hidrología, ingeniería de información, etc., siendo perseguidos estos estudios en las instalaciones del GSI, ubicadas en la Ciudad de Ciencia Tsukuba.

El GSI, con su tecnología, personal y equipo, sale del Japón para proveer sus experiencias y asistir con sus expertos a otros países, particularmente a los países en vías de desarrollo, en cartografía y otros campos relacionados con la cooperación internacional.

Organización del Instituto de Estudio Geográfico

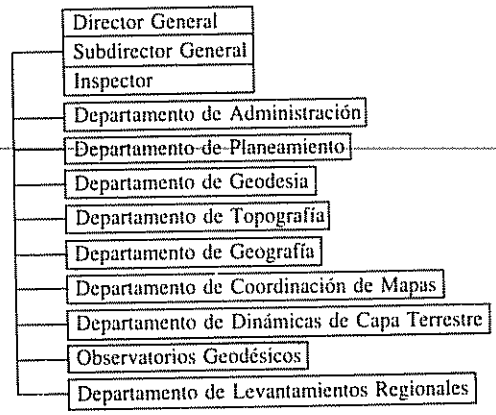
El GSI pertenece al Ministerio de Construcción.

Está ubicado en la Ciudad de Ciencia Tsukuba, aproximadamente 60 kilómetros al noroeste

El GSI está organizado en siete departamentos, y cada departamento tiene un número variado de divisiones bajo su responsabilidad

Además, hay diez Departamentos Regionales, ubicados en sus respectivas regiones, cubriendo el país entero, los cuales son responsables de los estudios fundamentales, administración y coordinación de los resultados de estudios de acuerdo con lo estipulado en la Ley de Levantamiento hasta que estén concernientes las respectivas regiones

En los dos observatorios geodésicos se ejecutan observaciones constantes de geomagnetismo, gravedad y satélites.



Cooperación internacional del Instituto de Estudio Geográfico

Con el objeto de ayudar a los países en vías de desarrollo en el adelantamiento de la preparación de mapas y el mejoramiento de sus observaciones y tecnología cartográficas, el Gobierno del Japón da cooperación internacional a esos países confeccionando mapas para ellos, enviando expertos e impartiendo adiestramiento a ingenieros a través de la Agencia de Cooperación Internacional de Japón (JICA con su sigla en inglés)

Trabajando con la JICA, el GSI ofrece consejo técnico, envía expertos y facilita su equipo y personal para programas de adiestramiento a fin de apoyar las actividades de cooperación internacional. Los proyectos cartográficos de base nacional como parte de los programas de cooperación internacional son, en general, asignados por la JICA a la Asociación Internacional de Consultantes de Ingeniería (IECA con su sigla en inglés) para su cumplimiento con la ayuda y guía técnica del GSI.

El GSI participa activamente en organizaciones y conferencias internacionales sobre agrimensura y confección de mapas para el intercambio de información y tecnología y juega un papel directivo en el desarrollo de agrimensura y tecnología cartográficas.

Cooperación internacional en cartografía

La JICA realiza estudios en un área específica y con su propio costo en respuesta a pedidos de países en vías de desarrollo. Estos programas con el fondo no reembolsable incluyen la confección de mapas de base nacional.

El GSI coopera con la JICA en cartografía proveyendo de consejo técnico y personal supervisor.

La IECA, comisionada por la JICA, toma responsabilidades como organismo ejecutor en la confección de mapas. Los países que desean la asistencia japonesa en la confección de estos mapas deben hacer la solicitud oficial al Gobierno del Japón a través de la Embajada del Japón en el país.

La información concerniente a los trámites de solicitud y servicio consultivo se encuentra en las Embajadas del Japón y oficinas locales de la JICA.

Observación de la Antártida

Desde 1956, el Gobierno del Japón ha enviado equipos de especialistas a la Antártida todos los años para la observación y el estudio de la geografía y biología antárticas. El GSI contribuye a esos esfuerzos proporcionando su personal a tales equipos.

Actividades en organizaciones y conferencias internacionales

El GIS envía regularmente representantes en nombre del Gobierno del Japón a reuniones de la Conferencia Cartográfica Regional de las Naciones Unidas para Asia y el Pacífico y de la Conferencia de las Naciones Unidas para Normalizar los Nombres Geográficos. El personal del GSI participa activamente en conferencias internacionales patrocinadas por organizaciones académicas, como la Unión Internacional de Geodesia y Geofísica, la Sociedad Internacional de Fotogrametría, y la Asociación Cartográfica Internacional.

Las actividades del GSI en este campo de cooperación internacional incluyen también esfuerzos bilaterales, como el Panel Norteamericano-Japonés de Recursos Naturales sobre Tecnología de Predicción de Sismos y la Reunión Japonés-Coreana de Cooperación Técnica en Tecnología Geodética.

Envío de expertos

La JICA envía expertos en varios campos a países en vías de desarrollo como parte de sus programas de cooperación internacional en asistencia técnica y traspaso de tecnología.

Respecto a agrimensura y cartografía, un número de expertos del GSI y otros recomendados por él han sido enviados a tal efecto. Los expertos recomendados por el GSI son principalmente de la IECA.

Programas de adiestramiento

La JICA invita a ingenieros de países en vías de desarrollo al Japón para adiestramiento técnico con el propósito de traspasar tecnología.

Hay dos tipos de programas de adiestramiento, en grupo e individual. El primero se realiza para grupos de estudiantes por períodos y con contenidos de estudio previamente establecidos. En cuanto al segundo, los períodos y programas se determinan adaptándolos a cada estudiante.

El adiestramiento de grupos para agrimensura y cartografía se realiza todos los años en el Centro del GSI ubicado en la Ciudad de Ciencia Tsukuba. El adiestramiento se lleva a cabo en tres cursos: reconocimiento geodético, fotogrametría y compilación/reproducción cartográfica, durando cada curso de 6 a 7 meses y alternándolos cada 3 años.

El costo de transporte hacia y desde Japón y otros gastos de adiestramiento, incluyendo gastos de vida, corren por cuenta de la JICA.

NATIONAL REPORT*

Paper submitted by Jordan

RÉSUMÉ

Le Centre géographique national jordanien a été créé en 1975. Il établit des plans et des cartes topographiques de la Jordanie pour les besoins de l'administration centrale.

Un plan-cadre a été établi à cette fin, qui comprend trois éléments: la formation de personnel, l'achat du matériel nécessaire et la construction de bâtiments adéquats.

Le Gouvernement jordanien a conclu un accord avec le Gouvernement français [Institut géographique national (IGN)], en vertu duquel des ressortissants jordaniens seront envoyés en France pour y suivre un stage de formation tandis qu'un certain nombre d'experts français seront employés par le Service de la formation du Centre géographique national jordanien.

On trouvera ci-après une récapitulation des activités du Centre entre 1975 et 1984:

a) Création d'un réseau géodésique de premier ordre et de deuxième ordre;

b) Etablissement de cartes et plans topographiques dont les échelles varient du 1/500 au 1/250 000;

c) Révision de la carte de base de la Jordanie au 1/50 000;

d) Etablissement de cartes thématiques indiquant les services publics;

e) Publication d'un atlas national de la Jordanie;

f) Etude géomorphologique de la Jordanie;

g) Production d'un atlas relatif à la question de Palestine;

h) Formation de 361 techniciens à des niveaux divers.

La neuvième Conférence cartographique régionale des Nations Unies pour l'Asie et le Pacifique, qui s'est tenue à Wellington (Nouvelle-Zélande) en 1980, a adopté une résolution dans laquelle elle a prié l'Organisation des Nations Unies d'étudier la possibilité de créer un centre régional de formation dans la partie nord-ouest de la région de l'Asie et du Pacifique.

* The original text of this paper appeared as document E/CONF 77/L 75

Lors du Séminaire des Nations Unies sur les levés topographiques et hydrographiques, qui s'est tenu à Doubai (Emirats arabes unis) en 1983, le Gouvernement jordanien a fait une proposition indiquant clairement qu'il était prêt à jouer un rôle central dans la création d'un organisme régional qui desservirait tous les pays arabes.

The Jordan National Geographic Centre was established in late 1975, having among its major objectives the coverage of Jordan in terms of plans and topographic maps to serve all State purposes. In addition, it aims at meeting the needs of all State organs for trained manpower in the various disciplines required by these organs in the area of mapping and surveying.

By virtue of its geographical location and its demographic characteristics, Jordan, which considers the citizen as the corner-stone of its national development, looks forward to serving the region in all technical areas. We are, therefore, willing to put the facilities of the Centre at the disposal of the Arab countries, whether for the production of maps or for the training of technical personnel.

Master plan

In order to bring this project to fruition, an integral and balanced plan has been developed with the following three components:

(*a*) Training of technical personnel;

(*b*) Procurement of necessary machinery and technical equipment;

(*c*) Construction of appropriate buildings.

The most important component is, understandably, training, upon which depends the success of the project. It would be useless to provide buildings and equipment without providing the technical personnel to operate this equipment and use the buildings to meet national needs. To this end, an agreement was concluded between the Government of France (Institut géographique national (IGN)) and the Government of the Hashemite Kingdom of Jordan, under which Jordanian nationals are sent for training in France and a number of French experts are employed in the Training Branch at the Jordanian Centre. The Training Branch would continue to be partially supervised by the French through 1988, when Jordan would have qualified Jordanian personnel to undertake the task of training. New agreements have been concluded with the United States of America and the United Kingdom of Great Britain and Northern Ireland to train Jordanian technical personnel during the coming years, covering both basic training and supplementary training (higher degrees and specialized courses).

Achievements, 1975-1984

Geodesy

In view of the dire need for a geodetic network which would form an accurate scientific basis for mapping projects, the Jordanian Geographic Centre established a primary network and a secondary one. Work on a tertiary network began in mid-1984, in addition to primary and secondary accurate levelling networks.

Aerial photography

For purely financial reasons, the Jordanian Geographic Centre does not have an aeroplane for photography. It has to sub-contract this function to private companies, although it has the required technical personnel. It has photographed large tracts of Jordanian territory at varying scales for mapping purposes.

Topographic maps and plans

The Centre has been able to meet national needs for topographic maps and plans at scales varying from 1:500 to 1:250,000 for different purposes, including plans of villages and towns, and the needs of agriculture, engineering and construction work, in addition to general-purpose topography. The 1:50,000 basic map of Jordan is being revised, and the production of geological maps at scale 1:50,000 began in 1985.

Studies

The Department of Studies at the Jordan Geographical Centre has undertaken the following works:

(*a*) *Service maps*. Governorship and national-level maps were completed, each sheet of which shows a certain service provided, i.e., electricity, water, education, health, municipal services, port etc. These maps have proven useful for all government organs concerned;

(*b*) *National Atlas of Jordan*. This project aims at providing an accurate, scientific and highly specialized reference work to be at the disposal of government ministries and enterprises as well as private enterprises, researchers and investment corporations. It also aims at showing the economic and social development experienced by Jordan during the past decades and portraying national and regional differences, thereby helping to prepare sound development plans for each region, while taking into consideration the other regions of the country;

(*c*) *Geomorphology of Jordan*. The centre undertakes morphological and geomorphological studies for use by all civilian and military organs of the State. These have several different applications. It is currently working on the production of geomorphological maps of Jordan;

(*d*) *Atlas of the Palestine Question*. The Centre produced a portfolio and an atlas of the Palestine question, showing in the form of maps and commentaries in Arabic and English the true history of Palestine and the various phases of the Palestine question. It should serve as a reference work for those interested in the Palestine question all over the world.

Training

As noted above, one of the most important requisites for the success of a project is the training of technical personnel able and qualified to carry out the tasks and functions entrusted to the Centre. Hence the highest priority accorded by the Centre since its establishment to the training of technical cadres as per the following programme:

1. A number of students were sent to IGN (France) to pursue courses of study at the level of (*a*) engineer and (*b*) assistant engineer.

2. A local training centre was established employing French experts to train the required personnel in various disciplines at various levels, as follows:

(*a*) A training course for assistant engineers for a duration of 27 months continuously in the following disciplines:

(i) Surveying;

(ii) Drafting and plotting;

(*b*) A training course for technicians for a duration of 15 months continuously in the following disciplines:

(i) Surveying technician;

(ii) Drafting and plotting technician;

(iii) Printing and photography technician.

A number of Jordanian engineers and technicians have joined the Training Centre to collaborate with their French colleagues in the training of such personnel. As a result of this intensive training programme, the Centre has the following technical cadres (as of end 1984):

(*a*) 23 engineers;

(*b*) 127 assistant engineers (surveying);

(*c*) 70 assistant engineers (drawing);

(*d*) 48 printing and photography technicians;

(*e*) 73 drawing and drafting technicians;

(*f*) 20 surveying technicians.

There are, in addition, a number of students studying in France and the United Kingdom at various levels of study.

Remote sensing

Jordan now has a core of trained technicians but lacks the necessary equipment and programmes for the establishment of a remote sensing centre. Jordan requests that the United Nations help in this regard, both in training and in the provision of equipment

Call for the establishment of an Arab training centre for surveying/mapping

The Ninth United Nations Regional Cartographic Conference for Asia and the Far East, held at Wellington in 1980, in its resolution 5, called for the establishment of a regional training centre in the Arab world. It also called for a seminar to be held at Dubai in 1983 to discuss this matter. The said resolution confirmed what Jordan has always believed: that training in the home country or a neighbouring country is the best way to meet a country's needs for technical personnel. Although Jordan did not participate in the New Zealand Conference, it did submit a proposal to the Dubai Seminar of 1983 in which was made clear the willingness of the Government of Jordan to become the nucleus for the establishment of such a centre to serve all Arab countries

INFORME NACIONAL*

Documento presentado por México

El desarrollo de la cartografía en la República Mexicana puede visualizarse como una respuesta a las demandas y necesidades de información geográfica planteadas por los distintos grupos sociales, particularmente en lo que respecta a la satisfacción de requerimientos necesarios para apoyar las actividades de planeación del desarrollo económico y social del país

Es sobre esta base que se ha experimentado un notable incremento en la producción cartográfica, tanto al haberse completado cubrimientos con información básica, como al haberse logrado importantes avances en la generación de productos de aplicación e iniciado la producción de otros en varios temas. Característica del desarrollo es el esfuerzo por actuar dentro de marcos sistemáticos que permitan el aprovechamiento eficiente de la información en un contexto integral y de congruencia global. Es así como ahora puede decirse que existen los elementos para un mejor conocimiento del país en lo que respecta a sus características físicas, recursos y condiciones socioeconómicas, aun cuando falta bastante por hacer.

Este reporte se basa en información proporcionada por las siguientes instituciones:

Instituto Nacional de Estadística, Geografía e Informática de la Secretaría de Programación y Presupuesto

Dirección General del Servicio Cartográfico de la Secretaría de la Defensa Nacional

Dirección General de Oceanografía de la Secretaría de Marina

Dirección General de Agricultura de la Secretaría de Agricultura y Recursos Hidráulicos

Comisión del Plan Nacional Hidráulico de la Secretaría de Agricultura y Recursos Hidráulicos

Dirección del Sistema de Información para el Desarrollo Urbano de la Secretaría de Desarrollo Urbano, Vivienda y Ecología

Dirección General de Planeación de la Secretaría de Comunicaciones y Transportes

Subdirección de Fotogrametría y Proceso de Datos de la Secretaría de Comunicaciones y Transportes

Instituto de Geografía de la Universidad Nacional Autónoma de México

Comisión de Conurbación del Centro de la Secretaría de Desarrollo Urbano, Vivienda y Ecología

Dirección General de Información Agraria de la Secretaría de la Reforma Agraria

Dirección General de Información Pesquera de la Secretaría de Pesca

Geodesia

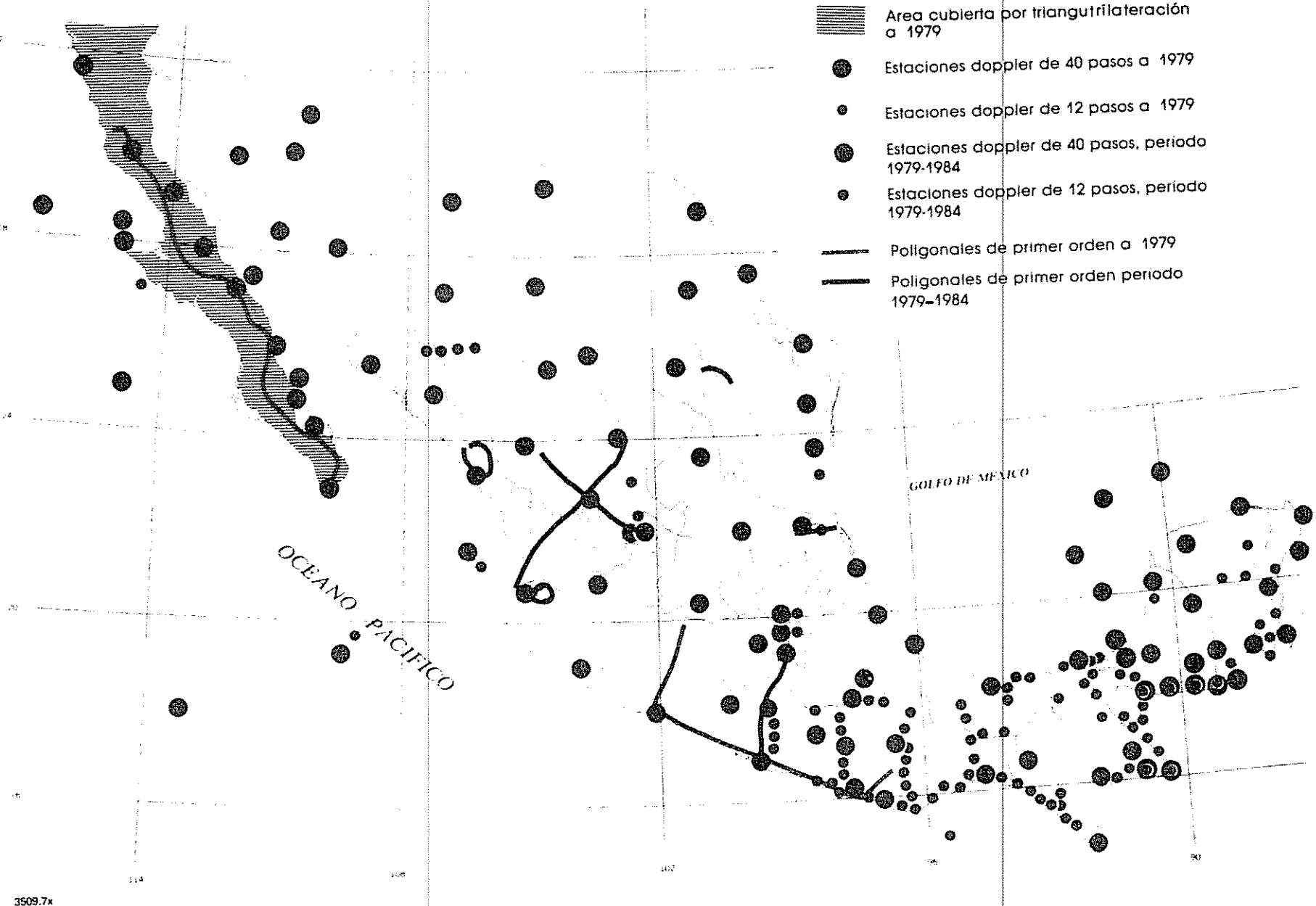
Los trabajos geodésicos desarrollados en el país cubren una amplia variedad de actividades, que agregan a los avances anteriores los de poligonación precisa y de segundo orden, posicionamiento Doppler, densificación general y hacia áreas de interés prioritario, apoyo a la red mareográfica y extensión de las nivelaciones, desarrollo de la red gravimétrica y la realización de investigaciones geoidales.

Durante el período 1979-1984 se establecieron 1 056 vértices de poligonal con un desarrollo de 10 750 km, de los cuales, 500 km corresponden a vértices de primer orden. Del resto, 284 vértices forman parte de la densificación del control horizontal en 15 áreas urbanas de interés prioritario, con un cubrimiento de 9 024 km^2. A la red Doppler se agregaron 11 estaciones, 10 de ellas de precisión (véanse figuras 7 y 9)

La red mareográfica cuenta con 34 estaciones en servicio, en tanto que en nivelación se agregaron 1 635 bancos de precisión y 2 491 bancos de segundo orden, con un desa-

*The original text of this paper appeared as document E/CONF 77/L 62

Figura 7. México: Control geodésico horizontal



rrollo conjunto de 20.082 km (véase figura 8). De estos últimos, 594 bancos forman parte de la densificación del control vertical en 21 áreas urbanas de interés prioritario, con un desarrollo de 3 114 km en 8.800 km² de territorio.

Cerca de un 99% del territorio se encuentra cubierto con apoyo vertical de segundo orden y aproximadamente con un 80% de horizontal del mismo orden (véase figura 9). Los trabajos de gravimetría experimentaron un impulso significativo al haberse establecido 10 642 estaciones en aproximadamente 940 000 km², lo que representa un cubrimiento del 47% del territorio (véase figura 10).

En el cuadro 1 se presenta un concentrado del progreso alcanzado durante el período, en comparación con el registrado hasta 1979, y los totales respectivos a la fecha.

CUADRO 1. GEODESIA

Tipo de control	Hasta 1979		Avance 1979-1984		Total		
	Puntos	Desarrollo o cubrimiento	Puntos	Desarrollo o cubrimiento	Puntos	Desarrollo o cubrimiento	Figura
Horizontal							
Poligonal de 1er orden	91	900 km	51	500 km	142	1 400 km	7
Poligonal de 2o orden	848	8 650 km	1 005	10 250 km	1 853	18 900 km	9
Triangutrilateración	58	180 000 km²	—	—	58	180 000 km²	7
Doppler, 1er orden	91	—	10	—	101	—	7
Doppler, 2o orden	87	—	1	—	88	—	7
Vertical							
Nivelación, 1er orden	1 732	2 745 km	1 635	2 642 km	3.367	5 387 km	8
Nivelación, 2o orden	2 692	18.850 km	2.491	17.440 km	5 183	36 290 km	9
Gravimetría	—	—	10.642	940.000 km²	10.642	940.000 km²	10

FOTOGRAFÍA AÉREA

Durante el periodo 1979-1984, las actividades de toma de fotografía aérea continuaron desarrollándose en sus modalidades de vuelo alto a las escalas de 1:50.000 y menores, vuelo bajo en escalas de 1:40.000 y mayores, y vuelos de propósitos específicos en escalas variables, principalmente de 1:10 000 y mayores. Durante el período se completó el cubrimiento del país en vuelo alto con 242.728 km² de aerofotografía en las zonas que hacían falta de cubrir y se realizaron 150.436 km² de vuelos en escalas de 1:5 000 a 1:40.000, 97% de las cuales se tomaron para apoyo de actividades cartográficas en los aspectos de infraestructura vial y desarrollo urbano.

De igual modo y para la atención de actividades especiales, situaciones de desastre y otros propósitos, se fotografiaron 215.017 km² en escalas de 1:10.000 y mayores. Realización importante durante el período fue el establecimiento del Sistema Nacional de Fotografía Aérea (SINFA), orientado a regular y controlar técnicamente las actividades. Dentro del sistema, se realizaron vuelos de actualización a la escala de 1:75.000 en 838.413 km² de territorio, lo que representa un avance del 42%, en tanto que en vuelo bajo a la escala de 1:37.500 se cubrió un 3,4% del país con 67.869 km² volados.

En el cuadro 2 se muestran las estadísticas generales del caso y las figuras 11 y 12 representan los avances y estado actual de la aerofotografía nacional en sus aspectos más significativos.

CUADRO 2. FOTOGRAFÍA AÉREA

Tipo de vuelo	Hasta agosto de 1979		Período 1979-1984		Acumulado a la fecha	
	Area cubierta (km²)	% de avance	Area cubierta (km²)	% de avance	Area cubierta (km²)	% de avance
Vuelo alto, escalas de 1:50 000 y menores	2 111 410	89,7	242 728	10,3	2 354 138[a]	100,0
Vuelos de actualización del SINFA, escala de 1:75.000	—	—	838 413	41,9	838 413	41,9
Vuelo bajo, escalas de 1:40 000 y mayores	1 052 201	49,0	150 436	7.0	1 202 637	56,0
Vuelo bajo del SINFA, escala de 1:37 500	—	—	67.869	3,4	67 869	3.4
Vuelos especiales varias escalas, mayormente de 1:10 000 y mayores	82.449	—	215.017	—	297.466	—[b]

[a] Incluye vuelos repetitivos y sobreposiciones entre zonas de vuelo.
[b] No se incluyen porcentajes de avance por no corresponder a programas de cubrimiento específico.

MAPAS TOPOGRÁFICOS

La producción y avances que se reportan de estos mapas comprenden varias escalas, desde 1:20 000 hasta 1:50 000. Durante el período 1979-1984 se lograron progresos significativos en la producción, especialmente por lo que respecta a las escalas de 50.000 y 250.000, al haberse llegado con ellas al cubrimiento completo del país.

Se terminó el cubrimiento del país con cartografía a la escala de 1:50.000, al haberse elaborado la edición provisional de 722 mapas y la definitiva de 864 (véase figura 13), con lo que se llega en la actualidad a tener un avance de 2.072 mapas en términos de ediciones definitivas, equivalente a un 88% del cubrimiento total. Se inició la etapa de actualización de la cartografía topográfica en esta escala.

En la escala de 1:100.000 (véase figura 14), con un cubrimiento previo de 286 mapas en cerca del 60% del territorio, las labores se concentraron en la revisión y reedición de 188 hojas y en la elaboración de 7 hojas nuevas, con un cubrimiento de aproximadamente 780.000 km² durante el período.

Figura 8. México: Control geodésico vertical

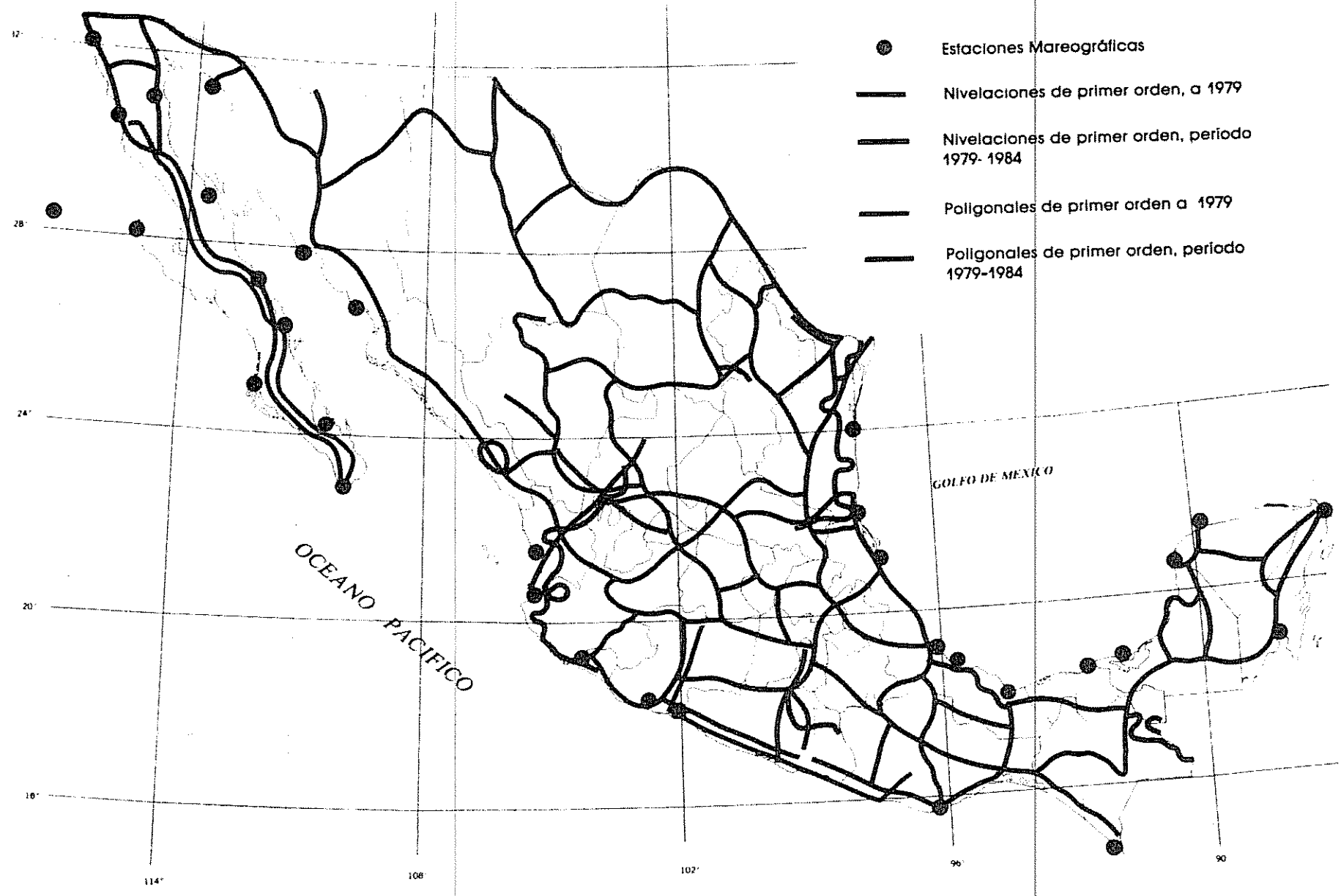


Figura 9. México: Control geodésico horizontal y vertical de segundo orden

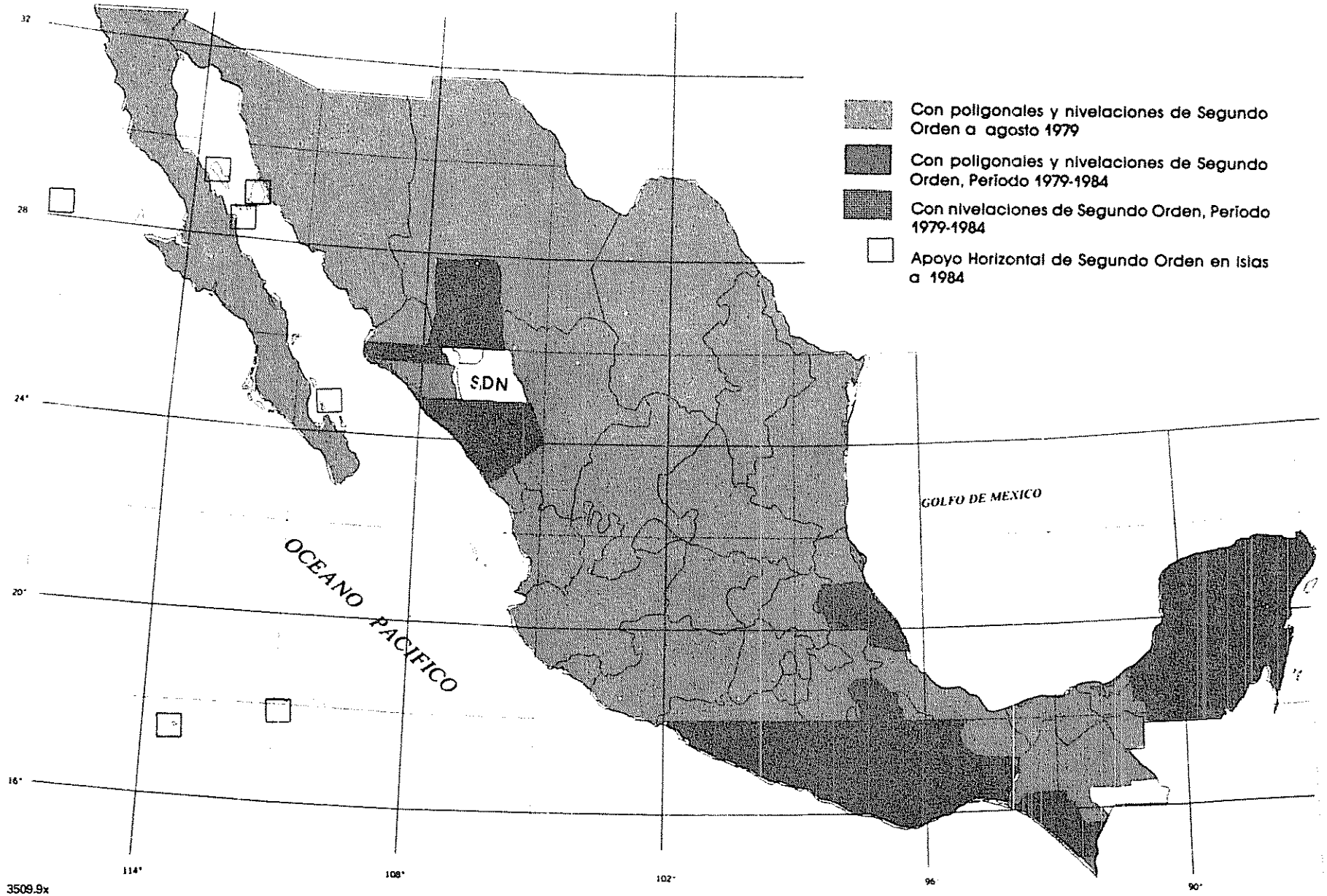


Figura 10. México: Levantamientos gravimétricos

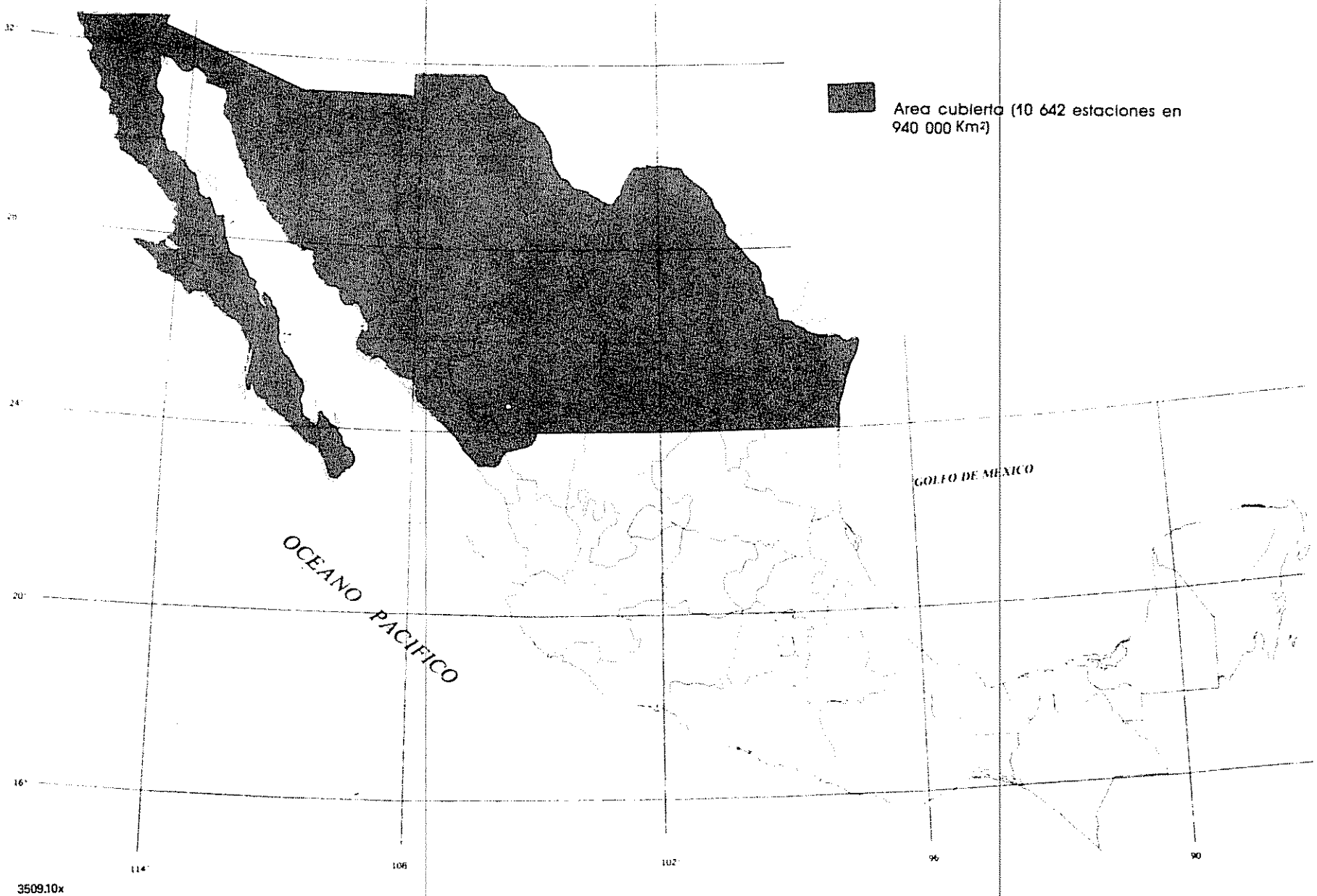


Figura 11. México: Fotografía aerea, escalas de 1:50.000 y menores

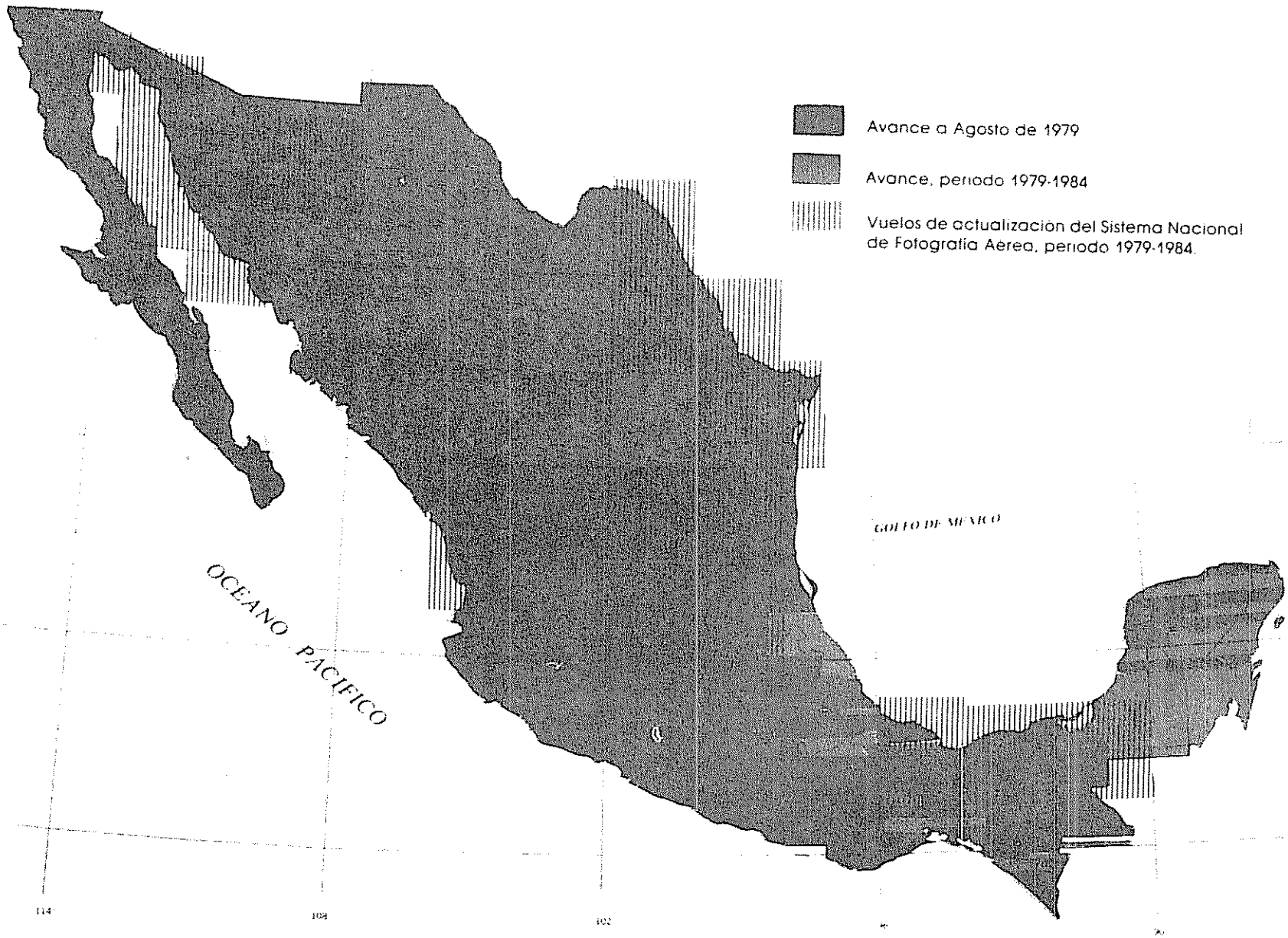


Figura 12. México: Fotografía aérea, escalas de 1:40.000 y mayores

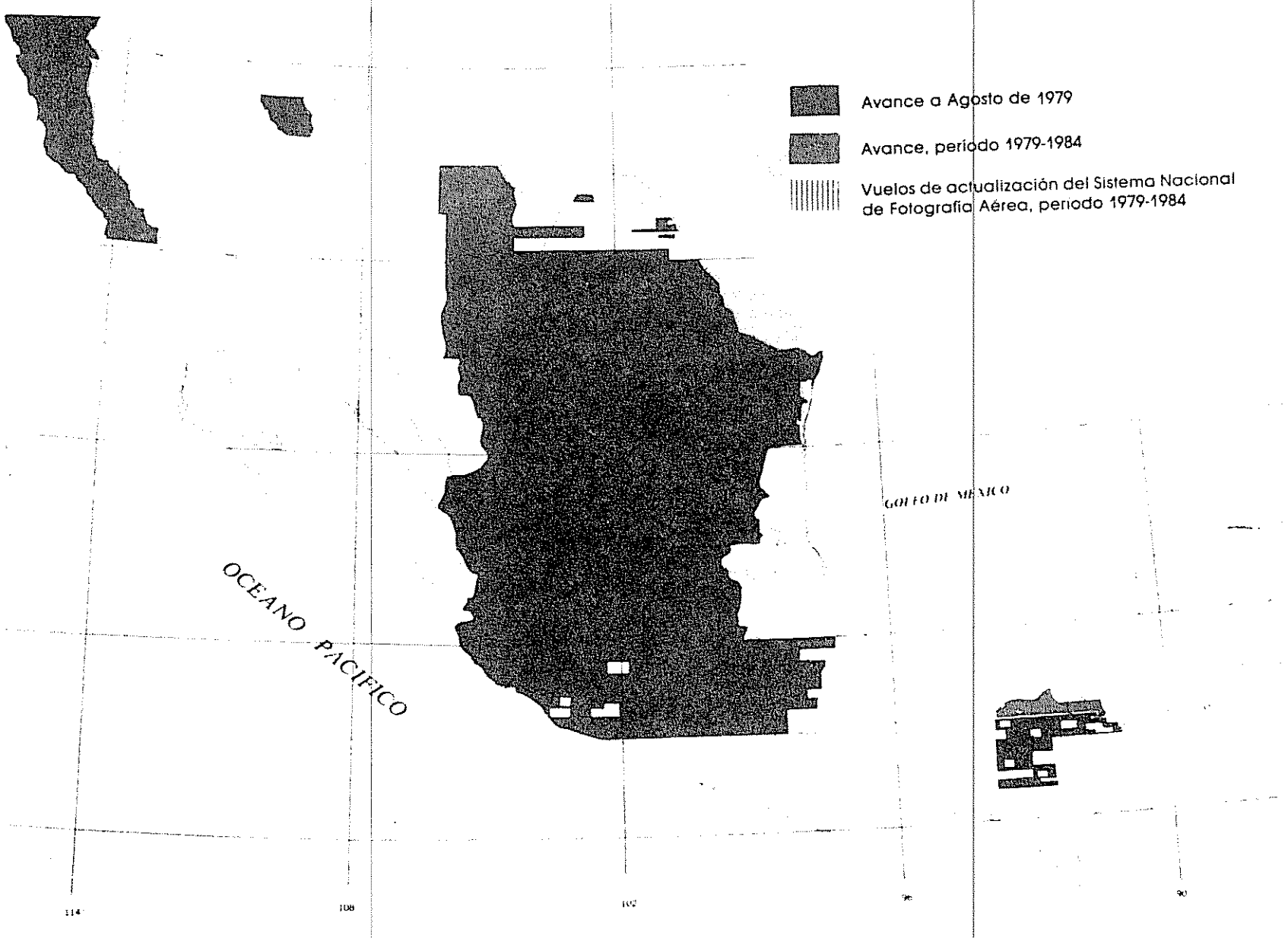


Figura 13. México: Cartografía topográfica, escala 1:50.000

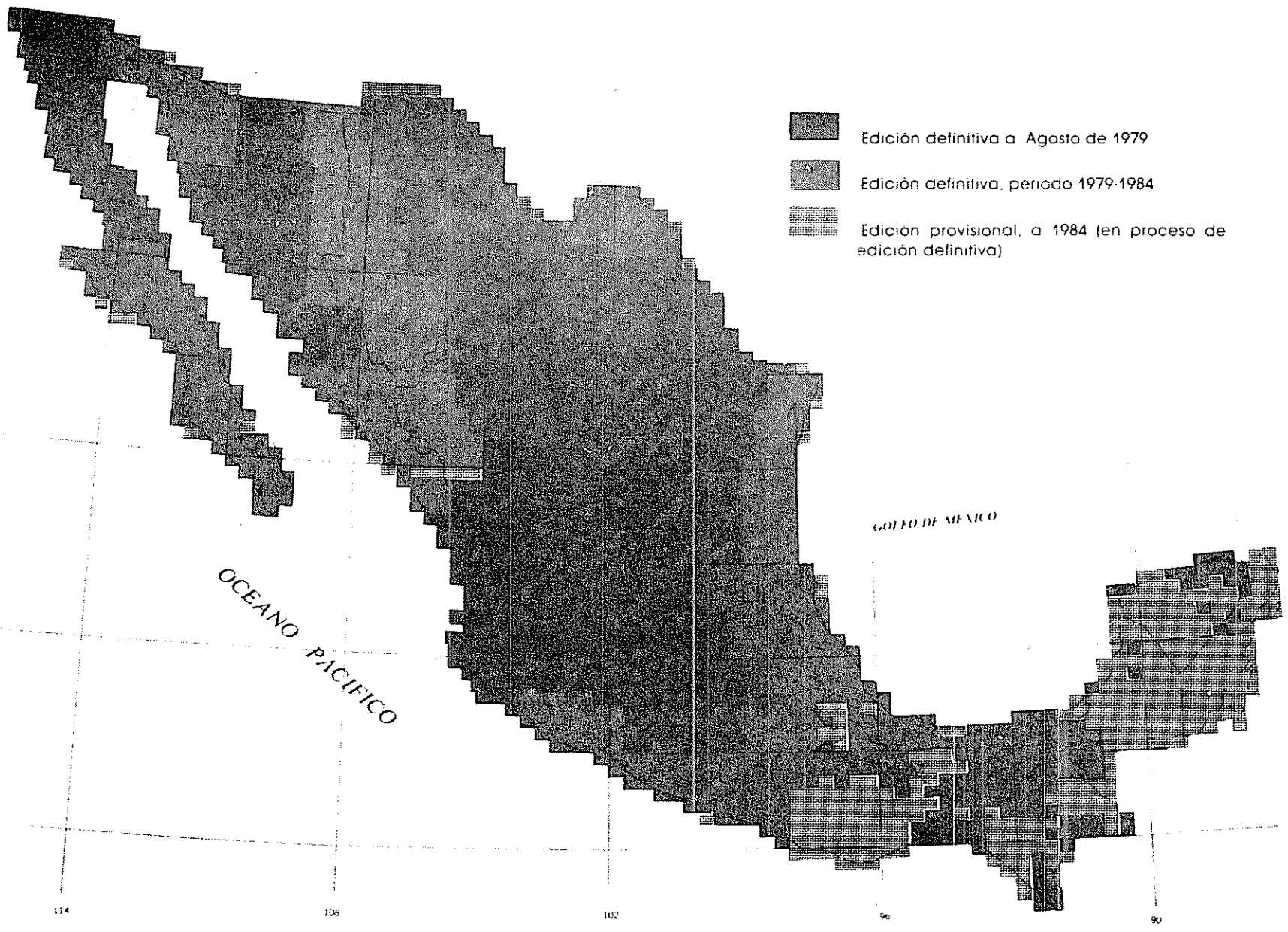
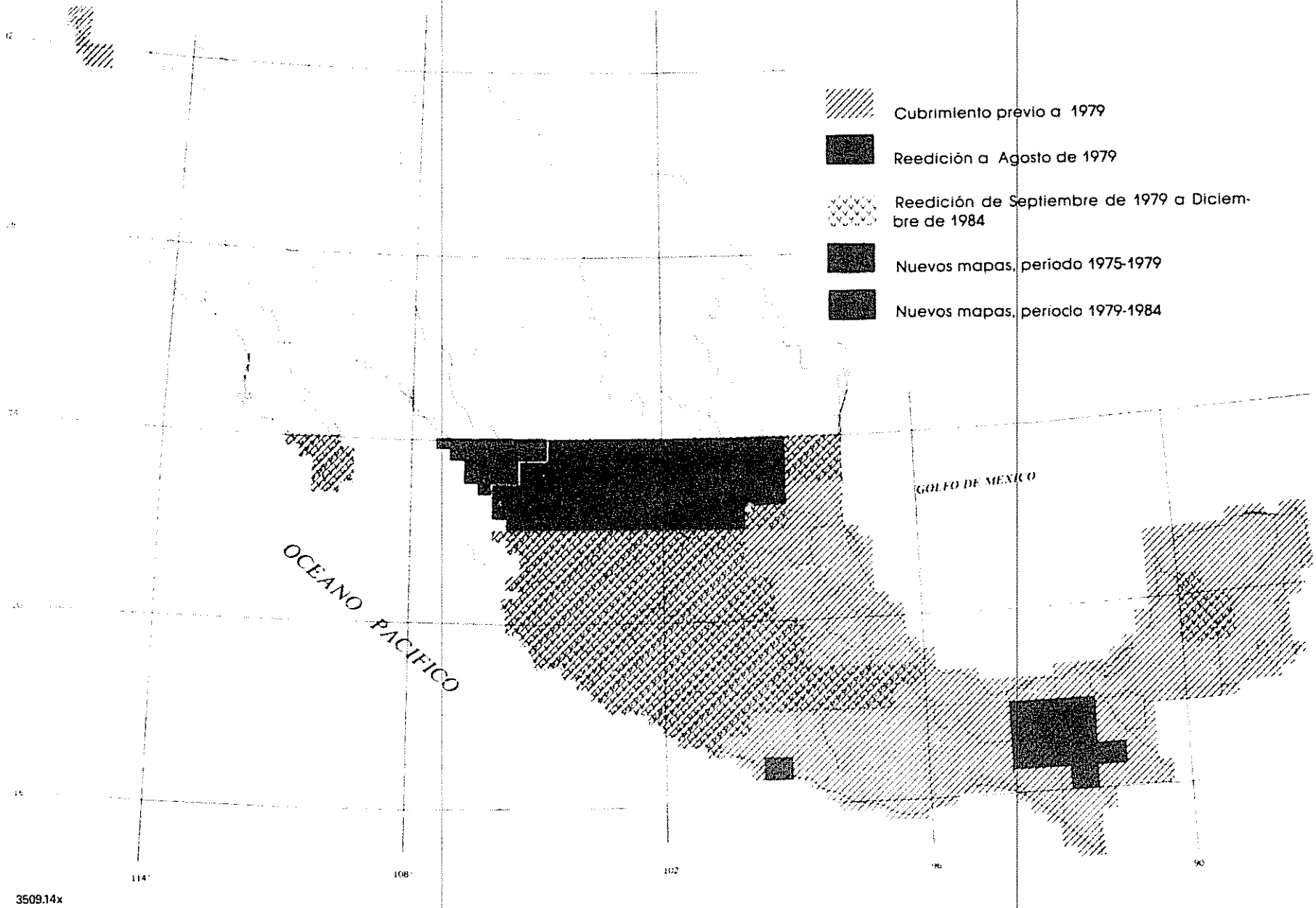


Figura 14. México: Cartografía topográfica, escala 1:100.000



La escala de 1:250.000 (véase figura 15) utilizó parcialmente la restitución fotogramétrica de 85 cartas a la escala de compilación de 1:100.000. El cubrimiento del país se terminó con la publicación de 93 mapas, 42 de los cuales sustituyen a los editados en fechas anteriores. Se hizo además un fotomapa en un área insular.

La escala de 1:25.000 comprende 33 cartas elaboradas en la parte central del país desde hace algún tiempo, no incluidas en reportes anteriores. Durante el período se actualizaron 16 cartas, con un cubrimiento global de aproximadamente 4.000 km².

En la escala de 1:20.000 se elaboraron 405 ortofotomapas en diversas zonas del país y 95 imágenes para el cubrimiento de un estado.

Los mapas topográficos de escalas menores se reportan en el capítulo de cartografía en pequeña escala. El cuadro 3 muestra las estadísticas generales en el avance de la cartografía topográfica.

CUADRO 3. MAPAS TOPOGRÁFICOS

Escalas	Acumulado a 1975			Período 1975-1979			Período 1979-1984			Avance total		
	Mapas	Cubrimiento (km²)	Avance (%)	Mapas	Cubrimiento (km²)	Avance (%)	Mapas	Cubrimiento (km²)	Avance (%)	Mapas	Cubrimiento (km²)	Avance (%)
1:20 000 (Ortofotomapas)	—	—	—	—	—	—	405	67 500	—	405	67 500	—
1:25 000	33	8 250	—	4	1 000	—	(16 mapas reeditados)			37	9 250	—
1:50.000, edición provisional	1 187	1 010 000	50,5	439	375 000	18,7	722	615 000	30,8	2 348	2 000 000	100
Edición definitiva	780	664 000	33,2	428	365 000	18,2	864	736 000	36,8	2 072	1 765 000	88,2
1:100 000	265	1 060 000	53,0	21	84 000	4,2	7	28 000	1,4	293	1 172 000	58,6
							(188 mapas reeditados)					
1:250.000	—	—	—	28	463.000	23,1	93	1.537.000	76,9	121	2.000.000	100

NOMBRES GEOGRÁFICOS

Las actividades relacionadas con nombres geográficos estuvieron orientadas, por una parte, a la elaboración de los catálogos y nomenclátores nacionales, sobre la base de información cartográfica y estadística, y, por otra, a desarrollar los criterios para la integración del Registro Nacional de Nombres Geográficos y la normalización. En los trabajos se dio impulso al uso de procesos automatizados para el manejo de la información.

Se elaboró el Catálogo de Integración Territorial, con base en el Censo Nacional de Población; constituye un listado de nombres de localidades, con referencia a la división político-administrativa y a la población. Se trabajó asimismo en un catálogo de localidades que integra información del Nomenclátor y del Catálogo de Integración Territorial; su presentación es por estados y se han completado siete de ellos.

El Nomenclátor General incluye información sobre nombres de localidades, accidentes geográficos naturales e instalaciones diversas, tomados de la cartografía topográfica en las escalas de 1:50.000 y 1:250.000. Se presenta por estados, con un avance actual de 17 estados sobre la base cartográfica de 1:50.000, 10 estados con base 1:250.000 y cinco con información tomada de ambas escalas, con lo que se tiene cubrimiento para todo el territorio.

Se trabajó también en dos nomenclátores especiales: el Nomenclátor Nacional integrado con información de la carta geográfica a la escala de 1:5 000.000, y el Nomenclátor de Cabeceras Municipales y de localidades con poblaciones mayores de 2.500 habitantes.

MAPAS TEMÁTICOS

Durante el período 1979-1984, la cartografía temática nacional experimentó un amplio desarrollo, tanto en lo que respecta a cubrimientos, como en lo relativo al tratamiento de nuevos temas en las escalas más pequeñas que 150.000.

En esta escala, el avance, referido a los temas tradicionalmente tratados que se consignan en el reporte a la II Conferencia, fue relativamente reducido, como resultado de las prioridades asignadas a la producción de cartografía temática en escalas menores; se elaboraron así un total de 448 mapas en edición definitiva, más 151 en ediciones provisionales, los que en conjunto representan un avance promedio del 6,4% sobre las cifras de producción anterior. El avance global al 31 de diciembre de 1984 es de un 32,5% respecto al cubrimiento del país, con un total de 3.052 mapas en los cuatro temas básicos de geología, edafologia, uso actual del suelo y uso potencial del mismo. Las cifras de producción y avance y el estado actual pueden observarse en el cuadro 4 y en las gráficas correspondientes (véase figuras 16, 17, 18 y 19)

CUADRO 4. CARTOGRAFÍA TEMÁTICA, ESCALA 1:50.000

Tema	Avance hasta agosto 1979			Progreso 1979-1984			Avance a la fecha		
	Cantidad de mapas	Cubrimiento (km²)	% de avance	Cantidad de mapas	Cubrimiento (km²)	% de avance	Cantidad de mapas	Cubrimiento (km²)	% de avance
Geología									
Edición definitiva	733	733.000	31,2	129	129.000	5,5	862	862 000	36,7
Edición provisional	896	896 000	38,2	38	38.000	1,6	934	934.000	39,8
Edafología									
Edición definitiva	591	591.000	25,2	162	162.000	6,9	753	753.000	32,1
Edición provisional	698	698 000	29,7	64	64 000	2,7	762	762 000	32,4
Uso del suelo									
Edición definitiva	609	609 000	25,9	97	97 000	4,1	706	706 000	30,0
Edición provisional	763	763.000	32,5	49	49 000	2,1	812	812 000	34,6
Uso potencial									
Edición definitiva	484	484.000	20,6	60	60 000	2,6	544	544 000	23,2
Edición provisional	544	544 000	23,2	—	—	—	544	544 000	23,2
Frontera agrícola									
Edición definitiva	85	85.000	3,6	—	—	—	85	85.000	3,6

Figura 15. México: Cartografía topográfica, escala 1:250.000

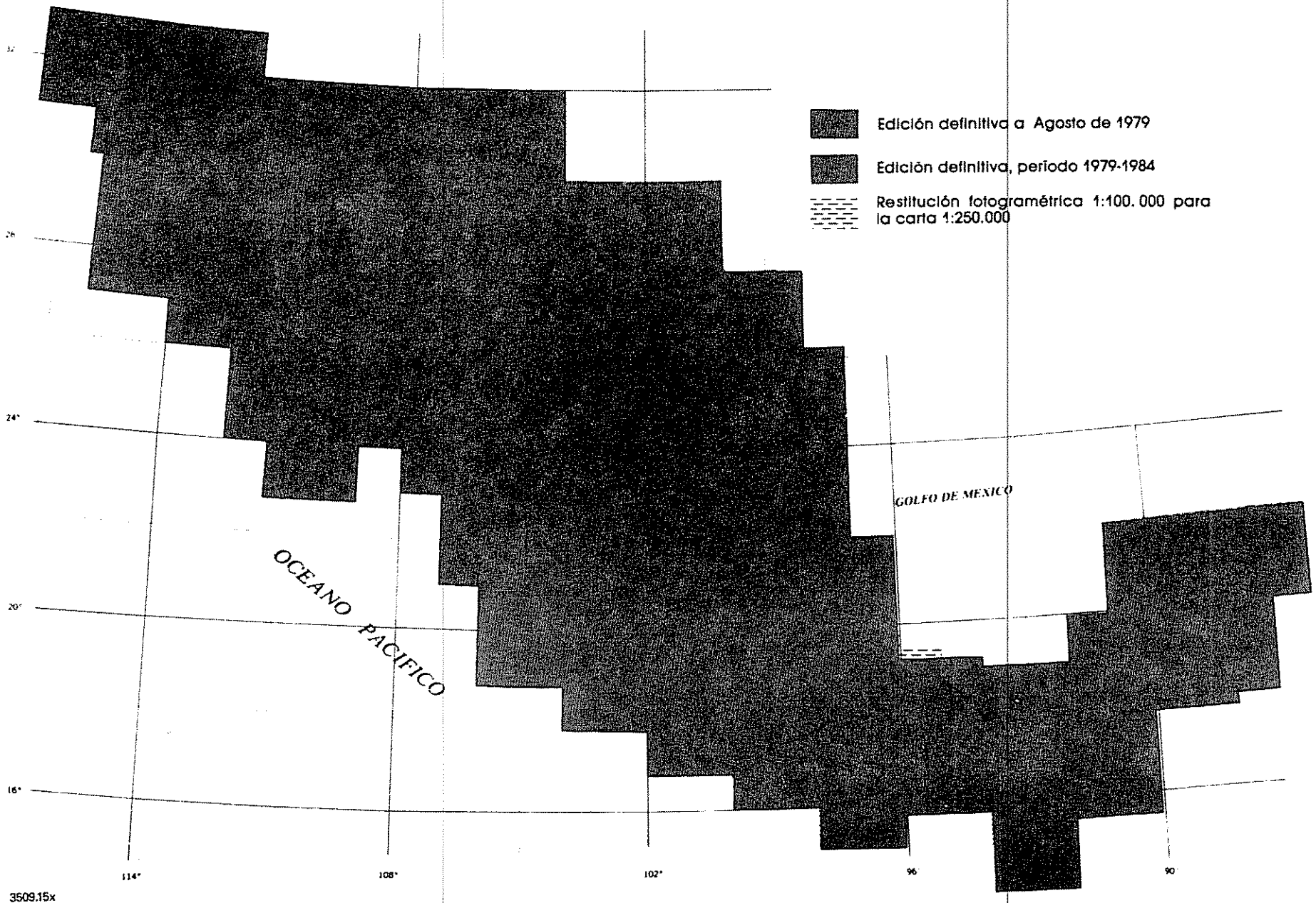


Figura 16. México: Cartografía de uso del suelo y vegetación, escala 1:50.000

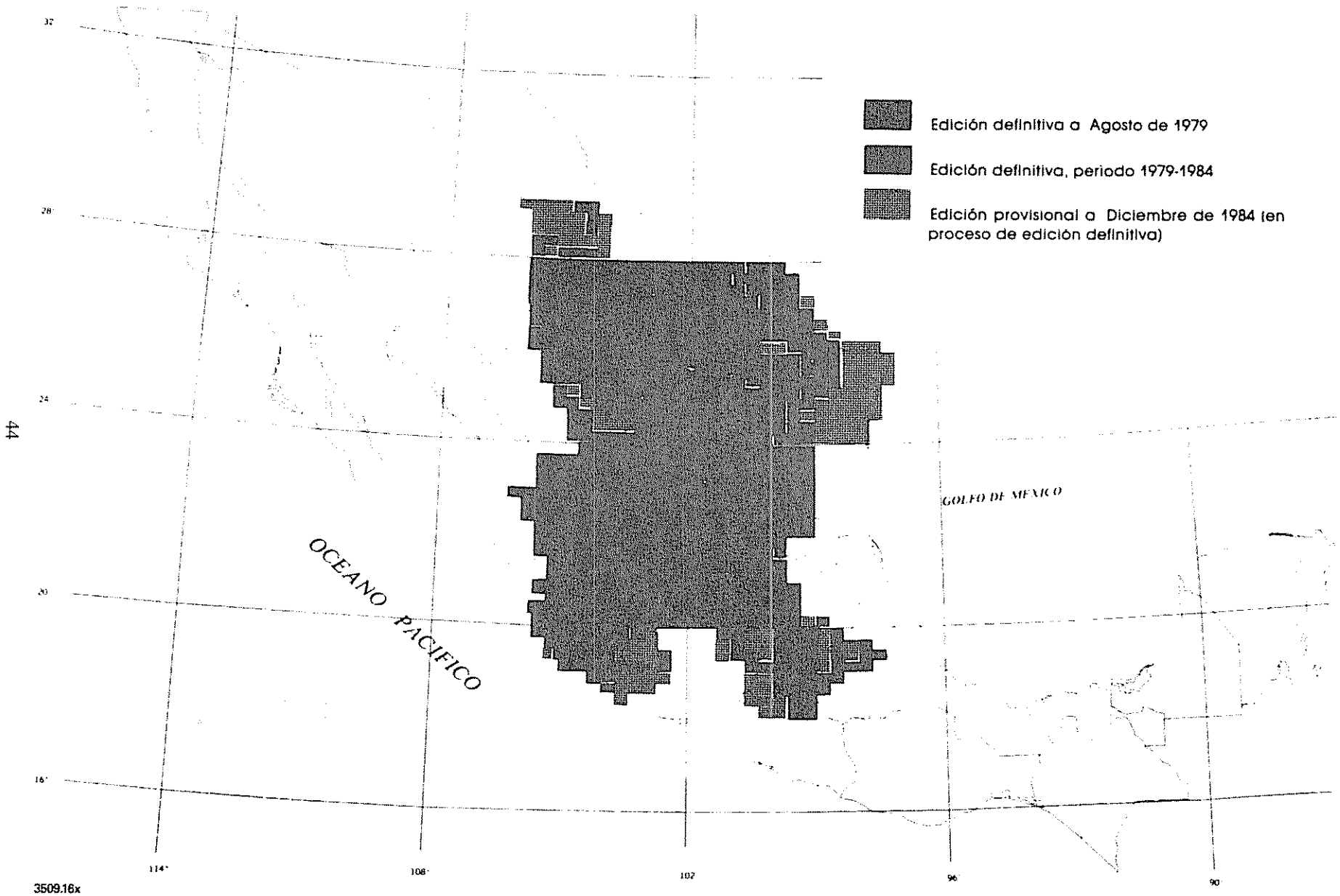


Figura 17. México: Cartografía geológica, escala 1:50.000

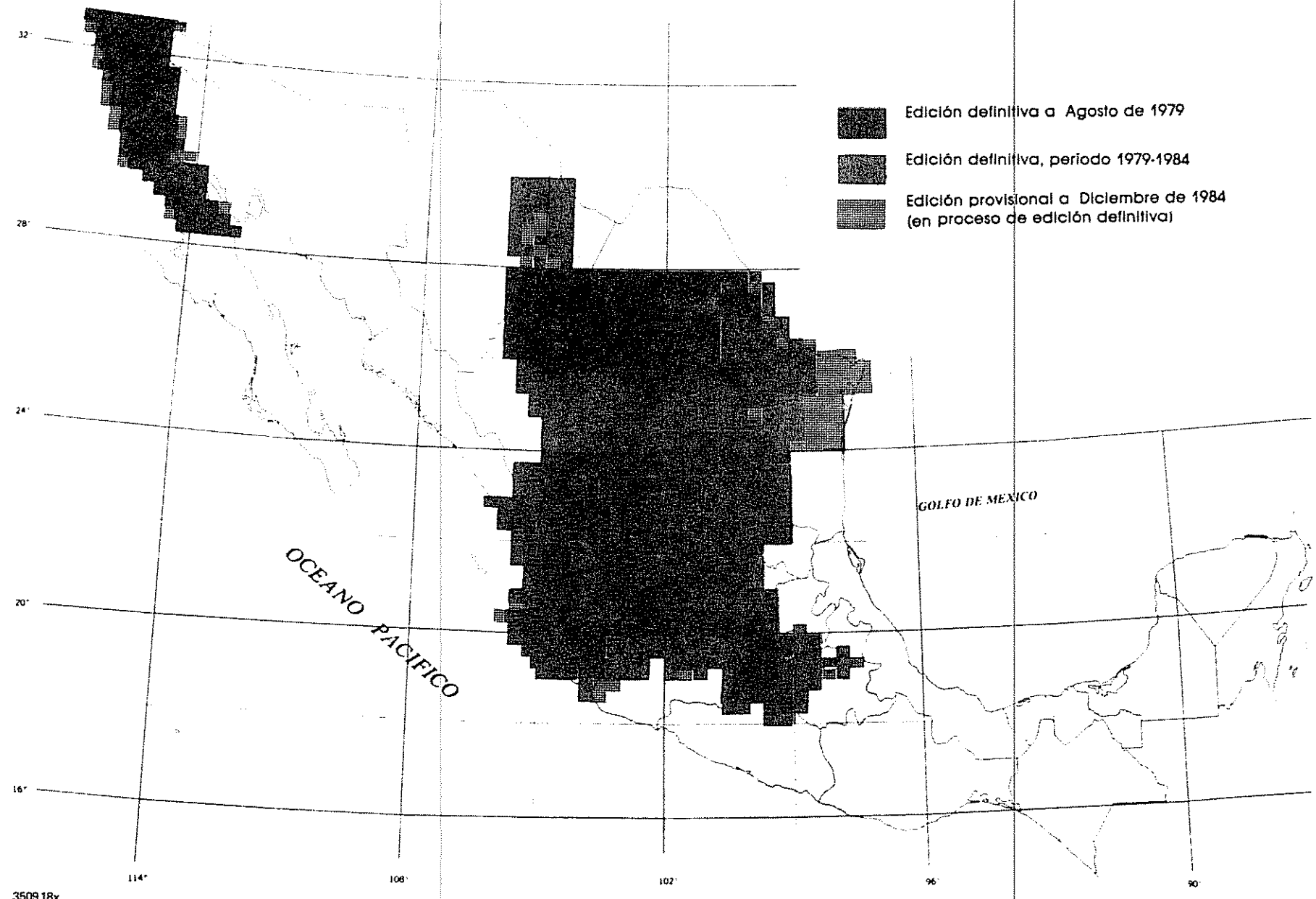


Figura 18. México: Cartografía edafológica, escala 1:50.000

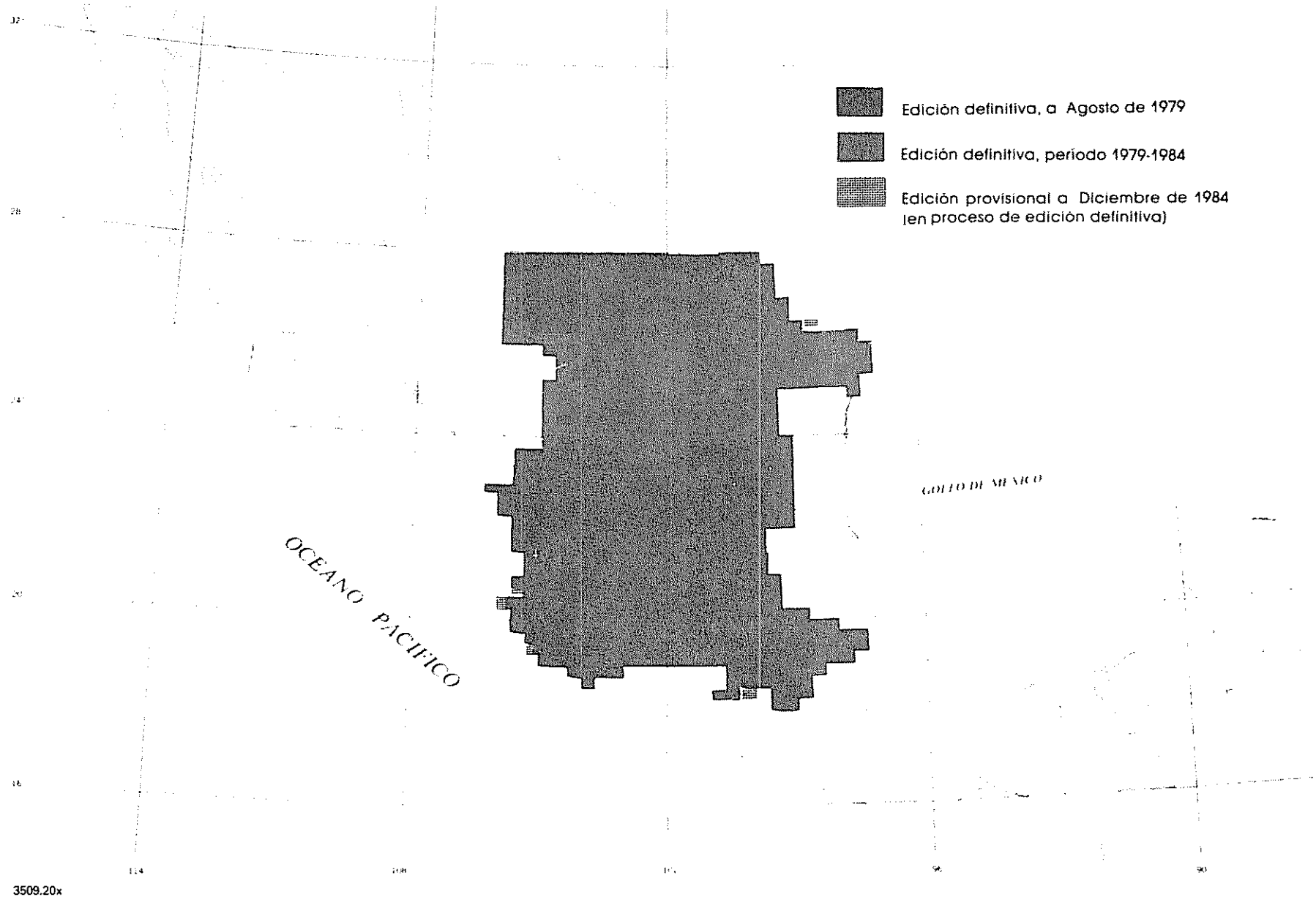
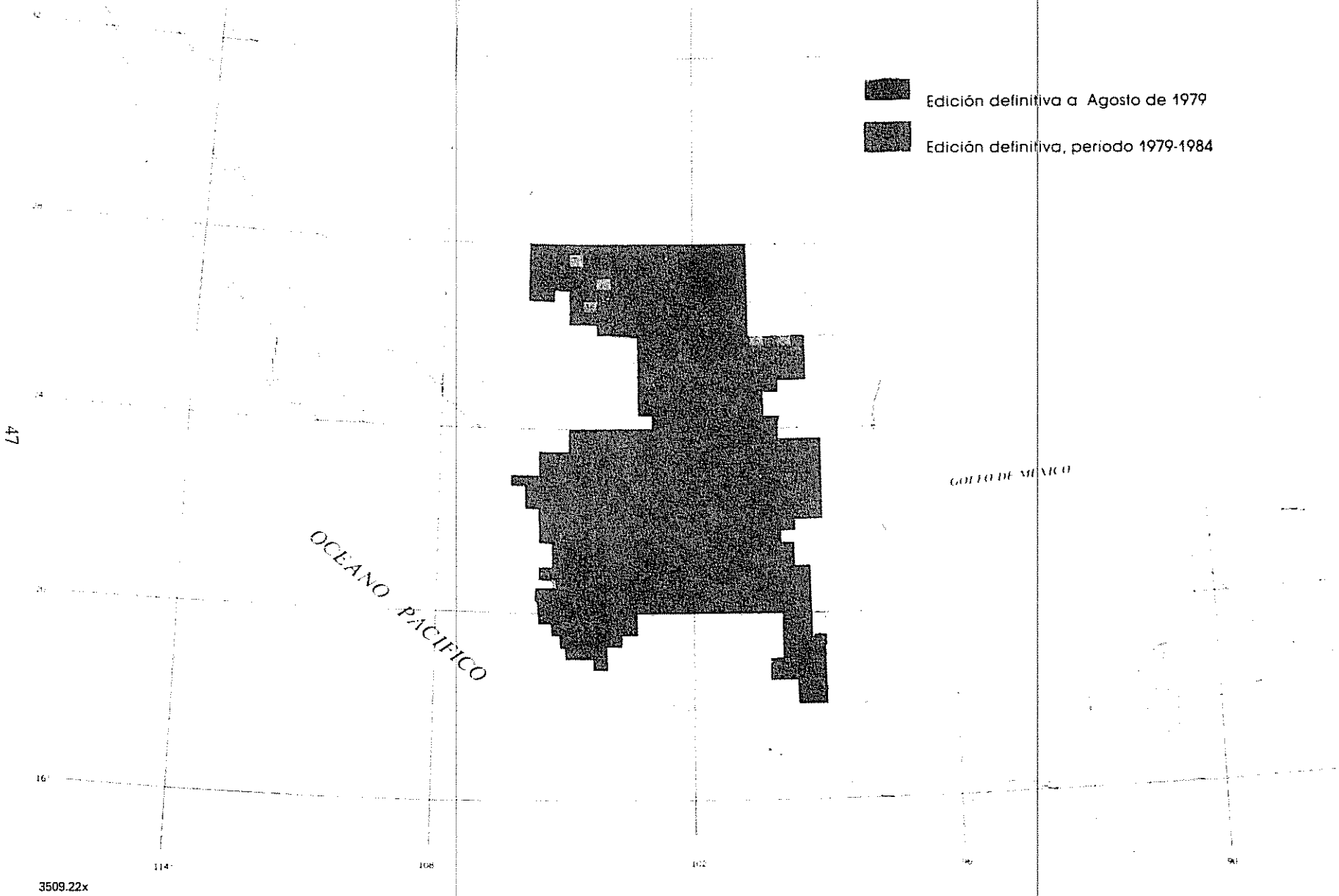


Figura 19. México: Cartografía de uso potencial del suelo, escala 1:50.000



En la escala 1:250.000, además de los temas ya indicados, se agregan los de Hidrología, Efectos Climáticos Regionales, Frontera Agrícola y Capacidad de Uso del Suelo, todos ellos con un desarrollo que data de 1979 a la fecha (véanse figuras 20, 21, 22, 23, 24, 25 y 26). En tres de los nuevos temas existen dos o más versiones para una misma carta. Así, en la Carta Hidrológica hay una versión para aguas superficiales y otra para aguas subterráneas; en la de Uso Potencial se hace una carta para agricultura, otra para ganadería y una tercera para forestería, y en la Carta de Efectos Climáticos Regionales se produce una versión para cada uno de los dos semestres significativos del año.

Las cifras de producción y estado actual por tema se pueden observar en el cuadro 5 y en las gráficas anexas. En el conjunto se produjeron durante el período 652 mapas, de los cuales 574 están ya en edición definitiva, lo que, en conjunto, representa un avance promedio del 62% para todos los temas. El avance total respecto al cubrimiento nacional es de un 64,4%, con un total de 678 mapas, de los cuales 597 corresponden a ediciones definitivas.

CUADRO 5 CARTOGRAFÍA TEMÁTICA, ESCALA 1:250 000

Tema	*Avance hasta agosto 1979*			*Progreso 1979-1984*			*Avance a la fecha*		
	Cantidad de mapas	*Cubrimiento (km^2)*	*% de avance*	*Cantidad de mapas*	*Cubrimiento (km^2)*	*% de avance*	*Cantidad de mapas*	*Cubrimiento (km^2)*	*% de avance*
Geología									
Edición definitiva	13	300 000	10,7	73	1 206 000	60,3	86	1 506 000	71,0
Edición provisional	13	300 000	10,7	84	1 388 000	69,4	97	1 688 000	80,1
Edafología									
Edición definitiva	—	—	—	55	908 000	45,4	55	908 000	45,4
Edición provisional	—	—	—	69	1 140 000	57,0	69	1 140 000	45,4
Uso del suelo y vegetación									
Edición definitiva	—	—	—	61	1 008 000	50,4	61	1 008 000	50,4
Edición provisional	3	50 000	2,5	74	1 222 000	61,1	77	1 272 000	63,6
Uso potencial [a]									
Edición definitiva	—	—	—	51	843 000	42,1	51	843 000	42,1
Edición provisional	—	—	—	63	1 040 000	52,0	63	1 040 000	42,1
Geohidrología [b]									
Edición definitiva	10	120 000	4,1	156	1 290 000	64,5	166	1 410 000	68,6
Edición provisional	10	120 000	4,1	156	1 290 000	64,5	166	1 410 000	68,6
Efectos climáticos regionales [c]									
Edición definitiva	—	—	—	90	744 000	37,2	90	744 000	37,2
Edición provisional	—	—	—	108	893 000	44,6	108	893 000	44,6
Frontera agrícola y capacidad de uso del suelo									
Edición definitiva	—	—	—	88	1 520 000	76,0	88	1 520 000	76,0
Edición provisional	—	—	—	98	1 700 000	85,0	98	1 700 000	85,0

[a] Comprende tres versiones: agrícola, ganadera y forestal.
[b] Comprende dos versiones: aguas superficiales y aguas subterráneas.
[c] Comprende dos versiones, una para cada semestre del año.

CARTOGRAFÍA EN PEQUEÑAS ESCALAS

La cartografía en pequeña escala elaborada en el país durante el período 1979-1984 experimentó un desarrollo altamente significativo al haberse llegado al cubrimiento nacional en la gran mayoría de los casos, y agregar a las cuatro cartas topográficas impresas y ocho cartas temáticas editadas provisionalmente, que se reportan en el informe a la II Conferencia, la producción de 212 nuevos mapas de escalas variables entre 1:500.000 y 1:5.000.000. La cartografía así desarrollada cubre los aspectos topográficos con distintas presentaciones y 17 diferentes temas, además de los de batimetría y cartografía censal que se reportan en otra parte de este informe.

Con la información cartográfica en pequeña escala desarrollada a la fecha, el país cuenta con un valioso instrumento informativo, especialmente en lo que respecta a la escala de 1:1.000.000. Esta escala agrupa la gran mayoría de los productos en una presentación uniforme, sobre la misma base y con los mismos formatos, lo que permite la comparabilidad de la información y proporciona una visión integral del territorio en los distintos aspectos de interés inmediato para los investigadores y planificadores.

En el cuadro 6 (pág. 56) se detallan los diversos productos elaborados, con la indicación de escalas y temas.

LEVANTAMIENTOS HIDROGRÁFICOS Y CARTAS NÁUTICAS

Durante el período 1979-1984 se experimentó un significativo avance en la producción de cartografía marina, comparado con avances anteriores, al incluir en el tema los aspectos oceanográficos e incrementar la realización de estudios y levantamientos hidrográficos en áreas de interés (véase figura 26).

Se elaboraron 32 nuevas cartas náuticas a diversas escalas, nueve cartas batimétricas con cubrimiento nacional a la escala de un millón, 14 cartas de propósitos especiales, una carta de pesca y dos portulanos, para un total de 58 nuevas cartas durante el período. Asimismo se llevó a cabo la revisión e impresión de 38 cartas elaboradas con anterioridad al período, de las cuales 33 corresponden a cartas náuticas y cinco a portulanos. Se realizaron 50 estudios diversos y seis levantamientos hidrográficos con un cubrimiento global de 82.000 km^2.

En el cuadro 7 (pág. 56) se puede hacer una comparación de la producción durante el período 1979-1984 con los avances anteriores y observar el progreso a la fecha. Además de lo anterior, se elaboraron cuatro prototipos de cartas referidas a variables de oceanografía física y se trabajó activamente en la integración y desarrollo del Centro de Datos Oceanográficos, el cual contiene información relacionada

Figura 20. México: Cartografía de frontera agrícola y capacidad de uso del suelo, escala 1:50.000 y escala 1:250.000

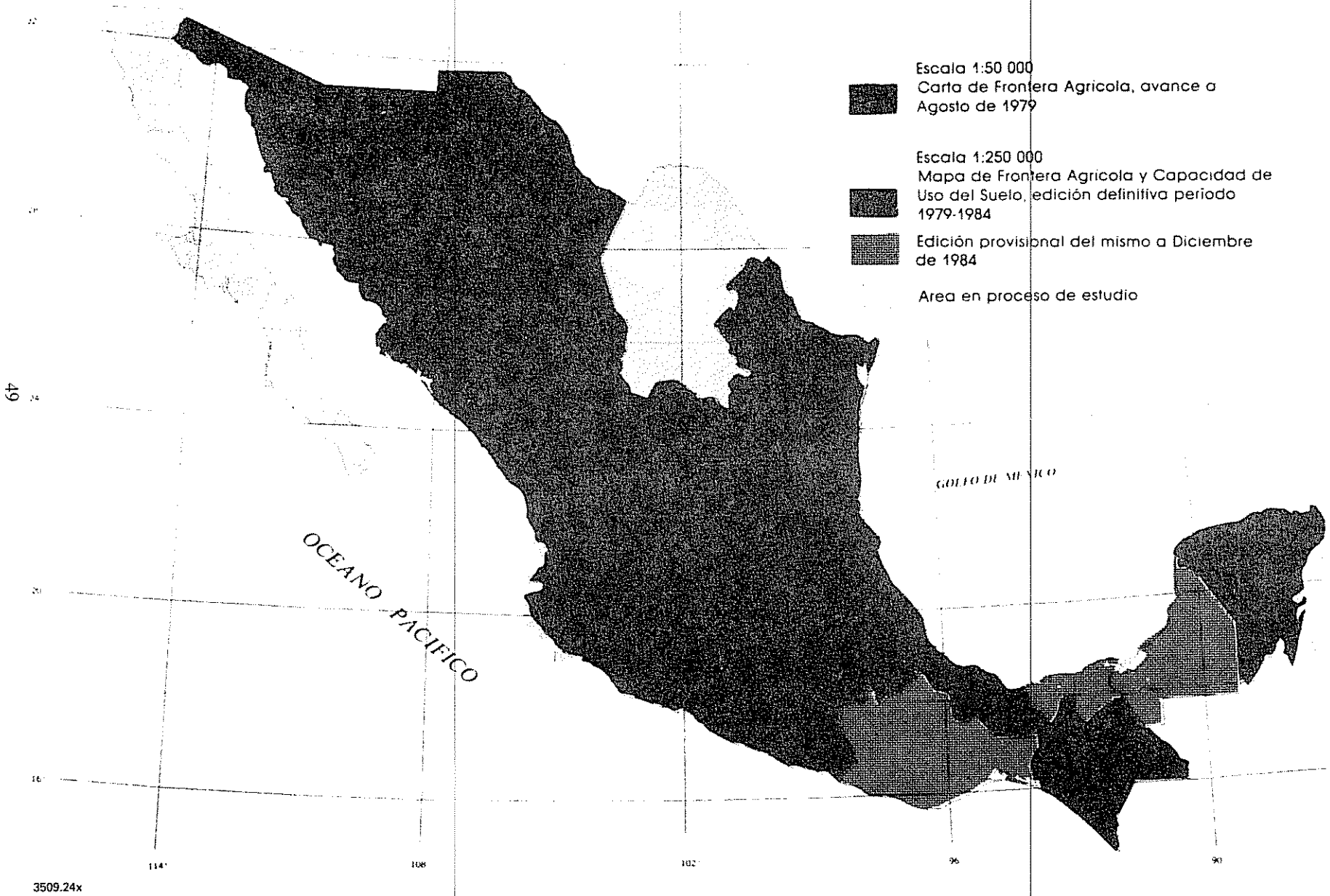


Figura 21. México: Cartografía de uso del suelo y vegetación, escala 1:250.000



Figura 22. México: Cartografía geológica, escala 1:250.000

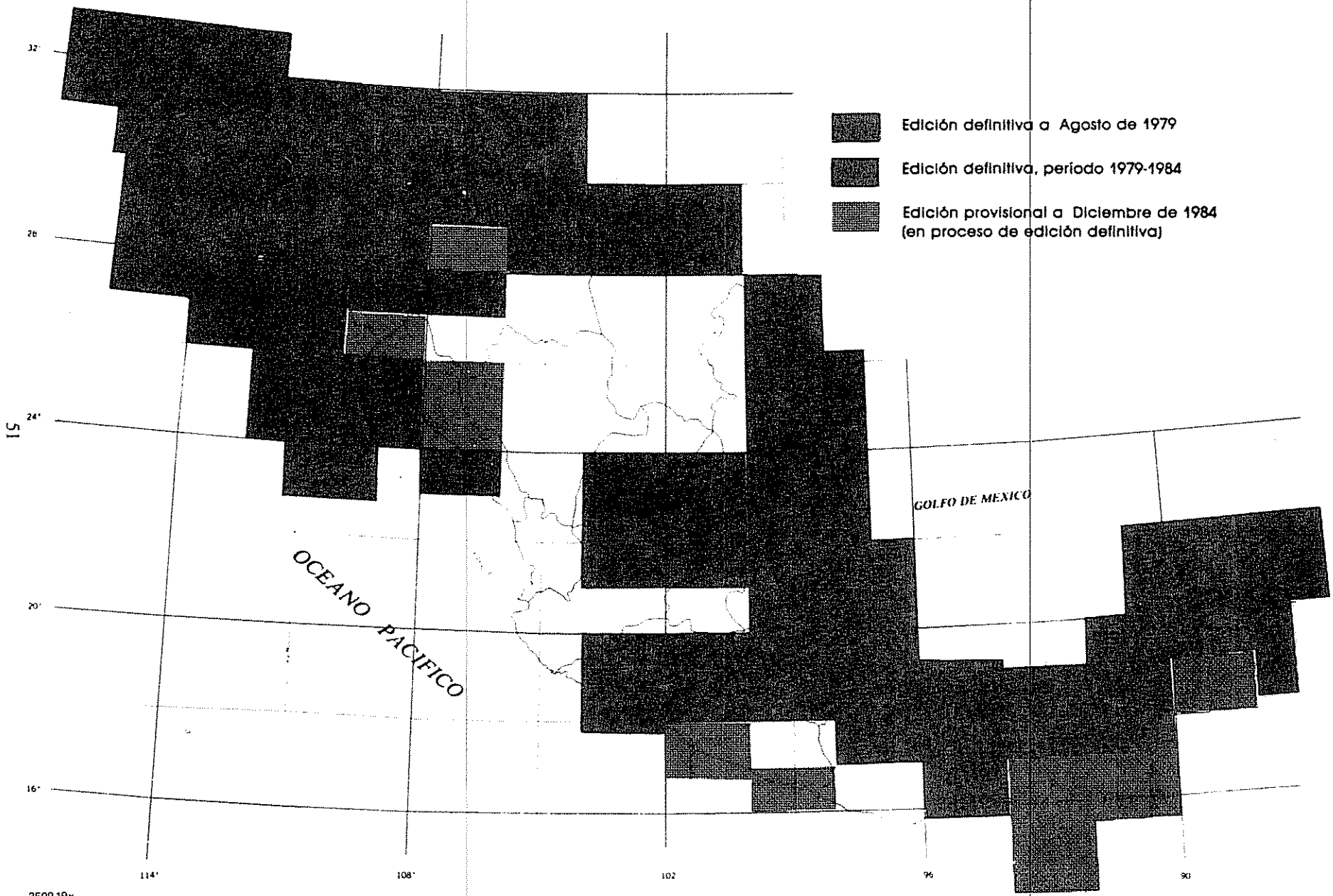


Figura 23. México: Cartografía edafológica, escala 1:250.000

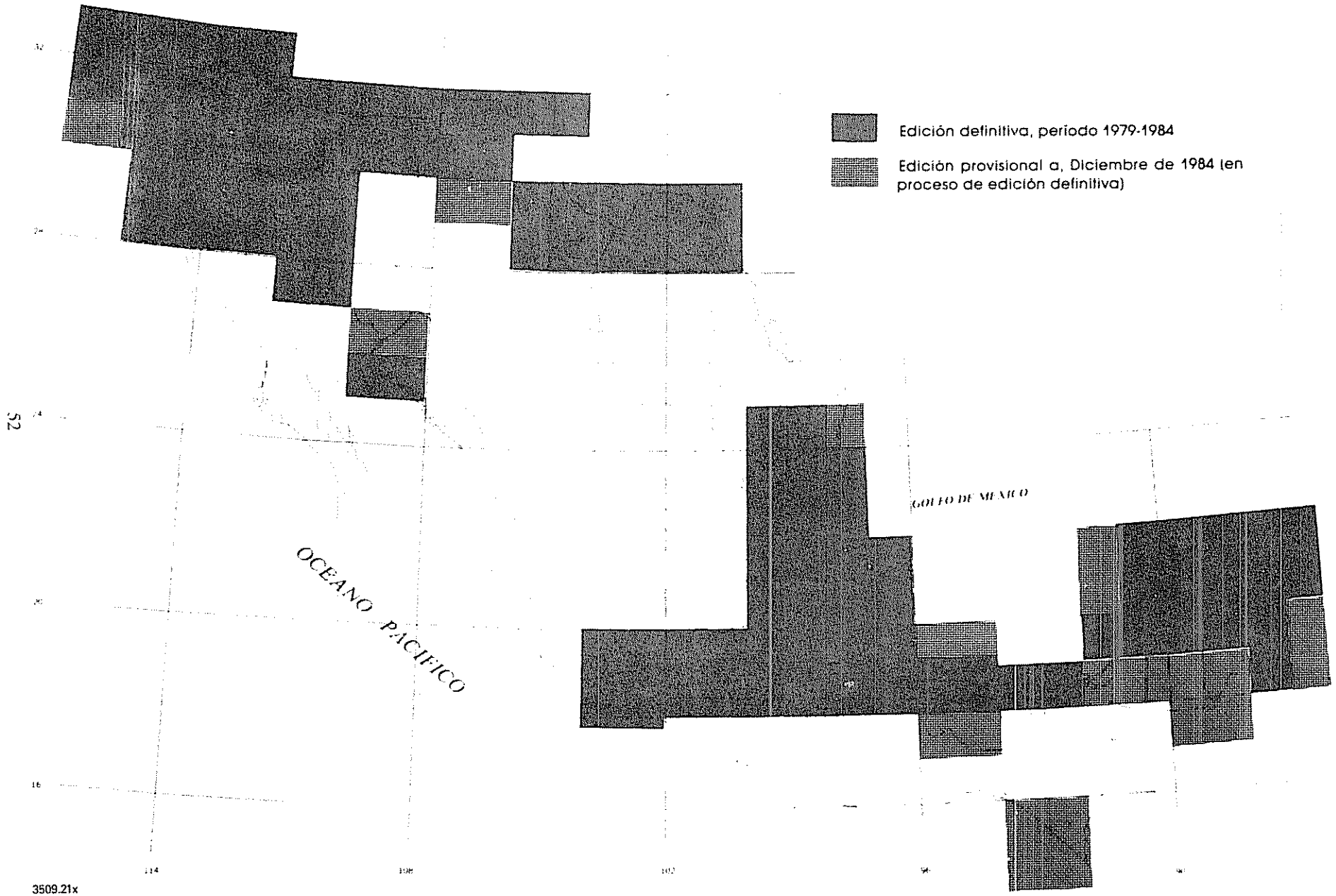
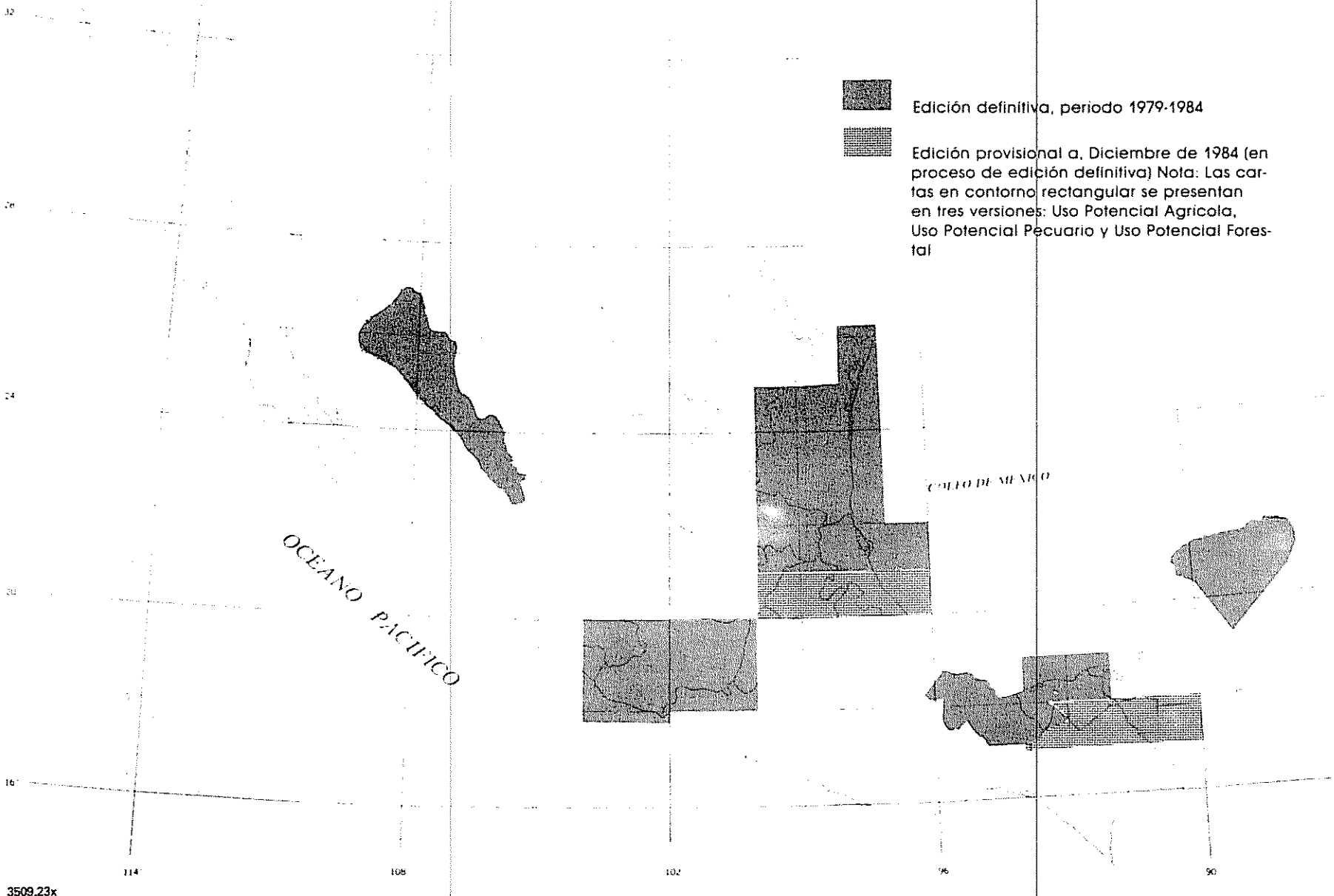


Figura 24. México: Cartografía de uso potencial del suelo, escala 1:250.000



3509.23x

Figura 25. México: Cartografía de efectos climáticos regionales, escala 1:250.000

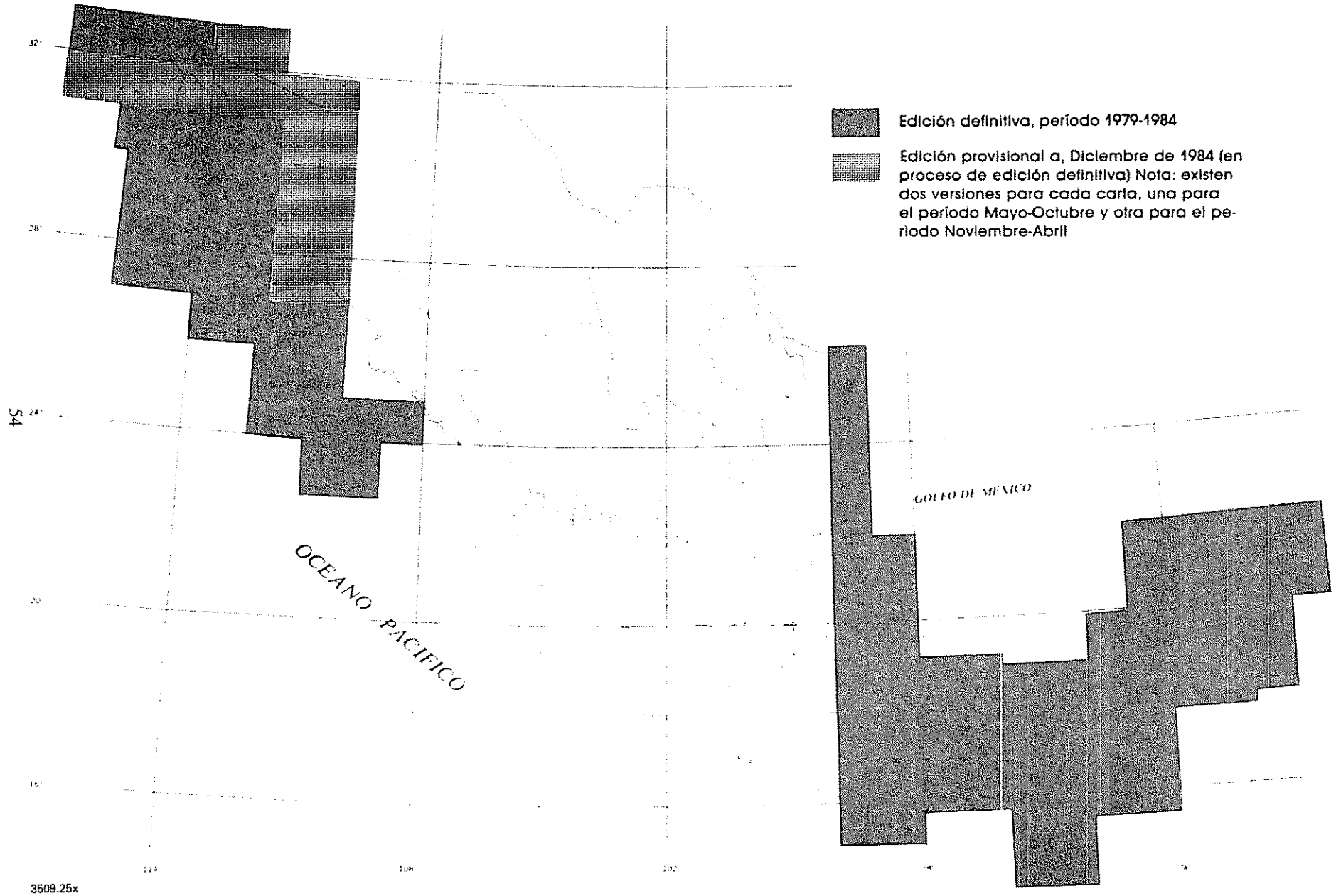
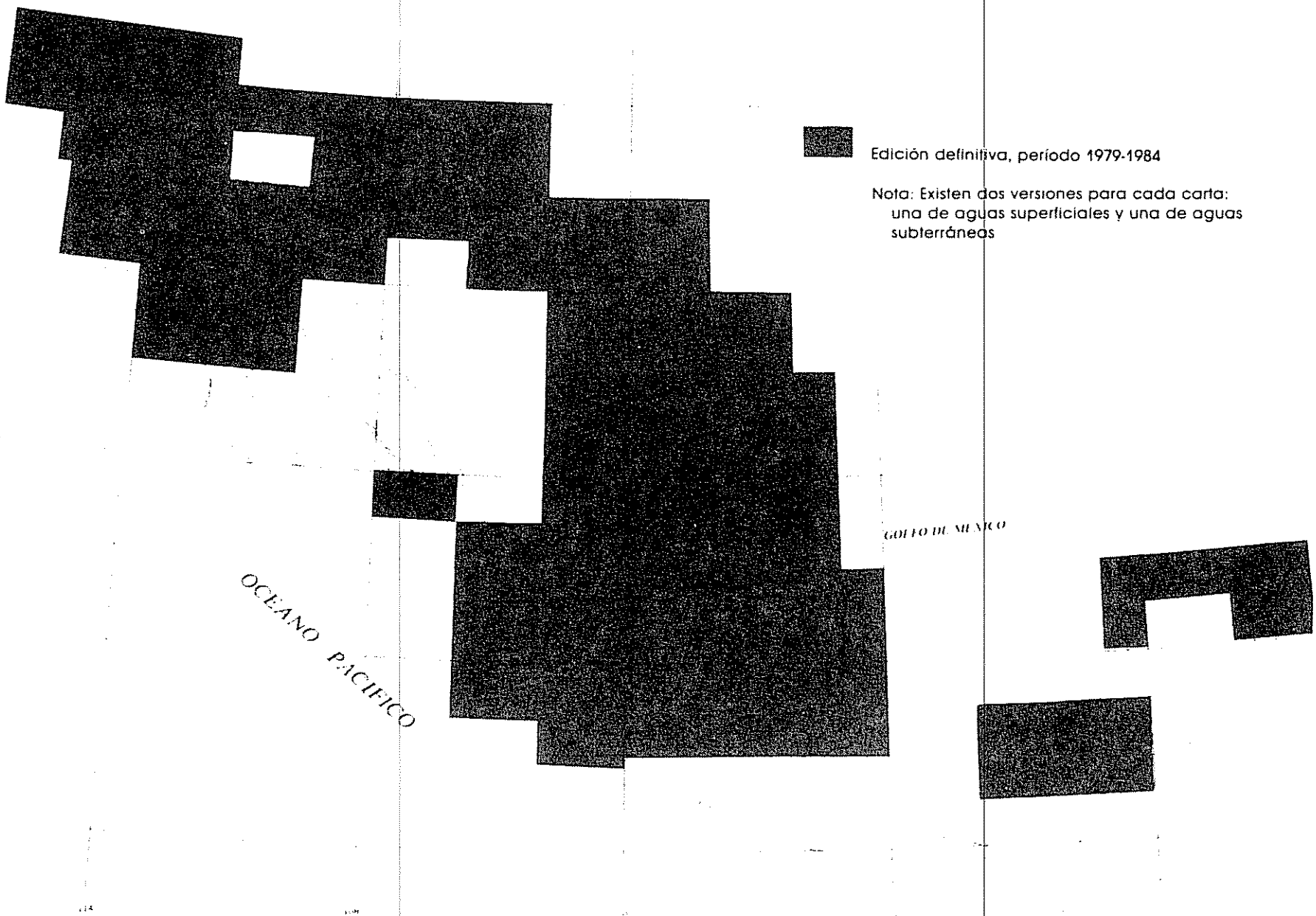


Figura 26. México: Cartografía hidrológica, escala 1:250.000



3509.26x

con características físico-químicas, corrientes superficiales, batimetría, batitermografía, islas mexicanas y reportes de campañas oceanográficas.

CUADRO 6. CARTOGRAFÍA EN PEQUEÑAS ESCALAS

Escala	*Denominación o tema*	*Número de hojas*	*Observaciones*
A. *Cartas geográficas*			
1:500 000	Carta geográfica por estados	3	Se hicieron además 2 reediciones Cubrimiento de 145.206 km, 7,3% del país
1:1 000 000	Carta topográfica	8	Segunda edición
	Carta hipsográfica	8	Cubrimiento total
	Carta hipsográfica en relieve	8	Cubrimiento total
	Fotomapa de imágenes LANDSAT	8	Cubrimiento total
1:4 000 000	Carta geográfica	1	Cubrimiento total
	Carta hipsográfica	1	Cubrimiento total
	Carta hipsográfica en relieve	1	Cubrimiento total
1:5 000 000	Carta geográfica	1	Cubrimiento total
Varias	Mapa estatal en relieve	3	Cubrimiento 9,4%
	TOTAL	42	
B *Cartas temáticas*			
1:500 000	Mapa de uso del suelo	10	Cubrimiento total
1:1 000 000	Carta geológica	8	Cubrimiento total
	Carta de uso del suelo y vegetación	8	Cubrimiento total
	Carta edafológica	8	Cubrimiento total
	Carta hidrológica de aguas superficiales	8	Cubrimiento total
	Carta hidrológica de aguas subterráneas	8	Cubrimiento total
	Carta de climas	8	Cubrimiento total
	Carta de temperaturas medias anuales	8	Cubrimiento total
	Carta de precipitación total anual	8	Cubrimiento total
	Carta de humedad del suelo	8	Cubrimiento total
	Carta de evapotranspiración y déficit de agua	8	Cubrimiento total
	Carta fisiográfica	8	Cubrimiento total
	Carta de uso potencial, agricultura	8	Cubrimiento total
	Carta de uso potencial, ganadería	8	Cubrimiento total
	Carta de uso potencial, forestería	8	Cubrimiento total
	Carta turística	7	Segunda edición, incluye una carta a 1:250 000 en la zona centro Cubrimiento total
	Carta turística en inglés	4	Cubrimiento, 67%
1:2 000 000	Mapa de uso del suelo	1	Cubrimiento total
1:3 500 000	Mapa turístico y de carreteras	1	2 reediciones Cubrimiento total
1:4 000 000	Carta edafológica	1	Cubrimiento total Edición provisional
	Carta de uso del suelo	1	Cubrimiento total Edición definitiva
1:5 000 000	Carta geoidal	1	Cubrimiento total
Varias	Carta general de carreteras de la República Mexicana	32	Cubrimiento total Se hicieron dos reediciones
	TOTAL	170	

CUADRO 7. LEVANTAMIENTOS HIDROGRÁFICOS Y CARTAS NÁUTICAS

A. Cartas náuticas, batimétricas, de pesca, portulanos y otras

Escalas	*Tema*	*Producción hasta agosto de 1979*	*Producción, 1979-1984*		*Total a la fecha*	
			Cartas nuevas	*Revisiones*	*Por tema*	*Por escala*
Mayores que 1:50 000	Náuticas	13	24	16	37	47
	Portulanos	8	2	5	10	
1:50 000 a 1:250 000	Náuticas	2	4	3	6	7
	Pesca	1	—	—	1	
Menores que 1:250.000 hasta 1:4.000 000	Náuticas	9	4	14	13	39
	Batimétricas	—	9	—	9	
	Pesca	2	1	—	3	
	Otras	—	14	—	14	
Totales	Náuticas	24	32	33	56	Todas las escalas: 93
	Batimétricas	—	9	—	9	
	Pesca	3	1	—	4	
	Portulanos	8	2	5	10	
	Otras	—	14	—	14	
Todos los temas		35	58	38	93	

B Estudios y levantamientos hidrográficos

	Hasta agosto de 1979		*Sep. 1979-dic. 1984*		*Total*	
	Estudios	*Levantamientos*	*Estudios*	*Levantamientos*	*Estudios*	*Levantamientos*
Cantidad	13	4	50	6	63	10
Cubrimiento	—	23 722 km²	—	82 000 km²	—	105 722 km²

Levantamientos catastrales

Todas las entidades federativas continúan realizando levantamientos catastrales, especialmente en el ámbito de las capitales estatales y cabeceras municipales. En los levantamientos rurales los trabajos se desarrollan en forma coordinada con instituciones del gobierno federal, aprovechando la infraestructura cartográfica existente y generando la necesaria para fines específicos.

Durante el período 1979-1984 se llevó a cabo el levantamiento cartográfico de un total de 1 173 780 km² con presentaciones en cartas a línea a la escala de 1: 50 000 y ortofotográficas a la escala de 1: 20 000, constituyendo esta última el programa para la generación de la Carta Agraria y de Tenencia de la Tierra a Nivel Nacional. La cifra anterior, agregada a los 50 000 km² reportados en el informe a la II Conferencia, representan un cubrimiento territorial del 58,7% hasta el 31 de agosto de 1984, del cual una tercera parte se realizó durante los dos últimos años del período.

En lo que respecta al catastro urbano, las 31 entidades federativas y el Departamento del Distrito Federal cuentan con programas de producción de cartografía catastral en escalas grandes y con fines predominantemente fiscales. En varios casos se está actualizando la información conforme a las más modernas técnicas y se está dando una orientación multifinalitaria al catastro.

Mapas urbanos

Durante el período 1979-1984, la producción de cartografía en este tema se vio impulsada en razón del interés por generar información para apoyar los programas de desarrollo urbano, dentro de esquemas de elaboración sistemática correspondientes a productos uniformes en escalas y formas de presentación.

Se elaboró solamente una carta en la escala de 1:5 000 y 785 productos se realizaron en la escala de 1:10 000, de los cuales 272 corresponden a cartas a línea, 250 a ortofotomapas y 263 a mosaicos fotográficos semirrectificados.

En la escala de 1:20 000 se elaboraron 8 cartas a línea y 8 ortofotomapas. En el conjunto, la producción de cartografía urbana durante el período comprende la elaboración de 802 unidades cartográficas que involucran a 220 distintas localidades y áreas urbanas.

Cartografía censal

A partir de 1979 se iniciaron los trabajos de elaboración de la cartografía censal, necesaria para apoyar el levantamiento de los X Censo de Población y Vivienda 1980, VI Censo Agrícola, Ganadero y Ejidal y los Censos Económicos. Estos trabajos quedaron plasmados en el Marco Geoestadístico y otros productos cartográficos, representados por un total de 27 640 mapas en diversas escalas y con diferentes tipos de cubrimiento, como puede observarse en el cuadro 8 y la figura 27, referida esta última a los cubrimientos en las escalas de 1:50 000 y 1:100 000.

Cuadro 8. Cartografía censal

Escalas	*Denominación*	*Mapas*	*Tipo de cubrimiento*
1:2 500 000	Marco geoestadístico	1	Nacional
1:1 000 000	Marco geoestadístico	4	Nacional
1:250 000	Marco geoestadístico	121	Nacional
1:100 000	Marco geoestadístico	262	Regional, ver figura 27
1:50 000	Marco geoestadístico	1 739	Regional, ver figura 27
1:50 000 y 1:100 000	Áreas geoestadísticas básicas rurales	21 000	Subregional
1:5 000 y 1:10 000	Planos urbanos	2 081	Urbano
Escalas variables	Condensados estatales	32	Estatal
	Croquis municipales	2 400	Municipal
	TOTAL	27 640	

Atlas nacionales y regionales

Durante el período que comprende este informe, se elaboraron seis Atlas nacionales, conforme se indica a continuación:

a) *Atlas Nacional del Medio Físico.* Comprende la presentación cartográfica de 11 distintos temas a la escala de 1:1 000 000 con ocho cartas para cada tema, una carta geográfica a la escala de 1:5 000 000 y un Nomenclátor Nacional.

b) *Atlas Carta de México Topográfica.* Comprende la integración en un solo volumen de las 121 cartas de la serie topográfica a la escala de 1:250 000, más una carta índice a la escala de 1:5 000 000.

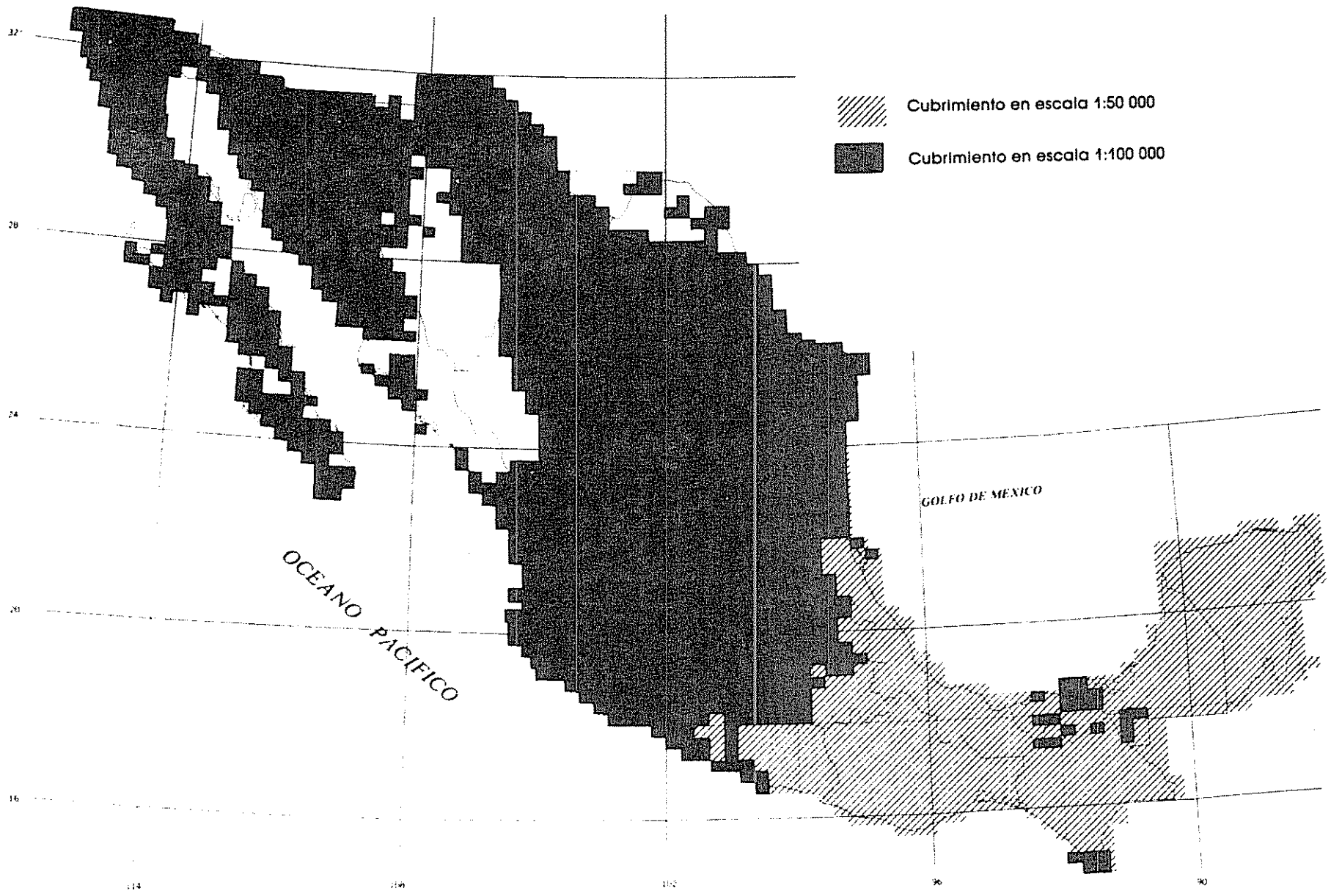
c) *Atlas Cartográfico Histórico.* Presenta la evolución de la cartografía mexicana en 10 tipos de mapas, con información de los siglos XVI al XX.

d) *Atlas de Carreteras por Entidades.* Quinta edición, con 32 cartas estatales a diversas escalas.

e) *Atlas Urbano de la República Mexicana.* Primera edición. La información se presenta por entidad federativa con 39 mapas de diversas escalas y ocho del área metropolitana de la Ciudad de México a la escala de 1:25 000.

f) *Atlas de Uso del Suelo.* Segunda edición. Contiene información por estados con cartas a la escala de 1:100 000 e información adicional sobre topografía, fisiografía, climas y tipos de vegetación.

Figura 27. México: Cartografía censal



Cartografía automatizada, banco de datos y cartografía computarizada

En estos aspectos, el desarrollo durante el período se ha caracterizado por una intensa labor de estudio e investigación que en algunos casos ha permitido generar sistemas operables. En lo que respecta a cartografía automatizada, se desarrolló un Sistema Integral de Cartografía Automatizada para la producción de mapas en forma automática, y el Proyecto de Cartografía Temática Automatizada, lo que posteriormente desembocó en el desarrollo del Sistema Integral de Tratamiento Gráfico para el diseño, manejo, producción, transferencia y tratamiento de información, gráfica en general y geográfica en particular, mediante el procesamiento digital de datos.

Se elaboró una Carta de Uso del Suelo y Vegetación a la escala de 1:250 000 a partir de información de satélite, como prueba de los programas elaborados para tal fin. En este mismo tema y como parte del desarrollo de teorías para la generación de unidades integradas, se trabajó en el Sistema de Interpretación Automática de Imágenes de Satélite, el cual se ha hecho operable para la evaluación territorial en cuanto a uso actual del suelo, con un cubrimiento a la fecha de 500 000 km^2.

Las investigaciones en el campo de la teledetección se han concentrado en diversos proyectos, dentro de los que se cuentan la detección de áreas de cultivo, delimitación y cuantificación de áreas urbanas, procesos de desertificación y mantos de algas marinas, dinámica de zonas costeras y monitoreo forestal, este último en etapa operativa total.

Las actividades en el campo de la formación de bancos de datos han permitido la implantación en forma operable de los Bancos de Datos Geodésico, de Información Climatológica, del Catálogo de Localidades y del Sistema Recuperador de Información Geográfica, este último como parte operativa de un sistema de información general, además de otros bancos en proceso de desarrollo.

Por lo que se refiere a cartografía computarizada, se continuó trabajando en el desarrollo de sistemas y programas para la generación de cartografía temática, implementando procesos computarizados de apoyo en algunas fases de la producción.

Otros productos

Dentro de este rubro se incluyen algunos productos que por su naturaleza no pueden ser ubicados con facilidad dentro del marco de los diversos temas tratados en este informe. Se elaboraron cuatro guías turísticas estatales, y una de una capital federativa, con información cartográfica incluida.

Se produjeron 16 Síntesis de Información Geográfica Estatal, documentos que, en general, tienen características de atlas regionales. Contienen información documental y cartográfica en escalas variables de 1:50 000 a 1:1 000 000 sobre 13 diferentes temas de geografía física y económica. Cada síntesis se refiere a un estado y va acompañada con un anexo cartográfico y un nomenclátor estatal. Con los 16 documentos elaborados en el período se tiene un cubrimiento por estados del 50%.

Por otra parte, se han desarrollado actividades de coordinación, normatividad y evaluación respecto a la producción nacional de información cartográfica, como resultado de la promulgación de la Ley de Información Estadística y Geográfica en diciembre de 1980. Dentro de los aspectos de normatividad técnica, se han elaborado las Normas para Levantamientos Aerofotográficos, Geodesia y Cartografía Topográfica y se encuentran en proceso los de Fotogrametría.

Asistencia técnica

La asistencia técnica a que se refiere este informe incluye, además de la asistencia propiamente dicha, los aspectos educativos y la realización de cursos y eventos relacionados con la cartografía y ciencias de la tierra.

En términos de asistencia técnica, ésta ha involucrado fundamentalmente a las instituciones oficiales que para el desarrollo de sus actividades requieren de la generación o uso de información geográfica. Con más de 20 de estas instituciones se han celebrado acuerdos o convenios en los aspectos de transferencia e intercambio de información, asesoría, proporcionamiento de servicios, elaboración de dictámenes técnicos y desarrollo de programas.

En el aspecto educativo, durante el período 1979–1984 se observó un notable incremento en el número de profesionales y técnicos egresados en relación con el período anterior (véase cuadro 9). De 20 instituciones de educación superior, egresaron 3 264 profesionales en ocho distintas ramas, en tanto que 32 planteles de educación técnica media produjeron 403 técnicos en diversas disciplinas de aplicación.

Por lo que respecta a cursos de capacitación a nivel nacional, se impartieron un total de 53, con 866 participantes, dentro de los que se incluye a 17 especialistas de diversas partes del mundo. Por otra parte, 12 personas asistieron a seis cursos internacionales de alta especialidad.

Durante el período se celebraron 25 eventos nacionales del tipo de seminarios, congresos y conferencias, y se asistió, con 54 participantes, a 35 eventos internacionales.

Cuadro 9 Asistencia técnica

Educación

Carrera	*1979*	*1979–1984*	*Total*
Ing topógrafo	[a]	556	556+
Ing topógrafo-geodesta	243	881	1 124
Ing topógrafo-fotogrametrista	153	274	427
Ing topógrafo-hidrólogo	[a]	221	221+
Ing topógrafo-hidrógrafo	[a]	281	281+
Ing geofísico	[a]	197	197+
Ing geógrafo	[a]	203	203+
Lic en geografía . . .	225	651	876
Técnico (varias especialidades)	[a]	403	403+
Total	621+	3 667	4 288+

Cursos

Nacionales		*Internacionales*	
1979	*1979–1984*	*1979*	*1979–1984*
130	53	6	6

Eventos

Nacionales		*Internacionales*	
1979	*1979–1984*	*1979*	*1979–1984*
[a]	25	25	35

[a] No reportado anteriormente

NATIONAL REPORT ON CARTOGRAPHIC ACTIVITIES*

Paper submitted by Nepal

Nepal is a developing country, with an area of 147,181 km^2 and a population of 16.5 million. It is an agricultural country where 95 per cent of the population earn their living directly or indirectly from the land.

For development purposes Nepal has been divided into five regions, namely, eastern, central, western, mid-western, and far western in order to provide equal opportunities to the people to have equal shares of the fruits of development. Each region has launched various plans and programmes, social and economic. Therefore there is great demand for surveys and maps to execute various kinds of projects efficiently.

To meet the demand for surveys and maps the Government of Nepal has established a Survey Department under the Land Reform Ministry as a central organization for all mapping services within the country. It has three Survey branches, namely (*a*) the Geodetic Survey Branch; (*b*) the Cadastral Survey Branch; and (*c*) the Topographical Survey Branch, which includes a training institute, the Survey Training Centre.

Geodetic survey

During the 1960s second-order triangulation points in Nepal were established, with the co-operation of the Survey of India under the Colombo Plan, for preparation of maps at the scale of 1"/1 mile.

With the further development of geodetic survey activities, in the 1970s 7 Laplace stations, 14 azimuth stations, 19 Doppler stations as well as a baseline were established.

The existing second-order triangulation points are being broken down to provide lower-order ground control points for different types of large-scale mapping. First-order triangulation is being carried out with the co-operation of the British Army Survey. There is also a plan to adjust the existing second-order control points after completion of first-order triangulation. The first-order triangulation network consists of 73 stations including the existing 7 Laplace stations and 14 Azimuth stations. At present, the lower-order control points, that is the fourth-order trigonometrical survey, have been completed in 18 districts and are being carried out in 11 districts out of the total 75 districts of Nepal. The progress of trigonometrical control work is also shown in figure 28.

Further, the Survey Department has a geodetic observatory situated in Katmandu Valley and a circumzenithal instrument has been installed there. Observation is mostly engaged in observation of stars for azimuth and time. Besides that, the observatory has a plan to observe groups of stars for latitude and time.

For different engineering projects bench-marks with elevations above mean sea level of different orders are in great demand. As Nepal is a land-locked country it is obvious that there is a problem in establishing sea level; but with the co-operation of the Survey of India in 1975 two precise bench-marks were established at two places: one at Birgunj and the other at Bhairahawa. Further, a request has been made to the Survey of India to establish six more precise bench-marks inside Nepalese territory near the international border between Nepal and India. Precise levelling from the existing two bench-marks along the highways of Nepal has been conducted since 1976. The progress of this levelling and location of fundamental bench-marks are shown in figure 28. The lower-order bench-marks are being provided along the minor tracks.

It is also planned to provide gravity stations at different places in Nepal, and observation is being carried out. One of these points, situated at Tribhuvan International Airport at Katmandu, had already been connected with a gravity station of Bangkok, and further there is a plan to connect again with that of Delhi (India).

Cadastral survey

In cadastral survey, the graphical method is adopted, in which plane table and telescopic Alidade are used. Three to four trigonometrical control points are plotted in each mapping sheet, and thus the plans are tied with the national frame-work. 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 sheets or districts. During field-work, land-owners and farmer tenants are identified, land is classified and the correct area of parcels is determined. Then ownership certificates are issued to the owner as a security to their right of property. There are nine field survey parties, each consisting of about 140 personnel who perform the above-mentioned tasks. Photogrammetric compilation for producing a cadastral plan is not feasible in Nepal, since the average size of parcels is less than a hectare.

Districts where cadastral survey has been completed are included in the cadastral system with the Maintenance Survey Section attached to the land revenue office of that district. The Maintenance Survey Section will update the cadastral plan during land transactions.

As the earlier cadastral plans were island-type maps of agriculture areas unconnected with the national geodetic network, it is planned to microfilm all cadastral plans and records with the assistance of the Government of the Federal Republic of Germany. This project will assist in preserving the cadastral maps, data and documents. The documents will be easily accessible and will avoid unforeseen fraudulent acts.

Even in the plain areas, in many cases dual ownership of land, owners and farmer tenants on land still exist. In the hilly and mountainous parts of Nepal, valleys are narrow and slopes are steep with full vegetation. Hence, until now traditional ground survey methods have been adopted.

Scale of cadastral plans vary between 1:500 to 1:2,500 depending upon the size of the parcel and value of the land. For example, the scale selected for Katmandu, the capital, is 1:500 because of the high value of land.

In Nepal, there are 75 districts as administrative units, and the cadastral survey of 50 districts is so far complete. The survey is in progress in 10 districts. It is planned to complete the cadastral survey of remaining districts on or before 1990. Regarding built-up areas, there are 29 towns in Nepal, out of which four towns so far have been surveyed and plans are also being prepared. The progress of cadastral survey work is shown in figure 29.

*The original text of this paper, prepared by A. B. Basnyat, Director-General of the Survey Department, appeared as document E/CONF.77/L.77.

Figure 28. Nepal: Progress in trigonometrical control work

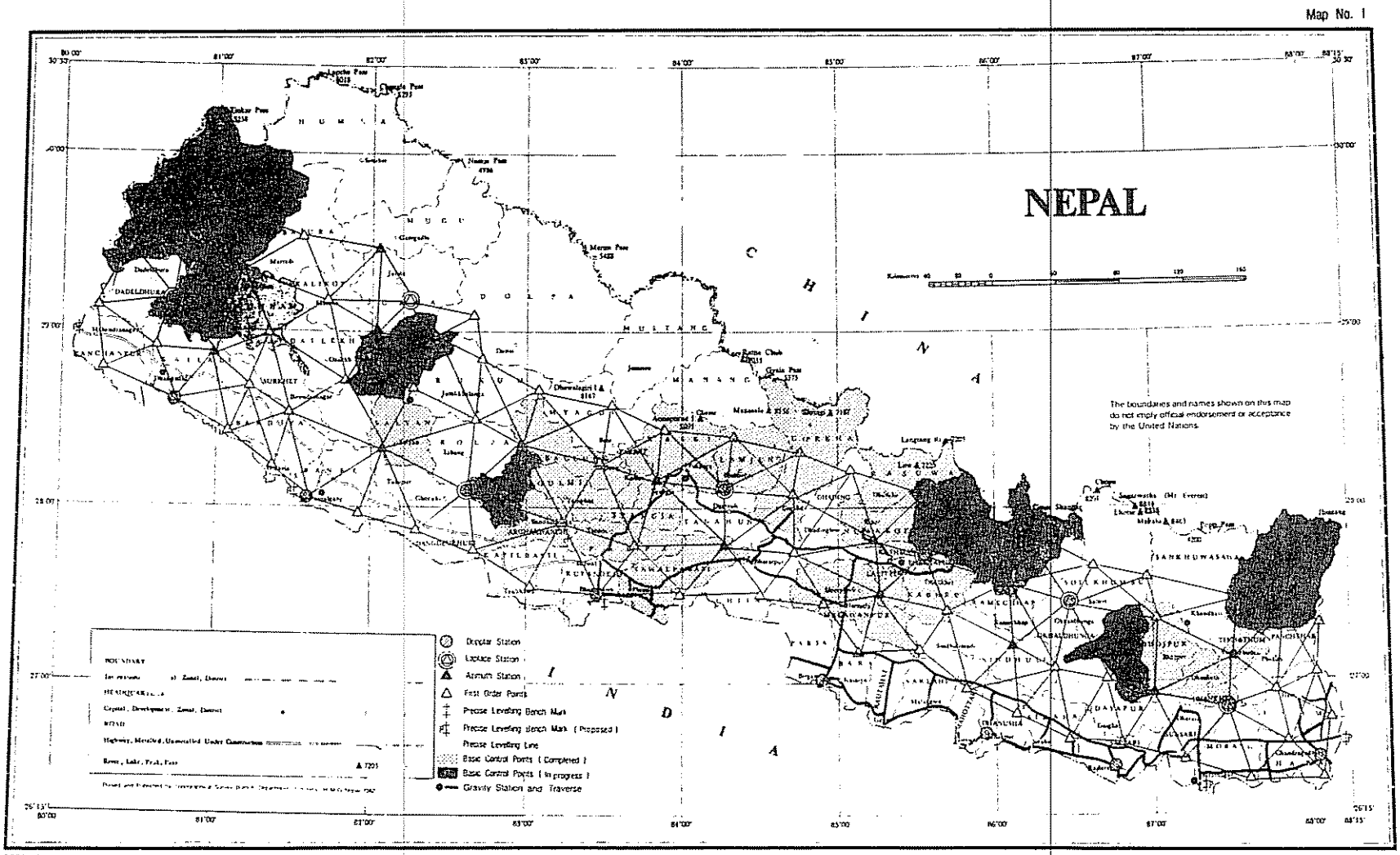
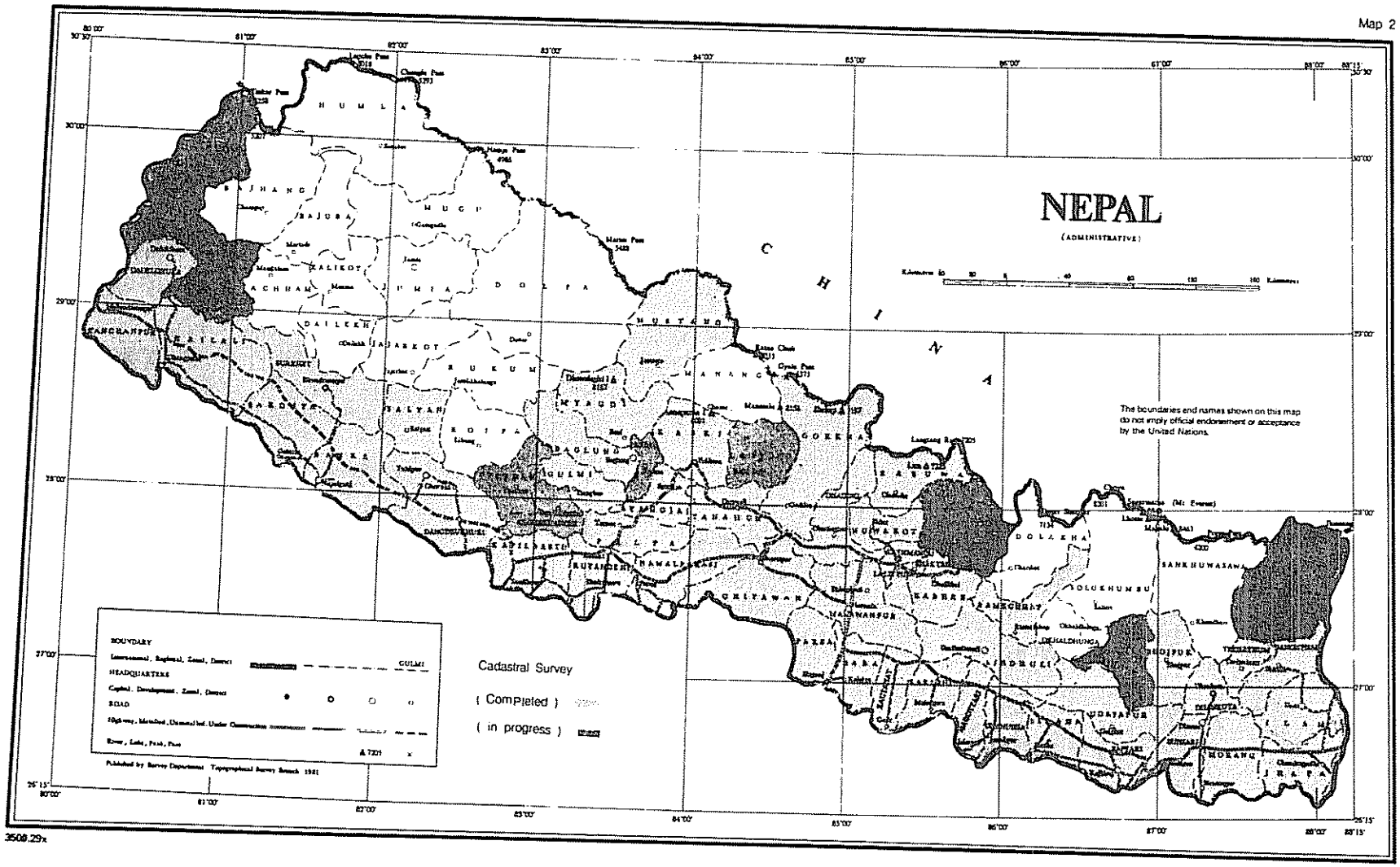


Figure 29. Nepal: Cadastral survey



TOPOGRAPHICAL SURVEY

The Topographical Survey Branch was established in 1972 with the existing Survey Department as the Topographical Survey Unit, and it was upgraded to "branch" in 1976. Assistance by the United Nations Development Programme (UNDP) started in January 1976 and continued till 1982 to procure major equipment, training of Nepalese staff and service of United Nations experts for the establishment and strengthening of the Branch.

The Branch has capability for the production of aerial photographs, map compilation by field and photogrammetric survey methods, cartographic work and map printing. The functions of the Branch also include furnishing topographic services to all agencies in the country

At present, it is equipped with mapping equipment, for example: 1 precision stereoplotter; 9 stereoplotters; 1 aerial camera Wild RG-10; 1 rectifier/enlarger; 1 process camera; a two-colour offset printing press; and other minor equipment. It has a staff of about 400, including the field survey section.

So far the Branch has published the following maps:

	Title	*Scale*	*In sheet*	*Remarks*
1	*Map of Nepal* (English and Nepali)	1:2,000,000	4	
2.	*Map of Nepal* (English)	1:1,000,000	1	Under publication
3	*Regional maps of Nepal* (Nepali and English)	1:5,000,000	10	New revised edition under publication
4	*Zonal maps of Nepal* (Nepali)	1:250,000	15	New revised edition under publication
5	*District maps of Nepal* (Nepali)	1:125,000	80	45 preliminary copy available only in ammonia prints for authorized projects
6	*Topographical map*	1:50,000	248	1"/1 mile maps are being updated and new series planned
7	*Aerial photography*	1:50,000 1:20,000	104,000 km² 61,000 km²	Only for authorized projects
8	*Large-scale maps* (Towns and project areas)	1:2,500 1:10,000	300 km² annually	Preliminary copies available only in ammonia print

Besides that, the Land Resources Survey of Nepal with the assistance of the Canadian Government is completing the production of land resources maps as required to develop the land-use policy of Nepal; related reports are also being prepared. The following monocolour maps of the entire country were produced:

	Purpose of maps	*Scale*	*In sheets*
1	*Land utilization* (present land use)	1:50,000	266
2	*Land system* (soil map)	1:50,000	266
3	*Land capability* (land potential)	1:50,000	266
4	*Geology*	1:125,000	82
5	*Climatology*	1:250,000 1:1,000,000	7 1 (under preparation)

In our view the land resources maps and the topographic maps, which are on the same format and scale, and the related data will be adequate for national, regional and local level planning as well as providing general information for the Geographic Information System (GIS) or the Land Information System (LIS).

SURVEY TRAINING CENTRE

The Survey Training Centre was established in 1968 with the main objective of producing skilled, medium and technician-level manpower.

At present the centre conducts the following training courses:

1. Amin (Recruit)
2. Junior Surveyor
3. Senior Surveyor
4. Special course on photogrammetry, cartography, geodetic observation and map reproduction.

Duration of the courses and the minimum qualifications required to enter them are tabulated below

	Course	*Duration (months)*	*Minimum qualification for entry*
1.	Amin (Recruit)	12	S.L.C. with mathematics
2	Junior Surveyor	12	Intermediate Science (I. Sc.) with math; or completed Amin course with 5 years experience in survey
3	Senior Surveyor	16	Bachelor of Science (B.Sc.) with math or Master of Arts (M.A.) Geography; or completed Junior Surveyor course with 10 years experience in survey
4	Special course	3	S.L.C. with mathematics

REMOTE SENSING

The Nepal Remote Sensing Centre is established in the Soil and Watershed Management Department. The aim of the Centre is to make available remote sensing technology to the user agencies. The Centre also conducts training programmes and seminars regarding application of remote sensing techniques to users of government agencies such as the Survey Department, the Agriculture Department, the Forest Department, etc.

CONCLUSION

The Survey Department of Nepal is generally well equipped with modern and scientific equipment, but lacks highly sophisticated computer-assisted cartographic equipment and computer-aided analytical plotters. The topographical resources, cadastral and other maps should be produced urgently in various scales and forms. Producing such maps with existing manpower and equipment is a slow process. Hence, the modernization of mapping procedures, i.e. computer-assisted mapping, has been realized as indispensable. With limited resources, the Survey Department cannot acquire such new equipment; further, after a few years the present equipment will be obsolete and spare parts for maintenance and repair, when necessary, may not be available. Technical assistance to buy computer-assisted cartographic equipment and computer-aided analytical plotters would be highly beneficial

REPORT ON MAPPING*

Paper submitted by the Republic of Korea

* The original text of this paper, prepared by the National Geographic Institute, Ministry of Construction, appeared as document E/CONF 77/L 63

The information presented, updated to 1986, may be found in *Eleventh United Nations Regional Cartographic Conference for Asia and the Far East, Bangkok, 5-16 January 1987*, vol II, *Technical Papers* (United Nations publication, Sales No E/F/S 88 I 18)

REPORT ON SURVEYING AND MAPPING**

Paper submitted by the Union of Soviet Socialist Republics

RÉSUMÉ

En Union soviétique, les activités topographiques et cartographiques sont menées sous l'égide du Conseil des ministres par l'Administration générale de géodésie et de cartographie (GUGK) par l'intermédiaire de ses organismes ou par d'autres ministères et organisations. Ces activités permettent de répondre à toutes les demandes d'informations géodésiques et topographiques présentées par les divers services de l'économie nationale à des fins scientifiques, éducatives et démographiques.

Le Service géodésique a acquis une expérience considérable en matière de coopération internationale en travaillant avec les membres du Conseil d'assistance économique mutuelle (CAEM) et avec des pays en développement. Cette coopération se fonde sur les principes de l'intérêt et de l'avantage.

Le Service géodésique est membre de l'Association cartographique internationale, de la Société internationale de photogrammétrie et télédétection, de la Fédération internationale des géomètres et d'autres organisations.

Surveying and mapping in the Union of Soviet Socialist Republics are carried out under the Council of Ministers by the General Administration of Geodesy and Cartography (GUGK), through its agencies, as well as by other ministries and organizations.

Since 1919, after the signing by V. I. Lenin of a decree establishing the Higher Geodetic Administration, surveying and mapping have aimed at development of industrial production, land resources and socialist construction. Surveying capacities have been built up to meet the needs in survey and mapping materials of the national economy, science, education and tourism.

The national geodetic services have gained considerable experience in international scientific technical and economic co-operation with members of the Council for Mutual Economic Assistance (CMEA) and developing countries. This co-operation is based on principles of mutual interest and profit. Soviet surveyors and cartographers are active in Afganistan, Angola, Cuba, Democratic Republic of Yemen, Ethiopia, Lao People's Democratic Republic, Mongolia, Mozambique, and other countries often working together with colleagues of these countries. While performing surveys in the field they train personnel of local survey organizations; such surveys include production of topographic maps at different scales for the entire territory of the country or for separate regions, town surveys, thematic maps based on space photography and other works.

GUGK is a member of the following international nongovernmental organizations: International Cartographic Association, International Society of Photogrammetry and Remote Sensing, International Federation of Surveyors and others. In September and October 1983 the United Nations International Course on Thematic Mapping was held in the USSR.

Land resources inventory and air survey

Space imagery is a great contribution to USSR land resources inventory and mapping with MKF-6 and KATE-140 cameras, scale 1:1,000,000-1:2,500,000. It is widely used in studies of the bowels of the earth and geological mapping. A number of important practical results has been achieved. Purposeful interpretation of space imagery permitted the location of a number of promising regions for oil and gas prospecting. The structures located by means of space imagery were confirmed by geological and geophysical data, as well as by drilling operations.

The use of space imagery for mapping aimed at planning engineering constructions has proved practical. The Berkakite-Yakutsk railway planning was done using space-imagery thus saving 10 per cent of the cost of prospecting.

The use of space imagery is an efficient way to study land resources and to estimate agricultural resources. It was used for land conservation and land reclamation purposes.

** The original text of this paper appeared as document E/CONF 77/L 60.

The work permitted location of zones of high erosion and sites of avalanche and land-slide hazards. Palaeo-valleys of rivers were traced for fresh underground water prospecting using space imagery. The method proved to be trustworthy after drilling operations.

Space imagery is widely used in forestry: a photostatistic method is successfully applied, based on the use of spectrozonal and multiband imagery. Space imagery is used for forest inventory to estimate variations of forest resources, as well as for forest inventory in *taiga* zones.

Experience gained by Soviet specialists proved the worth of a multilateral complex use of space imagery and a compilation of conjugate thematic maps based on it. Such work has been done for the territory of the USSR, and together with Mongolian colleagues for the territory of the Mongolian People's Republic in accordance with an agreement on economic co-operation.

A large amount of small-scale topographic map production is done at present using space imagery. The main technological versions are performed using standard photogrammetric equipment.

Space imagery is also used for small-scale mapping of shoals.

To increase the efficiency of applying space imagery in the national economy, new instruments and technologies have been developed, aimed at automatization of space images processing and compilation of cartographic products as well as developing new types of intermediate and final products.

A new technique of producing coloured and black-and-white orthophoto-plans using ES computers has been mastered. It is applied via digital terrain models and back to a rectified image. Methods of digital primary space imagery correction have been developed, thus providing efficient ways for further processing.

Methods and software for automated interpretation of multiband space imagery have been developed that are now used for complex inventory and mapping of land resources.

In 1982-1983, remote sensing from automated interplanetary stations (AIS) were used to map the surface of Venus. Cartographic data were obtained from landing modules of the Venus-13 and Venus-14 AIS and from orbiting modules of Venus-15 and Venus-16 AIS.

Large-scale photo-plans on scale 1:20 were made for landing sites of the Venus-13 and 14 modules, using the obtained survey data. A computer-aided method with an image input-output system was used.

A continuous radar survey of the northern Venus areas with resolving power of 1.5 to 2 kilometres was done, starting from November 1983. Radar mapping equipment includes a side-looking radar and a radio altimeter. Each orbital loop provides a radar panorama of about 100 × 7,000 km, with a radio profile along the module orbital route. The scale of 1:5,000,000 was chosen to map the Venus surface, taking into account the resolution of the radar survey and the ability to interpret the data. The entire Venus surface was divided into 90 sheets. A stereographic projection was chosen for the northern and southern polar regions; for the medium latitudes the Lambert-Gauss projection was chosen, and the Mercator projection for the equatorial belt.

Air survey for map compilation in the USSR is done from aeroplanes and helicopters by domestic-made cameras with various focal lengths. The scale of a photo-image is usually two to five times smaller than that of a map (a plan).

To make a photo-plan and to plot topography by a stereomodel a photogrammetric control is developed, usually by means of analytical block photo triangulation, using ES computers.

Map originals are compiled using home-made plotters-stereographers.

Digital methods of terrain representation: digital terrain models are being developed for automatization of surveys.

A computer operated system for large-scale map compilation was developed in the USSR. It includes a complex of technologies and software for topographic map production of settlements including towns, industrial sites and so on. Taking into account modern requirements for computer-aided map production, a system of codes and symbols for topographic maps at scales 1:500-1:5,000 is being completed. It has been successfully tested and now is being gradually introduced into map production.

The amount of large scale survey (1:500-1:10,000) is increasing in the USSR to satisfy the needs of towns and settlements, land reclamation, agriculture, large industrial and agricultural objects, mineral excavation and construction. At the same time 1:10,000 and smaller-scale map revision is being done. Methods and technology of surveys are based on valid instructions and guide-books, which include all types of surveying work.

Cartography

Cartographic products such as maps, atlases etc. are published in the USSR in large numbers. About 600-700 titles of cartographic products are prepared for publication annually.

Work in computer-aided cartography is under way. Software for map compilation and generalization is being developed.

Tools for mechanization of draft and compilation work have been improved; scribing instruments are successfully and widely used.

In co-operation with Bulgarian colleagues, technology has been developed and mass plastic globe production has been started.

Methods for multicoloured polygraph printing of photo-maps and photo-images were elaborated.

Reference and information atlases are very popular among users, and they are published in large numbers. Among them the *Complex Atlas of the USSR* can be remarked; aimed at a wide circle of users, it contains systematic information about the whole country and its separate provinces.

Series of regional geographic atlases of Ukraine and Moldavia (1983), the Baltic republics (1983), Siberia and the Far East (1984) and others have been issued since 1983.

Production of small-size geographical atlases (7 × 9 5 cm) has been started.

A new (second) edition of the *World Political Atlas*, containing 350 pages of maps and references, was published in 1983.

The most important trend in thematic mapping is the production of maps of large territorial-industrial complexes and separate provinces of the country (Kansk-Achinsk power-station complex; Baykal-Amur railway; non-black-earth zone of the RSFSR); as well as maps concerned in the realization of the Food Production Programme (soil maps of the USSR and provinces, maps of agro-industrial complexes).

The new map series for high schools was started at the end of the 1970s and the beginning of the 1980s. The first

maps of the series were published, among them the *Orographic and Soil Map of the World*, scale 1:15,000,000; *Transport Network of the USSR*, scale 1:4,000,000; *The European Socialist Countries*, scale 1:1,000,000

To meet the requirements of schools for educational maps, including those in the native languages of various peoples of the USSR, production of screen-demonstration maps (transparent maps) was started, plastic globes of different thematic content are being produced, and the number of published maps is increased. More tourist maps are published. Studies of users' demands for tourist maps show that within 5-10 years new types of tourist maps must be produced along with schemas for certain types of tourism; among them mountain tourism and hiking are of primary importance.

In the USSR work on standardization of geographical names and instructions for Russian transliteration of national geographic names of Soviet socialist republics and autonomous republics and instructions for Russian transliteration of geographical names of foreign countries and dictionaries of geographical names of foreign countries are in constant production. According to legislation valid in the USSR such instructions and dictionaries are examined by an Interdepartmental Commission on Geographical Names and are approved by GUGK as documents of national importance; they are obligatory for all ministries and departments, organizations and agencies of the USSR.

Computer-aided methods are developed for this work also.

Geodesy

The USSR astro-geodetic network is a uniform reference base of co-ordinates and altitudes. Its density and precision meet requirements for mapping, construction, agriculture and science.

The work on modernization of the State levelling network continues. It is aimed at uniform coverage of the national territory with levelling control. Repeated levelling is performed systematically. The obtained data are used to estimate vertical Earth crustal movements. A map of contemporary Earth crustal movements is being compiled, based on geodetic data.

Geodetic work on the Earth's crustal deformations is being further developed in order to study the tectonic and anthropogeneous crustal movements for initiation of earthquake forecasts. Geodetic observations are performed in cooperation with the USSR Academy of Science on special test-sites established in active seismic zones of the country.

To increase the efficiency of geodetic operations and to promote precision of astro-geodetic control, a serial production of electronic range-finders of "Granat" (accuracy $\pm 5 + 2.10^{-6}D$) and radio-wave range-finder "Trap" (accuracy $\pm 3 + 3.10^{-6}D$) was started.

A uniform approach is used to map underwater and ground features when making maps of sea-shelf, lake-bottoms, water reservoirs and rivers. The same accuracy is achieved in plotting underwater features and subsurface topography. The most efficient instruments and technologies are used.

The GUGK agencies work on development of geodetic control, and topographic mapping, including sea-shelf and underwater areas, surveying of underwater communication lines, location of surface and subsurface facilities and construction, mainly for oil.

The USSR Geodetic Survey will continue and develop international scientific/technological and economic cooperation.

REPORT ON CARTOGRAPHIC ACTIVITIES*

Paper submitted by the United States of America

RÉSUMÉ

...uis la deuxième Conférence cartographique régionale ...s Nations Unies pour l'Amérique, tenue en 1979, les activités cartographiques des Etats-Unis ont consisté aussi bien à poursuivre la collecte et la gestion des données planimétriques et altimétriques qu'à perfectionner l'utilisation des techniques informatiques, de la télédétection et des systèmes de localisation par inertie et par satellite dans les programmes de levés et d'établissement des cartes.

De septembre 1979 à septembre 1984 — période sur laquelle porte ce rapport — la mise au point et l'introduction de nouvelles techniques cartographiques automatisées et du matériel qui s'y rapporte ont influencé profondément toutes les opérations de cartographie aux Etats-Unis. Les ordinateurs ont été utilisés notamment pour établir, réviser, conserver et produire des cartes topographiques, des orthophotocartes, des photocartes et des cartes aéronautiques et marines.

RESUMEN

Desde la Segunda Conferencia Cartográfica Regional de las Naciones Unidas para América, celebrada en 1979, las actividades cartográficas de los Estados Unidos han abarcado desde la continuación de la reunión y la conservación de datos horizontales y verticales, hasta la aplicación de los adelantos en la tecnología de las computadoras, la teleobservación y los sistemas de determinación de posición inercial y por satélite en apoyo de los programas de levantamientos cartográficos.

En el período que abarca el presente informe, de septiembre de 1979 a septiembre de 1984, han influido en todas las fases de la elaboración de mapas y cartas en los Estados Unidos los continuos adelantos registrados en las técnicas y equipos de cartografía automatizada y los progresos en su aplicación. En los Estados Unidos, la aplicación de las computadoras a los problemas cartográficos ha abarcado la recopilación, revisión, conservación y elaboración de mapas topográficos, ortofotográficos y de imagen, así como de cartas aeronáuticas y náuticas.

Los adelantos registrados en los últimos cinco años en la tecnología de las computadoras, así como la disponibilidad de grandes cantidades de mapas y cartas terminados, han

* The original text of this paper appeared as document E/CONF.77/L.26. Use of trade names and trademarks is for identification purposes only and does not imply endorsement by the Government of the United States.

Les progrès accomplis en informatique au cours des cinq dernières années et la disponibilité d'un grand nombre de cartes achevées ont incité les services cartographiques fédéraux à consacrer plus d'efforts à la constitution de bases de données numériques dans les catégories utiles en géologie, pédologie, hydrologie et étude de l'occupation des sols.

Le Service géologique des Etats-Unis (USGS), dans le cadre du programme national de cartographie, est responsable de l'établissement et de la diffusion de cartes à buts multiples et de données cartographiques de base. La Division nationale de cartographie du Service géologique des Etats-Unis s'intéresse surtout aux données de base reportées sur les cartes topographiques (relief, réseaux hydrographiques et systèmes de transports). D'autres organismes fédéraux et d'autres divisions du Service géologique des Etats-Unis sont chargés de réunir d'autres données cartographiques d'intérêt général. Le Service océanographique national (NOS) a la responsabilité des levés géodésiques et de l'établissement de cartes aéronautiques et marines. La Defense Mapping Agency (DMA) établit des cartes répondant aux besoins de la défense nationale dans le monde entier.

Les activités menées au cours de la période considérée par les principaux organismes fédéraux s'occupant de cartographie sont examinées sous les rubriques suivantes :

a) Géodésie;
b) Photocartes;
c) Cartes topographiques;
d) Hydrographie et océanographie;
e) Cartes aéronautiques;
f) Noms géographiques;
g) Cartographie numérique.

impulsado a los organismos cartográficos federales a intensificar sus esfuerzos para establecer bases de datos digitales de categorías útiles en los estudios de geología, suelos, hidrología, usos de la tierra y condición de la superficie terrestre.

El Servicio Geológico de los Estados Unidos (USGS), mediante el Programa Nacional de Cartografía, está encargado en el plano interno de elaborar mapas de finalidad múltiple y datos cartográficos fundamentales, y de ponerlos a disposición de los usuarios. La División Nacional de Cartografía (NMD) del Servicio centra sus actividades en los datos de categoría básica que se encuentran en los mapas topográficos, como los datos sobre los sistemas hipsográficos, hidrográficos y de transporte. Otros organismos federales y otras divisiones del Servicio Geológico se encargan de la reunión de datos adicionales que sean de interés público para los mapas. El Servicio Oceanográfico Nacional (NOS) tiene a su cargo los levantamientos geodésicos y la preparación de cartas aeronáuticas y náuticas. La Agencia de Cartografía para la Defensa (DMA) está encargada de elaborar, en el plano mundial, los mapas y cartas necesarios para los fines de la defensa nacional.

En el examen de las actividades de estos organismos federales básicos de levantamiento cartográfico de los Estados Unidos durante el período a que se refiere el presente informe se ha utilizado la siguiente clasificación:

a) Geodesia;
b) Cartografía de imágenes;
c) Cartografía topográfica;
d) Hidrografía y oceanografía;
e) Cartografía aeronáutica;
f) Nombres geográficos;
g) Cartografía digital.

Since the Second United Nations Regional Cartographic Conference of the Americas was held in 1979, the scope of cartographic activities in the United States has ranged from the continuation of horizontal and vertical data collection and maintenance to advances in the use of computer technology, remote sensing and inertial and satellite positioning systems in support of surveying and mapping programmes.

Throughout the period of the present report, September 1979 to September 1984, all phases of mapping and charting in the United States have been significantly influenced by the continued development and implementation of automated cartographic techniques and equipment. The application of computers to cartographic problems in the United States has included compilation, revision, maintenance and production of topographic, orthophoto, and image maps and aeronautical and nautical charts.

Advances in computer technology over the last five years, coupled with the availability of large amounts of finished mapping and charting, have prompted Federal mapping and charting agencies to increase their efforts to build digital data bases of categories that are useful to the study of geology, soils, hydrology, land use and land cover.

The United States Geological Survey (USGS), through the National Mapping Program, has the domestic responsibility for preparing and making available multipurpose maps and fundamental cartographic data. The National Mapping Division (NMD) of USGS has concentrated its efforts on base category data as found on topographic maps, such as hypsography, hydrography and transportation systems. Other Federal agencies and other USGS divisions are responsible for collecting additional map data of public value. The National Ocean Service (NOS) is charged with responsibility for geodetic surveys and for the preparation of aeronautical and nautical charts. The Defense Mapping Agency (DMA) is responsible for maps and charts on a worldwide basis to meet national defense requirements.

The activities of these primary Federal agencies concerned with mapping and charting in the United States during the reporting period are discussed under the following categories:

Geodesy
Image mapping
Topographic mapping
Hydrography and oceanography
Aeronautical charting
Geographic names
Digital cartography

Geodesy

The United States continues to support technological investigations covering a broad spectrum of geodetic disci-

plines, including the preparation for acquisition of radar altimeter data from GEOSAT, scheduled to be launched in early 1985. This will contribute significantly to the upgrading of the geoidal model over the ocean areas of the world.

Along with the satellite radar altimetry development, the United States has continued efforts in satellite-to-satellite tracking, having developed a Global Positioning System (GPS) receiver for use aboard LANDSAT. The GPS receiver will provide an enhanced capability for positioning to high accuracy in three dimensions.

The National Geodetic Reference System (NGRS) is established and maintained by the NOAA National Geodetic Survey Division. In 1984 significant progress was made in the readjustments of the horizontal and vertical networks, development of new horizontal positioning techniques using GPS, new levelling techniques, and in monitoring the effects of crustal motion.

Global Positioning System

Development of a geodetic receiver using the NAVSTAR GPS began in 1982, in a joint effort by the USGS, DMA, and the National Geodetic Survey (NGS). The GPS is a navigation system that, when fully operational in the late 1980s, will consist of a constellation of 18 satellites, providing world-wide all-weather satellite navigation and positioning capabilities. There will be three satellites in each of six evenly spaced orbital planes, arranged so that four to seven satellites will be visible from anywhere on the Earth's surface at any given time. Currently, 6 of the 18 satellites are operational, confining usage to 6-8 hours per day for a given Earth location.

The geodetic technique is based on simultaneous signal readings from the multiple satellites. Improved techniques and equipment result in accuracy on the order of centimetre positioning and fractional-knot velocity measurement. Use of GPS to obtain geodetic positional data will require less time and effort than is now needed for current field data collection methods.

Testing of the production prototype GPS geodetic receiver (GEOSTAR TI-4100) is under way. These instruments will be used to exploit the GPS system as a full replacement for the NAVSAT system by the late 1980s.

Sophisticated software is being used to conduct extensive sensitivity analyses regarding GPS error sources as they relate to point positioning and the process of ephemerides determination.

Three GPS tracking stations collocated with TRANET stations continue to collect data that are being used to support a variety of tests concerning the development of a GPS precise ephemerides capability at DMA's Hydrographic/Topographic Center. A fourth station has been established in Argentina. These four DMA stations, plus data from the United States Air Force monitor stations, will be used until the permanent Air Force monitoring stations are in place.

Under the auspices of the Federal Geodetic Control Committee (FGCC), NGS, in co-operation with other Federal, state, and local agencies, completed a test along level lines in two subsiding basins in Arizona that demonstrated the ability of GPS instrumentation to monitor elevation changes to an accuracy of 1 to 2 cm.

Horizontal control network

The readjustment of the North American Datum of 1983 (NAD-83) project continued in close co-operation with the Geodetic Survey of Canada. Formal meetings have been held and regular progress reports and data exchanges are made to ensure compatibility within the datum. A final list of junction stations has been accepted by Canada and the United States.

Block validation of the horizontal control network is a current major activity. This activity consists of the systematic analysis of the network, partitioned into 843 blocks, each containing approximately 300 stations. The block validation process combines all horizontal survey data within a predefined area, and edits the data by removing duplicate information, adding missing data, and resolving inconsistent data. Validated blocks are loaded into the NGS data base when completed. Validation began in July 1982; 608 blocks have been completed, and completion is scheduled in 1984.

Helmert blocking adjustment is used for the simultaneous adjustment of horizontal observations of an extremely large system of equations. To date, activities have centred around software development. However, the entire network in Alaska was successfully adjusted using the new software to furnish a consistent set of preliminary NAD-83 co-ordinates for a major USGS mapping project. The adjustment was the largest ever completed by NGS. The Alaska horizontal network, composed of 23,874 stations and 134,869 terrestrial and 534 Doppler observations, was divided into 17 first-level blocks. The adjustment had 59,610 degrees of freedom and a variance of unit weight of 2.39.

A total of 20 NOS control survey projects comprising 572 stations in 7 states and 39 projects completed by other Federal, state, and private surveying agencies containing 5,030 stations in 14 states were received in fiscal year 1984 for incorporation into the NGRS. The processing of new field projects for inclusion into the NGRS on the North American Datum of 1927 was discontinued in August 1982 to fix the NGRS data for the NAD readjustment. All observational data received before June 1981 will be included in the readjustment of the NAD-83. Data received after this date will be processed after the NAD-83 readjustment has been completed.

Co-operative efforts to provide first-order coverage using classical methods continued with the States of Connecticut and South Carolina. Co-operative GPS surveys were completed in Summit and Franklin Counties, Ohio; Fort Stewart, Georgia; Jackson, Mississippi; Phoenix, Arizona; and in Mississippi along the Mississippi River.

Transfer of technology to state, county, and private surveyors and engineers is becoming an increasingly important activity within NGS. A 3-day surveying instrumentation and co-ordinate computation workshop, a 1-day workshop on state plane co-ordinates, and a 1-day co-ordinate transformation workshop were presented through co-sponsorship with the American Congress on Surveying and Mapping.

Vertical control network

The NGS adjustment of the North American Vertical Datum of 1988 continued in close co-operation with DMA and counterparts in Canada and Mexico, the Geodetic Survey of Canada, and Dirección General de Geografía del Territorio Nacional. Formal notice of the designation of the new datum was published in the Federal Register in November 1983, and stated in part: "The new Datum shall be known as the North American Vertical Datum of 1988", and will be referred to as "NAVD of 1988, or NAVD-88". The North American Vertical Datum of 1988 will replace the present Datum of 1929, "also called 'NGVD of 1929' or 'NGVD 29'. . . Completion is scheduled for 1988. Until then, the published height values will continue to be referenced to the National Geodetic Vertical Datum of 1929".

NGS VERTICAL CONTROL PRODUCTION SUMMARY

	Fiscal year 1984	*Total to date*	*Programme total (completion date)*
Vertical control points positioned	156.200	514.800	514,800 (May 1984)
Historic observation data merged with publication file (number of points)	205.400	615.000	615,000 (June 1984)
New field surveys performed (km)	9.900	51.100	100,000 (1987)
Provisional (analytic) adjustments performed (number of points)	47,900	114,000	615,000 (1987)

NGRS was strengthened through agency-funded, Federal Geodetic Control Committee and NAVD field survey projects. The levelling surveys were accomplished primarily by nine NGS field units, North Carolina Geodetic Survey, South Carolina Geodetic Survey, and Florida Department of Natural Resources and Transportation.

Co-operative surveys involving NGS field and office personnel included (co-operating organizations in parenthesis):

Coalinga, California, earthquake evaluation; Idaho earthquake evaluation; and California fault zone monitoring projects (USGS)

Wasatch fault zone, Utah, crustal deformation study (USGS and Boise State University)

Vertical control survey along Mississippi River levees south of Memphis, Tennessee (Corps of Engineers)

St. Mary's River relevelling project to support the International Great Lakes Datum (Corps of Engineers and National Ocean Service)

Connection of Dauphin Island, Alabama, tide station and Lake Champlain, Vermont, water-level station to (NGRS and NOS)

Vertical control survey along Atlantic Ocean coastline between Duck, North Carolina, and Virginia Beach, Virginia (North Carolina Geodetic Survey)

Denver Front Range relevelling project to assess subsidence (United States Army and various county and city governments in Colorado)

Connecticut vertical control project (State of Connecticut)

Technology transfer and preservation of vertical control points in Rhode Island (State of Rhode Island)

South-eastern Louisiana relevelling project to monitor subsidence (Louisiana parishes)

Houston-Galveston (Texas) regional subsidence monitoring project (Harris-Galveston Coastal Subsidence District)

Vertical control monumentation and connection to NGRS (Georgetown University, Washington, D.C.)

Additional progress was made to account for atmospheric refraction error in geodetic measurement. The final analysis of the 1981 USGS-NGS Saugus to Palmdale, California, levelling refraction test was completed, and published in NOAA Technical Report NOS-98 NGS-27. A magnetic calibration test facility is operational at the NGS facility, Corbin, Virginia. Most of NGS's compensator (automatic) levelling instruments have been calibrated at this facility. The influence of DC-induced magnetic fields (the Earth's geomagnetic field) on NGS compensator levelling instruments is now well understood. The effect of AC-induced magnetic fields (those associated with large electric generator/transporter systems) is still poorly understood and undergoing further evaluation. When the magnetic calibration of all NGS compensator instruments is completed, the NGS facility will be available to calibrate other organizations' compensator instruments.

Increased efficiency in field levelling is being evaluated in two ways. The first involves a field test of existing off-the-shelf total-station instrumentation to determine if first-order levelling can be efficiently performed using a high-accuracy trigonometic levelling technique. Field tests using specially modified compact trucks are under way along existing lines of levelling near Corbin, Virginia, to evaluate field accuracy/progress of such a system. Results should be available this autumn. The second involves an international co-operative effort under the direction of NOS personnel to develop new instrumentation specifically designed to maximize productivity. A feasibility study is under way to determine the optimum field observation application. This study would lead to field production instruments in approximately three years.

Doppler satellite surveys

Doppler satellite survey positions, numbering 138, were established in the United States, Puerto Rico, and the Virgin Islands, primarily in support of the new adjustment of NAD-83. Four Doppler stations along the Canadian border were occupied in 1979 for compatibility studies of the United States and Canadian Doppler networks. Doppler observations continued through the reporting period at the Ukiah Latitude Observatory, California, in support of the international polar motion project. In addition, Doppler satellite observations began at the Richmond, Florida, POLARIS very long baseline interferometry (VLBI) station in October 1983. The Doppler Point Position data base file now contains information for over 800 stations.

Doppler satellite survey positions have been established at approximately 149 stations, including projects by the USGS in support of NAD-83.

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 programmes should be checked by testing the precision of the measurements and by comparing the results with known geodetic control.

Gravity surveys

Gravity observations in support of the general adjustment of the vertical control network continued during the reporting period. Observations are being performed over existing level lines where needed. Gravity values are being provided for the adjustment by interpolation for all benchmarks within the network.

New data input formats as well as accuracy standards and specifications have been developed. Computer programs to handle these formats and standards are being developed.

Gravity data continued to be recorded at the Gaithersburg, Maryland, Earth Tide Station as well as in Boulder, Colorado. Software to process these data is being developed.

Investigation of gravity meter characteristics continued. In addition, NGS has temporarily assigned one person to the Joint Institute for Laboratory Astrophysics (JILA) at Boulder, Colorado, to assist in the development of an absolute gravimeter. A joint programme with JILA is under

way to develop the most current absolute gravity instrumentation to support DMA's extensive gravity collection programme with calibration baselines/stations.

Investigations into the local variations of the vertical gravity gradient were performed in North Carolina. These data indicated that the variations in the gradient were significant. This test indicated that an improvement in the prediction of gravity can be realized with the addition of gradient information.

The development of a gravity gradiometer survey system is now in progress. The system is being designed and built for both ground and airborne applications and will be integrated with a GPS receiver system. It is expected that field testing will commence in late 1986.

Aerial profiling of terrain system

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 the Aerial Profiling of Terrain System (APTS) by USGS. APTS includes a laser profiler, TV camera, inertial measuring unit, laser tracker, computer, and a magnetic tape recorder. The fabrication, integration and extensive laboratory testing of the components were completed in 1983 at the Charles Stark Draper Laboratory in Cambridge, Massachusetts. The components have been installed in a Twin-Otter aircraft based at Hanscom Field, Massachusetts, where both ground and flight tests have been made to determine accuracies. System simulations and laboratory testing to identify and calibrate systematic error sources and flight tests indicate the system accuracy goal of + or −0.5 feet vertically and + or −2.0 feet horizontally were achieved.

The current phase in the APTS development process consists of a series of applications tests designed to determine the effectiveness of APTS as a surveying system to gather data for various USGS earth-science programmes. After the planned completion of the application testing in May 1985, APTS is planned to be used as an operational earth-science data collection system.

Geodetic astronomy

In support of the NOS astrogeodetic densification programme to enhance geoid modelling efforts, astronomic positions were observed at Chincoteague Inlet on the Maryland-Virginia border, in northern New York and along the New York-Pennsylvania border, and in south-western Texas. Six positions were observed at Chincoteague Inlet, 10 positions in the New York-Pennsylvania project and 13 positions in the south-western Texas area.

Geodetic data processing efforts at NOS have expanded significantly since 1983, in the area of polar motion/Earth rotation studies using VLBI. Formerly, VLBI observing sessions were conducted once every 7 days, using primarily two antennae—Westford, Massachusetts, and Fort Davis, Texas—with monthly participation by geodetic astronomers at Onsola, Sweden.

Beginning 2 September 1983, VLBI observing sessions were conducted at 5-day intervals in support of the MERIT (*M*onitor *E*arth *R*otation and *I*ntercompare the *T*echniques of observations and analysis) international effort, sponsored jointly by the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG). In addition, Wettzell, Federal Republic of Germany, joined the network on 16 November 1983, and the National Geodetic Survey Antenna at the USNO timing substation at Richmond, Florida, was added on 21 December 1983. When Wettzell (operated by the Institute für Angewandte Geodäsie at Bonn) began participating in the VLBI effort, the official name of the polar motion/earth rotation analysis programme became IRIS (International Radio Interferometric Survey).

DMA maintains an ongoing programme for improving astronomic procedures and instrumentation. During 1983, extensive field tests of precise astrolabes were conducted and results indicate that this type of instrumentation has good potential to significantly improve determinations of latitude and longitude.

Inertial positioning system

Developments have begun to improve the hardware/software characteristics of DMA's inertial positioning systems (IPS). Essentially, these efforts will provide an improved man-machine interface, automated data recording, and better platform stability/accelerometer performance.

Investigations have commenced regarding the integration of IPS with GPS receivers to increase system accuracy in the airborne mode.

Geodetic information services

In support of the 1983 adjustment of the North American Datum, approximately 200,000 horizontal station descriptions have been loaded into the horizontal network data base.

Information products include: digital outputs of horizontal control data and vertical control data, diagrams, and charts on printed media; other products include software which deal with geodetic applications and digital data dealing with gravity, astronomy, horizontal and vertical control. Other products include calibration baselines, satellite surveying data, polar motion data, archived records, crustal motion data and news-sheets. All of the information aspects of these products are entered into the National Environmental Data Referral Services (NEDRES), a user-friendly telecommunication-access, environmental data reference system developed by NOAA.

There are 875 diagrams in the various series depicting the National Geodetic Networks. New Alaskan geodetic control diagrams are being compiled on NOS aeronautical sectional chart bases (1:500,000 scale); 5 have been printed and 11 remain to be compiled. As inventories are depleted, diagrams for parts of the conterminous United States are reprinted or revised at the rate of 50 per year.

The NGSD installed an "Intelligent Electronic Printing System" in FY-1984 consisting of a laser printer and information processor. This enables NGSD to print and disseminate publications of horizontal and vertical control data on demand.

The NGSD is automating certain phases of cartographic operations. Intergraph work stations were delivered in November 1983 and are now being used to produce geodetic diagrams.

Inter-American Geodetic Survey

The DMA Inter-American Geodetic Survey (IAGS) continues to provide liaison, support, and training to the Latin American associate mapping agencies. Aerial photographic working arrangements were supported in five countries, while specifications and inspections were provided in two more countries. Doppler programmes were enhanced through direct station observations or training of personnel and loan of equipment. Nautical cartography was augmented through dedicated technical support to survey and carto-

graphic processes. Aeronautical charting was emphasized through technical support. Map maintenance was supported through dedicated technical assistance as well as equipment assistance. The gravity and geomagnetic programmes were re-initiated on a hemisphere basis. Expanded capital equipment and personnel investments were made at the Cartographic School to advance the transfer of technology. Quality control programmes were initiated throughout the cartographic processes in several countries. ADP support was augmented and covers data reduction for geodesy, photogrammetry, autocarto and geophysics. Remote sensing was promoted through image acquisition and distribution; and new courses were developed at the Cartographic School. IAGS continues to support the Pan American Institute of Geography and History (PAIGH) through service by its staff on several working groups.

Image mapping

Mapping agencies in the United States have increasingly recognized that remotely sensed image products are valuable mapping tools, map supplements, and alternatives to standard maps. Programmes in high-altitude photography, orthophotography, satellite imagery, and side-looking airborne radar, have evolved to respond to these needs.

The National High Altitude Photography Programme

The National High Altitude Photography (NHAP) programme began during the reporting period. In this Federal multiagency activity, the USGS co-ordinates the acquisition of high-altitude aerial photography for 14 participating agencies who are involved in national mapping and resource management tasks. The objectives of the NHAP programme are to complete coverage of the conterminous United States and develop a first-time national photographic data base before the end of 1986, provide periodic updates of the data base, and ensure that the photographs are easily available.

The NHAP data base consists of both 1:58,000-scale black-and-white panchromatic and 1:80,000-scale colour-infrared 23 × 23-cm photographs taken from an aircraft equipped with two cameras and flown 12,220 metres above the terrain.

There were approximately 7.4 million square kilometres (km^2) high-altitude coverage over the conterminous United States contracted during the reporting period. Presently, about 80 per cent of that coverage is available to the user.

Orthophotography

Orthophotoquads show land features on photographic images that have been processed to show detail in true position. Orthophotoquads do not include contours and are printed in shades of gray without image enhancement or cartographic symbolization. The demand continues for orthophotoquads for use either as an interim map in unmapped areas at 1:24,000-scale, or as a companion to a published topographic map. Approximately 30,000 orthophotoquads have been produced by the USGS to date; approximately 10 per cent of these have been published and the remainder are available either as diazo or photographic reproductions. During this reporting period the USGS prepared 16,000 orthophotoquads.

Certain orthophotoquads have been produced with colour portrayal of the terrain and selected cartographic symbolization. In 1980, a 1:25,000-scale simulated natural-green rendition made from colour-infrared photographs was chosen as the standard product for the United States/Mexico Border Mapping Project. The United States/Mexico Border Mapping Project is being conducted by the USGS in collaboration with the United States Customs Service, the International Boundary and Water Commission, and the Dirección General de Geografía of Mexico. At the end of the reporting period, 48 of a projected 203 photo-image maps of the United States/Mexico border have been published.

Satellite Image Mapping Programme

Since the launch of the first LANDSAT in 1972, USGS has published a variety of experimental image maps. By the end of the reporting period, 37 LANDSAT image maps, ranging from 1:100,000 to 1:1,000,000 in scale, have been published for distribution by USGS. Numerous experimental image maps have also been produced by USGS for Bangladesh, Brazil, Ethiopia, Kenya, Liberia, Mexico, Morocco, Nepal, Nigeria, Pakistan, Saudi Arabia, and Tunisia under co-operative mapping projects.

Early in 1982, the Las Vegas 1:250,000-scale quadrangle was selected for a test of a newly developed geometric registration capability together with advanced digital image processing techniques available at the Earth Resources Observation Systems (EROS) data centre. The Las Vegas area was selected because of the diversity of features—urban areas, desert, mountains, lakes, rivers, and irrigated agriculture. Four LANDSAT multispectral scanner (MSS) scenes were required to cover the mapped area. The final product was a conventional false-colour image map with a standard line map printed on the reverse side.

Also in 1982, the area around Dyersburg, Tennessee, became the first area to be mapped at 1:100,000-scale using data from the LANDSAT-4 thematic mapper (TM). The process used to develop the Dyersburg image map laid the groundwork for future uses of TM 30-metre resolution data. Like the Las Vegas image map, the Dyersburg map was printed with a standard line map on the reverse side.

During 1984, experimental TM image mapping resulted in an image product of the Washington, D.C., area prepared from bands 1, 3, and 4 (blue, red, and near-infrared, respectively). A companion product was USGS miscellaneous investigation report I-1616, entitled "Landsat thematic mapper (TM) colour combinations of Washington, D.C., and vicinity". This report illustrates various colour combinations and permutations possible from the six TM spectral bands suitable for image mapping.

The USGS is preparing 25 LANDSAT-3 1:250,000-scale image maps of the north slope of Alaska for the Minerals Management Service of the Department of the Interior. The image maps involve the use of return beam vidicon (RBV) data for 14 of the 25 quadrangles, and MSS for the remainder.

Satellite imagery is being used to produce image maps of glacier areas in Antarctica. LANDSAT imagery also is being combined with SEASAT radar-altimeter data to generate a 1:1,000,000-scale hybrid map of the Amery Ice Shelf, East Antarctica. In addition, NOAA advanced very-high-resolution radiometer (AVHRR) data are being digitally processed to produce a 1:5,000,000-scale image base map of the entire Antarctic continent. In 1983, the USGS completed a combined "Index map and table of optimum LANDSAT images of Antarctica", which will serve as a guide for future image mapping of the continent.

As a result of experience gained from producing experimental LANDSAT image maps, the USGS has made considerable progress in improving techniques for the

processing and printing of satellite image products that meet national map accuracy standards.

The availability of LANDSAT MSS, TM, RBV, and other experimental image maps has created interest in acquiring additional coverage, especially where the imagery can provide data on surficial geologic detail, texture, and colour not available from topographic maps. International users' interest has been primarily targeted at acquiring coverage in unmapped and poorly mapped areas of their respective nations.

Side-looking airborne radar

In 1980, USGS began the side-looking airborne radar (SLAR) programme as a result of a Congressional request "to begin the use of side-looking airborne radar imagery for topographic and geologic mapping, and geologic resource surveys in promising areas". Since the programme began, more than 500,000 square miles of SLAR data have been acquired in the conterminous United States and Alaska.

The cloud-penetration capability of radar has provided the opportunity to obtain imagery of the normally cloud-covered Aleutian Islands in Alaska, where conventional aerial photographs are difficult to obtain. Since 1980, USGS has prepared and published twelve 1:250,000-scale SLAR image mosaics of the Aleutian Islands. The topographic maps of the area were originally published in the 1950s and are classified as reconnaissance editions in recognition of the technology prevalent at that time. The radar mosaics are printed back-to-back with the corresponding topographic maps, which are updated to show the latest feature names, township and range lines, and locations of offshore leasing tracts. The mosaics and topographic maps are also available separately.

Topographic mapping

Domestic topographic mapping in the United States is the primary responsibility of the United States Geological Survey. The Defense Mapping Agency is responsible for mapping requirements related to national defense.

The principal cartographic activities of the National Mapping Program can be related to the types of conventional map products—1:24,000-scale topographic maps (the largest activity and the largest-scale national map product), 1:24,000-scale orthophotoquads, and 1:100,000- and 1:250,000-scale regional maps. There is also significant activity in land use and land cover mapping at 1:100,000 and 1:250,000-scale, state and national small-scale maps, and a variety of special maps, including image maps prepared from high-altitude aircraft and satellite data.

The large-scale maps include the following categories of base map data: reference systems, hypsography, hydrography, vegetative cover, non-vegetative features, boundaries, transportation systems, geodetic control, survey monumentation and geographical names.

Because of newly defined mapping requirements and the development of new mapping, remote sensing, and photographic techniques, USGS has reorganized its cartographic and geographic activities and expanded its product lines.

Since the Second United Nations Regional Cartographic Conference for the Americas took place in 1979, the National Mapping Division (NMD) of USGS has been formed to respond to this expanding role. In 1981, the former Geography Program and elements of the Publication Division were merged with the Topographic Division to form NMD. In 1983, the EROS programme joined and broadened the Division's role in the field of remote sensing.

The expanding role of NMD has influenced greatly the evolution of new and improved user products. The following synopsis gives the progress in the National Mapping Program by major categories since the Second Conference in 1979.

Large-scale mapping and revision

During the reporting period, 7,300 new standard topographic maps were published covering an area of approximately 670,000 square kilometres (km^2). Most of these maps were in the 7.5-minute 1:24,000-scale series (1:63,360-scale and 15-minute series in Alaska). At the end of the reporting period 18 states had complete, published topographic map coverage at 1:24,000-scale.

These maps are periodically reviewed for revision with emphasis on changes in urban areas, coastal zones, airports, and other high national interest areas. Since September 1979, 8,900 7.5-minute maps have been revised and published.

Even though most primary quadrangle maps produced under the National Mapping Program are being published using customary English units, over 1,350 7.5-minute quadrangles are currently in the works as metric editions.

Intermediate-scale mapping

Intermediate-scale mapping at scales ranging from 1:50,000 to 1:100,000 continues to be a growing part of the National Mapping Program. With the expanding interest in energy and mineral development and Federal land management, the demand for quadrangle maps at 1:100,000-scale has increased. Presently, intermediate-scale maps in quadrangle and county format are available or under production for the entire conterminous United States. During the reporting period the USGS produced 1,375 intermediate-scale maps.

Small-scale mapping

Topographic map coverage of the United States is complete at 1:250,000-scale, totalling 631 sheets. The series is currently maintained by USGS. During the five-year period of the present report, 165 revisions of these maps have been published. Digital terrain data for the 1:250,000-scale map series are available.

Other small-scale maps at 1:500,000, and 1:1,000,000-scale include state base maps and international maps of the world.

Provisional mapping

During the last decade, USGS became increasingly aware of the impact of declining budgets on the National Mapping Program. In 1980, 12,000 7.5-minute quadrangles remained to be mapped in the 48 conterminous United States. Because of the emphasis placed on programmes such as photorevision, orthophotoquads, county maps, the 1:100,000-scale series, and the National Digital Cartographic Data Base (NDCDB), the completion of 7.5-minute map coverage might not be accomplished until well after the year 2000. To ensure completion in a more reasonable time frame, the provisional map programme was developed.

Provisional maps are prepared to the same map accuracy standards and contain essentially the same level of content as standard topographic maps but reflect a provisional rather than final appearance. For most map features and type, the original map manuscripts that are compiled from aerial photographs, including hand lettering, serve as the final copy for printing.

In 1982, compilation of a series of provisional edition topographic maps got under way to expedite completion of the remaining 7.5-minute quadrangle areas not covered by 1:24,000-scale mapping. Under this accelerated mapping programme, most of the unmapped areas are targeted for provisional mapping, allowing complete coverage of the conterminous United States by 1989. Provisional maps of unmapped 15-minute quadrangle areas in Alaska are also being produced, allowing 1:63,360-scale map coverage of Alaska to be completed also by 1989. After completion of the provisional mapping programme, the maps will be updated and reissued as standard topographic editions.

During the reporting period 2,000 provisional edition maps have been published by the USGS.

Special-purpose mapping

Special-purpose maps of national parks, monuments and historic sites are produced by the USGS at various scales. Many of these maps have been developed with shaded-relief overprinting, i.e., the topograpy is made to appear three-dimensional by the use of shadow effects. The Amistad National Recreation Area, Texas, 1:50,000-scale map is an example of the most recent of the National Park series maps to be published in co-operation with the National Park Service.

USGS continues its support of the United States Antarctic Research Program by conducting geodetic ground surveys and compiling topographic maps of the continent. To date, 91 1:250,000-scale maps of Antarctica have been published.

Land-use and land-cover mapping

The USGS continues its development of land-use and land-cover maps and associated overlays for the United States. These maps are being digitized, edited and incorporated into a digital data base.

These 1:100,000 and 1:250,000-scale maps are helping to satisfy a longstanding need for a consistent level of detail, standardization of categories and consistent use of scales of compilation of data used by government land-use planners, land managers and resource-management planners. Once this bench-mark series of maps is completed, updating of the maps will provide a much needed tool for analysing trends, problems in local and regional areas throughout the nation and changes in land-use patterns.

In addition to the land-use/land-cover maps, the associated maps consist of political units, hydrologic units and census county subdivisions. Federal and state land ownership overlays are available only in states where co-operative funding was available. State land ownership maps are not part of the standard land-use/land-cover set.

During the reporting period 211 land-use/land-cover maps of the United States have been published.

The nationwide land-use/land-cover mapping programme of USGS began in 1974 and since that time approximately 80 per cent of the United States (excluding Alaska) has been mapped. Since 1978, the USGS has prepared LANDSAT-derived land-cover products in Alaska for Federal and State resource management agencies under co-operative arrangements. Products include digital tapes, area statistics and maps in varying formats. In FY 1985, USGS is planning to reformat some of these products into a common 1:250,000-scale quadrangle format featuring a uniform land-cover classification system developed in co-operation with principal resource management agencies in Alaska. The sample products will be evaluated by the user community to determine the feasibility of preparing statewide land cover data in a common format and classification system.

HYDROGRAPHY AND OCEANOGRAPHY

The National Ocean Service (NOS) is charged with the domestic charting responsibility for United States oceanic coastal waters and the Great Lakes and connecting waterways, amounting to about 2.5 million square nautical miles (nmi). In meeting this requirement NOS has issued about 980 different charts covering these areas. DMA has responsibility for national defence charting, which includes hydrographic and photogrammetric surveys to furnish data needed to produce charts and maps.

Hydrographic charting

During the reporting period, maintenance of the nautical charts for the United States, and its possessions, including the Great Lakes, was continued at a level of over 400 new editions each year and five to seven new charts each year.

To support the United States offshore energy development programme, NOS has produced 174 1:250,000-scale bathymetric maps covering potential leasing areas on the Gulf of Mexico, Alaska and the Pacific and Atlantic coasts. All the maps are produced in metric units and contain the Department of the Interior's Minerals Management Service (MMS) offshore lease block grid. MMS is responsible for administering the United States Outer Continental Shelf (OCS) lease-sale programme, and uses the bathymetric maps to prepare environmental impact statements for the lease areas. NOS has an ongoing commitment to provide bathymetric maps to support the OCS programme and other United States deep-ocean resource development projects.

At present, the United States 200-mile Fishery Conservation Zone limit is printed on 55 nautical charts which provide complete coverage of the offshore waters of Alaska, Hawaii, Puerto Rico and the contiguous United States. The 3-nmi (territorial sea) and 12-nmi (contiguous zone) seaward boundaries are printed on 141 navigational charts covering the coastal waters off the contiguous United States, Alaska, Hawaii, Guam and Puerto Rico.

At present NOS publishes 15 metric charts. Five are international charts, five are on Lake Erie, and the others are two on Lake Ontario, the LOOP Deep Water Port, Navassa Island and the entrance to the Strait of Juan de Fuca. As resources permit, all Great Lakes charts will be converted from customary English units to metric units. Lake Ontario, Lake Erie and the St. Lawrence Seaway will be the first areas covered by a complete set of metric charts.

Reformatting of NOS' 74 small-craft charts for recreational boaters into the road-map type of design continues. This redesign will cut the cost of reproduction and it is easier for the recreational boater to use and store.

Under the agreement with the International Hydrographic Organization (IHO), the United States publishes five international charts covering the eastern part of the North Pacific Ocean. Four of these charts are published at scale 1:10,000,000.

To co-ordinate and establish standard procedures in charting United States and Canadian waters, the United States/Canada Hydrographic Commission was established in April 1977. The Commission is responsible for planning, design, specification and other cartographic/hydrographic functions. Exchanges of personnel between NOS and the Canadian Hydrographic Service are taking place. This on-site training provides a better insight to the cartographic concepts and hydrographic techniques used by each country.

The NOS Automated Nautical Charting System (ANCS), which includes all of the cartographic activities and systems

that support the automated construction and production of nautical charts, is being re-evaluated to determine requirements for new systems and hardware upgrades. The Automated Information System (AIS) is the main component of the ANCS. It includes the nautical charting feature data base and data base maintenance interface (colour graphic work stations). It will be replaced in order to incorporate technological advancements and software enhancements, and to increase production speed and quantity. These advancements will also provide capabilities consistent with recent and future NOS initiatives, e.g., the desire to exchange digital data with others having digital data bases, and interest in supplying certified digital data for use in navigation systems being developed for shipboard use. In order to implement these requirements, a new project called the Advanced Automated Cartography Project has been established.

In collaboration with Colombia, Ecuador and Peru, DMA recently completed the total charting of their respective coasts. Currently, similar efforts are in progress for the recharting of the coastlines of the Dominican Republic, Guyana and Venezuela.

Coastal mapping

In April 1975, NOS and USGS jointly initiated a new series of 1:24,000-, 1:100,000- and 1:250,000-scale topographic/bathymetric maps of the United States coastal zone. These multipurpose maps show USGS topography and NOS bathymetry on one single sheet, thus providing a detailed picture of the total physical environment in coastal areas. Of these topo/bathy maps 161 have been published by the end of the reporting period. In addition, NOS has delivered 150 maps to USGS for publishing, and 97 maps are in production by NOS.

The 1:10,000 topo/bathy map is a metric product, as compared to the 1:24,000 and 1:25,000 products which will be a combination English/metric version—topography in feet, bathymetry in metres.

Orthophoto imagery will be used on the 1:24,000 maps when possible to provide more land detail. Gradient tints will be used to enhance the bathymetric contours. Depending on the slope of the bottom and the scale of the map, the bathymetry contour intervals of this series will range from 0.5 to 100 m.

Hydrographic surveys

Under the auspices of the Caribbean Basin Initiative (CBI), DMA has co-ordinated charting and survey efforts with the member nations of this consortium. The countries involved include Jamaica and the Cayman Islands, the Bahamas, the Turks and Caicos and other islands in the Lesser Antilles chain. DMA has also closely participated in British Admiralty survey operations in these areas for the purposes of reciprocal exchange of data and co-ordination of charting efforts.

The United States Naval Oceanographic Office (NAVOCEANO) has conducted extensive surveys in the waters of the Nicaraguan Rise and the Yucatan Peninsula in support of DMA charting programmes in these regions. Also in progress are NAVOCEANO surveys of the Navassa Strait and the coastal waters of Honduras, Panama, Costa Rica, Guatemala and El Salvador in order to update charts of these countries. DMA has also completed charting of the Cuban coast based on that nation's survey data.

Hydrographic services accomplished by NOS during the reporting period included basic surveys in the Gulf of Mexico, Alaska, Hawaii, the Great Lakes and major ports of the United States. Revisory, reconnaissance and chart evaluation surveys were conducted in the Great Lakes, Alaska, and major harbours along the Atlantic coast and in the Gulf of Mexico.

In addition, special hydrographic survey projects of Haiti and the Bahamas were started in 1983 for the United States Navy. Similar surveys of Honduras for the Navy will commence in early 1985 and continue for at least five years. Bathymetric swath surveys of the United States exclusive economic zone (EEZ) began in 1984 off the coast of California, and will continue for a number of years as the scope of the project is extended to other portions of the EEZ.

Hydrographic survey equipment development

Side-scan sonar systems have been acquired by NOS for use by hydrographic field units as acceptable search and detection tools to verify or disprove charted wrecks and obstructions. These systems are also used in selected areas to supplement other echo sounding for detecting dangers to navigation between sounding lines.

The Bathymetric Swath Survey Station (BSSS), a multibeam hydrographic data acquisition system installed aboard the NOAA ship Davidson, was certified operational in 1982. Several surveys have been accomplished using this system, including present hydrographic surveys in the EEZ.

A two-year development programme was completed in 1983 by NOS when the NOAA ship Mt. Mitchell was equipped with the new Raytheon DSF-6000N shallow-water echo-sounder. The DSF-6000N is now standard equipment for NOS survey units and incorporates many new features to aid the hydrographer such as:

(*a*) Uses simultaneous dual frequency (24/100 kHz) and dual beam width (47/7.5 degree) transducers which significantly increase the ensonified sea-bottom area, thereby improving the probability of feature detection while preserving the accuracy of a narrow beam system;

(*b*) Allows sounding to greater depths (1,500 fathoms) than previous shallow-water units;

(*c*) Detects slurry bottom conditions through the use of two different transmitted frequencies;

(*d*) Automatically tracks over the sea-bottom and annotates the analog records, allowing the operator to concentrate on survey requirements.

Over the past few years, NOS has developed and implemented the Automated Wreck and Obstruction Information System. It serves a twofold purpose: (*a*) to provide a specialized research tool for hydrographic survey planning and assigning wrecks and obstructions for field investigations; and (*b*) to provide a public service to users, such as divers, salvage operators, fishermen, marine historians and archaeologists. This automated system now contains over 4,000 reports of navigational hazards within United States waters. It is anticipated that more than 20,000 wrecks and obstructions will eventually be listed.

DMA is presently developing three major advanced systems for collection of bathymetric data from airborne platforms. These systems are unique in being designed to operate independently of surface ship support and to provide complete areal coverage as opposed to the traditional "line of soundings". All systems are being developed for transfer to the Navy for actual collection and processing of data.

The Hydrographic Airborne Laser Sounder (HALS) is a high-pulse-rate blue-green laser designed to provide precision (to within IHO standards) measurement to depths of 50 metres, depending upon the water clarity.

The Multispectral Active/Passive Scanner (MAPS) is a solid-state multispectral scanner calibrated with a low-pulse-rate blue-green laser designed to provide bathymetry in clear, coastal waters down to 30 metres. MAPS differs from HALS in being designed primarily for hydrographic reconnaissance and survey planning, and in not having a capability to process data during collection.

The Airborne Electromagnetic (AEM) bathymetric system will seek to expand existing geophysical techniques to measurement of depth to 100 metres. AEM differs from HALS and MAPS in being independent of optical conditions, although being less accurate. Preliminary field tests have been conducted.

Automated Information System

Parts of the Automated Information System (NOS-AIS) are currently about nine years old. The Advanced Automated Cartographic Project (AACP) has been established to design and develop the next generation Automated Nautical Charting System (ANCS). The ANCS will have the functional capability and the system capacity to handle the total requirement for both nautical charting production and the inquiries of users of digital charting data. During 1985, AACP will develop a project and technical development plan and functional specifications for the ANCS II.

The current AIS digital data base is maintained by two prototype vector refresh colour graphic work-stations and two upgraded colour raster graphic work-stations. One production work-station was certified as operational early this year. Five additional upgraded work-stations were on-line by the end of 1984. Data currently includes the published nautical charting features and supporting information for graphic depiction of nautical charts along the United States coastline from Mexico to Cape Fear River, North Carolina. Included also is Puerto Rico and the Great Lakes. It is estimated that when the rest of the nautical chart data are loaded, the AIS data base size will exceed 3 billion bytes of charting information.

In addition to acquisition of the hardware needed to implement the six upgraded colour raster graphic work-stations, a high-precision raster graphics system was procured. This system includes a laser plotter for large-format charts and an editing station capable of editing the raster formatted data. The system includes software permitting conversion to vector format for editing and back to raster format for updating the raster data.

Satellite altimetry applications

Satellite altimetry of the sea surface has been applied by NOS to the study of the undulations of the geoid. These undulations have been interpreted in terms of convective motion of the viscous mantle and static loads on the rigid lithosphere caused by sea-floor features such as sea-mounts, trenches, ridges, oceanic rises and fracture zones. In 1984, NGSD produced 32 overlays of sea-surface profiles for 16 maps of the General Bathymetric Chart of the Oceans series. The overlays display sea-surface slopes along the satellite tracks. In poorly charted areas, the satellite altimeter has revealed many undetected features of the sea floor. Nearly 100 previously undiscovered sea-mounts were found in the South Pacific.

Surface currents can be measured as sea-surface slopes relative to the geoidal surface. In 1984, progress was made toward the ultimate goal of determining long-term general circulation of the oceans with the preparation of a global map of ocean circulation using only three days of altimeter data together with a model of the gravity field. Accumulating evidence has allowed NOS to track the cause of a predicted long-term rise in mean sea level to the climatic effect of global warming coincident with the increasing levels of atmospheric carbon dioxide (the "greenhouse effect"). Last year NGSD developed a new technique based on satellite altimeter data to monitor the sea-level changes caused by El Nino with an accuracy of a few centimetres.

An important part of the satellite altimetry programme is the planning and preparation involved for upcoming projects. Current NGSD activities include defining requirements for GEOSAT and TOPEX altimeter satellites and application of GPS satellite navigation for aircraft altimeter profiling. Existing computer facilities are being upgraded, and a special computer centre is being established to handle the altimeter data from GEOSAT, beginning in 1985. NOAA will supply various groups with GEOSAT data and marine products in support of climate studies and operational forecasts.

Hydrographic applications of satellite data and imagery

DMA is utilizing LANDSAT imagery in a number of ways which directly enhance DMA's production, maintenance and data collection efforts. For example, analog LANDSAT-MSS imagery of shallow seas is being used to locate and validate reported navigational hazards. It is also used in the compilation of medium- and small-scale hydrographic charts, and as a planning tool for hydrographic surveys.

Digital LANDSAT data are being used to analyse areas for hydrographic survey planning graphics. In areas with uniform bottom reflectivity, MSS-derived relative depth information has an accuracy within 10 per cent of the depth measured. Over mixed bottom types, its use is limited, owing to the fact that only one band (green) has effective water penetration.

Nautical publications

The NOS *Hydrographic Manual*, fourth edition, published in 1978, has been updated by three changes. The third change was published in June 1981. The manual is at present out of print, but electrostatic copies are available at a cost of $US 14.75 by writing to: Chief, Hydrographic Surveys Branch, N/CG24, National Oceanic and Atmospheric Administration, NOAA, Rockville, Maryland, 20852, United States of America.

DMA's *Notice to Mariners* is a weekly publication issued to advise mariners on matters affecting navigational safety, including new hydrographic discoveries, changes in channels, and modifications to navigational aids. It presents corrective information affecting charts as well as "Coast pilots" "Sailing directions", "Fleet guides", catalogues and nautical charts, light lists, "Radio navigation aids", and such other publications as may from time to time require updating. The *Notice to Mariners* is produced in an easy to use format with the aid of automated data processing and typesetting equipment, thus minimizing production costs and expediting dissemination. This world-wide series of DMA publications is compiled by ocean basin, i.e., North Atlantic, South Pacific, Indian Ocean, etc. A Planning Guide for each area describes oceanography, meteorology, countries and routes, and is accompanied by two or more *en route* publications describing approach and coastal information. The group consists of a total of 46 publications and is designed for modern deep-draft ships provided with electronic navigational and communication equipment. Graphic directional displays designed to supplement textual

material provide the mariner with recommendations for the approaches to channels, harbours and anchorages. Photographs, coastline displays and navigational aid drawings are routinely used to further assist in the identification of landmarks.

Electronic navigation

Eight Omega Electronic Navigation stations, namely A-Norway, B-Liberia, C-Hawaii, D-North Dakota, E-Reunion, F-Argentina, G-Australia, and H-Japan provide worldwide continuous radio-navigation coverage of medium accuracy. Operating at 10 kW of power, they provide hyperbolic lines of position computed by phase comparison of VLF radio signals. There are 126 Omega Plotting Charts issued in the 7600/7700 series, which are designed to give global coverage on Mercator projection with a scale of 1:2,187,400 overprinted with Omega zero phase-difference contours for standard propagation conditions. On these plotting charts, the Line of Position (LOP) for a corrected receiver reading of a station pair is constructed by graphical linear interpolation between the charted LOPs.

There are presently 874 DMA hydrographic charts overprinted with Omega lattices, and recommendations have been submitted for 161 more. In addition, there are 255 Omega lattice tables and 172 Omega Propagation Correction tables (PPC) for the 10.2 kHz transmission frequency. Additionally, there are 76 PPC tables for the 13.6 kHz frequency, and an Omega Coverage Diagram publication giving the positions of the stations, areas of coverage and accuracy data.

The DMA LORAN-C system consists of pulsed long-range low-frequency (100 kHz) radio-navigation signals for both time-difference and phase-shift comparison. There are 14 LORAN-C chains world-wide which comprise a total of 42 stations. There are a total of 302 DMA charts overprinted with LORAN-C lattices, which includes 32 charts in the 7800 Series Plotting Charts and 4 in the 7400 Interim Series. Lattices have been recommended for an additional 128 charts at DMA, and NOS publishes another 267 charts with LORAN-C information. There are also 23 Additional Secondary Factor (ASF) correction charts and 14 LORAN-C Reliability Diagrams published by DMAHTC. Further, there are 42 LORAN-C lattice tables and 55 ASF correction tables presently in the system.

Aeronautical charting

The NOS aeronautical charting programme consists of the compilation, printing and distribution of charts and other materials and other special services which are the basic requirements for all aircraft operations in the United States as stipulated by the Federal Aviation Administration (FAA). NOS produces approximately 10,000 charts annually covering the National Airspace System in the United States, including charts for pilots flying under visual flight rules and under instrument flight rules. To ensure that these aeronautical charts and chart-related products are accurate and up to date, the NOS maintains an aeronautical chart data base of over 6 million elements.

NOS continues to provide material for reproduction of base charts at scales 1:500,000 and 1:1,000,000 to the Defense Mapping Agency Aerospace Center (DMAAC). DMAAC updates the aeronautical information to satisfy domestic military requirements. These requirements include Flight Information Publications (FLIPs) and *Notices to Airmen* (NOTAMs) for use in military flight planning and operations.

In 1981, NOS began a comprehensive chart reconstruction effort to enhance the quality of information portrayed on aeronautical charts. The reconstruction programme involved a combined total of 150 visual-flight-rule (VFR) and instrument-flight-rule (IFR) charts which will take 10 years to complete. The programme was initiated to reap some of the benefits derived from improved cartographic techniques as well as advances in computer technology. To date, eight sectional aeronautical charts and two world aeronautical charts have been published under the auspices of the chart reconstruction programme.

The United States Gulf Coast VFR Chart is a new NOS aeronautical chart product. At a scale of 1:500,000, it shows offshore mineral leasing areas and blocks, oil-drilling platforms, and high-density helicopter activity areas in and around the Gulf of Mexico.

North Atlantic Route Chart

The *North Atlantic Route Chart* (NARC) is another new NOS chart product. This five-colour chart was designed for air traffic controllers in monitoring transatlantic flights and for aviation planners. The chart depicts oceanic control areas, coastal navigation aids, major coastal airports, and oceanic reporting points. Geographic co-ordinates for navigation aids and reporting points are also included. The chart can be used for pre-flight planning as well as inflight use.

Airport/Facility Directory

The *Airport/Facility Directory* (A/FD) continues to improve with the addition of new elements of data to better serve the user. The *Directory* was revised to include data on the Automated Weather Observation System and unmanned aerospace vehicles, and 3,000 Flight Service Station telephone numbers. This manual contains information on airports, seaplane bases, and heliports open to the public, communication data, navigational facilities and certain special notices and procedures. The *Directory* is published in seven volumes, each covering a specific geographic region of the conterminous United States, Puerto Rico, and the United States Virgin Islands.

VFR flyway planning charts

In August 1983, the Los Angeles and San Diego VFR flyway planning charts (FPC) were published. In the same period, the Los Angeles and San Diego VFR terminal area charts (TAC), which were printed back-to-back, were separated, and the Los Angeles TAC and FPC, and San Diego TAC and FPC, were printed back-to-back. In July 1984, the Dallas/Ft. Worth FPC and TAC were printed back-to-back, followed by the Houston FPC and TAC back-to-back printing in August 1984.

Flyway charts enhance VFR transition through the areas they cover. They are provided to show multiple VFR routings, and may be used as an alternate to routes within established terminal control areas.

NOS Aeronautical Chart Automation Project

The Aeronautical Chart Automation Project is continuing to provide automated support to the chart compilation process through its enhanced aeronautical data base. During the reporting period it has improved the capability to provide plotted output from that data base. Development and production work is continuing on the NOAA UNIVAC 1100, with later implementation on a planned minicomputer system. Late in February 1983, a major procurement for minicomputers and cartographic work-stations was awarded. The equipment was delivered in March 1984; full implementation is expected by 1985.

GEOGRAPHICAL NAMES

The United States has continued to be active in programmes to standardize domestic and foreign names of geographical features. These programmes are carried out through the services of the interdepartmental United States Board on Geographic Names, while technical staff support and publication efforts are provided by DMA and USGS.

Since 1979, the United States has continued to be active in the maintenance of files of geographical names in Latin America. This work has been based on the receipt of source material from several countries and includes information on new administrative subdivisions and other names data. Among major sources have been gazetteer-type publications and other materials produced by Chile, Guatemala and other countries. The DMA Inter-American Geodetic Survey also has been active in procurement of names information in co-operation with individual countries.

In addition, the United States has been active in names programmes through the Pan American Institute of Geography and History (PAIGH). With the support of Mexico and other countries, the United States initiated a meeting in 1981 in Panama to discuss the creation of a PAIGH body to produce a series of national gazetteers based on 1:250,000-scale topographic maps. This programme was approved at the 1982 XII General Assembly of PAIGH in Chile. The Assembly also approved working group efforts to develop and strengthen national names authorities. The programme for gazetteers is based on a set of common specifications adopted by participating nations. Since 1982, correspondence between three designated regional project co-ordinators has helped to develop further agreement as to the assigned tasks. The Inter-American Geodetic Survey is currently providing resources to advance the programme.

An automated information system, the Geographic Names Information System (GNIS), was designed by USGS in 1975 to meet a need for a data base of official United States geographical names. GNIS is presently capable of providing basic information for about 2 million names used in the United States and its Territories. During the period of this report, activities at USGS have included a number of projects consisting of standardization of geographical names and the development and maintenance of the national GNIS. This included the development of procedures for the preparation of names data covering the United States-administered Trust Territory in the Pacific, for the complete automation of the Board on Geographic Names data base, and for the preparation of an abridged gazetteer of the United States. Other work involved utilization of GNIS in automated name placement and other activities supporting the National Mapping Program.

In November of 1982, the "New Jersey" volume was published as the first volume of the *National Gazetteer of the United States of America*. All volumes of the *National Gazetteer* will be published as parts of USGS Professional Paper 1200, including an abridged volume containing names of major places, features and areas of the United States. Each state gazetteer contains the official name, feature class, official status of the name, county in which it is located, geographic co-ordinates, elevation of place or feature, and the name of the USGS topographic map or the number of the NOS chart on which the feature is found.

DIGITAL CARTOGRAPHY

The application of computers to cartography and the growing potential of spatial data handling systems presents a formidable challenge in the 1980s to mapping agencies in the United States. The basic challenge over the reporting period has been to make efficient and effective use of advanced surveying and mapping systems technology in the solution of multifaceted earth science problems. Since the 1970s the functional needs of geographers, oceanographers, geologists, and other scientists and engineers have rapidly progressed toward systems capable of electronically generating special graphic displays of information that can be used for analysis, inventory or design. Prompted by this user need, progress has been made by United States mapping agencies during this reporting period in the development of procedures and techniques for merging other spatial data with conventional hypsographic and planimetric map information generated in the past.

The Secretary of the Interior directed USGS in 1979 to include digital cartographic data in the National Mapping Program and to address other agencies' needs for such data. The digital cartographic data were to be considered standard products of NMD, and procedures for distribution were to be developed to ensure availability to the public. A strong in-house research capability was developed to address basic and applied research issues. Since the then current state-of-the-art in data base management and computer technology did not permit an optimum system implementation, a phased development strategy was adopted to provide a series of optimized systems during the 1980s. Since that time USGS has been actively collecting data and responding to other Federal agency requirements for digital cartographic data.

In 1982, the Secretary issued further instructions assigning responsibility to USGS to establish and administer the National Digital Cartographic Data Base (NDCDB) and, in the Department of the Interior, to be the primary producer of base category digital cartographic data. One purpose was to achieve uniformity of data format and content, thus achieving a necessary degree of Federal standardization.

In 1983, the Director of the Office of Management and Budget issued a memorandum on "Coordination of Federal Digital Cartographic Programs" and the Federal Interagency Coordinating Committee on Digital Cartography was established. This includes a steering committee and various working groups, which are currently functioning to co-ordinate government digital cartography programmes in conjunction with the rapidly evolving technology.

The first phase of the digital cartographic system of the National Mapping Division of USGS has been completely installed and operating successfully since about 1982. It includes Altek digitizing tables in each Mapping Center together with Intergraph interactive data editing equipment and communication facilities for transmitting data to two central Amdahl 470 V/7-8 computers. Gerber 4477 and Versatec plotters and Perkin Elmer 3230 minicomputers are located at each Center. A major software system processes and structures the data for the centrally-managed NDCDB. Elevation data have been acquired principally with a Gestalt photomapper simultaneously with the production of orthophotos. Some provisional maps are being prepared using automated techniques, from digital data acquired during photogrammetric compilation, through interactive editing, to film separations being produced by a photoplotter.

The second phase of the system, called Mark II, is currently undergoing development. It will consist of several major improvements and reconfigurations of the current system as well as the procurement of several new systems.

Software and techniques are being developed with respect to raster-formatted data for digital cartographic applications. These efforts centre on the capabilities of a SCITEX map scanning and digitizing system. Developments have focused

primarily on automatic capture and editing of various categories of digital data. Procedures for the collection of hydrography and transportation networks at 1:100,000 scale are in place.

The USGS has entered into a major co-operative programme with the United States Bureau of the Census to produce by 1987 a 1:100,000-scale data base containing hydrography and transportation data for use in the 1990 Decennial Census of Population and Housing. The creation of this data base will have a major impact on digital cartography, automation of the mapping process, and the development of geographic information systems.

During this reporting period USGS entered about 9,750 digital elevation models (DEM) and about 19,600 digital line graphs (DLG), mostly from 1:24,000-scale maps, into the NDCDB. In addition, data from the map separates of 1:2,000,000-scale sectional maps in the *National Atlas* were produced to meet the need for a small-scale digital data base covering the entire United States. The 1:2,000,000-scale data categories include civil boundaries, Federal lands, roads and railroads, hydrographic features, populated places, and such miscellaneous cultural features as airports.

Digital cartography systems for nautical and aeronautical chart production, maintenance, and distribution continue to be developed by NOS. Nautical charting software has now been developed and installed to perform automated selection of soundings critical to navigation, background soundings to portray the bottom configuration, and information about natural channels including least depth.

Investigation at NOS is continuing on contouring algorithms; the present method tends to generalize in areas of great relief. Further, work has begun on the interactive editing of soundings and contours by allowing the cartographer to make final selections at the AIS work station.

DMA continues to produce digital data products for use in flight simulation. Information on cultural and natural surface features and on vertical obstructions to low-level aircraft flight is stored in digital form and displayed as digital graphics.

Elevation data are an integral part of almost all DMA products, usually in the form of a matrix of digital terrain elevation data. Except where adequate data already exist, DMA has generated elevation data from aerial photographs by photogrammetric stereo-compilation. This process is now done using automated stereo-correlation techniques on the Universal Automatic Map Compilation Equipment (UNAMACE), developed and introduced some 15 years ago, the Advanced Compilation Equipment (ACE) epipolar scanning stereo-plotter, and most recently the UNAMACE upgrade.

Rapid developments in computer technology, particularly in the area of digital image processing, indicate that the greatest opportunity for advancing the DMA capability for elevation data collection (as well as for feature analysis) lies in the development of a Digital Image Exploitation System. Components of the system will include (*a*) a universal rectifier (UR), which will accept digital imagery in various forms, rectify the imagery if desired, and convert the digital imagery to film; and the Advanced Image Digitizing System (AIDS), which will rapidly scan film imagery and output that imagery in digital form; (*b*) a digital stereo-comparator/compiler (DSCC), capable of using digital imagery from the AIDS or UR and performing such operations as stereomensuration, stereo-compilation, and automatic elevation data collection.

Annexes I, II and III contain information on selected digital cartographic capabilities and systems supplied by the principal Federal agencies that have contributed to the present report. The agencies themselves should be contacted for additional information on their activities.

ANNEX I

Defense Mapping Agency Automated Cartography/Hydrography

A *SCITEX 250 Response Mapping System*

The Defense Mapping Agency (DMA) has acquired a SCITEX-250 Response Mapping System which consists of four editing stations, a scanner and a laser plotter. The system can scan up to twelve colours simultaneously and will produce photographically ready plates. The SCITEX production capabilities include the preparation of final manuscripts and generation of open-window masks.

B *Advanced Cartographic Data Digitizing System*

The recently acquired Advanced Cartographic Data Digitizing System (ACDDS) has one host computer and four work stations. Two additional work stations are being purchased to increase DMA's automated chart compilation capabilities.

Chart 62097 was the prototype for the first automated compilation. The ACDDS is used for the processing of hydrographic source data. Improved type placement software has been developed for the ACDDS and the CRT Printhead Plotter. Hydrographic data gathered on the ACDDS is subsequently colour-separated on the CRT Printhead Plotter.

C *Second Image Processing System*

The Second Image Processing System (SIPS), including software, is designed to exploit LANDSAT imagery for hydrographic charting applications. It will provide the Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC) with the capability to exploit digital LANDSAT-MSS and TM data, as well as other remote sensor data, to detect, position, and delineate heretofore unknown navigation hazards, and to update information relative to known, but poorly described or positioned, hazards.

D *Voice digitizer*

A voice digitizer is in use for recording bathymetric data in DMA. An operator whose voice pattern has been previously stored in the computer's memory can have both hands free while reading off bottom-depth soundings. While presently limited to sounding data, the system has been demonstrated to accept other kinds of information, natural features (such as reefs) and man-made objects (buoys, piers, wrecks).

E *Computer plotting program*

A number of special computer programs have been developed for specific plotters. These include programs for projection, graticule, grid, magnetic declination and, optionally, the plotting of geodetic control on the Concord plotter.

F *Other support systems and equipment*

1 *Electronic beam recorder*

An electronic beam recorder has been developed to permit electron beam exposure of both vector and raster digital data to five micrometre accuracy on 70 millimetre and 125 × 200 millimetre film.

2 *Automated-type placement*

The Engineer Topographic Laboratories at Fort Belvoir, Virginia, has implemented an automated-type placement system at DMA. The system comprises keyboards and digitizing tables to key and position the names, plus cathode-ray tube printheads attached to precision plotters for exposing them.

3 *Automated Graphic Digitizing System*

The Automated Graphic Digitizing System (AGDS) is a major production support system for the collection of large volumes of digital cartographic data. Tedious and time-consuming manual digitizing is largely

replaced by high-resolution scanning techniques. The system contains a processor dedicated to the task of vectorizing the new raster data. The AGDS also contains several powerful interactive editing subsystems allowing for CRT verification and real-time feature tagging and file update.

4 *Cathode-ray tube printhead*

A high-resolution cathode-ray tube is mounted on a Gerber Model 32 precision plotter. This procedure is designed to produce colour-separated film sheets from digital names/symbols data. The system accesses digital type alphanumerics and symbols stored on magnetic disc to electronically draw a raster representation of each character or symbol, thus eliminating off-line photocomposition of characters or symbols.

5 *Digital Ortho-Rectification Program System*

The Digital Ortho-Rectification Program System (DORPS) is designed to compute the horizontal ground positions of selected features (points or lines) which have been digitized from unrectified photographs.

6 *Versatec Plotter Model 9-1600*

The Versatec Model 9-1600 electrostatic plotter plots as a raster scan electrostatically as opposed to a vector pen plotter. Electrostatic plotting speed is unaffected by data density and is about 20 times faster than a pen plotter. The Versatec will be used primarily to verify very dense terrain elevation profiles.

7 *Verification/Colour-Separation Plotter*

The Verification/Colour-Separation Plotter (V/CSP) system will support both automated cartography and digital data production. It will accept, as input, magnetic tapes produced by various data collection equipment or by the SPERRY 1100 systems. Verification plots will be produced with ink on plastic or paper. Final product colour-separated plots on scribecoat or optical materials can also be produced.

8 *Advanced Edit System*

The Advanced Edit System (AES) is an automated cartography system developed for digital data and chart production. The system provides the ability to digitize and edit chart and digital products and to symbolize and plot chart data. The AES has the interactive capability to edit symbolized and centre-line digital data in various digital formats. These formats are read into the internal design file of the system, interactive editing is performed, and the data are outputted to a film plotting device.

9 *Cartographic Compilation/Revision System*

It is intended that the Cartographic Compilation/Revision System (CC/RS) should provide compilation, recompilation, and revision capabilities by interacting with the digital chart data in Standard Linear Format (SLF). It will compile, recompile, or revise the chart features to bring them into agreement with the latest horizontal, vertical and feature information. Source material will be either photographic, cartographic or digital. The CC/RS will interface with the Clustered Processing System and various colour-separation and proofing plotters.

10 *Clustered Processing System*

The Clustered Processing System (CPS) is specially designed to perform all post-processing functions required to produce Digital Feature Analysis Data (DFAD). The functions include automatic panelling, merging and validation of data sets, and also interactive graphic editing of data sets. The CPS controls all system resources and data sets with sophisticated management and information control software.

ANNEX II

Selected USGS Digital Mapping Systems

(Abstracted from *Alpha Study*, June 1981)

M&S	digital map data editing systems
SCITEX	scanner and editing subsystem: two-colour large-format graphic drum scanners; two-colour raster editing systems
SCITEX	plotting subsystem: one large-format black-and-white drum plotter
GIRAS	Geographic Information Retrieval and Analysis System: to edit, verify and structure digital land-use data
UCLGES	Unified Cartographic Line Graph Encoding System: to capture, in a structured form, digital line graph data
DCASS	Digital Cartographic Software System: to capture and edit from stereomodel digitizing
DEMRS	resampling software for DEM data
CAM	plotting and projection package using World Data Bank I and other data to produce graphic products
DCDB	file management system using System 2000
Datapoint	intelligent data communications terminal and distributed file management system (5)
Altek	manual digitizing systems; angle digitizer, for map symbols
Gradicon	manual digitizing systems
Gerber	0 001" high-precision digital flatbed plotter (1 EMC) and 0 003" medium-precision large-format digital drafting machine
Versatec	electrostatic printer/plotters
Kongsberg	map-symbol-plotter
Calcomp	large-format flatbed plotter and Model 1055 four-pen, drum plotter with Model 967 controller
GPM	automatic image correlation digital elevation matrix generators
Perkin-Elmer	general-purpose 32-bit minicomputer systems
SEL	32/55 general-purpose minicomputer

ANNEX III

National Ocean Service Integrated Digital Photogrammetric Facility

Development of the Integrated Digital Photogrammetric Facility (IDPF) began in 1984. The development of the IDPF was spurred owing to the increased emphasis within the National Ocean Service (NOS) and the mapping and charting community in general on digital charting products and production techniques. When developed, the IDPF will provide an environment for efficiently producing and managing digital photogrammetric compilation source data in support of the NOS digital charting programs.

The IDPF programme has as its goals the following:

(*a*) To develop a highly integrated and automated photogrammetric environment based on analytical plotters, computer graphics, and data base technologies;

(*b*) To provide the capability for computer-assisted image point transfer, stereoscopic superimposition of digital cartographic data through analytical plotter viewing optics, photobathymetry, and photogeodesy;

(*c*) To accommodate nonconventional photographic sensors such as the large-format camera (LFC), panoramic photography, strip photography, radar and video imagery.

The initial phase of the IDPF development is currently undergoing operational testing. This phase has involved the development of new analytical plotter operating software and a provisional data base in order to improve the capabilities of the current photogrammetric resources. These enhancements are currently demonstrating:

(*a*) A capability for rapid instrument setup during triangulation and compilation operations;

(*b*) An improved aerotriangulation capability resulting from advanced data collection and data handling techniques;

(*c*) An automated data management capability at the project level that is significantly reducing the requirement for manual data handling;

(*d*) An improved consistency and accuracy of photogrammetric output through the use of rigorously computed parameters for instrument settings.

Future phases of IDPF development will bring all aspects of the aerotriangulation process on-line and provide a system capable of handling standard as well as unconventional applications; fully develop the capability of stereoscopic superimposition; and create a network of analytical stereo-plotter work stations integrated around a state-of-the-art data base management system.

AGENDA ITEM 5

Review of the latest technology and its relationship to policy, economy and development in cartographic data acquisition and supporting activities

(a) *Conventional and satellite geodesy*

ESTABLECIMIENTO DE LA RED GEODESICA SATELITAL EN LA ZONA AUSTRAL DE CHILE COMO ESTRUCTURA BASICA PARA EL CONTROL FOTOGRAMETRICO*

Documento presentado por Chile

SUMMARY

The climate and difficult terrain of the southern zone of Chile have been a serious obstacle to the planning and execution of geodetic work by traditional means; until 1975 this was reflected in an inability to cover the national territory with a first-order trigonometric network that would support the field-work required as a pre-condition for photogrammetric checking of maps of this area, which extends from 43°30′ to 56°00′ south latitude.

The terrain in this zone is of the archipelagic-Andean type; in other words, it is broken up into numerous islands which form a unit when taken together with the channels, fjords and rivers generated by the strong forces of glacial erosion that have greatly affected the territory from the forty-first parallel south.

Thus, this type of terrain is extremely inaccessible, since its coasts meet the water in sheer, rugged cliffs; the relief is markedly Andean in type with climatic conditions that are normally very rigorous at this latitude.

With the placing in orbit of artificial satellites for geodetic purposes, the meteorological and topographical factors that had always directly affected the execution of field-work for compiling maps have now ceased to be a significant problem.

It should be noted that there was a similar effect from the introduction of photogrammetry, analytical systems and the programmes of aerotriangulation developed by Professor F. Akerman, which enabled photographic blocks to be prepared using 300 independent models and measurements.

Account should also be taken of the valuable assistance given by the Inter-American Geodetic Service in planning the work and in providing the photogrammetric coverage.

In achieving what was planned, some interesting results were obtained: the most notable were the expansion of memory registers, in the Zeiss C-113 Planicomp, which enabled 504 models to be adjusted independently; the transfer of

* The original text of this paper appeared as document E/CONF.77/L.44

RÉSUMÉ

Le climat et la configuration complexe de la partie australe du Chili rendent extrêmement difficiles la planification et l'exécution des travaux de géodésie classique, si bien que, jusqu'en 1975, il a été impossible de couvrir le territoire national d'un ensemble de points du premier ordre destiné à appuyer les opérations au sol préalablement requises pour effectuer le canevas photogrammétrique dont dépend l'équipement cartographique de cette région, qui s'étend entre 43° 30′ et 56° de latitude sud.

Le paysage propre à cette zone est du type archipel andin, c'est-à-dire que l'on est en présence d'un territoire morcelé en un grand nombre d'îles qui constituent une unité géographique avec les chenaux, les fjords et les fleuves créés par les processus d'érosion glacière qui ont profondément marqué le territoire à partir de 41° de latitude sud.

Il découle de ce type de paysage qu'il est très difficile d'avoir accès au terrain car le passage des côtes aux eaux est brutal, les pentes sont abruptes et le relief fortement andin est encore aggravé par les conditions climatiques généralement plus rigoureuses sous cette latitude.

A l'heure actuelle, grâce à la mise en orbite de satellites géodésiques, les facteurs météorologiques et topographiques, qui ont longtemps gêné les opérations au sol, ne constituent plus un obstacle insurmontable.

Il ne faut pas oublier non plus l'importance de l'utilisation en photogrammétrie des systèmes d'analyses et des programmes d'aérotriangulation mis au point par le professeur F. Akerman, qui ont permis d'effectuer la compensation des blocs de bandes de clichés établis pour près de 300 modèles et mesurés de façon indépendante.

Il importe également de rappeler l'aide précieuse fournie par le Service géodésique interaméricain en vue de la planification des travaux et de la réalisation de la couverture photogrammétrique.

Lors de la phase d'exécution, on a pu réaliser d'intéressantes expériences dont les plus remarquables ont été l'extension des registres de mémoire du Planicomp C-113 (Zeiss), qui a permis de corriger 504 modèles de façon indépendante; le transfert de points photographiés à l'aide de chambres métriques de 35 mm depuis des hélicoptères sur des photogrammes au 1/60 000, qui a donné d'excellents

photographs taken of points by means of 35-mm cameras on board helicopters to photogrammetric images at scale 1:60,000, which provided excellent results; and the accuracy achieved through the use of geo-receptors and various measurement procedures.

All these factors, supplemented by the excellent and modern instruments of the Military Geographical Institute of Chile, have enabled cartographic coverage to be obtained at scales 1:50,000 and 1:100,000 of the southern zone of Chile, which is characterized by some of the most adverse conditions in the world.

résultats; et les précisions obtenues à l'aide de récepteurs et de diverses méthodes de mesure.

Tout ce qui précède, ainsi que la qualité des instruments modernes dont dispose l'Institut géographique militaire du Chili, a permis d'obtenir une couverture cartographique au 1/50 000 et au 1/100 000 de la partie australe du Chili —une région qui figure parmi les plus difficiles à cartographier dans le monde.

La zona austral del territorio chileno se caracteriza por una integración de factores geográficos, morfológicos y climáticos que han dado como resultado la generación de un paisaje fuertemente accidentado, especialmente hacia la zona occidental, que está constituida básicamente por el emplazamiento del Macizo Andino Magallánico, que se extiende a lo largo de la vertiente occidental del territorio continental occidental y sur, Tierra del Fuego e islas menores.

El paisaje es del tipo archipiélago-andino, es decir, está constituido por un territorio desmembrado en numerosas islas que constituyen una unidad con los canales, fiordos y ríos generados por los fuertes procesos de degradación glaciaria que han afectado profundamente al territorio desde el paralelo 41° latitud sur hasta el territorio antártico.

De esta manera, la accesibilidad en este tipo de paisaje es de alta dificultad, debido a que sus costas son de brusco contacto con las aguas y con abruptas pendientes, agravado todo lo anterior por condiciones muy rigurosas de clima en esas latitudes.

La difícil topografía presentada en el sector occidental cambia bruscamente hacia el oriente, donde predomina el relieve plano, con algunas colinas o cordones de cerros menores cuya altitud no va más allá de 20 a 50 metros en muchos kilómetros de superficie, lo cual obviamente constituye un factor de alta dificultad para las mediciones geodésicas, acompañado por niveles freáticos normalmente altos, generándose vegas, pantanos y turberas que impiden o limitan fuertemente el desplazamiento.

Todo lo antes mencionado ha constituido un serio obstáculo en la planificación y ejecución de los trabajos geodésicos por métodos tradicionales, lo cual impidió hasta 1975 cubrir el territorio nacional con una red trigonométrica de primer orden que sirviera como apoyo a los trabajos de terreno que se requieren como condición previa en el control fotogramétrico de la cartografía del área que se extiende desde los 43°30′ hasta los 56°00′ de latitud sur.

Actualmente, gracias a la puesta en órbita de satélites artificiales con fines geodésicos, los factores topográficos y climáticos, que a lo largo del tiempo afectaron en forma directa la ejecución de los trabajos de terreno para elaborar la cartografía, han dejado de constituir un problema significativo.

Al mismo tiempo es importante hacer presente que igual influencia tuvo la puesta al servicio de la fotogrametría de sistemas analíticos y los programas de aerotriangulación desarrollados por el profesor F. Akerman, que permiten ajustar bloques fotográficos compuestos por hasta 500 modelos y medidos independientemente. Además, es necesario dejar constancia de la valiosa ayuda que proporcionó el Servicio Geodésico Interamericano (IAGS) en la planificación de los trabajos y en la entrega de la cubierta fotogramétrica de algunos sectores.

Planificación realizada para materializar la red geodésica satelital

Determinación de zonas y escalas a emplear

Considerando la necesidad de contar con la cartografía regular en el total del país, se efectuó un estudio acerca de las escalas que se emplearían para representarlo de acuerdo a la importancia económico-social de cada parte del territorio nacional y a la cubierta fotográfica que se tenía en esos momentos. Fue así que se determinó que:

a) Desde los 17°30′ hasta los 43°30′ de latitud sur se confeccionarían 951 hojas a escala 1:50 000;

b) Desde los 43°30′ hasta el Cabo de Hornos sería cubierto con 592 unidades, constituyendo esta última la cubierta cartográfica de la zona austral de Chile.

En esta zona se consideró el empleo, en una primera etapa, de la escala 1:50.000 en aquellas zonas potencialmente económicas y que el uso de suelo así lo justificase, y la escala 1:100.000 en aquellas zonas de baja incidencia en el Producto Geográfico Nacional, tales como islas, campos de hielo, etc., las cuales fueron predeterminadas en la planificación de detalle (véase figura 30).

Formato de las hojas

El formato de las hojas sería:

a) Escala 1:50.000:
   i) Desde los 43°30′ a los 50°00′ de 15′ × 20′;
   ii) Desde los 50°00′ a los 56°00′ de 15′ × 22′,5;

b) Escala 1:100.000:
   i) Desde los 43°30′ a los 50°00′ de 30′ × 40′;
   ii) Desde los 50°00′ a los 56°00′ de 30′ × 45′.

Parámetros de la cartografía

Para ambas cartografías se emplean los siguientes parámetros:

a) Proyección Universal Transverse Mercator (UTM)

b) Elipsoide de referencia: Internacional de Hayford

c) Datum geográfico: South American Datum (SAD) "CHUA" 1969

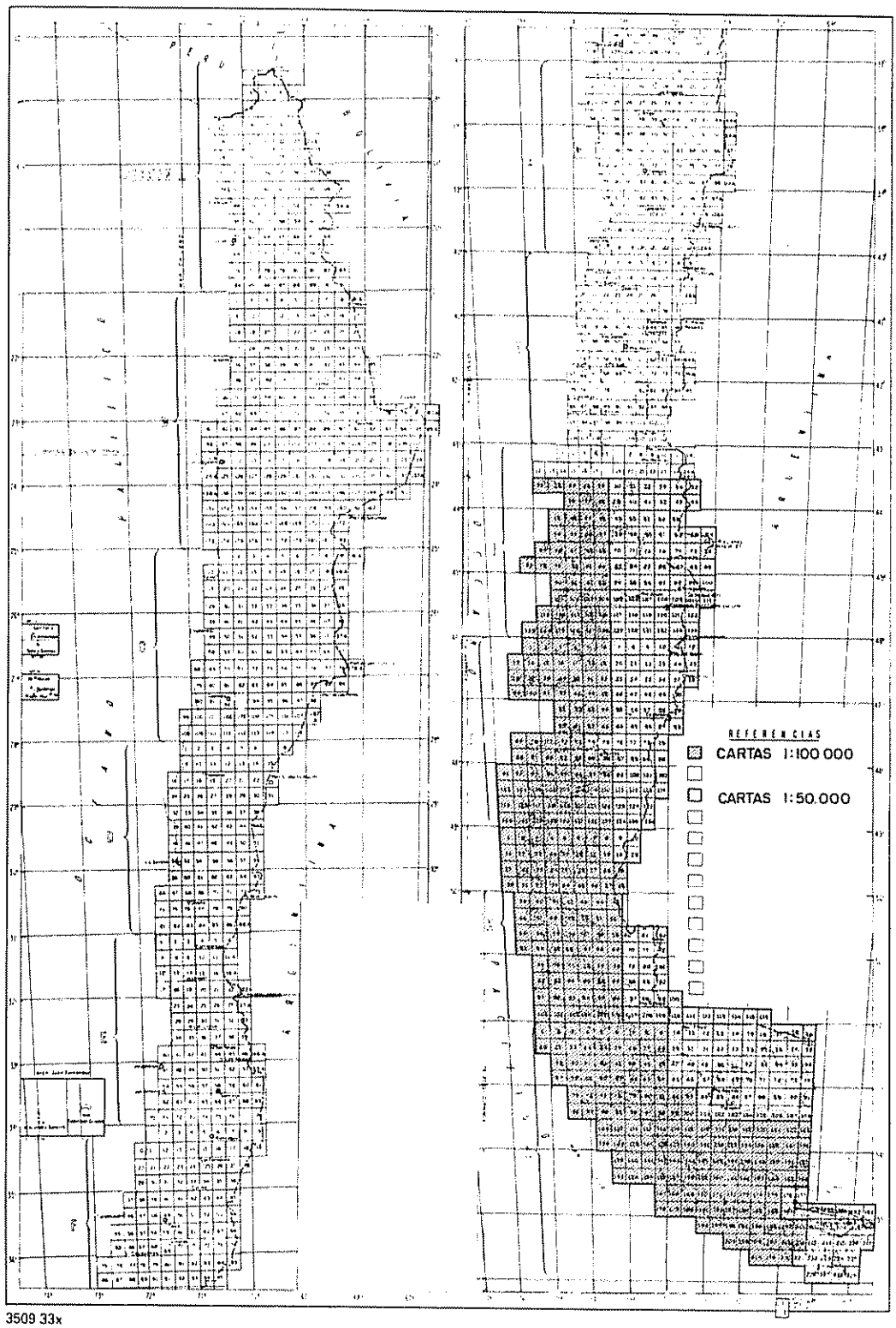
d) Datum altimétrico: Nivel medio del mar.

e) Huso: Las hojas adyacentes a los 72° longitud W. límite entre las bandas UTM de los husos 18 y 19 llevarían las cuadrículas correspondientes a los dos husos, teniendo como básica la del huso al que realmente pertenece la hoja.

Medición de coordenadas de estaciones

El establecimiento de coordenadas y alturas de las estaciones terrestres que se necesitaron, debieron ser determinadas mediante el empleo de los instrumentos JMR o Georeceiver, mediante el registro de los pasos de los satélites geodésicos en órbita, procedimiento similar al que se deba utilizar para el levantamiento del territorio antártico y de

Figura 30. Chile: Cartografía regular de la zona austral, escalas 1:50.000 y 1:100.00



FUENTE: Instituto Geográfico Militar

las islas esporádicas, e incluso en aquellos levantamientos especiales requeridos en sectores alejados de la red de triangulación principal.

Proyecto de plan de trabajo

Mediante la confección de un Plan Decenal se establecieron premisas básicas sobre los cuales se basaría el trabajo posterior. Ellas fueron:

a) La zona quedaría cubierta con una adecuada cubierta fotogramétrica durante el inicio del decenio que cubre el plan;

b) Una vez que estuviese disponible el vuelo, se efectuaría un análisis fotointerpretativo de las áreas que serían cubiertas a escalas 1:50.000 y 1:100.000;

c) Por no disponer de la cubierta fotográfica necesaria para efectuar el estudio preliminar de costo, se planificó sobre la base hacer el levantamiento de 78 hojas a escala 1:100.000;

d) Las coordenadas, alturas y otros parámetros de medición fueron aquellos que ya se mencionaron;

e) La cantidad de cartografía 1:50.000 de la zona austral, que, como ya se dijo, es de 592 hojas, inicialmente se consideró sólo en aquellas zonas de gran interés económico y que alcanzaban a 197 hojas.

Determinación de la cantidad de puntos que integran la red

Con la colaboración del IAGS, se efectuó un estudio preliminar para determinar la cantidad de puntos de apoyo mínimo para el levantamiento total del área, cifra que alcanzó a 230 puntos desde los 43°30′ de latitud sur.

En base a esto y a la cantidad de hojas se subdividió el área en cinco sectores prioritarios para medir (véase figura 31).

Reconocimiento y clasificación

Además de las mediciones de terreno para obtener las coordenadas y alturas, se consideró una clasificación de terreno detallada en aquellas zonas a levantar, dependiendo de la escala, y que se efectuaría junto con el establecimiento de los puntos Doppler.

Toma de las fotografías aéreas

El completar el Plan de Cartografía Nacional para la zona austral que comprende 229.000 km² es objetivo prioritario del Supremo Gobierno. Tomando en cuenta esto, la Agencia de Cartografía para la Defensa (DMA) promovió la contratación de la toma de fotografías aéreas de casi un 50% de la zona, acción que fue llevada a efecto por el Mark Hurd Aerial Survey (USAF) hasta 1975 (véase figura 32). A partir de esa fecha, el Servicio Aerofotogramétrico de la Fuerza Aérea de Chile ha continuado desarrollando este plan hasta su término total.

MATERIALIZACIÓN DE LOS TRABAJOS

Planificación

Considerando las capacidades que tiene el Navy Navigation Satellite System y aquellos propios de la fotogrametría, se planificó la toma de fotografías consistente en 26 líneas de vuelo y 504 modelos a escala 1:60.000, y que comprendió el sector denominado "sección I, block II", ubicado entre los 43°30′ y los 44°45′ de latitud sur. Se eligió esa zona debido a que existían puntos trigonométricos pertenecientes a la Red Geodésica Nacional que servirían como Puntos de Control Fotogramétrico y de enlace con los Puntos Doppler que se establecerían (véase figura 33).

Mediciones de los puntos Doppler

Como una forma de entrenar a los operadores de los instrumentos, se hicieron mediciones en Isla de Pascua, en el Astronómico San Cristóbal y otras estaciones de primer orden en la zona central del país.

En forma posterior y con el objeto de amarrar satelitalmente la Red de Triangulación Principal a las mediciones de la zona austral, se establecieron puntos Doppler sobre tres astronómicos ubicados en los 33°, 36° y 41° de latitud sur, aproximadamente.

En 1977, mediante el empleo de cuatro instrumentos JMR-1 del IAGS y a partir de 1970 con cuatro Satellite Surveyor MX-1502, de propiedad del Instituto Geográfico Militar, se han medido 150 estaciones Doppler y la gran mayoría con sus marcas de azimut, determinado con el giroteodolito MOM y GIMO.

Para la medición de estos puntos, aquellos de primer orden se han medido con 40 pasos de satélite y los secundarios con 12 pasos, utilizando los sistemas de traslocación, posicionamiento en un punto y arco corto.

Considerando el posterior procesamiento y compensación en bloques de los puntos de terreno y aerotriangulados, el trabajo de terreno se sectorizó en bloques, coincidiendo éstos con los bloques de compensación analítica.

En aquellas ocasiones en que existió visibilidad entre puntos seleccionados como estaciones Doppler, se eligió aquel que mediante sus coordenadas permitiese obtener por métodos clásicos la medición de otros puntos de apoyo, utilizando giroteodolitos y distanciómetros electrónicos, con los cuales se densificó la red en la sección I, block II, alcanzando a seis puntos de control y 78 puntos de apoyo.

Las condiciones de terreno y clima de esa zona, ya descritas anteriormente, obligaron a hacer uso intensivo de medios aéreos (helicópteros) para el traslado de operadores y equipo, como así también para la obtención de imágenes del punto marcado mediante paineles con una cámara de 35 mm y a una altura de 6.000 pies aproximadamente, lo que permitiría efectuar el traspaso de puntos.

Para la determinación de los puntos se emplearon:

a) Cuarenta pasadas de satélite y 10 días de trabajo en total para aquellos de primer orden o que fuesen puntos de salida de poligonales;

b) Doce pasadas secuenciales y tres días para los secundarios o puntos de apoyo.

Lectura de las cintas

Utilizando programas computaciones tales como el MX LIST (que lista el contenido del cassette), MAGNET (que efectúa el cálculo de posiciones geográficas a partir del Datum Satelitario) y otros utilizados en sistemas computacionales afines, se entregaron los datos necesarios para efectuar el ajuste, que en principio se planificó en bloques de hasta 270 modelos.

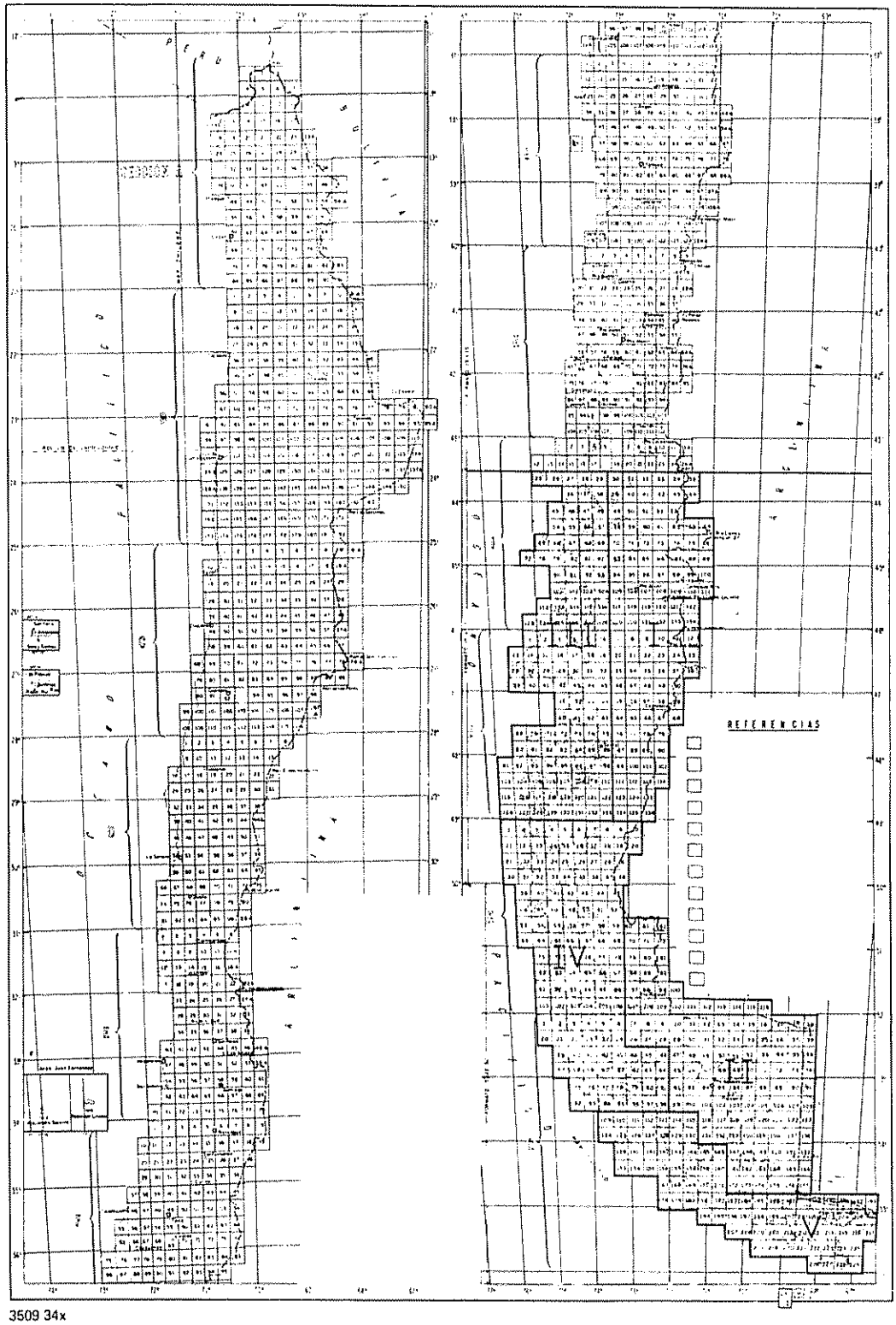
Compensación y aerotriangulación analítica

La zona austral se preparó para efectuar la aerotriangulación utilizando el monocomparador MC 102 (WILD), la transferencia de puntos en el PUG IV (WILD) y ejecutando el ajuste de bloque mediante el programa GIANT.

La lectura de puntos se efectuó utilizando el monocomparador MC 102, actividad que se efectuó con la asesoría del IAGS en cuanto al proceso de pinchado del apoyo y aerotriangulación.

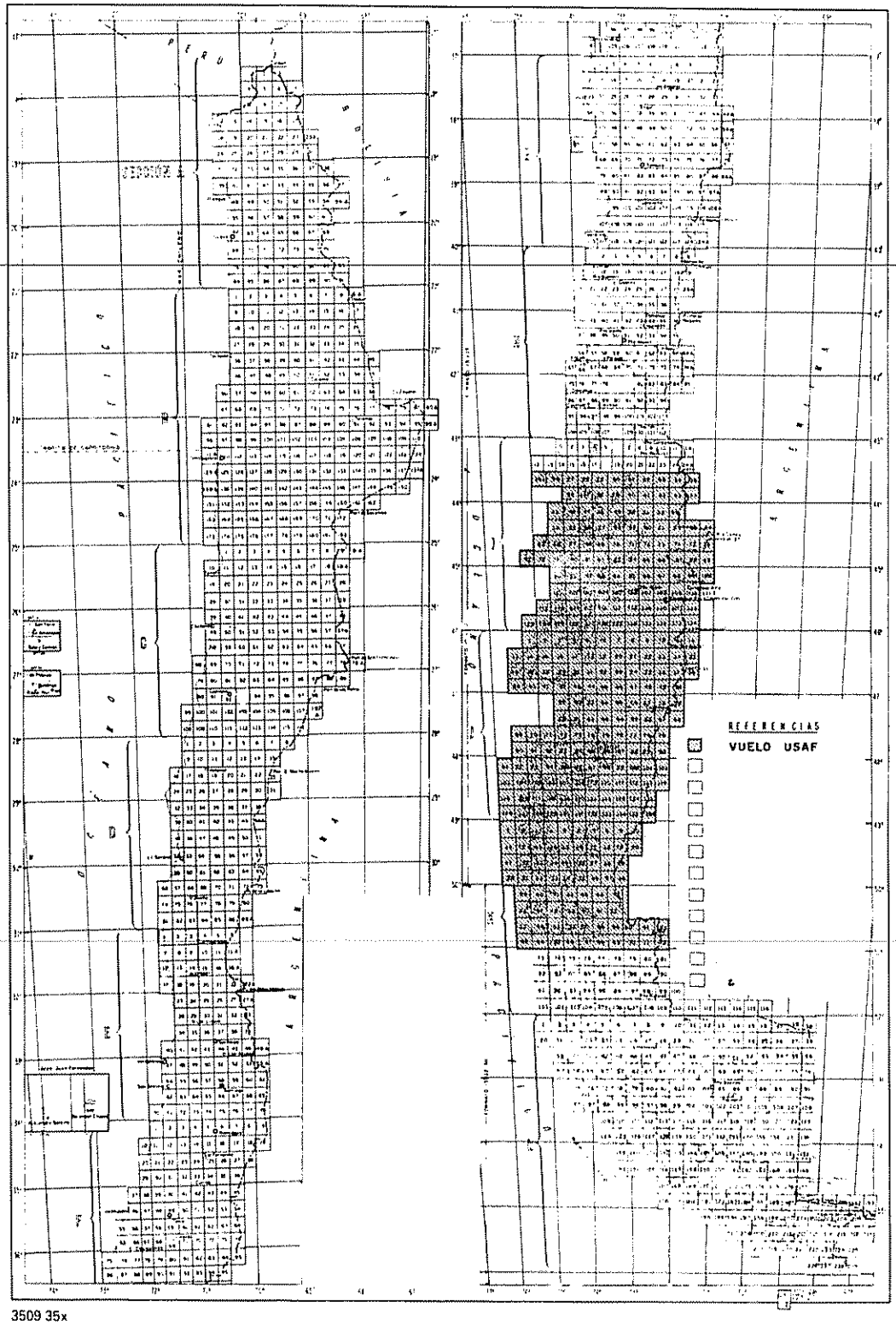
El control y la transferencia de puntos se efectuaron en el Pug IV, que, mediante el uso del *zoom*, permitió transferir

Figura 31. Chile: Cantidad de puntos de apoyo mínimo para el levantamiento total del área



FUENTE: Instituto Geográfico Militar

Figura 32. Chile: Fotografía aérea de la zona austral



FUENTE: Instituto Geográfico Militar

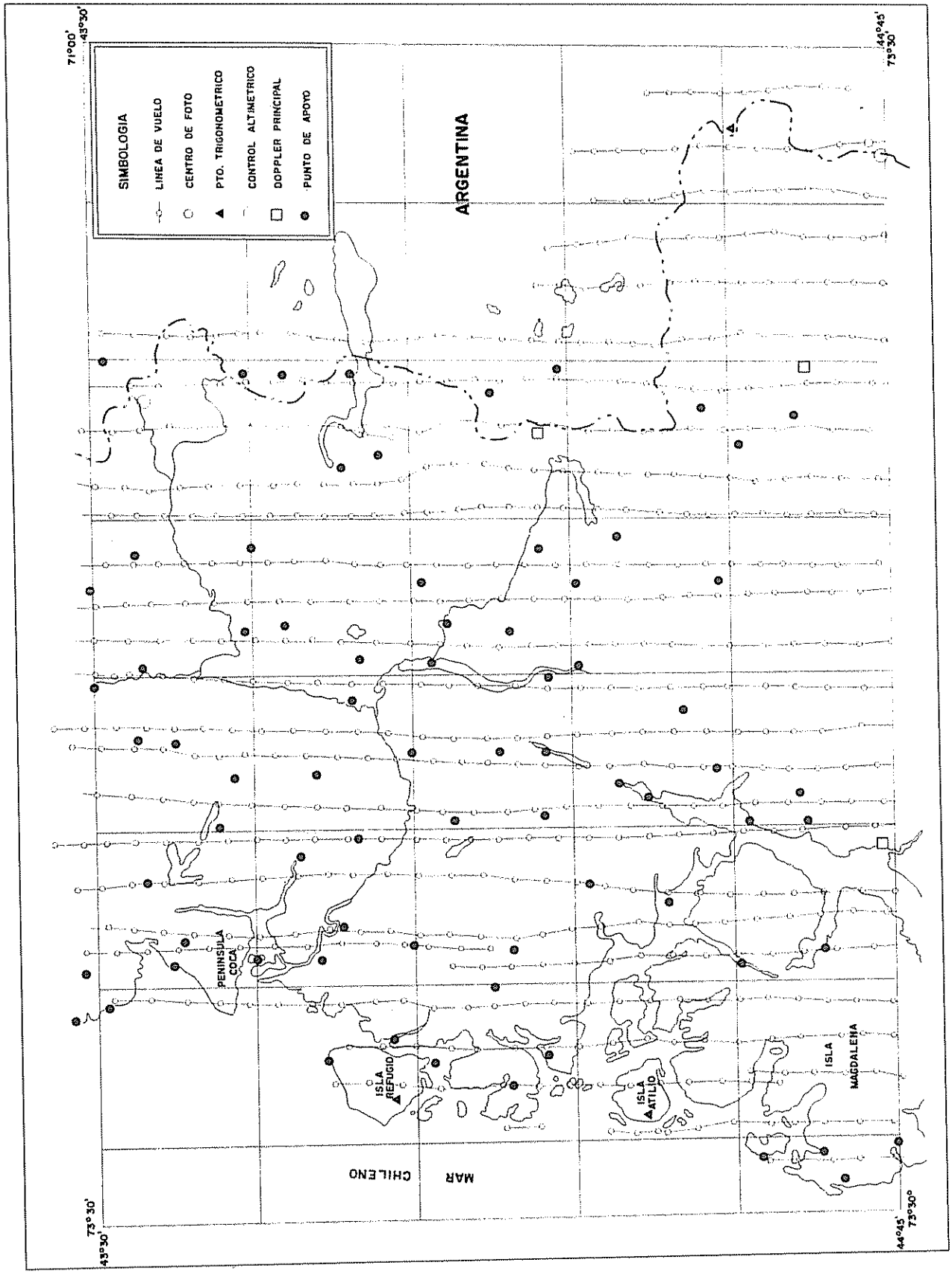


Figura 33. Chile: Zona austral, sección I

de las fotografías 35 mm tomadas desde helicópteros a los fotogramas 1:60 000, actividad que hasta la fecha se sigue realizando y que ha dado excelentes resultados

Todas las mediciones efectuadas se perforaron en el Centro de Computación de la Universidad de Chile para ser ordenadas por el programa GIANT y procesadas para su ajuste en el IAGS (Texas, Estados Unidos de América)

Durante el transcurso de estos acontecimientos, el Instituto Geográfico Militar de Chile adquirió el sistema Planicomp C-113 de Zeiss, por lo que decidió efectuar la aerotriangulación y ajuste en ese sistema, empleando las mismas fotografías preparadas para el monocomparador y por el método de modelos independientes

Debido a que el bloque constaba de 504 modelos y el programa PAT-M43 podía ajustar solamente hasta 300 modelos como máximo, se estudió la posibilidad de ampliar la capacidad del sistema, lo cual se hizo con la participación de la empresa Zeiss, formateándose nuevamente los sectores de los discos y aumentando la capacidad hasta más de 500 modelos.

El ajuste de este bloque tan grande dio excelentes resultados, obteniéndose las precisiones necesarias para el levantamiento de la cartografía regular

Precisiones y tolerancias

Las normas de precisión en la elaboración de la cartografía regular en la zona austral están definidas en los siguientes conceptos:

a) Planimétricos: El 90% de los elementos bien definidos o constituidos, a excepción de los que estén desplazados por la simbología con los cuales se representa, deben estar colocados con una tolerancia de 0,51 mm de su proyección geográfica en relación a la proyección del mapa, no pudiendo desplazarse más de 1,3 mm, lo que significa en la escala 1:50 000 una tolerancia de 25 m aproximadamente. Además, todo trazo en la carta es posible de medir (recuperable en el terreno) hasta los 0,25 mm.

b) Altimetría: El 90% de todas las curvas de nivel y elevaciones interpoladas de curvas de nivel deben tener una exactitud de ¼ del intervalo de las curvas de nivel básicas.

Resultados obtenidos mediante posicionamiento satelital por el Instituto Geográfico Militar en la cubierta cartográfica

Mediciones de terreno. Utilizando los instrumentos georreceptores Magnavox MX 1502 y los procesos computacionales del Sistema PDP 11/70 DIGITAL, las precisiones obtenidas luego de utilizar los procedimientos *point positioning*, traslocación y arco corto son los siguientes:

a) Point positioning (54 pasos) ± 1,50 m en X, Y, Z;

b) Traslocación (18 pasos) ± 0,50 m en X, Y, Z con un punto Master;

c) Arco corto (18 pasos) ± 0,30 m en X, Y, Z con dos puntos Master.

Como ejemplo se puede expresar que el punto astronómico "Lynch" fue medido satelitalmente (Doppler No. 43123) con un error medio cuadrático de ± 0,38 m mediante traslocación con "Fuerte Bulnes", y, recíprocamente, "Fuerte Bulnes" (Doppler No. 43127), con un error medio de ± 0,36 m mediante traslocación con "Lynch".

Error de marcado de puntos. Es originado por la dificultad para posicionar plenamente la marca flotante del Instrumento de Traspaso de Puntos (PUG IV) sobre el mismo detalle en fajas continuas

Por falta de antecedentes muestrales, se ha considerado que un 1‰ de los pinchados tienen un error mayor que 40 micrones. Luego, por cálculo de probabilidades, podemos decir que el error medio por marcado de puntos es de 13 micrones a la escala de la fotografía empleada.

Error instrumental. La precisión del Sistema Planicomp es de 4 micrones en planimetría y de 0,04% de la altura de vuelo en altimetría.

Error del operador. Se genera en la dificultad de colocar la marca flotante exactamente sobre el detalle y tiene un valor de 20 micrones en planimetría y 0,15‰ de la altura de vuelo en altimetría.

Precisión final obtenida. Si se considera que la escala de la cartografía es 1:50 000 y obtenida desde fotogramas 1:60 000, su error medio cuadrático es:

a) Altimetría: ± 1,91 m

b) Planimetría: ± 1,27 m

y que corresponde a un tercer orden geodésico.

Extensión a toda la zona austral y conclusiones

Una vez que fueron analizados los resultados obtenidos utilizando los métodos y elementos ya mencionados, se decidió continuar el Plan Decenal hasta completar la totalidad de la zona austral de Chile.

La capacidad de su personal, el moderno instrumental con que cuenta y la experiencia adquirida permitirán que el Instituto Geográfico Militar de Chile complete a corto plazo la cubierta cartográfica 1:50 000 y 1:100 000, tal cual fue inicialmente planificada.

A la fecha se han medido 150 de los 230 puntos de control planificados, trazado el 65% de las hojas y obtenido casi el 95% de la cubierta fotogramétrica de esa zona, de tan difíciles condiciones.

La utilización de estos métodos ha permitido un menor gasto de un 50% en comparación con métodos clásicos puros, que por la configuración del terreno serían casi imposibles de emplear.

Como conclusión final se puede establecer que la red creada mediante posicionamiento satelital, como apoyo al control fotogramétrico, ha dado los resultados esperados con precisiones suficientes para la elaboración de la cartografía en una de las zonas de características geográficas más difíciles del mundo.

THE MODULAR TRANSPORTABLE LASER RANGING SYSTEM AND ITS APPLICATION IN DETECTING EARTH PLATE MOTION*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Le rapport décrit la configuration d'un système mobile de télémétrie des satellites par laser MTLRS-1 ainsi que les premiers résultats obtenus

Il s'agit d'un système transportable de conception modulaire qui permet différentes configurations pour le transport et l'exploitation. Il a été conçu par l'Institut de physique appliquée TNO-TH (TPD) en coopération étroite avec l'Institut für Angewandte Geodäsie (IfAG) à Francfort-sur-le-Main et avec l'Observatoire de géodésie par satellite de l'Université technique de Delft. Le système a été mis à l'essai à l'Observatoire à Kootwijk en avril 1984 et il a été livré à l'IfAG en juin 1984. Les essais de contrôle sont maintenant en cours à la station de recherche fondamentale de Wettzell en République fédérale d'Allemagne. Un système identique, MTLRS-2, a été livré à l'Observatoire et mis à l'essai en novembre 1984. Les premières utilisations majeures sur le terrain doivent commencer en avril 1985 en Amérique du Nord et en 1986 en Méditerranée orientale dans le cadre du projet WEGENER

Le rapport donne un aperçu du calendrier des observations et des objectifs du Groupe de travail de scientifiques européens pour la mise en place d'un réseau de recherches sismographiques (WEGENER) dans la région méditerranéenne.

RESUMEN

Se describe la configuración de un sistema móvil de telemetría mediante láser y satélites (MTLRS) y sus primeros resultados

El MTLRS es un sistema transportable de telemetría mediante láser de diseño modular, que permite varias configuraciones de transporte y operacionales. El sistema fue diseñado por el Instituto de Física Aplicada TNO-TH (TPD) in Delft en estrecha cooperación con el Institut für Angewandte Geodäsie (IfAG) de Frankfurt am Main y el Observatorio para geodesia mediante satélites (OSG) de la Universidad de Tecnología de Delft. El MTLRS-1 fue ensayado en el OSG en Kootwijk en abril de 1984 y entregado al IfAG en junio de 1984. Se están realizando ahora ensayos de verificación en la estación fundamental de Wettzell en la República Federal de Alemania. Un sistema idéntico, el MTLRS-2, fue entregado al OSG y ensayado en noviembre de 1984. Se prevé que las primeras aplicaciones importantes sobre el terreno comiencen en abril de 1985 en América del Norte y en 1986 en el Mediterráneo oriental como parte del proyecto WEGENER.

Se indica el programa de observaciones y los objetivos del Grupo de Trabajo de los geocientíficos europeos para el establecimiento de redes para la investigación de terremotos (WEGENER) en la zona del Mediterráneo.

"MTLRS" is a transportable laser ranging system of modular design enabling various transport and operational configurations. The system was designed by the Institute for Applied Physics TNO-TH (TPD) at Delft, Netherlands, in close co-operation with the Institute for Applied Geodesy (Institut für Angewandte Geodäsie (IfAG)), at Frankfurt am Main, Federal Republic of Germany, and the Observatory for Satellite Geodesy (OSG) of Delft University of Technology (1,3). MTLRS-1 was put to test at OSG at Kootwijk in April 1984 and saw delivery to IfAG in June 1984. Verification tests are now ongoing at the Satellite Observation Station at Wettzell in the Federal Republic of Germany. The identical system, MTLRS-2, was delivered to OSG, and testing began in November 1984. The first significant field applications are planned to commence in April 1985 in North America and 1986 in the eastern Mediterranean as part of the WEGENER project.

The design of MTLRS satisfies the requirements of state-of-the-art laser ranging accuracy and ease of transportability. It is capable of observing at the 1–2 cm noise level to a maximum range of approximately 12,000 km. The transportation requirement called for a relatively light-weight and compact system which could be relocated and made operable again within a few days at most, even in remote areas.

The system was optimized for the measurement of crustal motion by repeated accurate determinations of interstation baseline length. With a view to this principal objective a method was implemented for a precise and reliable reoccupation of measurement locations to within a few millimetres, both horizontally and vertically (2,3).

System configuration

The system consists of two separate integrated units:

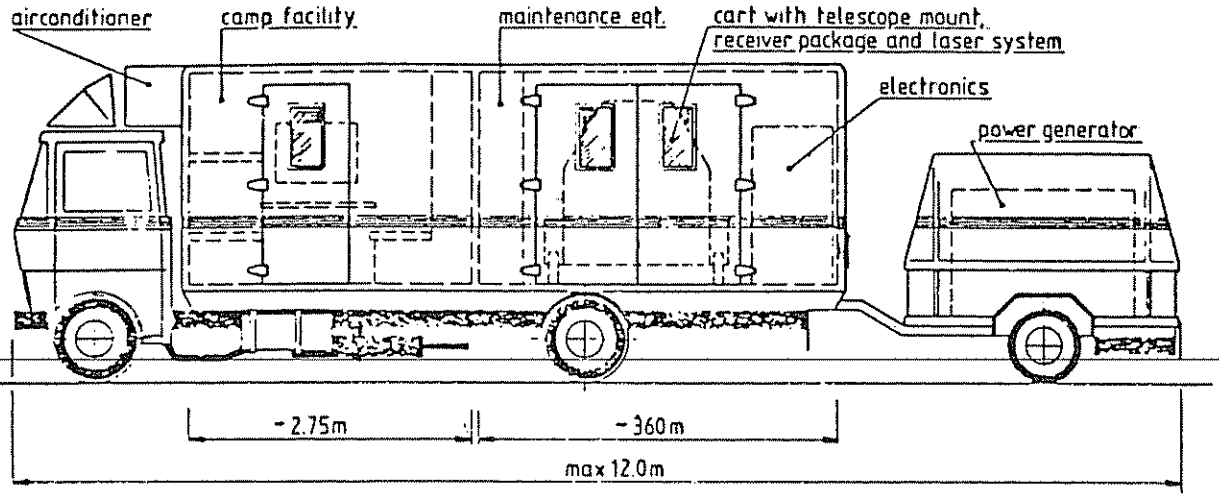
(*a*) The transmit/receive telescope, mount, laser and detector, contained together in a small stand-alone cart that can be opened for operation and closed for protection against environmental effects;

(*b*) The vehicle for transportation containing all electronics hardware, i.e., the computers, epoch clock, units for mount positioning and laser control, time interval counters and command panel.

The telescope, mount, laser (including power supply and cooling) and detector, configured together on the separate cart, can be loaded into the vehicle for road transportation and run out to a position adjacent to the ground marker for ranging operations. The complete surface-transportable configuration, on the other hand, consists of a 6.5 × 2.4 × 2.3 m^3 cabin containing the electronics cabinet, a supply of cooling water and work-space when the telescope cart has been unloaded at the observation site. The loaded cabin can be transported by a donated, but commercially available, standard Mercedes truck or by a suitable rental vehicle. A diesel-run power generator towed by the transport vehicle is part of this configuration (figs. 34 and 35). In an air-freight configuration the total measuring system will fit onto a single standard freight pallet.

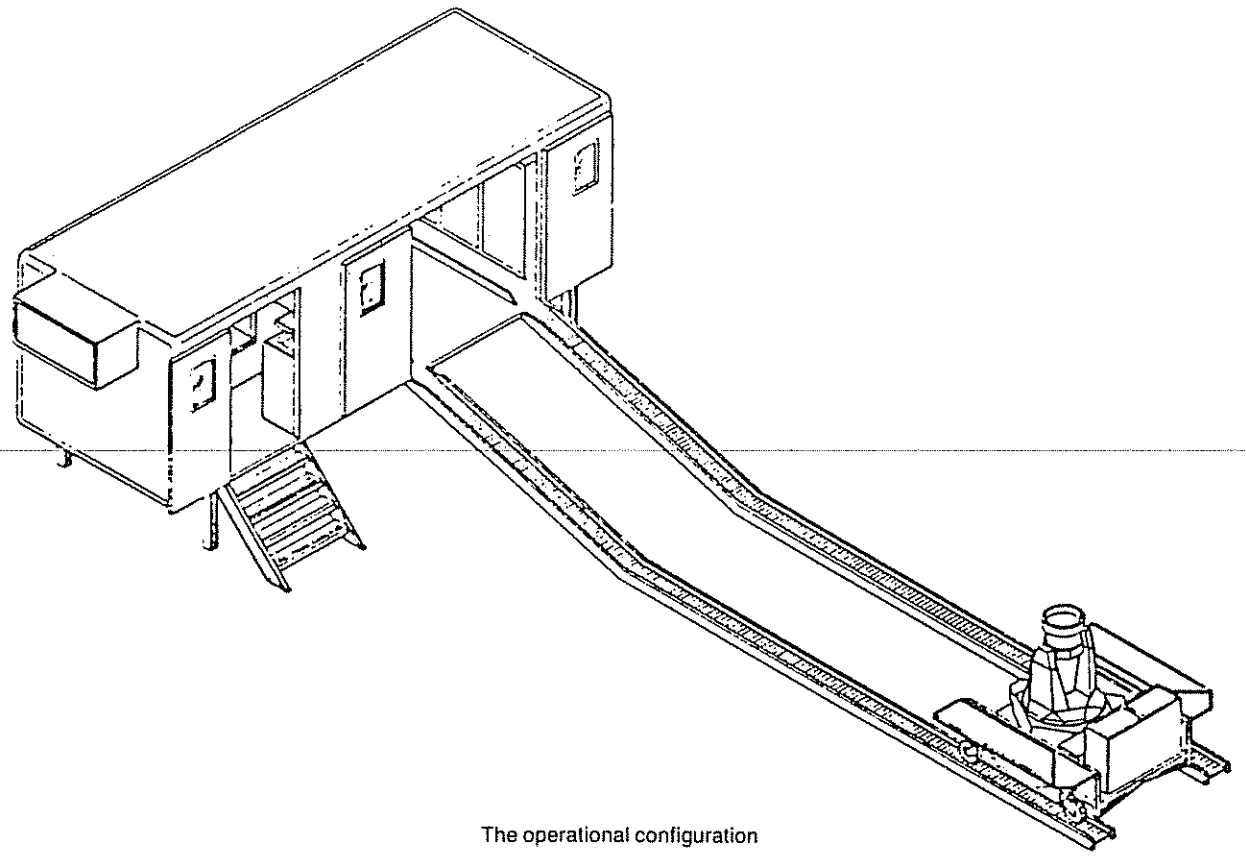
* The original text of this paper, prepared by E. Reinhart, Institut für Angewandte Geodäsie, appeared as document E/CONF 77/L 7.

Figure 34. Federal Republic of Germany: The mobile laser ranging system on the road



The mobile laser ranging system on the road

Figure 35. Federal Republic of Germany: MTLRS, operational configuration



The operational configuration

The dimensions of this system's modules permit 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. The system will be operated by two engineers and one technician. The table below summarizes some of the main MTLRS specifications.

Telescope	Aperture	40 cm
	Beam divergence	0 02 to 1 00 mrad
Mount	Type	AZ/EL Coudé
	Encoder resolution	0 0002 degrees
	Maximum angular velocity	AZ 10 degrees/s EL 4 degrees/s
	Maximum angular acceleration	AZ 5 degrees/sxx2 EL 2 degrees/sxx2
	Weight	500 kg
Laser	Type	Neodymium-YAP
	Output energy	10 microjoules
	Wave-length	539 nanometres
	Pulse width	300 picoseconds
	Repetition rate	10 hertz
Detectors	Photo multiplier	RCA 8850
	Start detector	HP 5082-4207
	Quadrant detectors	HAMAMATSU R1166
	Multistop counter	
Time of flight equipment		HP 5370A + const fract discr ORTEC 934
Time Standard		User determined
Computers	Main	HP 1000L model 5, 128K
	Slaves	2 MPU's M6809 1 APU AM9511
Normal point range accuracy		Better than 2 cm
Terrestrial ranging		Possible
Operating personnel		3

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 observing at the single photoelectron level. A quadrant detector serves to enable adjustment of the pointing to maximize signal return at the main photo-multiplier, and multi-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 computational procedure controlling the prediction and pointing, with a direct data feedback link between the formatter and prediction processors. 2 × 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 systems and the outside world.

MTLRS-1 initial performance evaluation

In June 1984 MTLRS-1 was delivered to IfAG. Many ranges to the LAser GEOdynamics Satellite (LAGEOS) have been measured. The overall precision turned out to be very consistent, showing typical root-mean-square of 4–6 cm for single shots and 1–2 cm for normal points, without any significant difference between day and night-time ranging (5). Ranges to the STARLETTE Satellite have also been measured.

Observational programme

After MTLRS-1 was delivered to IfAG in June 1984 the instrument was transferred to the Wettzell observing station for further performance evaluation and co-location with the permanent laser ranging instrument (7834) there. The Dutch system MTLRS-2 has been undergoing performance test at the Kootwijk OSG, starting in November 1984. From March 1985 MTLRS-2 will be co-located with both MTLRS-1 and the 7834-system at Wettzell. In the summer of 1984 MTLRS-1 will join the NASA crustal dynamics programme in North America.

With MTLRS 1 and 2 and the NASA mobile laser ranging system TLRS-3 a 10-month observing period is foreseen as the initial phase of the first-epoch measurements in the eastern Mediterranean area to be carried out in 1986 in co-operation with NASA. This area was selected by the *W*orking group of *E*uropean *G*eoscientists for the *E*stablishment of *N*etworks for *E*arthquake *R*esearch (WEGENER) and the measurements and their analysis are to be executed in the framework of NASA's crustal dynamics project (6). The measurements in the Eastern Mediterranean area are expected to be repeated in alternate years 1988, 1990 etc.

The brief summary of a proposed work plan given here was developed in discussions involving geodesists, geologists and seismologists from several countries.

The circum-Aegean region, as part of the boundary between the African/Arabic and Eurasian plate, is tectonically the most active area of Europe and a complex pattern of platelets and belts of deformation has been suggested (7, 8). Relative motion rates of up to about 5 cm/year may occur in the area. Space techniques are ideally suited to help to 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 observational 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 for earthquake research and hazard assessment throughout the areas of Greece and Turkey covered by the network of points.

Large seismic gaps have been suspected in these countries, especially along the Anatolian and the Hellenic arc plate boundaries. The expectation that these gaps may rupture 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 laser ranging stations should be established in the eastern Mediterranean area capable of measuring accurately (within 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 relative to those stations occupied simultaneously. Depending on weather conditions the observation period at each site can be expected to last up to four weeks.

As it is planned that three systems will be available for use in the area to be covered, special attention must be paid to the selection 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.

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 Dionysos (Greece), Grasse (France), Herstmonceux (Great Britain), Graz (Austria), Kootwijk (Netherlands), Matera (Italy), Wettzell (Federal Republic of Germany), Zimmerwald (Switzerland). A further new observatory is under construction in Israel between Jerusalem and Tel Aviv.

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ON THE SIGNIFICANCE OF DOPPLER ANTENNAE CALIBRATION RESULTS*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

L'incertitude concernant l'emplacement des centres de phase des antennes est l'un des problèmes restant à résoudre pour les chercheurs qui s'intéressent au positionnement par la méthode Doppler. Si l'on veut améliorer la précision, il serait utile de mener des campagnes spéciales d'étalonnage des antennes.

Le présent rapport a pour objet de résumer les résultats obtenus au cours de plusieurs campagnes d'étalonnage des antennes Doppler et d'étudier dans quelle mesure ces résultats peuvent être généralisés. Enfin, on utilise les coordonnées utilisées lors d'une campagne récente pour démontrer les avantages qu'il y a à appliquer des méthodes permettant de compenser l'effet de l'altitude.

RESUMEN

Uno de los problemas que se continúan presentando en la determinación de posición utilizando el efecto Doppler es la incertidumbre respecto de la ubicación de los centros de fase de las antenas. Si se desea una mayor exactitud se considera útil llevar a cabo programas especiales de calibración de antenas.

Este informe tiene por finalidad resumir los resultados de varios programas de calibración de antenas utilizando el efecto Doppler e investigar la posibilidad de reproducir los resultados. Por último, se utilizan los puntos fundamentales de un programa reciente para demostrar que se obtiene un mejor efecto al aplicar compensaciones de las diferencias de altitud.

Based on experiences from a large number of Doppler observation campaigns performed during the last decade and from comparing the results with precise terrestrial surveying results, several European members of the Doppler community consider it useful to organize special antennae calibration campaigns with all the receivers that are to be used within a planned campaign, especially if maximum accuracy is desired. This is of special importance for activities whose primary goal is the determination of ellipsoidal heights. The reason such calibration campaigns are requested is uncertainty about the location of the antennae phase centres. It is a well-known fact that the electrical phase centre of antennae may vary during a satellite pass, and that even the phase centre of the 400 megahertz (MHz) and the 150 MHz signals may be different. Ground reflections may even produce variations of the antennae phase centres.

The nominal phase centre, which is normally marked by the manufacturer, should represent an average position for several satellite passes of varying elevations of the points of closest approach. Possible variations of the horizontal position of the antennae phase centres are obviously compensated by using observations well distributed over the horizon. More dangerous, and of significant influence, are those variations that appear in height as they may produce systematic errors of a few decimetres.

The goal of this report is to summarize the results of several calibration campaigns and to investigate the reproducibility of the results. The data available for such an investigation are somehow favourable for the following reasons:

(*a*) They were collected during several calibrations with partly the same receivers;

(*b*) The calibration campaigns were performed at different locations under varying circumstances (e.g., concerning possible ground reflections);

(*c*) All the Doppler data have been computed with the same program (GEODOP III), using the multipoint mode and in most cases the precise ephemeris.

CHARACTERISTICS OF THE CALIBRATION CAMPAIGNS

The general performance of the calibration campaigns discussed here is identical: the receivers to be calibrated

* The original text of this paper, prepared by F. J. Lohmar and H. Seeger, Geodetic Institute, University of Bonn, appeared as document E/CONF.77/L.42.

were operated in neighbouring positions (within about 100 × 100 m) for at least one week. The only requirements for the selected area have been: (*a*) free horizon (as far as possible); (*b*) no reflecting surfaces in the neighbourhood of the antennae; and (*c*) no transmitters nearby.

Moreover, there should be enough space between the antennae to avoid interferences; a 5-metre difference was generally considered to be sufficient. The nominal phase centres of all the antennae were connected relative to each other and to a local reference mark by conventional survey so that the eccentricities between these marks are known up to the 1-cm level.

The calibration campaigns analysed up to now

The investigations reported here are based on the observations of five calibration campaigns performed between 1980 and 1982 at different sites within Europe. The campaigns were performed in each case immediately before or after a field campaign in order to meet highest accuracy for the Doppler project in question. All these activities have been performed as common projects of those institutions owning the receivers.

The results of the following campaigns are summarized and analysed below in more detail.

ALPCAL

The observations were performed at the Satellite Observation Station Wettzell from 17 to 27 July 1980. The campaign was the opening activity of ALGEDOP, an international project to determine geoid heights in the area of the Alps.

TESTCAL

This calibration campaign was observed from 17 to 20 September 1980 at the Technical University of Graz, Austria, and was thought to improve the results of TESTDOC 80, a campaign within the local test-net of the Steiermark area around Graz.

CICAL

In order to prepare the CIDOC-campaign, a project to determine a zero-order network of 17 stations on the territory of Côte d'Ivoire in West Africa, all the receivers in question were operated from 19 to 29 November 1981 at the Satellite Observation Station Todenfeld near Bonn.

TRSCAL

Immediately before the second ALGEDOP field campaign the participating receivers were calibrated during a special field campaign from 28 July to 9 August 1982 at the Astronomical Observatory Basovizza near Trieste.

BLNCAL

In order to improve the results of BLNDOC, which was a campaign to determine Doppler positions in the area of Berlin (West), the participating receivers were calibrated on top of a building of the Technical University of Berlin from 8 to 15 September 1982.

Table 1 includes a survey of the individual Mx 1502 receivers engaged in the various calibration campaigns (receivers of the other manufactures have been used only occasionally).

Table 1: Survey of receivers and calibration campaigns

ALPCAL	*TESTCAL*	*CICAL*	*TRSCAL*	*BLNCAL*	*Mx 1502 Serial number*	*Owner*
X	X	—	X	—	018	University of Trieste, Italy
X	X	X	X	X	083	University of Bonn
X	X	—	—	—	104	University of Trieste, Italy
X	X	X	—	—	140	ETH Zürich
—	—	X	X	—	164	University of Stuttgart
—	—	X	X	X	170	Armed Forces University, Munich
—	—	X	X	X	181	Armed Forces University, Munich
—	—	X	X	—	234	ETH Zürich
—	—	—	X	X	305	Technical University of Berlin, Berlin (West)

Results derived from individual calibration campaigns

The numbers reported here for the different calibration campaigns have been determined through the following procedure:

The Doppler-derived 3D-positions of the different antennae were referred to one single mark, using the well-known eccentricities as derived by conventional survey. The differences in the numbers are then only influenced by the random errors of the Doppler solutions and by systematic differences in the antennae phase centres. Then the differences of each centred Doppler position to the arithmetic mean of all the positions are computed and the differences are listed in table 2 (*a*)–(*e*). As the horizontal offsets generally are assumed to show no significant systematics, the remaining differences represent the overall accuracy of Doppler-positioning in optimum conditions.

Table 2 Results of calibration campaigns
(In centimetres)
(*a*) ALPCAL

Receiver	$\Delta\phi$	$\Delta\lambda$	ΔH
018	− 6	+25	−26
083	+10	− 8	+24
104	− 4	+ 6	+12
140	− 2	−22	− 8

(*b*) TESTCAL
(height offsets only)

Receiver	ΔH
018	−46
083	+29
104	− 2
140	+18

TABLE 2 (*continued*)

(*c*) CICAL

Receiver	$\Delta\phi$	$\Delta\lambda$	ΔH
140	− 4	+30	+20
164	0	−37	− 4
170	+17	+22	+17
234	−12	−14	−33

(*d*) TRSCAL

Receiver	$\Delta\phi$	$\Delta\lambda$	ΔH
018	+ 9	−11	−27
083	+19	+11	+19
164	−24	+15	+17
170	− 5	−31	+24
181	− 1	+17	− 6
234	+ 8	+ 3	−26
305	−13	−12	− 2

(*e*) BLNCAL

Receiver	$\Delta\phi$	$\Delta\lambda$	ΔH
083	0	0	+17
170	+ 6	+36	+18
181	− 3	−36	−43
305	−21	+55	+ 7

In table 3 only the offsets of the height components are compiled. Although these differences are not larger than the general accuracy of Doppler positioning, there is quite obviously a certain systematic effect in the results of the different campaigns. Therefore, to obtain optimal results it may be useful to carry out calibration campaigns, e.g., once per year and to correct the different results by the average offsets derived from several of such efforts.

The mean offsets in height derived from the calibration campaigns discussed in this report have been applied to the results of RPDOC'83, a special Doppler campaign covering the area of the state of Rhineland-Palatinate, Federal Republic of Germany. Tables 4 and 5 show the residuals between the ellipsoidal heights determined by terrestrial data and the corrected and uncorrected Doppler heights after applying a 7-parameter transformation. Obviously, a significant improvement is obtained for that solution, which includes the results of the antennae calibrations

TABLE 3. HEIGHT OFFSETS OF RECEIVERS CALIBRATED DURING AT LEAST TWO OF THE FIVE CAMPAIGNS

(In centimetres)

Receiver	*ALPCAL*	*TESTCAL*	*CICAL*	*TRSCAL*	*BLNCAL*
018	−26	−46		−27	
083	+24	+29		+19	+17
104	+12	− 2			
140	− 8	+18	+20		
164			− 4	+17	
170			+17	+24	+18
181				− 6	−43
234			−33	−26	
305				− 2	+ 7

TABLE 4 RESIDUALS AFTER APPLYING CALIBRATION OFFSETS AND A 7-PARAMETER TRANSFORMATION

Station	*East*	*North*	*Height*
STK	−17	1	3
WST	18	− 8	9
LOE	−22	8	−28
MEL	19	5	− 2
DON	− 5	−39	− 3
KST	−16	13	− 5
HOE	6	14	28
KLP	17	6	− 1

TABLE 5 RESIDUALS AFTER APPLYING A 7-PARAMETER TRANSFORMATION (WITHOUT CALIBRATION OFFSETS)

Station	*East*	*North*	*Height*
STK	−16	−10	3
WST	14	8	−32
LOE	−25	9	51
MEL	21	20	−15
DON	− 5	−37	3
KST	−14	20	− 1
HOE	5	17	−27
KLP	19	−10	18

ESSAIS DE NIVELLEMENT INDIRECT DE PRÉCISION MOTORISÉ À L'INSTITUT GÉOGRAPHIQUE NATIONAL*

Document présenté par la France

TRANSLATION

Motorized indirect precision levelling (Nivellement indirect de précision motorisé (NIPREMO)) is an application of trigonometric levelling used for measuring level differences in geodesy. However, the stations, instead of being fixed, are mobile owing to the use of two special vehicles for transporting the observation teams and their equipment.

In each two-man team:

(*a*) The operator stands on the vehicle platform to make the observations. The theodolite is fixed permanently on a heavy tripod whose legs pass through the vehicle floor and rest directly on the ground. A toothed-bar lifting system

*The original text of this paper, prepared by M. Kasser, appeared as document E/CONF 77/L. 29

TRADUCCION

La nivelación indirecta de precisión mediante vehículos motorizados (NIPREMO) es una aplicación de la nivelación trigonométrica utilizada para medir la diferencia de niveles en geodesia. Sin embargo, las estaciones, en lugar de ser fijas, son móviles debido a la utilización de dos vehículos especiales para el transporte de los equipos de observación y el material correspondiente.

Cada equipo está integrado por dos personas:

a) El operador permanece de pie en la plataforma del vehículo para efectuar las observaciones. El teodolito está fijado permanentemente en un pesado trípode cuyos soportes atraviesan el piso del vehículo y reposan directamente en el suelo.

Un sistema de elevación mediante cremallera permite que el operador levante la unidad completa del instrumento y el trípode durante el viaje.

enables the operator to raise the complete instrument-tripod unit during transit;

(*b*) The secretary-driver is in two-way communication with the operator, who transmits to him the data to be introduced into the machine. The National Geographical Institute currently uses Simca Break 1100 vehicles for these operations. The instruments are Kern DKM 2A theodolites and DM 502 electro-optic distance-meters.

Operational procedure

The basic principle consists in making simultaneous reciprocal height observations of one theodolite from the other, using the centre of the objective lens as target. The operation is carried out by traversing between two levelling marks, the vehicles passing alternately one in front of the other, i e , by "leap-frog" progression.

An observation, strictly speaking, consists of two complete series of height measurements carried out simultaneously, and a distance measurement between the two stations. The main station is equipped with a theodolite on which is mounted an electronic distance-meter for double telescope reversal whilst the responder station is equipped with a similar theodolite and a reflecting prism.

The observation values are transmitted by radio and recorded at the main station. They are introduced directly into a programmed calculator which instantly carries out the checking and calculations. The level differences at the bench-marks at the beginning and end of operations are obtained by direct levelling, using a 3-metre survey rod graduated in centimetres.

Results of tests

As a result of tests carried out around Ermenonville, near Paris, over a total of 129 km, a probable error of 3 mm/km was estimated, with average distances of 610 m between stations and with no limits other than the distance-meter range (1,600 m for the longest observation).

In the trial zone, which was quite suited to the use of this method (slightly wooded region and winding traverse), progress was about 4.5 km/hour.

On the basis of the first test there is reason to believe that costs will be reduced by half with respect to current costs of normal levelling.

Conclusion

The advantages of rapid observation and respectable accuracy for this type of levelling makes it possible to consider using it, particularly in those countries lacking basic survey networks, in mountainous regions and in tectonically unstable zones.

(*b*) El secretario-chofer se encuentra en comunicación de doble sentido con el operador que transmite los datos que se han de introducir en la máquina.

El Instituto Geográfico Nacional de Francia utiliza actualmente vehículos Simca Brake 1100 para estas operaciones modelo. Los instrumentos son teodolitos Kern DKM 2A y telémetros electroópticos DM 502.

Procedimientos seguidos en las operaciones

El principio básico consiste en hacer dos observaciones de altura simultáneas y recíprocas de un teodolito a otro utilizando como blanco el centro del lente del objetivo. La operación se realiza atravesando dos puntos de nivelación, en que los vehículos pasan alternativamente uno frente al otro, es decir, en una progresión alternada.

La observación propiamente dicha consta de dos series completas de mediciones de altura realizadas simultáneamente y una medición de distancia entre ambas estaciones. La estación principal cuenta con un teodolito sobre el que se instala un telémetro electrónico que permite una vuelta doble del telescopio, en tanto que la estación respondedora cuenta con un teodolito análogo y un prisma reflector.

Los valores de la observación se transmiten por radio y se registran en la estación principal, se introducen directamente en una calculadora programada que efectúa instantáneamente las verificaciones y los cálculos. Las diferencias de nivel en los puntos de referencia al principio y al final de las operaciones se obtienen por nivelación directa utilizando una mira de 3 metros graduada en centímetros.

Resultados de los experimentos

Como resultado de los experimentos realizados en los alrededores de Ermenonville, cerca de París, en un total de 129 km, se estimó un error probable de 3 mm/km, con una distancia media de 610 m entre las estaciones y sin más límite que el alcance del telémetro (1.600 m para la observación a mayor distancia).

En la zona de ensayos, bastante favorable para utilizar el método (una zona con pocos árboles y donde el camino seguido por vehículos era sinuoso), que avanzaba a unos 4,5 km por hora.

Sobre la base del primer ensayo cabe considerar que los costos disminuirán en un 50% respecto del costo que demanda la nivelación que se efectúa ahora habitualmente.

Conclusión

Las ventajas que presenta la observación rápida y una exactitud apreciable para este tipo de nivelación permite considerar la posibilidad de utilizarlo, en particular en los países que carecen de redes básicas de reconocimiento topográfico, en regiones montañosas y en zonas tectónicamente inestables.

Le nivellement indirect de précision motorisé (NIPREMO) est une application du nivellement trigonométrique utilisé pour la mesure des dénivelées en géodésie. Mais les stations, au lieu d'être fixes, sont rendues mobiles par l'utilisation de deux véhicules spécialement aménagés pour le transport des équipes et du matériel d'observation.

Chaque équipe est composée de deux personnes :

a) L'opérateur se tient debout sur la plate-forme du véhicule depuis laquelle il observe. Le théodolite est fixé à demeure sur un trépied alourdi dont les branches passent au travers du plancher du véhicule et dont les extrémités reposent directement sur le sol. Un système de levage à crémaillère permet à l'opérateur de relever l'ensemble trépied-instrument pendant les déplacements;

b) Le chauffeur-secrétaire est en liaison duplex avec l'opérateur qui lui transmet les éléments à introduire en machine.

Les véhicules utilisés actuellement à l'Institut géographique national pour cette opération sont du type Simca Break 1100. Les instruments sont du type Kern DKM 2A pour les théodolites, DM 502 pour le télémètre électro-optique.

Procédé opératoire

Le principe consiste essentiellement à effectuer des visées zénithales réciproques et simultanées d'un théodolite à l'autre en prenant pour cible le centre de l'objectif des instruments. L'opération s'effectue par cheminement entre deux repères de nivellement, les véhicules passant alternativement l'un devant l'autre selon la progression dite en «saute-mouton».

L'observation proprement dite comprend deux séries complètes de mesures zénithales effectuées simultanément, et une mesure de distance entre les deux stations. L'une des stations, la station principale, est équipée d'un théodolite sur lequel se trouve monté un télémètre électronique permettant le double retournement de la lunette, l'autre, dite «station répondeuse», est équipée d'un théodolite similaire et d'un prisme réflecteur.

Les valeurs résultant de l'observation sont diffusées par radio et collectées par la station principale. Elles sont introduites directement dans une calculatrice programmée qui effectue instantanément les contrôles et les calculs. Les mesures de dénivelées au départ et à l'arrivée sur les repères s'effectuent en nivellement direct sur une mire de 3 m à graduation centimétrique.

Résultats de l'expérience

A l'issue de l'expérience, réalisée dans la région d'Ermenonville et qui a porté sur 129 km, on a pu estimer à 3 mm l'erreur probable kilométrique, avec des distances moyennes de 610 m entre stations et sans limite autre que la portée du télémètre utilisé (1 600 m pour la plus longue visée).

Dans la zone d'essais, moyennement favorable à la mise en œuvre de la méthode (région légèrement boisée et tracé sinueux du cheminement), la progression a été de l'ordre de 4,5 km/h.

Par ailleurs, sur ce premier test, on peut penser raisonnablement que le prix de revient sera réduit de moitié par rapport au coût actuel du nivellement classique.

Conclusion

L'atout que présente la rapidité des observations d'une part, ainsi que la précision honorable obtenue d'autre part par ce type de nivellement permet d'envisager son emploi tout particulièrement dans les pays dépourvus d'équipement de base, en région montagneuse et dans les zones tectoniques instables.

LES PRINCIPES GÉNÉRAUX DE LA CONCEPTION DU RÉSEAU GÉODÉSIQUE CONTINENTAL AFRICAIN ET SON ASPECT INTERNATIONAL*

Document présenté par la Pologne

SUMMARY

The capital importance of a good map, or rather of a whole collection of high-quality maps at various scales, has created the need to draw up a general geodetic programme in Africa. The problem is the subject of numerous discussions and activities within international geodetic organizations. This paper presents the principles of the concept of the African Continental Geodetic Network (ACGN) proposed by Poland's Geodetic and Cartographic Society (GEOKART) in co-operation with the National Geographical Institute (IGN) of France.

The concept is based on existing networks, as well as on supplementary measurements using modern techniques. The final co-ordinates of the horizontal network will be obtained by joint processing and adjustment of Doppler measurements made on each point of the ACGN and of ground measurements, mainly distances between ACGN points deduced from these measurements. The results of the Doppler data and of accurate levelling will yield information concerning geoid undulation on the African continent. For proper calculation of the reductions, at every ACGN point the astronomical measurements of ϕ and λ are suggested. In the concept of the ACGN the horizontal, vertical and gravimetric networks are considered jointly; as a result an integrated geodetic network covering the entire African continent can be established.

The significance of the ACGN is both scientific and practical. It should lead to the general concept of a geodetic network as an information system.

* The original text of this paper, prepared by Z. Adamczewski, A. Krynski, J. Sledzinski, J. Wysocki, Geodetic and Cartographic Society, appeared as document E/CONF.77/L.47.

RESUMEN

La importancia capital que tiene un buen mapa, o más bien una familia de mapas de gran calidad y elaborados en las diferentes escalas, ha creado la necesidad de establecer en Africa un programa geodésico general. Ese problema es objeto de numerosos debates y actividades en las organizaciones geodésicas internacionales. En la presente comunicación se presentan los principios de la concepción de la Red Geodésica Continental Africana (RGCA) propuesta por el GEOKART polaco en cooperación con el Instituto Geográfico Nacional (IGN) francés.

Esa concepción se basa en las redes ya existentes, así como en las medidas complementarias ejecutadas por medio de técnicas modernas. Las coordenadas finales de la red horizontal se obtendrán mediante el tratamiento y la compensación común de las medidas Doppler tomadas en cada punto de la RGCA y de las medidas terrestres, sobre todo las distancias entre los puntos Doppler deducidas de esas medidas. Los resultados de los datos Doppler y del nivelamiento de precisión brindarán las informaciones sobre el recorrido del geoide en el continente africano. Para el cálculo correcto de las reducciones, se proponen las medidas astronómicas de φ y λ en cada punto de la RGCA. La concepción de la RGCA considera la red horizontal, la red de nivelación y la red gravimétrica como un conjunto, lo que dará como resultado una red geodésica integrada que abarcará todo el continente africano.

La importancia de la RGCA es tanto científica como práctica. Debe dar lugar a la concepción general de la red geodésica como sistema informático.

Le but de cette communication est de présenter à la troisième Conférence cartographique régionale des Nations Unies pour l'Amérique une information sur le Réseau géodésique continental africain (RGCA) et son aspect interrégional et international. Il s'agit d'une conception qui paraît être le moyen effectif de résoudre les problèmes géodésiques de l'Afrique. La conception créée par une collaboration entre la Société polonaise de GEOKART et l'Institut géographique national français a d'abord donné l'élan à la réalisation de la campagne ADOS établissant le réseau d'ordre zéro, uniforme sur tout le continent africain. Cette opération a pu être réalisée (ou presque réalisée) grâce à l'esprit de compréhension qui caractérisait les réunions successives internationales sur la géodésie et elle fait aussi une preuve du succès qui peut être achevé comme résultat d'une coopération sincère et efficace entre les nations

Le Réseau ADOS est composé de points distants de 300 à 500 km établis au moyen de la géodésie par satellites, avec une haute précision par la méthode Doppler. Elle constitue la première étape de la réalisation du Réseau géodésique continental africain. Les principes du RGCA seront exposés en bref ci-dessous. Il convient toutefois de dire dès maintenant qu'il s'agit d'une densification du Réseau ADOS de façon à obtenir un réseau géodésique uniforme, de haute qualité, intégrant les réseaux nationaux et assez denses pour servir de base à l'établissement des cartes topographiques et thématiques, indispensables pour le développement économique de tout pays.

Le point de départ de l'idée était la nécessité de créer de telles cartes, ce qui fut l'objet d'une résolution des pays africains prise au symposium cartographique au Caire en 1974. En effet, il n'y a que la carte qui permet d'acquérir une connaissance complète de la Terre, autrement dit du milieu dans lequel nous vivons et que nous devons rendre aussi utile pour nous que possible. Cette maîtrise de la Terre est la seule chance pour l'humanité de survivre. Il suffit de se rendre compte que la population du globe s'accroît d'une manière effrayante, surtout dans les milieux pauvres où il manque déjà de nutrition pour plus de la moitié de la population

Et pourtant, il n'y a pas de doute que la Terre contient encore autant, ou peut-être même plus, de richesses qu'il n'en faut pour assurer une vie acceptable pour tous les peuples, y comprises les générations qui viendront pour doubler et même tripler le nombre de la population d'aujourd'hui. Il s'agit ici de richesses minérales, de ressources minières, de terres qui ne sont pas cultivées et qui devraient l'être, de réservoirs d'eau non découverts ou mal exploités, de terrains qui souffrent de sécheresse, de sources d'énergie demandant des investissements hydrauliques, de l'industrie qui demande des constructions solidement basées, des villes où la vie pourrait se poursuivre normalement, dans des conditions répondant aux besoins de l'homme et à son progrés physique et intellectuel. L'activité humaine, surtout celle qui porte sur la technique, engendre les problèmes de la protection de l'environnement, de la lutte contre la pollution de l'air, de l'empoisonnement des eaux et du détriment de la végétation.

Pour répondre à toutes les exigences posées par la vie de notre époque et pour avoir la possibilité de diriger un Etat d'une façon rationnelle et sensée, la possession de la carte est une condition *sine qua non*. Ainsi la cartographie devient une vraie mission d'Etat. Nous disons «cartographie» parce qu'il ne s'agit pas que d'une carte, qui pourrait à elle seule suffire à explorer et exploiter la Terre et ses ressources. Pour avoir la vraie maîtrise de ces richesses, il faut avoir toute une famille de cartes, dont les unes pourraient servir par exemple à l'aménagement régional, les autres au développement et à la planification des villes aux différents niveaux, les autres encore aux recherches géologiques, hydrogéologiques, pédologiques, etc. Le but auquel une carte doit servir est déterminé par l'échelle de la carte et par son contenu. L'échelle peut varier entre 1/50 000 ou même 1/100 000 pour l'activité sur des terrains très vastes, jusqu'à 1/1 000 ou même 1/500 pour les problèmes précis, surtout en ce qui concerne la planification et le développement des villes, soit le bâtiment industriel

Le contenu peut être celui des cartes topographiques servant de base pour les cartes spéciales par leur liaison avec la géodésie et les lois mathématiques qui la gouvernent, ainsi que par leurs modes de représentation de plus en plus précis et explicites. Cela peut être aussi le contenu des cartes thématiques elles-mêmes, qui représentent des questions particulières telles que par exemple l'agriculture, la géologie, l'hydrologie, l'hydrogéologie, les anomalies gravimétriques, le réseau routier, les questions de l'infrastructure rurale, la répartition de phénomènes dus à l'activité humaine et encore bien d'autres.

Toute cette famille de cartes, si variées et différentes qu'elles puissent sembler, doit être basée sur un seul système géodésique. Sans un tel système, il y aura toujours une insuffisance du développement de la cartographie. C'est peut-être surtout en Afrique que ce problème apparaît évident, mais c'est certainement vrai pour toutes les régions du monde

La création de cartes topographiques et thématiques nécessite une base. Cette dernière à son tour ne peut pas être créée par des actions isolées effectuées par différentes institutions, non coordonnées entre elles, étant de précision hétérogène et se servant de fondements mathématiques différenciés et dispersés. Il n'y a que la carte homogène, uniforme, de valeur technique élevée et de qualité cartométrique indiscutable qui peut devenir un élément essentiel de l'information et en même temps un instrument de travail pour tous les secteurs de l'économie.

Le développement peut marquer son progrès partout et la bonne cartographie peut toujours témoigner la plénitude de son importance. Il y a beaucoup de régions sur la Terre (non seulement en Afrique) où vont s'établir des énormes étendues de cultures agricoles, où on découvrira des nouveaux gisements de richesses naturelles, où on construira des nouvelles industries et des villes industrielles tout en sauvegardant les villes anciennes — témoins des anciennes cultures et arts humains. On attribue à la cartographie un rôle tellement important pour que le développement puisse se poursuivre d'une manière vraiment intégrée et efficace.

Cette vraie cartographie, homogène, complète et de haute valeur ne peut exister que sur une base géodésique ayant les mêmes qualités. Le réseau géodésique n'est d'ailleurs pas que le point de départ pour la cartographie. Il joue un rôle très important par lui-même, étant le canevas de mesures directes relatives à l'ingénierie. Il s'agit ici de systèmes complexes de levés en vue de réalisation de projets des établissements industriels et des ouvrages d'art, de la surveillance topographique des constructions telles que celles de grandes usines, des établissements hydroélectriques, des réacteurs nucléaires et des barrages. C'est aussi sur la géodésie que s'appuie la réalisation des projets de chemins de fer, des routes, des lignes de haute tension, de télécommunication et de nombreux autres éléments du développement économique du pays.

Pour satisfaire les besoins de la cartographie aussi bien que pour les buts directs mentionnés ci-dessus, un réseau géodésique homogène, uniforme, moderne et précis doit s'étendre sur les surfaces, aussi vastes que possible — même sur les surfaces de tous les continents

La conception du Réseau géodésique continental africain a été adoptée comme base d'action pour la géodésie en Afrique au niveau international par la quatrième session de l'Association africaine de cartographie à Dakar (Sénégal) en décembre 1983.

Les principes de ce réseau peuvent être énumérés de la façon suivante :

1. Le réseau d'ordre zéro est un réseau Doppler établi selon les standards strictement déterminés et très élevés. Il contient 200 à 300 stations distribuées à travers tout le continent. Ce réseau est réalisé par la campagne ADOS — un effort international sous les auspices de l'Association internationale de géodésie.

2. Les réseaux existants et autres achèvements géodésiques de qualité convenable sont tous utilisés pour la construction du RGCA. Ces matériaux, complétés par des mesures supplémentaires — surtout les mesures de distances — serviront au calcul des cordes joignant les points fondamentaux du Réseau ADOS — l'échelle optimale du Réseau sera ainsi assurée.

3. Les coordonnées finales du réseau horizontal seront déterminées par le traitement commun de résultats des mesures effectuées par les méthodes modernes par satellites et de toutes les données terrestres incorporées au RGCA.

4. Un réseau général africain de nivellement sera établi en utilisant le nivellement de précision existant, complété par les mesures nouvelles; ce réseau, basé sur plus de 20 marigraphes, donnera un niveau de référence uniforme et deviendra une base pour les réseaux de nivellement d'ordre inférieur, tous étant calculés dans ce même système uniforme.

5. On procédera à la création du réseau panafricain gravimétrique qui doit constituer une liaison de tous les réseaux gravimétriques existants et sera établi en une échelle uniforme en accord avec l'unité internationale de milligal.

6. Les résultats obtenus sur les points Doppler joints aux altitudes finales calculées à partir du nivellement de précision et des mesures gravimétriques fourniront des données pour examiner le parcours du géoïde sur le continent africain.

7. Les mesures astronomiques de φ et λ seront exécutées pour assurer un propre calcul de réductions sur chaque point du RGCA.

8. La conception du RGCA traite le réseau horizontal, le réseau de nivellement et le réseau gravimétrique conjointement, en tant qu'éléments du réseau intégré couvrant tout le continent africain. Une compensation commune sera appliquée aux mesures nouvelles en même temps qu'aux données existantes incluses dans le RGCA après l'analyse de leur précision. De cette façon seront obtenues les conditions nécessaires pour la création du système géodésique africain.

9. Avec une telle conception du réseau, chaque pays peut à tout moment établir sur son territoire des points indépendants par satellites selon le standard ADOS. Ces points peuvent alors être inclus dans le réseau horizontal par la méthode de translocation. Il y a une relation mutuelle très étroite entre le réseau continental et les réseaux nationaux. Basé sur les points du RGCA, un réseau homogène de surface sera établi en utilisant aussi bien les mesures angulaires que linéaires au moyen des télémètres à laser. Les points appartenant à de tels réseaux et situés près de frontières devraient, si possible, être communs aux deux Etats voisins. Ceci permettra d'effectuer une compensation commune des réseaux étendus sur les surfaces plus grandes. Ainsi seront créées de nouvelles bases géodésiques qui pourront être utilisées plus tard, au cours de l'établissement du réseau continental, et en particulier au cours de son futur renouvellement et sa revalorisation. De cette façon, les réseaux nationaux de haute précision, à part leurs tâches à remplir à l'intérieur du pays, auront aussi un rôle important à jouer dans le procès d'un perfectionnement permanent du réseau panafricain.

10. L'établissement du réseau continental intégré avec les réseaux nationaux qui seront attachés crée les conditions favorables pour réaliser la conception générale du réseau géodésique comme système informatique. Ce système, agissant aussi bien dans l'aspect scientifique que technique doit assurer :

a) La possibilité de construire des modèles mathématiques les plus convenables au niveau de tout le continent;

b) La possibilité d'une correcte déduction scientifique;

c) Le service d'ordinateurs complet et infaillible.

Ces postulats fourniront la base pour l'activité du système informatique dont les fonctions principales sont les suivantes :

a) Collection des informations sous forme de données;

b) Traitement des données;

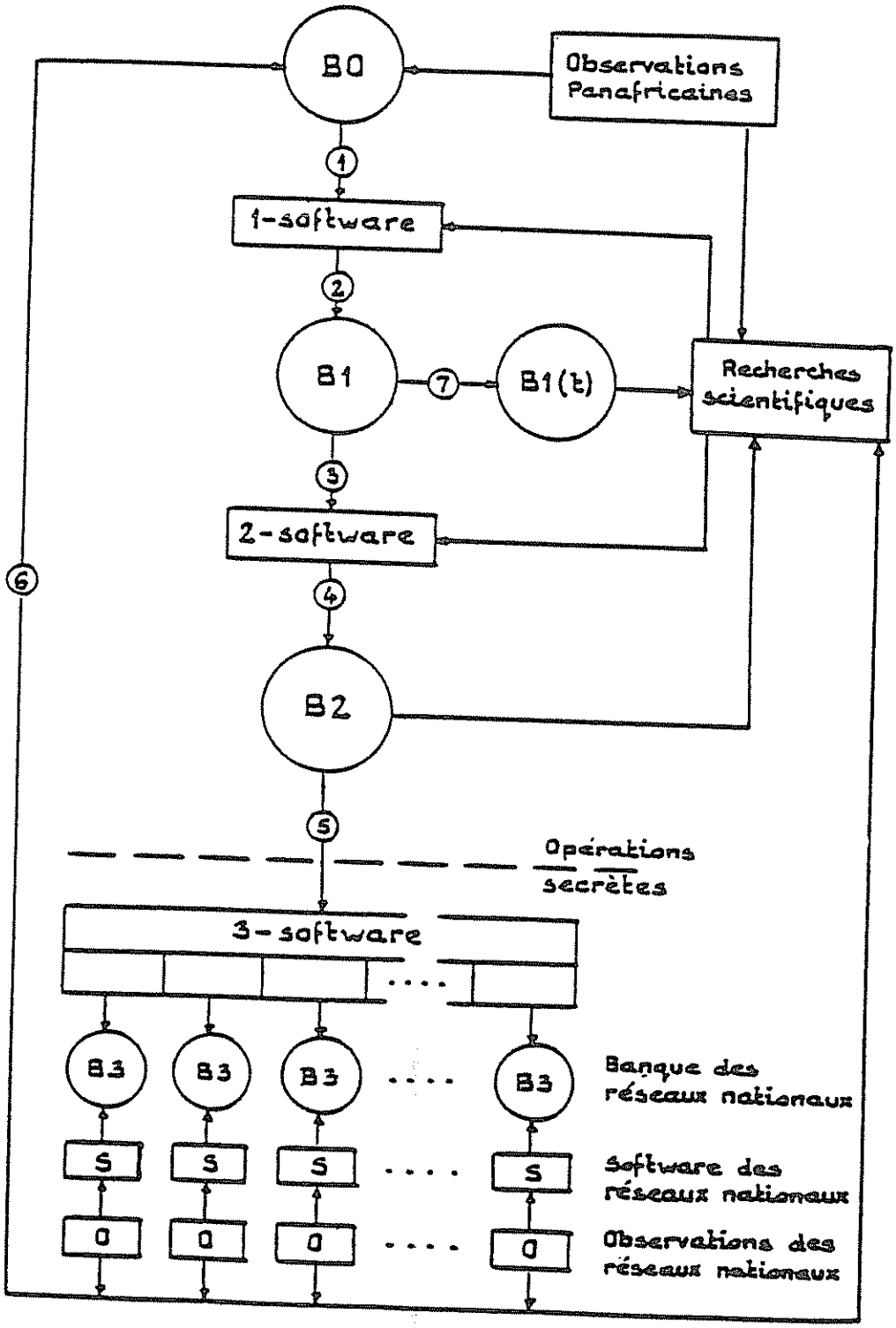
c) Emission des résultats du traitement aux utilisateurs.

L'idéogramme ci-joint (figure 36) présente la circulation des données fournies par les observations relatives à la construction du RGCA et des réseaux nationaux. Ces données passent par les blocs appropriés de «software» aux banques d'information correspondant aux différents niveaux de traitement. Elles sont aussi transmises au bloc de «recherches scientifiques» alimenté par les données provenant des deux susdites sources en même temps que les données sur l'histoire du réseau (paramètre du temps) et aussi par celles concernant le modèle actuel final du RGCA.

On présume que les fonctions réelles du système informatique du RGCA seront confiées à la responsabilité de plusieurs centres régionaux de calcul.

Il est évident qu'un énorme effort est nécessaire pour la réalisation d'une aussi importante entreprise telle que la création d'un réseau continental auquel les réseaux nationaux sont rattachés. Ce ne sont pas seulement les questions financières, mais aussi celles d'organisation qui constituent des problèmes très sérieux. L'idée a été tout de même comprise et acceptée par pratiquement tous les pays d'Afrique. Comme il a été dit, c'est maintenant l'objet de discussions et de considérations concertées menées parmi les différents pays et organisations internationales. Les possibilités d'accomplir cette tâche paraissent de plus en plus réelles. L'exemple d'une coopération internationale efficace a déjà été fourni par le succès de la campagne ADOS. Le fait est que la question du progrès de la géodésie en Afrique a atteint un moment vital et constitue aujourd'hui un élément inséparable du développement général de la géodésie. Ceci montre aussi que les géodésiens de toutes les parties du monde, provenant de différents milieux géographiques, techniques et même politiques, sont capables de se concentrer effectivement dans un effort commun pour la promotion et le développement de notre profession.

Figure 36. Pologne : Idéogramme



OBSERVATION OF TECTONIC PRECURSORS OF EARTHQUAKES BY GEODETIC METHODS*

Paper submitted by the Union of Soviet Socialist Republics

RÉSUMÉ

Du fait des déformations qui se produisent avant un tremblement de terre, les modifications de la roche montagneuse jouent un rôle décisif parmi les divers phénomènes de différente nature qui peuvent permettre de prévoir l'approche d'un séisme.

En se fondant sur l'analyse de 282 séismes, on a noté 15 types de signes avant-coureurs, dont 37 % étaient caractérisés par des phénomènes tectoniques.

Selon leur ampleur et le moment où elles apparaissent, il est possible d'enregistrer les déformations de la croûte terrestre en utilisant des méthodes géodésiques.

RESUMEN

A consecuencia de las deformaciones que se producen antes de los terremotos, los cambios que experimentan las rocas de las montañas desempeñan un papel decisivo entre los diversos fenómenos de diferente naturaleza que pueden servir de aviso de la proximidad de un seísmo.

A partir de los análisis de 282 terremotos, se identificaron 15 tipos de fenómenos precursores, el 37% de los cuales se caracterizaron por fenómenos tectónicos.

Las deformaciones de la corteza terrestre pueden registrarse con métodos geodésicos, aunque esta posibilidad depende de su magnitud y del momento en que aparecen.

Because of deformations that occur prior to earthquakes, mountainous rock changes play a decisive role among the various phenomena of different nature that may give warning of quakes.

Based upon analysis of 282 earthquakes, 15 types of precursors were obtained. Of these, 37 per cent are characterized by tectonic phenomena.

Depending on the magnitude and time of their appearance, earth crust deformations can be recorded by geodetic methods.

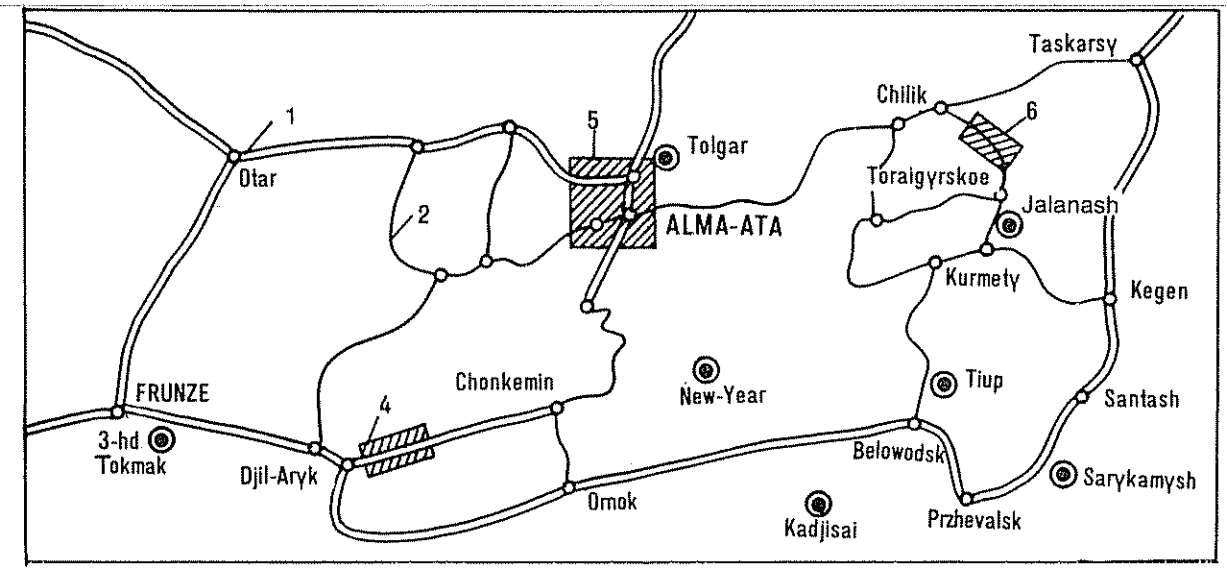
J. A. Mescheriakov was a pioneer in classification of phases of contemporary vertical earth crust movements (CVEM) in seismic areas. He subdivided CVEM into three types which have become widely known: alpha (α), beta (β) and gamma (γ). Of them, β-movements are the most important ones in earthquake forecasting; they are in fact earthquake forewarnings. Other scientists later described in detail these phases, and their number has grown to seven.

Comparing the patterns of β and γ movements and the amount and stress of mountain rock described by fissure formation enables the correlation of periods before and after seismic activities. As a result of 15 years of continuous work at the Alma-Ata geodynamic test-site by high-precision repeated levelling lines, it was confirmed that CVEM phases related to seismic activity appeared in Pleistocene zones at 170 km distance from the epicentre. This pattern can be described by an acceptance of a uniform system of horizontal stress in the earth crust which is transformed into vertical movement. The variations in length of traverse lines at Alma-Ata and Chonkemin test-sites prove that point of view (fig. 37).

* The original text of this paper appeared as document E/CONF 77/L.58

Figure 37. Soviet Union: Scheme of test-site locations in the northern Tian-Shan mountains

1, 2: levelling lines of first and second order respectively; 3: earthquake epicentre; 4. 5, 6: Chonkemin, Alma-Ata and Chilik test-sites



There were six cycles of line and angle measurements made at the Alma-Ata test-site during the period 1972-1981. As a result it was found that lines between points on slopes of the Zailiysky Alatau mountain range and the southern edge of the Ili Depression became continuously shorter at the rate of 4 mm per year. At the Chonkemin test-site, the length of lines crossing the Chilik-Kemin fault and joining points located on the slopes of Zailiysky Alatau and Kungei Alatau became shorter at the rate of 2 mm per year in the period 1974-1980. The genesis of the horizontal crust movements caused by compression in the orogenetic area under examination is also proved by geomorphologic and seismic data.

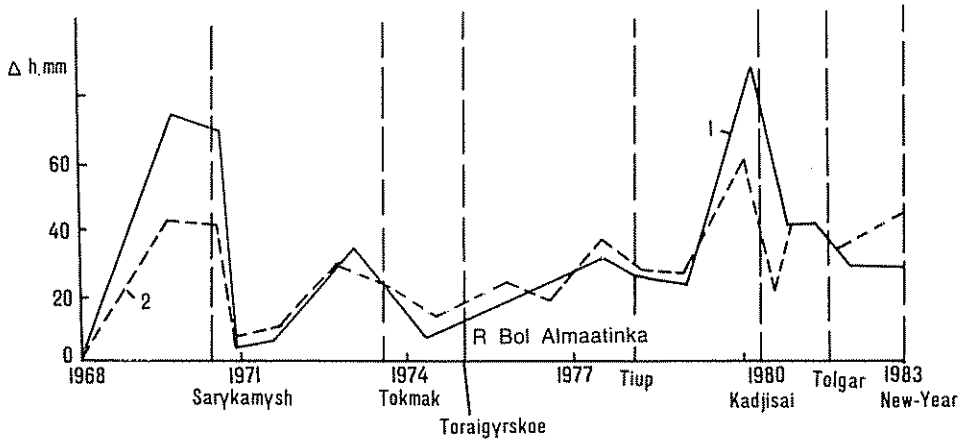
According to a theory of block tectonics, the development of mountain structures in Central Asia is related to Euro-Asian and Indostan block confrontation, which causes seismic activity in this area.

To find possible earthquake tectonic precursors, repeated levelling is done along test-site lines of the northern Tian-Shan mountains, and, at the Alma-Ata test-site four independent profiles have been levelled twice a year since 1968. Besides, angular and linear observations have been performed since 1972.

Figure 38 shows patterns of CVEM variations along two levelling lines of length 12 km (profile 3) and 7 km (profile 4). Therein variations of elevations are clearly seen. They are related to earthquakes. During the period 1968-1970, Sarakamysh earthquake occurred on 5 June 1970; the epicentre was 170 km south-east of Alma-Ata. There were evident precursors observed as fast movements causing vertical shifts up to 35 mm 20 months before; then a slowdown was recorded one month before the quake. The seismic displacement was recorded by results of the levelling, performed in August 1970. Levelling performed from June 1971 to April 1974 recorded alterations in the direction of tectonic movement. During the period June 1971 to April 1974 Tokmak earthquake occurred on 14 April 1973, with an epicentre 170 km south-west of Alma-Ata.

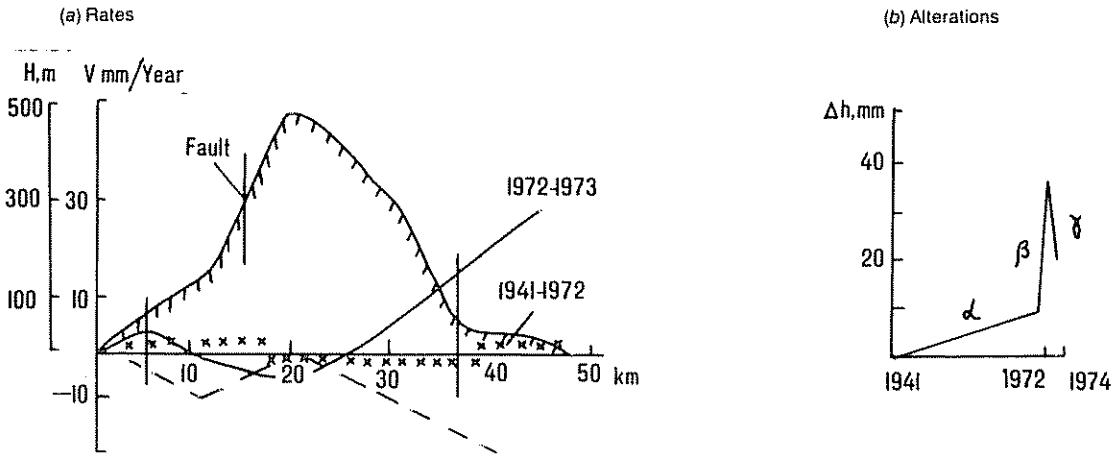
Figure 38. Soviet Union: Pattern of vertical crustal movements in the Alma-Ata region, 1968-1982

1 - profile 3; 2 - profile 4



Otar-Frunze levelling line, which is 50 km from the epicentre of the Tokmak earthquake (see figure 37) was run in 1941 and 1972-1974. The results are shown on fig. 39. From there one can see that direction and magnitude of CVEM were different in various cycles. During the period 1941-1972 the vertical earth-crust movements made up only 10 mm and they can be regarded as secular movements of phase α. During 1972-1973 the maximum value of vertical movements made up 30 mm, the correlation to the topography being negative, which corresponds to the β-phase. The results of levelling run in 1974 proved an alteration in the direction of movements and their concordance with to-

Figure 39. Soviet Union: Rates of vertical crustal movement and alterations in pattern



pography. Besides, after comparison with 1973 levelling data a seismic shift value was obtained, corresponding to γ-phase of the movements. Comparing alterations of CVEM, recorded by the levelling data in the earthquake area and at Alma-Ata (especially along profile 3; see fig. 38), their full compliance can be seen, and all three types of CVEM observed by J. A. Mescheriakov for seismic areas can be marked out.

The Toraigyr earthquake (12 February 1975) precursors were marked out in 1974. The map of vertical earth-crust movements of the northern Tian-Shan mountains, compiled in 1972, was used therein. The area of the would-be earthquake was featured on the map by vertical movement rates of about 14 mm per year.

Owing to a great number of repeated levelling along one of the levelling lines of the Alma-Ata test-site all phases of seismic movements were marked out for the Tiup earthquake. There were the following phases (figure 40):

(*a*) β_1, fast movements, foretokens of earthquakes, corresponding to quick growth of elastic deformations related to the increase in the amount of rock caused by formation of microfissures;

(*b*) β_2, ceasing of movements corresponding to development of plastic deformation without growth of the amount of rock;

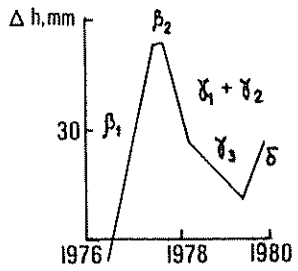
(*c*) γ_1 and γ_2, corresponding to the pre-seismic and spontaneous seismic displacements;

(*d*) γ_3, relaxation based on the ceasing of deformations after an earthquake;

(*e*) δ, transition to secular trend.

The epicentre of the Kadjisay earthquake (6 August 1980) was located 110 km to the south of Alma-Ata. β movements, the earthquake precursors, are especially marked on profile 3 (see figure 38), and they are featured by irregular displacements of more than 30 mm. Based on this, advance forecast information was delivered to the Institute of Seismology of Kazakh Academy of Science.

Figure 40. Soviet Union: Phases of seismic movement in the Alma-Ata region



To prove the trustworthiness of the examined earthquake precursors marked out by the results of repeated levelling in epicentral zones and at Alma-Ata, the magnitudes of seven earthquakes occurring in the Tian-Shan mountains were calculated by the time tectonic precursors appeared and they were compared with magnitude values obtained by seismic observations.

Calculations were done using two formulae. One was obtained by T. Rikitake as a result of processing data on 13 types of precursor that had appeared in 125 earthquakes on different continents. The other formula was obtained by A. A. Nickonov as a result of eight earthquakes occurring in the Mediterranean and Central Asian belts, i.e. for Alpine plicate belt, to which the region examined in this article is referred. The formulae of Rikitake and Nickonov are:

$$\lg T = 0.76\,M - 1.83 \qquad (1)$$

$$\lg T = 0.56\,M - 2.88 \qquad (2)$$

where T is the time of appearance of a precursor in days and years

M is the magnitude of an earthquake.

The results of calculations by formulas (1) and (2) are given in the table

Earthquake	*Magnitude*	*Time of precursor appearance*		*Magnitude, calculated by formula*			
				(1)		*(2)*	
		in epicentre	*at Alma-Ata*	*in epicentre*	*at Alma-Ata*	*in epicentre*	*at Alma-Ata*
Sazakamysh	6.8	3.0	2.5	6.7	6.3	6.0	5.9
Takmak	4.6	1.0	1.8	5.8	6.1	5.2	5.6
Taraigyr	5.0	2.3	0.8	6.3	5.7	5.8	5.0
Tiup	6.5	3.7	1.8	6.5	6.1	6.2	5.6
Kadjisay	6.1	—	1.2	—	5.9	—	5.3
Talgar	4.1	—	0.8	—	5.6	—	5.0
New Year	5.8	2.4	1.1	6.3	5.8	5.8	5.2

It can be seen from the table, that results obtained by formula (2) correlate better with actuality, than those obtained by formula (1), and they differ by not more than 1, corresponding to the accuracy of the formulae. There is a small difference in precalculated magnitude values for Sarakamysh, Tokmak, Toraigyr, Tiup and New Year earthquakes.

Last year's seismic activity in the Djambul region increased. There was an earthquake of the 14th energy class (M = 5.7) in 1971, and in 1984 there were two more approximately equal in magnitude. Levelling was performed in 1936, 1954, 1970, 1972 and 1974. It was established that vertical crustal movements related to the earthquakes occurred as far as 150 km from the epicentres.

Energy of the earthquake was calculated based on the results of seismic movements obtained from levelling, data on this earthquake and data of geosciences. This energy is estimated as a power A.

$$A = mgh \qquad m = V\rho$$

where m is the mass of rock brought into movement during the earthquake,

h is a traversed path equal to the seismic displacement,

V is volume,

ρ is compactness,

g is acceleration of free fall

The extent of the Pleistocene zone of the Djambul earthquake (1971) is 50 km², the depth of seismic focus is 15 km. At such a depth $\rho = 2.7$ g/cm². By repeated levelling data, $h = 100$ mm.

Considering the above values let us calculate the value of $A = 2 \cdot 10^{12}$ joules (J). Actually this earthquake can be referred to the 14th energy class, which corresponds to energy loss of 10^{14}J, i.e. there is a good correlation of the precalculated and actual values.

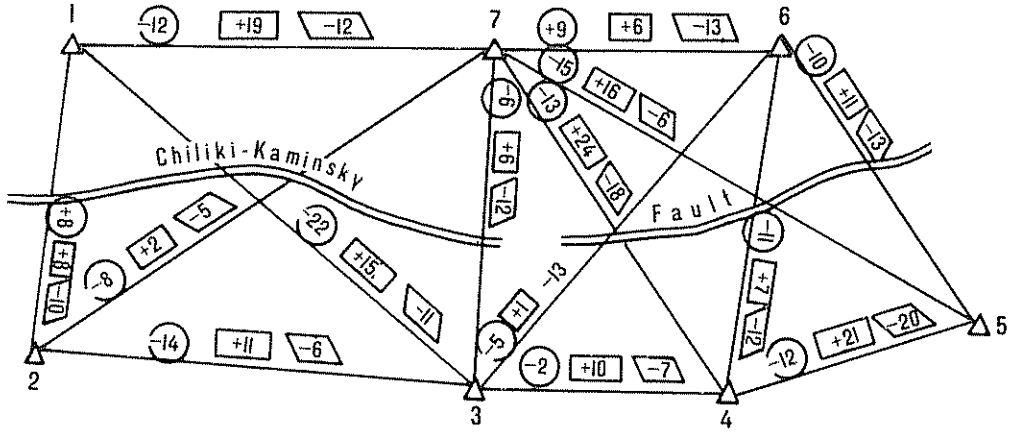
The latest wave of vertical earth-crust movements (see figure 38) is related to the New Year earthquake (31 January 1982). Its epicentre was located 90 km from Alma-Ata and Chonkemin test-sites (see figure 37). The earthquake precursors obtained by CVEM and by geophysical data were negligible. However here for the first time a horizontal component of earthcrust movements was obtained in connection with seismic activity.

Figure 41 shows a scheme of variations in length of lines obtained by range-finders in the Chonkemin test-site (differences of lines are marked by digits in circles, squares, and parallelograms for the periods 1974-1980, 1980-1982, 1982-1983 respectively). As was pointed out and as is clearly seen from figure 41 nearly all test-site lines during 1974-1980 became shorter (12 from 14), which corresponds to a theory of regional compression.

From the measurements done in 1982, four to five months before the earthquake, a general elongation of lines was observed with the rate nearly five times greater than was marked during the preceding six years. In 1983, eight months after the earthquake a new shortening of lines was observed. A similar pattern was observed in the San Andreas fault in the United States.

Therefore, a scientifically based programme of tectonic movement observations using geodetic methods on test-sites of the Northern Tian-Shan mountains made it possible to observe the presence of tectonic earthquake precursors. Where they appear, distances were determined. The possible use of geodetic data, together with geophysical and seismic data, was proved useful in marking out earthquake precursors and their features.

Figure 41. Soviet Union: Scheme of distance measurements at the Chonkemin site



OVERVIEW OF THE NAVSTAR GLOBAL POSITIONING SYSTEM*

Paper submitted by the United States of America

RÉSUMÉ

Le Système mondial de localisation NAVSTAR (GPS) est un système de navigation tous temps par satellite que le Département de la défense est en train de mettre en place, compte tenu de la nécessité pour les forces armées de déterminer constamment avec précision, en tous points de la surface de la Terre ou à proximité, position, vitesse et heure par rapport à un système de référence commun. La Division de l'espace du Commandement des systèmes de l'armée de l'air est l'agent d'exécution du Département de la défense pour la gestion du programme NAVSTAR. Le Bureau du programme, installé au siège de la Division de l'espace à Los Angeles, compte des représentants de l'armée de terre, de la marine, des Marines, de la Defense Mapping Agency (Agence cartographique de la défense), du Département des transports, de l'OTAN et de l'Australie. La mise en place

RESUMEN

El sistema mundial de determinación de posiciones NAVSTAR (GPS) es un sistema de navegación de base espacial y apto para condiciones meteorológicas de todo tipo, que está elaborando el Departamento de Defensa a fin de satisfacer las necesidades de que las fuerzas militares puedan determinar exactamente y en forma continua su posición, velocidad y tiempo en un sistema común de referencias, en cualquier lugar de la Tierra o cerca de ella. La División del Espacio del Comando de Sistemas de la Fuerza Aérea sirve de organismo de ejecución del Departamento de Defensa en la administración del programa del sistema mundial de determinación de posiciones. La oficina conjunta del programa, ubicada en la sede de la División del Espacio en Los Angeles, tiene representantes del ejército, la marina, la infantería de marina, el Organismo de Cartografía de Defensa, el Departamento de Transporte, la OTAN y Australia. El sistema se está elaborando en tres fases: fase I, validación de conceptos; fase II, construcción y desarrollo

* The original text of this paper prepared by William H. Wooden, Defense Mapping Agency, appeared as document E/CONF.77/L.19

du système s'effectue en trois phases : validation des concepts; études techniques et mise au point; et construction

Le programme GPS en est actuellement à la phase des études techniques et de la mise au point. Au cours de cette phase, on utilise un groupement de cinq à six satellites pour les essais, afin de vérifier l'efficacité opérationnelle du concept du Système pour les utilisateurs tant militaires que civils. La mise en place du groupement opérationnel commencera vers la fin de 1986 et durera environ deux ans. Bien que le Système ne soit pas pleinement opérationnel, il y a plusieurs possibilités d'applications civiles.

a escala total, y fase III, producción. Actualmente, el programa del sistema se halla en la fase de construcción y desarrollo a escala total. Durante esta fase se mantendrá una constelación de cinco a seis satélites para ensayos a fin de que se pueda verificar la eficacia operacional del concepto del sistema mundial de determinación de posiciones para los usuarios militares y civiles. El emplazamiento de la constelación operacional comenzará a fines de 1986 y se completará en unos dos años. Aunque el sistema no funcione plenamente, hay varias aplicaciones civiles potenciales.

The NAVSTAR Global Positioning System (GPS) is a space-based radio positioning, navigation, and time-transfer system that will become fully operational in the late 1980s. GPS has the potential for providing highly accurate three-dimensional position and velocity information along with Coordinated Universal Time (UTC) to an unlimited number of suitably equipped users under all weather conditions, continuously, anywhere on or near the surface of the Earth.

GPS is being developed by the United States Government and is in the full-scale engineering development phase. The system is managed by the United States Air Force Space Division as a joint programme involving all the services, plus the Defense Mapping Agency, the Department of Transportation, The North Atlantic Treaty Organization (NATO) and Australia. In this phase of the programme the production baseline for the operational satellite will be established, the operational control segment will be completed, and the final determination on the configuration of user equipment to accommodate all classes of system users will be accomplished.

System description

The NAVSTAR GPS navigation and time-transfer system operates on two L-band frequencies, L_1 (1,575.4 megaherz (MHz)) and L_2 (1,227.6 MHz). The system consists of three major segments: a space segment, satellites that transmit radio signals; a control segment, ground-based equipment to monitor the satellites and update their signals; and a user segment, equipment which passively receives and converts satellite signals into positioning and navigation information.

When fully operational at the end of 1988, the space segment will contain 18 satellites in six orbital planes, each having three satellites. The satellites will operate in circular 20,000 kilometre orbits at an inclination of 55 degrees with 12-hour periods. Precise spacing of the satellites in orbit will be arranged so that a minimum of four satellites will be in view to a user at any time on a world-wide basis. Each satellite will transmit an L_1 and an L_2 signal. Superimposed on these signals will be navigation and system data, including a predicted satellite ephemeris, atmospheric propagation correction data, satellite clock error information, and satellite health data.

The control segment includes a master control station (MCS) and a number of monitor stations and ground antennas located throughout the world. It consists of equipment and facilities required for satellite monitoring, telemetry, tracking, commanding and control, uploading and navigation message generation. The monitor stations passively track the satellites, accumulate ranging data from their signals, and replay them to the MCS where they are processed to determine satellite position and signal data accuracy. The MCS updates the navigation message of each satellite and relays this information to the ground antennas which transmit it to the satellites. The ground antennas are also used for transmitting and receiving satellite control information.

The user segment includes low, medium and high dynamic receivers designed to different requirements of various users. The user equipment is designed to receive and process signals from four orbiting satellites either simultaneously or sequentially. The processor in the receiver then converts these signals to three-dimensional navigation information in World Geodetic System co-ordinates. Positioning data are presented on a display unit in any other co-ordinate system desired by the user. In addition, precise time information is available for use in the host vehicle.

System capabilities

GPS is being developed to provide multiple users with accurate continuous, world-wide, all-weather, common-grid, three-dimensional positioning and navigation information. Because of the unique capabilities of the system, it is reversing the trend of proliferation of radio navigation systems within the United States Department of Defense. The following table compares the nominal GPS user set performance characteristics with other operational navigation systems.

To obtain a navigation solution of position and time (four unknowns), four satellites must be selected. The GPS user measures pseudo-range and pseudo-range rate by synchronizing and tracking the navigation signal from each of the four selected satellites. Pseudo-range is the true distance between the satellite and the user plus an offset due to the user's clock bias. Pseudo-range rate is the true slant range rate plus an offset due to the frequency of the user's clock. By decoding the ephemeris data and system timing information on each satellite's signal, the user's receiver/processor can convert the pseudo-range and pseudo-range rate to user three-dimensional position and velocity. Four measurements are necessary to solve for the three unknown components of position (or velocity) and the unknown user time bias (or frequency).

The navigation accuracy that can be achieved by any user depends primarily on the variability of the errors in making pseudo-range measurements and the instantaneous geometry of the satellites as seen from the user's locaton on Earth (Payne, 1982). Additional information on the navigation solution and navigation technique is given in Milliken and Zoller (1980).

In phase I engineering development models of user equipment sets were built and tested. The overall test objectives were to validate the GPS concept, to identify preferred set

TABLE. NAVIGATION SYSTEM COMPARISON

System	Position accuracy (metres)	Velocity accuracy (m/sec)	Range of operation	Comments
GPS	15 (SEP) 3-D	0.1 (rms per axis)	World-wide	Operational world-wide with 24-hour all-weather coverage
LORAN-C[a]	180 (CEP)	No velocity data	U.S. coast; continental U.S.; selected overseas areas	Operational with localized coverage Limited by skywave interference
OMEGA[a]	2,200 (CEP)	No velocity data	Near global (90% coverage)	Currently operational with localized coverage System is subject to multipath errors
Std INS[b]	1,500 max after first hour (CEP)	0.8 after 2 hour (rms per axis)	World-wide	Operational world-wide with 24-hour all-weather coverage Degraded performance in polar areas
TACAN[a]	400 (CEP)	No velocity data	Line of sight (present air routes)	Position accuracy is degraded mainly because of azimuth uncertainty which is typically on the order of ±1.0 degree
TRANSIT[c]	200 (CEP)	No velocity data	World-wide	The interval between position fixes is about 90 minutes For use in slow-moving vehicles

[a] Federal Radio Navigation Plan, July 1980
[b] ENAC-77-IV, "Characteristic for a moderate accuracy inertial navigation system", August 1979.
[c] *Journal of the Institute of Navigation*, vol. 27, No. 2 (Summer 1979).

requirements, to define and bound system costs, and to demonstrate GPS military and commercial value.

Currently, two United States contractors are developing a family of user equipment sets for demonstration and testing in the current phase of the GPS programme. In order to enhance reliability and maintainability objectives of the user equipment, three main design features have been emphasized: the development and procurement of a small number of user equipment classes, the commonality/interchangeability of units across user classes, and the utilization of a higher-order language. These design features prevent the proliferation of a large number of peculiar user sets, afford the advantage of large-lot buys and common spares, and permit more efficient programming and reprogramming of requirement changes. The primary objective is to design and build a family of GPS user sets at a minimum life cycle cost consistent with performance and functional capabilities. Testing continues on the host vehicles to collect data to support the source selection decision in February 1985 for the phase III user equipment production contract. Since 1977 more than 800 test missions have been accomplished. In virtually all of these tests the NAVSTAR GPS has exceeded specifications.

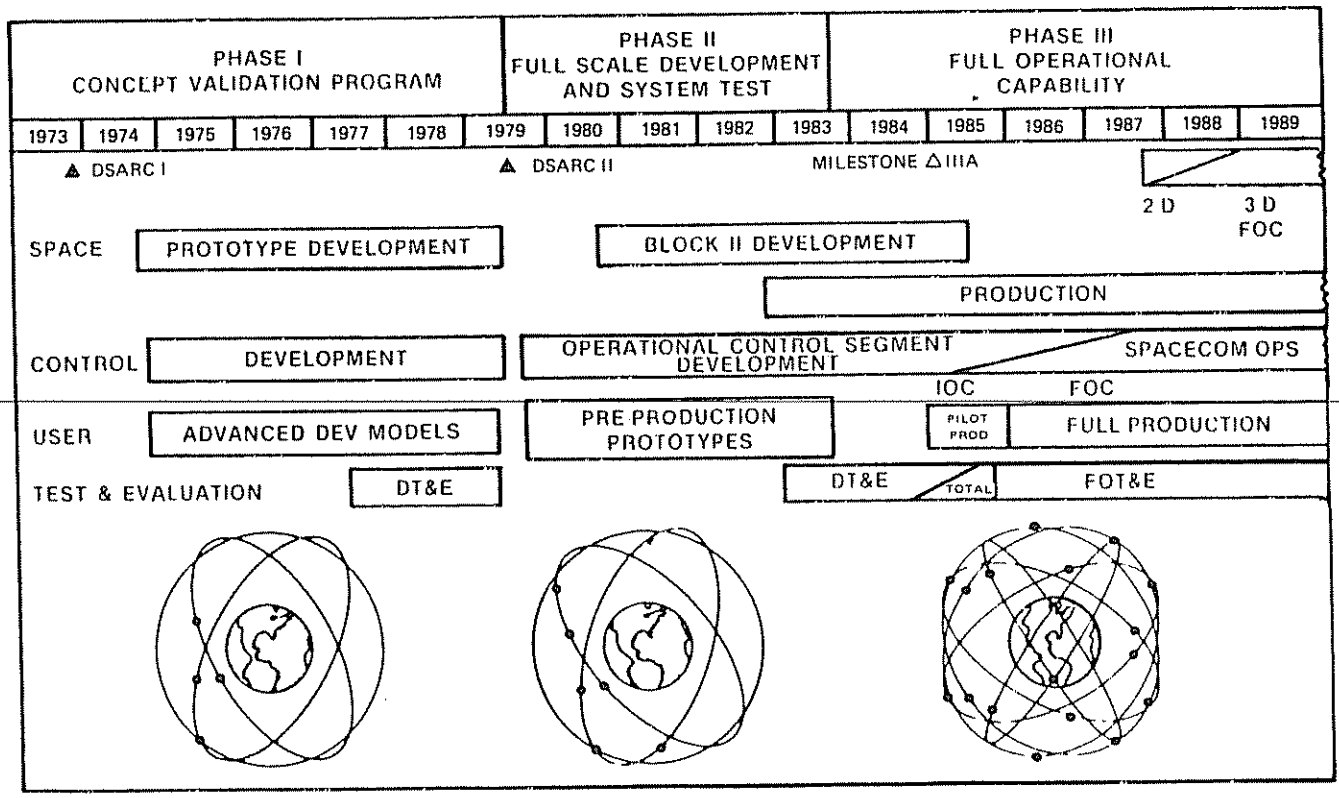
SYSTEM MANAGEMENT

The policies for use and operation of all radio navigation systems controlled by the Department of Defense are reflected in the Federal Navigation Plan. The plan is a joint annual publication by the Departments of Defense and Transportation. The operational satellites will provide two unique and distinct navigation services, the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). The PPS will be available to military users and access will be controlled by the use of cryptographic devices. The PPS is the service of highest accuracy which provides a positioning accuracy of 15 metres SEP, a velocity accuracy of 0.1m/sec (1 sigma), and a timing accuracy of better than 100 nanosec (1 sigma). The SPS will be made available to the world-wide community of civil users. Current policy (Department of Defense, 1983) sets the accuracy of SPS at 100 metres with a 95 per cent level of confidence. The United States Congress had directed that civil and other Government users would pay a fee for use of both the SPS and PPS. However, Congress is now in the process of rescinding that action. The Department's policy is for NAVSTAR GPS to become its primary radionavigation system. As GPS becomes operational, the Department will terminate operations with other radionavigation systems.

APPLICATIONS

Even though NAVSTAR GPS is not fully operational, several potential civilian applications exist. GPS will provide a broad spectrum of civilian users with an accurate position, velocity, and time determination capability at a reasonable cost. Ultimately, it will replace many existing navigation systems.

Figure 42. United States of America: Evolution of the NAVSTAR program



System status

In December 1973 the Defense System Acquisition Review Council (DSARC) authorized a step-wise, design-to-cost development and test programme which would lead, in successive phases, to an operational GPS. The system concept resulted from the integration of the best features of previous navigation satellite concepts being pursued independently by the United States Navy and Air Force.

The NAVSTAR programme is being developed in three phases: phase I, concept validation; phase II, full-scale engineering and development; and phase III, production. The details of the schedule are shown in figure 42. During phase I, prototype satellites were developed, a control segment was established, and advanced engineering models of user equipment were tested. Currently, the programme is in phase II. The main tasks of this phase include developing the prototype operational satellite, the operational control system and the prototype user equipment, and completing the developmental test and evaluation/initial operational test and evaluation.

The current GPS constellation consists of a limited number of developmental satellites configured in two planes inclined at 63 degrees with respect to the Equator. There are six good satellites (NAVSTAR 3, 4, 6, 8, 9, 10), plus one satellite (NAVSTAR 1) which is generally not being used for navigation because it is operating with a quartz crystal clock. The current constellation is shown in figure 43. The plan is to maintain a minimum constellation of five satellites for completion of the test and evaluation period for the system. It is currently projected that the last Block I test satellite will be launched in mid-1985 to maintain the test configuration.

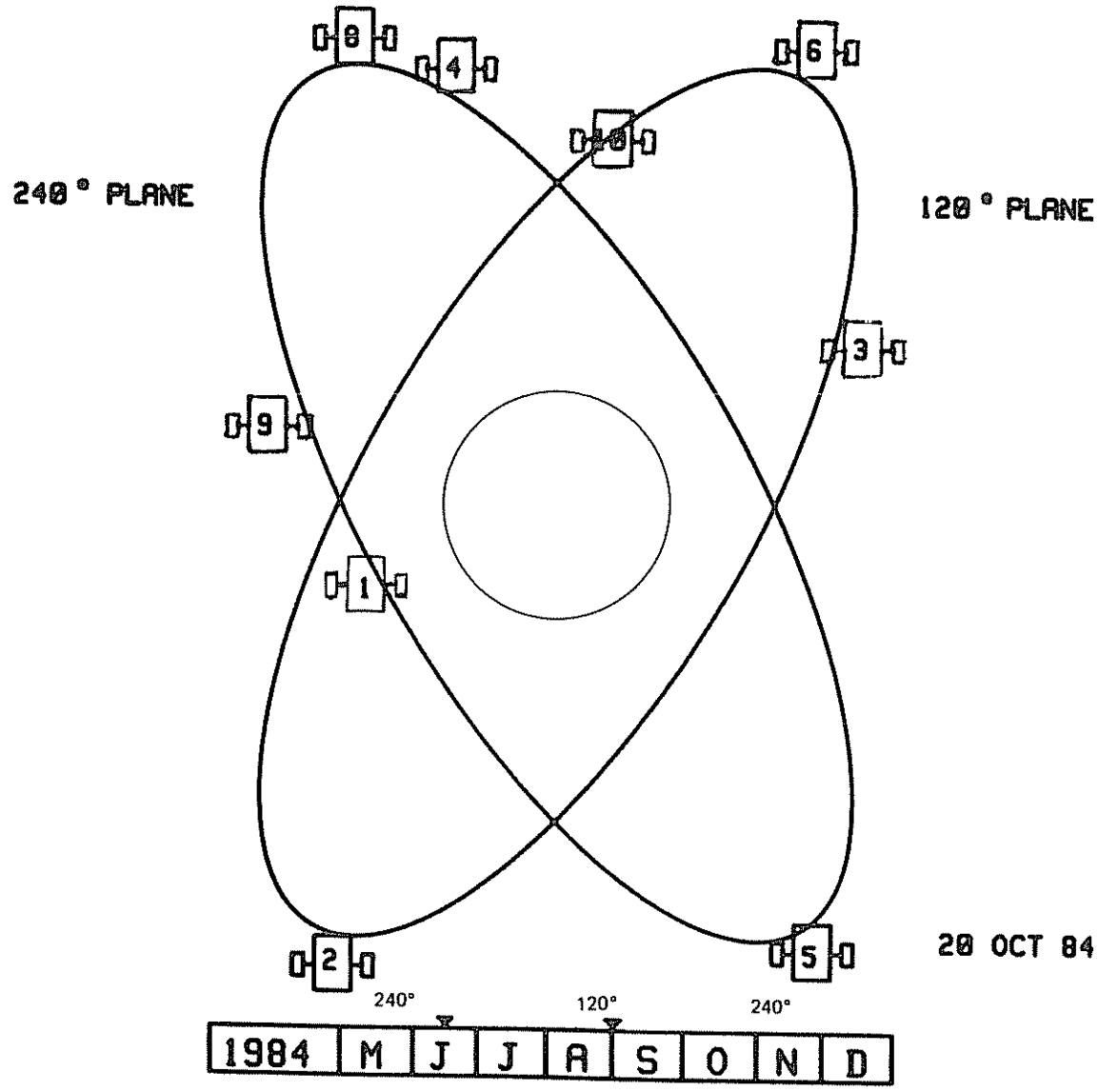
The operational constellation is a 6-plane, uniform 18-satellite configuration plus three active spares. The spares are necessary to guarantee very high system availability for the 18-satellite constellation. The planes of the constellation are 60 degrees apart in longitude with each plane containing three satellites separated by 120 degrees. The phasing from plane to plane is 40 degrees, so that a satellite in one plane has a satellite 40 degrees ahead (north) of it in the adjacent plane to the east. According to the current plan, the Block II (operational) satellites will be launched at a rate of eight per year, beginning in October 1986. Two-dimensional coverage should be available by the latter part of 1987 and three-dimensional coverage, barring failures, should be available by the end of 1988.

The phase I control segment consisted of a master control station and antenna located at Vandenberg Air Force Base in California and monitor stations located at the Vandenberg base, and at Alaska, Guam and Hawaii. The initial control system, which will fill the control segment gap between phase I and the final operational control system, became fully operational in January 1983.

The final operational control system (OCS) will consist of a master control station, three ground antennas, and five monitor stations. The master control station will be located at the Consolidated Space Operations Center (CSOC), Colorado Springs, Colorado. A ground antenna and a monitor station will be located at Kwajalein, Diego Garcia and Ascension. Two additional monitor stations will be located at CSOC and in Hawaii. The initial operational capability for the OCS is scheduled for January 1985.

Many potential applications are shown in figure 44. Civilian users of airborne, land-based, and maritime vehicles will benefit from GPS for optimal course navigation, which will in turn reduce fuel costs and transportation time. Search-and-rescue techniques can be enhanced because of the pre-

Figure 43. United States of America: NAVSTAR GPS constellation



cision position identification capability of GPS. The mineral exploration and geophysical survey communities will be able to accurately locate potential petroleum bearing areas, ore bodies, and active fault belts in a shorter period of time. Other GPS applications to mapping, charting, and geodesy have been given elsewhere (Senus and Hill, 1981). The GPS common grid feature will enhance many land-vehicle operations. Airborne collision avoidance systems and maritime hazard systems are also potential uses of the system. GPS time transfer applications include scientific, intra-system synchronization, and inter-system synchronization uses (Van Dierendonck and Melton, 1983).

In addition to the potential applications given above, GPS has demonstrated performance in space applications and baseline determinations. Continuous 10 to 15 metre positioning in space without the use of ground tracking systems has been demonstrated on LANDSAT-4 using a GPS receiver (Birmingham *et al.*, 1983). Relative positions have been demonstrated to be accurate to within several centimetres over baselines varying from hundreds of metres to tens of kilometres (Counselman *et al.*, 1983). The potential applications for GPS are boundless.

Conclusions

The NAVSTAR GPS is evolving into a highly accurate, world-wide, all-weather navigation/positioning system applicable to the needs of both the military and civilian communities. Since 1977 extensive testing has taken place which verified the established accuracy goals and the system operation under various mission-oriented conditions. There are numerous applications for which GPS can be exploited. Even though the system is not fully operational, it is being used by diverse civilian groups such as NASA for orbit determination on-board LANDSAT-4 and oil companies for geodetic positioning. As the system gains acceptance by the civilian community, more sophisticated uses for the system will be established.

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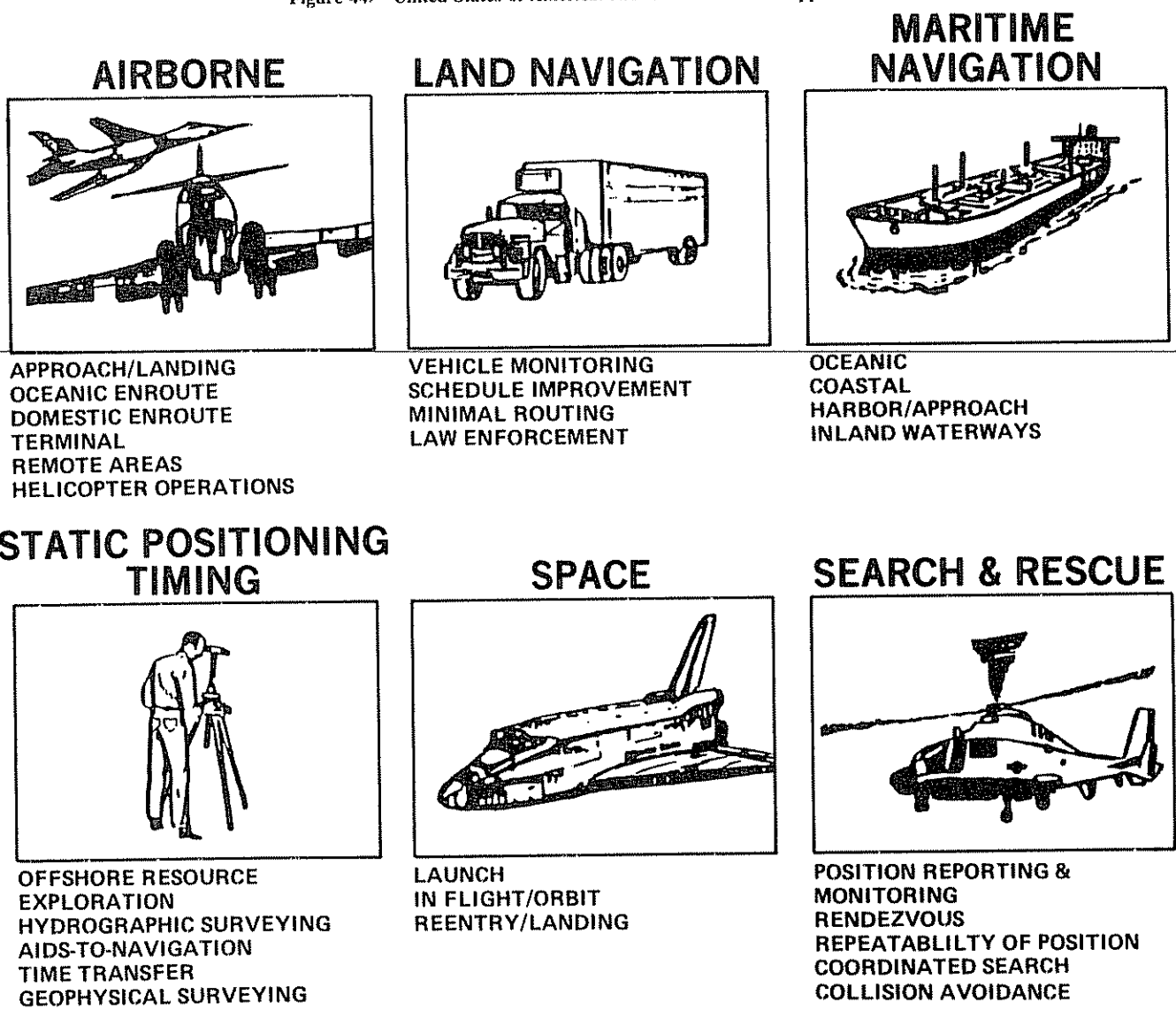
Figure 44. United States of America: NAVSTAR GPS civil applications



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WORLD GEODETIC SYSTEM 1984*

Paper submitted by the United States of America

RÉSUMÉ

Le Département de la défense des Etats-Unis a mis au point un système géodésique mondial (WGS 84) pour les

RESUMEN

El Departamento de Defensa de los Estados Unidos ha elaborado un Sistema Geodésico Mundial 1984 para aplicaciones cartográficas en los casos en que se desea levantar mapas con respecto al centro de masa de la Tierra. El empleo de este sistema se iniciará en 1985, pero su aplicación com-

* The original text of this paper, prepared by Mark M. Macomber, Defense Mapping Agency, appeared as document E/CONF 77/L 20

applications de la cartographie lorsqu'on veut se référer au centre massique de la Terre. On commencera à l'utiliser dès 1985, mais il ne sera pas mis en place complètement avant plusieurs années.

Outre le Système géodésique de référence de 1980, adopté par l'Union geodésique et géophysique internationale, ce système comporte un modèle gravitationnel de la Terre jusqu'au degré 12 ainsi que des équations de transformation permettant de passer des ellipsoïdes de référence locaux au WGS 84. Les équations de transformation sont données pour les systèmes géodésiques de l'Amérique du Nord de 1927, de l'Amérique du Sud de 1969, de l'Europe de 1950, de Tokyo et de l'Australie. Les transformations d'autres ellipsoïdes seront incorporées ultérieurement.

pleta no tendrá lugar, sino luego de un periodo de varios años.

El Sistema Geodésico Mundial 1984 incorpora el sistema geodésico de referencia de 1980 que fue aprobado por la Unión Internacional de Geodesia y Geofísica, pero añade un modelo gravitatorio de la Tierra que incluye hasta el grado y el orden 12 y proporciona ecuaciones de transformación para efectuar conversiones de los sistemas de referencia geodésicos locales al Sistema Geodésico Mundial 1984. Se dan las ecuaciones de transformación para el sistema de referencia de Norteamérica de 1927, el sistema de referencia de Sudamérica de 1969, el sistema de referencia de Europa de 1950, el sistema de referencia de Tokio y el sistema de referencia geodésico australiano. Posteriormente se incorporarán otras transformaciones de sistemas de referencia.

The Defense Department of the United States has developed a World Geodetic System 1984 (WGS-84) for cartographic application in those cases where mapping with respect to the centre of mass of the Earth is desired. Use of this system will start in 1985, but complete implementation will not be effected for several years.

WGS-84 consists of the following components:

Ellipsoidal model;
Ellipsoidal gravity formula;
Earth gravitational model;
Transformation equations from conventional geodetic datums to WGS-84.

The ellipsoidal model is based on the Geodetic Reference System model of 1980 (GRS-80), adopted by the International Union of Geodesy and Geophysics (IUGG), but the flattening term is indicated by a normalized second harmonic coefficient in lieu of the regular coefficient. The defining parameters are given in table 1.

The ellipsoidal gravity formula is given in table 2. Only the closed form of the formula is given, since the ready availability of effective calculators has eliminated the need to use a truncated infinite series as an approximation.

The Earth gravitational model, given in table 3, is complete through degree and order 12. This model is based on three independent data types:

(*a*) Dynamics of near-Earth satellites that have been tracked by means of Doppler shift, and the higher altitude LAGEOS satellite tracked by laser ranging;

(*b*) Satellite altimetry data from the world's oceans;

(*c*) Surface mean anomaly data (3-degree grid).

The transformation equations from conventional geodetic datums to WGS-84 have been based primarily on Doppler positioning operations; however, the determination of the longitudinal zero point was made using very long baseline interferometry (VLBI). Table 4 (*a*)-(*e*) provides the equations to transform to WGS-84 from:

North American Datum 1927;
South American Datum 1969;
European Datum 1950;
Tokyo Datum;
Australian Geodetic Datum.

In the past a mean datum shift has been used for each datum, and the Molodensky transformation equations were employed for conversions. The primary reason for using such a technique is the ease of transformation. An undesirable consequence of that technique is that distortions in the geodetic network are transformed into the world geodetic system positions. In WGS-84, regression equations are used which fit the existing geodetic net to the observed Doppler positions, thus removing many of the distortions inherent in the older geodetic nets.

In addition to being used by the Defense Mapping Agency for charting purposes, WGS-84 will be the reference frame used by the Global Positioning System (GPS) when it becomes operational.

TABLE 1. WGS-84 ELLIPSOID: DEFINING PARAMETERS

Parameters	*Notation*	*Value*	
Semi-major axis	a	6,378,137 m	
Second degree normalized zonal harmonic coefficient of the geopotential	$\bar{C}_{2,0}$	−484 166	85×10^{-6}
Angular velocity of the Earth	ω	72 921	15×10^{-6} rad s^{-1}
The Earth's gravitational constant (including mass of Earth's atmosphere)	GM	398,600 5	$\times 10^{9}$ $m^3 s^{-2}$
Parameter values for special applications			
Angular velocity of the Earth	ω′	72 921 151 467	$\times 10^{-6}$ rad s^{-1}
The Earth's gravitational constant (not including mass of Earth's atmosphere)	GM′	398,600.15	$\times 10^{9}$ $m^3 s^{-2}$

TABLE 2. WGS-84: ELLIPSOIDAL GRAVITY FORMULA

$$\gamma = 978{,}032\ 677\ 14\ \frac{(1 + 0.001\ 931\ 851\ 386 \sin^2 \phi)}{(1 - 0\ 006\ 694\ 379\ 990\ 13 \sin^2 \phi)^{1/2}} \text{ mgals}$$

Mean value of theoretical (normal) gravity

$\bar{\gamma}$ = 979,764.465 6 mgals

TABLE 3. WGS-84: EARTH GRAVITATIONAL MODEL
(Truncated to n = m = 12)

Degree and order		Normalized geopotential coefficients	
n	*m*	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$
2	0	−0 4841 6685 E-07	
2	1		
2	2	0.2439 5796 E-05	−0.1397 9548 E-05
3	0	0 9570 6390 E-06	
3	1	0 2031 8729 E-05	0 2508 5759 E-06
3	2	0 9066 6113 E-06	−0 6210 2428 E-06
3	3	0 7177 0352 E-06	0 1415 2388 E-05
4	0	0 5369 9587 E-06	
4	1	−0 5354 8044 E-06	−0 4742 0394 E-06
4	2	0.3479 7519 E-06	0.6557 9158 E-06
4	3	0 9917 2321 E-06	−0 1991 2491 E-06
4	4	−0 1868 6124 E-06	0 3095 3114 E-06
5	0	0 7109 2048 E-07	
5	1	−0 6418 5265 E-07	−0 9249 2959 E-07
5	2	0 6518 4984 E-06	−0 3200 7416 E-06
5	3	−0 4490 3639 E-06	−0 2132 8272 E-06
5	4	−0 2971 9055 E-06	0 5321 3480 E-07
5	5	0 1752 3221 E-06	−0.6705 9456 E-06
6	0	−0 1506 4821 E-06	
6	1	−0.7418 0259 E-07	0.3278 0040 E-07
6	2	0 5182 4409 E-07	−0 3586 6634 E-06
6	3	0 5337 0577 E-07	0.6133 4720 E-08
6	4	−0 8869 4856 E-07	−0 4726 0945 E-06
6	5	−0 2681 8820 E-06	−0 5349 1073 E-06
6	6	0 1023 7832 E-07	−0.2374 1002 E-06
7	0	0 8581 9217 E-07	
7	1	0 2790 5196 E-06	0 9423 1346 E-07
7	2	0 3287 3832 E-06	0 8883 5092 E-07
7	3	0 2494 0240 E-06	−0 2122 3369 E-06
7	4	−0 2712 3034 E-06	−0 1269 6607 E-06
7	5	0 1024 6290 E-08	0 1732 1672 E-07
7	6	−0 3584 3745 E-06	0 1520 2633 E-06
7	7	−0 2099 1457 E-08	0.2280 5664 E-07
8	0	0 4297 9835 E-07	
8	1	0 1888 9342 E-07	0 4785 6967 E-07
8	2	0.7355 3952 E-07	0 4786 7963 E-07
8	3	−0 1213 2459 E-07	−0 8346 1853 E-07
8	4	−0 2420 8264 E-06	0 7160 3924 E-07
8	5	−0 2496 6587 E-07	0 8775 1047 E-07
8	6	−0 6509 3424 E-07	0 3090 4202 E-06
8	7	0 6632 3292 E-07	0 7466 1766 E-07
8	8	−0 1237 2281 E-06	0 1221 0258 E-06
9	0	0 3317 3231 E-07	
9	1	0 1474 7969 E-06	0 2389 4354 E-07
9	2	0 2205 2093 E-07	−0 2687 6665 E-07
9	3	−0 1625 6047 E-06	−0 8592 8431 E-07
9	4	−0 1719 3827 E-07	0 2607 7030 E-07
9	5	−0 1690 2791 E-07	−0 5033 7365 E-07
9	6	0 6571 7910 E-07	0 2227 5858 E-06
9	7	−0 1164 8016 E-06	−0 9729 8769 E-07
9	8	0 1889 6045 E-06	−0 3102 6222 E-08
9	9	−0 4827 5744 E-07	0 9638 1072 E-07
10	0	0 5093 1575 E-07	
10	1	0 8870 6517 E-07	−0 1253 6457 E-06
10	2	−0 8237 5203 E-07	−0 3828 0049 E-07
10	3	−0 1313 7371 E-07	−0 1555 3732 E-06
10	4	−0 8742 4319 E-07	−0 7921 5732 E-07
10	5	−0 5398 0821 E-07	−0 4629 4947 E-07
10	6	−0 4237 1448 E-07	−0 7968 0607 E-07
10	7	0 8373 6045 E-08	−0 2563 6582 E-08
10	8	0 4123 9589 E-07	−0 9226 9095 E-07
10	9	0 1253 9514 E-06	−0 3768 7117 E-07
10	10	0 1012 4370 E-06	−0 2487 4984 E-07
11	0	−0 5811 4696 E-07	
11	1	0 9537 5839 E-08	−0.2209 4828 E-07
11	2	0.2171 6225 E-07	−0.1022 4810 E-06
11	3	−0.3002 3695 E-07	−0 1342 2019 E-06
11	4	−0 3040 7161 E-07	−0 6982 3333 E-07
11	5	0.3510 4609 E-07	0.4917 5170 E-07
11	6	−0.3791 1105 E-08	0 3684 8522 E-07
11	7	0.2577 4039 E-08	−0.8865 8395 E-07
11	8	−0 7139 6627 E-08	0 2324 3077 E-07
11	9	−0.3024 6313 E-07	0 4177 6400 E-07
11	10	−0.5342 4279 E-07	−0 1871 6766 E-07
11	11	0 4751 4858 E-07	−0 7041 5796 E-07
12	0	0.3407 3235 E-07	
12	1	−0 6060 9926 E-07	−0.3818 9082 E-07
12	2	0 7420 0188 E-08	0 2464 0620 E-07
12	3	0 4214 9817 E-07	0.3218 9594 E-07
12	4	−0.6434 6831 E-07	−0 2536 4931 E-08
12	5	0.3312 6200 E-07	−0.4065 8586 E-09
12	6	0 8698 1502 E-08	0 3671 1094 E-07
12	7	−0 1659 8048 E-07	0 3447 5954 E-07
12	8	−0.2684 3700 E-07	0 1783 8309 E-07
12	9	0 4229 3015 E-07	0 2710 7811 E-07
12	10	−0 4423 7357 E-08	0 3082 3394 E-07
12	11	0 9646 2514 E-08	−0 6071 1291 E-08
12	12	−0 3087 8714 E-08	−0 1093 2316 E-07

NOTE: E-03 = × 10^{-3}; E-05 = × 10^{-5}; etc

TABLE 4. TRANSFORMATION EQUATIONS

(a) *Conterminous United States: North American Datum 1927 (NAD-27) to WGS-84*

$$\Delta\phi\,('') = +\,0.18248 - 0.86722\,U + 0.11882\,V + 1.21366\,U^2 - 0.90132\,U^3 + 0.28702\,V^3 - 0.39213\,U^3V - 2.39061\,U^4V - 0.10417\,V^5 + 1.01204\,U^4V^3 - 0.06532\,UV^6$$

$$\Delta\lambda\,('') = -\,1.16464 + 1.99762\,V - 0.76293\,UV - 2.64159\,U^3 - 0.06681\,UV^2 + 0.06283\,V^3 + 2.23121\,UV^3 + 4.96664\,U^5 - 1.20212\,UV^5 + 0.13948\,UV^7 - 0.03079\,UV^8$$

$$\Delta H\ (m) = -37.486 + 4\,476\,U - 7.333\,V - 12.375\,U^2 + 6.543\,UV + 7.968\,V^2 - 5.168\,U^2V - 4\,237\,UV^2 + 0\,883\,V^3 - 47.903\,U^3V + 160.491\,U^5V + 121.064\,U^4V^2 - 41\,751\,U^2V^4 + 17\,008\,U^2V^6 + 17.751\,U^6V^9$$

where: $U = K(\phi - 37)$ $\quad K = 0\,0523599$

$V = K(\lambda - 265)$

ϕ = geodetic latitude in degrees and decimal part of a degree—positive north

λ = geodetic longitude in degrees and decimal part of a degree—positive east from 0° to 360°

H = geodetic height

$\phi(\text{WGS 84}) = \phi(\text{NAD-27}) + \Delta\phi$

$\lambda(\text{WGS 84}) = \lambda(\text{NAD-27}) + \Delta\lambda$

$H(\text{WGS 84}) = H(\text{NAD-27}) + \Delta H$

These equations reproduced Doppler-derived WGS-84 positions to an rms accuracy of ± 1 3 metres at over 390 stations.

Test case: $\phi = 34°\ 47'\ 08''833$ $\quad \Delta\phi = 0''376$

$\lambda = 273°\ 25'\ 07''825$ $\quad \Delta\lambda = -0''254$

$\Delta H = -40\ 03$ m

(b) *South America*

South American Datum 1969 (SAD-69) to WGS-84

$$\Delta\phi\ ('') = -1.70423 + 0\,32457\,V + 1.47643\,U^2 + 0.16325\,U^3 - 1.25510\,U^2V - 0\,91714\,V^3 - 2\,04195\,U^4 - 0\,23666\,U^3V + 0\,60041\,V^5 + 0.97497\,U^6 - 0\,19572\,U^5V^2 + 3\,98279\,U^4V^3 - 0.15899\,U^8 + 1\,07084\,U^4V^4 - 1.74285\,U^2V^6 + 0\,03167\,U^9V + 0.64519\,U^7V^4 - 1.77266\,U^6V^5 + 2.28485\,U^4V^8 - 1.36268\,U^7V^8 - 0.72115\,U^9V^7 - 1.77821\,U^9V^8 - 0.93127\,U^9V^9$$

$$\Delta\lambda\ ('') = -2\,01792 + 0.43588\,U + 0.45994\,V - 0.08554\,U^2 - 0.48166\,UV - 0\,94304\,V^2 - 0\,39748\,U^2V + 0.19540\,UV^2 + 2.26011\,V^4 + 4\,14470\,U^3V^3 - 0\,22411\,U^2V^4 - 2.29019\,V^6 - 2\,30331\,U^4V^3 - 2.61500\,U^5V^3 + 0.86795\,V^8 - 3\,64267\,U^4V^5 - 0\,09489\,V^9 + 1.69296\,U^7V^3 - 3.79714\,U^5V^5 + 11.04801\,U^6V^5 - 2.72999\,U^7V^5 + 2\,42904\,U^5V^7 - 1\,57488\,U^9V^5 - 6.46086\,U^8V^7 + 4\,36655\,U^9V^7$$

$$\Delta H\ (m) = +5\,527 - 8\,550\,U - 26\,828\,V + 43.525\,U^2 + 12.372\,V^2 - 33\,781\,UV^2 + 9.410\,V^3 - 104\,522\,U^4 - 10.616\,U^5 + 19.940\,U^2V^3 + 81\,922\,U^6 - 175\,734\,U^4V^2 + 172.237\,U^5V^2 + 28.891\,U^3V^4 - 9.569\,V^7 - 21.417\,U^8 + 228.440\,U^6V^2 + 17.699\,U^2V^6 + 18.454\,UV^7 + 3\,190\,U^9 - 193.669\,U^7V^2 - 68.982\,U^8V^2 - 31\,362\,U^4V^6 - 54\,635\,U^3V^7 + 53\,829\,U^9V^2 + 31.681\,U^5V^9 - 4\,609\,U^9V^9$$

where: $U = K(\phi + 20)$ $\quad K = 0\,0523599$

$V = K(\lambda - 300)$

ϕ = geodetic latitude in degrees and decimal part of a degree—positive north, negative south

λ = geodetic longitude in degrees and decimal part of a degree—positive east from 0° to 360°

H = geodetic height

$\phi(\text{WGS 84}) = \phi(\text{SAD 69}) + \Delta\phi$

$\lambda(\text{WGS 84}) = \lambda(\text{SAD 69}) + \Delta\lambda$

$H(\text{WGS 84}) = H(\text{SAD 69}) + \Delta H$

These equations reproduced Doppler-derived WGS 84 positions to an rms accuracy of ± 1.6 meters at over 75 stations in Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad, and Venezuela.

Test case: $\phi = -45°\ 54'\ 34''179$ $\quad \Delta\phi = -1''418$

$\lambda = 291°\ 30'\ 18''344$ $\quad \Delta\lambda = -2''909$

$\Delta H = -32\ 10$ m

(c) *Western Europe*

European Datum 1950 (ED-50) to SGS-84

$$\Delta\phi\ ('') = -2\,65468 + 2\,05138\,U + 0.42259\,V + 0.48984\,U^2 + 0.73355\,V^2 + 0\,90920\,U^3 + 2\,53147\,U^2V - 0.72020\,UV^2 + 3\,86471\,UV^3 - 0.59211\,U^5 - 4\,04947\,U^4V - 3\,38467\,UV^5 + 4\,77265\,U^4V^3 + 0.54156\,V^8 - 7\,56917\,U^6V^9$$

$$\Delta\lambda\ ('') = -4.45500 - 1.61659\,U + 1.95078\,V - 1.81975\,U^2 + 0.53202\,UV - 0\,65346\,U^3 - 3.67576\,UV^2 + 2.10356\,U^4 - 2\,43915\,U^2V^2 + 1.38903\,V^4 + 1\,14509\,U^4V + 11\,89961\,UV^4 - 8\,48517\,UV^6 - 0.51702\,V^8 - 3.31646\,U^9V^4 + 6.46701\,U^9V^9$$

TABLE 4 (*continued*)

ΔH (m) = + 36 052 − 28 813 U − 18 352 V + 13.678 U^2 + 3.769 UV + 3 316 V^3
+ 33 994 U^7V + 5 416 V^8 − 129 330 U^6V^4 + 147 344 U^6V^8

where: U = K(ϕ − 52) K = 0 0523599
V = K(λ − 10)
ϕ = geodetic latitude in degrees and decimal part of a degree—positive north
λ = geodetic longitude in degrees and decimal part of a degree—positive east from 0° to 180° and negative west from 0° to 180°
H = geodetic height
ϕ(WGS 84) = ϕ(ED 50) + $\Delta\phi$
λ(WGS 84) = λ(ED 50) + $\Delta\lambda$
H(WGS 84) = H(ED 50) + ΔH

These equations reproduced Doppler-derived WGS-84 positions to an rms accuracy of ± 1 2 metres at over 128 stations in Austria, Denmark, England, Federal Republic of Germany, Finland, France, Gibraltar, Greece, Netherlands, Norway, Portugal, Scotland. Sicily, Spain, Switzerland and Wales

Test case: ϕ = 46° 41′ 42″893 $\Delta\phi$ = − 3″115
λ = 13° 54′ 54″088 $\Delta\lambda$ = − 3″717
ΔH = 41 16 m

(d) *Japan/Republic of Korea: Tokyo Datum (TD) to WGS-84*

$\Delta\phi$ (″) = + 11.95340 − 9 62801 U + 0 88665 U^3 − 0 47946 U^2V + 7 58688 UV^2
+ 0 77749 V^3 − 1 17313 UV^6 − 0 08409 V^9 − 0 13521 U^2V^8 − 0 27780 U^3V^8

$\Delta\lambda$ (″) = − 10.36350 − 2 05554 V + 1 65977 U^2V − 2 78777 U^5 − 6 06792 U^4V
+ 4 94331 U^7 + 1 85890 U^4V^4

ΔH (m) = + 11 514 + 43 175 U − 24 604 V − 14 246 U^2 + 9 263 U^3V

where: U = K(ϕ − 35) K = 0 1570796
V = K(λ − 135)
ϕ = geodetic latitude in degrees and decimal part of a degree—positive north
λ = geodetic longitude in degrees and decimal part of a degree—positive east from 0° to 360°
H = geodetic height
ϕ(WGS 84) = ϕ(TD) + $\Delta\phi$
λ(WGS 84) = λ(TD) + $\Delta\lambda$
H(WGS 84) = H(TD) + ΔH

These equations reproduced Doppler-derived WGS-84 positions to an rms accuracy of ± 1 0 metre at 13 stations in Japan, the Republic of Korea and Okinawa.

Test case: ϕ = 40° 42′ 38″260 $\Delta\phi$ = 9″715
λ = 141° 22′ 23″979 $\Delta\lambda$ = −13″117
ΔH = 20 84 m

(e) *Australia: Australian Geodetic Datum (AGD) to WGS-84*

$\Delta\phi$ (″) = + 5 19094 + 0 10880 U + 0.53546 V − 0.26415 U^2 + 0 66905 U^2V
+ 0 70726 UV^2 − 1 08711 U^2V^2 − 0 97089 UV^3 + 2 86844 U^4V^2
− 5 96789 U^4V^3 − 6 11875 U^2V^6

$\Delta\lambda$ (″) = + 4 38095 − 0 91915 U − 0.62471 V + 0.20891 UV − 0 27391 V^2
+ 0 93129 U^4 + 0 57341 U^3V^2 − 0 67696 U^8

ΔH (m) = + 7.838 + 54 741 U + 35 354 V + 11 794 UV − 2 373 V^2
− 29 286 U^3V − 3 921 U^3V^2 − 11 470 UV^4 + 30 504 U^5V
+ 19 619 UV^8 + 14 894 UV^9

where: U = K(ϕ − 27) K = 0 0523599
V = K(λ − 134)
ϕ = geodetic latitude in degrees and decimal part of a degree—negative south
λ = geodetic longitude in degrees and decimal part of a degree—positive east from 0° to 360°
H = geodetic height
ϕ(WGS 84) = ϕ(AGD) + $\Delta\phi$
λ(WGS 84) = λ(AGD) + $\Delta\lambda$
H(WGS 84) = H(AGD) + ΔH

These equations reproduced Doppler-derived WGS-84 positions to an rms accuracy of ± 1 2 metres at over 100 stations

Test case: ϕ = 17° 00′ 32″776 $\Delta\phi$ = 5″476
λ = 144° 11′ 37″245 $\Delta\lambda$ = 3″636
ΔH = 55 81 m

(b) *Acquisition of cartographic data from space*

FIRST RESULTS OF THE EUROPEAN SPACELAB PHOTOGRAMMETRIC CAMERA MISSION*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Pendant la mission Spacelab 1, une chambre métrique a pris environ 120 vues à haute résolution, en infrarouge couleurs et en noir et blanc au-dessus de l'Asie, de l'Afrique, de l'Europe et de l'Amérique. Ces images peuvent être utilisées pour la cartographie topographique et thématique jusqu'à l'échelle de 1/100 000. Le rapport présente les premiers résultats de l'évaluation dans certains secteurs.

RESUMEN

En el curso de la misión del Spacelab 1 se obtuvieron, mediante una cámara fotogramétrica, cerca de 120 fotografías de alta resolución en color infrarrojo y en blanco y negro de Asia, Africa, Europa y América. Las imágenes son apropiadas para el levantamiento de mapas topográficos y temáticos a escala de 1:100.000. Se exponen los primeros resultados de la evaluación de determinadas zonas.

Photogrammetry, the photographing of landscape features from aircraft, is now considered to be a standard topographic data acquisition tool the world over. And yet, the progress of mapping from aerial photographs is too slow to have accomplished more than 40-45 per cent of the desired topographic map coverage of the world at the necessary scales of 1:50,000 or 1:100,000. With the existing methods of aerial photogrammetry it will not be possible to achieve a world land coverage at these scales by the year 2000.

Since the first satellite—Sputnik—was launched in 1957, there has been interest in mapping from space. The first LANDSAT satellite of 1972 introduced satellite imagery to most countries of the world. LANDSAT film products, available from the United States and from various receiving stations of the world, did not, however, satisfy the demands of topographic cartographers for sufficient detail.

Even the use of more costly digital computer tapes with computer enhancement techniques does not make it possible to deduce from the 79-metre pixel data objects smaller than 200 m. A transportation network, for example, important in topographic maps, could not be detected in the images.

As of 1982, with LANDSAT 4 and 5, it is possible to utilize 30-m pixels with the thematic mapper. This image evaluation requires a computer effort about 10 times as high as for LANDSAT-MSS known from earlier missions. The object detection capability of the thematic mapper images of 30-m pixels is restricted to about 80 m on the ground.

As early as 1973, Skylab photography rendered better resolution with an image detection capability of 40 m or a pixel equivalent of 15 m.

Starting from the requirement for topographic mapping at scale 1:50,000, the University of Hanover has tried to determine the requirements for digital and photographic sensor resolution. Any enlargement of a digital LANDSAT-MSS image, compared to the content of a 1:50,000 topographic map, shows clearly that LANDSAT-MSS is not suitable for topographic mapping at that scale. However, 1:50,000 aerial photography can be used for mapping at that scale.

Aerial photography has been digitized at scale 1:50,000, with an Optronics drum scanner at ground pixels of 1 m, 2.5 m, 5 m, 10 m, 20 m and 40 m etc. not only for single images, but also for overlapping stereo-images. In evaluating these stereo-pairs, digitized at various intervals, one finds that for European topographic mapping standards a pixel size of 2.5 m is required in monoscopic observation to derive roads, buildings, hydrology and vegetation to be shown on the topographic maps. If stereo-observation is used, this requirement may be relaxed to 5 m pixels.

For non-European mapping standards, with individual buildings and some drainage not shown, it is sufficient to use 5 m pixels with monoscopic observation, or 10 m pixels with stereoscopic observation. It is for this reason that a suggestion was made to the Government of the Federal Republic of Germany in 1977 to conduct a photogrammetric camera experiment on the first mission of Spacelab with a photographic resolution of about 20 m, which is the equivalent of about 8 m pixel size.

The first Spacelab mission was prepared jointly by the European Space Agency (ESA) of the Western European countries and the National Aeronautics and Space Administration (NASA) of the United States of America. The Federal Republic of Germany funded the experiment. Consequently the project management was in the hands of the German Space Agency (DFVLR), the task of the cartographic input was at the University of Hanover and the integration of the experiment into Spacelab, as well as its representation to NASA, was done by ESA.

The first Spacelab mission was launched on NASA's space shuttle flight number 9 from Cape Canaveral on 28 November 1983. The shuttle landed nine days later, on 7 December, at Dryden, California. The shuttle carried the European-built Spacelab, which was suitable for work for five astronauts.

The pressurized laboratory and its open cargo bay carried 37 major experiments. Experiment 33 was the photogrammetric camera experiment. The hardware consisted of an aerial mapping camera RMK 30/23 from Zeiss Oberkochen, which was mounted over the Spacelab window. This camera was operated from the 250-kilometre orbit, using two film cassettes. The first cassette contained Kodak 2443 false-colour infrared film, and the second Kodak Double-X black-and-white film. The exposure of the film was made under computer control.

In this way 550 colour infrared and 470 black-and-white images were exposed, covering about 13 million km² at the image scale of 1:820,000 in single strips of 190 km width; these were taken mostly at 60 per cent overlap, but in mountainous areas also at 80 per cent overlap to increase height precision.

About 10 million km² of the imagery is cloud-free, and covers parts of China, the Middle East, Africa and Europe.

*The original text of this paper, prepared by G. Konecny, appeared as document E/CONF.77/L.6.

Parts of North America and Central and South America were also taken. While the Government of the Federal Republic of Germany provided the funding for the experiment, ESA regulated the areas to be photographed by an international call for experiment proposals. A total of 103 imagery requests were obtained from mapping or resource agencies in all continents. Unfortunately, owing to time-line restrictions imposed by the other 36 Spacelab experiments, not all could be satisfied.

A few examples can demonstrate the type of imagery. One of the first images obtained was a strip ranging from the Ganges Valley over Mt. Everest into China. The highlands of Tibet with their frozen lakes look particularly interesting. The Chinese images extend over the Gobi Desert. Unfortunately, owing to a delay in launch date, the images had to be taken during the winter for the Northern Hemisphere, at a very low sun angle determined by the launch time. However, this was of advantage for showing relief in Somalia. Vegetation appearing red on the infrared film is well pronounced in the irrigation areas of the Al Gezirah in the Sudan, where the Blue Nile irrigates the land close to the White Nile. Images of the Netherlands and the northern part of the Federal Republic of Germany show the field patterns of European cultivation.

The more sensitive black-and-white film was exposed last, when the solar illumination dropped from 25° solar altitude to less than 15° solar altitude. The images had to be partially under-exposed and overdeveloped, which affected the expected higher black-and-white resolution somewhat.

After a film transport problem, which was dramatically repaired, images were taken over western Europe. Snow had fallen there, therefore good contrasts were obtained over the Alps of Austria and Germany. Magnification of this imagery to a scale of 1:100,000 shows the street patterns of Munich, in which individual buildings, such as the German Museum and the Octoberfest area, can be recognized.

A full appreciation of this imagery is, however, only possible in stereo.

All 1,020 images obtained have been reproduced on a microfiche catalogue. This catalogue and first-generation diapositives can be ordered from DFVLR at Oberpfaffenhofen at their reproduction cost. The images are now being evaluated the world over for their mapping capability. At the Institute of Photogrammetry the following investigations were made.

First, the resolution was analysed by edge traces of lakes with a microdensitometer in some images. Analysing these traces, a resolution of 40 lines/mm was obtained for black-and-white and for colour infrared images for estimated contrasts of 2:1. This corresponds to 20-m photographic resolution or a pixel equivalent of 8 m.

As a measuring and mapping instrument an analytical plotter Planicomp C100 from Zeiss, Oberkochen, was used. Bundle block aerial triangulation adjustments and single model evaluations with this instrument yielded point accuracies expressed in standard deviations of about 10 m in planimetry and 20 m in elevation. While the investigations for the capability for line mapping are not yet completed, experiments were undertaken for photomapping. The instrument for this purpose was a Z2 orthoprinter by Zeiss, Oberkochen.

In order to execute the differential rectification with this instrument, a digital terrain model (DTM) had to be measured in the Planicomp. Such a DTM is also obtainable by calculation from available digitized contours. The photogrammetrically measured DTM can be utilized to derive contours by calculation. On the basis of the DTM the position-correct orthophoto was derived for the mountainous area of Innsbruck. Other orthophotos have been derived in colour for an area near Bremen in the northern part of the Federal Republic of Germany.

While previously about six images were required to derive one orthophotomap sheet at scale 1:100,000, it is now possible to derive six orthophoto sheets from one image at a considerable saving of time.

A superposition of an orthophoto with an existing Sudanese map has revealed large local discrepancies in the available African maps.

Spacelab images are also suitable for evaluation by digital image processing, if one wishes to do so. For this purpose the images must be digitized by a drum scanner, e.g. the Optronics P1700. If this is done in three colours the digitized image is suitable for multispectral classification; or a Spacelab black-and-white image may be superimposed in a colour additive manner, e.g. in red with a LANDSAT-RBV and a LANDSAT-MSS image in blue and green. Since all are taken at different times, colour represents change.

A comparison between an existing topographic map 1:100,000 and a Spacelab image may finally be made by a colour-space transformation of both images and their ratio into hue, intensity and saturation. This depicted huge difference of generalization in the city area for the map of 1:100,000 of Munich.

Due to the bad illumination conditions, NASA has promised a reflight of the experiment on the EOM-1 mission in September 1985. For this mission, image motion compensation will be used, which moves the film during the exposure to compensate for satellite forward movement. Because less sensitive higher-resolution films may be used, this is expected to raise the resolution by a factor of 2 to 3. In this way a resolution with a pixel equivalent of 3 m may be reached, which is likely to satisfy the requirements of 1:50,000 topographic mapping.

In the United States NASA has conducted a similar experiment with the large-format camera. This camera of an image format 24 × 48 cm and a focal length of 30 cm has been produced by Itek Inc. in the United States. It operates from a container on an unmanned platform. It returned another 2,000 high-resolution photographs from space, suitable for topographic mapping at medium scale.

The USSR is using camera technology with good success with the MKF-6 camera, obtaining images of 10 m photographic or 4 m pixel size resolutions whenever a Sojuz-Saljut mission takes place.

While other satellite systems, such as the thematic mapper of the anticipated SPOT-satellite, will better satisfy the demands for repeated image coverage and object classification, image acquisition by electro-optical systems is now and will most likely in the future be limited, cost-wise, to a data transmission rate of 200 Mbit/sec, leading to a 10 m pixel size in one colour or 20 m pixel size in several colours.

Photographic images of a pixel equivalent up to 3 m have the added advantage that they may be evaluated by standard photogrammetric equipment, which is already available world-wide.

Therefore there is hope that photography from space will remain as a cost-effective alternative for mapping from space, which can be optimally used in combination with other satellite imagery types.

ACQUISITION DE DONNÉES CARTOGRAPHIQUES À PARTIR DE L'ESPACE : PARTICIPATION AUX PROGRAMMES SPACELAB ET SPOT*

Document présenté par la France

SUMMARY

The National Geographical Institute of France is closely involved in space programmes that are useful in cartography. LANDSAT has already enabled space maps to be prepared on the scale 1:250,000, but it is inadequate for more accurate cartography. The first flight of the metric camera installed on board Spacelab in December 1983 has indicated the advantages of using photographic captors for aerotriangulation and identification of planimetric details.

The SPOT satellite, for which the Institute has developed cartographic pre-processing software, is to be launched in 1985. Its use for altimetric plotting and revision has already been assessed with the aid of simulations, especially in Ecuador

RESUMEN

El Instituto Geográfico Nacional de Francia participa en forma constante en los programas espaciales que son útiles para la cartografía. El LANDSAT ya permite levantar mapas desde el espacio a escala 1:250.000, aun cuando no es suficiente para la adquisición de datos cartográficos más precisos. El primer vuelo que efectuó el Spacelab llevando a bordo una cámara métrica, en diciembre de 1983, demuestra el interés que reviste la utilización de sensores fotográficos para la aerotriangulación y la identificación de detalles planimétricos.

El satélite SPOT, para el cual el Instituto Geográfico Nacional de Francia ha elaborado programas de preprocesamiento cartográfico, será lanzado al espacio en 1985. Ya se ha evaluado su utilización para la restitución y revisión altimétricas mediante simulaciones, especialmente en el Ecuador.

L'Institut géographique national (IGN) utilise déjà, depuis 1972, les images du satellite américain LANDSAT et a ainsi réalisé de nombreuses cartes à des échelles comprises entre le 1/100 000 et le 1/500 000. Le capteur MSS dont la résolution au sol est de 80 m est insuffisant pour une cartographie précise, surtout dans les pays dont le parcellaire est de petite taille.

C'est pourquoi l'IGN s'est intéressé de très près aux projets européens et français d'observation de la Terre à partir de satellites : le projet caméra métrique de l'Agence spatiale européenne (ASE) et le projet SPOT du Centre national d'études spatiales (CNES) de France. Dans les deux cas, l'IGN a apporté son concours dans le développement des programmes spatiaux et a commencé à évaluer les images obtenues par ces systèmes.

Rôle de l'IGN dans le programme Spacelab

Le premier vol de la caméra métrique dans le laboratoire Spacelab a eu lieu début décembre 1983 et les premiers résultats de l'évaluation des clichés obtenus viennent d'être présentés à Munich lors d'un séminaire organisé par l'Agence spatiale européenne.

Préparation

Avant le vol, un groupe de travail dirigé par le professeur Konecny a étudié et défini les spécifications de l'expérimentation : choix de la chambre de prise de vues et des films photographiques à utiliser

Des opérations aéroportées ont eu lieu en 1978 et 1979 dans le centre et le sud de la France. Des avions de l'IGN et du DFVLR d'Allemagne (German Air and Space Agency) ont réalisé des prises de vues à l'aide de plusieurs caméras (de focale 305 mm et 610 mm) et de plusieurs films (7 films en noir et blanc, 1 en infrarouge noir et blanc, 2 en infrarouge couleurs et 3 en couleurs).

Les tests effectués sur les images obtenues (mesure de FTM, de sensibilité, etc.) ont permis de choisir les émulsions photographiques suivantes :

a) Kodak Double X Aerographic 2405 pour le noir et blanc;

b) Kodak Aerochrome Infrared 2443 pour l'infrarouge couleurs.

Mission

Rappelons que la caméra métrique, fournie par la firme allemande Zeiss, était une chambre aérienne modifiée pour le spatial, de focale 305 mm, couvrant avec chaque cliché photogrammétrique standard 23 × 23 cm pris à 250 km d'altitude une surface au sol de 180 × 180 km à l'échelle de 1/820 000.

Deux magasins à films étaient embarqués, chacun d'une capacité de 550 images, l'un en noir et blanc (NB), l'autre en infrarouge couleurs (IRC)

Le film IRC a permis à l'ASE de recueillir 547 images réparties sur 13 traces du globe.

Le film NB, victime d'un incident de fonctionnement, n'a pu fournir que 507 images, groupées en 10 traces sur le sol. Au total, la moisson atteint donc 1 054 images, toutes à recouvrement stéréoscopique, généralement de 60%, quelquefois de 80%, traversant 4 continents (l'Océanie n'a pas été levée), sillonnant 65 pays différents, survolant de nombreuses régions peu ou mal cartographiées et couvrant 10 millions de km², dont plus de la moitié est exempte de masses de nuages gênantes. Ce résultat est d'autant plus impressionnant qu'il n'a nécessité que 2 h 20 mn de fonctionnement de la caméra métrique.

Evaluation des images

Le premier examen des images de Spacelab est très favorable. Certes, les conditions d'éclairage d'un début décembre n'ont pas été des meilleures et la faible hauteur du soleil sur l'horizon a nui au contraste et obligé souvent à un temps de pose de 1/250 s. Le filé atteint ainsi 30 m sur bien des zones et les ombres sur les versants montagneux sont assez denses.

* The original text of this paper, prepared by A. Baudoin, J. Denegre, G. Ducher and G. Lestringand, appeared as document E/CONF.77/L.38.

Cette valeur entraîne sur les images des régions septentrionales et en particulier sur l'Europe des altérations plus importantes que sur celles d'Asie, d'Afrique ou du Mexique, où l'on a souvent pu utiliser un temps de pose de 1/500 s. La résolution du film devrait permettre de distinguer des objets de 15 à 20 m. La faiblesse du contraste et l'importance du filé risquent de rendre difficilement visibles des détails isolés aussi fins. En revanche, les éléments linéaires seront moins affectés. Les routes ressortent bien, quoique inégalement; une voie ferrée sans doute à voie unique apparaît remarquablement sur un tirage IRC d'Asie, peut-être par suite de l'ombre portée par le talus et le contraste offert par l'environnement sableux. Les panaches, émissaires, estrans et turbidités marines diverses figurent remarquablement dans les zones littorales. On aperçoit, par exemple, sur un tirage noir et blanc, des courants en Méditerranée venant du Rhône sur peut-être 80 km de longueur. D'une manière générale, l'orographie et l'hydrographie sont les thèmes les mieux exprimés. Le chevelu des cours d'eau, leur divagation, les méandres anciens ou actuels sont d'une finesse et d'une clarté étonnantes. Ces images offrent, ainsi qu'on a déjà pu le constater sur des clichés pris dans des missions spatiales antérieures, des synthèses saisissantes sur de vastes étendues, d'où se dégagent les grandes unités géomorphologiques, qu'il s'agisse d'alignements de dunes, de glaciers, de plateaux désertiques, de massifs montagneux avec les diverses formes de relief entraînées par les plissements, les failles et l'action de l'érosion. Ces tableaux, éclairés par la stéréoscopie, et d'où la beauté picturale n'est pas exclue, parlent au moins expert des observateurs.

L'ASE fait actuellement procéder à un examen minutieux des principaux documents en les répartissant gracieusement auprès de quelques 110 investigateurs principaux, à raison de 10 clichés contretypes-contact positifs par personne. Ces experts appartiennent à 32 pays dont 18, survolés par Spacelab, auront notamment à évaluer des images sur leur propre territoire. C'est le cas de nombreux pays d'Europe et de quelques autres d'Afrique comme l'Algérie et la République-Unie de Tanzanie.

Les experts des 14 autres pays, non survolés, auront des images standard prises sur d'autres territoires; c'est le cas, en Afrique, de la Haute-Volta et de l'Ethiopie (siège de la Commission économique pour l'Afrique (CEA) des Nations Unies, intéressée par des investigations sur le Soudan, l'Afrique du Nord, la Somalie, le Zaïre, etc.).

En Asie de nombreux investigateurs d'Indonésie, de Malaisie ou de Thaïlande recevront également des images saisies sur d'autres pays tandis que l'Inde et la Chine bénéficieront d'une trace fascinante sur leur territoire, en IRC, en enjambant l'Everest et le Tibet, jusqu'à la Mongolie.

Les investigateurs secondaires qui le souhaiteraient pourront sans difficulté se joindre aux premiers, ce qui serait très utile, tant est vaste la moisson.

Les recherches portent sur le contenu informatif de l'image et la détectabilité rencontrée, sur l'estimation de la précision permise, sur la mise au point de logiciels appropriés à la réfraction atmosphérique et à la courbure de la terre depuis une altitude de 250 km et sous un champ de 54° (qui provoquent des dépressions allant jusqu'à 1 300 m dans les coins des photographies, valeur inhabituelle pour un photogrammètre).

On étudie les diverses possibilités d'application de ces images, qu'il s'agisse de la production de cartes topographiques aux traits, avec restitution de courbes de niveau, sans doute à équidistance de 40 ou 50 m, de la confection de mosaïques photos et orthophotographiques au 1/200 000 et 1/100 000, de la création de spatiocartes, superposant des surcharges aux traits aux fonds photos, de la spatio-triangulation analytique, de la révision des cartes à 1/100 000, de la photo-interprétation, de la géographie ou de la cartographie thématique (géologie, géomorphologie, tectonique, études sur les linéaments, le littoral, les zones arides, l'érosion éolienne, la désertification au Sahel, les sols, l'inventaire des végétations, des forêts, etc.).

Ces images, dont le caractère métrique apparaît pour la première fois avec une telle ampleur dans les saisies spatiales, n'en constituent pas moins des données de télédétection particulièrement précieuses par leur facilité d'exploitation, bien adaptée aux pays en développement. Cet aspect sera aussi examiné par les investigateurs.

En France, on compte actuellement une douzaine d'investigateurs principaux appartenant à l'IGN, au BRGM, au GDTA, aux universités, à l'INRA, ou à l'ORSTOM. Ils s'intéresseront bien entendu aux images françaises et, en particulier, à celles allant de Marseille à Grenoble où va se constituer un polygone d'essai européen sur lequel un sous-vol d'accompagnement de la navette par un Mystère-20 de l'IGN a pu être effectué, recueillant deux heures après Spacelab une trentaine de clichés au 1/60 000, au titre de vérité aérienne.

Mais des images de nombreux autres pays seront également étudiées en France, entre autres des images du Soudan, de l'Arabie saoudite, de Mauritanie, de la Jamahiriya arabe libyenne, du Sahara ex-Rio de Oro, de l'Inde ou d'Amazonie, etc.

Rôle de l'IGN dans le programme SPOT

Définition des traitements cartographiques

Lorsqu'en 1978 fut décidée la réalisation du satellite SPOT, le CNES fit naturellement appel à l'IGN pour étudier et développer les applications cartographiques de ce nouveau système.

Dès lors l'IGN consacra des moyens importants pour préparer l'exploitation opérationnelle des données du satellite.

L'étude des propriétés géométriques des images SPOT et des contraintes liées à leur utilisation cartographique a montré qu'il était nécessaire de prétraiter géométriquement ces images avec des méthodes différentes selon la précision recherchée et celle des données cartographiques disponibles.

Quatre niveaux de prétraitement furent ainsi définis :

Niveau 1 : pour les applications non cartographiques

Le niveau 1 est un prétraitement automatique qui n'utilise que les données fournies par le satellite pour obtenir une précision de localisation de l'ordre de 2 km.

Niveaux 2 et 3 : pour les applications cartographiques

Lorsque les données topographiques existantes sont déjà suffisamment précises, les images SPOT pourront être corrigées grâce à celles-ci en vue de leur exploitation pour la révision et la cartographie thématique.

Le niveau 2 permet, à l'aide de points d'appui, de corriger les vues verticales pour obtenir une précision géométrique de l'ordre de 50 m.

Le niveau 3 permet, avec en plus des points d'appui un modèle numérique de terrain, de corriger les vues verticales ou obliques pour obtenir une précision géométrique de l'ordre du pixel.

Niveau 4 :

Lorsque les données topographiques existantes sont insuffisantes, l'exploitation photogrammétrique des couples stéréoscopiques de SPOT avec un minimum de mesures

géodésiques sur le terrain permettra de générer le canevas de points d'appui et les données altimétriques nécessaires pour réaliser des cartes nouvelles à l'échelle du 1/100 000.

Ces différentes chaînes de prétraitement des images SPOT sont actuellement en cours de développement et seront opérationnelles très prochainement : les niveaux 1 et 2 au CRIS (Centre de rectification des images spatiales) à Toulouse, et les niveaux 3 et 4 à l'IGN à Saint-Mandé.

Le rôle de l'IGN au CRIS

Ce rôle est triple :

a) L'IGN assure avec le CNES la maîtrise d'ouvrage du CRIS. A ce titre, une équipe d'ingénieurs des deux organismes ont défini les spécifications techniques de ce centre dont la réalisation a été confiée à la SEP (Société européenne de propulsion).

Pour sa part, l'IGN a étudié et suivi la réalisation de plusieurs sous-systèmes du CRIS :

i) L'ensemble des prétraitements de niveau 2;
ii) Le sous-système de génération des images sur film ou bande magnétique (dit PRODIMAGE);
iii) L'ensemble de gestion du centre (dit CONTREX)

(le CNES étant responsable des systèmes d'acquisition, d'archivage et de prétraitement de niveau 1);

b) La SEP a elle-même fait appel à l'IGN pour écrire les logiciels liés aux prétraitements de niveau 2. Des ingénieurs informaticiens et photogrammètres de l'IGN travaillent ainsi depuis 1981 dans les locaux de la SEP sur les ordinateurs SOLAR et la console de traitement d'image TRIADE qui seront installés à Toulouse fin 1984.

Les logiciels développés sont destinés à pouvoir corriger entre 8 et 15 scènes SPOT par jour au niveau 2. Notons que ces logiciels permettent également de superposer des images du même terrain prises à des dates différentes (nous parlons alors de prétraitement de niveau S).

Parmi ceux-ci signalons :

i) Un logiciel de gestion d'une base de données cartographiques qui décrit les caractéristiques des cartes topographiques archivées au CRIS (plusieurs dizaines de milliers à des échelles comprises entre le 1/25 000 et le 1/50 000);
ii) Le logiciel de mesure des coordonnées cartographiques (sur table à numériser) et des coordonnées image (sur console) des points d'appui;
iii) Le logiciel de rectification qui utilise les résultats du calcul précédent pour générer une nouvelle image dont les pixels forment une grille régulière dans le système de projection cartographique choisi (par exemple : 10 m en Lambert II pour une image panchromatique sur la France).

c) Le CNES a confié à l'IGN l'exploitation du CRIS. Des ingénieurs, techniciens et ouvriers de l'IGN seront chargés d'exploiter les matériels et logiciels réalisés par la SEP pour archiver systématiquement toutes les images reçues à la station de réception d'Aussaguel (environ 700 scènes par jour) et pour produire, avec la qualité demandée, les images dont SPOT-image aura reçu la commande.

Une quarantaine de personnes de l'IGN seront ainsi employées pour atteindre les capacités et les délais de production prévus (70 images de niveau 1 par jour en moins de 24 heures). Déjà une dizaine de personnes préparent l'installation du centre. (Le CNES, pour sa part, assurera le contrôle de la qualité des produits et la maintenance des matériels et logiciels avec la SEP).

Le développement de la chaîne de niveau 3 et ses applications

Besoins

Les traitements de niveau 3 sont destinés, dans un premier temps, à exploiter au mieux les images du territoire français pour faciliter la révision des cartes au 1/100 000 et peut-être au 1/50 000 et surtout pour constituer une base de données géographiques susceptible de produire des cartes générales de l'occupation du sol et des cartes plus spécifiques à la demande des utilisateurs.

Bénéficiant du fait que fin 1984 l'ensemble de l'altimétrie française sera numérisée, il sera possible de rectifier certaines images SPOT avec une grande précision (environ 10 m).

La necessité de corriger les images SPOT au niveau 3 apparaît très vite en cartographie où il faut pouvoir superposer différentes images SPOT entre elles pour effectuer des traitements multitemporels mais aussi superposer ces images à d'autres fichiers géographiques et pouvoir juxtaposer des images contiguës sans discontinuités.

Bien sûr, l'effet du relief est important pour des images obliques mais il n'est pas négligeable pour des vues verticales

A 45° de latitude, les parallaxes introduites par le relief dans les deux images verticales prises depuis des orbites adjacentes sont de l'ordre de 10 m pour 100 m de dénivelée.

Applications à la révision planimétrique

Des simulations d'images SPOT prétraitées au niveau 3 ont été étudiées pour vérifier, d'une part, leurs qualités géométriques et analyser, d'autre part, la richesse des informations qualitatives qu'elles pourront apporter. Bien qu'il soit nécessaire d'examiner de nombreuses autres simulations pour parfaire notre évaluation, nous pouvons dire que SPOT pourra être utilisé pour :

i) Réaliser des orthophotocartes au 1/50 000, complétées éventuellement par des images obliques pour obtenir la vision stéréoscopique (semblable à des stéréo-orthophotos).

Ces documents, pouvant être délivrés très rapidement après la prise de vues (quelques semaines), assureraient une actualité qui fait défaut à nombre de cartes topographiques au 1/50 000.

ii) Réviser les cartes "au trait" :

— Au 1/25 000, les données SPOT seront sans doute insuffisantes, mais il pourra être envisagé de les utiliser pour mieux gérer les prises de vues aéroportées et les travaux de complètement sur le terrain;
— Au 1/50 000 de nombreux détails pourront être identifiés sur les images SPOT : nouvelles routes, constructions et lotissements récents, coupes forestières, etc

Selon les besoins des utilisateurs, il peut être envisagé soit de définir un nouveau type de carte, sans doute plus économique et révisé plus fréquemment (tous les deux à trois ans), mais adapté à la vision spatiale du paysage, soit de compléter cette vision depuis SPOT par des données complémentaires aéroportées ou sur le terrain pour respecter les spécifications cartographiques actuelles.

Dans tous les cas, SPOT laisse présager une automatisation plus grande des procédés de rédaction cartographique

pour réduire les coûts et surtout les délais de production de ces cartes.

— Pour le 1/100 000 et les échelles plus petites, SPOT sera parfaitement adapté, permettant non seulement d'obtenir une représentation plus objective du paysage (en évitant des erreurs dues à la généralisation des détails à partir des cartes au 1/25 000) mais également d'enrichir les cartes existantes de données sur l'occupation du sol.

Applications à la mise à jour des fichiers géographiques et à la cartographie thématique

Les cartes sur un support papier sont indispensables pour la plus grande partie des utilisateurs, qu'elles soient une représentation graphique (cartes au trait) ou photographique (photocartes) du paysage.

Cependant, un nombre de plus en plus grand d'administrations, d'entreprises ou de collectivités locales sont amenées à gérer des informations géographiques sous forme numérique à l'aide de systèmes informatiques. Le développement des micro-processeurs et de la péri-informatique, ainsi que le fait que les images spatiales sont le plus souvent sous forme numérique, incite l'IGN à concevoir le traitement informatique des images spatiales non seulement comme un moyen pour automatiser la réalisation des cartes traditionnelles mais également comme celui d'inventer une représentation purement informatique du paysage.

Les fichiers ainsi créés forment la «carte» dont la lecture, sur un écran de visualisation ou sur un support papier, peut être adaptée aux besoins spécifiques de l'utilisateur.

De tels fichiers existent déjà au niveau de certaines agglomérations et sont issus des cartes à grande échelle (1/2 000 ou 1/5 000). SPOT permettra de créer des fichiers d'intérêt non plus local mais régional ou national.

Une nomenclature générale des types d'occupation du sol français a déjà été proposée pour définir une cartographie générale, référence commune à tous les utilisateurs, qui peut servir de base à de nombreuses analyses thématiques plus fines.

Par exemple, la connaissance *a priori* des surfaces boisées et du relief (en particulier des pentes et leur orientation) permet de mieux interpréter une nouvelle image SPOT en différenciant peut-être certaines espèces, identifiant surement des zones incendiées, analysant l'état sanitaire des plantations.

Les traitements de niveau 4 (restitution photogrammétrique)

Besoins

Nombreux sont les pays qui ne possèdent pas encore une cartographie topographique précise, c'est-à-dire des cartes couvrant l'ensemble de leur territoire, de façon homogène et révisées régulièrement à des échelles de l'ordre du 1/50 000 au 1/100 000.

Nous pouvons estimer qu'actuellement les besoins en ce domaine concernent une cinquantaine de pays représentant plusieurs dizaines de millions de km^2.

Pour ces pays, SPOT devrait être un outil privilégié pour établir, plus économiquement et plus rapidement que par la cartographie traditionnelle, des cartes au 1/100 000 dont la précision planimétrique et altimétrique (quelques dizaines de mètres) serait suffisante pour une cartographie de base dans les régions les moins peuplées et permettrait la mise à jour des cartes de base au 1/50 000 dans les zones de densité urbaine plus importante

Utilisation de SPOT pour établir le canevas de base

L'utilisation simultanée des deux capteurs HRV sur des paysages différents (l'un regardant par exemple vers l'ouest, l'autre vers l'est) permet de calculer la position précise (10 à 20 m) de points remarquables du paysage formant un "canevas de points d'appui" qui sera ensuite utilisé pour "caler" les images par rapport au terrain et pouvoir transformer les prises de vues stéréoscopiques en cartes topographiques.

Cette possibilité est actuellement unique dans l'ensemble des satellites existants ou des systèmes spatiaux en projet. Elle permet de diminuer une grande partie des travaux coûteux de géodésie, ce qui n'est pas le cas lors de l'utilisation d'autres systèmes spatiaux utilisant la stéréoscopie verticale (chambres photographiques de la navette spatiale ou du Spacelab) ou la stéréoscopie dite "avant-arrière" (le satellite vise le long de sa trace simultanément vers l'avant et vers l'arrière : la même zone est ainsi vue à quelques secondes d'intervalle depuis deux points de vue).

Seule la stéréoscopie latérale (de part et d'autre de la trace du satellite) permet de "quadriller" un vaste territoire avec des images prises depuis des orbites différentes, ce qui assure une précision homogène.

Notons que les points d'appui déterminés à l'aide des images SPOT pourront servir pour exploiter d'autres images spatiales ou pour servir de base à un canevas photogrammétrique pour restituer des photographies aériennes.

Exploitation photogrammétrique des couples stéréoscopiques

De même qu'à partir de deux photographies aériennes verticales formant un couple stéréoscopique il est possible de déterminer la forme et les dimensions du terrain avec suffisamment de points d'appui dont les coordonnées cartographiques sont déjà connues, deux images SPOT prises depuis des orbites différentes forment un couple stéréoscopique. Le même terrain aura des formes légèrement différentes sur les deux images. Des parallaxes apparaissent, dont la mesure permet l'évaluation de l'altitude du terrain. Cette mesure est différente de celle des photographies, car les caractéristiques géométriques de la prise de vue sont différentes (la photo est un instantané du paysage depuis un seul point, l'image SPOT sera le résultat de l'analyse continue, ligne par ligne, du paysage vue depuis chacun des points de l'orbite).

Cependant l'utilisation d'appareils de restitution photogrammétrique analytique est possible et des ingénieurs IGN ont réalisé des logiciels pour l'appareil TRASTER fabriqué par MATRA de façon à rendre possible cette exploitation à partir des films photographiques qui seront réalisés par le CRIS.

Il sera alors possible d'obtenir sur ses appareils, d'une part, le tracé planimétrique au 1/100 000 et, d'autre part, le dessin des courbes de niveau.

Des mesures effectuées sur des simulations montrent qu'une précision de 10 à 20 m peut être atteinte en planimétrie et en altimétrie.

L'utilisation du TRASTER est intéressante pour constituer directement une cartographie numérique et pour générer un modèle numérique du terrain pouvant être utilisé ensuite pour corriger des images au niveau 3 et produire par exemple des photocartes au 1/50 000.

Notons que pour les pays qui ne disposeront pas du matériel du type du TRASTER d'autres procédures pour exploiter les images sont à l'étude sur des systèmes optiques plus simples, utilisés actuellement pour examiner les stéréo-

orthophotographies dont un exemple est l'ORTOSTER conçu par l'IGN.

Il peut être également envisagé de traiter directement les images numériques à l'aide de logiciels de corrélation automatique pour améliorer la précision des modèles numériques de terrain (de 3 à 7 m), et la vitesse de calcul de ceux-ci.

Evaluation de la restitution photogrammétrique sur une simulation SPOT en République d'Equateur

Dans le cadre d'un accord entre le Gouvernement de la République d'Equateur et la Banque interaméricaine de développement (BID), le Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos (CLIRSEN) et le Centre national d'études spatiales (CNES) ont pu rédiger et signer, le 2 novembre 1983, un protocole dont l'objet est d'évaluer l'utilisation potentielle cartographique et thématique du satellite SPOT, sur une zone de 20 km par 22 km, sélectionnée dans la République d'Equateur.

Le protocole prévoyait de réaliser différents produits de simulation SPOT, en sept mois, à partir de photographies aériennes à 1/60 000 et d'un équipement de 29 points d'aérotriangulation de l'Instituto Geográfico Militar (IGM); un ingénieur équatorien devait participer à la fin des travaux de simulation en France; un expert français devait présenter à Quito un rapport, les produits réalisés et les formules de base permettant de restituer la cartographie à partir de la géométrie du satellite SPOT.

En juin 1984, l'ensemble des travaux prévus dans le protocole était achevé avec succès.

Méthodologie

Les travaux furent réalisés en trois parties : une phase préparatoire, une phase de simulation proprement dite et une phase de contrôle et d'investigation des fournitures à livrer à Quito.

Phase préparatoire

a) Partie réalisée par l'Institut géographique national (IGN France) à l'aide de ses outils de photogrammétrie moderne :

- — Enregistrement des courbes de niveau suivi d'un tracé automatique d'une planche de courbes de niveau répondant aux spécifications de la cartographie équatorienne;
- — Calcul par interpolation d'une grille de 420 × 481 nœuds, au pas de 50 m, dénommée modèle numérique de terrain (MNT);
- — Réalisation de six orthophotographies;
- — Analyse numérique des orthophotographies, au microdensitomètre PDS du Laboratoire d'astronomie scientifique de Marseille;

b) Partie réalisée par le CNES et l'IGN d'assemblage des six fichiers numériques :

- — Assemblage numérique des six orthophotographies numérisées pour obtenir une seule image de base;
- — Restitutions diverses sur film de cette «image de base» (échelles 1/50 000 et 1/100 000).

Phase de simulation

Réalisée par la Division de traitement d'image du CNES :

a) Réalisation des images de niveau 1A à partir de l' "image de base" et du modèle numérique de terrain, des simulations obliques + 270 et − 270 brutes (niveau 1A) de SPOT, prenant en compte l'orbite, le déplacement et les attitudes du satellite sur son orbite, les caractéristiques de l'instrument de visée et l'orientation du miroir, etc., pour chaque détecteur, il faut déterminer la direction du rayon élémentaire, son intersection avec le MNT et interpoler la radiométrie dans l'image de base; les dimensions des images ainsi obtenues sont de 2496 par 2746 pixels;

b) Construction des images de niveau 1B, par application aux images précédentes 1A, des corrections de forme et de mouvement de la terre.

Phase de contrôle et investigation menée à l'IGN

Les images créées lors des différentes phases, disponibles sur bandes magnétiques CCT et restituées sur film, ont été étudiées et mesurées une à une, puis stéréoscopiquement, sur les équipements de traitement d'image et de photogrammétrie de l'IGN.

La mesure des coordonnées image d'environ 95 points a été réalisée à l'aide du TRASTER sur les simulations de niveau 1A. Le calcul de la géométrie de la prise de vues a été effectué grâce à 14 points d'appui et le calcul de l'altitude des autres points a montré que l'erreur moyenne quadratique par rapport au MNT était de l'ordre de 5 m.

Intérêt économique

L'ensemble des opérations pour réaliser la cartographie au 1/100 000 d'une vaste région sera beaucoup moins coûteuse avec SPOT qu'avec des photographies aériennes.

Les cartes réalisées avec SPOT devraient être de 3 à 6 fois moins chères que celles obtenues actuellement à l'aide des photographies aériennes : 3 à 5 dollars US par km^2 au lieu de 15 à 20 dollars US par km^2.

Conclusion

Les études effectuées sur les simulations d'images SPOT montrent l'intérêt d'un satellite d'observation verticale et oblique de la Terre, à haute résolution. Cet intérêt n'est pas seulement scientifique mais aussi économique.

Plusieurs dizaines de millions de kilomètres carrés de notre globe sont encore très mal cartographiés. SPOT devrait permettre de réaliser des cartes au 1/100 000 (par exemple) de ces régions de trois à six fois moins coûteuses que les méthodes actuelles utilisant des photographies aériennes.

Dans beaucoup de pays également la cartographie à petite échelle n'est pas à jour. SPOT pourra alors aider à réaliser la révision des cartes topographiques plus rapidement et à une fréquence plus grande.

Enfin, les données numériques fournies par les images SPOT aux cartographes et aux utilisateurs de cartes devront bien sûr être confirmées lorsque le satellite sera lancé en 1985 par des "opérations pilotes" associant les producteurs d'images, les services cartographiques et les organismes utilisateurs. Dès à présent, nous devons encourager la préparation de ces expérimentations, suite logique de l'évaluation des simulations, pour que la communauté cartographique puisse bénéficier le plus rapidement possible de cette révolution technique, SPOT — aussi importante que l'utilisation des photographies aériennes il y a une cinquantaine d'années.

THE SATELLITE IMAGE MAPPING PROGRAM OF THE UNITED STATES GEOLOGICAL SURVEY*

Paper submitted by the United States of America

RÉSUMÉ

Le Service géologique des Etats-Unis fait des recherches sur les applications cartographiques des données spatiales depuis plus de 10 ans. Jusqu'à récemment, l'imagerie spatiale était surtout utilisée pour l'évaluation des ressources terrestres. L'intérêt de ces données pour l'établissement de cartes est à présent reconnu, étant donné les résultats obtenus ces dernières années dans la production de mosaïques expérimentales. L'adoption de méthodes de traitement nouvelles et innovatives permet d'abaisser plus que jamais auparavant la limite de résolution spatiale et spectrale sur les cartes obtenues. Ces nouvelles méthodes font une large place à l'automatisation.

Le Service géologique vient de publier, à titre expérimental, des cartes réalisées à partir d'images obtenues par le scanneur multibande, l'instrument de cartographie thématique et la caméra vidicon à retour de faisceau de LANDSAT; celles-ci ont immédiatement suscité l'intérêt des utilisateurs désireux d'obtenir plus de documents cartographiques, en particulier lorsque l'emploi de couleurs, de tons, de textures et de formes permet de révéler des détails de surface jugés utiles, et d'avoir des images de zones pour lesquelles il n'existe pas de cartes. L'établissement de cartes à partir d'images satellite a donc été officiellement inscrit dans le Programme cartographique national en 1984. On prévoit actuellement d'établir environ 20 à 25 cartes de ce type en 1985 et en 1986 afin de répondre aux besoins des utilisateurs.

En réalisant ces mosaïques, le Service géologique cherche à fournir des cartes à moyenne et petite échelle, complétant les cartes topographiques usuelles aux mêmes échelles, tout comme les documents orthophotoquadrangulaires ordinaires sont complétés par des cartes topographiques quadrangulaires à 7,5 minutes. Accessoirement, il commence à constituer, à l'intention de divers groupes d'utilisateurs, une série de mosaïques à différentes échelles comme il existe des cartes topographiques à différentes échelles. Ces mosaïques sont utilisées notamment par les géologues, les géographes, les planificateurs et administrateurs dans le domaine des ressources naturelles et tous ceux qui s'intéressent aux renseignements géographiques que ces cartes fournissent directement.

Depuis que le Service géologique a commencé à utiliser des techniques améliorées d'établissement de cartes à partir d'images à l'aide d'ordinateurs, la production sur pellicule d'images géométriquement correctes s'est améliorée et les produits imprimés aux échelles usuelles sont de meilleure qualité. On prévoit que la poursuite de la recherche-développement en cartographie à partir d'images assistée par ordinateur permettra de réduire de façon significative les coûts et d'améliorer encore la qualité des cartes produites.

Le Service géologique oriente actuellement ses efforts de recherche dans le domaine des applications cartographiques

RESUMEN

El Servicio Geológico de los Estados Unidos efectúa desde hace más de un decenio investigaciones sobre el uso de datos obtenidos mediante satélites en la elaboración de mapas. Hasta hace poco, las imágenes obtenidas de los satélites se utilizaban primordialmente como medio de evaluación de los recursos de la Tierra. El valor de los datos en la elaboración de mapas ha quedado reconocido gracias a los buenos resultados obtenidos en la producción de mapas experimentales de imágenes en los últimos años. La introducción de procedimientos nuevos e innovadores de procesamiento ha permitido obtener una resolución de detalle y de color jamás antes lograda en la elaboración de mapas de imágenes. Estos nuevos procedimientos se centran en la aplicación de técnicas y equipo automatizados.

La publicación experimental hecha últimamente por el Servicio Geológico de los Estados Unidos de mapas de imágenes obtenidas mediante el explorador multiespectral LANDSAT, el cartógrafo temático y los tubos vidicón de haz de retorno despertó el interés inmediato de los usuarios por adquirir una mayor cobertura geográfica, especialmente cuando la imagen puede mostrar detalles superficiales mediante el uso de colores, tonos, texturas y dibujos que se consideran útiles para la interpretación de las características de la superficie terrestre, y por lograr la cobertura para las zonas respecto de las cuales no existen mapas. Por consiguiente, en 1984 se agregó oficialmente al Programa Nacional de Mapas la elaboración de mapas mediante imágenes obtenidas de satélite. Los planes actuales son elaborar entre 20 y 25 mapas con imágenes al año en los años fiscales 1985-1986, para satisfacer las necesidades de los usuarios.

Una de las metas de los esfuerzos de elaboración de mapas mediante imágenes obtenidas de satélites del Servicio Geológico de los Estados Unidos es proporcionar mapas de imágenes a escala intermedia y pequeña como productos complementarios de los mapas topográficos normales de objetivo general a la misma escala, en una relación semejante a la que existe entre los productos normales ortofotocuadrangulares y los mapas topográficos cuadrangulares de 7,5 minutos. Otra consideración secundaria es comenzar a elaborar una serie de mapas de imágenes a escala múltiple para diversas comunidades de usuarios, similar a la secuencia de escalas de que disponen los usuarios de mapas topográficos. Entre los usuarios de mapas de imágenes están geólogos, geógrafos, planificadores y administradores de recursos naturales y otros interesados en el tipo de información geográfica que puede obtenerse fácilmente de los materiales elaborados con imágenes.

La aparición de técnicas perfeccionadas de elaboración de mapas de imágenes con ayuda de computadoras ha permitido que el Servicio Geológico de los Estados Unidos pueda producir en forma más eficaz imágenes geométricamente correctas sobre película y producir materiales mejor impresos a escala de publicación. Se espera que la investigación y el desarrollo continuados de la elaboración de mapas de imágenes con ayuda de computadoras reduzca apreciablemente los costos y permita mejorar todavía más la calidad de los productos basados en imágenes

* The original text of this paper, prepared by Richard D. Sánchez and Frederick S. Brownworth, United States Geological Survey, appeared as document E/CONF 77/L.24. Use of trade names and trade marks is for identification purposes only and does not imply endorsement by the Government of the United States.

des données satellite vers la production régulière de cartes de haute qualité. Ses travaux portent notamment sur : 1) les techniques de traitement de données obtenues par scanneur multibande au-dessus de zones géographiques présentant une gamme étendue de réponses spectrales; dans les expériences en cours, on traite séparément les zones à réflectivité très élevée ou très basse, on apporte des corrections tonales radiométriques pour chaque portion et ensuite, on les juxtapose pour composer l'image finale; 2) l'utilisation d'un programme de restauration par transformation géométrique, au lieu de la convolution cubique, pour procéder à un nouvel échantillonnage des données fournies par le capteur; et 3) la production de films complémentaires tramés de format définitif directement à partir de bandes traitées utilisables sur des ordinateurs différents sur un scanneur appareil de restitution guidé par ordinateur.

En la actualidad, las investigaciones del Servicio Geológico de los Estados Unidos acerca de las aplicaciones cartográficas de los datos obtenidos de satélites se encaminan a producir en forma rutinaria materiales de alta calidad a partir de imágenes obtenidas de satélites. Entre las esferas que se investigan actualmente cabe citar: 1) Las técnicas para el procesamiento de datos de exploradores multiespectrales para zonas geográficas en que hay una amplia gama de respuestas espectrales; los experimentos en curso abarcan el procesamiento separado de zonas de reflexión extrememadamente alta y baja, los ajustes tonales radiométricos de cada porción y, por último, su integración en el mosaico que constituye la imagen final; 2) La utilización de un programa de transformación geométrica de restauración en lugar de la convolución cúbica para el remuestreo de datos de los sensores y 3) La elaboración directa de películas separadas de tamaño definitivo, listas para su proyección, a partir de cintas compatibles con computadoras plenamente procesadas en un explorador/trazador controlado por computadora

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Over the past decade, the National Mapping Division of the United States Geological Survey (USGS) has made considerable progress in improving LANDSAT image quality and developing methods to produce image maps that meet National Map Accuracy Standards. Until recently, however, satellite imagery has been used primarily as a research tool for the evaluation of earth resources. The value of digital data in preparing maps is now being recognized as a result of the successful production of experimental image maps over the past several years.

Recent USGS experimental editions of LANDSAT multispectral scanner (MSS), thematic mapper (TM), and return-beam vidicon (RBV) image maps created an immediate user interest in acquiring additional geographic coverage, especially where the imagery can show surficial detail by the use of colours, tones, textures, and patterns considered useful in the interpretation of surface features, and in providing coverage of remote unmapped areas. Consequently, satellite image mapping was formally added to the National Mapping Program in 1984. Present plans are to prepare about 20 to 25 image maps a year in fiscal years 1985-1986 to meet user needs.

One of the goals of the satellite image mapping effort is to be able to provide intermediate- and small-scale image maps as companion products to standard general-purpose topographic maps at the same scale, similar to the relationship of standard orthophotoquad products to 7.5-minute topographic quadrangle maps. A secondary consideration is to begin developing a family of multiscale image map products for various user communities, similar to the scale sequence available to users of topographic maps. The image map users include geologists, geographers, natural resource planners and managers, and others interested in the type of geographic information readily available from image products.

By applying improved computer-aided image map development techniques, the USGS has been effective in producing geometrically correct images on film and printed products at publication scale. Continued research and development in computer-aided image mapping are expected to significantly reduce costs and further improve the quality of image products.

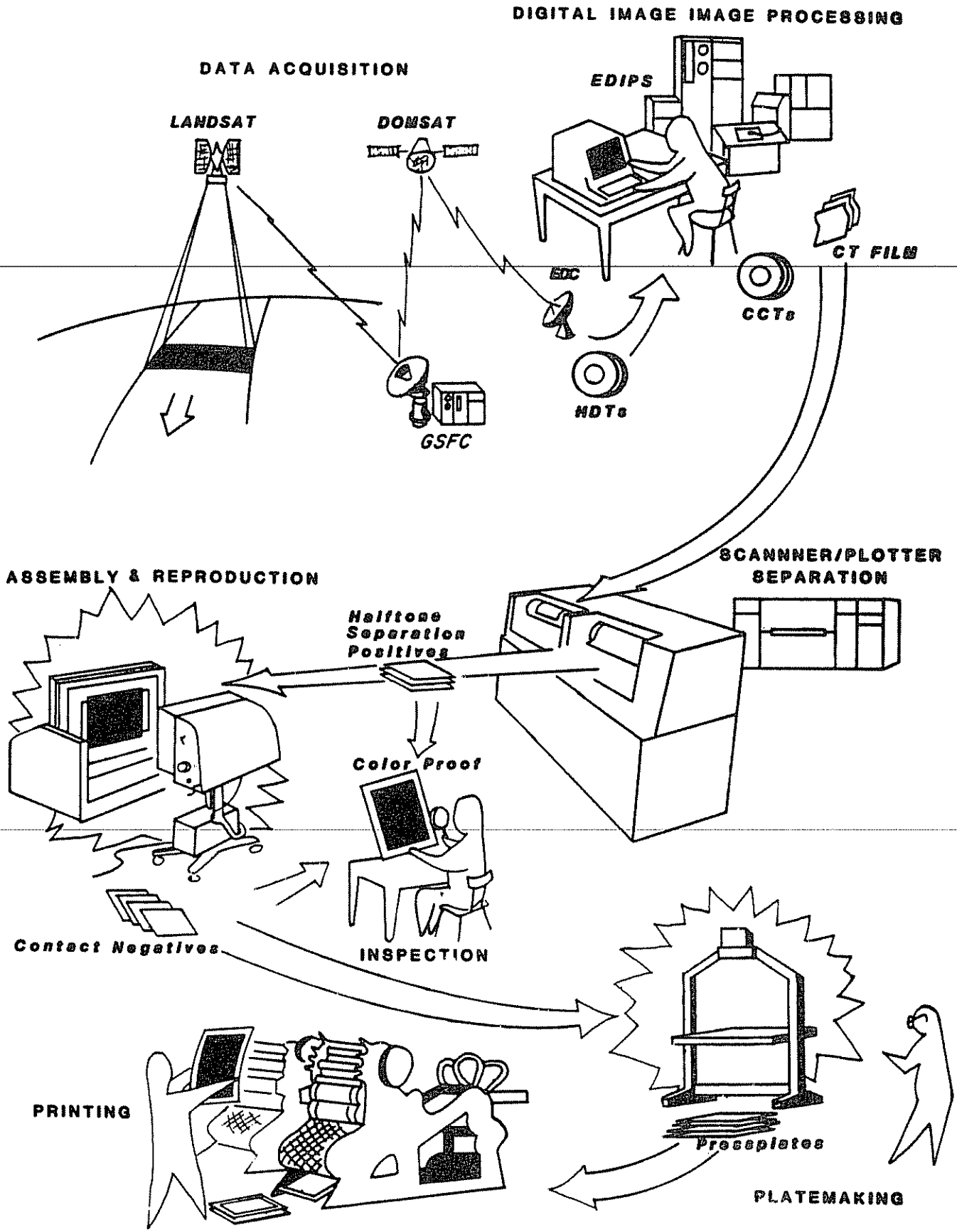
The image map preparation process from satellite signal transmission to printing is illustrated in figure 45. Pre-processing of the satellite sensor data is performed at the Goddard Space Flight Center Image Processing Facility at Greenbelt, Maryland. At Goddard, the sensor digital data are partially or fully corrected (radiometrically and geometrically) and recorded on high-density digital tapes before distribution. The USGS's image processing facility at the Earth Resources Observation Systems Data Center (EDC) at Sioux Falls, South Dakota, provides most of the digital processing for satellite image mapping. The processing of the multispectral bands of each image scene are performed on EDC's digital image processing system. The remaining processing is completed at the USGS's mapping and printing facility at Reston, Virginia. Here the processed digital data film separates are examined for detail, tone balance, and lithographic compatibility. Tone adjustments, neutral balance, half-tone screening, and scale enlargements are rendered on a computer controlled scanner/plotter. After inspection and approval of the Cromalin colour proof, the film separates are assembled and reproduced (including a line/type separate) as contact negatives, followed by platemaking and lithographic printing.

The following development background of two key experimental image map projects reveals some of the new and innovative procedures that have evolved over the past several years to produce greater resolution of detail and colour imagery than ever before possible.

Background

Early in 1982, the Las Vegas, Nevada, 1:250,000-scale quadrangle was selected to test a newly developed geometric registration capability together with advanced digital image processing techniques available at the EDC. Since satellite scanner-generated data are distorted from the true configuration of the earth's surface, the imagery does not correspond with the geometry of any map projection. Therefore, it is necessary to transform the digitally recorded LANDSAT-MSS data to fit a map projection. This geometric registration requires two stages: first, the determination of the spatial location of the input sensor image picture elements (pixels) in the output images; and secondly, the determination of the new value for the output pixel. The geometric registration parameters for Las Vegas were determined by locating a series of map control points on the image for which the true geographic locations could be determined by line and sample within the digital data. A geodetic-correc-

Figure 45. United States of America: Image map preparation flow process



tion processing module derived from geometric correction matrices extracted control point neighbourhoods from the image data and cross-correlated them with control point chips to generate a geodetic correction function. This function produced an accurate transformation of input sensor pixels to the Universal Transverse Mercator (UTM) projection. (UTM projection is normally used by the USGS when the scene's latitude is 65 degrees or less, and Polar Stereographic projection when the scene's latitude is greater than 65 degrees.) Once the spatial location of the output pixels was determined, the new values were interpolated from adjacent input pixels, a procedure commonly referred to as resampling.

A comparison between the cubic convolution and the nearest neighbour transformation programmes resulted in the former being applied to the resampling of the Las Vegas image data to reduce geometric distortion. The resampling technique of nearest neighbour was applied by assigning the interpolation value of the closest input image pixel to the output image pixel of the transformation grid. By comparison, cubic convolution was applied by assigning the weighted value of the surrounding 16 input pixels to the output pixel as illustrated in figure 46. During the image processing of Las Vegas, each of the three LANDSAT scenes (plus an overlap) was registered to control points using map projection values before the scenes were merged into a mosaic, a procedure commonly employed in digital computer mosaicking.

The digital image processing of the Las Vegas experimental image map also encompassed a number of innovative improvements involving the selective alterations in contrast and edge enhancement of particular features of each image scene. These selective improvements were critical to the final image map portrayal. In order to gain the full benefit of image enhancement, an appropriate relationship was necessary between each digitally processed image band separate and the film recorded images used to lithographically reproduce the image map. Without a compatible relationship, the results of well processed digitally enhanced image separates cannot be lithographically printed at optimal density. The contrast stretching of the MSS input data of bands 4, 5, and 7 for the Las Vegas experimental image map provided new insight in the improvement of radiometric enhancement of image-band separates. In selecting the appropriate contrast stretch method, certain characteristics of the image band histogram were evaluated to achieve optimal stretch because of the variability of satellite data. These characteristics included shape, symmetry, skewness of the pixel frequency distribution, and modes of pixel frequency.

On 16 July 1982, LANDSAT 4 containing the TM system was put into orbit. The resolution of the TM sensors created the potential for image mapping at 1:100,000 scale. In the fall of 1982, the preparation of the Dyersburg LANDSAT-TM image map provided an opportunity for additional investigation, especially in the optimum band selection (Chavez, Guptill and Bowell, 1984) and radiometric enhancement of a wider portion of the electromagnetic spectrum. The LANDSAT-TM 30-m resolution data sets consist of seven wave bands that can be combined in a wide variety of ways, giving rise to a large number of possible three-band colour combinations for image mapping.

After resampling (cubic convolution) and evaluation of six TM bands (thermal band 6 excluded), bands 2, 3, and 5 were selected for the Dyersburg image map. A multipoint linear stretch was applied to each of the three bands, resulting in the radiometric responses or input data being stretched to provide a photographic density near the optimum required for lithographic reproduction. In figure 47, the outcome of the stretching procedure is shown in the relationship between the histogram of the TM input/output data of band 2 and the density gradation curve of the photographic film (Sanchez and McSweeney, 1983). If the narrow input distribution of band 2 in figure 47 is recorded on black-and-white photographic film, the result would be a near all-gray image (possibly three shades of gray) with very little contrast. To distinguish the subtle density differences in the TM band 2 data, it was necessary to transform each pixel brightness level into a new value. This was accomplished by setting the input minimum pixel value of 10 at 0, the input mid-point pixel value of 15 at 59, the input maximum pixel value of 33 at 127, and near equally spacing the intervening input pixel values.

In both the Las Vegas and Dyersburg projects, a 5-by-5-edge enhancement programme was applied to accentuate the boundaries between features of different response and to improve the visual definition.

The actual digital-to-analog film transfer was accomplished on a high-resolution laser beam film recorder by table look-up for computer efficiency. The resultant relationship between the newly spaced increments of band 2 output stretched data and the output film transfer distribution can be seen in the right-hand set of graphs in figure 47. Keeping in mind that the film densities portrayed in the graphs are continuous tone negatives (that is, black is read at the toe of the curve), one can deduce that the tone contrast of the output image was more intense in the shadows than in the density-compressed highlights. This particular intensity corresponds with the greater spacing between the intervening pixel values from 0 to 59. The same stretching procedure was applied similarly for bands 3 and 5. The net results provided the essential control over density and differential enhancement of the three band separates.

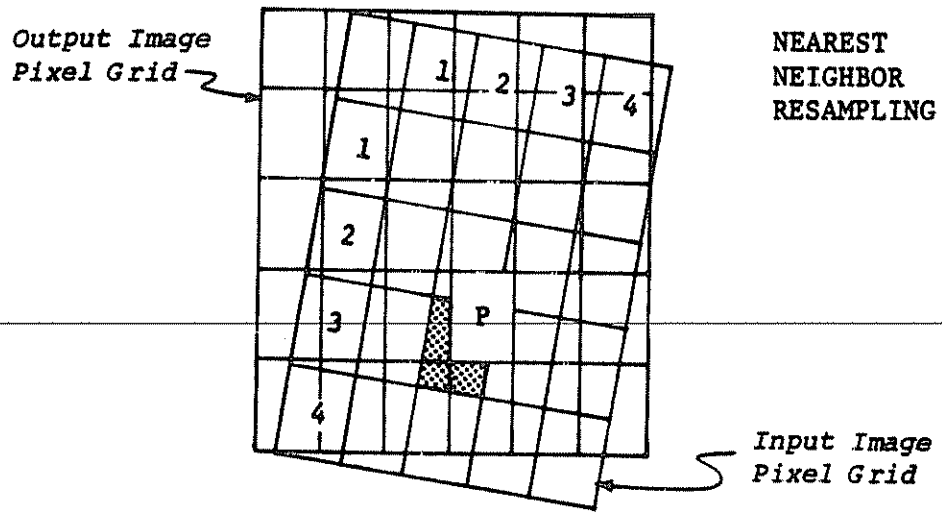
After transforming the fully processed digital data of each project to film by laser beam recorder, the resultant small-scale continuous tone transparencies required minor tone balance adjustments, density range compression, halftoning, and final size enlargement. These modifications were necessary to prepare the film separates for lithographic printing. New experimental procedures were introduced to perform these functions on the Hell CP-340 scanner/plotter. These new techniques were successful and are serving as guidelines for preparing new USGS satellite image map products. The latest USGS experimental image map prepared using these techniques is of Washington, D.C. and vicinity, at 1:100,000 scale (Colvocoresses, 1984). This image map is the forerunner of a new group being prepared.

Other projects which have contributed to USGS knowledge and experience in producing satellite image maps include: the Saudi Arabia MSS image map series at various scales; Alaska RBV and MSS image map series at 1:250,000 scale; the Mexico MSS image map series at various scales; Bangladesh MSS image map at 1:500,000 scale; Kenya MSS image map at 1:1,000,000 scale; and Morocco and Western Sahara MSS image map series at 1:250,000 scale.

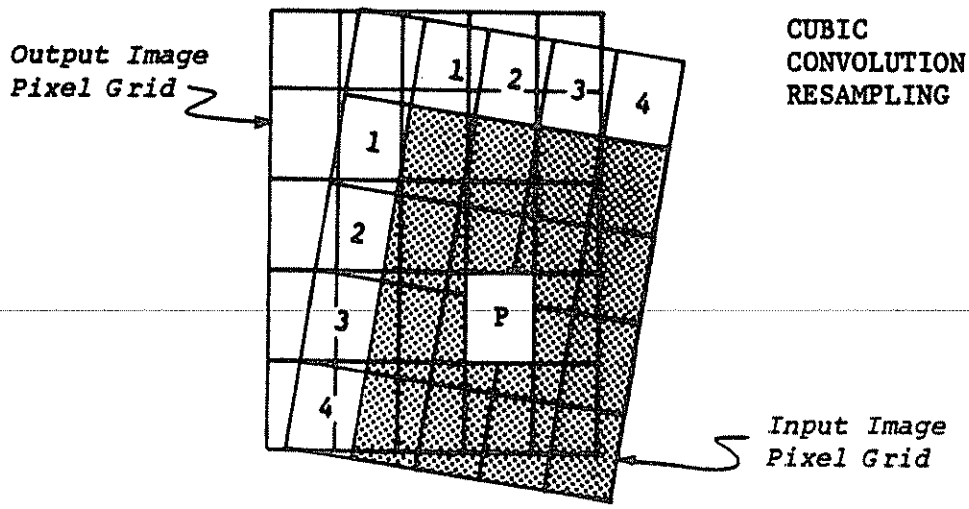
Programme plans and requirements

Present research efforts in the cartographic application of satellite data at USGS are being devoted to producing high-

Figure 46. United States of America: Resampling techniques for the assignment of values to output pixels

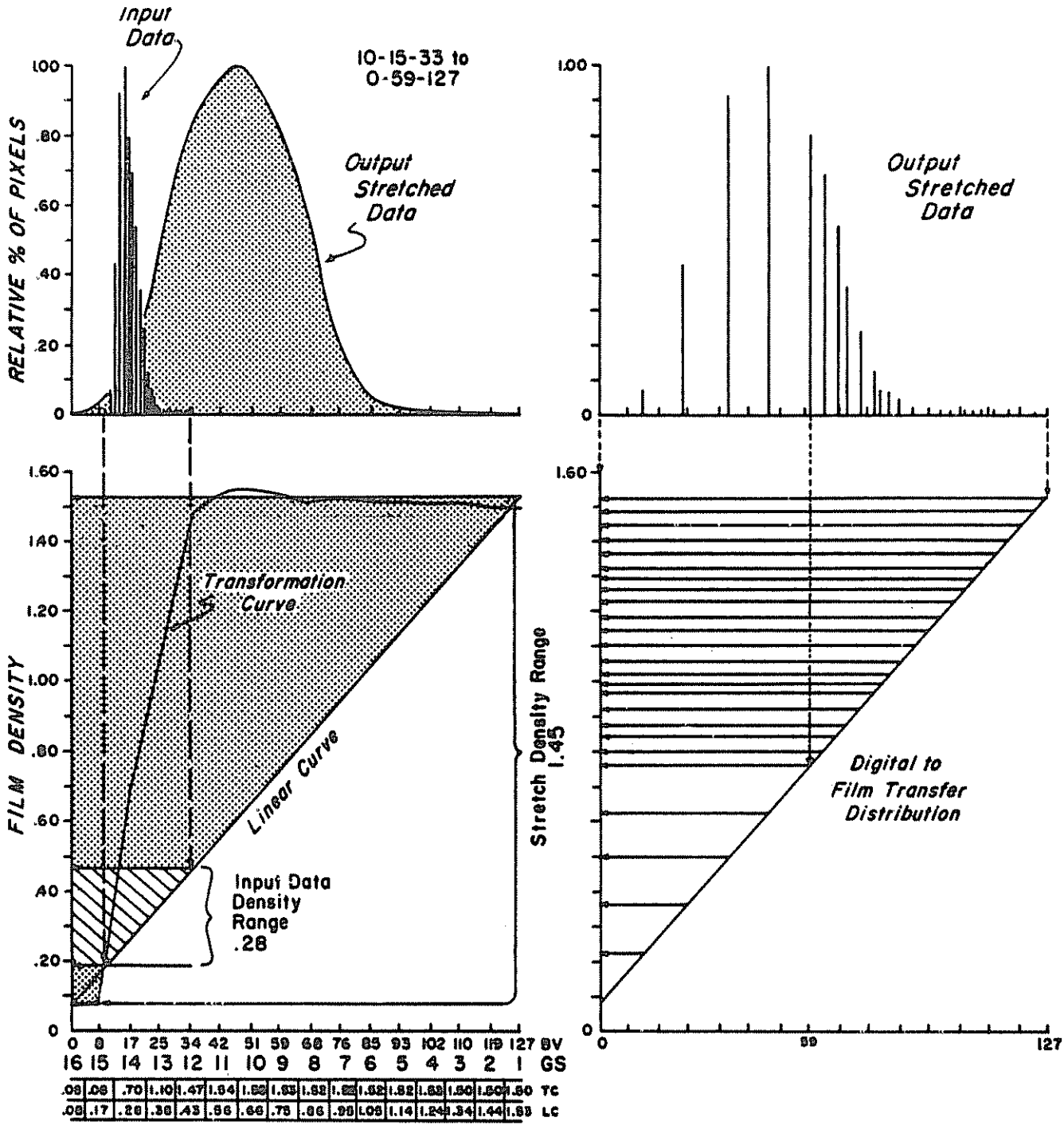


Nearest neighbor resampling showing the nearest adjacent pixel (stipple pattern) from which the value of the output pixel (P) is derived. The input image pixel grid is skewed with respect to the path of the satellite.



Cubic convolution resampling showing the 16 adjacent pixels (stipple pattern) from which the value of the output image pixel (P) is derived (weighted value derivation). The input image pixel grid is skewed with respect to the path of the satellite.

Figure 47. United States of America: Relationship of thematic mapper input digital data and output density distribution of band 2, Dyersburg satellite image map



quality satellite image products on a routine basis. Several areas currently being investigated include:

(*a*) Techniques for processing MSS data for geographic areas exhibiting a wide range of spectral responses — ongoing experiments include processing extremely high- and low-reflective areas separately, performing radiometric tonal adjustments of each portion, then mosaicking them for the final image;

(*b*) Replacement of cubic convolution with a restoration geometric transformation programme for resampling sensor data;

(*c*) Producing final-size screened film separates directly from processed computer-compatible tapes (CCT) on a computer controlled scanner/plotter. This latter procedure may provide a means to produce multiple scale products from the same data base.

The availability of USGS generated LANDSAT experimental image maps products has created a broad user interest in acquiring specific coverage for their respective needs. These interests include requirements for national products where the imagery can provide data on surficial geology, hydrology, natural vegetation, and land use/land cover information not available from conventional maps, and for international products where base maps are unavailable.

The following areas of national and foreign user interests and requirements are being considered by USGS in planning its Satellite Image Mapping Program for the next several years (Brownworth, 1984).

Federal, state, and private user interest

In geology, user interests in satellite image products have been identified with regard to studies in: geomorphic boundaries and deep-seated geologic structures; saline districts; major fault zones, foothill and mountain structural patterns; caldera complexes, with particular interest in the central California volcanic-prone Mammoth Lakes and Long Valley caldera regional structure; geologic formations of the Grand Coulee Dam area with respect to dam safety; seismic activity and earth movement in Idaho; earthquake hazard reduction along the Wasatch Front Range in Utah; and other areas of potential geologic hazard.

In hydrology, interest has been expressed in satellite image products for studying water movement, structural deformation, and erosion potential and, specifically, to assist in on-going investigations on land stability and subsidence in Reno and the Carson sink area of Nevada. Of special interest is the use of TM image products for long-term cyclic studies of the Great Salt Lake, Utah.

Satellite imagery also introduces the potential for visual flight rule (VFR) aeronautical charts that will be more realistic in their presentation of ground features. Such image base charts would be helpful for off-route visual navigation.

In the private sector, user interest is especially focused on image map products useful in oil, gas, and mineral exploration.

Several state government agencies have expressed an interest in satellite image maps to study potential flooding and mudslide hazardous areas, and vegetation and wildlife habitats in remote areas. Florida has conveyed its interest in a second edition of the state image map to replace the ERTS edition of 1976. A project already authorized under the National Mapping Program will provide a block of four 1:250,000-scale image maps of eastern Colorado for soil surveys, land-use studies, and investigation of the impact of centre-pivot irrigation practices on the Ogallala Aquifer.

Foreign user interest

It is anticipated that the USGS satellite image mapping capability can be used to support future United States foreign assistance programmes, especially those addressing third world concerns in the economic development of natural resources. Useful inventories and information about natural resources which were not easily available to developing countries in the past are more readily obtainable through the cartographic application of satellite data (Sanchez, 1984). Satellite image mapping technology has been shared with developing countries through co-operative mapping programmes. Co-operative programmes with countries such as Kenya, Mexico, Saudi Arabia, Tunisia, Yemen and others, have provided USGS with a general understanding of the foreign user's requirements and interests.

Foreign users interests are focused especially on image base maps of unmapped areas. The scope of image map requirements includes reconnaissance of geologic formations and structures, planning tools for delineating priority study areas, agricultural intensity studies, land-use and land-cover studies, forest inventory, resettlement projects, transportation surveys, coastal studies, base maps for petroleum and mineral exploration, and water and irrigation projects.

In Antarctica, national and international interests in image map products of this remote area of the world are for glaciological and coastal studies which are important to better understanding of such processes. Plans for an Antarctic image data base will provide cost-effective repetitive coverage for monitoring glacier and ice-shelf life cycles and analysis of their interrelationship with climatic factors.

Conclusions

USGS has the responsibility for providing accurate, up-to-date base maps of the United States, its territories and commonwealths, and under co-operative mapping arrangements other areas of the world. There are large areas of the world where satellite image maps would be an effective means of providing current image maps as companions to topographic line maps, and providing coverage of remote and inaccessible unmapped areas. Advanced digital image processing and reproduction techniques developed and used to produce the USGS experimental image map editions will be further improved to meet user interests and requirements. With this new technology, intermediate- and small-scale image maps can be produced quickly and at less cost than traditional line maps.

In addition to cost reduction benefits, satellite image maps are superior to conventional maps for providing invaluable geographic data for the inventory and planning of natural resources. The synoptic view that satellite imagery provides is ideal for determining priority study areas in developed and developing countries. User interests in image map products range from national land-use planning at a broad level to the study of geologic and biologic phenomena at a detailed level.

It is anticipated that products from the USGS Satellite Image Mapping Program will be widely used by federal and state agencies that have responsibility for resource inventory, planning, and mapping. The private sector, notably companies involved in oil, gas, and mineral exploration, will also be major users of image map products. Foreign user interest is also anticipated with the growing demand for economic development of their natural resources.

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SPACE PHOTOGRAPHY: PRESENT STATUS AND FUTURE DIRECTIONS*

Paper submitted by the International Society for Photogrammetry and Remote Sensing (ISPRS)

RÉSUMÉ

Depuis le début de l'ère spatiale, photogrammétriciens et cartographes attendent de la photograhie spatiale les mêmes gains de productivité pour la cartographie que ceux qui ont accompagné la substitution des photographies aériennes aux levés à la planchette Dans les premières années, les astronautes des véhicules Mercury et Gemini ont pris à la main des photos qui ont montré la beauté de la Terre vue de l'espace La première expérience scientifique a été SO-65 : lors de la mission Saturn Apollo 9, en 1965, quatre caméras Hasselblad ont été montées sur un cadre et placées devant le hublot de la cabine de commande du vaisseau spatial. Cette expérience a démontré l'utilité de la photographie multibande et a confirmé le choix des bandes spectrales qui ont été par la suite retenues pour la série de LANDSAT. Parmi les équipements d'expériences sur les ressources terrestres de Spacelab figuraient deux ensembles de prise de vue, le S-190A, qui utilisait aussi des films multibande, et le S-190B qui était une chambre à longue focale haute résolution Toutefois, aucun de ces dispositifs expérimentaux n'a débouché sur un système opérationnel permettant d'assurer une couvertue systématique. Ils ont été remplacés par les systèmes électro-optiques de LANDSAT qui, bien que toujours classés comme expérimentaux, assurent une couverture systématique. La limite de résolution au sol est passée d'un pixel de 80 m au pixel actuel de 30 m, mais ce système ne permet pas la stéréorestitution nécessaire à l'établissement des cartes topographiques, et les normes de précision des cartes planimétriques requièrent une vingtaine de points de contrôle au sol par scène Depuis lors cependant, les appareils photocartographiques et les chambres panoramiques embarqués sur les véhicules Apollo 15, 16 et 17 ont montré la remarquable aptitude des dispositifs photographiques à établir avec une très grande précision des réseaux géodésiques et des cartes topographiques à échelle moyenne Mais toutes les possibilités offertes par les dispositifs de prise de vue à partir de l'espace aux fins de la cartographie de la Terre n'ont pas encore été exploitées

RESUMEN

Desde comienzos de la era espacial, fotogrametristas y cartógrafos han esperado que la fotografía tomada desde vehículos en órbita aumentara la productividad en la confección de mapas, al igual que la fotografía aérea cuando reemplazó a la plancheta En los primeros años, los astronautas de las misiones Mercury y Gemini sacaron manualmente fotografías que demostraron la belleza de la Tierra vista desde el espacio El primer experimento cientifico, realizado en 1965, fue el SO-65, en el que se instalaron cuatro cámaras Hasselblad fijas en la ventanilla del módulo de mando orbitante de la misión Saturn/Apollo 9 Con ello se demostró la utilidad del enfoque multiespectral y se confirmó la elección de bandas espectrales, las que posteriormente se incorporaron a la serie LANDSAT En el programa experimental sobre recursos terrestres de SPACELAB se utilizaron dos grupos de cámaras, el S-190A, en el que también se empleaban películas multiespectrales, y el grupo S-190B, con cámaras de gran distancia focal y alto poder de resolución. No obstante, ninguno de esos experimentos condujo a la creación de sistemas operacionales que suministraran algún tipo de cobertura sistemática Fueron reemplazados por los sistemas electroópticos del LANDSAT, que si bien aún están clasificados como experimentales, proporcionan una cobertura sistemática Si bien el grado de resolución sobre el terreno ha mejorado respecto del pixel 80-m originario hasta llegar al actual pixel 30-m, el sistema no proporciona visión estereoscópica para la compilación topográfica y requiere unos 20 puntos de control sobre el terreno por cada cuadro para poder satisfacer las normas de exactitud cartográfica en posición planimétrica. No obstante, los sistemas de cámaras cartográficas y panorámicas de las misiones Apollo 15, 16 y 17 demostraron la extraordinaria capacidad de los sistemas fotográficos para establecer redes de control y compilar mapas topográficos a escalas intermedias con alto grado de fidelidad No obstante, en su mayor parte la capacidad de los sistemas de fotografía espacial para lograr mapas terrestres útiles sigue inexplotada

From the beginning of the space age, photogrammetrists and cartographers have expected that photography from orbiting vehicles would provide the same increase in productivity for mapping as was obtained when aerial photography replaced the plane-table. In the early years, hand-held photography was acquired by the Mercury and Gemini astronauts and demonstrated the beauty of the Earth as seen from space The first scientific photography was acquired by experiment SO-65 in which four Hasselblad cameras were mounted in a frame and placed in the window of the orbiting command module on Saturn/Apollo 9 in 1965 This demonstrated the utility of the multispectral approach and confirmed the choice of spectral bands which were eventually incorporated into the LANDSAT series The Skylab Earth Resource Experiment Package contained two camera systems, the S-190A, which was again a multispectral film

* The original text of this paper, prepared by Frederick J Doyle, former President, International Society for Photogrammetry and Remote Sensing, appeared as document E/CONF 77/L 55

system, and the S-190B, which was a long focal length high-resolution camera. None of these experiments, however, resulted in operational systems to provide any kind of systematic coverage. They were overtaken by the LANDSAT electro-optical systems, which though still classed as experimental, do provide systematic coverage. Though the ground resolution has been improved from the original 80-m pixel to the current 30-m pixel, the system does not provide stereo coverage for topographic compilation, and it requires approximately 20 ground control points per scene in order to meet horizontal map accuracy standards. Meanwhile, however, the mapping and panoramic camera system carried on Apollo Missions 15, 16 and 17 demonstrated the exceptional capability of photographic systems to establish control nets and compile topographic maps at medium scale with very high accuracy. For the most part, however, the capability of space photographic systems to perform useful Earth mapping remains to be exploited

Systems used in the Union of Soviet Socialist Republics

The only operational space photographic programmes are conducted by the USSR. The Salyut-7 manned spacecraft has been in orbit at altitude approximately 350 km and inclination 52° since April 1982. In addition to hand-held cameras, the spacecraft carries two camera systems designed for systematic coverage. Fresh film is brought to the spacecraft and exposed film returned to Earth by means of the Soyuz and Progress vehicles which regularly supply the Salyut-7 space station

The principal camera system is the MKF-6 multispectral camera built by Zeiss Jena in the German Democratic Republic. The parameters of this system are:

125 mm focal length, 55 × 81 mm format;
6 dielectric filters, 0.48 to 0.80 μm;
ground resolution, 20 to 60 m;
coverage per frame, 154 × 227 km;
stereo overlap, 20, 60 or 80 per cent.

A special colour composite viewer/printer MSP-4 has been built for use with the MKF-6 photographs. This permits the combination of any three spectral bands to produce colour photographs in either natural or colour-infrared response.

In addition to its current operation on Salyut-7, the MKF-6 camera has been carried on several Soyuz missions and on Salyut-4, -5 and -6. Only a few photographs have been released to the western countries, and these have been photolithographed, rather than contact prints. In 1982, the Space Research Institute of the Academy of Sciences of the USSR, the faculty of geography of the Moscow State University, and the Central Institute of Physics of the Earth of the Academy of Sciences of the GDR, published a volume entitled *Atlas of Interpretation of Multispectral Aerospace Photographs*. This presented enlargements of the photographs to scale 1:400,000, and the methods and results of interpretation for various Earth science disciplines. These illustrations seem to corroborate the fact that 20- to 60-m ground resolution is obtained.

The second camera system on Salyut-7 is the KATE-140, designed by the Central Research Institute of Geodesy, Air Survey and Cartography. Its principal parameters are:

140 mm focal length, 18 × 18 cm format;
ground resolution, 30 to 40 m;
coverage per frame, 450 × 450 km;
stereo overlap, 60 per cent.

A few of these photographs have been seen in exhibits at the international professional societies. According to the USSR literature, they are routinely used in 1:1,000,000-scale mapping.

A number of spacecraft in the Cosmos series have been identified as Earth resources missions. Typically, these film recovery missions operate at an altitude of around 250 km, 82° inclination, and have a 15- to 30-day lifetime. The camera system has sometimes been identified as the MKF-6. However, there has also been reference to a Cosmos Earth resources satellite camera which has a 30-cm focal length, and 30 × 30 cm format. Colour-infrared film is used, and a monthly catalogue of available photography is distributed to interested organizations.

These spacecraft obviously operate over areas of the world other than the socialist nations. Undoubtedly very useful information could be obtained if the USSR would release their data or make their capability available to other nations.

Spacelab camera

In late November 1983, Shuttle Mission STS-9 carried into orbit the Spacelab, which was a joint venture between the United States National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). The orbit was 250 km altitude and 57° inclination, and the mission had a lifetime of 10 days. The remote-sensing payload from ESA included the metric camera (MC) in the manned module and a microwave remote sensing experiment (MRSE) which was mounted on the cargo bay pallet. The MC provided excellent data, but the MRSE did not operate properly, and very little useful information was obtained.

The MC is a standard Carl Zeiss Oberkochen aerial mapping camera specially modified for operation in the space environment. Its principal parameters are:

modified Zeiss RMK-A 30/23 frame camera;
30 cm focal length, 23 × 23 cm format;
60 or 80 per cent forward overlap;
2 film magazines, 1,100 total frames;
performance from 250 km orbit:
  image scale, 1:820,000;
  ground resolution (b/w film), 20m/line pair;
  coverage per frame, 190 × 190 km.

Two film cassettes were carried, one loaded with colour-infrared film (Kodak 2443) and the other with black-and-white panchromatic (Kodak XX).

During the mission, a failure of the film transport mechanism during exposure of the second cassette was overcome by the astronauts. A total of 350 colour-infrared and 470 black-and-white photographs were acquired. Many exceptional scenes were obtained, although, owing to the time of year, there was excessive cloud cover and low sun illumination at the northern limits of the flight. ESA had accepted proposals from over 100 institutions to evaluate the utility of the photographs. Each of these investigators was supplied photographs for their areas of interest. Subsequently the photographs have been made available for general worldwide distribution through the Air and Space Research Agency of the Federal Republic of Germany (DFVLR), at Oberpfaffenhofen, and through the ESA-Earthnet office at Frascati, Italy.

A workshop was conducted by ESA-DFVLR in February 1985 to present the results of the investigations which had been undertaken. The workshop proceedings have not yet

been published, but the preliminary results indicate that the best ground resolution was about 20 m per line/pair, which is marginal for image maps at scale 1:100,000. The geometric integrity, however, is adequate for maps at 1:50,000 scale, and contours at 50-m interval can be compiled.

NASA and ESA have agreed to a reflight of the MC on the Shuttle Earth Observation Mission (EOM-1), which is scheduled for late 1986 or early 1987. For this mission Zeiss has constructed a magazine which provides forward motion compensation. This should greatly increase the resolution of the photographs, and probably make them suitable to accomplish the objective of 1:50,000-scale mapping.

NASA LARGE-FORMAT CAMERA

Shuttle Mission STS-41G was launched from the Kennedy Space Center on 5 October 1984. The orbit inclination was 57° and the spacecraft operated at three different altitudes during the course of the mission: 352 km, 272 km and 225 km. Included in the cargo bay payload was the large-format camera (LFC) built by Itek Optical Systems Division of Litton Industries under contract to the NASA Johnson Space Center. The principal parameters of the camera optical system and magazine are:

Lens

Focal length 30.5 cm, aperture f/6.0;
Resolution 80 line pairs/mm AWAR;
Maximum distortion less than 20 μm;
Interchangeable haze and minus blue filters;
Rotary capping and chopping shutter;
Automatic exposure control, 1/250 to 1/30 sec.

Magazine

Format 23 × 46 cm, long dimension in direction of flight;
12 illuminated fiducials;
Back illuminated 5 × 5 cm réseau;
Forward overlap, 10, 60 or 80 per cent;
Adjustable forward motion compensation;
Film capacity, 2,400 frames;
Automatic data recording.

These parameters were designed particularly to permit topographic mapping at scale 1:50,000. By operating the camera with the long dimension of the format in the direction of flight and with 80 per cent forward overlap, it is possible to select pairs of photographs which will provide a range of base/height ratio from 0.3 to 1.2, thus permitting the maximum precision in elevation determination from the stereo-models. The combination of high focal plane resolution and adjustable forward motion compensation permits the use of high resolution, low speed films to provide the maximum detail in the ground scene. The arrangement of the 12 illuminated fiducials permits use of either the forward, centre or aft 23 × 23 cm section of the full format. The centre sections can be used in conventional stereo-plotting instruments, and the stereo-model will have a base/height ratio of 0.3. The forward and aft sections are particularly adaptable to analytical plotters in which the principal point can be mathematically offset. This permits the use of the maximum base/height ratio. The 5 × 5 cm réseau permits analytical correction of any film distortion, and also provides geometric reference so that enlarged sections of the photographs can be compiled with no loss of integrity.

Also built by Itek was a stellar camera Attitude Reference System (ARS) for use with the LFC. The principal parameters of the ARS are:

two lenses directed 45° fore and aft;
focal length, 150 mm; aperture, f/2.8;
format, 2 frames 60 × 60 mm on single 70 mm film web;
focal plane réseau, 5 × 5 mm;
exposure 25 msec, synchronized with LFC exposure.

The three-camera array is mounted on the mission-peculiar equipment support structure (MPESS), which is designed as a drop-in payload for any Shuttle mission that has a useful Earth viewing time.

On Mission STS-41G the LFC exposed 2,160 frames of which 1,300 had less than 35 per cent cloud cover. Photographs were acquired of all the inhabited continents. Many exceptional photographs were obtained. From the lowest altitude of 225 km, a single frame covers a ground area of 170 × 340 km. It is not possible to appreciate the quality of the photographs by examining contact prints. Enlargements of about 20X over urban areas show approximately the same image quality as conventional high altitude aerial photographs. In addition the large-area coverage with good stereo-overlap is particularly advantageous for geologic and other types of Earth science interpretation.

After NASA completed its evaluation of the original film it was transferred to the USGS EROS Data Center in Sioux Falls, South Dakota. Qualified investigators will be able to obtain copies from that source. Prices have been established to cover the cost of processing, and indexes, quality evaluation, and film and paper products are available.

NASA has agreed to a second flight of the LFC but a mission has not yet been designated. There is a possibility of a 57° inclination mission in late 1985 or a near-polar inclination mission in late 1986, but no Shuttle launch schedules are firm that far in advance.

MAPPING WITH SPACE PHOTOGRAPHS

The MC and LFC experiments show great promise for solving the geometrical problems of topographic mapping at scales around 1:50,000. However these experiments are a long way from operational mapping systems.

Space photographs cover an enormous area. A single frame from the LFC, for example, covers the area of about 100 standard quadrangles at scale 1:50,000. Making allowances for cloud cover, stereo-overlap, and duplicate coverage arising from low- and medium-inclination missions, it is still possible to acquire coverage for about 40,000 standard quadrangles at 1:50,000 scale from a single mission. This is more than enough work to absorb the total capacity of several very large mapping organizations. Consequently, it is necessary to organize very large projects, probably on an international basis, before space photography can be justified.

One of the principal advantages of space photography also works to its disadvantage. Standard photogrammetric procedures for aerial photography employ an enlargement of 1 to 5X from photographs to map scale. The high resolution of the space photos requires magnifications of about 10 to 20X in order to extract the information content. Thus, it will be necessary to exercise extreme care in every stage

of the procedure in order to maintain the information content of the original photographs.

There is no body of experience in topographic mapping from space photographs on which to base procedures, instrumentation, and particularly costs. It is relatively easy to demonstrate theoretically that the photographs have the necessary information content and geometric integrity. But the transformation of this theoretical capability into a functional operating system has yet to be accomplished. It is anticipated that research projects conducted with the MC and LFC photographs will develop the standard procedures and cost figures to permit a valid comparison of space techniques with those of conventional aerial photographs.

The resolution of the space photographs is probably sufficient for producing image maps at 1:50,000 scale. However, most of the nations which have the capability for operating space systems are already mapped at scales larger than this. The utility of the space photographs will therefore be found in revising maps, and perhaps in pointing out those areas where lower altitude aerial photography may be required. The maximum utility of the space photographs will be found in less developed countries where large- and medium-scale maps do not exist at all. The resolution of the MC and LFC is sufficient to delineate all topographic and cultural features, but is not really adequate to interpret all of the cultural features, e.g., it may be difficult to distinguish the various classes of roads, railroads, and buildings. Experience has shown that a resolution of about 2-m per line pair is required for this purpose, regardless of the scale at which an image map may be reproduced.

Finally, even if space photographs prove to be remarkably successful in accomplishing significant mapping for the developing areas of the world, there is no assured source of further data. As has been mentioned, there is now planned one additional flight of the Spacelab MC, and one additional flight of the LFC. However, after these two missions, there is no provision for continuing flights. In the United States the current administration is philosophically opposed to the Government's operating remote-sensing systems. They have adopted the position that if such systems are economically feasible, they should be operated by private enterprise. This feeling is beginning to be shared by the ESA.

Future developments of photographic systems

Mention has already been made that a new magazine having forward motion compensation has been built for future operations of the MC. This will significantly increase the quality of the photographs produced.

There is within NASA a proposal—as yet unfunded—to substantially enhance the capability of the LFC System. NASA still has two of the panoramic cameras used in the Apollo Lunar Program. The parameters of these cameras are:

Lens: 610 mm f.1, f/3.5, 135p/mm AWAR;
Film: 127 mm x 2,000 m, 1,650 frames, 110 x 1,150 mm format, EK 3404;
Features: ±54° sweep, ±12½° stereo, forward motion compensation, automatic exposure control.

If operated in Earth orbit at altitudes between 200 and 300 km, these cameras will provide a ground resolution of 2 to 3 m per line pair. Two of the cameras would be mounted on the MPESS structure, together with the LFC. One of the pan-cameras would look forward, and the other aft to provide adequate stereo-coverage. Also, the ARS would be changed from the stellar film cameras (which require laborious and time-consuming post-flight measurements) to an electro-optical system with a focal plane array of charge-coupled devices. An integral microcomputer will determine the three attitude angles at intervals of about 30 seconds, and with a precision of about 3 arcseconds. These data would be recorded directly on each frame of the film. Also a Global Positioning System (GPS) receiver would be added to the payload. This would permit the determination of the spacecraft position with an accuracy of about 15 m in all three co-ordinates. Such a system would have the capability of providing data to compile 1:50,000-scale maps with annotated cultural features any place in the world without any requirement for ground control points.

Platforms for space photographic systems

Although photographic systems like the MC or the LFC can acquire enormous amounts of coverage on Shuttle missions of 7 to 10 days duration, the areas actually photographed are pretty much a matter of luck. Photography is accomplished where it is convenient in the time-line of a multi-purpose mission, and desired areas may well be cloud-covered at the time the mission operates. In principle it would be possible with many missions to build up a world-wide data base, but in practice the coverage obtained from a very limited number of missions will only fortuitously be in the areas of high priority for mapping. What is needed is a free-flying spacecraft in a near-polar orbit, the spacecraft having a life-time sufficient to allow all of the film to be exposed in cloud-free areas where mapping is required. There are several possibilities for such a platform.

Shuttle Pallet Satellite

The Shuttle missions STS-7 and STS-11 carried a small deployable spacecraft called the Shuttle Pallet Satellite (SPAS) which was built by Messerschmidt Bolkow Blohm (MBB) in the Federal Republic of Germany. The spacecraft carried the modular optical multispectral scanner (MOMS), also built by MBB. Images with a 20-m pixel and 140-km swath were successfully obtained from an altitude of 300 km. There was a scheme to use SPAS/MOMS in a commercial venture, but this did not materialize because of problems in financing, and United States policy with regard to distribution and access to the data obtained. Nevertheless, SPAS remains a viable candidate as a platform for future missions carrying photographic systems. It would, of course, need an attitude control system and a GPS receiver. The idea would be to launch the spacecraft from the cargo bay of the Shuttle, and leave it in orbit until all film had been usefully expended. Then two options are available. In the first option, the spacecraft could be retrieved by a subsequent Shuttle mission and serviced in the cargo bay. The exposed film magazine would be removed and a fresh magazine installed. The spacecraft would then be relaunched into its operating orbit. The second alternative is to retrieve the spacecraft by a subsequent Shuttle flight and return it to Earth for refurbishment and relaunch. This second alternative would certainly be easier to do, but would also be more expensive.

The European Retrievable Experiment Carrier

The European Space Agency is designing the European Retrievable Experiment Carrier (EURECA) which is built upon the same technology as the SPAS. It would be a self-contained deployable spacecraft, launched and retrieved by the Space Shuttle. One of the possible payloads would be the MC flown on Spacelab. However, considerable modification would be required to make this camera operate in the open space environment, or a pressurized thermal container would have to be built to mount the camera on the EURECA structure.

Lease-craft

One of the more attractive proposals is the "lease-craft" built by Fairchild Space and Electronics Company. This system would be based upon the multi-mission modular spacecraft (MMS) which is the basic bus for the LANDSAT-4 and -5 remote sensing spacecraft. Fairchild proposes to build a number of such spacecraft which would be launched and serviced by the Shuttle. Payload space would be leased to government agencies or other enterprises. The spacecraft could remain in orbit for one week to two years at an operating cost of about $3 million per month. Preliminary discussions have been held with Fairchild about carrying the LFC-PAN Camera package, but there is no commitment at this time to move ahead with this scheme.

Space station

NASA's next major project will be the design, construction, and operation of the manned space station. Although the final configuration has not yet been determined, it is generally agreed that the eventual components of the station will include a permanently manned laboratory operating at about 400-km altitude in a 28.5° inclination orbit. There may be one man-tended spacecraft operating in the same orbit, but as yet not many uses have been identified for this spacecraft. There would also be two polar-orbiting man-tended spacecraft, one designed primarily for atmospheric and ocean sensing with an Equator-crossing time in the early afternoon, and the other designed for atmospheric and land sensing with an Equator-crossing time early in the morning. Finally, there would be a reuseable orbit-transfer vehicle which could be used for moving payloads from the low-Earth orbit to the geosynchronous orbit. "Man-tended" does not mean that astronauts would occupy the spacecraft, but rather that it could be brought into co-orbit with the manned laboratory or with the Shuttle, and astronauts could perform maintenance operations on the spacecraft or its instruments before releasing the spacecraft again into its own orbit.

After their experience in trying to co-ordinate many experiments on the Shuttle, scientists are somewhat concerned about placing their instruments on another multipurpose spacecraft. Nevertheless, within the next five years, the space station may be the only opportunity available, and remote-sensing scientists will have to use its capabilities for lack of any other. Although the atmospheric remote-sensing experiments are reasonably well planned for the polar orbiters, there has as yet been no definition of the land-observing sensors. Electro-optical data transmission systems are certainly one possibility, but the fact that the man-tended orbiter will rendezvous with the manned laboratory or the Shuttle at periodic intervals makes it a feasible candidate for a film-return system.

Policy problems

There is evidently no technical impediment to building a system which would be capable of performing medium-scale topographic mapping anywhere in the world, and it is expected that this capability will be demonstrated by experiments currently under way with the MC and LFC photographs. It has been demonstrated (Doyle, 1984) that such systems can be economically feasible only if very large areas are involved. This means that international co-operation is essential, but there is currently no mechanism by which such international co-operation can be effected. The United Nations has struggled with the problem, but has not resolved the questions of the right of one country to photograph another and make the photography available to a third country. There is, however, reasonable agreement in the scientific community that the benefits of shared space photography far outweigh the possible security implications. There have been no strong protests raised about the Spacelab MC photographs or the Shuttle LFC photographs. Perhaps the principal reason for this agreement is that film photographs are always historical. They show the situation as it existed at some time past rather than as it exists at the moment, which is possible with real time electro-optical data-transmission systems. There is not much cause for optimism that the United Nations will resolve the political and economic problems in the time-frame in which technically feasible systems could be operated.

There is, however, one possible mechanism for implementing such a system in the very near future. The International Society for Photogrammetry and Remote Sensing (ISPRS) is a non-political, non-governmental professional organization. It is considering the possibility of serving as a broker between its member organizations—which are primarily the mapping organizations within each country—and a commercial operator, such as Fairchild, which would supply the spacecraft and the camera system. Photographs could be ordered by any one of the member organizations through the ISPRS, whose primary role would be to consolidate the requirements of a number of countries in order to make an economically feasible mission. The ISPRS would then deal with the commercial operator of the system, who would acquire the photographs which would then be distributed through the ISPRS. There is also the possibility that a commercial venture may perform the mapping under contract to countries that do not have that capability. Such a scheme might avoid many of the political impediments to co-operative projects.

Obviously the administrative and economic details of these proposals have not been resolved, but they do hold out the possibility of applying the technology of mapping from space to the 70 per cent of the world's land area that does not have adequate mapping at scale 1:50,000 or larger.

Reference

F Doyle (1984) The economics of mapping with space data *ITC Journal*

(c) *Aerial photography and remote sensing from space**

LE NOUVEAU SYSTÈME DE DÉTECTION APR-LASER DE L'INSTITUT GÉOGRAPHIQUE NATIONAL**

Document présenté par la France

SUMMARY

The National Geographical Institute has developed a new system for airborne profile recording (APR) of terrain in order to establish an altimetric network for small-scale photogrammetric surveys. This system replaces the APR-radar system previously used at the Institute, which was less accurate and could not be placed on board pressurized aircraft such as Mystère 20 or Beechcraft Super King Air.

The APR-Laser system is composed of a TAY 130 laser telemeter built by CILAS and of a statoscope, data from which are recorded and processed on an HP-9825 computer and printed on a line-printer on board the aircraft. The localization of profiles is given by a 35-mm camera, which can be supplemented by 24 × 24 cm stereoscopic coverage where topographic details are very sparse.

RESUMEN

El Instituto Geográfico Nacional ha elaborado un nuevo sistema para el registro de perfiles del terreno mediante la fotografía aérea (APR) a fin de establecer una red altimétrica de levantamientos fotogramétricos en pequeña escala. Este sistema reemplaza al sistema de radar APR, utilizado previamente en el Instituto Geográfico Nacional, que era menos exacto y no se podía embarcar en aviones con cabinas presurizadas, tales como el Mystère 20 o el Beechcraft Super King Air.

El sistema APR-Láser consta de un telémetro láser TAY 130 construido por CILAS y de un estatoscopio cuyos datos se registran y elaboran en una computadora HP 9825 y se imprimen en una impresora de líneas a bordo del avión. Se obtiene la localización de los perfiles mediante una cámara de 35 mm, que podría complementarse con una cobertura de vistas estereoscópicas en caso que los detalles topográficos fueran deficientes.

Les travaux d'établissement du canevas de restitution photogrammétrique se heurtent à des difficultés sérieuses dans le cas de levés à petite échelle (1/100 000, 1/200 000) de zones désertiques. Ces régions sont en général étendues, pauvres en moyens logistiques, d'accès difficile et dépourvues d'équipement géodésique et de nivellement. Le canevas de restitution doit donc être fourni par une méthode se satisfaisant d'une infrastructure d'appui très peu dense afin de limiter les travaux au sol au strict minimum. En particulier, le canevas altimétrique peut être obtenu par exploitation en aérotriangulation analytique de profils du terrain enregistrés à bord d'un avion et rattachés au réseau de nivellement par des travaux au sol : c'est la méthode des profils aéroportés dite APR (Airborne Profile Recording). A l'Institut géographique national (IGN), cette méthode est mise en œuvre depuis plus d'une vingtaine d'années, en utilisant un télémètre radar monté sur avion HD-34 ou B-17. Mais ce télémètre ne peut être monté sur avion pressurisé moderne, tel que Mystère-20 ou Beechcraft Super-King-Air; d'autre part, ses performances étaient limitées : angle d'ouverture du faisceau radar important (2°) ne convenant pas en région accidentée, précision de mesure de l'ordre de 3 m.

Conscient de ces limites, l'IGN avait étudié, dans les années 60, un enregistreur aéroporté de profils utilisant un télémètre laser [4], mais le prototype de cet appareil avait rencontré des difficultés d'utilisation. L'idée a été reprise en 1978, à partir d'appareillages ayant fait leur preuve dans d'autres domaines d'utilisation, et son étude par le Service des activités aériennes de l'IGN a abouti à la réalisation d'un nouveau système APR-Laser embarquable sur avion pressurisé.

Le présent article a pour objet de donner une description de ce système. En ce qui concerne l'exploitation des profils qu'il enregistre, elle se fait selon la même méthode que celle qui a été longuement appliquée par l'IGN pour les profils APR-Radar [2,3] et que nous résumerons simplement de la façon suivante.

Le profil du terrain enregistré à partir d'un avion est référencé à une surface isobare. Or, aux altitudes couramment utilisées (de 2000 à 6000m) les couches atmosphériques ne sont ni parfaitement régulières ni absolument stables. Pour un profil isolé, il serait donc nécessaire, en principe, de coter chacune de ses extrémités afin de tenir compte de la pente moyenne de la surface isobare (mais en négligeant ses déformations intermédiaires). En fait, on établit un réseau de profils APR orthogonaux dont on assure l'homogénéité interne avant rattachement au nivellement. Cette méthode permet de tenir compte des variations dans le temps d'une surface isobare donnée. En effet, au point d'intersection de deux profils orthogonaux correspond évidemment une altitude-terrain unique.

Les mesures APR permettent alors, en ces points, de coter les surfaces isobares de référence les unes par rapport aux autres et d'effectuer une compensation interne globale du réseau. Le rattachement au nivellement est réalisé aux endroits où un profil APR coupe une maille de nivellement (ou en tout autre endroit d'altitude connue : mer par exemple). L'introduction de points d'altitude connue permet de faire une deuxième compensation du réseau, d'obtenir ainsi l'altitude de l'origine commune à tous les profils du réseau et, par conséquent, de déterminer ensuite l'altitude de n'importe quel point situé sur un profil.

ORGANISATION GÉNÉRALE DU SYSTÈME

(figures 48 et 49)

Le but de ce système est l'enregistrement à bord d'un avion d'un profil de terrain, c'est-à-dire l'intersection du

* See also document E/CONF 77/L 24, discussed under agenda item 5 (*b*).

** The original text of this paper, prepared by Raymond Brossier, National Geographical Institute, appeared as document E/CONF 77/L 30.

Figure 48 France : schéma de principe de l'ensemble émission-réception laser

$$D = C \frac{t}{2}$$

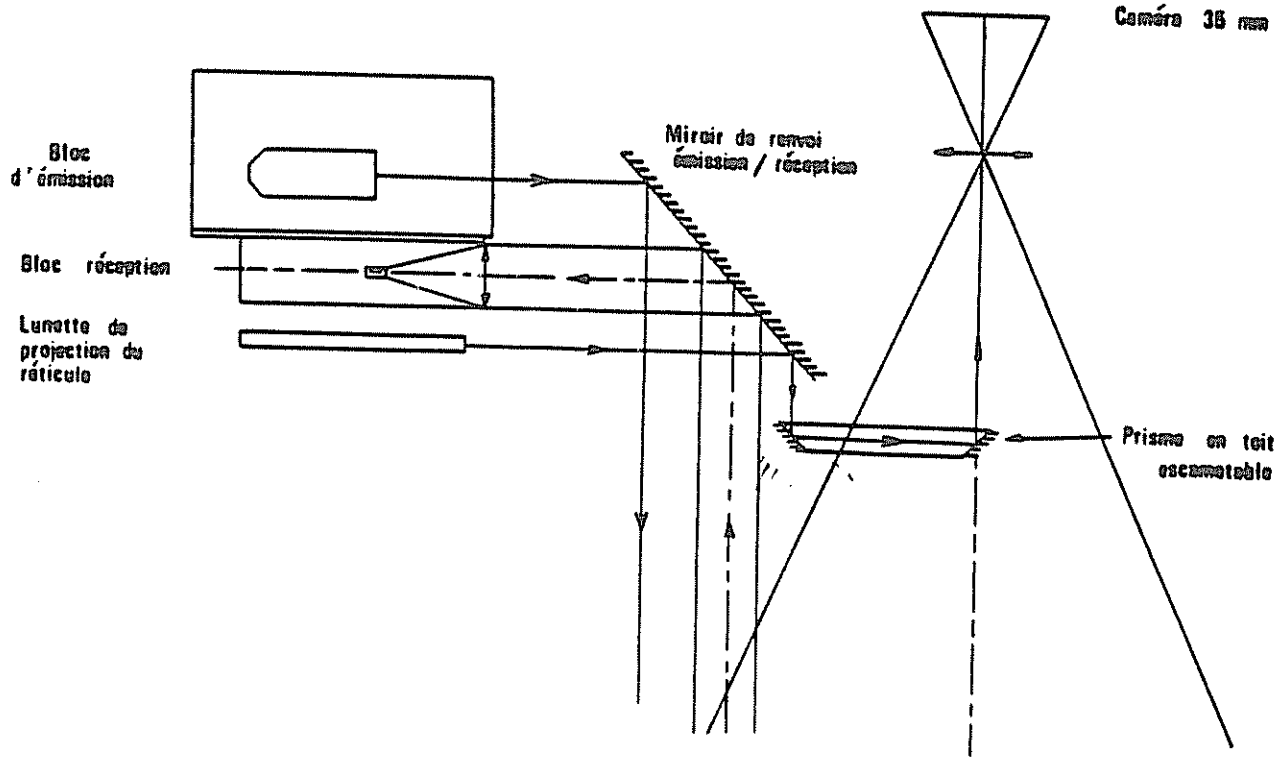
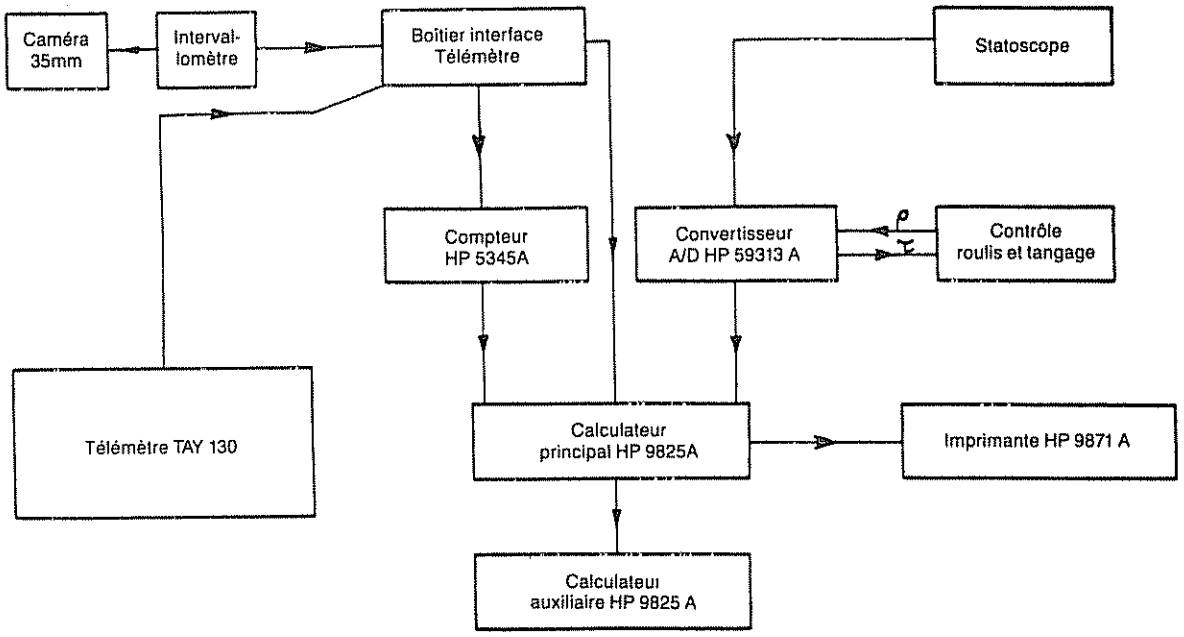


Figure 49. France : schéma synoptique du système APR-Laser de l'IGN



terrain avec la surface générée par le faisceau laser au cours du déplacement de l'avion. Ce profil est obtenu à partir de deux ensembles de mesures.

La mesure selon une certaine fréquence de la distance avion-sol est effectuée à l'aide du télémètre laser. Ces mesures seraient directement exploitables si la route de l'avion était parfaitement horizontale. Ce n'est généralement pas le cas et il est nécessaire de tenir compte des variations d'altitude de l'avion.

Ces variations sont mesurées à l'aide d'un baromètre différentiel, ou statoscope, l'avion étant maintenu au mieux sur une ligne isobare à l'aide de l'altimètre de bord.

Les données fournies par le télémètre et le statoscope sont enregistrées sur cassette, sur calculateur Hewlett-Packard 9825.

Le profil ainsi enregistré doit pouvoir être localisé avec précision sur le terrain. C'est le rôle d'une camèra 35 mm, dite camera auxiliaire, solidaire du télémètre qui travaille au coup par coup, selon une cadence préalablement choisie. Son axe de prise de vues est réglé pour être parallèle au faisceau laser : le point d'impact au sol est enregistré sous forme d'une croisée de réticule venant sur le cliché 35 mm. La position de cette croisée peut être repérée par rapport au centre du cliché.

La prise de vues par caméra 35 mm peut être complétée par une prise de vues stéréoscopiques normale avec chambre Wild RC 10, format 24 × 24 cm, installée sur la seconde trappe de l'avion, si le terrain présente peu de détails topographiques (cas des régions désertiques, par exemple). La chambre RC 10 est montée sur une suspension Wild PAV 10, télécommandable par le navigateur qui maintient l'axe de prise de vues 24 × 24 cm en position verticale. La cadence de cette prise de vues est réglée pour obtenir le recouvrement stéréoscopique (au moins 60%).

Les tops de la caméra 35 mm sont déclenchés simultanément à ceux de la prise de vues 24 × 24 cm; toutefois il est possible d'augmenter la cadence des clichés 35 mm afin de suivre en détail l'incidence des variations en roulis et en tangage de l'avion. Cependant, la meilleure solution pour tenir compte du roulis est de le mesurer par système gyroscopique, de l'enregistrer et d'effectuer, sur le calculateur HP-9825, la correction correspondante sur la distance avion-sol.

Présentation des éléments constitutifs du système

Le télémètre à laser TAY 130

Ce télémètre est construit par la CILAS (Compagnie industrielle des lasers). Il est conçu pour être monté sur aéronef et se trouve alimenté par le réseau 28 V continu de bord.

Le principe de la télémétrie laser consiste à chronométrer le temps écoulé entre l'émission d'une impulsion lumineuse et son retour après réflexion sur le sol. L'impulsion se déplaçant à la vitesse de la lumière, il est facile d'obtenir la distance laser-point d'impact par la relation :

$$D = C\frac{t}{2}$$

dans laquelle :

D = distance en mètres
C = célérité de la lumière en mètres par seconde ($C = 299{,}71 . 10^6$ m/s)
t = temps en secondes mis par l'impulsion pour faire le trajet aller et retour.

Description (figure 48)

Le télémètre TAY 130 est constitué de deux sous-ensembles : l'émetteur-récepteur et le bloc optique.

L'*émetteur-récepteur* se présente sous la forme d'un boîtier étanche de fonderie. Il comprend une semelle équipée recevant le système laser et ses accessoires : condensateur de stockage d'énergie, circuits de commande, éléments de puissance et un capot recevant les optiques d'émission et de réception ainsi que les circuits électroniques de réception.

Le *bloc optique* comprend :

i) Un ensemble de pièces optiques
   —Miroir de renvoi à 90°, pour diriger vers le sol le faisceau d'émission (et renvoyer vers l'optique de réception le signal retour);
   —Prisme en toit escamotable servant à renvoyer l'image du réticule vers la caméra 35 mm;
   —Atténuateur escamotable pour diminuer l'énergie émise par impulsion lors de vols à basse altitude, pour des raisons de sécurité;
ii) Un système mécanique pour la fixation de la caméra 35 mm et le réglage de la direction de son axe optique.

Caractéristiques

Distance maximale de mesure	15 km
Fréquence des mesures (soit une impulsion toutes les 50 millisecondes)	20 Hz
Emetteur laser YAG (Grenat d'Yttrium Aluminium) dopé au néodyme	
—Longueur d'onde d'émission	1,06 µm
—Energie maximale par impulsion	40 mJ
—Durée de l'impulsion	18 ns
—Divergence d'émission (angle au sommet du cône contenant 86% de l'énergie totale émise)	0,5 mrad
—Champ géométrique de réception de l'onde retour	8 mrad
—Précision de mesure	±0,50 m
Erreur d'alignement entre les axes du réticule et de l'émission laser	0,25 mrad
Diamètre de la pupille de réception	70 mm
Température de fonctionnement	0 à 40° C
Alimentation par le courant continu de bord	28 V
Consommation	400 W
Dimensions	30 × 35 × 85 cm
Poids : environ	25 kg

Fonctionnement

Le bloc émetteur-récepteur comporte les éléments suivants :

i) Un générateur d'impulsion comprenant une cavité laser et son électronique d'alimentation et de commande de tir;
ii) Un circuit de réception de l'impulsion retour.

La cavité laser (figure 50) est terminée par deux miroirs; l'un a un coefficient de réflexion maximal (Rmax), l'autre un coefficient de réflexion de l'ordre de 30% : c'est par cette lame que sort le faisceau. L'ensemble comprenant le barreau, le tube flash et le diffuseur constitue une cartouche dans laquelle circule un liquide de refroidissement.

L'émission de l'impulsion laser est réalisée par déblocage de la cavité optique. Le barreau actif de la cartouche laser est mis en état d'excitation (pompage optique) par l'allumage d'un tube flash obtenu par la décharge d'un condensateur; la lumière de ce tube flash est répartie autour du barreau actif par un diffuseur. Le déblocage de la cavité est

Figure 50. France : télémètre CILAS TAY 130; cavité laser (d'après document CILAS)

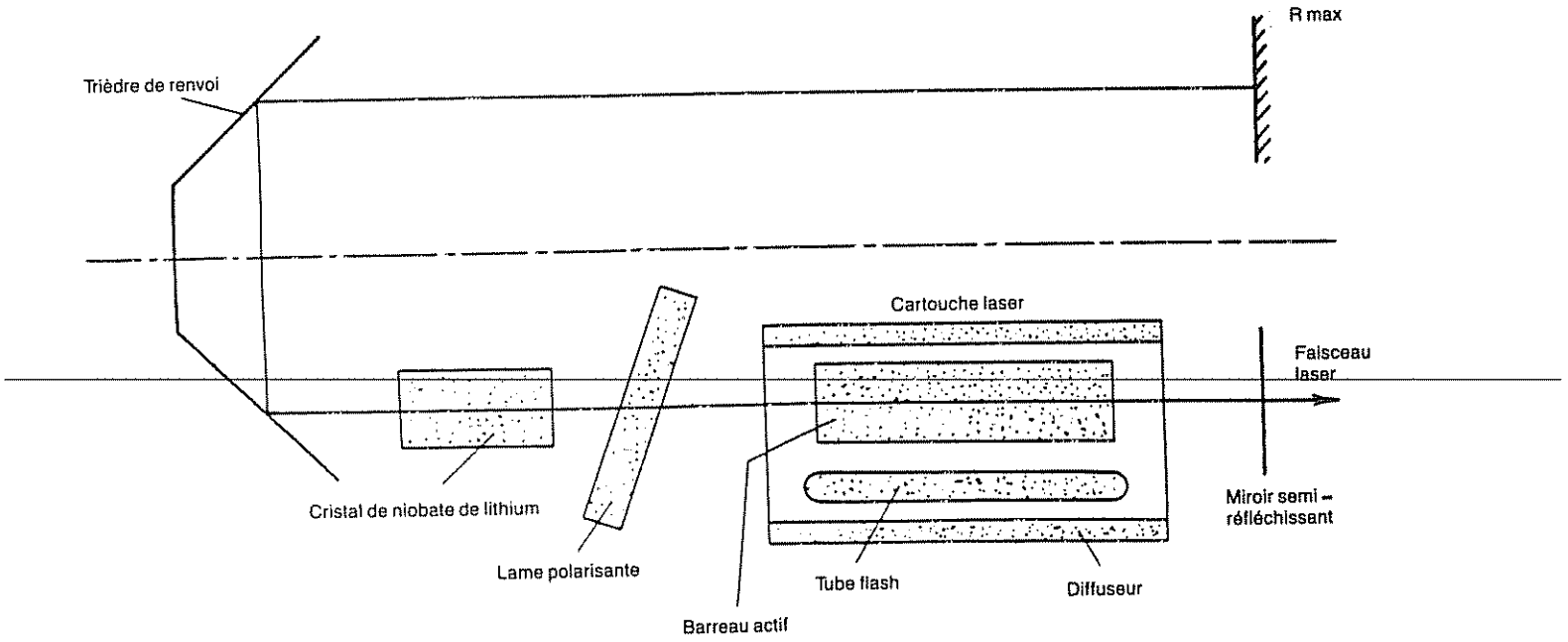
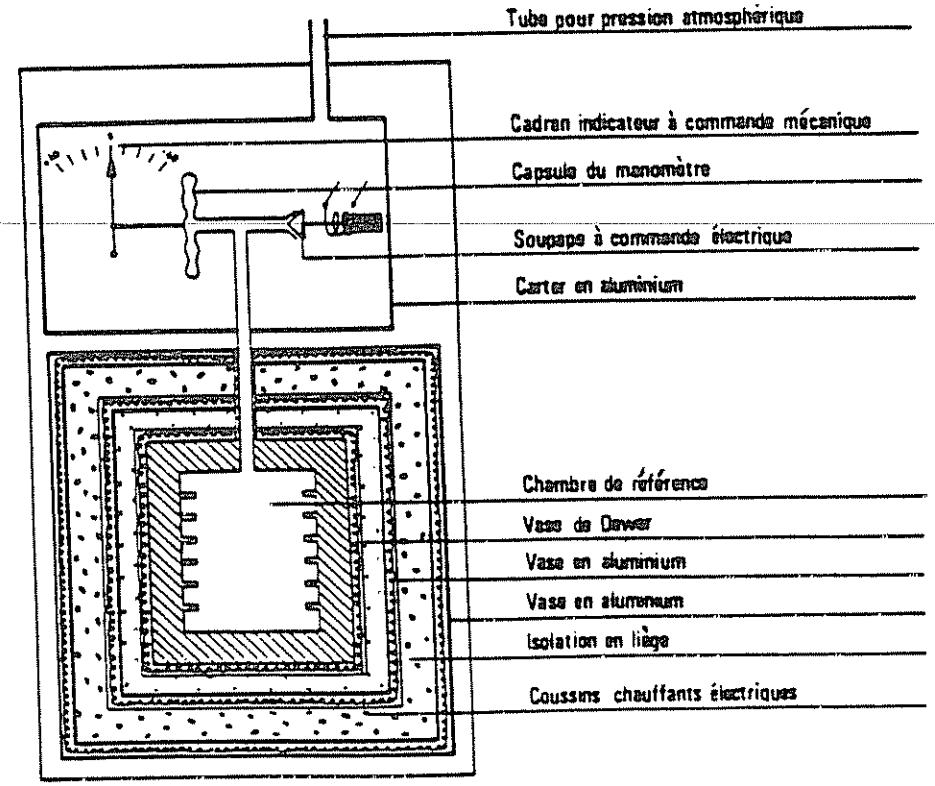


Figure 51. France : schéma du principe du statoscope Wild RST.2 (d'après document Wild)



assuré par l'ouverture d'un obturateur électro-optique déclenché au moment où la fluorescence du milieu actif est voisine de son maximum. Les miroirs délimitant la cavité entretiennent un mouvement d'aller et retour des photons induits : il en résulte une oscillation, l'amplification à chaque passage étant supérieure aux pertes de la cavité.

L'impulsion de départ du comptage de la distance est obtenue par la détection d'une faible partie de la puissance émise. La puissance réfléchie constitue l'impulsion écho; elle est détectée par une photodiode, les circuits de réception assurant l'amplification et la mise en forme de ces impulsions.

Le statoscope Wild RST 2

Le statoscope Wild utilisé dans le système APR-Laser de l'IGN n'est pas le modèle le plus récent produit par la firme d'Heerbrugg. Toutefois, l'appareil RST 2 dont dispose l'IGN convenant au but recherché, c'est-à-dire la mesure et l'enregistrement des variations d'altitude de vol par rapport à une surface isobare, et ayant d'excellentes références de précision et de fiabilité, son incorporation dans le nouveau système APR-Laser a été retenue dans un premier temps. Pour les lecteurs peu familiarisés avec ce type d'instrument, il nous paraît utile d'en rappeler les caractéristiques principales.

Description technique (figure 51)

Le statoscope Wild RST 2 est constitué par un manomètre anéroïde avec vase de référence et un dispositif de commande électrique. Il est installé dans un boîtier solide tenant lieu de caisse de transport.

Le manomètre anéroïde est lié à un vase de compensation contenant de l'air maintenu à température constante (+ 50° C) grâce à un système d'enveloppes à isolation multiple dont le chauffage électrique est réglé par des thermostats.

Le dispositif électrique a pour tâche de maintenir une température constante dans le vase de référence et de délivrer un signal électrique correspondant aux dénivelées. La gamme utile de mesure est de ± 2,5 V. Ce signal est numérisé à l'aide d'un boîtier interface HP 59313 A afin d'être pris en compte par le calculateur HP 9825 du système. Les indications du statoscope sont par ailleurs visualisées sur un cadran placé au poste du pilote; elles sont exprimées en mètres, pour une altidude de référence de 5 000 m.

Le dispositif électrique assure également les fonctions de sécurité suivantes :

i) Allumage d'une lampe signale sur le statoscope et dans le poste du pilote lorsque les différences d'altitude dépassent ± 25 m.

ii) Mise hors circuit du statoscope à l'aide d'une soupape de sécurité lorsque la portée de ± 40 m est dépassée.

Caractéristiques techniques

Dimensions : 27,5 × 27,5 × 51 cm

Masse : 25 kg

Alimentation : 28 V continu de bord

Consommation : 400 V maxi en préchauffe

Précision de mesure : ± 0,5 m pour une amplitude des dénivelées de ± 20 m à 5 000 m d'altitude.

Le compteur électronique HP 5345 A

Cet appareil a pour objet de mesurer :

i) Des fréquences, entre 50 μHz et 50 MHz;

ii) Des périodes, entre 2 ns et 20 000 s;

iii) Des intervalles de temps, entre 10 ns et 20 000 s.

Dans le cas de l'APR-Laser, le compteur mesure l'intervalle de temps séparant l'émission des impulsions et leur réception par le télémètre. Cette donnée est transmise sous forme numérique au calculateur HP 9825. La précision de mesure est de 2 ns.

Le compteur est équipé d'une base de temps stabilisée, délivrant une fréquence de référence de 10 MHz. Cette fréquence peut être utilisée pour piloter des phénomènes périodiques : en particulier pour l'APR-Laser, elle sert à élaborer l'impulsion de cadence de déclenchement des tirs lasers, à la fréquence de 20 Hz.

Prise en compte des paramètres d'altitude de l'avion

La distance avion-sol est affectée de l'erreur due au roulis ρ et au tangage τ de l'avion.

Si l'on mesure à l'aide de deux gyroscopes les valeurs angulaires de ρ et de τ, la distance corrigée sera de la forme :

$$D' = D \cos \rho \cos \tau$$

En pratique, on utilise une centrale bigyroscopique mesurant le roulis et le tangage et délivrant deux signaux électriques correspondants. Ces signaux sont numérisés à l'aide de l'interface HP 59313 A à quatre voies, à la fréquence de 1 Hz, et enregistrés par le calculateur sur cassette HP.

Le calcul de la distance corrigée D′ est fait en temps différé.

Enregistrement des données

Le système APR-Laser est articulé autour d'un calculateur HP 9825 de 64 K mots. Le calculateur reçoit les informations suivantes :

i) Mesure du temps de parcours aller et retour, transmise par le compteur HP 5345 A à la cadence de 20 Hz ;

ii) Dénivelée point de vue—surface isobare mesurée par le statoscope, exprimée en volts et à la cadence de 1 Hz;

iii) Valeurs du roulis et du tangage exprimées en degrés;

iv) Recueil du top de déclenchement de la caméra auxiliaire.

Ces données sont enregistrées sur cassette HP à l'aide d'un deuxième calculateur HP 9825 afin de ne pas perdre d'informations pendant le temps de transfert des données sur cassette.

Restitution en temps réel à bord de l'avion

Afin de pouvoir fournir un listage de contrôle des données, le calculateur principal déduit la distance avion-sol D par application de la relation :

$$D = C\frac{t}{2}$$

Le calculateur fait la moyenne des distances brutes D, quatre par quatre, et les envoie sur l'imprimante associée HP 9871 A à la cadence de 5 Hz. Le listage ainsi produit donne le profil brut du terrain et permet de s'assurer de la cohérence des données. Il est complété par les tops de déclenchement de la caméra (traduits par une croix) et la numérotation du premier cliché de chaque axe ainsi que d'un cliché sur dix.

En temps différé, on réalise à l'aide de l'imprimante le profil corrigé, tenant compte des données du statoscope et de la centrale bigyroscopique

Le calculateur détermine alors la dénivelée DH entre le point de vue et la surface isobare à partir de la valeur V du signal électrique fourni par le statoscope :

$$DH = K_h \cdot V$$

Le coefficient K_h varie en fonction de l'altitude et doit être introduit selon la mission Par exemple, si

H = 0	K_h = 6,1 m/V
H = 2 500 m	K_h = 7,8 m/V
H = 5 000 m	K_h = 10,0 m/V
H = 7 500 m	K_h = 12,9 m/V

le calculateur détermine également la distance corrigée de l'altitude de l'avion,

$$D' = D \cdot \cos \rho \cdot \cos \tau$$

La caméra auxiliaire 35 mm

Cette caméra a pour objet de fournir les imagettes 18 × 24 mm servant à repérer au sol l'impact du tir laser Le système APR-Laser est actuellement équipé d'une caméra Carle de caractéristiques suivantes :

Objectifs disponibles : 28 - 50 - 90 mm de focale

Gamme d'ouverture : de 1/2,8 à 1/32 variable selon les objectifs

Obturateur à vitesse fixe 1/100 seconde

Cadence maximale : 3 images par seconde

Alimentation par chargeur équipé de film 35 mm perforé, de 30 m, soit 1 500 vues

Cependant, la caméra Carle et son intervallomètre sont des appareils anciens dont la fabrication est arrêtée depuis longtemps Pour les remplacer, l'IGN a fait l'acquisition d'une caméra Eclair-Camematic avec boîtier de commande séparé. Ce boîtier permet le réglage de l'intervalle de temps entre clichés ; il fournit au calculateur les tops de déclenchement des clichés. Les caractéristiques de cette nouvelle caméra sont les suivantes :

Objectifs disponibles : de 18,5 à 85 mm de focale

Gamme d'ouverture : de 1/2 à 1/22, variable selon les objectifs

Obturateur : vitesse suivant réglage de l'angle d'ouverture du secteur de l'obturateur préalablement à la mission, entre 1/75 et 1/1000

Cadence : vue par vue — 4 images par seconde maximum en rafale — 32 images par seconde maximum

Alimentation par chargeur équipé de film 35 mm perforé de 120 m de longueur, soit 6 000 vues

Conclusion

D'autres systèmes APR-Laser et d'autres méthodes d'utilisation des enregistrements fournis par ces systèmes ont vu le jour dans certains pays. Le lecteur pourra se faire une idée des différentes solutions retenues en consultant la littérature spécialisée, par exemple, parmi les publications récentes, les études mentionnées en bibliographie sous les références [1] et [5].

A l'IGN, le système que nous venons de décrire a montré des performances satisfaisantes et a redonné un nouvel élan aux applications de la technique APR aux levés photogrammétriques à petite échelle.

On peut même envisager, en dehors des utilisations à des fins purement cartographiques, des applications à l'étude et au choix d'itinéraires routiers ou ferroviaires, aux tracés de lignes électriques, etc. La précision intrinsèque des éléments constitutifs du système, supérieure à un mètre pour le télémètre laser et pour le statoscope, devrait permettre de telles applications.

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(d) *Surveys for mapping and charting*

TRABAJOS GEODESICOS Y CARTOGRAFICOS EN EL ESTRECHO DE GIBRALTAR*

Documento presentado por España

SUMMARY

The study of the feasibility of establishing a fixed link across the Strait of Gibraltar necessitates prior geodynamic investigation of possible relative movements between the Euro-Asian and African tectonic plates

The National Geographical Institute of Spain and the Map Division of the Government of Morocco have begun the

RÉSUMÉ

L'étude de faisabilité concernant la construction d'une voie de communication sur le détroit de Gibraltar implique tout d'abord une étude géodynamique des éventuels mouvements relatifs des plaques tectoniques eurasiatique et africaine

L'Institut géographique national de l'Espagne (IGNE) et la Division de la Carte du Maroc (DCM) ont entrepris les travaux géodésiques nécessaires pour déceler ces mouvements et les quantifier dans le temps

* The original text of this paper appeared as document E/CONF 77/L 2

geodesic work necessary to detect such movements and quantify them over a period of time.

This report details the activities carried out and their present status, and offers provisional conclusions.

Le rapport décrit les travaux effectués à ce jour ainsi que les conclusions provisoires qui ont pu être dégagées.

En la reunión mantenida en Fez (Marruecos) en el año 1979 entre los Monarcas de los Reinos de España y Marruecos, se adoptó, entre otras varias, la decisión de impulsar los estudios y trabajos conducentes al establecimiento de un enlace permanente a través del Estrecho de Gibraltar, proyecto considerado como factible y ambicionado por numerosos ingenieros desde finales del pasado siglo.

Consecuencia de tal decisión fue la constitución de un Comité Mixto Hispano-Marroquí encargado del seguimiento del proyecto y la formación de dos sociedades estatales, una española, denominada Sociedad Española de Estudios para la Comunicación Fija a través del Estrecho de Gibraltar (SECEG) y otra marroquí, la Societé Nationale d'Etudes d'Etroit (SNED), con la misión de planificar, coordinar y financiar parcialmente los trabajos a efectuar por diversos organismos nacionales o extranjeros en las diferentes fases del proyecto.

Por lo que se refiere a las operaciones geodésicas indispensables para el estudio de posibles desplazamientos relativos entre las márgenes del Estrecho y formación de la cartografía necesaria para la ejecución de todos los trabajos, en el año 1981, la SECEG estableció el adecuado contacto con el Instituto Geográfico Nacional de España (IGNE), organismo de la Administración Central responsable de todas las operaciones geodésicas en España, firmándose entre ambas partes un Concierto de Colaboración, mediante el que el IGNE, con el apoyo económico y de gestión de SECEG, asumía toda la responsabilidad en la ejecución de los trabajos geodésicos en el Estrecho de Gibraltar. De forma análoga, SNED encargó a la Division de la Carte de Marruecos (DCM) las operaciones a efectuar en territorio marroquí.

En el año citado, ambos organismos geodésicos, el IGNE y la DCM, mantuvieron las reuniones necesarias para establecer un plan de trabajos geodésico/cartográficos, acordando una estrecha colaboración e intercambio de material científico y personal técnico.

De esta forma, a finales de 1981, quedó redactado un anteproyecto de Plan Geodésico General que abarcaba dos conceptos perfectamente diferenciados:

a) Establecimiento de una red geodésica de muy alta precisión, constituida por vértices ubicados en ambas orillas del Estrecho y cuya finalidad es el control geodinámico de la zona, es decir, la detección y cuantificación de posibles desplazamientos relativos entre las placas tectónicas euroasiática y africana que contactan en dicha zona. Esta red geodésica queda designada como RGOG (Red Geodésica para Observaciones Geodinámicas);

b) Trabajos geodésicos necesarios para la unificación de las redes geodésicas española y marroquí con finalidad cartográfica, es decir, para la constitución de un soporte adecuado a los levantamientos cartográficos en cualquier escala imprescindibles para el proyecto.

El estudio de medios requeridos para el cumplimiento del Plan Geodésico y de las disponibilidades técnicas del IGNE y la DCM puso de manifiesto la superior preparación del organismo español para abordar tal clase de trabajo, pese a encontrarse inmerso en la gigantesca tarea de la reconstrucción de la red geodésica de España. En consecuencia, se acordó la constitución de equipos mixtos que sirviesen para completar la formación técnica del personal marroquí y la cesión temporal, durante cada campaña, del material de observación —geodímetros, prismas reflectores, frecuencímetro, equipos meteorológicos— y de transmisiones necesarios. El IGNE solicitó de la SECEG aquel instrumental que, aun encontrándose en dotación propia, no podía destinar permanentemente a los trabajos de la RGOG por requerir su presencia en otras zonas. La SECEG suministró inmediatamente el material solicitado —un geodímetro, prismas, equipos meteorológicos, postes telescópicos para registro de datos a 10 m, barracas de observación, radioteléfonos, teodolito T'2000 y distanciómetro DI-20, etc.—que ha quedado adscrito a los trabajos del Estrecho, con lo que se han cubierto totalmente las necesidades españolas. Gran parte de este material es utilizado también en los vértices marroquíes por no haber sido dotada la DCM en forma análoga.

Red Geodésica para Control Geodinámico (RGOG)

La particular configuración del Estrecho de Gibraltar no permite el establecimiento de una red óptimamente conformada, como quedó demostrado en los análisis previos efectuados en gabinete, donde se escogieron las zonas en que debían ubicarse los vértices que, teóricamente, constituyesen la red mejor conformada posible. Una vez finalizado el estudio geológico del territorio español próximo al Estrecho, trabajo efectuado por el Dr. Esteras (SECEG), el IGNE y la DCM procedieron al reconocimiento en el terreno encaminado a la elección de los emplazamientos exactos de los vértices constitutivos de la RGOG, los cuales, además de configurar una red que simultáneamente pudiese ser trilaterada con geodímetro láser y triangulada, deberían cumplimentar una serie de requisitos, entre los que destacan:

a) Ubicación en terrenos geológicamente estables;

b) Proximidad a la costa a fin de reducir la longitud de los lados a valores mensurables con RANGE MASTER III;

c) Señalización permanente y especialmente diseñada para asegurar la inmovilidad de los vértices y la eliminación de los errores de centrado en los instrumentos de observación;

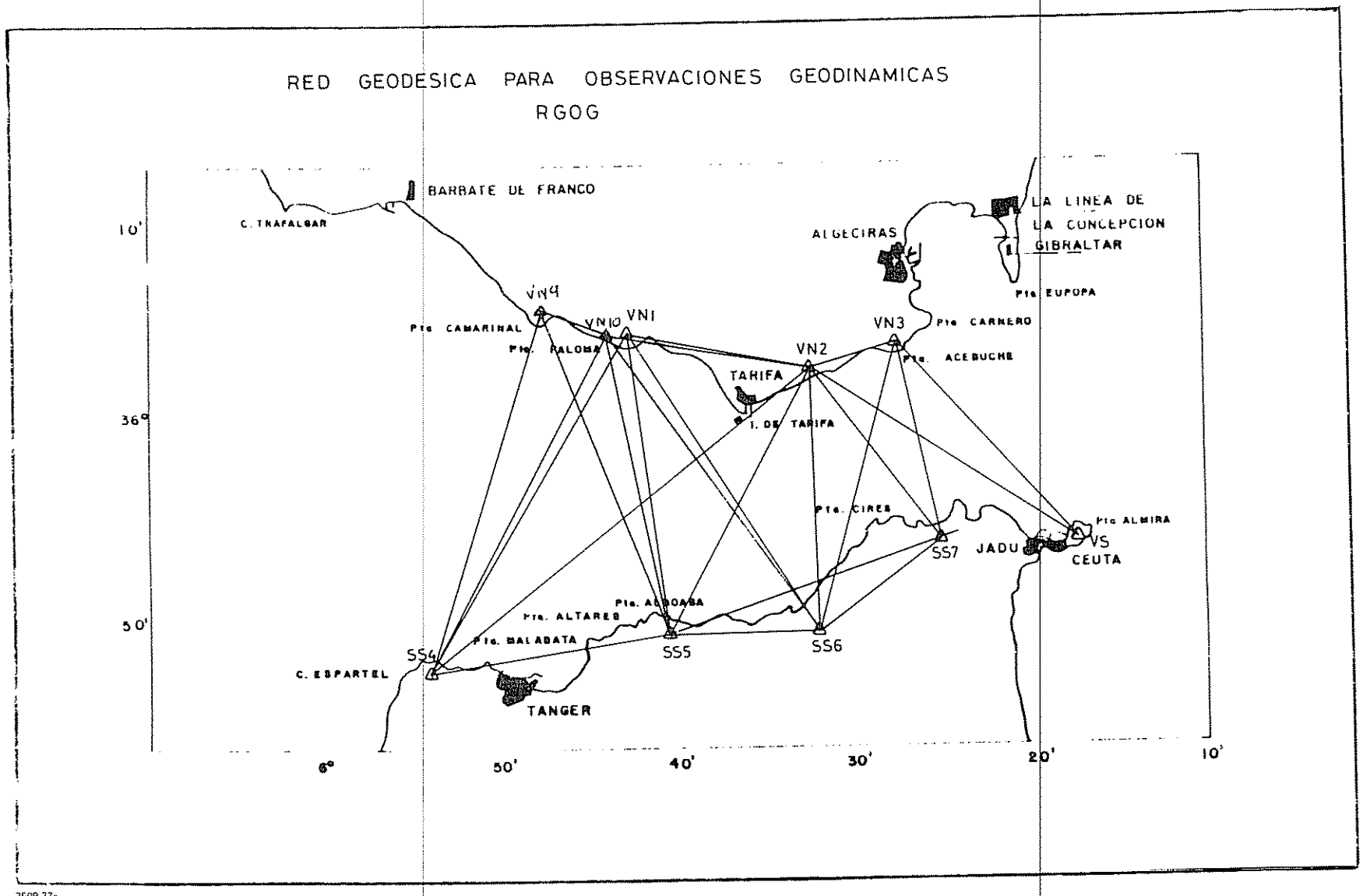
d) Posibilidad de efectuar la nivelación geométrica de alta precisión en todos los vértices;

e) Altitudes muy semejantes y tales que las visuales no resulten rasantes sobre el mar.

El reconocimiento demostró que muy pocas zonas cumplían todos los condicionantes exigidos, por lo que, en principio, la figura de la RGOG quedó constituida por las señales VN1, VN2 y VN3 en la costa norte y SS4, SS5, SS6 y SS7 en la sur (véase figura 52). Además, el IGNE estableció otra señal auxiliar, VS, en la ciudad de Ceuta (España), que, desafortunadamente, no puede enlazar con el vértice SS7 a causa del macizo de Yebel Musa, que, por su gran elevación, impide la intervisibilidad.

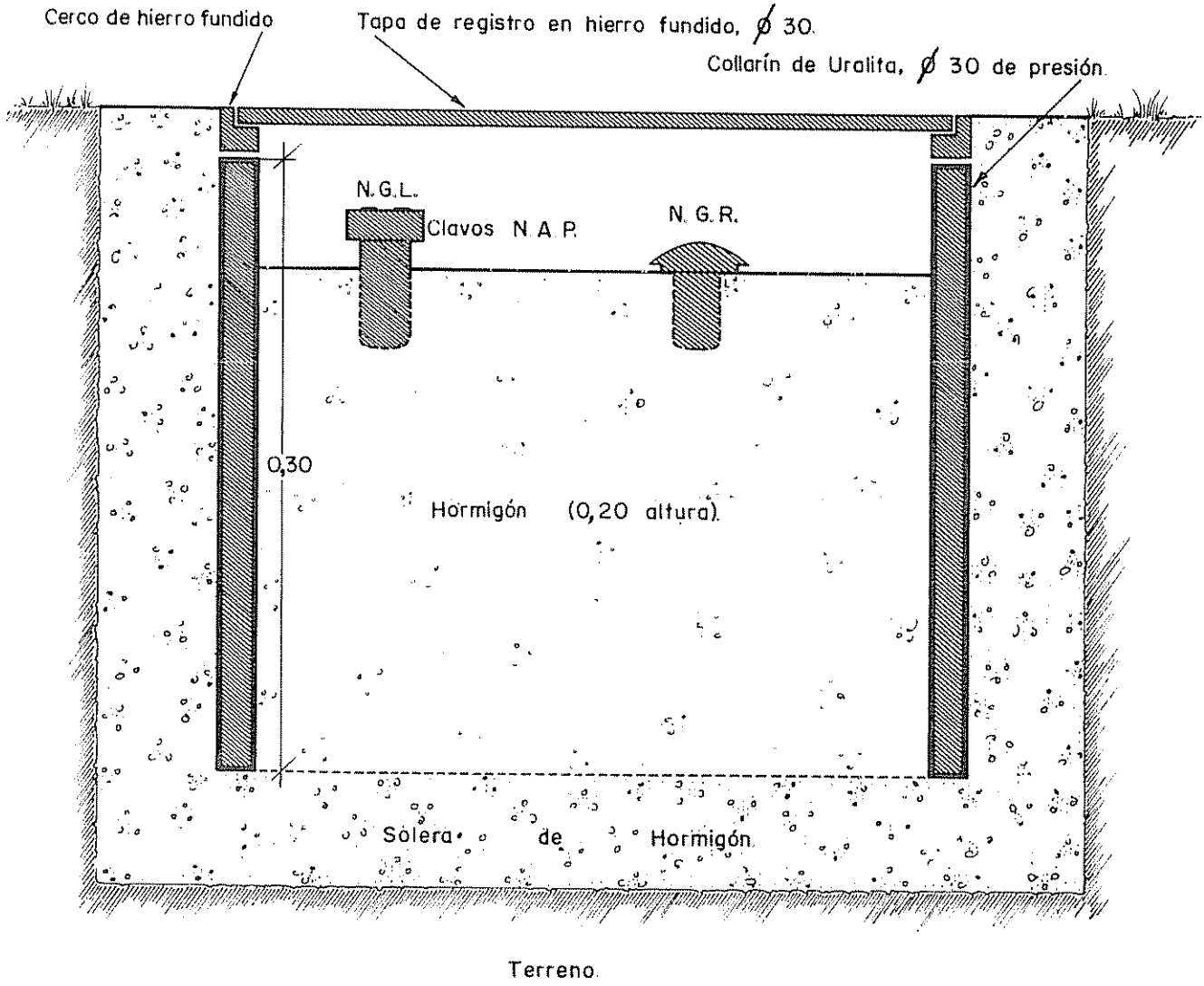
En la primavera y verano de 1982, el IGNE llevó a cabo la construcción de las señales geodésicas en territorio español (VN1, VN2, VN3 y VS) que responden a las especificaciones reflejadas en la figura 53, donde puede apreciarse el sistema adoptado para el centrado forzoso de las bases nivelantes de los instrumentos de observación.

Figura 52. España: Red geodésica del Estrecho de Gibraltar



3509 37s

Figura 53. España: Estación principal NAP: modelo de señal



Además, en las inmediaciones de cada vértice se establecieron otras señales auxiliares, visibles entre sí y con el vértice, que constituyen una red local para control de la inmovilidad de los pilares de observación. Simultáneamente el IGNE procedió a la actualización de la línea de nivelación NAP que, desde el mareógrafo fundamental de Alicante —definidor del nivel medio del mar origen de las altitudes de la España peninsular—, enlaza por la costa los mareógrafos de Almería y Cádiz. Con el fin de asegurar la permanencia de la señalización y facilitar las periódicas nivelaciones necesarias, en la zona comprendida entre Algeciras y Cádiz se construyeron seis referencias principales (véase figura 54), perfectamente estables y protegidas, que dividen la línea en tramos de unos 15 km de longitud. Asimismo se señalizaron los ramales que, partiendo de la línea NAP, conducen hasta los vértices RGOG. De igual forma se procedió en la ciudad de Ceuta, donde quedó señalizada una línea que atraviesa la ciudad desde la frontera sur de El Tarajal a la frontera oeste de Benzú, con un ramal que conduce al vértice VS y una referencia principal intermedia. En las fronteras, la línea española se solapó con la NAP de Marruecos.

De forma simultánea con estos trabajos de campo, el IGNE procedió a la redacción de unas exhaustivas instrucciones para todo tipo de observaciones —angulares, EDM, nivelación, etc.— que fueron facilitadas a la SECEG para su envío a la DCM y que pueden resumirse en:

a) Observación de direcciones: Empleo de Teodolito Wild T3 —sexagesimales los de IGNE y centésimales los de DCM— método de pares sobre referencia externa, observando cada dirección con 24 series (una serie compuesta de medida en CD y CI y cuatro punterías para cada una de las posiciones). El error medio de la media de una dirección no debe exceder de 0″3.

b) Medición de distancias: Empleo de geodímetros RANGE MASTER III con su equipo de prismas, cuyo número es función de la distancia a medir. En ambos extremos del lado medido se efectúan registros de datos meteorológicos consistentes en:

i) Temperatura seca y húmeda al nivel del instrumento (aspiropsicrómetro Lambrecht, 0°1 C de apreciación);

ii) Presión atmosférica al nivel del instrumento (microbarógrafo Belfort, 0,1 mm Hg de apreciación);

iii) Temperatura seca a 10 m de altura sobre el suelo (termómetro de platino sobre poste telescópico con lectura digital de 0°1 C de apreciación).

Cada lado se mide en ambas direcciones y cada dirección con 12 series (20 lecturas cada serie) repartidas en tres sesiones diferentes.

Para control de la frecuencia del geodímetro se utiliza un frecuencímetro TAKEDA.

c) Medida de distancias cenitales, llevadas a cabo de forma recíproca y simultánea con Teodolito Wild T3 al comienzo y final de cada serie de medidas de lado.

d) Nivelación de alta precisión de cada vértice con empleo de niveles de alta precisión Wild NA2 con micrómetro y ocular de 40 aumentos y miras invar Wild GPLE 3.

e) Determinaciones gravimétricas en todos los clavos de las líneas de nivelación y sus ramales con empleo de un gravímetro Lacoste y Romberg.

f) Observación de una red gravimétrica con densidad aproximada de una estación/km^2 en la zona comprendida entre los meridianos 5°19′W y 6°W y entre el paralelo 36°15′N y la costa.

g) Determinación de la desviación relativa de la vertical en todos y cada uno de los vértices de RGOG mediante observaciones astronómicas de latitud (método de Sterneck) y longitud (pasos meridianos y fórmula de Mayer) con empleo de un teodolito astrogeodésico DKM 3A —provisto de micrómetro semiimpersonal tipo Repsold— y reloj de cuarzo con cronógrafo binario incorporado CHRONOCORD. En el vértice VN2, además, se ha efectuado una determinación muy precisa de acimut astronómico por el método de 36 series sobre la Polar.

Al comienzo y final de cada campaña se lleva a cabo la calibración y contrastación de todo el instrumental, tanto meteorológico como de observación. Los geodímetros RANGE MASTER III se contrastan, en unión de las cajas de prismas, en la Base Interferométrica Väisälä de Valladolid (España). La calibración de sus frecuencias, así como la del frecuencímetro TAKEDA, se efectúa en los laboratorios del Observatorio de la Marina de San Fernando (Cádiz), muy próximo a los vértices de la costa norte. En la base de Valladolid se determinan cuidadosamente las constantes de los geodímetros y de los equipos de prismas.

Para las comunicaciones entre vértices se hace uso de radioteléfonos de 1 ó 2 w de potencia, con alcance superior a los 60 km, utilizando las frecuencias reservadas para el IGNE.

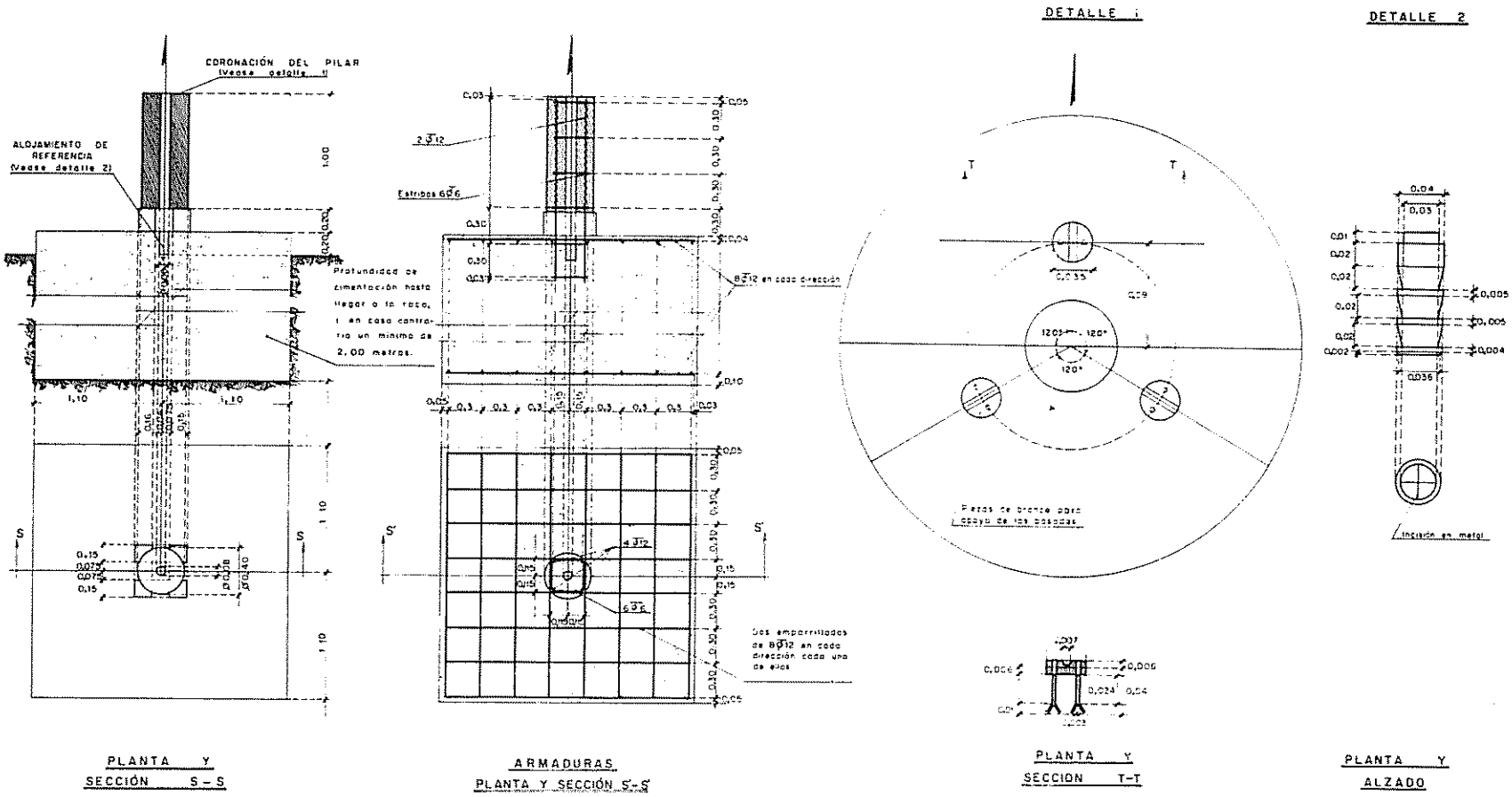
Las observaciones angulares se llevan a cabo sobre proyectores provistos de reóstatos que permiten regular en cada momento la intensidad de la luz para que durante la observación sea exactamente puntual.

Por otra parte, la Sección de Cálculos Geodésicos del Servicio de Geodesia del IGNE comenzó la selección de los programas más adecuados para el análisis y tratamiento de datos, cálculos, compensaciones y análisis de resultados, retocando el *software* ya existente e implementando programas absolutamente nuevos apropiados a la figura RGOG.

En el último trimestre de dicho año, el IGNE inició sus observaciones, solamente en territorio español, por no encontrarse operativos los vértices marroquíes. Se comenzó por la calibración del geodímetro RANGE MASTER III y el frecuencímetro TAKEDA en los laboratorios del Observatorio de la Marina de San Fernando para, posteriormente, efectuar la contrastación de geodímetro y equipos de prismas en la Base Interferométrica de Valladolid, operación a la que asistieron tres técnicos marroquíes a fin de familiarizarse con el instrumental. Finalizadas estas operaciones se ocuparon los vértices VN1 y VN2, llevando a cabo la medición de la distancia entre ellos, así como de las direcciones correspondientes. Se estacionó un receptor JMR 1-A en un pilar auxiliar de VN2 y se procedió a la cuidadosa medición de las redes locales de cada vértice. Por otra parte, se observó una red de enlace de los vértices VN1 y VN2 con dos vértices —VEJER y LUNA— de la Red de Primer Orden de España a fin de dotar de coordenadas ED 50 y ED 79 a toda la RGOG. Se nivelaron las líneas señalizadas y se efectuaron las observaciones gravimétricas correspondientes. Todos estos trabajos han quedado reflejados en la Memoria correspondiente.

Ya en esta campaña fue posible constatar la dificultad que para el buen desarrollo de las operaciones geodésicas suponen las desfavorables condiciones climatológicas de la zona del Estrecho de Gibraltar, donde la nubosidad baja es muy abundante y reinan casi constantemente fuertes vientos, alcanzando los de levante velocidades superiores a los 60 nudos, lo que ha provocado la destrucción de algunas tiendas de observación, y que hacen imposible toda clase de mediciones durante numerosos días al año. Por ello, las ob-

Figura 54. España: Red geodésica del Estrecho, para observaciones geodinámicas



NOTAS

- Coeficiente de minoración del acero: 1,20
- Coeficiente de minoración del hormigón: 1,70
- Coeficiente de ponderación de las acciones 1,70
- Nivel de control de calidad de los materiales y de ejecución: NORMAL.
- Resistencia característica del hormigón 125 Kp/cm^2
- Acero ordinario de 2200 Kp/cm^2 de límite elástico

servaciones tienen que efectuarse en los períodos comprendidos entre finales de abril y mediados de junio y entre mediados de septiembre y mediados de diciembre —durante los meses de verano, las calinas existentes en la zona hacen inútil todo intento de observación—, prolongándose la campaña de forma poco conveniente para el estudio de resultados y excesivamente incómoda para los operadores.

En el año 1983, dispuestos los vértices marroquíes para la observación, se estableció como objetivo fundamental la observación completa del cuadrilátero VN1, VN2, SS4 y SS5. La operación debía servir para el acoplamiento de los equipos de observación, formación técnica de los operadores marroquíes en las mediciones EDM y obtención de los datos necesarios para comprobación de los programas de nueva implementación.

Por parte del IGNE la operación comenzó a principios del mes de abril con la calibración y contrastación exhaustiva de todo el instrumental, tanto del utilizado en la anterior campaña como del recientemente facilitado por la SECEG. Finalizada esta fase, el día 23 de abril se efectuó la cesión a la DCM de todo el material EDM y de transmisiones requerido por la operación. La campaña se prolongó hasta el día 12 de julio, en que el fuerte calor reinante obligó a suspender las observaciones. Durante casi toda ella, operadores españoles estuvieron en los vértices marroquíes a fin de entrenar a sus colegas africanos, siendo digno de mencionar el excelente espíritu de camaradería y colaboración que presidió constantemente las relaciones entre los técnicos de ambas naciones. En esta fase de la campaña se cubrió el objetivo perseguido, es decir, quedó totalmente observado el cuadrilátero mencionado y, además, se observaron parcialmente los vértices VN3 y SS6.

En el mes de noviembre, el IGNE reanudó la campaña, pese a que por dificultades internas la DCM no pudo incorporarse a los trabajos de campo. Durante el corto período comprendido entre primeros de noviembre y el 18 de diciembre, en que el temporal obligó a suspender los trabajos, el IGNE llevó a cabo la observación completa del triángulo VN2, VN3 y VS, así como las determinaciones astronómicas de latitud y longitud en estos vértices y la observación angular de las direcciones VN1-VS y recíproca.

Es de destacar que, durante el año 1983, el IGNE llevó a cabo una serie de estaciones Doppler en territorio español, simultánea con las efectuadas en Marruecos para el proyecto ADOS. De esta forma se observaron con receptores JMR 1-A los vértices españoles ALTOS DE GALAPAGAR, BAÑOS, VILLAFRANCA, UMBRIA y VN2. Dado que la DCM remitió al IGNE las cassettes de sus estaciones RABAT, TANGER, GUERCIF, AGADIR, SKOURA y TENDRARA para su transformación a código EBCDIC sobre cinta magnética de 800 bpi y posterior devolución, el IGNE, con permiso de la DCM y con las Efemérides Precisas facilitadas por la Defense Mapping Agency, procedió al cálculo de todas las estaciones españolas y marroquíes —con excepción de AGADIR, SKOURA y TENDRARA, por no disponer de sus datos meteorológicos— por el método de Punto Aislado (PP), tanto con Efemérides Transmitidas (BE) como con Efemérides Precisas (PE). Actualmente se sigue investigando sobre el conjunto de estaciones, aplicando los metodos de traslocación (JMR) y arco semicorto (Pâquet)

También a lo largo del año se llevó a cabo el enlace de las nivelaciones española y marroquí en las fronteras de El Tarajal y Benzú y, por la Sección de Nivelaciones del Servicio de Geodesia del IGNE mediante el programa CAL-GEOP, se procedió al cálculo y compensación de las líneas NAP del Estrecho, obteniéndose las altitudes ortométrica, dinámica, GPU compensada y normal de todos los clavos de las mismas.

El IGNE colaboró en la campaña de gravimetría marina, llevada a cabo por el Instituto de Geofísica de la Universidad de Hamburgo (IGUH) a bordo del buque hidrográfico "Tofiño" de la Armada Española. Tanto la puesta a cero como el cálculo de la deriva instrumental del gravímetro marino Askania KSS30 del IGUH se realizaron en las estaciones terrestres del IGNE con dos gravímetros terrestres Lacoste Romberg del IGNE. Personal técnico español de la Sección de Gravimetría del Servicio de Geodesia del IGNE estuvo presente en el desarrollo de todas las operaciones terrestres y marítimas.

Por lo que a gravimetría terrestre se refiere, el IGNE continuó su labor de densificación de la red gravimétrica en la zona del Estrecho, ya iniciada en la anterior campaña, con la previa calibración del gravímetro en la línea de calibración entre las estaciones de Madrid-C y Bailén-B. A partir de las bases fundamentales de la Red IGSN71, Algeciras-B y Sevilla-B, se establecieron dos bases auxiliares en las proximidades de la zona de la RGOG. A finales de año, con el programa REGRAV, se llevó a cabo la reducción de las observaciones y se comenzó la elaboración de mapas a escala 1:50.000 de isoanómalas Aire Libre e isoanómalas Bouguer para una densidad 2,67 gr/cm^3.

A lo largo del año 1983, la Sección de Cálculos Geodésicos del IGNE continuó su investigación conducente a establecer el *software* más adecuado para el tratamiento de los observables de RGOG. En el período comprendido entre el 14 y 24 de diciembre, un técnico marroquí se incorporó a la citada sección, llevándose a cabo un análisis conjunto de datos y resultados del que se dedujeron interesantes consecuencias, algunas de las cuales se tratan más adelante.

Conviene decir en este momento que con el fin de ampliar la RGOG hacia Punta Camarinal, por entenderse que esta zona oeste debe quedar considerada, el IGNE llevó a cabo un nuevo reconocimiento que permitió incluir en la RGOG el vértice VN9, para lo cual ha sido necesario construir otro nuevo VN10, próximo a VN1 y destinado a sustituir a este último, que carece de visibilidad hacia occidente. En consecuencia, la actual RGOG queda constituida por los vértices VN9, VN10, VN2, VN3, SS4, SS5, SS6 y SS7 y el auxiliar VS (véase figura 52).

Entre las conclusiones deducidas del análisis anteriormente citado destaca la comprobación de que, una vez que todos los operadores han alcanzado el necesario grado de experiencia, es factible obtener observaciones angulares tales que la precisión (error medio) que afecta a la media de una dirección observada es del orden de 0″3 y que la correspondiente a una distancia medida y corregida es de 0,5 ppm. Bajo estas hipótesis, se ha procedido a una simulación de RGOG sobre unas coordenadas muy aproximadas de sus vértices, considerando diversos casos en cuanto al número de distancias y direcciones que es conveniente establecer. Como resultado de dicha simulación efectuada por el IGNE, se ha llegado a la conclusión de que la alternativa más favorable para la actual RGOG es medir 47 distancias —ninguna superior a 43 km— y 37 direcciones, obteniéndose así que la mayor elipse de error —correspondiente al vértice auxiliar VS—, dentro de un nivel de confianza del 95%, no llega a 0,02 m. En consecuencia, éste parece ser el límite de precisión a esperar en los resultados de la RGOG, lo que dadas sus dimensiones, configuración y desfavorable ambiente meteorológico, es más que satisfactorio.

Otra interesante deducción fue la de lo poco acertado que resulta el método de observación angular elegido, a causa de la gran diferencia atmosférica entre las referencias (situadas en la misma orilla que el vértice estacionado) y las visuales marítimas. Por otra parte, el método es lento y, como ya se ha dicho, los momentos buenos de observación escasos. Por tanto, de mutuo acuerdo, se ha decidido sustituir el método de series sobre referencia externa por el de Schreiber con observación simultánea desde varias estaciones.

Los primeros análisis y cálculos pusieron de manifiesto la excelente calidad de las observaciones angulares en los vértices VN1 y VN2, aceptable en SS4 y deficiente en SS5 y SS6, circunstancia que debe atribuirse a los defectos presentados por el teodolito empleado en estos últimos vértices y, quizá, a la poca experiencia de los observadores marroquíes, por lo que esta campaña se considera muy provechosa desde el punto de vista de formación del personal. Por el contrario, todas las medidas EDM pueden clasificarse como de buena calidad, encontrándose en promedio por debajo de 0,5 ppm la desviación típica interna de la medida.

La comparación entre las dos medidas de un mismo lado efectuadas invirtiendo la situación de geodímetro y prismas acusa una pequeña discrepancia entre ambas, más relevante cuando la medición ha tenido lugar sobre el mar, y cuya causa probable puede encontrarse en el mal comportamiento del modelo matemático atmosférico establecido, basado en la medición de presión y temperatura seca y húmeda al nivel del instrumento y a 10 m de altura en las dos estaciones. No existiendo posibilidad de introducir datos atmosféricos diferentes de los citados (en zonas intermedias de la trayectoria), se acordó adoptar las precauciones de medir todas las distancias en ambos sentidos y tratar cada sentido como una distancia independiente.

El IGNE llevó a cabo varias compensaciones libres de la red utilizando sus programas COREFER y COMPLI. En ambos, todas las direcciones son corregidas por reducción a la línea geodésica y altitud del punto visado. Dada la semejanza en altitud de todos los vértices de la RGOG y que las dimensiones de los lados son elevadas, la corrección por efecto de la desviación de la vertical en cada estación no alcanza 0″001, por lo que, de momento, no se ha tenido en cuenta para las medidas acimutales.

Tema todavía en discusión y sin decidir hasta disponer de todos los observables de la RGOG es el criterio de ponderación más adecuado. Para un conocimiento exhaustivo de los valores provisionalmente adoptados y de las compensaciones efectuadas y resultados obtenidos se remite al lector a la Memoria del año 1983.

En la citada reunión quedó acordado que, de momento, la cadena de cálculo reglamentaria para el tratamiento de la RGOG —que se efectuará en el Sistema Informático del IGN (FACOM M18 ON/OSIV-F4) adoptado como Centro de Cálculo Oficial— quedará compuesta por los siguientes programas:

GRAF (DC): Análisis gráfico preliminar de la distribución estadística de las observaciones de cada dirección.

ESTADI (IGN): Análisis de normalidad de la distribución de las observaciones de cada dirección y aplicación del Test de Pope para rechazo de las series erróneas. Obtención de la desviación típica de cada dirección.

CORDIS (IGN): Tratamiento de las distancias medidas electroópticamente. Aplicación de todas las correcciones sistemáticas. Análisis estadístico de las medidas redundantes de cada lado con obtención de su desviación típica.

Paralelamente, se modificará el programa DIST (DC) para cumplir las mismas funciones de CORDIS y, dentro de una precisión homogénea, permitir una comprobación redundante.

COREFER (IGN): Compensación libre bidimensional de la red geodésica, con análisis estadístico de los resultados. Utiliza métodos directos para la resolución. La comprobación redundante se llevará a cabo con el programa COMPLI (IGN) que proporciona los mismos resultados por métodos iterativos.

BIGEO (IGN): Compensación libre bidimensional con altitudes controladas.

TRIGEO (IGN): Compensación libre tridimensional con observables de direcciones, acimutes, distancias geométricas, distancias cenitales.

DISELI (IGN): Calcula y traza los elipses de error de vértices y observaciones.

Un tema que reviste gran interés es el relativo a la unificación de las altitudes de los vértices de ambos lados del Estrecho respecto a un único plano de comparación. Por el momento, cada costa está referida a un nivel medio del mar determinado por distintos mareógrafos, por lo que la unificación debe tener lugar a través de las muy numerosas medidas de distancias cenitales recíprocas y exactamente simultáneas realizadas, una vez se conozca el valor de la desviación de la vertical en cada vértice. En una primera prueba efectuada entre los vértices VN1 y VN2 —donde la desviación de la vertical ha de ser muy similar—, la discrepancia encontrada entre las diferencias de altitudes geométricas y trigonométricas fue de 0,021 m, si bien es conveniente tener presente que la distancia entre ambos es solamente de 14 km. De cualquier forma, este problema queda obviado si el tratamiento de los datos se efectúa mediante el programa TRIGEO, es decir, con una compensación tridimensional en la que intervienen los valores observados de direcciones, distancias geométricas y distancias cenitales corregidas por desviación de la vertical.

La campaña de 1984, cuya meta es la observación completa de la figura RGOG, así como la determinación de la desviación relativa de la vertical en todos los vértices —labor esta última asumida por el IGNE tanto para sus estaciones como para las marroquíes— , dio comienzo— con retraso imputable a condicionamientos burocráticos— el día 7 de mayo, quedando finalizada la primera fase el 15 de junio. La segunda fase comenzó por parte española el 17 de septiembre, con las observaciones astronómicas en los vértices VN9 y VN10, y, en el momento de redactar esta comunicación, se encuentra en pleno desarrollo.

Una vez finalizada y cuando se haya procedido a la preparación de los observables, se ha previsto una reunión en el Centro de Cálculo Oficial (Madrid) de los equipos de cálculo de ambos países para llevar a cabo conjuntamente la obtención de resultados que, según las previsiones, se confía queden ultimados a mediados de 1984, haciéndose públicos a continuación.

En el año 1985 deberá adoptarse la decisión sobre la periodicidad con que han de repetirse las observaciones. Si la limitación en la precisión a obtener se establece actualmente en el orden de 2 cm, aunque se desconoce la magnitud de los desplazamientos —si es que existen— , no parece lógico esperar que supere anualmente el citado valor, por lo que, en principio, parece aceptable dejar transcurrir un plazo de dos o tres años antes de efectuar otra campaña.

Levantamientos cartográficos en el Estrecho

Con el fin de establecer la cartografía más adecuada para todos los trabajos a realizar en la zona del Estrecho de Gibraltar, el IGNE procedió, en abril de 1984, a efectuar un detenido estudio sobre los diversos aspectos que comporta el problema cartográfico.

Como consecuencia del mismo, el IGNE redactó un documento, inmediatamente remitido a la DCM (a través del cauce normal de SECEG–SNED), cuyas principales conclusiones pueden resumirse en las siguientes propuestas:

1. Adopción, como sistema de referencia, del Sistema Geodésico 1980, tal como quedó definido en la XVIII Asamblea de la IUGG (Canberra, 1979).
2. Elección del vértice VN2 —en la costa española y centrado en la zona— como punto fundamental, cuyas coordenadas, obtenidas a través de una estación Doppler efectuada en 1982 y calculada con Efemérides Precisas (PE) por el método de Punto Aislado (PP), han sido corregidas mediante los parámetros más adecuados (Dr. Rutscheidt, "A review of some aspects of Doppler", *CSTG Bulletin*, No. 4) para acoplarlas al GRS 80. Observación del acimut astronómico VN1–VN2 e introducción del acimut Laplace correspondiente para orientación de la figura.
3. Elección de la proyección cónica conforme pseudosecante de Lambert para representación de la zona comprendida entre los meridianos 5°15'W y 6°W y los paralelos 35°42'N y 36°12'N, la cual abarca toda la zona terrestre y marítima objeto de estudio.

En principio, se considera indispensable disponer de cartografía a escala media, 1:25 000, de toda la zona, en la cual se refleje también la batimetría recientemente obtenida por el Instituto Hidrográfico de la Armada de España y el Instituto Español de Oceanografía. Posteriormente, a medida que los trabajos lo requieran, se podrán efectuar levantamientos parciales a escalas superiores hasta llegar a los planos de obras.

Por ello, la red geodésica en que tales levantamientos se apoyan ha de poseer una gran precisión relativa, a cuyo fin el IGNE ha procedido a enlazar a la RGOG con la red de orden inferior de la Provincia de Cádiz, que ha sido reobservada en la zona a considerar con teodolito T2000 provisto de distanciómetro DISTOMAT DI–20, previamente contrastado.

La cartografía de las zonas exteriores a la considerada no quedará unificada, ya que España tiene publicado su Mapa Topográfico Nacional a escala 1:50 000 apoyado en el Sistema ED 50, en tanto Marruecos dispone de cartografía en otro sistema geodésico diferente.

No obstante, pensando en una futura reunificación de las redes de ambos países en un mismo sistema geodésico, el IGNE ha procedido a la determinación de los siete parámetros óptimos de transformación de coordenadas satelitares calculadas con Efemérides Precisas al actual sistema ED 79 (Bloque Ibérico III), los cuales, aplicados a las estaciones marroquíes efectuadas durante la campaña ADOS, permiten, si Marruecos lo desea, unificar su red geodésica con la europea. Evidentemente, no es pensable en estos momentos la puesta en práctica de esta solución, que implicaría la total modificación de las cartas nacionales de ambos países, tarea que, por su excepcional costo, no resulta abordable.

REPORT OF THE MEETING OF THE *AD HOC* GROUP OF EXPERTS ON CADASTRAL SURVEYING AND LAND INFORMATION SYSTEMS*

Paper submitted by the United Nations Secretariat

RÉSUMÉ

Ce rapport constitue une mise à jour du rapport du Groupe spécial d'experts sur les levés et plans cadastraux, établi en 1972 (Rapport de 1972), compte tenu des progrès techniques, notamment dans le domaine des systèmes d'information sur les sols. Il contient des définitions des termes sol, occupation des sols, parcelle, information foncière, système d'information sur les sols, cadastre et publicité foncière et établit que le cadastre est un type d'information foncière.

L'importance du cadastre dans l'administration foncière et son intérêt pour les pays de régimes fonciers communautaires et traditionnels sont soulignés. Les systèmes d'information foncière sont classés selon qu'ils sont axés sur les fonctions — c'est-à-dire qu'ils appuient les objectifs d'un organisme donné — ou sur le service — c'est-à-dire

RESUMEN

El presente informe examina y actualiza el informe sobre la reunión del Grupo Especial de Expertos en Levantamientos y Cartografía Catastrales, celebrada en 1972 ("Informe de 1972"), a la luz de los adelantos tecnológicos, especialmente en la esfera de los sistemas de información sobre las tierras. En él se definen los términos tierras, utilización de las tierras, parcela de tierra, información sobre las tierras, sistemas de información sobre las tierras, catastro e inscripción de tierras, y se muestra que el catastro es un tipo de sistema de información sobre las tierras.

Se subraya la importancia del catastro como instrumento de administración de las tierras, y se destaca su interés para los países en los que la propiedad de las tierras se ajusta a pautas comunales y consuetudinarias. Los sistemas de información sobre las tierras se clasifican en sistemas orientados según las funciones, que respaldan los objetivos de organizaciones individuales, y sistemas orientados según la provisión, que sirven a las necesidades de otros. Un sistema

* The original text of this paper appeared as document E/CONF 77/L 1

qu'ils répondent aux besoins d'autres organisations. Outre qu'il permet d'identifier les problèmes, de formuler une politique et de prendre des décisions, un système d'information foncière facilite la gestion des projets.

Le rapport propose des directives pour l'introduction de systèmes d'information foncière et indique les domaines où il peut être nécessaire de revoir les lois, notamment le régime foncier, les lois foncières et la réglementation des levés, la publicité foncière et la planification physique. On y souligne qu'il importe que le public ait confiance dans le système

Les systèmes cadastraux et autres systèmes d'information foncière devraient être établis sur la base d'un réseau homogène de points géodésiques. On trouve dans le rapport un aperçu des progrès dans le domaine des levés et de la cartographie et on y mentionne des techniques telles que la détermination des positions par inertie et à l'aide de satellites, les progrès dans l'utilisation des restituteurs analytiques et en télédétection, mais les conclusions restent celles du rapport de 1972. L'importance de la rapidité, de l'économie et de l'efficacité est soulignée.

Avec le progrès des techniques informatiques, l'ordinateur permet d'éliminer beaucoup d'opérations manuelles et, malgré les dépenses d'investissement élevées, peut entraîner des réductions sensibles des coûts. L'élément le plus onéreux et nécessitant le plus de temps dans un système d'information foncière est la collecte et la transformation des données. On constate une tendance à la décentralisation et à la déconcentration, avec petits systèmes spécialisés reliés entre eux pour former un grand système global. Ces liaisons exigent la formulation de normes pour l'échange de données et un système commun de coordonnées spatiales. Il est essentiel d'assurer une coopération et une coordination effectives entre les organismes

On souligne la nécessité de garanties. Il faut protéger les données contre la destruction, définir les types de données pouvant être introduites dans le système et contrôler qui peut extraire ou introduire des données et qui peut effacer d'anciennes données. Il faut respecter la confidentialité. Il peut être nécessaire d'adopter des lois dans ce domaine.

Les systèmes d'information foncière ont besoin d'administrateurs. Les disciplines qu'un administrateur de l'information foncière doit étudier sont énumérées. On souligne la nécessité de connaissances interdisciplinaires. Quelques publications et sociétés s'intéressant aux cadastres et aux systèmes d'information foncière sont indiquées dans le rapport. Le Groupe spécial d'experts sait qu'étant donné l'immensité de la question il ne peut donner qu'un aperçu de quelques-uns des problèmes. Il est toujours possible d'obtenir des informations supplémentaires auprès du Service de l'infrastructure, Département de la coopération technique pour le développement, Secrétariat de l'Organisation des Nations Unies.

de información sobre las tierras es un instrumento para la identificación de problemas, la elaboración de políticas y la toma de decisiones, así como para ayudar a la gestión de proyectos.

Se sugieren directrices para la introducción de sistemas de información sobre las tierras, y se indican las esferas en que puede ser necesario revisar la legislación. Esas esferas incluyen la posesión de tierras, el derecho sobre tierras y levantamientos, la inscripción de tierras y la planificación física. Se destaca la necesidad de que haya confianza pública en el sistema.

Los sistemas catastrales y otros sistemas de información sobre las tierras deben basarse en una red homogénea de puntos de control. Se indican los progresos recientes en materia de levantamientos y cartografía, y se mencionan técnicas tales como la determinación de posición inercial y mediante satélites, los progresos realizados en la utilización de trazadores analíticos y la teleobservación, pero las conclusiones siguen siendo las mismas que las del "Informe de 1972". Se subraya la necesidad de actuar con velocidad, economía y eficiencia.

El desarrollo de la tecnología en materia de computadoras e información está reemplazando muchas tareas manuales y, pese al alto desembolso de capital que requiere, puede permitir importantes reducciones del costo. La parte más costosa de un sistema de información sobre las tierras computadorizado y la que requiere más tiempo es la reunión y conversión de los datos. Se advierte cierta tendencia a la descentralización y la desconcentración, mediante sistemas menores vinculados entre sí para formar un sistema general más amplio. Para establecer esa vinculación, hay que establecer normas para el intercambio de datos y aplicar un sistema común de referencias espaciales. Es esencial la cooperación y la coordinación efectivas entre los organismos.

Se destaca la necesidad de salvaguardias. Es preciso proteger los datos contra la destrucción y definir los tipos de datos permitidos en el sistema, y tiene que haber controles relativos a quién puede utilizar los datos, quién puede introducir nuevos datos y quién puede eliminar datos anticuados. Hay que respetar la intimidad de las personas. Puede requerirse la promulgación de legislación en relación con esas cuestiones.

Los sistemas de información sobre las tierras requieren gestores. Se enumeran los temas que debe estudiar el gestor de información sobre las tierras. Se destaca la necesidad de conocimientos interdisciplinarios. Se incluye una selección de publicaciones y de asociaciones relacionadas con el catastro y los sistemas de información sobre las tierras. El Grupo Especial de Expertos es consciente de que la amplitud del tema no le permite presentar más que una visión general de algunos de los problemas. Para obtener mayor información y asesoramiento, puede recurrirse a la Dependencia sobre Infraestructura del Departamento de Cooperación Técnica para el Desarrollo de la Secretaría de las Naciones Unidas.

This report reviews and updates the 1972 report of the meeting of the *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping[1] (hereinafter referred to as the "1972 Report"), in the light of technological developments, especially in the field of land information systems. It gives definitions of the terms land, land use, land parcel, land information, land information systems, cadastre and land registration and shows that the cadastre is one type of land information system.

The importance of the cadastre as an instrument of land administration is outlined and its relevance to countries where landownership operates along communal and customary lines is stressed. Land information systems are classified as either function-oriented, supporting the objectives of individual organizations, or provision-oriented, servicing the needs of others. A land information system is a tool for problem identification, policy-making and decision-making and for helping in the management of projects.

Guidelines for the introduction of land information systems are suggested and areas are indicated where legislation may need to be reviewed. These areas include land tenure, land and survey law, land registration and physical planning. The need for public confidence in the system is stressed.

Cadastral and other land information systems should be based on a homogeneous network of control points. An overview of new developments in surveying and mapping is given and such techniques as inertial and satellite-position fixing and developments in the use of analytical plotters and remote sensing are mentioned, but the conclusions remain as in the 1972 Report. The need for speed, economy and efficiency is stressed.

The development of computer and information technology is taking over many manual tasks and, in spite of the high capital outlay, can offer significant reductions in cost. The most expensive and time-consuming part of a computerized land information system is the collection and conversion of data. A trend towards decentralization and deconcentration, with smaller dedicated systems linked together to form a larger overall system, is seen. To provide that linkage, standards for the interchange of data must be established and a common spatial referencing system enforced. Effective co-operation and co-ordination among agencies is essential.

The need for safeguards is stressed. The data must be protected against destruction, the types of data permitted in the system must be defined and there must be controls over who may retrieve data, who may insert new data and who may delete old data. Personal privacy must be respected. Legislation to enforce such matters may be necessary.

Land information systems need managers. Subjects that should be studied by the land information manager are listed. The need for interdisciplinary knowledge is stressed. A selection of publications and of societies involved in the cadastre and land information systems is given. The *Ad Hoc* Group of Experts is aware that the vastness of the subject prevented it from presenting more than just an overview of some of the problems in this report. Further information and advice can always be sought from the Infrastructure Branch, Department of Technical Co-operation for Development of the United Nations Secretariat.

Background

Pursuant to resolution 12 of the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific,[2] the *Ad Hoc* Group of Experts on Cadastral Surveying and Land Information Systems was reconstituted and met in Berlin (West) from 4 to 8 July 1983, with the following terms of reference:

> "To review and update the '1972 Report' of the Meeting of the *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping in the light of the rapidly changing technologies, specially in the field of land information systems."

The meeting was held at the Foundation for International Development (DSE) in Villa Borsig, Berlin (West), and was conducted in parallel with the Seminar on Methods and Techniques of Land Organization in Rural Areas, organized by DSE from 25 June to 16 July 1983, as a result of resolution 14 of the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific.[2]

Andreas Christofi served as Chairman of the Group, while Angus Hamilton served as Rapporteur. Peter Dale assisted in the drafting of the report. The Chief of the Cartography Section, Department of Technical Co-operation for Development, acted as Secretary of the Group.

From the papers presented under item 5 (*g*) of the agenda of the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific and the discussion at the sessions of Committee III of that Conference dealing with the subject, it was obvious that the rapid progress in technology called for a fresh look at the subject of cadastral surveying and mapping and the appraisal of the even more rapidly developing concept of land information systems. It was felt that there was a pressing need for the reconstitution of the *Ad Hoc* Group of Experts, which had not met after its first meeting, and for the submission of its outstanding report. After lengthy discussion and contributions from various participants of the Conference, resolutions 12, 13 and 14 were drafted and finally adopted by the Conference. Those resolutions were later endorsed by the Economic and Social Council.[3]

Being conscious of the above resolutions and bearing in mind the fact that while the population on the Earth's surface is increasing at an alarming rate, the size of the Earth remains constant and resources are becoming scarce, information on the land becomes all the more important in quest of social and economic development. The collection, storage and orderly dissemination of land information are important factors in the success of such development.

The *Ad Hoc* Group of Experts reviewed the 1972 Report in the light of the tremendous progress made in the last decade in the fields of surveying, mapping, remote sensing and land information systems. Among the subjects discussed by the Group were the definitions of various terms in use today. The definition of cadastre and its role, factors to be considered before establishing a cadastral system, methods of establishing a cadastre, principles for the selection of survey methods and so on remain the same as in the 1972 Report except for some minor amendments which are given under the heading "Developments in survey techniques" below. The work of the Group was greatly facilitated by the participation of representatives from the International Society of Photogrammetry and Remote Sensing (ISPRS), the International Federation of Surveyors (FIG) and the International Cartographic Association (ICA).

Definitions and Explanations

In this report certain terms are used which have been defined in many different ways. For the sake of clarity these terms are here redefined to give them the meaning used in this report.

Cadastral surveying and mapping and land information systems are all concerned with recording and processing information about land. In this context *land* is an area of the surface of the Earth together with the water, soil, rocks, minerals, and hydrocarbons beneath or upon it and the air above it. It embraces all things fixed to the soil, including man-made features such as buildings or parts of buildings. There are many attributes associated with land—some physical such as the soil or the vegetation, and some abstract such as the land value, the land use or the land tenure.

Land use is a combination of those activities of men carried out on land that are specifically related to that land together with those things which are on its surface such as artificial constructions and those things growing upon it. In all societies there is concern to manage the land in an optimal way and studies of the existing land use and the land use capability or potential are important if land as a resource is

not to be wasted. Few countries can afford the luxury of wasting good land.

Land records must be based on some spatial unit of area. For some types of information, such as geology, the boundaries of these areas may be determined by physical attributes of the land. For the cadastre the basic spatial unit is known as the parcel. A *land parcel*, known in some countries as a *lot*, *plot* or even *plat*, is an area of land whose separate identity may be defined by the limit of legal rights, by responsibility for taxation payments or by use. In all cadastres, the unit for recording information is the land parcel; in land information systems this is not necessarily so.

Land information is, as its name implies, information about land. Data are collections of facts, and by implication a land data bank is a series of records of facts about attributes and aspects of land. Information, on the other hand, is more than just facts. Information is a basis for problem identification, for decision-making and for the day-to-day implementation of these decisions. It is the collecting and manipulation of data into an easily understandable form. The International Federation of Surveyors has defined land information systems as follows:

> "*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."[4]

A great variety of land information systems exist. Some are concerned with legal land registration, some with fiscal systems and some with development control. There are systems concerned with the management of buildings or road networks or the utilities such as the lines for gas, sewerage, water, telephones or electricity. There are urban and rural planning systems, land resource systems, demographic and social data systems, to name but a few.

The contents of a land information system depend on the purpose for which it is developed. The system may include geodetic survey data, cadastral data, data on natural resources, data on man-made installations, on environmental matters or on economic or sociopolitical factors. It is not practical and probably not possible to contain all land-related data and to serve all possible users of the information within one technical system. What is emerging is a network of systems each having its own functional and technical identity but linked wherever possible to other systems. An advantage of this approach is that new systems can be added at a later date.

The relationship between land information systems and the cadastre, especially the so-called multi-purpose cadastre, causes much confusion. The *cadastre* is a methodically arranged public inventory of data of the properties within a certain country or district based on a survey of their boundaries; such properties are systematically identified by means of some separate designation. The outlines of the property and the parcel identifier are normally shown on large-scale maps which together with registers may show for each separate property the nature, size, value and legal rights associated with that parcel. In the process of *land registration*, there is an official record of rights in defined limits of land. The process is sometimes referred to as the legal or juridical cadastre. In some countries emphasis is placed on value for levying taxes and this is known as the fiscal cadastre. Where other attributes of land are recorded for the benefit of planning and development, the term multi-purpose cadastre may be used.

The multi-purpose cadastre may contain a variety of information about the physical, legal, economic and social aspects of land. It is essentially land parcel-oriented and provides a service through which the dynamics of the land parcel may be studied. Because of the problems of compiling land records, the emphasis in many cadastral systems has been on acquiring, processing, and presenting land information; this has often led to a greater concern for these processes rather than to a clear understanding of the nature of the land parcel. In all versions of the cadastre, there are land records and therefore the cadastre is one kind of land information system.

The reverse, however, is not true. Land information systems need be concerned neither with the cadastre nor with land parcels. There are many systems in which the data are collected, stored and disseminated within areas enclosed by polygonal boundaries which bear no relationship to land-ownership or land-use patterns. Soil, geology, geophysics, climatology and hydrology are examples where the basic spatial element is a polygon but which are not directly connected with the cadastre. Some systems are concerned with regions—for instance the so-called Geographic Information Systems (GIS). In this report, however, emphasis has been laid on those systems which are more directly related to detailed land administration.

Most countries already operate land information systems, if only in rudimentary form. The storage, processing and output from a land information system may be based on manual methods, including handwritten records and graphic output on maps. Computer technology is making significant changes in the methods of acquiring, storing, processing and presenting data and has led to the development of more complex systems, handling greater volumes and more varieties of data. Aspects of computer technology are considered under the heading "Computers" below. The more advanced systems are based on electronic data processing. One of the best known is the Swedish Land Data Bank System. Although the development costs of this system were reportedly high, estimates now show that the overall benefits and savings outweigh the costs.

The role of the cadastre and other land information systems

Land is a base for most human activity and is our ultimate resource. We all require land on which to live and what we do with our land inevitably affects our neighbours. Every society exerts some form of control over the use and rights in land and it might seem axiomatic that if the State has power and policies to control the use of the land, it should have the necessary information at its disposal to do so. The deficiencies in many land record systems and notably their failure to be kept up-to-date is evidence that such an argument lacks persuasion.

Some of the advantages offered by a cadastre were highlighted in the 1972 Report. They include the greater ease, cheapness and security to landowners in dealing in land; a consequent stimulation of the land market and investment, particularly through longer-term credit secured on land; a reduction in litigation with consequent saving in cost and time to individuals and the State; the machinery for assessing

and levying land tax; and the availability of basic data and machinery for the implementation of land reform.

The fact that registration of the real rights to land is usually associated with a system that recognizes private property does not warrant the conclusion that such a system would be superfluous in countries where landownership operates along communal or customary lines. In countries where private property rights have little or no place, a systematic, methodical, clearly laid out inventory of land data is essential on behalf of land reform, and of town and country planning. It is further of benefit to economic planning, especially in the sphere of agriculture. A national cadastral system serves the economic development of a country and is of benefit to all users of land.

Land information systems can be classified in many different ways. One such classification distinguishes between function-oriented and provision-oriented. Function-oriented systems serve organizations in their own activities or in parts of their activities such as planning, management and control. The purpose of such systems is to facilitate and to achieve greater efficiency in the work within the organization—as for example in property and land registration systems, road management or underground service networks. The provision-oriented systems such as digital map data bases and statistical data base systems serve organizations other than those who provide the information. In either case the objective may be to support problem identification, policy- and decision-making at a high level or, at the low level, to help in the management of projects and implementation of decisions taken by higher authority.

Many users and uses of land information exist. Figure A lists some of the products from different land information systems and indicates where these are used. In addition, the output from such systems may go to the compilation of atlases, road maps and political boundary maps and to many other types of national thematic maps.

In place of maps compiled manually and printed on paper and with data assembled in longhand, typewritten or typeset for distribution, computerized land information systems are beginning to take over. Before using digital computers, interactive graphic editing systems, electronic storage and automated plotting equipment there was only very little collaboration among producers of land information products; the new technology makes collaboration essential.

Almost all national, regional and municipal agencies use land information in one form or another. An example of some of the potential benefits to users in the United States, as cited in *Procedures and Standards for a Multipurpose Cadaster*, is quoted below:

"Potential Benefits to Local Governments:

- Assures that the best available data are used in each public transaction.
- Avoids conflicts among land records of different public offices.
- Improves accuracy of real-property assessments.
- Provides base maps for local planning and preliminary engineering studies.
- Provides a standardized data base for neighbourhood, municipal, county or regional development plans.
- Avoids costs of maintaining separate map systems and land-data files.
- Encourages co-ordination among public programmes affecting land.
- Improves public attitudes towards administration of local government programmes.

"Potential Benefits to State Governments:

- Provides accurate inventories of natural assets.
- Provides accurate locational references for administration of state regulations such as pollution controls.
- Accurately locates state ownerships or other interests in land.
- Provides a standardized data base for management of public lands.
- Provides large-scale base maps for siting studies.
- Simplifies co-ordination among state and local offices.

"Potential Benefits to the Federal Government:

- Provides a flow of standardized data for updating federal maps and statistics, e.g. for the federal censuses.
- Provides a data base for monitoring objects of national concern, e.g., agricultural land use and foreign ownership of U.S. real estate.
- Provides a reliable record of the locations of federal ownerships or other interests in land.
- Provides standardized records for managing federal assistance to local programmes such as housing, community development, and historic preservation.

"Potential Benefits to Private Firms:

- Produces accurate inventories of land parcels, available as a public record.
- Produces standard, large-scale maps that can be used for planning, engineering, or routing studies.
- Speeds administration of public regulations.

"Potential Benefits to Individuals:

- Provides faster access to records affecting individual rights, especially land title.
- Clarifies the boundaries of areas restricted by zoning, wetlands restrictions, pollution controls, or other use controls.
- Produces accurate maps that can be used for resolving private interests in the land.
- Reduces costs of public utilities by replacing present duplicative base-mapping programmes.
- Improves efficiency of tax-supported government services, as described earlier in this table."[5]

The effectiveness of any administration is highly correlated to the quality of its information control. There is little doubt that land-related information is of great and increasing importance to the orderly, fair and intelligent use and development of land. Studies are beginning to indicate the cost-effectiveness of such systems. Provided that the information available is fully utilized and kept up to date, the overall benefits of land information systems can outweigh the costs.

Guidelines

The cautionary note sounded in chapter III above stems from the basic definition of information, namely, that its function is to support decision-making at whatever level. In the case of land, the decision might relate to the transfer of rights at the time of conveyance or to changes in land value or in land use, for instance, when introducing land consolidation or during land redevelopment.

The processes for determining the optimum content of a land information system are complex. The problem areas to be serviced by the system must be defined. From there

Figure A. Major groups of land information products for which land information systems are being developed

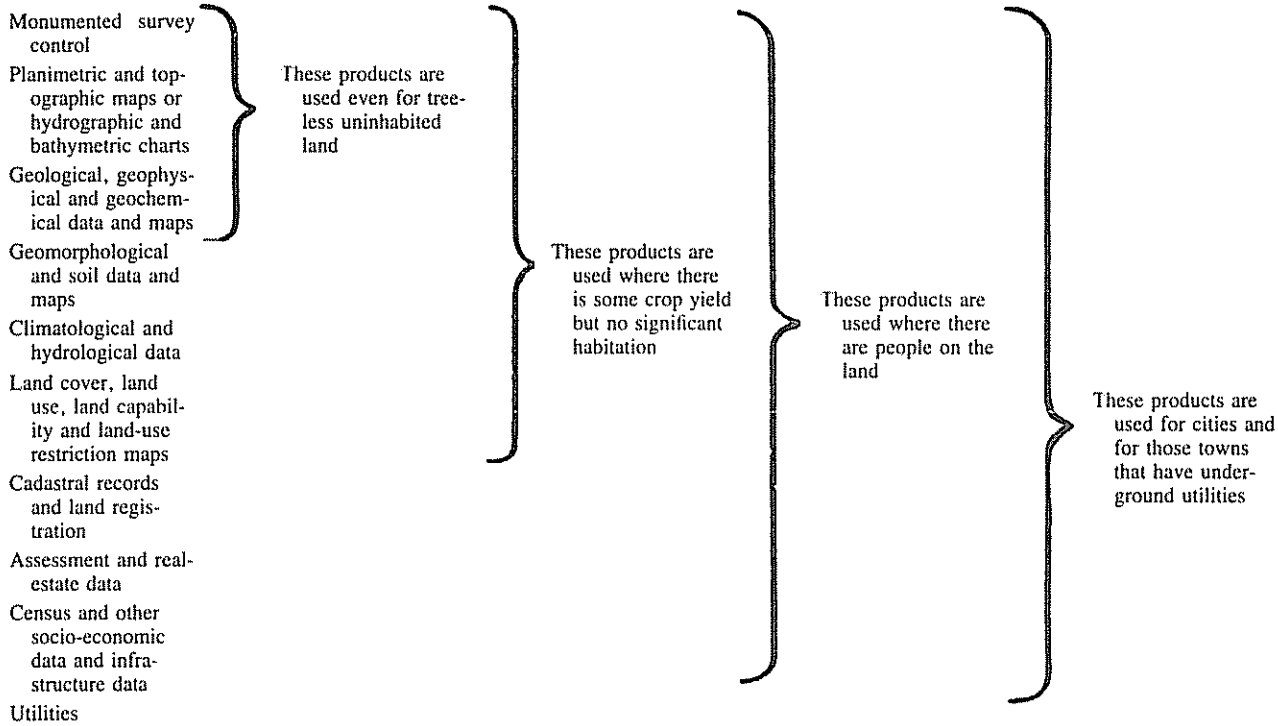
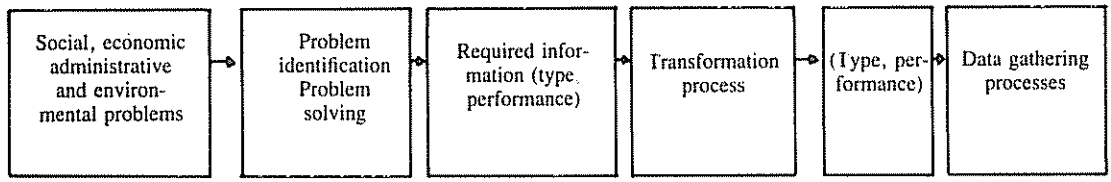


Figure B. Problem-oriented data gathering



the actual problems may be identified and solutions to the problems postulated. The solutions should indicate what information is required and hence what data transformation processes and what data will be needed. Having identified all these, the data gathering may be planned and implemented and the process then reversed to produce the solution. The flow of decisions and information is shown in figure B. The tendency to start with the data gathering and the data before identifying the problem areas should be opposed.

The simple identification of a problem and its solution may in practice necessitate a more far-reaching examination of the existing and potential users of any land information system. Social, political and economic conditions vary so widely throughout the world that no common course of action is advisable. The following elements should, however, be borne in mind:

(*a*) If the rights in land may be affected by proposed reforms, then a first essential is to identify and describe the existing forms of tenure and the extent of both statutory and customary rights. Failure to do so will almost certainly cause great difficulties when implementing land policies;

(*b*) With time, the social and physical environment around every society evolves. So must the law. The existing land laws should be analysed, outdated concepts revised or removed and, where appropriate, new legislation introduced;

(*c*) For a cadastral system to be effective, there must be clear rules binding all parties, including the Government and all public officials responsible for the operation and maintenance of the system. Regulations should indicate:

(i) Where land registration exists and what it entails;
(ii) Who takes care of and is responsible for the system;
(iii) How it operates and what procedures exist for lodging objections and appeals;
(iv) To what extent the data held in the system have legal force and what guarantees exist;
(v) How and when updating must be effected;

(*d*) For the cadastre to be an effective land information system, procedures and, where appropriate, regulations must ensure that:

(i) The identification of the parcels is unambiguous;

(ii) The data are as far as possible kept up to date;
(iii) Adequate provisions are made to ensure the continuity of the data so that archival material is retained for some period of time;
(iv) The data are correct and complete;
(v) The data can be examined effectively, efficiently and quickly;
(vi) Provision is made for new data to be introduced and new developments accommodated;

(*e*) The laws and regulations relating to land management in general and physical planning in particular should be reviewed. When first introducing a cadastre in areas already developed, records are compiled of what is on the ground; but where land reforms are undertaken or when subsequent mutations occur and hence parcels change in size and shape, development control must be exercised. Subdivisions must conform to certain standards which should be reviewed;

(*f*) The existing survey records must be examined and their reliability assessed. In reforming a cadastre which already exists in rudimentary or better form, the desirability and cost-effectiveness of utilizing the old records should be evaluated. Sometimes it may be more economical to start again using new and modern techniques in which case the legal status of the old records must be changed;

(*g*) Cadastral systems in the past have been slow in taking advantage of new developments; such developments may open up new technical opportunities. Cadastral maps and other land information systems should always be based on a network of homogeneous control points, preferably connected to the national geodetic control. Although the primary concern is that the position of each parcel must be correct relative to its immediate surroundings, longer-term considerations indicate that it should also be correct in its absolute position in space in respect of the national coordinate system. Investment in time and cost in establishing a good basic geodetic network is rarely wasted;

(*h*) Before undertaking the cadastral survey, the existing and potential uses of land information should be assessed. There is no point in collecting data which will not be used. Any additional information extending the legal or fiscal cadastre into a multi-purpose role should be carefully evaluated, taking into account both short- and long-term considerations;

(*i*) Alternative strategies should be considered and the various constraints assessed. Any constraints which inhibit the use of modern cost-effective methods should be removed, for example by amendment of the land laws and regulations; others are more problematical. The optimum solution should be adopted. Often 95 per cent of the objectives can be achieved for a fraction of the cost of achieving 100 per cent and it may be cheaper, quicker and more effective to provide an indemnity fund and, in the case of guaranteed title, pay out where errors have occurred, rather than invest more heavily in trying to reach perfection;

(*j*) Because citizens are involved with land registration or the cadastre, their confidence in the system must be assured. The public must be informed of the purpose of the system and must understand how and why it works. Failure to do so will lead to subsequent dealings in land going unrecorded and this will sooner or later lead to legal and other difficulties. To be successful, a cadastral system must enjoy popular support;

(*k*) In planning and implementing a system, adequate procedures for maintaining and updating the system are essential. Legal and fiscal data in the registers must be kept up to date at all times and the records must reflect what is currently the position with regard to rights in land. The methods and techniques for first compilation of the register may differ from those used in subsequent maintenance; photogrammetry may be the optimum technique for the initial survey but unsuitable for recording single subdivisions at a later date. A flexible approach should be adopted allowing for the most economical method to be used for updating the records.

Developments in survey techniques

The 1972 report[1] went into some detail outlining the principles and procedures involved in the survey of land parcel boundaries. Although there have been a number of technical advances, especially in the fields of data processing as discussed below, significant developments which have direct application to cadastral surveying enhance the previous report and in no way invalidate it.

In terms of field surveying, there has been the introduction of the so-called total station instrument. This is a single device which measures both angles and distances and records the data electronically. From there the data may be passed directly into a computing system for storage and processing and where appropriate for plotting. The devices may be used for establishing control, especially by traversing, or for fixing points of detail such as the turning points of property boundaries. They may be used to survey large numbers of points in one day provided that there is reasonable access to the points and lines of sight but are currently more expensive than separate conventional angle and distance measuring devices and require the support of computer technology to make them cost-effective.

High technology has also provided inertial positioning systems and satellite positioning. Inertial devices are capable of providing relative three-dimensional co-ordinates to a precision of better than half a metre. The systems available at present are carried in motorized vehicles or by helicopter, have high capital cost and need substantial computer support to achieve the maximum accuracy. Their advantage lies in the speed of the system and their suitability for use in difficult types of terrain. Satellite position fixing systems both for absolute and for differential or relative position fixing likewise require substantial capital investment in technology. Capable of being used for control surveys with relative accuracies within a few centimetres, they are likely to play a role of growing importance over the next decade, especially when the GPS is fully developed.

One application for such positioning systems is in the provision of control for photogrammetric surveys. The advantages of using photogrammetric techniques were outlined in the 1972 Report. They have limited application in the day-to-day recording of subdivisions, but they have great relevance to the initial establishment of a cadastre and to the collection of additional information that may be required for land information systems. Colour aerial photography is now used to a much larger extent because of the much better interpretability of the images.

Since 1972 a new generation of analytical plotters has emerged and, though once again requiring substantial capital investment, they offer an opportunity for extending control through aerotriangulation and for fixing many more points of detail, both in plan and in height, in a cost-effective way. Techniques for processing digital elevation models combined with a new generation of orthophoto projectors have

improved the quality and reduced the costs of production of orthophotos and orthophoto maps.

Perhaps the most spectacular advances have come in the fields of remote sensing. This term covers the collection of data from satellites as well as from devices carried in aircraft. Satellite imagery has relevance to the compilation of geographic information systems, but the resolution of the imagery currently available is not such that it can be used for any cadastral purposes. Large-scale imagery using aircraft-borne sensors should be seen as a supplement to rather than a replacement for colour aerial photography.

Computers

Land information systems based on manual techniques have been around for centuries—long before the term "land information system" was ever coined. The new emphasis has come about in part because of the new problems caused by high levels of population and the increasingly complex societies in which man lives but more especially through technical developments in electronic data processing (EDP). The advantages offered by computerized land information systems include the greater volume, variety and speed with which data can be handled and converted into information. Not only does the computer take over many of those tasks that were previously handled manually but by its very speed and power it creates a new social and economic environment. EDP can, if applied with care, reduce the costs of running a system. There seems little doubt that almost all societies will in time adopt electronic methods for data handling. The significant question is "When?".

At present those countries which are leading the field have a capital-intensive approach—savings coming from reductions in duplication of effort, from wages and salary bills and from the greater all-round efficiency of the operation. Further benefits come from exploiting the capabilities of EDP to search out, calculate, compile and present information to an extent that can rarely be achieved by manual methods.

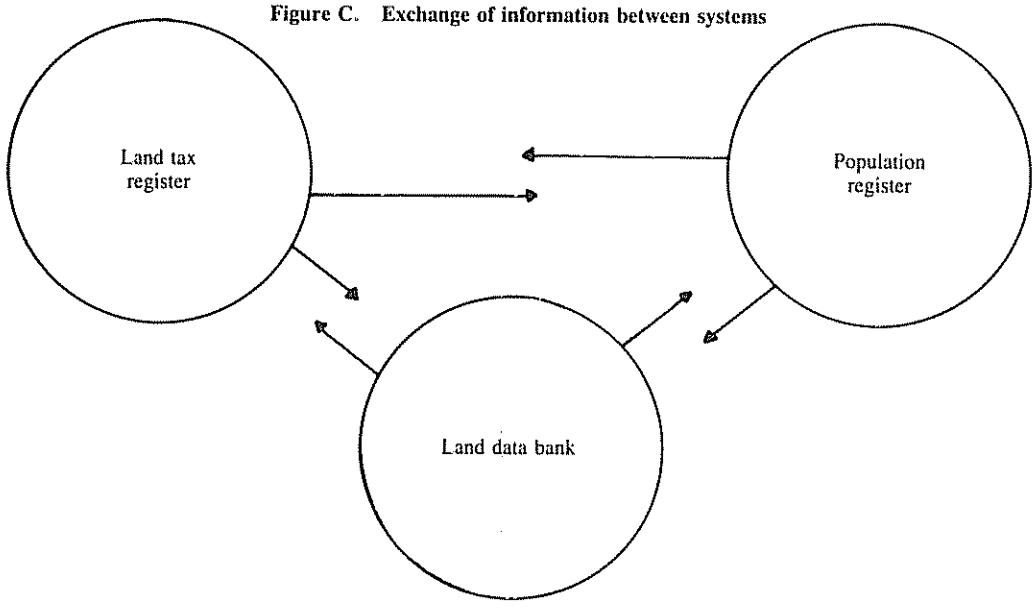
There are, however, disadvantages. Capital must be invested in the equipment and software. Staff must be trained and displaced labour must be found alternative employment. The cost of software development, that is, the programmes which control the processing, is often high. Although there are an increasing number of "turnkey" systems available—those where the development has already been completed and the purchaser has in theory just to plug in the system and turn it on—such systems do not normally meet all the requirements of the user. Some systems are protected so that the user must pay the supplier for every refinement and amendment that he subsequently wishes to introduce; others are designed to meet a wider range of users and in consequence may be relatively expensive and inefficient in meeting the needs of an individual agency.

The most expensive and time-consuming part of a computerized land information system is often in the data collection or its conversion into computer-readable form. The process of transcribing all the manual records into a form in which they are error-free and can be read by the computer may take at least a decade. During that time the needs of users may have changed and therefore at the initial stage standards and procedures must be laid down to allow for the modification of records already entered and to permit possible restructuring of the data. Investment in high technology brings with it the possibility of high gains but also a risk of heavy losses.

The pace of change and development is rapid. Microcomputers and new storage systems under development offer the prospect of significant reductions in the unit costs of handling data. Individual components are available at relatively low cost that can store, process and present fairly large amounts of spatial data in graphic form. They are reasonably robust and open up opportunities for exploitation by countries with a low gross domestic product rate. However, the problem of putting the data into the systems still remains.

A characteristic of these smaller systems is the relative technical ease with which they may be interfaced, that is, connected to other systems. This permits a number of small systems to be developed, each dedicated to a particular task but each capable of passing its information to other systems. An example of interaction and exchange of information between systems can be taken from Sweden where there are three particular systems, each based on a large computer. The principle behind their interrelationships, however, illustrates what can be done (see figure C).

Figure C. Exchange of information between systems



The land tax register and the population register each link the details from 24 separate counties. The land data bank contains data on landownership on a national basis. If there is a subdivision the information can be passed to both the land tax register and the population register; conversely, if there is a change in, for instance, the address of the owner of a property, this will be recorded on the population register and passed from there to the land data bank. The key or linkage in the overall system is the designation or unique property reference. Similar examples can be cited from several other countries.

Such reference may be alphanumeric (letters and numbers) or purely numeric. It may be the street address or town and plot number, a geographic co-ordinate (geocode) or simply an arbitrary number with no spatial significance. The important characteristics are that it should be simple, unique, understandable by the user so that he can remember it, flexible in its use, capable of being updated and suitable for handling by computer.

As a first step towards establishing a computerized cadastre, a suitable parcel referencing system should be developed. Given such a reference, a network can be built up using small computers. One system might contain the geometrical survey details such as the co-ordinates of points and the connections between them based on files containing the links and nodes. Each parcel description can be traced through the unique property reference so that the relevant strings of co-ordinates defining the property can be extracted and the details plotted using automated drafting equipment which can be interfaced with the computer. Another system might contain the list of property owners, the value of their property, the rights they possess, the mortgages they have and any easements over their land. Again, each set of records about a parcel would use the same identifier as in the boundary record system. Systems that have been built up in this way can later be developed and expanded to a higher degree of automation and integration.

It is worth repeating that it is not practical to contain all land-related data and serve all activities from *one* technical system. Earlier ideas and visions to create huge systems which could cover many functions and serve almost all activities now have been replaced by trends towards systems dedicated for each purpose and towards decentralization and deconcentration. It should, however, be emphasized that dedicated systems must not be developed in isolation. The trends towards dedication and decentralization make it extremely important to find appropriate keys by means of which it is possible to link these different systems to each other and to establish standards so that data can be exchanged between systems simply, cheaply and quickly.

Data protection

Data protection is concerned with safety, security and integrity. Data already within the system must be copied so that, in case of disaster, they can be reconstituted. Decisions must be taken as to what data should be recorded in the system, who may have access to retrieve the data and who may be allowed to introduce new data or to delete those which are already there.

Exchange of data between systems has traditionally been undertaken by manual methods producing printouts on paper or microfilm and by physically sending them to interested parties. Similar transfers can take place in EDP by writing the data onto a magnetic tape and dispatching it to the user. In the highest level of automation the data are sent over telephone wires or by other direct connection between the host computer and its satellite. This makes the exchange of data possible with very little delay. Concern, however, is often expressed that it opens up greater opportunities for the invasion of privacy and for bringing about accidental or fraudulent changes in the data and information. In practice, this is not necessarily so.

The problem has always existed but has become a matter of greater concern in recent times. It is not specifically a problem of land information systems. In most countries rules or guidelines are already in existence for safeguarding government information against destruction or damage through all kinds of calamities. For important data, so-called shadow records may be kept in case of fire or other disaster. In particular, microfilm copies of land registration records should always be maintained. With EDP systems copies of magnetic tapes or discs may be stored but they have a limited life and physically decay after a period of time.

The prevention of errors occurring in the records, either deliberately or by accident, is possible and can be enforced to a large degree. There are various technical ways for limiting access by a user to only parts of a system, though, it must be admitted, there are few, if any, systems that cannot ultimately be defeated. In addition to errors in the system, many citizens are concerned about infringement of privacy. Two aspects are discernible in the protection of personal privacy: first, there is the protection of privacy in its true sense and, secondly, the protection of the individual against the power the Government derives from being better informed.

Privacy in its true sense is the right of individuals, groups or institutions to decide for themselves when, how and in what measure information concerning them is passed to others. In order to protect the citizen, the Government can take and maintain the following measures, for which it should acquire the necessary legal backing:

(*a*) Restricting the compilation and maintenance of specific kinds of personal data;

(*b*) Permitting the citizen to know what information is stored about him;

(*c*) Restricting the storage of data to that which is necessary for the purposes concerned;

(*d*) Defining categories of users who may have access to retrieve the data but who may not alter them;

(*e*) Defining categories of people who may insert new data or delete existing data;

(*f*) Establishing procedures to ensure that the security of the system cannot be breached.

As with the cadastre, most kinds of land information systems should operate within a framework of legal regulations. These laws and regulations should provide guarantees that land-related information is correct, complete, reliable and up to date. The extent and content of the legal regulations governing land information systems will depend on the general legislation of a country and will differ between countries according to their political, religious and traditional beliefs. Often the regulations can be based on existing laws governing, for example, land registration or the cadastre. Because the legal basis for the legislation on land information systems must cover many agencies, there must be co-operation and co-ordination so that the relevant land-related laws are not in conflict with each other. There is a tendency for laws and regulations governing the collection, storage and supply of land-related data to be covered in separate paragraphs of the law. There is need to avoid conflict.

Institutional Aspects

The 1972 report[1] states succinctly:

> "Institutional problems are among the most difficult to resolve in the establishment and maintenance of a cadastre; the lack of recognition and adequate resolution of such problems are probably the most common causes for the ineffective functioning of a cadastre The effective implementation of a cadastre is a complex operation involving the establishing of a functional system of relationships among several institutions for its establishment, maintenance, effective use and continuing development "

The above statement applies equally to land information systems.

In view of its complexity and wide scope, the development and management of land information systems requires interdisciplinary team-work and co-ordination in a broad sense. It is therefore important that the Government assume this responsibility since:

(*a*) The output of a land information system can and should contribute to many governmental policy decisions;

(*b*) Its output can mean success or failure in the implementation of many major government decisions, e.g. resource exploration and exploitation, industrialization and land reform;

(*c*) Its effective operation may require new legislation or modifications to existing legislation affecting many ministries

Education and training

Although it has been stressed that many countries operate land information systems at a rudimentary level, recent developments, notably in the field of computer science, are posing new challenges. The title of land information manager has been suggested for those who are involved in the management of land information systems, but as yet there are few educational courses specifically directed at such a person.

Resolution 304 of the XVII Congress of the International Federation of Surveyors (FIG) stated that:

> "The establishment of land information systems requires a large number of specialists with perspective and knowledge to advise and supervise the formulation of nationally compatible systems. Since there exist rather small groups of people with broad experience or knowledge, while the problem is large and diverse, FIG underlines the importance of education and training of scholars and teachers, who in turn, prepare other professionals and technicians for the variety of land information activities.
>
> "FIG recommends to those who are responsible for education and training in countries, at universities etc. to pay attention to the changing and increasing demands in these fields and to take steps to improve the situation."[6]

In the initial stages such courses are likely to start at the post-graduate level, taking people who have already developed expertise in one particular field and providing information in sufficient depth to master the new discipline. There are various possible backgrounds from which the land information managers may come. For instance, they may have been cadastral surveyors, geodetic scientists, survey engineers or computer scientists. Graduates who come from a cadastral background should already have studied elements of land law, land tenure, land registration, land administration, land survey law and practice, land economics, physical (town and country) planning, land use and possibly aspects of anthropology, sociology and demography. To this they should add a knowledge of geodetic science, further knowledge of photogrammetry and cartography, including remote sensing and digital mapping (both topographic and thematic). In addition, they should study informatics and computers, data base management systems, data structures, data coding, classification and generalization, spatial data processing, sampling techniques and statistics. On top of that they should understand public administration. Graduates in geodetic science or surveying engineering will already have quite a high level of mathematics and computer science as well as specialized knowledge in geodesy, photogrammetry, remote sensing, digital mapping, land law, cadastral surveying and land information systems. These graduates will then need to acquire additional knowledge in public administration and possibly further study in computerized data base management. Graduates in computer science would have to complement their specialization by acquiring a good understanding of data collection methodology, including field survey, photogrammetry, remote sensing and assessment of data quality as well as a good understanding of cadastral systems, land information systems and their role in policy-making, regional planning and project implementation.

The list of subjects and breadth of knowledge required pose considerable challenges. Educational programmes covering the topics listed above are beginning to emerge. Time will no doubt see the introduction of courses in land information systems for the undergraduate and the technician, but at this stage, the land information manager will tend to be recruited at the post-graduate level.

Reference sources

Besides the documents submitted to the United Nations regional cartographic conferences, there is a large volume of literature on cadastral and land information system topics. To aid the reader in pursuing the subject further, some selected lists of resources are presented in annex I, which contains lists of:

(*a*) Recently published textbooks;

(*b*) Prodeedings of conferences and congresses and other publications;

(*c*) Relevant papers;

(*d*) International societies, federations and unions with the names of relevant commissions.

For those seeking advice at the State or national level, it is suggested that they address the Secretary of the *Ad Hoc* Group of Experts on Cadastral Surveying and Land Information Systems, Department of Technical Co-operation for Development, United Nations, New York, N.Y. 10017, USA.

Conclusion

The Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Teheran in 1970, recommended in its resolution 10[7] on cadastral surveying and urban mapping, *inter alia*, that an *ad hoc* group of experts should be convened by the United Nations to study in depth the problems of cadastral survey and to consider the setting up of a permanent committee to keep developments in this field under constant review.

The United Nations took action on the appointment of an *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping, which met at the United Nations Headquarters from

9 to 20 October 1972. But there was no recommendation in its report about the setting up of a permanent committee, nor was there any follow-up of the developments since then. The present Group of Experts believes that this was an omission, because the 11 years that have elapsed without taking stock of new developments is a long time. The Group therefore recommends that a stock-taking of developments should be carried out a few months before the convening of each United Nations regional cartographic conference in order to prepare an appropriate paper for the conference to enable the conference to concentrate on the application of these new concepts to developing countries.

As the present report covers new developments and techniques in a new concept over the past decade or so, it is felt that, for maximum benefit from the work put into it by the Group, it should have a wide circulation among all States Members of the United Nations. It is recommended, therefore, that the report be translated into all the official languages of the United Nations.

The Group also took note of the report of the United Nations Seminar of Experts on Land for Housing the Poor, which was held at Tällberg and Stockholm, Sweden, from 14 to 19 March 1983, and was organized by the United Nations Centre for Human Settlements (Habitat) in co-operation with the Ministry of the Interior of Finland and the Swedish Building Research Council. The Group fully endorsed the recommendations contained therein, especially those pertaining to the land registration aspects for housing the poor (for the text of these recommendations, see annex II below).

The present report covers a variety of topics falling within the discipline of the subject-matter included in the terms of reference. Apart from analysing and defining terms, it gives a first-hand perspective of land information systems in their wider sense. It touches upon the institutional aspects of such systems, indicating without commitment its feeling on responsibility for the establishment and operation of such systems. The report further gives an outline on education and training and a bibliography and other aids for the acquisition of knowledge in the above disciplines.

The Group is aware of the vastness of the new field and does not purport that the subject has been exhausted in great depth all round in the available time. The report is not intended to replace any textbook and it does not advocate in favour of any system against another, conventional or contemporary. The Group recommends that this report be studied always in conjunction with the 1972 Report. Decisions taken as a result of such study should be tried out experimentally and proven before embarking on expensive and sophisticated systems. Advice can always be sought from the Cartography Section, Department of Technical Co-operation for Development of the United Nations Secretariat, which, after identification of the problem, will take the necessary steps.

NOTES

[1] *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15-27 October 1973*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.74.I.25), pp. 275-284.

[2] *Tenth United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 17-28 January 1983*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.83.I.18), chap. VII.

[3] See Economic and Social Council decision 1983/120 of 26 May 1983.

[4] *XVI Congress of the International Federation of Surveyors. Montreux, 9-18 August 1981*, vol. O, *Archives: Report of the Congress* (Lausanne, Swiss Bureau FIG, 1981), p. 219, resolution R 301.

[5] *Procedures and Standards for a Multipurpose Cadaster* (Washington, D.C., National Academy Press, 1983).

[6] *XVII Congress of the International Federation of Surveyors. Sofia, Bulgaria, 17-29 June 1983. Report of the Congress*, resolution drafted by Commission 3, entitled "Land information systems".

[7] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East, Tehran, 24 October-7 November 1970*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), chap. VII.

ANNEX I

Selected resources

(a) *Recently published textbooks*

Dale, P. F. Cadastral surveys within the Commonwealth. London: Her Majesty's Stationery Office, 1976.

Durussel, R. Constitution du cadastre numérique à l'aide des mesurations existantes, analyse et méthode. Lausanne: Ecole polytechnique fédérale de Lausanne, 1980. (Thèse no. 371)

Eberl, Horst Karl Dobner. Sistemas cadastrales planeación, projectos, procediementos. Mexico, D.F.: Editoriäl Cencepto S.A., 1982.

Land records systems can be and should be modernized. Bernard J. Niemann, Jr., ed. Selected papers from the American Institute of Planners. Kansas City, 1977. (IES report 108)

Land use control and property registration in the Nordic countries, Erik Stupkjaer, ed. Aalborg, Denmark: Aalborg University Press, 1981.

McLaughlin, J. D. Standards of a multipurpose cadastre.

Moyer, D. D., and K. P. Fisher. Land parcel identifier for land information systems. Chicago Press, 1973.

Richter, Bengel and Simmerding. Grundbuch, Grundstück, Grenze-Handkommentar zur Grundbuchordnung unter besonderer Berücksichtigung katasterrechtlicher Fragen. Berlin: J. Schweitzer Verlag, 1978.

Simpson, S. Rowton. Land law and registration. Cambridge University Press, 1976.

Zwart, Rieter Roelof. A re-evaluation of the concept of integrated survey systems. Fredericton: University of New Brunswick, Department of Surveying Engineering, 1980. (Technical report 70)

(b) *Relevant proceedings of conferences and congresses*

United Nations publications

Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15-27 October 1973, vol. II, *Technical Papers* (United Nations publications, Sales No. E.74.I.25), pp. 275-284: "Report of the meeting of the *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping".

United Nations Interregional Seminar on Cadastral Surveying and Urban Mapping (Berlin (West). German Foundation for International Development, 1974).

Second United Nations Regional Cartographic Conference for the Americas. Mexico City, 3-14 September 1979, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.81.I.4).

Ibid., vol. II, *Technical papers* (United Nations publication, Sales No. E/F/S.82.I.14).

Fourth United Nations Regional Cartographic Conference for Africa. Abidjan, 1979 (documents submitted to the Conference).

Ninth United Nations Regional Cartographic Conference for Asia and the Pacific, Wellington, New Zealand 11-22 February 1980, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.81.I.2).

Ibid., vol. II, *Technical papers* (United Nations publication, Sales No. E/F.83.I.14).

Tenth United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 17-20 January 1983, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.83.I.18).

Ibid., vol. II, *Technical papers* (United Nations publication, Sales No. E/F.86.I.11).

Report of the *United Nations Seminar of Experts on Land for Housing the Poor, Tällberg and Stockholm, March 1983* (Stockholm, Swedish Council for Building Research, 1983) (See also annex II of the present volume.)

FIG (International Federation of Surveyors) publications

XV Congress of FIG, Stockholm, Sweden, June 6-14, 1977: Report of the Congress (Commission 7 "Cadastre and Rural Land Management")

FIG International Symposium on Land Information Systems, Darmstadt, Federal Republic of Germany, October 16–21, 1978 Report of the Symposium Technical University, Darmstadt

FIG International Symposium on Modern Technology for Cadastre and Land Information Systems, Ottawa, October 1979

XVI Congress of FIG, Montreux, Switzerland, August 9–18, 1981: Report of the Congress. (Commission 3 "Land information systems" and Commission 7 "Cadastre and rural land management")

XVII Congress of FIG, Sofia, Bulgaria, June 17–28, 1983: Report of the Congress. (Commission 3 "Land information systems" and Commission 7 "Cadastre and rural land management")

Other publications

Proceedings of a tri-state Conference on a Comprehensive, Unified Land Data (CULDATA) System, Cincinnati, Ohio, December, 1966 Cincinnati: University of Cincinnati, 1967.

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Proceedings of the North American Conference on Modernization of Land Data Systems (MOLDS): (a Multi-Purpose Approach), Washington, D C , April 1975 Washington: North American Institute for Modernization of Land Data Systems, 1975
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Proceedings of the Advanced Study Symposium on Topological Data Structures for Geographic Information Systems Harvard University, 1977

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Cadastral Surveying, Mapping and Land Information Report of the Inter-Regional Workshop on Cadastral Surveying, Mapping and Land Information, organized by the Government of the Federal Republic of Germany in co-operation with the United Nations, Hanover, 18 November - 20 December 1978 Hanover and Cologne: Carl Duisberg Gesellschaft, 1979.

World Congress on Land Policy Cambridge, Massachusetts: Lincoln Institute of Land Policy, 1980

Inter-Regional Photogrammetry Workshop, accompanying the 14th International Congress of the International Society for Photogrammetry and Remote Sensing, Hamburg and Koblenz, Federal Republic of Germany, 1980 Hamburg and Cologne: Carl Duisberg-Gesellschaft, 1981

Canadian Institute of Surveying, Centennial Convention Ottawa: Canadian Institute of Surveying, 1982

Proceedings of the International Symposium on Land Information at the Local Level: Surveying Engineering, Orono, Maine, United States of America, 9–12 August 1982 Orono: University of Maine, 1982

The Second Users' Conference on Land Information Systems, Edmonton, Alberta, Canada, September 9–10, 1982 Report of the Conference Alberta Land Surveyors Association

Procedures and standards for a multipurpose cadastre Washington D C : National Academy Press, 1983

Methods and techniques of land organization in rural areas Report of a seminar organized by the Government of the Federal Republic of Germany and the Senat of Berlin (West) in cooperation with the German Foundation for International Development, Berlin (West) and Munich, 27 June to 16 July 1983 (Berlin (West))

(c) *Relevant papers*

A J Brandenberger The world's surveying and mapping manpower and training facilities *Surveying and Mapping*, vol 41, No 3 (1981)

A Christofi Establishment and strengthening of cadastral surveying and mapping services—experience in Cyprus: a case study *World Cartography*, vol XIII (United Nations publication, Sales No E 75 I 6, p 26

Corporate author Le Foncier rural: Amélioration et harmonisation des moyens d'aménagement *Revue des géometres*, octobre 1979 Numéro spécial

Daniel Crémont Application de la photogrammetrie á la cartographie topographique et cadastrale *Bulletin No 73–74 de la Société française de photogrammétrie et de télédétection (1979)*

G Eichhorn Auf- und Ausbau von Landinformationssystemen in Industrie-und Entwicklungsländern *Zeitschrift für Vermessungswesen*, No 12 (December 1980), p 541

A Gonzales–Fletcher Modern technology in cadastral operations in developing countries *Canadian Surveyor*, vol 34, No. 1 (1980), p 54

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Max C de Henseler Mapping requirements in developing countries *ITC–Journal*, February 1982

J L G Henssen The cadastre in assessment and appraisal of real property *Aspects* (professional magazine of Ontario), No 17 (May 1975).

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J Y Ramelli L'informatique communale: tentances et perspectives, *Revue des geometres*, no 3 (mars 1982)

——— Les bases de données documentaires et les banques de données urbaines *Revue des géometres*, no 2 et no 6 (février et juin 1983)

R Roussat Derniers développements techniques du cadastre en France: la micrographie dans les services *Revue des géometres*, no 11 (mai 1981)

M Sautreau L'automation des plans cadastreaux, *Bulletin d'information de l'Institut géographique national*, no. 38 (février 1979)

Service de la documentation nationale en France, *Le cadastre*, avril 1983

I S Zonneveld, Land information, ecology and development, *ITC–Journal*, April 1974

(d) *International societies, federations, and unions*

International Federation of Surveyors (FIG)

Commission 3, "Land Information Systems"

Task: To inform about the possibilities and advantages of land information systems as a tool for decision-making, planning, etc , and to promote exchange of experiences and know-how in the wide scope of fields where land information systems have influence and can serve

Commission 7, "Cadastre and Rural Land Management"

Task: To study current problems of cadastre administration and surveying, landlaw and landtenure, and land-consolidation administration, surveying and procedures

Office International du Cadastre et du Régime Foncier (OICRF)

Task: (*a*) To collect and systematically file and index all documentation material relating to existing cadastral and land registration systems;

(*b*) To make comparative studies of collected material and publish the results;

(*c*) To give information and advice on cadastral and land registration systems to interested persons and institutions, whether for the purpose of

study or to help countries wishing to introduce cadastral or land registration systems, or to improve existing systems

International Cartographic Association (ICA)

Commission, "Computer-assisted Cartography"

Task: (*a*) To develop a technical exchange procedure between the members of the Commission at the Research and Development project level, ensuring that the Commission stays abreast of 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 for Photogrammetry and Remote Sensing (ISPRS) and Fédération internationale des géomètres (FIG) to implement the resolutions that were drafted at the joint FIG/ICA/ISPRS Conference at Zurich in 1979.

Commission, "Urban and Urban Planning Cartography"

Task: (*a*) To review existing topics in urban and urban planning cartography in order to identify the topics and representations that 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 at scales larger than 1:50.000 as an aid to international standardization in cartography;

(*c*) To identify future research required for planning cartography.

International Society for Photogrammetry and Remote Sensing (ISPRS)

Commission IV. "Cartographic and Data Bank Applications of Photogrammetry and Remote Sensing"

Task: To be responsible for:

(*a*) Photographic, analog and numerical mapping procedures;

(*b*) Compilation and revision of planimetric, topographic and thematic maps;

(*c*) Digital terrain models, cartographic data banks, and geographic information systems

ANNEX II

Recommendations of the United Nations Seminar of Experts on Land for Housing the Poor

(Excerpt from the report of the Seminar, organized by the United Nations Centre for Human Settlements (Habitat) in co-operation with the Ministry of the Interior, Finland, and the Swedish Council for Building Research, and held at Tällberg and Stockholm in March 1983.)

Theme III Land Registration

3.1 Legislation

(*a*) Many developing countries lack adequate legislation on land registration. It is recognized that present laws and regulations are very often inconsistent with the purpose for which land registration is used. There is often no attempt to adapt land-registration legislation to other forms of legislation. Often the type of legal force is not clear. Unless there is continuous and methodical updating of the registration information, the data will quickly cease to be useful, and the original effort in establishing the register will be wasted. Transfer information must include the price paid for the acquisition of the title or rights involved.

(*b*) GOVERNMENTS SHOULD ENACT EASILY UNDERSTOOD LAND-REGISTRATION LEGISLATION WHICH WILL PROVIDE FOR SYSTEM ESTABLISHMENT, MAINTENANCE AND IMPROVEMENT.

(*c*) This implies that:

(i) Governments should co-ordinate new and existing legislation;

(ii) legislation should be kept simple, to facilitate uniformity and updating;

(iii) any rules that govern alterations to the legal situation of land plots should be clearly stated;

(iv) procedures of appeal should be kept as simple as possible, to permit public accessibility (layman-jurisdiction and local committees);

(v) the type of legal force should be indicated (important for title or deed registration);

(vi) the procedures for notifying transfers must be simplified, so as to be readily understood by the whole population;

(vii) there must be close review of the reliability of the recording system, so that full confidence is created in the accuracy of the register and the relevant map;

(viii) there should be full access to the transaction recorded so that, for example, property valuation records can be kept up to date for land-tax purposes.

3.2 Multipurpose Registration Systems

(*a*) Existing land registration systems are rarely used for more than one purpose. However, it is essential for effective implementation of a land programme, that records be fully and consistently kept. This will allow harmonization of fiscal and land-development measures.

(*b*) GOVERNMENTS SHOULD ESTABLISH A MULTIPURPOSE LAND REGISTRATION SYSTEM CAPABLE OF BEING ADAPTED TO FUTURE CONDITIONS

(*c*) This implies that:

(i) the purposes of the land-registration system should be clearly identified and understood by all relevant parties, e.g. taxation, land reform, physical planning;

(ii) one public agency should be appointed as the responsible party for land registration, to avoid duplicated effort and confusion;

(iii) all land-registration operations should be co-ordinated with other relevant Government agencies and private organizations, e.g. revenue and planning authorities;

(iv) land parcels should be assigned one code of identification to be used by all public and private agencies, organizations and institutions.

3.3 Land Registration Methods

(*a*) One of the crucial components of a land registration system is a register of properties and property ownership. Where there is no system of survey controls for identifying property boundaries and where significant legal uncertainties exist, the compilation of a register and maps will have to be a gradual process and should start in the areas of most urgently needed action. Such a register must also be adapted to recording alterations in property boundaries (subdivisions and consolidations), changes in ownership and the existence of restrictions and caveats.

(*b*) TO CONSERVE SCARCE RESOURCES, THE LAND REGISTRATION SYSTEM SHOULD BE INITIATED IN AREAS OF HIGH-PRIORITY NEED USING LOW-TECHNOLOGY METHODS

(*c*) This implies that:

(i) studies and investigations should be made to determine where the need for land registration is greatest, e.g. high-density squatter settlements;

(ii) a reliable reference system (a geodetic network of control points) must be established to facilitate mapping;

(iii) the land-registration system must be based upon appropriate, affordable technologies that are within the operational capability of existing land-management institutions;

(iv) simple landmarks (e.g. boundary pegs) may be used initially for fixing boundaries.

3.4 Operation of the Land Register

(*a*) One of the reasons for introducing a systematic process of recording land titles, deeds and land transactions is to ensure speedy acknowledgement of ownership. This will expedite approval of mortgage loans and, thus, support the upgrading and consolidation process in low-income settlements. There should be provision for recording different degrees of title and deed interests, e.g. licence, lease, freehold.

(*b*) ESTABLISHMENT OF A PROPERTY REGISTRATION SYSTEM MUST BE ACCOMPANIED BY AUTHORITY TO ENFORCE NOTIFICATION OF PROPERTY TRANSACTIONS AND TO ISSUE CERTIFICATES OF TITLE OR DEED.

(*c*) This implies that:

(i) the issuing of title or deed certificates should become a routine procedure, once technical requirements have been met;

(ii) the charges for registering transactions and issuing certificates should be kept as low as possible, so as not to discriminate against the poor;

(iii) transaction procedures should be simplified, so that the poor can participate in the market without having to involve professional legal advice.

3.5 Public Information on Registration

(*a*) In many developing countries the establishment of a land-registration system has failed because the responsible agencies have not supplied policy-makers, administrators, professional staff and the public with adequate information. This means that professionals have not understood the value they can derive from the system. Furthermore, the public at large has not appreciated the benefits of title protection provided by the system.

(*b*) GOVERNMENTS SHOULD PROMOTE A WIDE UNDERSTANDING OF LAND REGISTRATION SYSTEMS PARTICULARLY AMONGST POOR POTENTIAL BENEFICIARIES.

(*c*) This implies that studies should be made to determine the most appropriate means of disseminating information on the need for land registration systems, so that there will be likelihood of public acceptance of and understanding for the establishment of a land-registration system, especially in countries which have customary, tribal or family rights.

(e) *Hydrographic surveying and nautical charting**

THREE RECENT DEVELOPMENTS IN CANADIAN HYDROGRAPHY**

Submitted by Canada

Three different, although interrelated, projects were carried out recently by the Hydrographic Service of Canada. The first project concerns the implementation of a Larsen 500 Lidar surveying system. The second project concerns the preparation of a system for compiling and dealing with interactive cartography (CARIS). The third project concerns the testing of the electronic map. These three projects are presented in the context of cartographic operations and present and future needs.

Trois innovations distinctes mais interdépendantes ont été apportées récemment au Service hydrographique du Canada. La première concerne la mise en application du système de levé Larsen 500 Lidar. La deuxième a trait à la mise au point du système de compilation et de traitement interactif cartographique (CARIS). La troisième consiste à utiliser le banc d'essai de la carte électronique. Ces trois innovations sont décrites dans le contexte des opérations cartographiques et des besoins actuels et futurs.

Tres acontecimientos distintos, pero correlacionados, ocurren en la actualidad en el Servicio Hidrográfico del Canadá. El primero se refiere a la puesta en funcionamiento del sistema de levantamiento Larsen 500 Lidar. El segundo se refiere al desarrollo del sistema de compilación y tratamiento interactivo cartográfico (CARIS). El tercero se refiere al desarrollo del banco de pruebas del mapa electrónico. Estos tres acontecimientos son tratados en el contexto de las operaciones y las necesidades cartográficas presentes y futuras.

* See also document E/CONF 77/L.17, discussed under agenda item 6 (*h*)

** Abstracts only; the subject was covered by video presentation during the Conference

MAPPING OF THE CONTINENTAL SHELF AND OTHER AQUATIC ZONES*

Paper submitted by the Union of Soviet Socialist Republics

RÉSUMÉ

Ce rapport aborde les principes fondamentaux de la topographie maritime, notamment du plateau continental. La topographie terrestre et la topographie maritime reposent sur les mêmes principes pour ce qui est du contenu des cartes et de la base mathématique. Seules les méthodes diffèrent.

RESUMEN

En el presente informe se examinan los principios básicos del levantamiento topográfico en la plataforma continental y otros espacios marinos

El estudio topográfico de la tierra firme y los espacios marinos se basa en los mismos principios relativos al contenido de los mapas y a la base matemática, sólo difiere el método aplicado.

* The original text of this paper appeared as document E/CONF 77/L.57.

In the Union of Soviet Socialist Republics, the mapping of continental shelf and inland water bodies is regarded as a task of State importance. It is aimed at solving economic problems connected with the study, appropriation and protection of natural resources.

Published topographic maps are used by a wider circle of users than are navigation maps. However, the basic technical requirements of the latter do not differ greatly from similar maps of dry land areas. In the preparation of topographic maps of shelf and inland water bodies the following principles are observed:

(*a*) A uniform approach to the study of shelf, inland water bodies and adjacent dryland territories;

(*b*) Complete study of the territory under survey to satisfy the demands of a maximum number of users;

(*c*) As far as possible, a uniform, complete and exact reflection of underwater topography, independent of the distance to shoreline and inland geodetic control from the territory under study;

(*d*) Equal reliability of procured cartographic information independent of depth and geographical position;

(*e*) Consistent depiction of information on the map: in other words, all elements have to be reflected uniformly;

(*f*) Contemporariness: the map content must be regularly updated;

(*g*) Specialization, arising from the need for in-depth study (according to the concrete demands of the user) of the most complicated and practically important parts of shelf for a specified map user;

(*h*) Economy: the maps must be prepared with least time, labour and money taking into account available vessels and cartographic/geodetic information about the area to be mapped.

The main features of topographic shelf maps

Topographic maps of shelf are compiled in Transverse Cylindrical Gauss projection, with standard map sheet division based on the uniform geodetic datum: measurements of altitude begin from the Kronstadt datum, and initial geodetic positions relate to points of the State geodetic control network.

To extend sea mapping along shore lines and islands the geodetic control networks are developed to afford unobstructed departure to sea for topographic/geodetic work. The geodetic height control is extended along shores of all seas with contouring accuracy error of no more than ± 15-20 cm relative to the Baltic Sea level (regardless of distance to the datum level).

The topography of the sea-bottom is depicted by contour lines. A contour interval between lines is chosen according to the survey scale, degree of slopes and complication of topography. The accuracy of the survey is governed by the scale of the maps and the accepted contour intervals. On the maps are depicted: soil type limits with separation by nature (sand, clay, mud, pebbles, mussel-shells, exposures, under- and above-water vegetation etc.); communication lines, including those under the mass of sediment, with features of actual condition at the moment of survey; working and conserved drill-holes; shore-line with details of under- and above-water structures; outlets of oil and gas deposits; under-water springs etc.

The question of possible amount of detail to be included on topographic maps is decided with due regard for the technical task involved, the features of objects under study and hydrometeorological conditions. Information that cannot be depicted directly on the map is given in reference notes at the margins of a map sheet or on the reverse side. Separate photo- and sonar frames, as well as photomaps, can be attached to the map.

Successive scales used

Insufficient topographic/geodetic information about shelf, it seems, would force preparation of small-scale maps to provide a topographic base for study of the aquatic zones; this would be done as quickly as possible, taking into consideration geodetic/geophysical research and prospecting for different deposits. A dry land analogy would be where geological works are conducted with the help of 1:1,000,000 maps. More detailed geological research connected to oil prospecting is usually terminated at the survey stage at 1:1,000,000-scale (sometimes 1:200,000), while search and prospecting work is done at scale 1:50,000. Considering that the successive order of shelf work and scales of survey are the same as those used on dry land, it can be seen that the high value of the work, the problems of positioning and difficulties of returning to established points call for mapping of the promising regions at a larger scale, 1:25,000 for example.

Topographic survey of aquatic zones

While the topographic survey of shelf involves the same work that must be done in dry land mapping, differences lie in the construction of surveying instruments, methods of survey and data acquisition, collection and manipulation.

The mapping process consists of geodetic control development; sea operation; office work and charting.

Geodetic control is done by known methods and instruments such as are used for similar work on dry land. The most important differences are in the methods and instruments used for sea work. The office work, as well as charting methods differ from those for dry land only because of the special character of information about subsurface features of sea and inland water bodies.

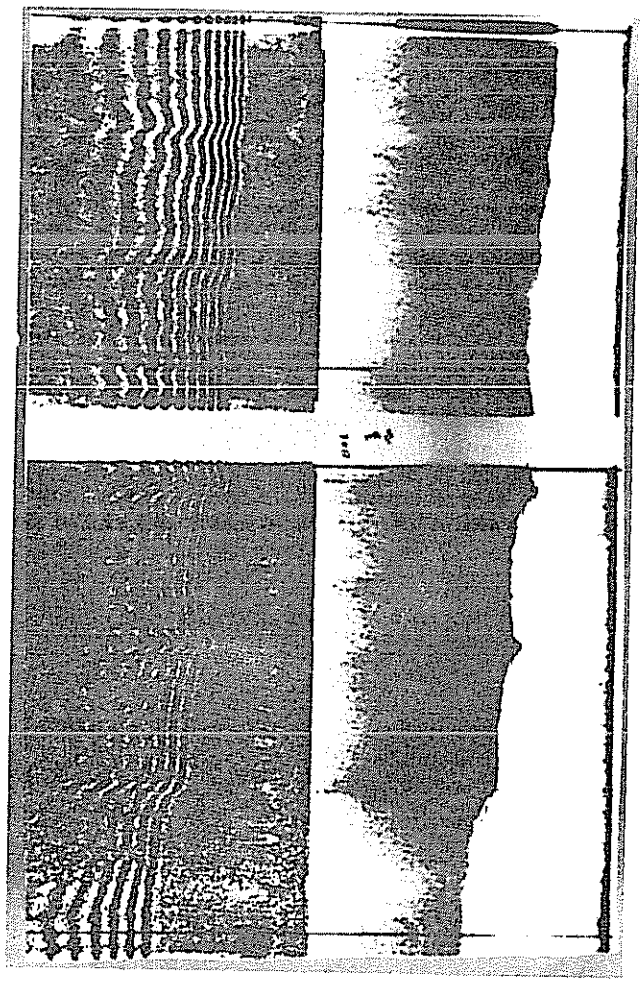
The sea work involves the following: air survey, remote sensing, sounding/sonar survey, under-water stereo-photo survey and survey with different geophysical instruments. Employment of one or another method of work depends on the features of the region under study, accessibility to that region and on the special hydrometeorological conditions. Shoals with depths of up to 10 m (or, if transparency permits, the depth can be more than 10 m) are surveyed with the use of air survey and sonar methods. If the water is deeper, sonar methods are mainly used.

It should be observed that limitations on the employment of optical instruments for shelf and water bottom surveys, as well as remoteness from the dry-land geodetic networks, oblige the simultaneous use of several methods of survey; for example, air survey, sounding and sonar survey. Thus, where information is lacking, one method supplements another; for example, sounding complements an air survey, while air survey provides a sounding with information about general topography and underwater features.

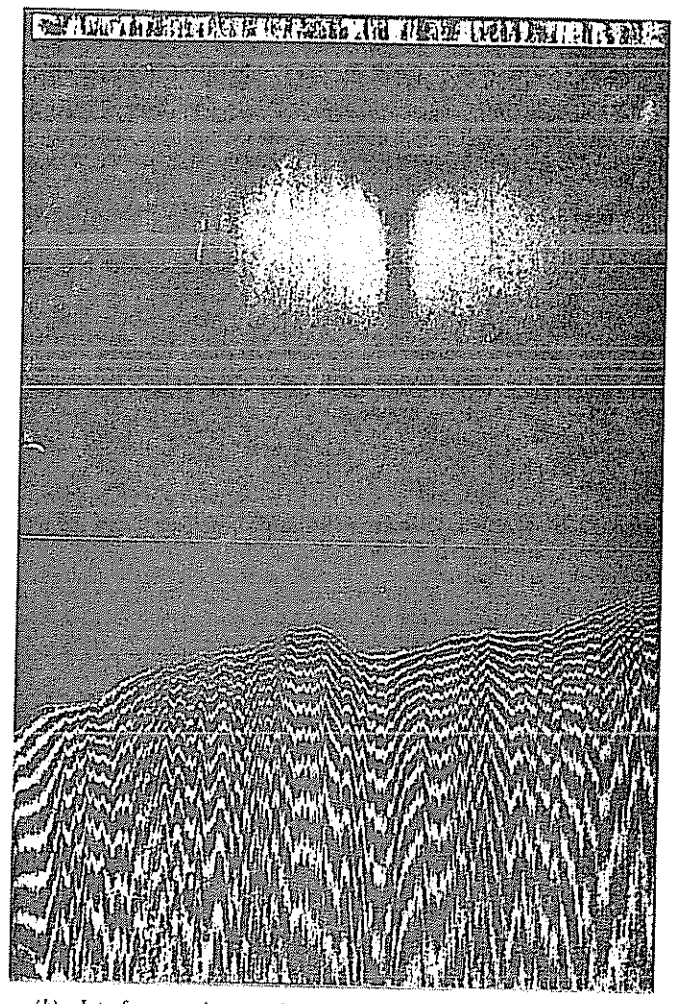
Aeromethods

Air survey is the most promising method for topographic and thematic charting of shelf. But, under present technical possibilities, air survey images afford study of under-water topography conditions only within the limits of a compar-

Figure 55. Soviet Union: Sonar picture of sea bottom



(*a*) General view of sea bottom surface



(*b*) Interference picture coherent to the general view of sea bottom surface

atively narrow shore strip and of the depths only where water transparency is sufficient to allow photography through the mass of water.

Results have shown that it is possible to make a sufficiently complete representation of under-water topography from good pictures to imagine its dependence on geological situations and processes that prevail in the part of the bottom under study

Owing to the metrical effect of an air image, it is possible to receive information on depth, relative altitude of topographic elements and angles of bank slopes. Repeated photos give necessary information on topography dynamics and afford an idea of the coherence of under-water topography with the topography of adjacent dry-land territory.

The information obtained from aerophotos has to be examined directly. For this purpose within the limits of typical sites, the field-worker has to measure depth, and to collect samples of soil, exposures, vegetation and benthos. These efforts will serve to record the characteristic features of model sites. Using these photos, under-water objects in the other sites can be recognized also.

In principle, maps produced using aerophotos on shelf do not conflict with those of adjacent parts of the dry land. Owing to this peculiarity, opportunities are open for extrapolation of geologic and biologic features from the dry land to the sea.

Aerophoto methods are not equally feasible everywhere. In estuaries the depths, where the bottom can be seen, are limited by several metres (1-5 m). In the shoals of middle latitudes and Arctic regions that limit extends to 20-25 metres. Hydrometeorological situation and under-water landscape morphology greatly affect photography. During air survey the sea has to be calm, overcast and the maximal height of sun above the horizon no more than 15-30°.

Interpretation is conducted by extrapolation, owing to the stability of macro/mesoform of shore and under-water topography, as well as of landscape-indicative imagery features based on knowledge of landscape formation principles, previously established for the areas within limits of model sites being mapped.

Colour synthesized photos, made from multizonal ones, could raise the credibility of interpretation.

Sonar methods

Since light and other electromagnetic waves severely degrade in water at depths of more than 20 m, such areas should be mapped with use of sonar devices. Sonar methods

permit the conducting of measurements at greater distances and obtain spatial co-ordinates of points on the bottom within the limits of observation range. Besides, sonar signals are able to penetrate the mass of sedimentary rocks, so that with their help it is possible to detect litter rocks and, buried under the coat of sedimentary rocks, different objects, for example, pipelines and electric cables. It requires the building of lines of sonar devices, including sounding devices and side-looking sonars.

For identification of sonar images (figure 55) supplementary tools, such as mechanical rock-pickers and cameras for under-water photography, have to be used. To provide metrical features of sonar information one has to conduct geometric and sonar calibration of devices and to employ computers for processing images.

By sonar images are established varied vegetation and soil, topography of the shore-line, natural and man-made objects and so on. To simplify sonar image interpretation and raise its credibility, it is necessary to use information from a low frequency sounding device, rock-picker and under-water photos.

The equal reflection of signals on a sonar image of different topography elements and rocks calls for separation of their patterns as well as demands for use of identification models.

The digital processing of sonar images involves distinguishing formations by density and patterns of their reflected signals, input of digital data in the computer and output of rectified sonar pictures.

The practice of topographic and thematic mapping management has proved the importance of documents of previous geographical, geological, hydrographical and hydrobiological studies. With adequate selection of materials, special surveys and reconnaissance are unneeded.

To raise the precision and amount of information gained by topographic survey of shelf waters, survey devices should be perfected and methods of digital processing extended by the use of computers.

HISTORY OF THE LORAN-C CHARTING AT THE NATIONAL OCEAN SERVICE*

Paper submitted by the United States of America

RÉSUMÉ

Depuis 10 ans, le National Ocean Service (Service océanique national) travaille à fournir au public des cartes marines LORAN-C précises qui tiennent compte de l'évolution et de l'expansion du réseau LORAN-C. Depuis le début, l'appui de la Garde côtière des Etats-Unis (U.S. Coast Guard) et du Centre de l'hydrographie et de la topographie de l'Agence cartographique de la défense (Defense Mapping Agency Hydrographic/Topographic Center-DMAHTC) a été nécessaire.

Bien que les utilisations commerciales du LORAN-C soient possibles depuis 1958, les lignes de position ne figurent sur les cartes marines du National Ocean Service que depuis 1973. En effet, le coût élevé des récepteurs décourageait quelque peu l'utilisation des cartes marines LORAN-C auparavant. Le système LORAN-A suffisait à la plupart des besoins civils en matière d'aide-radio. Les lignes de position LORAN-A étaient déjà surimprimées sur beaucoup des cartes du Service. Vers la fin des années 60, les progrès de la microélectronique ont permis aux fabricants de produire et de vendre des récepteurs LORAN-C à un prix abordable pour les utilisateurs commerciaux. Les récepteurs moins onéreux et l'expansion prévue du système LORAN-C ont stimulé l'intérêt du public pour les cartes LORAN-C.

RESUMEN

En los 10 últimos años, el Servicio Nacional de Océanos ha participado en un esfuerzo constante por proporcionar al público cartas LORAN-C precisas que tomen en cuenta los cambios y la ampliación de la red LORAN-C. Desde el principio, este proyecto ha dependido del apoyo del Servicio de Guardacostas de los Estados Unidos y del Centro Hidrográfico y Topográfico del Organismo de Cartografía para la Defensa.

Si bien las cartas LORAN-C han estado disponibles para su utilización comercial desde 1958, las líneas de posición no aparecieron en las cartas náuticas del Servicio Nacional de Océanos hasta 1973. Antes de esa época, el alto costo de los receptores limitaba el interés en la utilización de las cartas LORAN-C. El sistema LORAN-A existente satisfacía la mayoría de las necesidades de la población civil de contar con un instrumento de radionavegación. Las líneas de posición LORAN-A ya se superponían en forma impresa en muchas cartas del Servicio Nacional de Océanos, pero para fines del decenio de 1960, los adelantos en microelectrónica permitieron que los fabricantes produjeran y vendieran receptores LORAN-C a un precio accesible para los usuarios comerciales. A consecuencia del bajo costo de los receptores y de la expansión prevista del sistema LORAN-C, aumentó el interés en las cartas LORAN-C.

For the past 10 years the National Ocean Service (NOS) has been engaged in a continuing effort to provide the public with accurate long-range radio navigation system charts (LORAN-C) that keep abreast of the changing and expanding LORAN-C network. From the beginning, this project has been dependent on the support of the United States Coast Guard and the Defense Mapping Agency of the Hydrographic/Topographic Center (DMAHTC).

While LORAN-C has been available for commercial use since 1958, the lines of position were not shown on NOS nautical charts until 1973. Prior to that time, the high cost of receivers limited interest in the use of LORAN-C to the military and scientific research and survey groups. There was no widespread demand for LORAN-C charts. The existing LORAN-A system met most civilian needs for a radio navigational aid. The LORAN-A lines of position were already overprinted on many NOS charts. But by the late 1960s, advances in microelectronics made it possible for manufacturers to produce and sell LORAN-C receivers at

* The original text of this paper, prepared by Jeffrey S. Stuart, National Ocean Service, appeared as document E/CONF.77/1.14.

a price within the range of commercial users. Low-cost receivers and anticipated expansion of the LORAN-C system resulted in increased interest in LORAN-C charts.

In December 1971, the Coast Guard requested that the Marine Chart Branch of NOS should print a limited issue of NOS chart 13009, Gulf of Maine and Georges Bank, with a LORAN-C grid overlay. The purpose of this special issue chart was to facilitate an evaluation of the accuracy of LORAN-C in nearshore areas. Using LORAN-C overlays produced by DMAHTC, NOS overprinted LORAN-C lines on the existing chart base, and 300 copies were forwarded to the Coast Guard early in 1972.

In a follow-up request in November 1972, the Coast Guard asked NOS to overprint LORAN-C lattices on seven more NOS base charts for its use. This second request involved several more NOS nautical charts of the east coast as well as Aleutian Island charts 16006 and 16012. DMAHTC once again provided the necessary LORAN-C overlays for each chart base. Two hundred copies of the latest edition of each of these seven charts with LORAN-C overprinted were forwarded to Coast Guard headquarters by September 1973.

Fiscal constraints prevented NOS from complying with further requests for special-purpose LORAN-C charts. But in early summer 1973, the Coast Guard requested NOS to overprint LORAN-C on the next regularly scheduled editions of each of the seven charts for which limited-issue LORAN-C editions had previously been prepared. The Coast Guard also contracted with DMAHTC for the production of LORAN-C overlays to fit eight more NOS base charts being considered for future public issue.

The 19th edition of NOS chart 16006 (Bering Sea—Eastern Part), dated 8 September 1973, was the first regular issue chart to show LORAN-C lines overprinted. This chart, 1:1,500,000 in scale, was a prototype and the basis for discussions concerning the overprinting of LORAN-C lines on future charts. The lines of position were generated based on assumed all sea-water path with no correction for overland signal propagation delay, referred to as Additional Secondary Factor (ASF) corrections.

LORAN-A lines were already overprinted on NOS charts. Discussions with the Coast Guard and DMAHTC produced a general agreement that the most practical method for charting both LORAN-A and LORAN-C in a common area would be to print two versions of the same chart, back to back, with existing LORAN-A coverage on one face and LORAN-C lines of position on the other. A Marine Chart Branch cartographic order, dated 13 December 1973, formally authorized the overprinting of LORAN-C lines on NOS charts and outlined general charting policy.

The Department of Transportation endorsed LORAN-C as the primary government-provided radio navigation system for the coastal confluence zone (CCZ) of the United States in May 1974. Concurrent plans for the phasing out of LORAN-A service and growing public acceptance of the LORAN-C system increased the demand for LORAN-C chart coverage.

With several LORAN-C charts already on issue, NOS, the Coast Guard and DMAHTC finalized plans for future LORAN charting in May 1975. NOS agreed to overprint LORAN-C lattices reflecting existing LORAN-C coverage on approximately 150 charts at scales 1:80,000 and smaller during fiscal years 1975 and 1976. East-coast charts were given highest priority. NOS chart printing schedules were tentatively adjusted to accommodate this effort. Copies of these adjusted schedules were forwarded to DMAHTC and the Coast Guard.

Tentative plans were also developed to provide future chart coverage of several planned west-coast and Alaskan chains during fiscal year 1977. The Coast Guard desired that these NOS charts be on issue prior to the proposed operational dates for these chains, which were scheduled to begin service in 1977. NOS printing schedules for affected west-coast charts were also revised.

Still further charting plans were outlined involving the charting of the lines of position for two more new chains designed to provide new coverage on the east and Gulf coasts. These chains were scheduled to begin service in 1978 and 1979.

To facilitate this charting effort, DMAHTC agreed to provide NOS with accurate master and slave station positions for each chain based on the NOS charting datum (North America Datum of 1927: NAD-27) and other necessary data. In addition, DMAHTC agreed to provide NOS, for each lattice charted, with adjustment for overland signal transmission delay (ASF). These adjustments were necessary to bring the charted lattices within the ¼-nautical-mile accuracy (95 per cent, 2 drms) criteria established by the Coast Guard. Classified prior to 1978, these corrections were to be incorporated in the construction of the lattices, but the amount and direction of the adjustment was not to be made public.

DMAHTC agreed to provide these ASF corrections for all charts between 1:80,000 and 1:875,000 scale that were to have LORAN-C overprinted. For charts smaller in scale than 1:875,000, DMAHTC determined on a chart-by-chart basis whether or not a single correction could bring a particular lattice within the ¼-nautical-mile accuracy criteria over the entire area of chart coverage. They supplied corrections for those charts where they were deemed applicable. On charts of 1:1,500,000 scale and smaller, ASF corrections were not considered significant. The Coast Guard agreed to keep DMAHTC and NOS advised of system changes and to set priorities and to monitor the overall charting effort. All three agencies were to be involved in collection system calibration data.

There was also a consensus between NOS, the Coast Guard and DMAHTC that LORAN-C lines would not be shown on harbour or harbour entrance charts larger than 1:80,000 scale and that the lattices should not be shown in most inshore areas or inland waters on smaller-scale charts. The primary charting area of concern was the CCZ. The inner limit of that zone had been defined by the Department of Transportation as the harbour entrance.

Based on these general inter-agency agreements, NOS began to add LORAN-C lines of position to nautical charts. This was scheduled and accomplished in five basic phases, described below. (A synopsis of the project is given in the annex.)

Phase 1. Charting of lines of position for United States LORAN-C coverage existing as of 1 January 1973

LORAN-C overlays for the first seven charts overprinted by NOS had been prepared by DMAHTC for the earlier special-purpose issues of these charts requested by the Coast Guard. The DMAHTC overlays for all seven of these charts were constructed based on an assumed all sea-water path with no adjustment for ASF. These overlays were adequate

as constructed for overprinting the first two NOS LORAN-C charts on public issue. Both charts covered the Aleutian Islands and were smaller than 1:1,000,000 scale, and ASF corrections were not considered significant. Chart 16006 was issued in September 1973 and chart 16012 was issued in February 1974.

The remaining five charts for which DMAHTC had prepared LORAN-C overlays were east-coast charts varying in scale between 1:200,000 and 1:500,000. At these larger scales, accuracy of the lines of position was a primary concern. On the lattices for these charts some adjustment for ASF was required in order to meet the ¼-nautical-mile accuracy criteria.

On each overlay of these charts, DMAHTC indicated the distance in millimetres in the north-south direction and the distance in millimetres in the east-west direction that the corners of the overlay would have to be shifted to adjust the lattice for ASF. This had the effect of shifting the entire lattice by a constant amount representing an average ASF correction for the area of chart coverage. The 18th edition of NOS chart 11520, Cape Hatteras to Charleston, dated 30 March 1974, was the first NOS chart printed with lattices adjusted for ASF.

The corner shift method was used to adjust DMAHTC-generated LORAN-C overlays for ASF on the first several charts overprinted. This technique, however, proved cumbersome. Lines had to be extended on two adjacent chart edges to fill the void caused by the shift and painted out on the opposite edges where they extended beyond the chart limits.

In trying to find a simpler method of adjusting the lattices for ASF, NOS ran some test plots of its own in 1974. By altering the coding delay used as input in the generation of each lattice by the amount of correction for ASF provided by DMAHTC in microseconds, NOS was able to produce overlays that resulted in the identical placement of the lines of position as had been obtained using corner shifts.

From this point on DMAHTC furnished ASF correction data to NOS in terms of microseconds. If the ASF correction for a LORAN-C rate was negative, it was added to the coding delay. If the correction was positive, it was subtracted from the coding delay.

This technique of altering the coding delay was used to construct the lattices for the remaining Phase 1 charts for which ASF corrections were required. For each rate, a single correction was used representing an average of ASF correction data in the area of chart coverage. These corrections were theoretically derived by DMAHTC, but they were based on a relatively large volume of observed data collected over a period of years.

Largely completed by June 1976, the charting of existing LORAN-C chains provided coverage for the east and Gulf coasts, the Great Lakes, Alaska and Hawaii.

Phase 2. Charting lines of position for new west-coast and Alaskan chains

Prior to 1977 there was no operational LORAN-C service on the west coast. With LORAN-C chart coverage of much of the remaining United States coastal area available by 30 June 1976, the charting of the lines of position for the proposed west coast and Alaskan chains was scheduled to be completed between 1 July 1976 and 1 January 1977. NOS revised its normal printing schedule in order to accommodate this charting effort and to make it possible for LORAN-C charts of these areas to be available when these new chains became operational.

A problem developed concerning the first west-coast charts on issue showing the lines of position for the 9940 chain. Single ASF lattice shifts provided by DMAHTC were again incorporated in the construction of each lattice. But the theoretically derived ASF corrections furnished for the first west-coast charts did not prove sufficient to bring the lattices within the ¼-nautical-mile accuracy standard over the entire area of chart coverage.

The land and sea interface on the west coast was very different from other areas where calibration data for operating LORAN-C chains had been collected, and the Fallon, Nevada, master station was much farther inland than existing master stations. Moreover, the 9940 chain and other new west-coast chains had been operational on an experimental basis for a short period of time. There was very little reliable calibration data available upon which DMAHTC could base predicted ASF corrections.

As a result, the initial LORAN-C editions of southern California charts 18746, 18720, 18721, 18765, and 18744 were inaccurate. These charts were in error by 2 microseconds or more in some cases. This resulted in positioning errors of up to 2½ nautical miles. The five southern California charts overprinted with LORAN-C lines were originally printed between 19 March 1977 and 23 October 1977.

In response to this problem, the NOAA Ship *Rainier* conducted a calibration survey in the affected area which was completed in September 1977. The data collected were forwarded to DMAHTC for evaluation. Correction items for the charts in question were broadcast and published in DMAHTC's and the Coast Guard's *Notices to Mariners* in December 1977.

By November 1978, DMAHTC had forwarded revised lattice shifts concerning these charts to NOS. The single lattice correction technique was again used in the reconstruction of these LORAN-C overlays. But in order to meet the established accuracy criteria, it was necessary to divide some of the charts into as many as four separate sections. A single microsecond correction was incorporated in the construction of the lattices for each of these sections. A different correction was used for each section. Where the chart sections junctioned, corresponding lines of position were arbitrarily connected. These short junction lines were particularly noticeable on the revised edition of chart 18740. New editions of all five charts with corrected lattices were printed between 1 May 1978 and 2 June 1979.

Another charting problem affecting the accuracy of the lines of position developed concerning the new 9990 Alaskan chain. This chain was a reconfiguration of the previous 5930 chain. The original master station on St. Paul Island was retained along with slave stations located at Port Clarence and on Attu Island. The previous 5930 slave station on Sitkinak Island was abandoned in favour of a new slave station at Narrow Cape.

The first NAD-27 data sheet for the Alaskan chain received by NOS from DMAHTC was dated 5 March 1976. Positions for the St. Paul master station and slaves at Attu Island and Port Clarence were carried forward from a previous data sheet furnished by DMAHTC for the original 5930 chain dated 20 April 1966. A revised DMAHTC data sheet dated 23 June 1980 placed the St. Paul master station more than 2 seconds north and 7 seconds west of the original co-ordinates.

Complications involved in the original geodetic survey location of the St. Paul tower led to this discrepancy. The revised positions received in 1980 resulted in the need to revise or re-evaluate the printed lattices on approximately 40 charts, with particular attention given to larger-scale charts. Because many Alaskan charts are reissued infrequently, at 3- to 8-year intervals, the problem of revising the lattices was compounded.

In scheduling the overprinting of LORAN lines of position for the new west-coast and Alaskan chains, DMAHTC recommended that 19 charts be removed from the printing schedule and that the overprinting of LORAN-C lines on these charts be postponed until a later date. The coverage area of these charts contained land and water in such mixture that charting techniques available at that time could not bring the lattices within the required ¼-nautical-mile accuracy.

Phase 3. Charting of the Lines of Position for the Reconfigured East- and Gulf-Coast Chains

The experience gained in charting the LORAN-C lattices on west-coast charts caused the Coast Guard, DMAHTC, and NOS to re-evaluate existing charting methods. Before the charting of lines of position for the proposed east- and Gulf-coast chains began in June 1977, it was determined that a single average correction would not be sufficient to bring the lattices within ¼-nautical-mile accuracy on coastal charts at 1:100,000 scale and larger. Charting of the lattices on these charts was deferred until an adequate charting method was available. For charts of smaller scales, however, the single-lattice correction technique continued to be used.

At the request of the Coast Guard, DMAHTC forwarded to NOS a computer program to be used to construct the lattices on the large-scale charts. Added as an option to the existing NOS-LORAN plotting, the program produced contoured lines of position that were in agreement with ASF-corrected time-difference predictions provided at every 5 minutes of latitude and longitude in the area of chart coverage. Data tapes furnished by DMAHTC containing the corrected time differences were used in conjunction with this program to construct the lattices on all east- and Gulf-coast charts 1:80,000 to 1:100,000 scale.

The lines of position generated using these 5-minute data tapes were not smooth in areas where the curvature of the lines of position was very pronounced. The lines of position for rate 9960X on NOS chart 13237, Nantucket Sound and Approaches, were very segmented as originally charted using a 5-minute data tape. In these instances, DMAHTC provided data tapes with ASF-corrected time differences predicted at every minute of latitude and longitude. The lines of position constructed based on these 1-minute data tapes more nearly approached a smooth curve.

NOS attempted to have LORAN-C chart coverage for the new east- and Gulf-coast chains on issue prior to the operational dates for those chains. This led to an unavoidable charting error concerning the 7980Y lines of position. Based on the results of experimental operation of the Gulf-coast chain, the Coast Guard revised the proposed coding delay for the 7980Y rate from 41000 to 43000. Several small-scale charts were already overprinted and on issue before this change. Therefore the numeric labels for the 7980Y lines of position on these charts were 2,000 microseconds in error. Correction items were published in *Notices to Mariners* for the charts involved in November 1978.

Originally issued with 7980 lines of position between 4 March 1978 and 23 September 1978, all 11 charts were corrected and reprinted between 1 May 1979 and 31 October 1979.

The deferral of charting LORAN-C lines on large-scale charts until NOS could adapt the DMAHTC warped-lattice program delayed the entire charting schedule by a few months. Therefore, a few charts were not overprinted with the new 7980 and 9960 lines of position prior to the termination of the old 9930 service on 30 September 1979 and the start of the new service on 1 October 1979. This resulted in considerable inconvenience to mariners. In the Charleston, South Carolina, area, for example, shrimpers and commercial fishermen were left without current LORAN-C charts to use during a busy part of their working season. The charted 9930 lines were obsolete.

In order to avert serious economic loss in the Charleston area, NOS responded to an inquiry from Senator Ernest Hollings of South Carolina by rapidly generating several hundred mylar LORAN-C overlays and distributing them to mariners in the Charleston vicinity within two weeks of the operational date of the new LORAN service. These overlays were to be used in conjunction with NOS chart 11520, Cape Hatteras to Charleston; NOS chart 11521, Charleston Harbor and Approaches; and NOS chart 11009, Cape Hatteras to Straits of Florida. Though the 9960 lines of position were shown on chart 11520 at this time, part of the chart coverage area was at the limit of acceptable ground wave coverage for the 9960 chain. The mylar overlay generated for that chart showed the 7980 lines, which were indicated to be more useful in the Charleston area.

As a follow-up to this remedial action, a new edition of chart 11521 covering the immediate Charleston area was printed showing the 7980 lines of position. This new edition was dated 23 February 1980. The next editions of chart 11520 and chart 11009 also reflected appropriate LORAN-C additions and revisions.

Because the 9960Z and 7980Z rates were scheduled to become operational 8 to 10 months after the other rates in the reconfigured east- and Gulf-coast chains, the overprinting of lines of position for these rates was deferred until they became operational. This reduced the initial workload and facilitated the overprinting of LORAN-C on a large number of charts prior to the operational dates for the remaining rates.

Phase 4. Charting Lines of Position for New Chains on Great Lakes Charts

Following the termination of the original 9930 LORAN-C service on 30 September 1979, the Great Lakes region was without LORAN-C chart coverage for a few months. Small-scale chart coverage for each of the lakes was not available until early 1980.

On the eastern lake charts, Erie and Ontario, the lines of position for the existing 9960 chain were overprinted. Both the 9960 and 8970 lines of position were overprinted on the Lake Huron chart because Lake Huron is in the ground wave coverage area for both chains. On the western lake charts, Michigan and Superior, the lines of position for the 8970 chain were the only lattices overprinted. The ground wave coverage for the 8970 chain extended to the eastern lakes, but the signal strength from the 8970Y Baudette, Minnesota, slave was weak except in the northern part of Lake Erie.

The 1:100,000-scale coastal charts covering Lake Erie and Lake Ontario were the first large-scale lake charts overprinted with the new LORAN lattices. Since the old 9930 lines of position were not overprinted on lake coastal

charts, this represented the first large-scale LORAN-C chart coverage in the lakes area.

DMAHTC data tapes were used to construct the LORAN lattices for all the large-scale lake charts. Eastern lake charts were overprinted first because the 9960 chain had been in operation for about a year, and NOS and Coast Guard calibration surveys had been conducted in Lake Erie and Lake Ontario. Predicted time differences that were provided for these charts by DMAHTC were based, in part, on this preliminary survey data.

Editing and evaluation of existing NOS LORAN-C charts

During a fairly intensive charting effort, the primary concern of NOS was the rapid overprinting of accurate lines of position on a large number of charts in order to provide the public with accurate LORAN-C nautical chart coverage as quickly as possible. These overprinted charts and established chart specifications are now in the process of being evaluated in terms of both chart accuracy and clarity.

When the first LORAN-C charts were issued, the LORAN-C lines were overprinted on many charts already showing LORAN-A lattices. In the interest of chart clarity, the LORAN-A and LORAN-C lattices were initially printed back to back on separate faces of the same chart. But the results of a LORAN chart evaluation questionnaire distributed to all attendees at a LORAN-C users conference convened in Portland, Oregon, in December 1975 indicated that a majority of chart users desired that LORAN-A and LORAN-C lines be shown on the same chart base. This would facilitate conversion from the one system to the other.

Therefore, NOS abandoned back-to-back printings and began to print both systems on the same face of the chart. To reduce clutter, all LORAN-A lines were printed in a subdued gold colour to differentiate them from LORAN-C lines. This was done except in cases where the total number of LORAN-A and LORAN-C lattices to be overprinted was more than six. When the combined number of lattices was more than six, the LORAN-A rates were shown on one face of the chart and the LORAN-C lines on the other.

When the need arose to overprint the lines of position for the new east- and Gulf-coast and Great Lakes chains on charts already showing existing LORAN-C and LORAN-A lattices, the chart clutter problem became more serious. It became necessary to use the back-to-back printing method, again showing the new LORAN-C lines and the old LORAN-C lines on one side of the chart and the new LORAN-C lines and LORAN-A lines on the other. This facilitated the conversion of old LORAN-C positions and LORAN-A positions to new LORAN-C co-ordinates.

Future LORAN-C charting

The NOS LORAN-C charting effort, as outlined in the 1975 agreement with the Coast Guard and DMAHTC, is nearly complete. As more survey data are processed, the lattices on all overprinted charts are subject to revision. A list of NOS LORAN-C charts scheduled to be printed during a specific fiscal year is forwarded to DMAHTC. DMAHTC will then supply NOS with necessary data for those charts on which the lattices may need to be revised. The final decision to revise the lattices will be made by NOS in consultation with the Coast Guard. In most instances, revision of the lines of position should concern charts at 1:100,000 scale and larger. The lattices on smaller-scale charts should prove adequate.

At the time lattices were overprinted on large-scale charts of the west coast and Alaska, the DMAHTC "warped-lattice" program, using data tapes to correct the lines of position at every five minutes of latitude and longitude, was not available for NOS use. The single-lattice correction technique was used to construct the lattices on all these charts. The lattices may eventually need to be reconstructed using the "warped-lattice" method.

The addition of LORAN-C lines of position to harbour charts of scales 1:40,000 and larger is a future possibility. However, more extensive data collection and evaluation will be necessary before this is considered. While fairly constant offshore, the ASF corrections in nearshore and inland waters are more irregular. Improved charting techniques dealing with ASF may have to be developed before the lines can be overprinted on these charts.

There will be a future need to construct LORAN-C lattices for all new charts where they are appropriate. A proposed datum shift on NOS charts from NAD-27 to NAD-83 will also be a future consideration affecting the LORAN-C lattices.

The existing LORAN-C network serving United States coastal waters should remain stable for the near future.

ANNEX

Outline of the NOS/LORAN-C charting project

PHASE 1 CHARTING OF LINES OF POSITION FOR U S LORAN-C COVERAGE EXISTING AS OF 1 JANUARY, 1973

Chain	*Master*	*Slave pairings*	*Charts overprinted*	*Charting schedule*	*System operational date*
9930	Carolina Beach, NC	9930W Jupiter Inlet, Fla 9930X Cape Race, Newfndlnd 9930Y Nantucket, Mass 9930Z Dana, Indiana	107*	Mar 1974-Dec 1976	Jan 1969**
5930	St Paul Island, AK	5930X Attu I, Alaska 5930Y Port Clarence, AK 5930Z Sitkinak I, AK	38***	Sept 1973-Jan 1977	1962****
4990	Sand I, Johnston I	4990X Upolu Pt Hawaii 4990Y Kure I, Midway I	20	Oct 1975-Jan 1978	Jan 1961

* Includes 8 small-scale charts of Great Lakes
** Service terminated on 30 September 1979
*** Only 8 charts actually overprinted owing to termination of service.
**** Service terminated 28 February 1979

PHASE 2 CHARTING OF LINES OF POSITION FOR NEW WEST-COAST AND ALASKAN CHAINS

Chain	*Master*	*Slave pairings*	*Charts overprinted*	*Charting schedule*	*System operational date*
9990	St Paul Island, AK	9990X Attu I, Alaska 9990Y Port Clarence, AK 9990Z Narrow Cape, AK	46	July 1976-July 1986	March 1, 1977
9940	Fallon, Nevada	9940W George, WA 9940X Middletown, CA 9940Y Searchlight, Nev	21	July 1976-Jan 1977	April 26, 1977
7960	Tok Junction, AK	7960X Narrow Cape, AK 7960Y Shoal Cove, AK	43	July 1976-Jan 1977	June 28, 1977
5990	Williams Lake, British Columbia, Canada	5990X Shoal Cove, AK 5990Y George, WA 5990Z Port Hardy, Vanc*	16	July 1976-Jan 1977	Sept 5, 1977 Nov 20, 1980

* 5990Z rate added to those charts showing the 5990 chain in 1980, 1981 and 1982 as they came up in regular printing cycle

PHASE 3 CHARTING OF LINES OF POSITION FOR RECONFIGURED EAST-AND GULF-COAST CHAINS

Chain	*Master*	*Slave pairings*	*Charts overprinted*	*Charting schedule*	*System operational date*
9960	Seneca, NY	9960W Caribou, Maine 9960X Nantucket, Mass 9960Y Carolina Beach, NC 9960Z Dana, Indiana*	47	June 1977-Oct 1979	Sept 9, 1978 May 1, 1979
7980	Malone, Fla	7980W Grangeville, LA 7980X Raymondville, Tex 7980Y Jupiter Inlet, Fla 7980Z Carolina Beach, NC**	64	June 1977-Oct 1979	Dec 27, 1978 Dec 1, 1978 Dec 1, 1978 Oct 1, 1979

* 7980Z rate added to charts beginning in 1979 as they came up in regular print cycle
** 9960Z rate added to charts beginning in 1979 as they came up in regular print cycle

PHASE 4 CHARTING OF LINES OF POSITION FOR NEW CHAINS ON GREAT LAKES CHARTS

Chain	*Master*	*Slave pairings*	*Charts overprinted*	*Charting schedule*	*System operational date*
9960	Seneca, NY	Same as above	22	Jan 1980-Jan 1983	See above
8970	Dana, Indiana	8970W Malone, Fla* 8970X Seneca, NY 8970Y Baudette, Minn	31	Feb 1980-Jan 1983	March 31, 1980

* 8970W rate not charted because it is used primarily for overland LORAN-C applications

PHASE 5 CHARTING OF LINES OF POSITION FOR CANADIAN EAST-COAST CHAIN

Chain	*Master*	*Slave pairings*	*Charts overprinted*	*Charting schedule*	*System operational date*
5930	Caribou, Maine	5930X Nantucket, Mass 5930Y Cape Race, Newfndlnd	14	Feb 1982-June 1983	April 30, 1980

STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING WORLD-WIDE*

Paper submitted by the International Hydrographic Organization

PURPOSE

The Cartography Section of the Natural Resources and Energy Division of the Department of Technical Co-operation for Development of the United Nations Secretariat has regularly undertaken a survey of the status of world topographic mapping. The United Nations regional cartographic conferences for Asia and the Pacific and for the Americas have proposed that the scope of the survey should be enlarged to incorporate hydrographic surveying and nautical charting, both of which activities play an important part in many development programmes

To advance this study, the aid was enlisted of the International Hydrographic Organization (IHO)

BACKGROUND

In 1980, a questionnaire (see annex) was circulated to 128 States Members of the United Nations who were coastal States, the answers to which were to provide the basic data needed for the study. Responses were limited: only 39 States responded, and it was clear that some of the questions had been misinterpreted. It was therefore decided to reissue a revised questionnaire in 1983.

THE SECRETARIAT OF THE UNITED NATIONS AND THE INTERNATIONAL HYDROGRAPHIC BUREAU

The Cartography Section of the United Nations and the International Hydrographic Bureau (the secretariat of the IHO) have co-operated closely to ensure the fullest possible response to enable a sensible assessment to be made of the status of the world's hydrographic surveying and nautical charting resources.

The results were analysed by the Bureau staff and the present report was prepared jointly by the United Nations and the International Hydrographic Organization.

PARAMETERS OF THE STUDY

Hydrographic surveying and nautical charting are closely related, the latter being mainly, but not exclusively, dependent upon the former. The study is therefore addressed, first, to an assessment of the governmental resources available for conducting hydrographic surveys in terms of survey vessels and sea-going personnel; secondly, to resources available for chart production and maintenance in terms of cartographic staff, chart coverage, both present and planned, and printing facilities

An important element is the individual national assessment of national waters under three headings: "adequately surveyed", "requiring re-survey", and "not surveyed". From these data it is possible to judge the workload faced by the world in attempting to provide the mariner with reliable up-to-date charts upon which he can navigate his ship in safety.

At the time of the study, the questionnaire was circulated among 140 coastal States. All 52 member States of the IHO were approached through its routine channels; the remainder were approached through United Nations channels and, where appropriate, opportunities were presented directly by the Bureau of IHO.

The total responses numbered 60. The majority were from States that have, to a greater or lesser degree, some sort of hydrographic capability and were able to contribute a suitable reply. However, there were some notable exceptions in respect of non-responding States where a high level of capability is known to exist and for which data have been culled from either the first questionnaire or from Bureau records.

The reliability of some of the replies to the question given in section A.1 of the questionnaire, which is so important to the results of the study, is clearly in doubt; however, statistical averaging possibly reduces some of the doubt if it is assumed that the over-estimates balance out the under-estimates.

Of particular concern is the low response rate from Africa and the Pacific regions where very large exclusive economic zones (EEZ) exist, sea-borne trade is vital, and any capability for hydrographic surveying and nautical charting is minimal or even non-existent. Hydrography, when it is needed, is probably surveyed by commercial interests in pursuit of their own objectives.

Commercial surveying is not covered by the report, yet quite extensive capability within the commercial sector is evident. Unfortunately, without adequate co-ordinatory control, the results of work executed for a specific project are often lost, and the various world charting services seldom benefit from them.

Reliability of the present study in the world-wide sense should therefore be judged only on the basis of the eight selected regions.

CONCLUSIONS

The conclusions to be drawn are evident. Large areas of continental shelf and EEZ waters are inadequately surveyed or not surveyed at all. The majority of coastal States have little or no capability for carrying out even vital port, or port approach, surveys; for publishing charts that would ensure the safety of navigation in their waters; or for mapping the sea-bed of their EEZs. Given the high costs and length of time needed to create even an elementary hydrographic capability, these States have little hope of remedying the situation in the near future by their own efforts.

Even the highly developed industrial coastal States are not without immense problems: the United Kingdom, for instance, quotes 66.8 per cent of its maritime zones as "unsurveyed"; 23.3 per cent as "requiring re-survey"; and only 9.9 per cent as "adequately surveyed".

At the other end of the scale, Fiji's reply shows comparative figures of 99.1 per cent, 0 per cent, and 0.9 per cent. With 1,135,300 km^2 of EEZ, 2 survey boats and 3 surveyors, Fiji is faced with a daunting work-load.

Ship-owners instruct their masters to keep to well defined tracks to avoid the possibility of striking uncharted obstructions. Even so, evidence shows that vessels do become casualties of such perils.

Thus, a long-term plan is urgently needed to train personnel in basic skills and utilize all possible applicable technology for hydrographic and charting operations, including,

*The original text of this paper appeared as document E/CONF 77/L 12.

for instance, satellite remote sensing, to remedy (or stem the tide of) what is an ever-increasing world problem.

The global resources at present available are shown by the study to be:

67	National hydrographic offices
204	Survey vessels
323	Small survey craft
3,409	Survey staff employed on hydrographic surveys
1,836	Cartographers and supporting staff
17,728	Charts schemed
15,380	Charts published
48	Hydrographic offices having chart printing facilities
58	Hydrographic offices issuing *Notices to Mariners*
162	Nautical publications issued, of which there are:
43	Tide tables
39	Light lists
31	Sets of sailing directions
22	Sets of radio signals for mariners
27	Miscellaneous publications

The study is arranged in three sections. The first gives an inventory of coastal States with an indication of their hydrographic capabilities. The second section presents in tabular form the responses to the questionnaires. The final section contains graphs showing a statistical analysis of the information received (see table 9 and figures 56 to 60).

The annex reproduces the 1983 questionnaire.

I Inventory of coastal States with indication of responses to the questionnaire

** responding State; + known to have hydrographic capability but not responding*

Africa

29 States
8 responses

Angola
Benin
Cameroon
Cape Verde
Comoros
Congo
Côte d'Ivoire
Equatorial Guinea
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya*
Liberia
Madagascar*
Mauritania
Mauritius*
Mozambique*
Nigeria+
Sao Tome and Principe
Senegal*
Seychelles*
Sierra Leone
Somalia
South Africa*
Togo
United Republic of Tanzania*
Zaire

Australasia

4 States
4 responses

Australia*
New Zealand*
Papua New Guinea*
Cook Islands*

Europe and the Mediterranean

34 States
21 responses

Albania
Algeria*
Belgium*
Bulgaria
Cyprus
Denmark*
Egypt+
Finland*
France*
German Democratic Republic*
Germany, Federal Republic of*
Greece*
Iceland+
Ireland
Israel
Italy*
Lebanon
Libyan Arab Jamahiriya
Malta
Monaco
Morocco*
Netherlands*
Norway*
Poland*
Portugal*
Romania*
Spain*
Sweden*
Syrian Arab Republic
Tunisia
Turkey*
Union of Soviet Socialist Republics*
United Kingdom of Great Britain and Northern Ireland*
Yugoslavia*

North America

23 States
5 responses

Antigua and Barbuda
Bahamas
Barbados
Belize
Canada*
Costa Rica
Cuba+
Dominica
Dominican Republic
El Salvador
Grenada
Guatemala*
Haiti
Honduras
Jamaica
Mexico+
Nicaragua
Panama*
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Trinidad and Tobago*
United States*

Pacific

9 States
2 responses

Fiji*
Kiribati
Nauru
Niue
Samoa
Tonga
Tuvalu
Vanuatu
Solomon Islands*

South America

10 States
6 responses

Argentina*
Brazil*
Chile*
Colombia+
Ecuador*
Guyana
Peru+
Suriname
Uruguay*
Venezuela*

South Asia

20 States
4 responses

Bahrain*
Bangladesh+
Burma+
Democratic Yemen
Djibouti
Ethiopia
India*
Iran (Islamic Republic of)+
Iraq+
Jordan
Kuwait
Maldives
Oman
Pakistan*
Qatar
Saudi Arabia
Sri Lanka
Sudan*
United Arab Emirates
Yemen

South-East Asia

11 States
8 responses

China*
Democratic Kampuchea
Democratic People's Republic of Korea
Indonesia*
Japan*
Malaysia*
Philippines*
Republic of Korea*
Singapore*
Thailand*
Viet Nam

II Tables of responses

The following symbols and terms appear in the tables:

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

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

A blank indicates that no response was received to the questionnaire and that data are not available separately

A full stop (.) is used to indicate decimals.

The sign (o) indicates that data are from the 1980 questionnaire or from International Hydrographic Organization records.

The indication "incl" signifies that the adjacent number includes this element.

Years are indicated by the final two figures: 83 = 1983

Y or N indicates an affirmative or negative reply to questions B 4 (a) to 4 (f).

The designations employed and the presentation of material in this study do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations and of the International Hydrographic Organization concerning the legal status of any country, territory or area or of its authorities or concerning the delimitation of its boundaries. The regional divisions expressed throughout have been designed to serve the purpose of this study only

TABLE 1. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: AFRICA

Coastal State* / * IHO member / + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts* Scheme d/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Angola	605.7																			
Benin	27.1																			
Cameroon o	15.4				1 / 1	—	—	—	—	—	—	—	—							
Cape Verde	789.4																			
Comoros	249.0																			
Congo	24.7																			
Côte d'Ivoire	104.6																			
Equatorial Guinea	283.2																			
Gabon	213.6																			
Gambia	19.5																			
Ghana	218.1																			
Guinea	71.0																			
Guinea-Bissau	150.5				— / 1	—	—	—	—	—	—	—	—	77							
Kenya	118.0	25	75	0	— / —	2 / 4	2c / 50	2	2	—	6	1	— / —	N	N	N	N	Y	N	—
Liberia	229.7																			
Madagascar	1,292.0	30	35	35	— / 2	4 / 12	2 / 1	— / —	— / —	— / —	— / —	110 / —	— / —	N	N	N	N	Y	N	71 × 102 cm
Mauritania	154.3																			
Mauritius	1,113.0	0	0	100	— / —	— / —	— / 7	— / —	— / —	— / —	— / —	— / —	— / —	N	N	N	N	N	N	—
Mozambique +	562.0	85	15	0	— / 1	3 / 5		4	—	20	16	7	81 / 81	N	N	N	N	Y		—

TABLE 1 *(continued)*

Coastal State* • IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (%)	Requiring resurvey (%)	Not surveyed (%)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts* Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Nigeria * + o	210.9				1	5								Y				Y		
Sao Tome and Principe	128.2																			
Senegal	205.7	10	90	0	1	—	—					1	N	N	N	N	N	Y	Y	—
					1	—	—					1	N							
Seychelles +	1,349.3	2.5	6	91.5	—	1	2	—	—	—	1	1	83	Y	N		N	Y		—
					1	4	3	—	—	—	—	—	83							
Sierra Leone	155.7																			
Somalia	782.8																			
South Africa * +	1,553.4	30	50	20	1	8	2		—			15	82	Y	Y	Y	Y	Y	—	880 × 1,260 mm
						12	2	18	—	37	18	14	83							
Togo	2.1																			
United Republic of Tanzania	223.2	—	—	100	—	1[d]	22[c]	—	—	—	—	—	—	Y	N	N	N	Y	N	30 × 40 in.
					1	4[d]	165[c]	—	—	—	—	—	—							
Zaire*	1.0																			

[a] Of 29 coastal States, 3 are members of IHO; 4 have national cartographic services.
[b] Charts entered are included in world series.
[c] Land Survey Department.
[d] Tanzania Harbours Authority.

TABLE 2. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: AUSTRALASIA

Coastal State[a] * IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships Boats	Surveyors Assistants	Cartographers Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Latest symbols/ catalogue (year)	Publications: Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Australia * +	4,496.3	20(7)	16(5)	64 (88)	2 .	30 78	1 57	47 14	99 51	194 75	127 81	55 36	83 83	Y	N	N	N	Y	N	720 × 1,190 mm
New Zealand * +	4,833.2[b]	8	5	87	3 4	14 26	. 15	25 18	6 3	40 28	45 34	30 21	83 83	Y	Y	N	N	Y	Y	720 × 1,100 mm
Papua New Guinea +	2,366.6	5	5	90	— —	1 —	— —	. 8[c]	. 13[c]	. 14[c]	. 16[c]	. 1[c]	— —	Y	N	N	N	N	N	—
Cook Islands	. [b]	—	—	—	— —	— —	— —	—	—	—	—	—	—	—	—	—	—	—	—	—

[a] Of 4 coastal States, 2 are members of IHO; 3 have national hydrographic services.
[b] Includes data for Cook Islands.
[c] Included in world series or regional series.

TABLE 3. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: EUROPE AND THE MEDITERRANEAN

Coastal State[a] * IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Albania	12.3																			
Algeria +	137.2	90	10	—	1 2	7 25	1 6	6 3	— —	14 14	10 —	20 1		N	Y	N	N	Y		841 × 1,189 mm
Belgium * +	2.7	100	—	—	2 4	6 28	incl. incl.				13	3	80 82	Y	Y	N		Y	N	840 × 1,230 mm
Bulgaria	32.9																			
Cyprus o	99.4				— 1	4				1 1					N	N	N	Y		
Denmark * +	1,464.2[b]				2 2	11	29	32 29	1 1	22 22	89 75	36 36	82 83	Y	Y	Y	Y	Y	Y	840 × 1,200 mm
Egypt * + o	173.5	60	20	20	— 2	25	5	4 4	1 1	6 6	3 3	5 5	— —					Y		
Finland * +	98.1	80	15	5	1 9	8 16	5 9	4 4	1 —	10 7	118 118	6 6	83 83	N	Y	N	N	Y	Y	85 × 110 cm
France * +	7,145.9[c]	31	29	40	6 1	140 84	33 17	456	3	448	562	521	81 83	Y	Y	Y	Y	Y	Y	840 × 1,200 mm
German Democratic Republic +	9.6	70	30	—	1 1	7 10	9 8	5 5	6 6	26 26	46 44	4 4	74 82	N	Y	Y	Y	Y	Y	90 × 126 cm
Germany, Federal Republic of * +	40.8	100	—	—	4 9	36 incl.	30 17	229 229	67 67	266 263	328 326	116 116	83 83	Y	Y	Y	Y	Y	Y	840 × 1,200 mm
Greece * +	505.1	60	40	—	2 1	5 19	6 17	4 4	1 1	47 24	104 10	214 89	79 77	N	Y	Y	N	Y	N	86 × 120 cm
Iceland * + o	866.9	15	45	40	— 1	4	5	5 3	6 4	22 13	7 5	5 5		Y				Y		
Ireland	380.3																			
Israel o	23.3	100	—	—	— —	— —	— —	— —	— —	3 3	— —	4 4								
Italy * +	552.1	25	75	—	3 11[d]	21 35	6 7	18	—	85	64	156	80 82	Y	Y	Y	Y	Y	Y	890 × 1,260 mm
Lebanon	22.6																			
Libyan Arab Jamahiriya	338.1																			

TABLE 3 (*continued*)

Coastal State[a] / * IHO member / + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (%)	Requiring resurvey (%)	Not surveyed (%)	Ships: Boats	Surveyors: Assistants	Cartographers: Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light-lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Malta	66.2																			
Monaco *	—																			
Morocco	278.1	. . .	. . .	. . .	—	—	. . .	—	—	—	—	—	—	. . .	. . .	. . .	. . .	. . .	. . .	—
Netherlands * +	84.7	70	30	—	— / 3	14 / 13	incl. / 3	— / 6	— / 2	— / 7	— / 30	— / 5	— / 83	Y	Y	Y	N	Y	Y	. . .
Norway * +	2,024.8	2.9	7.1	90	. . . / 6 / 21	14 / 30 / 24	9 / 16 / incl.	6 / 30 / 30	2 / 8 / 8	7 / 61 / 56	30 / 134 / 131	5 / 45 / 34	83 / 80 / 83	Y	Y	Y	N	Y	Y	. . .
Poland * +	28.5	80	20	—	1 / 1	16 / 40	7 / 11	5 / 5	— / —	28 / 20	10 / 10	3 / 3	82 / 79	N	Y	Y	Y	Y	Y	900 × 1,150 mm
Portugal * +	1,774.2	45	15	40	1 / 5	30 / 50	3 / 4	17 / 17	— / —	39 / 36	54 / 54	136 / 133	81 / 82	Y	Y	Y	Y	Y	Y	102 × 144 cm
Romania +	31.9	100	—	—	1 / 1	3 / 1	2 / 4	26 / 19	— / —	58 / 15	25 / 11	3 / 1	83 / 83	N	Y	Y	Y	Y	Y	68 × 93 cm
Spain * +	1,219.4	45	55	—	6 / 8	24 / 67	25 / 19	12 / 11	51 / 50	133 / 125	49 / 32	192 / 176	81 / 81	Y	Y	Y	Y	Y	Y	830 × 1,120 mm
Sweden * +	155.3	5	95	—	3 / 10	20 / 40	19 / 50	11 / 11	1 / 1	37 / 37	86 / 69	10 / 10	82 / 83	N	Y	Y	Y	Y	Y	841 × 1,189 mm
Syrian Arab Republic *	10.3																			
Tunisia	85.7																			
Turkey * +	236.6	76	3	21	1(1) / 3	5 / 12	4 / 15	12 / 11	18 / 17	50 / 48	42 / 40	22 / 20	82 / 82	N	Y	N	N	Y	Y	100 × 140 cm
USSR * +	4,490.3	38	62	—	43 / . . .	. . . / . . .	. . . / . . .	. . . / 300	. . . / 110	. . . / 820	. . . / 487	. . . / 413	71 / 82	Y	Y	Y	Y	Y	. . .	89 × 119 cm
United Kingdom * +	1,785.3[c]	9.9	23.3	66.8	8 / 3	99 / 146	66 / 198	. . . / 96	. . . / 23	. . . / 225	. . . / 472	. . . / 268	79 / 83	Y	Y	Y	Y	Y	Y	910 × 1,215 mm
Yugoslavia * +	52.5	40	60	—	1 / 5	16 / 20	5 / 7	7 / 7	7 / 5	38 / 35	23 / 21	20 / 20	81 / 76	Y	Y	Y	Y	Y	Y	87 × 127 cm

[a] Of 34 coastal States, 21 are members of IHO; 22 have national hydrographic services.
[b] Including data for Greenland and the Faroe Islands.
[c] Including data for all overseas departments and territories.
[d] As required.
[e] Including data for: Bermuda, British Virgin Islands, Cayman Islands, Turks and Caicos Islands, Pitcairn, Henderson Ducie, Oeno Islands, St. Helena and Ascension.

TABLE 4. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: NORTH AMERICA AND THE CARIBBEAN

Coastal State* • IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (%)	Requiring resurvey (%)	Not surveyed (%)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Antigua and Barbuda																				
Bahamas	759.2																			
Barbados	167.3																			
Belize		66	—	34	— / —	— / —	— / 5						N	Y	N	N	Y	N	—	
Canada * +	2,939.4	45	30	25	10 / 88	112 / —	101[c] / incl.	177 / 128	57 / 23	234 / 105	912 / 625	846 / 774	83 / 81	Y	Y	Y	Y	Y		110 × 161 cm
Costa Rica	258.9																			
Cuba * + o	362.8				3 / 6	— /	— /	12 / 12	— / —	37 / 35	14 / 14	54 / 48	— / 78	Y	Y	Y		Y		
Dominica																				
Dominican Republic*	268.8																			
El Salvador	91.9																			
Grenada	267.5																			
Guatemala * +	99.1	10	10	80	— / —	1 / 1	1 /				2	5 / 3	— /	Y	N	N	N	N	N	—
Haiti	160.5																			
Honduras	200.9																			
Jamaica	297.6																			
Mexico +	2,851.2				2 /	— /	— /	74 charts listed						Y		Y		Y	Y	
Nicaragua	159.8																			
Panama +	306.5	70	20	10	— / 1	4 / 5	15 / 3	— / —	— / —	— / 7	— / 12	— / 6	— / —	N	N	N	N	N	N	—

TABLE 4 (*continued*)

Coastal State[a] * IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (%)	Requiring resurvey (%)	Not surveyed (%)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Saint Kitts and Nevis																				
Saint Lucia																				
Saint Vincent and the Grenadines																				
Trinidad and Tobago * +	76.8	51	49	—	— 4	3 .	3 .	— —	— 1	— —	— 6	— 2	— —	N	N	N	N	Y	N	—
United States * +	9,711.4[d]	42	57	1	8 4	120 100	139 —	66 64	9 9	86 78	568 535	299 290	83 79	Y	Y	Y	Y	Y		94 × 137 cm

[a] Of 23 coastal States, 6 are members of IHO; 7 have national hydrographic services.
[b] Included in British Admiralty charts.
[c] Split 1/3:2/3.
[d] Including data for Puerto Rico, United States Virgin Islands, American Samoa, Guam, Johnston Atoll, Wake Island, Jarvis Island, Kingman Reef, Howland and Baker Islands, Northern Marianas.

TABLE 5. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: PACIFIC

Coastal State[a] * IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Fiji * +	1,135.3	0.9	—	99.1	— 2	3 7	— 2	3 3		10 10	16 14	14 14	— —					Y		630 × 980 mm
Kiribati	2,641.0																			
Nauru	431.1																			
Niue	. .																			
Samoa	96.0																			
Solomon Islands	1,116.1	10	2	88	— 1	1 2	1 (1)	— —	— —	1 6	7 3	4 83	—	N	Y	N	N	Y	N	675 × 954 mm
Tonga	596.8																			
Tuvalu	328.2																			
Vanuatu	. .																			

[a] Of 9 coastal States, one is a member of IHO and has national hydrographic services.

TABLE 6. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: SOUTH AMERICA

Coastal State* / * IHO member / + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships: Boats	Surveyors: Assistants	Cartographers: Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:500,000	1:500,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Latest symbols/ catalogue (year)	Tide tables	Publications: Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Argentina * +	1,164.5	50(5)	50(35)	–(60)	2 / 2	5 / 30	2 / 23	38 / 27	5 / 3	54 / 31	64 / 53	140 / 68	83 / 81	Y	Y	Y	Y	Y	Y	80 × 120 cm
Brazil * +	3,168.4	40	40	20	5 / 14	200 / 200	15 / 20	62 / 53	— / —	91 / 82	94 / 88	94 / 92	82 / 74	Y	Y	Y	Y	Y	Y	100 × 140 cm
Chile * +	2,288.2	60(20)	40(80)	–(–)	2 / .	11 / 9	5 / 15	. / 23	. / 1	. / 43	. / 138	. / 283	80 / 79	Y	Y	Y	Y	Y	Y	816 × 1,162 mm
Colombia	603.2																			
Ecuador * +	1,159.0	55(30)	5(–)	40(70)	1 / 1	10 / 22	7 / 7	2 / 1	— / —	17 / 9	21 / 12	30 / 13	76 / 81	Y	Y	N	N	Y		93 × 130 cm
Guyana	130.3																			
Peru * + o	1,026.9	.	.		1 / 3	. / .	. / .	. / 9	. / —	. / 6	. / 6	. / 33	. / 81	Y	.	.	.	Y		
Suriname	101.2	30	—	70	— / 3	2 / 4	1 / 1	1 / 1	— / —	1 / 1	6 / 6	— / —	77 / 77	Y	N	N	N	Y	N	—
Uruguay * +	119.3	80	20	—	— / —	3 / 10	1 / 6	. / 1	. / 2	. / 6	. / 5	. / 28	59 / 81	Y	Y	N	N	Y	Y	80 × 115 cm
Venezuela * +	363.8	40	40	20	1 / .	4 / 12	5 / 3	4 / 1	10 / 4	1 / 1	15 / 9	50 / 10	— / 81	Y	Y	Y	N	Y	Y	1.07 × 1.07 m

[a] Of 10 coastal States, 7 are members of IHO; 7 have national hydrographic services.

TABLE 7. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: SOUTH-EAST ASIA

Coastal State[a] * IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships Boats	Surveyors Assistants	Cartographers Draughtsmen	Charts Schemed/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Publications: Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
China * +	1,355.8	25	75	incl.	26 36	240[b] incl.	60[b] incl.	66 60	39 39	70 64	217 203	112 109	76 76	Y	Y	Y	N	Y		700 × 1,140 mm
Democratic Kampuchea	55.6																			
Democratic People's Republic of Korea	129.6																			
Indonesia * +	5,408.6	15(6)	20(10)	65(84)	2 1	12 21	4 13	55 55	—	183 183	50 50	81 81	78 83	Y	Y	Y	N	Y	Y	833 × 1,176 mm
Japan * +	3,861.1				5 17	77 53	19 11	318	27	216	152	286	79 82	Y	Y	Y	Y	Y	Y	720 × 1,060 mm
Malaysia * +	475.6	10	40	50	2 . . .	32 200	— —	— —	— —	— —	— —	— —	— —	Y	N	N	N	Y	N	—
Philippines * +	1,786.0	70	10	20	3 6	21 38	10 60	12 12	— —	76 76	47 47	42 37	— 83	Y	Y	Y	Y	Y		104 × 148 cm
Republic of Korea * +	348.4	75	15	10	10 2	32 18	15 15	100 12	2[c]	131[c] 99	77[c] 23	50[c] 12	80 78	Y	Y	Y	Y	Y		90 × 120 cm
Singapore * +	0.3	90	10	—	— 4	11 15	4 10	— —	— —	3 3	11 6	7 3	77 83	Y	N	N	N	Y	N	720 × 1,020 mm
Thailand * +	85.8	75	20	5	1 4	26 28	8 16	1 —	— —	8 8	32 32	16 16	78 79	Y	Y	N	N	Y		72 × 92 cm
Viet Nam	722.1																			

[a] Of 11 coastal States, 8 are members of IHO; 8 have hydrographic services.
[b] Split 1/3:2/3.
[c] Estimated data.

TABLE 8. STATUS OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING: SOUTH ASIA

Coastal State* • IHO member + Has national hydrographic services	Area of EEZ (thousands of km²)	Adequately surveyed (percentages)	Requiring resurvey (percentages)	Not surveyed (percentages)	Ships / Boats	Surveyors / Assistants	Cartographers / Draughtsmen	Charts Scheme d/Published at scales: Smaller than 1:300,000	1:300,000	1:300,000 to 1:100,000	1:100,000 to 1:25,000	Larger than 1:25,000	Latest symbols/ catalogue (year)	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications	Maximum chart printing size
Bahrain +	5.1	50	40	10	— 2	5 2	2	— —	—	—	—	4 —	2 —	—	N	N	N	N	N	Y	—
Bangladesh + o	76.8				3 8	35 incl.															
Burma +	509.5													Known to have a hydrographic organization at Rangoon							
Democratic Yemen	550.3																				
Djibouti	6.2																				
Ethiopia	75.8																				
India * +	2,014.9	5	23.5	71.5	8	63 156	21 44	76 38	74 27	139 44	230 78	97 29	80 82	Y	N	Y	N	Y	Y	80 × 125 cm
Islamic Republic of Iran *+	155.7																				
Iraq	0.7																				
Jordan	0.7																				
Kuwait	12.0																				
Maldives	959.1																				
Oman	561.7																				
Pakistan * +	318.5	20	80	0	3	21 27	5 10	4 1	— —	9 1	12 7	2	— —	Y	N	N	N	Y	N	762 × 1,067 mm
Qatar	24.0																				
Saudi Arabia	186.2																				
Sri Lanka *+	517.4																				

TABLE 8 (*continued*)

Coastal State[a] * *IHO member* + *Has national hydrographic services*	*Area of EEZ (thousands of km²)*	*Adequately surveyed* (percentages)	*Requiring resurvey* (percentages)	*Not surveyed* (percentages)	*Ships* / *Boats*	*Surveyors* / *Assistants*	*Cartographers* / *Draughtsmen*	*Charts Schemed/Published at scales:* *Smaller than 1:100,000*	*1:100,000 to 1:300,000*	*1:300,000 to 1:1,100,000*	*1:1,100,000 to 1:25,000*	*Larger than 1:25,000*	*Publications* *Latest symbols/ catalogue (year)*	*Tide tables*	*Light lists*	*Sailing directions*	*Radio signals*	*Notices to mariners*	*Other publications*	*Maximum chart printing size*
Sudan	91.6	—	—	100	— / 1	5 / 6	2 / 65	— / —	— / —	— / —	— / —	— / —	— / —	N	N	N	N	N	N	1.0 × 1.5 m
United Arab Emirates[c]	59.3																			
Yemen	33.9																			

[a] Of 20 coastal States, 4 are members of IHO; 7 have hydrographic services.

[b] The Islamic Republic of Iran is known to have a new project to develop its hydrographic organization.

[c] Sri Lanka, Oman and the United Arab Emirates are known to have new projects to develop hydrographic organizations.

TABLE 9. TOTAL ELEMENTS, BY REGION: 1983

Region	Response		EEZ		HOs	Personnel		Vessels		Area charted			Charts (Schemed/Published)					HOs having chart printing facilities	Publications						
	Coastal States	Responses	Total area of EEZ (thousands of km²)	EEZ area for which data reported (%)	National hydrographic organizations	Total trained personnel	% of which are field staff	Survey vessels	Small craft	Adequately surveyed (%)	Requiring re-survey (%)	Not surveyed (%)	Smaller than 1:300 000	1:300 000	1:100 000 to 1:300 000	1:25 000 to 1:100 000	Larger than 1:25 000		Symbols	Catalogue	Tide tables	Light lists	Sailing directions	Radio signals	Notices to mariners	Other publications
Africa	29	8	10,853.1	61	4	323	20	4	8	22.8	33.9	43.3	18/18	—/—	37/37	18/18	16/15	3		4	1	1	1	8	1
Australasia	4	4	11,696.1	100	4	222	67	5	4	10.0	7.8	82.2	72/32	105/54	734/103	172/115	85/57	2		3	1	—	—	2	1
Europe and Mediterranean	34	21	24,228.8	96	26	1,896	62	97	101	56.5	28.8	14.7	1,285/1,268	306/299	2,446/2,333	2,756/2,577	2,203/2,029	21		13	20	16	13	23	16
North America	23	6	18,979.6	68	7	610	56	23	103	47.3	27.7	25.0	255/204	67/33	364/225	1,514/1,194	1,212/1,123	4		5	4	4	2	5	1
Pacific	9	2	8,146.9	28	2	17	76	—	3	5.4	1.0	93.6	3/3	—/—	10/10	16/14	14/14	2		—	1	—	—	2	—
South-east Asia	11	8	14,228.9	94	8	1,069	77	49	70	45.7	25.0	29.3	552/457	68/68	687/649	586/513	594/544	7		8	6	5	3	8	2
South America	10	7	10,124.8	93	8	639	82	12	23	41.0	31.0	28	140/116	18/10	219/179	349/317	658/527	6		8	6	4	3	8	5
South Asia	20	4	6,159.4	41	8	469	68	14	11	18.8	35.9	45.3	80/39	74/27	148/45	246/85	101/29	3		2	—	1	—	2	2

Figure 56. International Hydrographic Organization: Responses and hydrographic offices, by region and coastal State

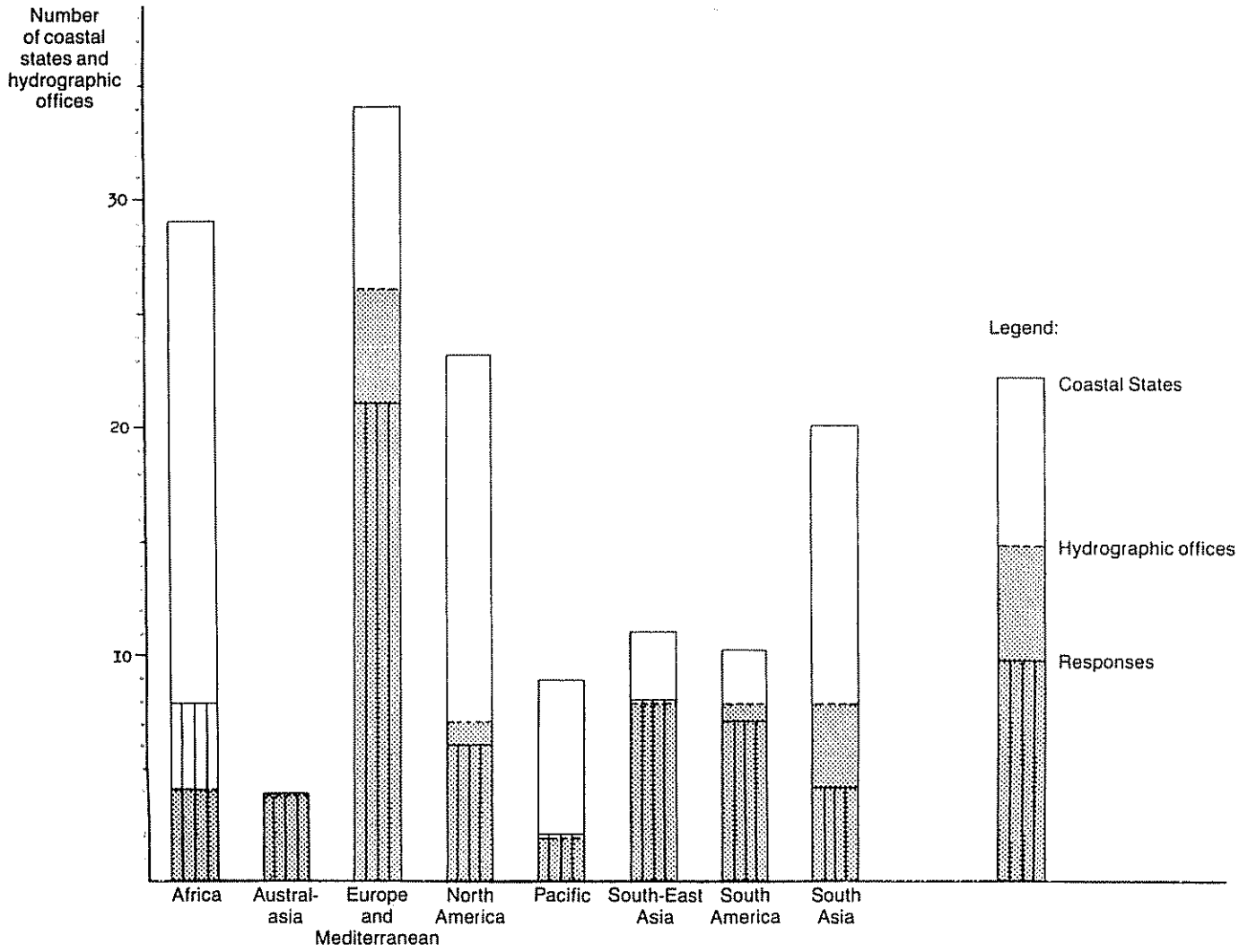


Figure 57. International Hydrographic Organization: Trained personnel, by region

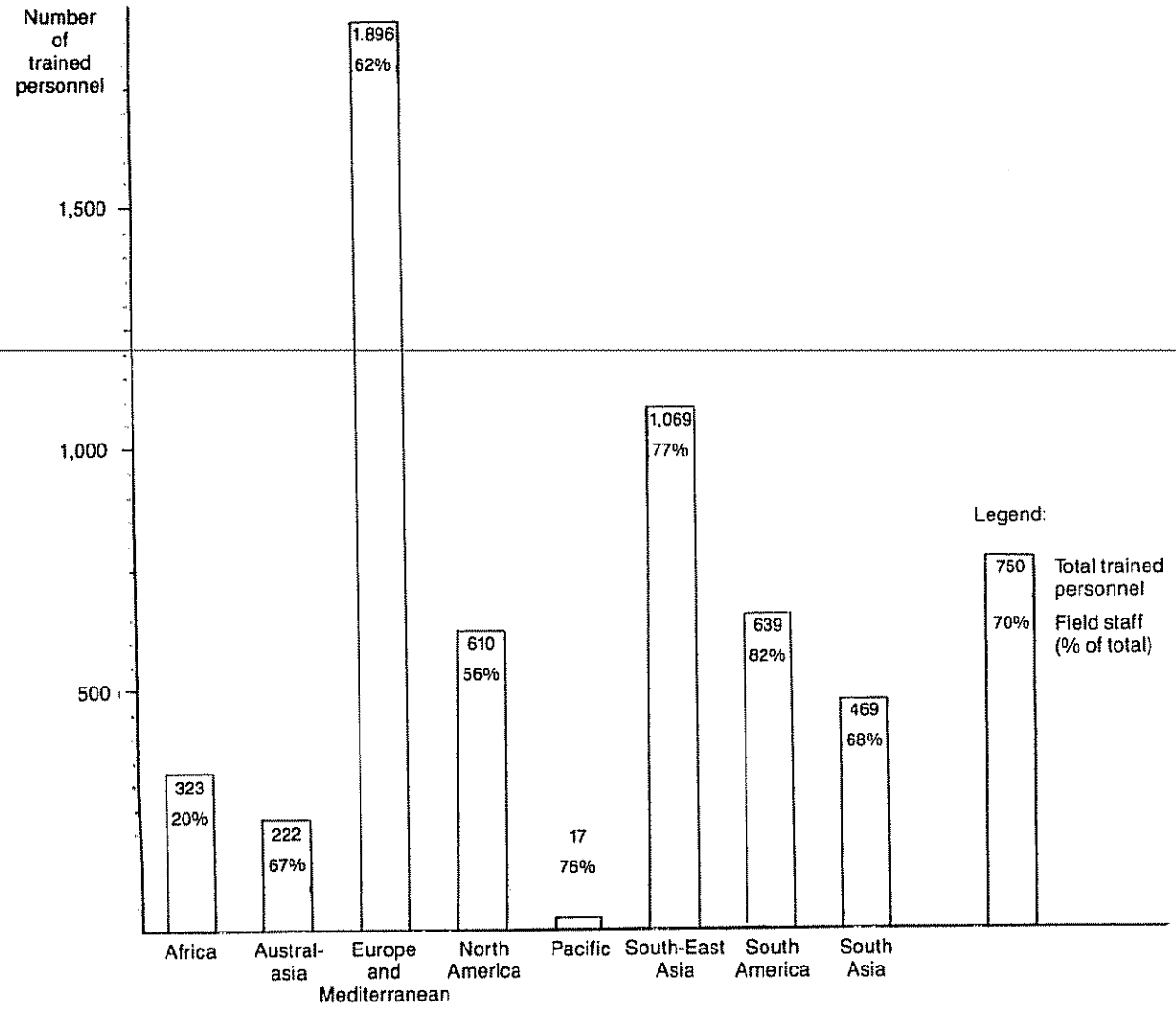


Figure 58. International Hydrographic Organization: Survey vessels and craft, by region

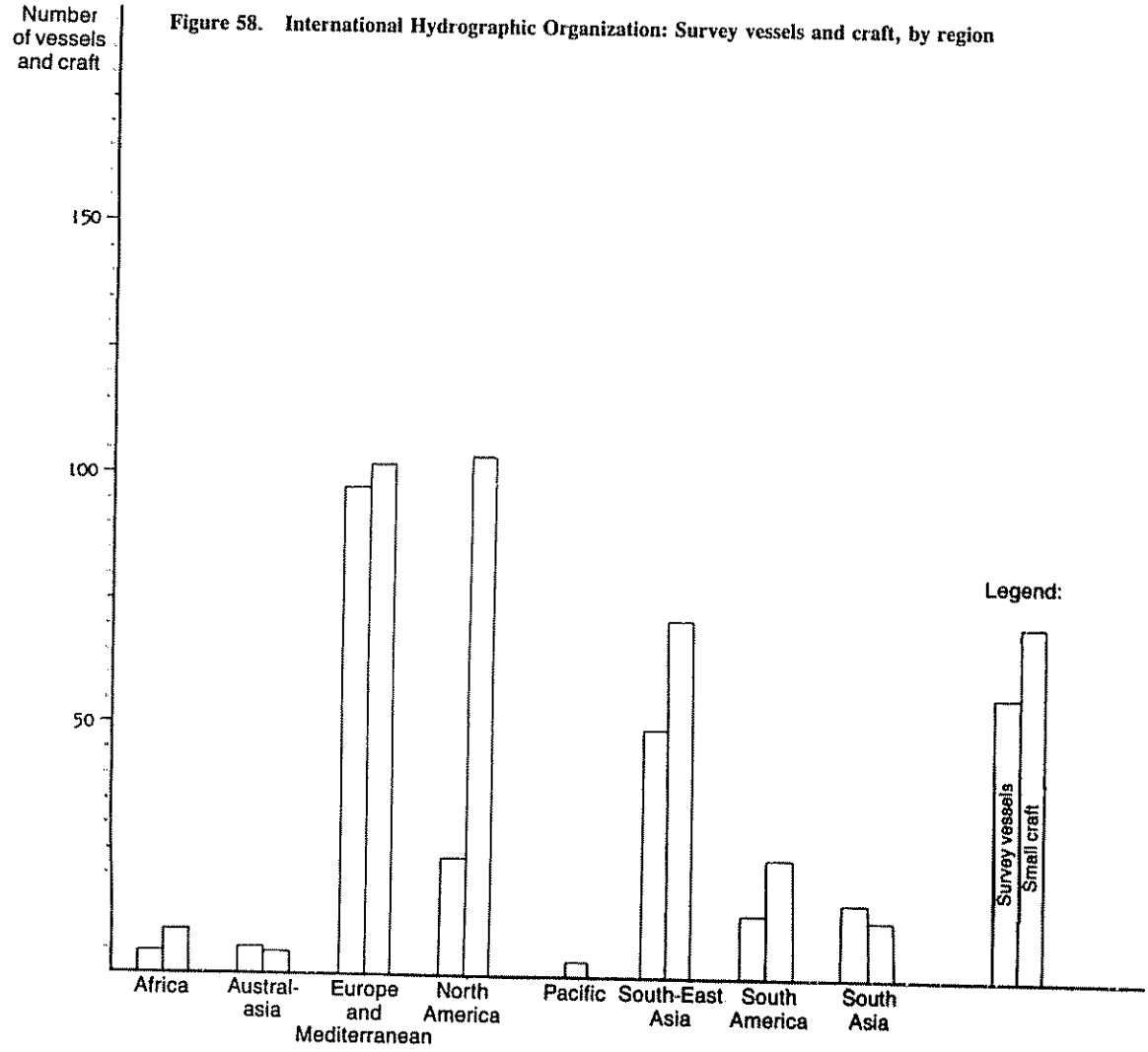


Figure 59. International Hydrographic Organization: Area charted, by region

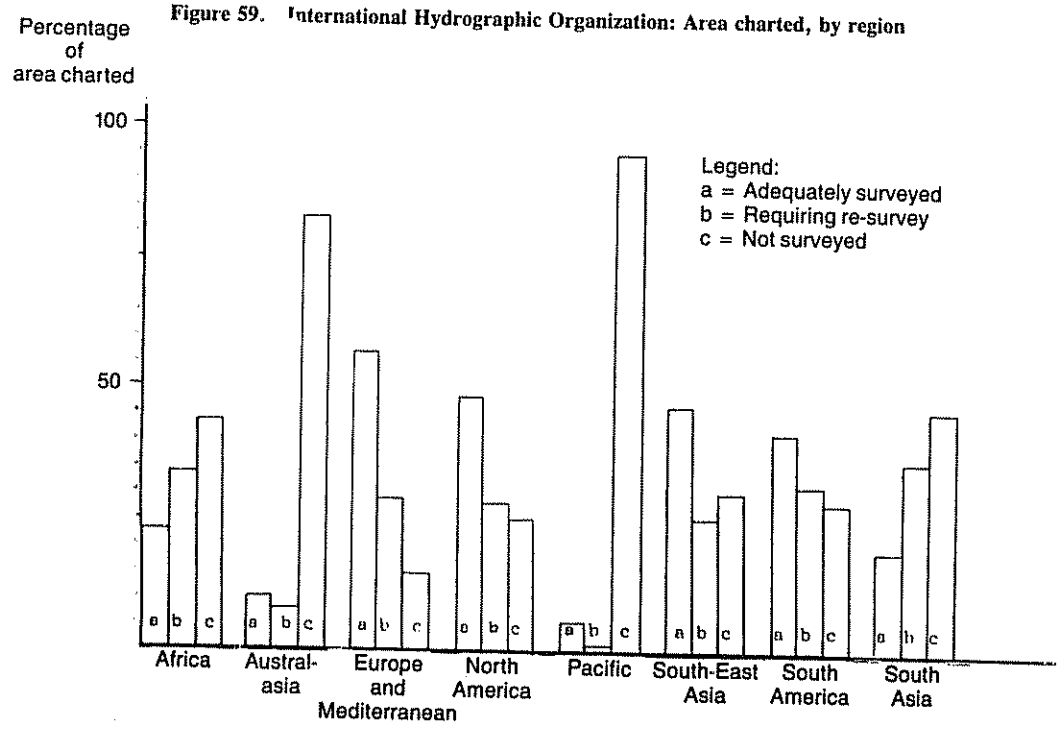
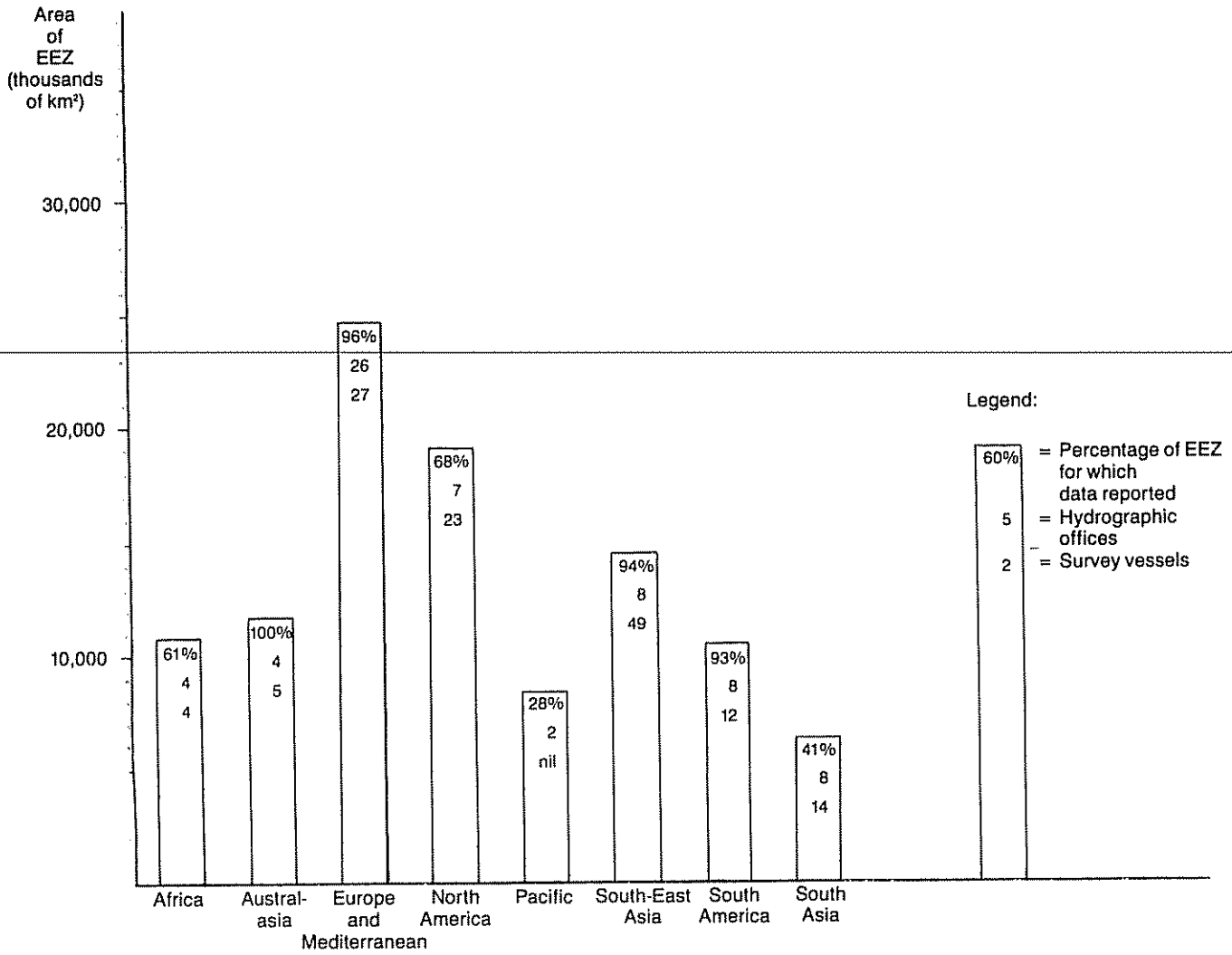


Figure 60. International Hydrographic Organization: Area of exclusive economic zones, by region



ANNEX

Questionnaire on the status of hydrographic surveying and nautical charting world-wide

Country (or Territory):

Date of validity of information:

1 The country has a national hydrographic organization:
YES _____ NO _____

2 By agreement(s), hydrographic surveys of national waters are carried out by: (NOTE: *Enter name of another country or "Private contractors"*)

A HYDROGRAPHY

1 The state of hydrographic surveying in the area of the national maritime zone:

(*a*) Percentage of area which is surveyed adequately for present requirements:

(*b*) Percentage of area which requires re-survey at larger scale or to modern standards:

(*c*) Percentage of area which has never been systematically surveyed:

TOTAL 100%

2 If primary responsibility is accepted for hydrographic surveying in areas external to the national maritime zone—give limits:

State of surveying such area:

(*a*) Percentage of area which is surveyed adequately for present requirements:

(*b*) Percentage of area which requires resurvey at larger scale or to modern standards:

(*c*) Percentage of area which has never been systematically surveyed:

TOTAL 100%

NOTE: Question A2 is intended to provide information concerning areas for which a developed nation may have accepted responsibility, by agreement, on behalf of a developing country.

3. Survey vessels and launches available for surveying:

Displacement or length	*Number of vessels*	*Number of hydrographers*	*Number of assistants*

4. Number of trained hydrographic personnel employed by the national hydrographic service:

a Hydrographic surveyors .....

b. Assistants/Survey recorders .....

B NAUTICAL CHARTING

1. If the area covered or intended to be covered by national charts extends beyond the national maritime zone, indicate the limits:

2. The number of charts schemed for the complete national series and the number which have already been published:

	Schemed		Published	
a. Smaller scale than 1/300 000	Schemed		Published	
b. Scale 1/300 000	"		"	
c 1/100 000 to 1/300 000	"		"	
d 1/25 000 to 1/100 000	"		"	
e. Larger scale than 1/25 000	"		"	
	TOTAL _____		TOTAL _____	

NOTE: These tables are intended to provide the means of assessing the overall status of world charting without regard to the standard of the surveys on which the charts are based; nevertheless, it will be assumed that the scale of the published chart is an indication of the scale of the survey on which it is based.

3. The date of the latest Catalogue/List of Charts and List of Symbols and Abbreviations used on National Charts:

Catalogue ☐ Symbols & Abbreviations ☐

4. Nautical documents published nationally:

	(YES/NO)		*(YES/NO)*
a Tide Tables		*d.* Radio signals	
b. Light Lists		*e.* Notices to Mariners	
c. Sailing Directions		*f.* Others	

5. The number of trained cartographers and/or cartographic draftsmen employed by the national cartographic authority:

a. Cartographers .....

b. Draftsmen .....

6. Does the national hydrographic service print its own charts?

YES ☐ NO ☐

7. The maximum size sheet which can be printed:

(f) *Development of digital data bases*

BASE DE DONNÉES À PETITE ÉCHELLE*

Document présenté par la France

SUMMARY

In view of the overall needs expressed and the circumstances as they relate to the present and the immediate future, the National Geographical Institute has provided in its programmes for the next 5 to 10 years for the setting up of digital data bases concerned with all information contained on small-scale maps (from 1:100,000 to 1:1,000,000) covering France's metropolitan territory.

The degree of accuracy of planimetric localization is about 10 metres, which is compatible with the SPOT-satellite resolution and with future capacities for rapid localization.

The contents of the data base are briefly referred to in the text and their structure in the base is explained.

This innovation will ensure a greater coherence of data and will enable small-scale data users to be supplied with specific regularly updated products.

RESUMEN

El conjunto de necesidades específicas y circunstancias coyunturales en la actualidad y en un futuro próximo han llevado al Instituto Geográfico Nacional a definir, en sus programas para los próximos cinco a diez años, la creación de bases de datos digitales relativas a todos los datos de mapas en pequeña escala, desde 1:100.000 hasta 1:1.000.000 que abarcan el territorio nacional de Francia.

La exactitud de la localización planimétrica se fija en unos 10 metros, valor compatible con el poder de resolución del satélite SPOT y la capacidad futura de localización rápida.

En el texto se recuerdan brevemente los objetos de la base de datos y su estructura en la base.

El concepto de la base de datos permitirá, al asegurar una mayor coherencia de los datos, atender a la comunidad de usuarios de datos en pequeña escala con productos específicos actualizados periódicamente.

L'ensemble des besoins exprimés et des circonstances conjoncturelles, situés dans l'immédiat et le futur proche, ont conduit l'Institut géographique national (IGN) à définir, dans ses programmes des cinq à dix prochaines années, la création de bases de données numériques concernant l'ensemble des informations des cartes à petite échelle du 1/100 000 au 1/1 000 000 couvrant le territoire national métropolitain.

La précision de localisation planimétrique est fixée à 10 mètres environ, compatible avec la résolution du satellite SPOT et les futures capacités de localisation rapide.

Les objets de la base de données sont rappelés succinctement dans le texte, et leur structure dans la base est évoquée.

Le concept de base de données permettra, tout en assurant une plus grande cohérence des données, de satisfaire la communauté des utilisateurs de données à petite échelle en produits spécifiques régulièrement mis à jour.

Besoins

La Commission nationale des informations géographiques a souligné le besoin de constituer une base de données topographiques dont le délai d'achèvement actuellement envisagé serait d'environ trente ans; la base de données à petite échelle peut être considérée comme une préparation à la problématique de la base de données topographiques : l'ensemble des problèmes d'organisation de la base, une partie de ceux relatifs à la saisie de l'information, en particulier l'affectation des attributs, en sont autant de contributions.

L'aspect numérique de la cartographie est une option à prendre, pour l'instant, non pas pour des gains de coûts à court terme sur la cartographie traditionnelle, mais pour la volonté de mise à disposition d'un plus grand choix de produits répondant au mieux aux besoins des utilisateurs pour leur permettre d'apporter leur surcharge afin de localiser les données qui leur sont propres.

A l'extérieur de l'IGN, parmi les utilisateurs potentiels de la base de données à petite échelle on trouve, sans conteste, les télédétecteurs dont l'échelle de prédilection sera le 1/100 000 dès l'avènement de SPOT. Citons l'intérêt que suscitera cette base de données chez les aménageurs, ministères, agronomes, agences de bassin, etc.

Enfin, et c'est là une constante historique, les militaires, qui ont toujours été, en France, à l'origine des séries cartographiques, sont eux aussi intéressés par la saisie numérique des données cartographiques à petite échelle.

A l'intérieur de l'IGN, les premières applications de la base de données à petite échelle se retrouvent en cartographie thématique, géomatique, cartographie aux échelles dérivées de la carte de base (1/100 000, 1/250 000, ...), télédétection, etc.

C'est en partie à cause du vieillissement des éléments de reproduction des séries dérivées que la proposition de constituer une base de données à petite échelle a été faite puis acceptée, dans le but d'assurer la réfection de ces séries, réfection qui est devenue une nécessité impérative.

Objectifs

La base de données à petite échelle sera constituée d'informations présentant les caractéristiques suivantes :

a) Précision de localisation compatible avec le 1/100 000 et avec SPOT;

b) Age moyen des informations de 1 et 2 ans.

Sa constitution doit prendre en considération, en priorité, les besoins propres de l'Institut tout en restant ouverte aux besoins de la communauté des utilisateurs.

* The original text of this paper, prepared by François Salge, National Geographical Institute, appeared as document E/CONF.77/L.32.

L'objectif premier de la base de données est bien sûr de satisfaire les besoins rappelés au paragraphe précédent.

Du fait de la coïncidence calendaire avec le projet SPOT, sa constitution devrait commencer au début de l'année 1986 pour être achevée vers 1992.

Tenir ce calendrier est d'une importance capitale; pour ce faire d'importants moyens sont mis en œuvre pour assurer les études théoriques liées à la structure des données et pour effectuer les développements informatiques d'outils nécessaires à la saisie des objets de la base, à leur gestion et à la production de planches mères pour l'édition cartographique.

La mise à jour des informations de la base devrait pouvoir se faire avec une périodicité d'un an (thèmes principaux) à deux ans (thèmes secondaires).

L'appellation BDPE découle de ces objectifs. En effet le contenu de la base devra répondre à des normes de type 1/100 000 même si l'information géométrique résulte de la numérisation de documents à plus grande échelle.

Le contenu de l'information

Il n'est pas nécessaire au niveau de cette présentation de détailler le contenu de l'information. Cependant, ce paragraphe précise globalement les objets que la base se propose de gérer. Par souci de clarté, ceux-ci sont classés selon une taxonomie évidente.

Communication :
- Routes
- Voies ferrées
- Echangeurs
- Itinéraires
- Nœuds des réseaux de communication (gare, péage, douane, . .)
- Zones de communication (aire de triage, parking, . .)

Hydrographie :
- Bassins versants
- Canaux et cours d'eau
- Eaux de surface (lacs, marais, glaciers, . .)
- Nœuds du réseau hydrographique (barrages, écluses, . .)

Autres réseaux et ouvrages filiformes :
- Réseaux de transport d'énergie (électricité, gazoduc, . .)
- Nœuds de réseaux (centrale électrique, . .)
- Ouvrages filiformes (téléphérique, . .)

Objets isolés :
- Objets ponctuels (mines, usines, . .)
- Objets zonaux (usines, . .)
- Agglomérations*

Orographie:
- Courbe de niveaux
- Points cotés
- Points orographiques (pics, caps, cols, . . .)
- Orographie de surface (monts, massifs, baies, . .)

Administration :
- Unités administratives (communes, département, . .)
- Parcs et assimilés

Matrice d'occupation du sol :
- Milieu naturel
- Milieu artificiel

*A priori, issues géométriquement de SPOT; ne sont considérés que les groupes d'habitations visibles sur les images spatiales (plus de 4 ha). Rien n'est décidé quant aux hameaux de moins de 4 ha; faut-il les garder ou est-ce une information inutile aux petites échelles?

Les toponymes et les caractéristiques culturelles et touristiques sont analysés comme des qualificatifs des objets de la base de données et à ce titre ils n'apparaissent pas dans la liste précédente.

La saisie des informations

Pour chaque ligne de la nomenclature précédente, il y aura lieu de mettre en œuvre par des méthodes distinctes une saisie séparée des éléments à numériser qui sont ceux que traditionnellement on trouve dans la *carte de France au 1/100 000* à quelques exceptions près.

Le contexte d'émergence de cette base de données cartographiques à petite échelle se caractérise entre autre par le lancement du satellite SPOT (octobre 1985). En ce qui concerne l'aspect traitement des images SPOT dans un contexte d'étude de télédétection, il est indéniable que cette base de données apportera les éléments indispensables de description de la topographie pour la corrélation entre image et terrain. En retour, les images SPOT formeront un ensemble de données particulièrement utiles pour sa mise à jour. Plusieurs méthodes peuvent être envisagées, de la simple photointerprétation à l'extraction automatique de formes.

D'une façon générale les éléments ponctuels et les éléments linéaires peu denses seront saisis directement à la table à numériser à partir de la cartographie au 1/50 000 ou au 1/25 000. Les éléments linéaires denses seront numérisés par scannage de redessins au 1/50 000 ou de masques généraux (cas des routes) à cette même échelle. Les éléments zonaux seront, quand c'est possible, issus de classifications d'images spatiales. Les courbes de niveau et les points cotés seront issus de la base de données altimétrique en cours de constitution à l'IGN à partir de la numérisation du relief francais déjà effectuée.

Les attributs des objets seront rentrés à l'aide de tables à numériser et de consoles de visualisation graphique.

L'IGN s'oriente vers la saisie de la géométrie des objets retenus, à partir de la cartographie au 1/50 000, pour des raisons d'actualité de la carte et de précision topométrique des éléments.

Siructure de la base

Il est encore trop tôt pour préciser la structure de la base de données et le choix définitif n'interviendra que vers l'été 1985. Cependant on pense utiliser trois concepts fondamentaux : les objets de la base seront décomposés en portions homogènes par rapport à une liste d'attributs; les informations graphiques reposeront sur une structure empruntée à la théorie des graphes (arcs-sommets) et elles seront regroupées par dalles de petite dimension, un maillage de l'espace étant assuré au préalable; chaque maille regroupe les informations ''vecteurs'' incluses géographiquement.

Conclusion

On peut espérer dans les années 1986-1990 mettre à la disposition de tous les utilisateurs d'informations cartographiques des fichiers de données topographiques servant de localisant aux études spécifiques et améliorer les productions cartographiques actuelles de l'IGN.

De même multiplier les capacités de cartographies spéciales à toutes échelles comprises entre le 1/100 000 et le 1/500 000 et dans tout découpage destiné à mieux satisfaire les besoins spécifiques est une perspective plausible pour les prochaines années.

Le concept même de base de données permettra une plus grande cohérence des données, tout en accroissant la multiplicité des produits. Ces objectifs et cette conception ne prennent tout leur sens aujourd'hui que par la ferme espérance suscitée par les données issues des satellites de pouvoir en assurer la mise à jour régulière dans les délais compatibles avec les besoins (un à deux ans).

UNE BASE DE DONNÉES ALTIMÉTRIQUES À L'IGN-FRANCE*

Document présenté par la France

SUMMARY

Early in 1985, the National Geographical Institute of France completed the digitalization of France's relief at medium scale. These data represent 1.5 billion bytes of information (about 200 million points obtained from 3,000 units).

Concurrently, a system was developed to manipulate these data, which will serve as a practical tool for the following purposes: space-imagery rectification, production of orthophotographs, slope, insolation and intervisibility maps, perspective views, hill-shading and generalized contours.

An "on-line" data base was selected containing the acquired data (contours and spot heights) in geographical coordinates.

Later, software was specified for:

(a) *Data base management*: information security; obtaining qualitative and quantitative information about the data-base content; and data correction and revision. The latter facility will be very important during the two years required for loading the data base, because of the need to ensure compatibility among the measurement units.

(b) *Use of the data base*: supplying drawings of any zone whatsoever, at the basic or a derived scale, and calculation of digital terrain models over a wide range of intervals and orientations as well as derived products, all at short notice (within a half day at most).

For the data-base structure, the principle was adopted of continuous space embracing all of France and divided into geographical boxes of the same size (about ¼ km²), the elements being linked from one box to the next. This data structure will improve access to the information both for data-base revision and digital-model calculations.

RESUMEN

A principios de 1985, el Instituto Geográfico Nacional de Francia terminó la digitalización del relieve en mediana escala de Francia. Estos datos representan 1.500 millones de octetos de información, es decir, unos 200 millones de puntos obtenidos en 3.000 unidades.

En forma simultánea, se elaboró un sistema para ordenar estos datos que constituirá un instrumento práctico para los siguientes fines: rectificación de imágenes espaciales, producción de ortofotografías, mapas de inclinación, insolación e intervisibilidad, vista de perspectivas, sombreado de colinas, perfiles generalizados del terreno.

El Instituto ha seleccionado una base de datos "en línea" que contiene los datos adquiridos (perfiles del terreno y cotas) en coordenadas geográficas.

Más tarde, el Instituto elaboró programas para lo siguiente:

a) *La gestión de la base de datos:* seguridad de la información, obtención de información cualitativa y cuantitativa acerca del contenido de la base de datos, corrección y actualización de los datos; cabe señalar que este último punto revestirá gran importancia durante los dos primeros años que demorará cargar la base de datos, debido principalmente a que es preciso asegurar los vínculos entre las unidades de adquisición de datos.

b) *La utilización de la base de datos:* el suministro de planos de una zona cualquiera, a escala básica o derivada, el cálculo de modelos digitales de terreno en una amplia gama de intervalos y orientaciones, así como productos derivados, en forma rápida, es decir, medio día como máximo.

Para estructurar la base de datos, el Instituto adoptó el principio de un espacio continuo que cubre toda Francia, dividido en cuadros geográficos del mismo tamaño (0,25 km²), cuyos elementos están vinculados de un cuadro al siguiente. Ello permitirá mejorar el acceso a la información para fines de revisión de la base de datos y efectuar cálculos sobre los modelos digitales del terreno.

De fait, beaucoup d'applications n'avaient pas jusqu'alors été sérieusement développées par manque de perspectives à court terme pour avoir les données. Maintenant que la numérisation s'achève, le besoin se fait sentir de mettre en place les moyens pour répondre, d'une part, aux nécessités d'études, d'autre part, à des grandes productions assez régulières (rectification d'images spatiales, confection d'orthophotographies, utilisations cartographiques telles que courbes de niveau généralisées et estompage).

Des études de faisabilité, des expériences et des démonstrations, il faut passer à la production. La première condition de ce passage était d'abord l'existence des données couvrant le territoire national, les suivantes sont la fiabilité et la disponibilité réelle de ces données. Pour cela, il est grand temps de passer des quelque 3 000 fichiers non parfaitement homogènes et répartis sur près de 300 bandes magnétiques à un ensemble informatique cohérent permettant à tous les usagers d'accéder simplement et rapidement aux données

* The original text of this paper, prepared by D. Piquet-Pellorce and A. Bernard, appeared as document E/CONF.77/L.33.

et comportant les outils essentiels pour mettre en œuvre les applications de grande exploitation.

Pouvoir traiter chaque jour l'accès à des zones de plus de 60 km sur 60 km avec une orientation quelconque et produire une matrice au pas de 50 m, soit environ 1 200 sur 1 200 points pour rectifier une image SPOT, pouvoir accéder à une zone de 40 km sur 60 km et en zone montagneuse sortir un modèle numérique au pas de 25 m pour produire une planche d'estompage et une planche de courbes de niveau généralisée, pouvoir dans l'heure produire le modèle numérique de terrain (MNT) au pas de 20 m ou 25 m pour une orthophotographie, voilà les vraies raisons pour créer une banque de données du relief.

Fonction et utilisations de la base

Sans rentrer dans les détails de l'architecture de la base de données, on indiquera du moins qu'elle repose sur un découpage en modules élémentaires de 0,8 × 0,4 cgr, les courbes de niveau restant sous forme vectorielle et chaînées d'un module à l'autre. L'archivage sur disques magnétiques s'est avéré nécessaire, du fait de la multiplicité des types d'utilisations prévues, dont notamment celles liées à la rectification d'images satellitaires, qui couvrent de grandes surfaces et mettent en jeu de nombreux fichiers altimétriques. Cet archivage en-ligne, compatible avec la technologie actuelle et avec l'avènement des disques optiques numériques, contraste avec l'archivage sur bandes magnétiques qui était seul retenu lors du premier système de gestion de base de données géographiques de l'IGN.

Nous distinguerons ici les programmes de gestion de la base et les programmes d'utilisation qui fournissent soit un produit "brut" (MNT, fichiers de CNN), soit un produit plus élaboré (carte de pente, d'intervisibilité, dessin des courbes généralisées ou non).

Gestion de la base

Les fonctions assurées sont l'insertion de nouvelles données, l'extraction, le remplacement de données anciennes, la gestion de l'état de la base, les corrections et mises à jour ainsi que les transformations de coordonnées. Les trois premiers points n'appellent pas de remarques particulières si ce n'est que ces opérations sont faites par nombre entier de pavés.

Gestion de l'état de la base

Sont enregistrées, pour chaque fichier (feuille au 1/50 000 normalisée), la méthode de numérisation, les dates de saisie des informations et des corrections éventuelles, des indications sur la qualité des données, que ce soit en vue de l'édition cartographique des CNN ou de l'utilisation à partir d'un MNT, ainsi que des indications quantitatives (altitudes extrêmes, nombre de points, équidistance, etc). Sont prévus des sorties graphiques et des états imprimés de ces informations.

Correction et mise à jour

C'est la partie la plus volumineuse de ce logiciel de gestion; il est à noter qu'elle sera utilisée intensivement durant la montée en charge de la base : il est en effet prévu d'y affecter une dizaine de personnes pendant deux ans. Les corrections concernent les erreurs dues à la numérisation, mais surtout les raccords entre les unités de saisie. A l'issue de ce laps de temps, nous posséderons une base suffisamment fiable dont le rythme de mise à jour sera beaucoup plus lent, suivant la réfection de la carte de base. L'opérateur ayant indiqué la zone sur laquelle il désire travailler, le système extrait les pavés concernés et constitue un fichier de travail qui sera modifé au cours des séances de correction; une fois celles-ci terminées, il replace dans la base les pavés utilisés. Le programme de correction utilise une table à numériser, une console graphique couleur à balayage télévision et une console alphanumérique, le tout connecté sur mini-ordinateur.

Le pavage défini plus haut est doublement bénéfique :

a) L'affichage sur la console graphique se fait par pavés entiers;

b) La désignation d'une courbe par pointé sur la table à numériser est extrêmement rapide (1 à 5 dixièmes de seconde), car la recherche ne se fait que dans un seul pavé. De plus, la souplesse d'agencement des pavés permet de définir un fichier de travail centré sur une zone intéressante (par exemple une ligne de raccords).

Transformations de coordonnées

Celles-ci étant archivées en coordonnées géographiques, et la plupart des utilisateurs travaillant dans d'autres systèmes de coordonnées, les transformations correspondantes seront utilisées très fréquemment; il est donc indispensable qu'elles soient rapides. C'est le cas grâce au pavage du territoire. En effet, la taille des pavés est telle qu'à l'intérieur d'un groupe de plusieurs pavés toutes ces transformations sont linéarisables, sans aucune perte de précision. Il s'ensuit que le coût informatique de ces transformations est très faible (environ 15 000 points transformés par seconde).

Utilisation de la base

Une fois mis en place les outils permettant de gérer la base, il s'agit de fabriquer ceux grâce auxquels les divers utilisateurs pourront utiliser la base de manière sûre et efficace; ils pourront obtenir des produits bruts, qui constituent le service minimal de la base, ou des produits finis, cartographiques ou numériques. Nous allons passer en revue tous les produits qui seront disponibles dès le démarrage de la base, étant entendu que la liste n'en est pas limitative, des développements étant toujours en cours à l'Institut géographique national (IGN). Précisons que pour tous les produits, le système de coordonnées est paramétrable, et que la zone de travail est définie par un polygone quelconque. Pour les sorties graphiques, nous pouvons actuellement utiliser, au choix, traceurs rapides (encres, pointes billes, feutres), imprimantes électrostatiques ou laser caméra. Les courbes de niveau seront, au gré de l'utilisateur, chaînées ou non; une équidistance différente de celle de la base pourra être spécifiée; un algorithme filtrant pourra éliminer un certain nombre de points jugés superflus.

Les MNT seront le produit le plus demandé; il est donc particulièrement important de les fournir à un coût raisonnable avec la meilleure précision compatible avec les données. Les méthodes de calcul à l'IGN, comme dans beaucoup d'autres organismes, ont fait l'objet de nombreuses études et développements depuis maintenant plus de 10 ans. La méthode que nous exposons ici est employée à l'IGN depuis 18 mois en production.

On commence par déterminer les intersections des courbes de niveau avec les droites du maillage $x = xi$ et $y = yj$. Sur chaque droite $x = xi$, on obtient une suite d'intersections que l'on classe par ordonnées croissantes et à partir desquelles on interpole les altitudes aux nœuds du maillage. L'interpolation est linéaire ou cubique selon que les altitudes entourant le nœud sont distinctes ou non. De manière symétrique, on obtient les altitudes aux nœuds à partir des intersections avec les droites $y = yj$. On adopte alors comme altitude du nœud l'altitude correspondant à la

direction selon laquelle la pente est la plus forte, si elle existe, la moyenne des deux altitudes sinon. On introduit alors les points cotés en affectant leur altitude au nœud le plus proche. On obtient à ce moment un modèle approché. Le modèle définitif est calculé par la méthode de la grille élastique de M. de Masson d'Autume programmée sur processeur de tableau AP 120 B. Les valeurs Zij des altitudes aux nœuds sont les solutions au sens des moindres carrés du système linéaire suivants :

$$Zi-1,j + 2\,Zi,j + Zi + 1,j = 0$$
$$Zi,j-1 + 2\,Zi,j + Zi,j + 1 = 0$$
$$Zi,j = zi,j \text{ avec un poids } Pi,j$$

Les z i,j étant les altitudes approchées.

Le choix des Pi,j est délicat; celui qui a été fait s'est révélé satisfaisant : dans le cas où zi,j est l'altitude d'un point coté, Pi,j a une valeur constante élevée, sinon, d étant la plus courte distance d'un nœud à une courbe de niveau suivant une des deux directions du réseau, Pi,j est une fonction décroissante de d. Cette méthode, éprouvée en production, fournit des MNT de qualité satisfaisante, avec lesquels on peut envisager des applications très exigeantes telles l'estompage et la généralisation. Les temps de calcul, avec les matériels dont nous disposons actuellement, VAX 11/780 de DEC et AP 120 B de FPS, sont de 10 à 15 minutes pour une grille de 300 sur 300 au pas de 50 m. Le pas étant fixé, ce temps est proportionnel au nombre de nœuds; par contre, si le nombre de nœuds est fixé, c'est une fonction décroissante du pas : en effet, plus le pas est faible, plus les Pi,j sont faibles, donc plus la convergence est longue à atteindre.

Les produits dérivés des MNT les plus courants sont les vues perspectives, les hypsométries, les estompages et les cartes de pente, ces dernières n'étant d'ailleurs que des estompages particuliers avec un soleil au zénith.

Seuls parmi ceux-ci,les estompages risquent d'être produits en grand nombre pour les besoins internes à l'Institut. Un cas un peu particulier est celui de la généralisation des courbes de niveau. Deux méthodes totalement différentes, qui donnent des résultats très comparables, ont été développées. La première concerne le lissage des courbes de niveau, la seconde est une interpolation de ces mêmes courbes à travers un MNT. Les essais que nous avons effectués montrent que la première méthode s'avère meilleure dans les terrains très peu accidentés et où les courbes de niveau sont assez indépendantes les unes des autres et, par ce fait, peuvent être lissées indépendamment, alors que la seconde est nettement préférable dans les terrains accidentés, là où les courbes s'emboîtent et où le traitement doit être global pour respecter ces emboîtements.

Les résultats obtenus soutiennent, du point de vue de la qualité, la comparaison avec la généralisation traditionnelle; de plus, les délais et les coûts sont de beaucoup inférieurs (une vingtaine d'heures d'opérateur contre 150 heures de dessinateur pour une feuille au 1/100 000), si bien que la production des planches d'altimétrie au 1/100 000 a commencé dès cette année par méthode automatique.

Conclusion

Dès la fin de 1983, avant même que la numérisation du relief français soit totalement terminée, nous disposerons des outils pour charger la base.

Dès le début de 1984, les corrections pourront commencer et les utilisateurs pourront faire calculer les premiers modèles numériques de terrain.

L'ensemble du logiciel que nous avons décrit sera intégré l'année prochaine et continuera à être développé. Nous avons la certitude que cette base va rendre opérationelles les productions automatisées à partir du relief numérique déjà programmées : généralisation, estompage, orthophotographies, rectification d'images spatiales (niveau 3 de SPOT) et faciliter les études et développements de nouveaux produits dont on perçoit nettement le besoin grandissant. Elle est aussi le premier élément d'une base de données topographiques dans la constitution de laquelle l'IGN s'engage résolument.

A STANDARD LINEAR FORMAT AND FEATURE/ATTRIBUTE CODING SCHEME FOR MAP DATA*

Paper submitted by the United States of America

RÉSUMÉ

L'Agence cartographique de la défense a mis au point un système maniable, efficace et souple de structuration et de présentation pour l'échange, la manipulation et le stockage des données numériques de détails cartographiques, c'est-à-dire des données planimétriques et/ou hypsométriques dérivées de l'établissement de cartes hydrographiques, topographiques ou aéronautiques. L'Agence a en outre élaboré un schéma de codage détail/caractéristiques, conçu pour accompagner le système de présentation linéaire normalisée, pour tous les documents cartographiques établis à partir de données numériques.

Le présent document contient un historique et une description technique du système de présentation linéaire normalisée (SLF). On y présente également un schéma de codage détail/caractéristiques (FACS), grâce auquel un code

RESUMEN

El Organismo de Cartografía de la Defensa ha elaborado una estructura y un formato de datos portátiles, eficaces y flexibles para el intercambio, la manipulación y el almacenamiento de datos sobre accidentes cartográficos digitales, consistentes en información planimétrica o hipsométrica originada en la obtención de materiales hidrográficos, topográficos y aeronáuticos. Además, el Organismo ha elaborado un esquema de codificación de accidentes y atributos que puede utilizarse en todos los materiales de datos cartográficos digitales en combinación con el Formato Linear Estándar.

La monografía presenta los antecedentes históricos y la descripción técnica del Formato Linear Estándar. También introduce un esquema de codificación de accidentes y de atributos que permitirá identificar un accidente determinado mediante un código común de cinco caracteres, cualquiera que sea el material en que aparezca. Análogamente, el esquema de codificación prescribe un conjunto independiente

* The original text of this paper, prepared by Opal R. Stroup, Defense Mapping Agency, appeared as document E/CONF.77/L.18

commun à cinq caractères permet d'identifier un détail cartographique donné indépendamment du produit sur lequel il figure. Ce schéma attribue de même à chaque détail déterminé un ensemble de caractéristiques possibles, indépendamment du produit.

La présentation linéaire normalisée offre plus de souplesse que les structures classiques de traitement numérique des données cartographiques et se prête particulièrement à la représentation de détails de zones limitrophes. Le FACS fournit une liste unique normalisée de détails et de caractéristiques pour la collecte des données numériques nécessaires à l'établissement des produits cartographiques — numériques ou imprimés — de l'Agence.

L'utilisation de la SLF et du FACS facilitera le stockage, l'échange et la collecte des données cartographiques numériques.

Mots clefs : Présentation linéaire normalisée (SLF), schéma de codage détail/caractéristiques (FACS), structure des données en réseau de points nodaux, structure des données spatiales, structure des données cartographiques, données cartographiques numériques.

del material de categorías de atributos admisibles para cada accidente determinado.

El Formato Linear Estándar proporciona una alternativa flexible a las estructuras tradicionales para los datos cartográficos digitales y se presta bien a la representación de accidentes superficiales colindantes. El esquema de codificación de accidentes y atributos proporciona una lista única y uniforme de accidentes y posibles atributos que pueden utilizarse en la recopilación de datos digitales en apoyo de los materiales cartográficos digitales y sobre papel del Organismo de Cartografía de la Defensa.

La utilización del Formato Linear Estándar y el esquema de codificación de accidentes y atributos facilitará el almacenamiento, el intercambio y la reunión de datos cartográficos digitales.

Palabras clave: Formato Linear Estándar, esquema de codificación de características y atributos, estructura de datos de nodos de conexión, estructura de datos espaciales, estructura de datos cartográficos, datos cartográficos digitales.

The mission of the Defense Mapping Agency (DMA) is to provide mapping, charting, and geodetic (MC&G) support and services for the United States Department of Defense through world-wide production and distribution of maps, charts, precise positioning data, and digital products. DMA's mission also includes statutory responsibilities to provide nautical charts and marine navigational data for use by vessels and navigators in general.

Although there is a standard format for storage of feature data within DMA (i.e., the polygon format (1)), there has not been an approved standard exchange format. Moreover, there has been no standard method of identifying features and attributes, resulting in the use of different codes for the same feature in different data files supporting various products.

The polygon format was found lacking as a portable, flexible and efficient digital data structure for the manipulation, storage and exchange of map data. Therefore, DMA developed the standard linear format (SLF) for the exchange of digital cartographic feature data, consisting of planimetric and/or hypsometric information created in the production of hydrographic, topographic and aeronautical products. The baseline SLF document was completed in May 1983 (2). A data collection guide (3) which provides a standard list of features and possible attributes for use in the collection of digital data to support current DMA digital and paper products was published in August 1984. It can be expanded to include additional features and attributes to support feature requirements.

Standard linear format data structure

SLF may be thought of as two overlying data structures: spatial and cartographic. The spatial structure associates cartographic features with their exact geometric placement. The cartographic structure acts as the link between the spatial structures and the attributes of the real world. The cartographic structure is represented by map features. There are three basic map features: point, linear and area. Each cartographic feature contains an attribute list and pointers to link(s) representing the spatial description of the feature. Table 1 illustrates the data content of the cartographic structures (4).

In a digital data base, the position of a cartographic feature is described numerically, with reference to some co-ordinate system, as a point (a single co-ordinate, with no dimension), a line (two or more co-ordinates, with one dimension) or an area (three or more co-ordinates, delineating the boundary of a two-dimensional feature). Various methods have been employed for storing this co-ordinate information, particularly for areal features. The polygon data structure method represents an areal feature by a single co-ordinate string delimiting the entire feature. Although this traditional structure may be appropriate for some products, it does not adequately represent abutting areal features. This is true because the co-ordinate strings delineating each feature are independent, making it impossible to assure that the features abut precisely, with no overlap or gaps.

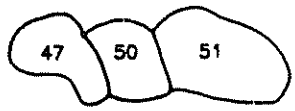
The link node data structure used in SLF solves this problem with abutting features by representing the common boundary between two areal features with one co-ordinate string, called a link, which is shared by both features. That is, a link is stored only once, regardless of the number of features of which it is a part. This structure avoids the overlap and gaps problems inherent in prior planimetric data structures (e.g., the polygon methods). The link node (i.e., SLF) format eliminates double storage of common boundaries, simplifies updates and correction, and is responsive to thinning and generalization algorithms. SLF and polygon formats are compared in figure 61.

DMA SLF goals are: to provide a standard format for internal exchange of digital data, to make maintenance easier, to eliminate the overlap and gaps problem inherent in the polygon format, and to store a string of data only once, regardless of the number of features of which it may be a part (link node format).

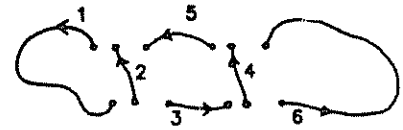
There were three requirements in the design of the SLF: portability, flexibility and efficiency.

Portability is defined as the ease of exchange between different computer systems. To ensure portability, SLF conforms to Federal Information Processing Standard (FIPS)

Figure 61. United States of America: Standard linear format



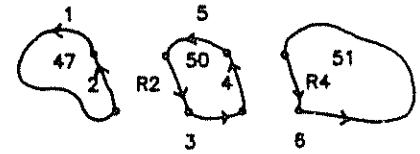
a. Manuscript



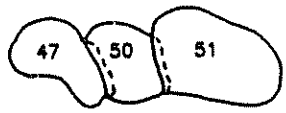
b. Digitized Segments



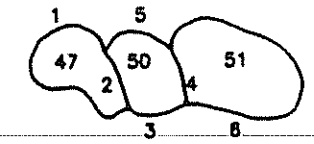
c. Digitized Polygons



d. SLF Display – Individual



e. Polygon Display – Combined



f. SLF Display – Combined

and American National Standard Institute (ANSI) standards for magnetic tape and tape labels and American Standard Code for Information Interchange (ASCII) characters. Physical block sizes, which ensure whole-word transfers on computers of all common word lengths (8, 12, 16, 24, 32, 36, 48, and 60 bits), were selected.

Flexibility refers to the accommodation of different digital products. Consideration of current and projected product specifications and use of a logical data structure known as link node structure enhance flexibility.

Efficiency is gained because the link node data structure eliminates the need for storing redundant line segment points which describe coincident or adjoining features and eliminates the potential for spatial displacements commonly introduced when processing the redundant segments. SLF allows easier update and correction because features with identical points or line segments need to be modified only once.

SLF DATA STORAGE

SLF data sets consist of cartographic features within a specified area. Data is stored on magnetic tape in the following four types of physical blocks.

Data set identifier (DSI) blocks
Segment (SEG) blocks
Feature (FEA) blocks
Text (TXT) blocks

The required order of the data on magnetic tape is: all DSI blocks, all SEG blocks, all FEA blocks, and all TXT blocks (if any) for each data set. The DSI record contains common descriptive information for the entire data set. The SEG record contains the actual co-ordinate strings for the segments which make up the features. The FEA record contains identifying and descriptive information for each feature in the data set, along with a list of keys to the segments (co-ordinate strings) which make up the features.

The TXT record(s) is/are optional record(s) containing free format textual information regarding the data set and/or special features within it.

The DSI (figure 62) record contains common descriptive information for the entire data set. It is always present and uniquely identifies a particular data set by providing the product type, unique data reference number, edition number of the data set, date the data set was compiled, and date the data set was updated. The DSI record is divided into the following groups:

Data set identifier group (DSIG): Uniquely identifies data set

Security group (DSSG): Security classification, handling, and release information

Data set parameters (DSPG): Parameters to interpret co-ordinates contained in SEG record

Map projection group (DSMP): Map projection, datum

History group (DSHG): Data collection method and accuracy information

Variable field address group (DSVG): Indicates first character position of optional, variable-length groups

Registration points group (DSRG): Number of registration points, ϕ, λ, H and x, y, z co-ordinates of registration points.

Accuracy subset group (DSAG): Number of multiple outlines, absolute and relative horizontal and vertical accuracies; ϕ, λ for each co-ordinate in accuracy outline.

The DSIG, DSSG, DSPG, DSMP, DSVG groups are *always* present. The DSRG and DSAG groups are optional and may be of variable length.

The segment (SEG) record (figure 62) contains the actual co-ordinate strings for the segments which make up the features. There is one SEG record for each segment in the data set. Each SEG record contains: the unique segment identification number, the count of features to which it belongs, the unique feature identification and orientation for each feature to which it belongs, and the x, y, and z co-ordinates or longitude, latitude and elevation for each point in the segment.

TABLE 1. SLF RECORD CONTENTS

Cartographic	*Spatial*
Area features	*Lines*
ID	ID
Attribute	Number of features contributing to
Number of lines in boundary	List of features contributing to
Feature boundary line list (FWD/reverse flag)	Number of coordinate sets
Linear features	Coordinate pair (triple optional)
ID	List
Attribute list	*Points*
Number of lines	ID
List of lines (FWD/reverse flag)	Number of features contributing to
Point features	List of features contributing to
ID	Coordinate pair (triple optional)
Attribute list	List
Number of points	
List of points	

The Feature (FEA) record (figure 62) contains identifying and descriptive information for each feature in the data set. Descriptive information as required by product specifications is stored in "n" 40-byte blocks.

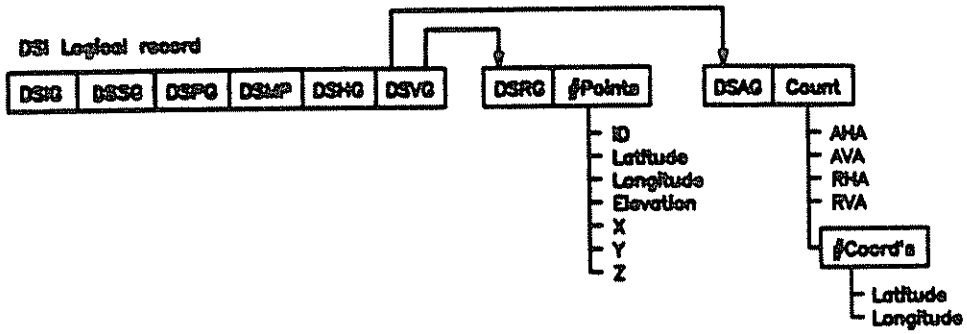
The text record(s) (figure 62) is/are optional and contain free format textual information about the data set and/or individual features.

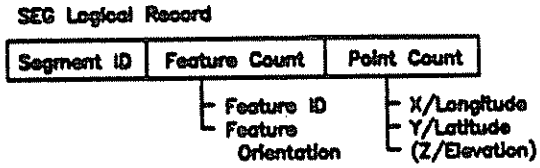
SLF ADVANTAGES

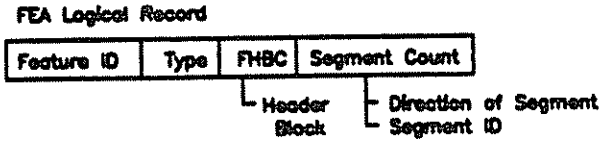
The SLF link node format has inherent advantages over the polygon format currently used for feature data storage. In cases where features adjoin (figure 61), digitizing in polygon format resulted in overlap of the features. This manual overlap could be removed by post processing, but subsequent computer processing resulted in overlap and gaps in the digital data. The link node format eliminates the overlap and gaps problem. Also, the link node format allows one-time storage of a string of data regardless of the number of features of which it forms a part. This one-time storage of data simplifies maintenance for coincident features. Unique node identifiers are not stored, but are implied by the start or stop x, y values of line segments and can be derived mathematically if necessary. SLF also provides a standard format for internal exchange of digital data, and accommodates different cartographic products.

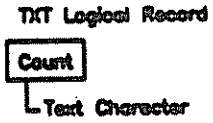
The SLF implementation will require several years. The implementation is occurring now in a phased manner. Implementation of SLF will provide a standard format for data exchange during the production process. This format is portable, flexible, and efficient.

Figure 62. United States of America: Standard linear format; logical record structure









FEATURE/ATTRIBUTE CODING SCHEME (FACS)

The purpose of the feature/attribute coding scheme (FACS) is to provide a common menu of features and attributes and a standard coding scheme to meet digital data collection needs. Standardization of feature codes will facilitate exchange of digital data. The FACS simplifies collection of feature and attribute information as the need for more types of features and more information about features arises.

The coding scheme described here provides a comprehensive menu of features; a common feature identification scheme; an extensive attribute listing; and a feature header structure.

FEATURE MENU

The FACS provides a common list (or menu) of features required for collecting digital data to provide: radar, visual and sensor simulation; situation display; avionics support, automated terrain analysis, automated hydrographic navigation; digital flight information and automated cartography. A sample of the list of features is illustrated in table 2 (3).

TABLE 2. ALPHABETICAL LIST OF FEATURES

Feature code	Feature
1 W005	Accommodations (airport)
2 W010	Administrative office
.	.
4 B040	Crevices (other than ice)
2 F005	Crib
.	.
1 H015	Fort
2 F020	Foul ground
.	.
6 A105	Indian treaty line
.	.
2 K060	Lake/Pond
.	.
1 U105	Medical facility
1 U110	Mess facility
1 B005	Metal ore slag dump
.	.
1 H045	Palace
.	.
1 A065	Quarry
1 B074	Quay
.	.
1 N030	R/R station/depot
.	.
1 B050	Wrecking yard
1 J075	ZOO use

FEATURE IDENTIFICATION SCHEME

FACS also provides a common feature identification scheme. Features are aggregated in the following seven major common feature categories. Culture-1; Hydrography-2; Hypsography-3; Physiography-4; Vegetation-5; Demarcation-6; and General-9. Each major category is divided into subcategories which are illustrated in table 3.

Each feature within the subcategories is identified with a five-character code. The first two digits of each feature code indicate the subcategory to which it belongs. For example, all the codes for features in subcategory "Navaids (Buoys and beacons)" in the Hydrography-2 category begin with the characters "2E" (table 4). Note that a "general" feature within the subcategory "Navaids (Buoys and beacons)" has a feature code whose last three digits are "000". This is true for features in all subcategories. That is, a feature that is described as "general" will always have a five-digit code ending in "000", regardless of the category or subcategory in which it falls.

ATTRIBUTE LISTING

Associated with each feature/feature code is a list of attributes which are allowable for that feature. Attributes provide additional information about a specific feature. There are 101 attribute categories. Each attribute category has a 3-character acronym, as illustrated in table 5. A single feature may be described by as many as 26 different attributes. The value of an attribute is indicated by a numeric code (table 6). For example, a water velocity average (WVA) less than 2.5 m/second is indicated by an attribute value of "1" while a WVA greater than or equal to 2.5 m/second has an attribute value of "2" (table 6). Allowable attributes for an oil well (feature code 1A040) and possible attribute values are illustrated in the sample at table 7. Feature attribute categories (table 5) and the placement of the attribute categories for each feature *are fixed*.

FEATURE HEADER STRUCTURE

FACS provides a structure for feature header records based on four 40-byte blocks. The first block contains source accuracy and security information; the second contains the feature identification and up to 15 attribute values for feature

TABLE 3. FEATURE CATEGORIES AND SUBCATEGORIES

Feature	Category	Subcategory
Culture	1	Extraction
		Disposal
		Processing industry
		Fabrication industry
		Associated industrial structures
		Commercial residential
		Institutional/Governmental
		Agricultural
		Recreational
		Miscellaneous features
		Closed storage
		Open storage
		Transportation R/R
		Transportation/Roads
		Associated transportation
		Airspace routes
		Communication/Transmission
		Airport
		Radio aids to navigation
Hydrography	2	Coastal hydro
		Ports and harbors
		Hydrographic stations
		Navaids (Lights)
		Navaids (Buoys and beacons)
		Dangers and hazards
		Depth information
		Bottom features
		Tide and current info
		Inland water
		Miscellaneous inland water
		Snow/Ice
Hypsography	3	Relief portrayal
		Spot elevations
Physiography	4	Exposed surface material
		Landforms
Vegetation	5	Cropland
		Rangeland
		Woodland
		Wetlands
Demarcation	6	Boundaries/Limits (Aeronautical/Topographic)
		Boundaries/Limits (Hydrographic)
		Zones (Topographic/Aeronautical)
		Zones (Hydrographic)
General	9	Annotation
		Control points
		Magnetic variation info
		Miscellaneous

TABLE 4. FEATURE CODES EXAMPLE

Category	Hydrography-2	
Subcategory	Navaids (Buoys and beacons)	
Features	Navaids-Floating (General)	2E000
	Beacon	2E005
	Buoy	2E010
	Superbuoy	2E015

TABLE 5. SAMPLE ATTRIBUTE CATEGORIES

Acronym	*Attribute*
ACC	Accuracy category
HRG	Highway/Road gradient
MTD	Mine tunnel direction
WVA	Water velocity average

TABLE 6 SAMPLE ATTRIBUTE VALUES

Acronym	*Attribute*
ACC	Accuracy category
	0 Undetermined
	1 Accurate
	2 Approximate
MTD	Mine tunnel direction
	0 Unknown
	1 Horizontal
	2 Vertical
WVA	Water velocity average
	0 No data
	1 2.5 m/second
	2 2 5 m/second

TABLE 7. SAMPLE OF FEATURE FILE CODING

Category:	Culture-1
Subcategory:	Extraction
Feature:	Oil well
Feature code:	1A040
Allowable attributes:	RSF, use
RSF	Radar significance factor
Attribute value	Meaning
0	Undetermined/Unclassified
1	Asphalt
14	Water
15	Wood (DTAD)
Use—use status	
Attribute value	Meaning
0	Unknown
1	Abandoned/Not operating
14	Aeronautical
15	Other
16	Seasonal

TABLE 8 SAMPLE OF FIXED PLACEMENT OF ATTRIBUTES FOR FEATURE

	Oil well – – – – – – – – – *1A040*	
Areal	*Linear*	*Point*
F-1 RSF	F-1 RSF	F-1 RSF
F-3 USE	F-3 USE	F-3 USE

TABLE 9. USING A TYPICAL FEATURE CODING SCHEME (BRIDGE)

Header block 1	Source	XX
	Scale	XX
	Collection system	XX
	Accuracy	XX
	Classification	XX
	Etc	XX
Header block 2	Feature ID	1Q060
	Attribute 1	BCV 15.5 (Clearance)
	Attribute 2	BSC 2 (Cantilever)
	Attribute 3	LOS 120 (Length of span)
	Attribute 4	SMC 1 (Metal structure)
	Attribute 12	20 (Width)
Header block 4	Text attribute 1	One way eastbound 0700-0900

attributes 1-15 (F-1 through F-15); the third contains values for feature attributes F-16 through F-26 and value attributes 1 and 2 (V-1 and V-2); and the fourth contains free text (T-1, T-2, T-3). Feature attribute categories (tables 5 and 6) and placement of the attribute categories for each feature are *fixed*. As illustrated (tables 7 and 8), the allowable attribute categories for an oil well are RSF (radar significance factor) and USE (use status). Value for RSF would occupy the first (F-1) feature attribute position and the value for USE would occupy the position for feature attribute three (F-3). The second attribute position would be blank filled because none of the attribute categories which may be placed in the second position are allowable for an oil well. Placement of attribute categories for all features are similarly provided by the FACS document.

The FACS is not a data base or a data file. Data collected under FACS rules can be stored in any number of files. There are no size, accuracy or granularity restrictions.

Moreover, FACS is not a product and cannot support a digital product without a product specification. The product specification determines which FACS features and attributes will be used and defines collection criteria such as accuracy and feature granularity. The FACS is not tied to any specific product line or data base. Therefore, features and attributes can be added to the FACS as requirements change.

FACS USE

FACS is used in conjunction with a product specification. The data are collected using the FACS. The product specification determines which FACS features and attributes will be used and defines such collection criteria as accuracy and feature granularity. A typical feature coding is illustrated in table 9.

FACS IMPLEMENTATION STATUS

FACS is ready for use now. Within DMA, implementation will initially be for new digital products.

For existing digital products, a phased implementation is envisioned. An integral part of the implementation is the creation of software to convert from existing feature codes to the FACS coding scheme and vice versa. DMA will initiate development of such software in 1984.

SUMMARY

The Standard Linear Format (SLF) provides an efficient alternative to the polygon format for storing, manipulating and exchanging digital cartographic data and is well suited for representing abutting areal features. The link node SLF data structure eliminates the overlap and gaps problem inherent in the polygon structure. SLF allows one-time storage of a string of data regardless of the number of features of which it is a part. This simplifies maintenance for abutting real features.

The Feature/Attribute Coding Scheme (FACS) provides a comprehensive menu of features, a common identification scheme, an extensive attribute listing, and a feature header structure. FACS provides a logical and expandable scheme for organizing digital cartographic information.

Use of the SLF and FACS will facilitate the storage, exchange, and collection of digital cartographic data. DMA is committed to both SLF and FACS and has begun implementation of both.

REFERENCES

1 "Defense Mapping Agency product specifications for Digital Landmass System (DLMS) data base", 2nd ed. (Aerospace Center, St. Louis, Missouri, Defense Mapping Agency, April 1983)

2 "Defense Mapping Agency Standard Linear Format (SLF) for digital cartographic data" (Washington, D.C., Defense Mapping Agency, 16 May 1983).

3. "Defense Mapping Agency Feature File (DMAFF) data collection guide" (St. Louis, Missouri, and Washington, D.C., Defense Mapping Agency, August, 1984)

4 "Standard Linear Format Overview: MC&G data base requirements study", final report (Defense Mapping Agency), appendix F

THE JOINT DEVELOPMENT OF A NATIONAL DIGITAL CARTOGRAPHIC DATA BASE AT 1:100,000 SCALE*

Paper submitted by the United States of America

RÉSUMÉ

Le Service géologique des Etats-Unis, agissant en collaboration avec le Bureau du recensement, a mis en route un nouveau programme d'envergure visant à constituer, d'ici à la fin de la décennie, une base nationale de données cartographiques numériques au 1/100 000. Cette base de données complétera l'actuelle base nationale de données au 1/2 000 000 et la couverture de certaines zones au 1/24 000. Elle permettra la couverture totale des détails relatifs aux transports (routes, voies ferrées, réseau électrique, pipelines) et des détails hydrographiques (cours d'eau, rivières, plans d'eau). On prévoit que ces données serviront à la fois pour l'infographie à la demande et comme entrées de base des systèmes d'information géographique.

La décision de constituer cette base de données a été prise en partie pour deux raisons : des techniques efficaces et économiques de saisie de données ont été mises au point et le Bureau du recensement a exprimé le besoin d'utiliser largement ces données. La série de cartes au 1/100 000 du Service géologique a été conçue pour faciliter la saisie automatisée des données (à l'aide de scanneurs, par exemple). Les méthodes et procédures utilisées pour la saisie des données sont suffisamment au point pour que les deux organismes puissent utiliser les détails portés sur les cartes au 1/100 000 et, allant plus loin, entreprennent de constituer une base de données cartographiques numériques. Lorsque ce sera chose faite, le Bureau du recensement a l'intention d'utiliser ces données comme canevas cartographique du système automatisé d'appui géographique qu'il compte mettre en œuvre lors du recensement de la population et de

RESUMEN

El Servicio Geológico de los Estados Unidos, en cooperación con la Oficina de Censos, ha iniciado un nuevo e importante programa destinado a crear, hacia fines del decenio, una base nacional de datos cartográficos digitales sobre la base de mapas a escala de 1:100.000. Esta base de datos complementará la base nacional de datos de que ahora se dispone a escala de 1:2.000.000 y la cobertura parcial de datos a escala 1:24.000. Se proporcionará así una cobertura completa en materia de transportes (caminos, vías férreas, cables eléctricos y oleoductos) y recursos hidrográficos (arroyos, ríos y lagos). Se prevé que la base podrá utilizarse tanto para la elaboración de gráficos especiales como en calidad de insumo básico para los sistemas de información geográfica.

La decisión de crear esta base de datos se adoptó en cierta medida como resultado de la conjunción de dos factores: el perfeccionamiento de tecnologías eficientes y económicas de recolección de datos y la necesidad expresada por la Oficina de Censos de los Estados Unidos de que se utilizaran en mayor medida los datos. La serie de mapas a escala 1:100.000 del Servicio Geológico tenía como objeto facilitar la recolección automática de datos (por ejemplo, mediante unidades exploradoras). Las metodologías y los procedimientos utilizados en el proceso de recolección de datos han avanzado hasta el punto en que los dos organismos pueden aprovechar las características de diseño de los mapas a escala de 1:100.000 y llevar a cabo las tareas complementarias necesarias para la creación de una base de datos cartográficos digitales. Una vez elaborados esos datos, la Oficina de Censos de los Estados Unidos los utilizará como marco cartográfico para su sistema de apoyo geográfico automatizado para el censo decenal de 1990 de población y vivienda. La colaboración desde el inicio de este proyecto entre uno de los principales productores y uno de los principales usuarios

* The original text of this paper, prepared by George M. Callahan, United States Geological Survey, and Frederick R. Broome, United States Bureau of the Census, appeared as document E/CONF.77/L.22.

l'habitation de 1990. La collaboration entre un grand producteur de données et un grand utilisateur de données dès le début de l'exécution de ce projet augure bien du succès de la constitution d'une base de données cartographiques numériques à échelle moyenne qui satisfera aux besoins nationaux

de datos permite esperar los mejores resultados en la creación de una base de datos cartográficos digitales a una escala intermedia que satisfaga las necesidades nacionales.

The production of a 1:100,000-scale digital cartographic data base for the conterminous 48 states of the United States and the District of Columbia is under way. The United States Geological Survey (USGS) and the United States Bureau of the Census signed an agreement in December 1983 committing the two agencies to the production of this data base by 1987. The positive results of the feasibility study and a following research project have led to the preliminary production system that is now in place in both agencies. The data base will provide complete digital coverage of all transportation features and hydrographic features. To fulfil the project goals, the USGS is accelerating its 1:100,000-scale mapping programme and the Census Bureau is rescheduling its map updating projects; it has developed an interactive feature-encoding and file-structuring system. The 1:100,000-scale digital cartographic data base will serve as the basis not only of the Census Bureau's automated geographic support system but also of similar systems in numerous other Federal and state agencies.

Background

In late 1981 the USGS and the Bureau of the Census formed an interagency task force to review current and projected requirements of both agencies for cartographic and geographic products. This review included the development of a series of research projects that addressed the application of state-of-the-art technology to the production of new and updated maps and related graphics as well as digital products needed to support the National Mapping Program and the 1990 Decennial Census. As a result of this activity, the requirement for a digital version of an intermediate-scale (1:100,000) data base was identified.

In early 1983 a co-operative digital production pilot project was begun to collect and process the transportation and hydrographic data shown on the 48 maps at 1:100,000 scale that cover the State of Florida. The purpose of the project was to enable the USGS to develop and test new production procedures and software, to incorporate the SCITEX Response scanning and editing system into its current digital production system (Callahan, 1983), and to enable the Census Bureau to develop the necessary software and production procedure to encode and structure data for incorporation into the National Digital Cartographic Data Base (NDCDB) (Loikow, 1983). This pilot project was accomplished by (*a*) the USGS performing the initial collection and processing of all transportation and hydrographic information using the SCITEX system; (*b*) the Census Bureau performing all attribute coding and structuring of the roads data; (*c*) the USGS performing all attribute coding and structuring of the hydrographic and other transportation data; and (*d*) the USGS performing final data verification, testing, and storing of the information (fig. 63). The successful completion of this pilot project has resulted in the implementation of a digital production system in each agency and the commitment by both, through an agreement signed in December 1983, for completion of a national 1:100,000-scale digital data base by 1987.

The production system

The production procedures and software that were developed as a result of the co-operative pilot project for the State of Florida have been implemented in both agencies to support the production of the 1:100,000-scale data base. The following paragraphs describe the production procedures as implemented in the two agencies, as well as ongoing development activities to improve the current system. The procedures described are those implemented within the USGS unless otherwise noted.

Material inspection

Before the authorization of any 1:100,000-scale map for digitization, maps are inspected to determine the level of content and complexity of the information to be collected. Based on this review it is determined which of two data collection processes are to be used, either manual tracing or automatic scanning. This inspection process aids the planning staff in balancing the assignment of work and the efficient utilization of existing resources. Features such as railroads, powerlines/pipelines, and all point features are manually digitized because the symbolization and low density of these features do not lend themselves to efficient data collection by scanning.

Pre-digital preparation of material

For those maps that have been assigned for scanning data collection, the preparation of materials is very important. Preparation of the materials is performed by the mapping centre where the original 1:100,000-scale map was compiled. The preparation of these materials for automated scanning is a two-step process: (*a*) combination of feature separates in the photolab, and (*b*) the manual colour coding of features that will require special processing once the initial data collection has been done. The photolab processing of the road data involves the combining of two road feature separates on a sheet of stable-base white scribecoat. The hydrographic data require some additional processing because areal hydrographic features such as swamps and mangrove do not have specific limit lines shown. For these features the open-window feature separate is combined with the line data on white scribecoat. Each feature type is shown in a different solid colour, that is, swamp in blue, mangrove in red. The drainage lines are all shown in black.

After the composites are made, a cartographer inspects the materials and colour-codes the features that will require special processing on the SCITEX editing station. The types of features coded are (*a*) airfields; (*b*) changes in classification of roads or drains at other than intersections; and (*c*) miscellaneous point features.

Data collection

After the preparation phase has been completed, the materials are sent to the Eastern Mapping Center (EMC) in Reston, Virginia, for scanning data collection. With the exception of a very short initial set-up procedure in which

the colours on the input document are calibrated, the scanning resolution is set and the limits of the area to be scanned are set, the digitization operation is automatic. On an average, 3 to 3.5 hours is required to scan one 1:100,000-scale composite, at 35 points per millimetre (approximately 10 feet per point at scale), regardless of line density or complexity.

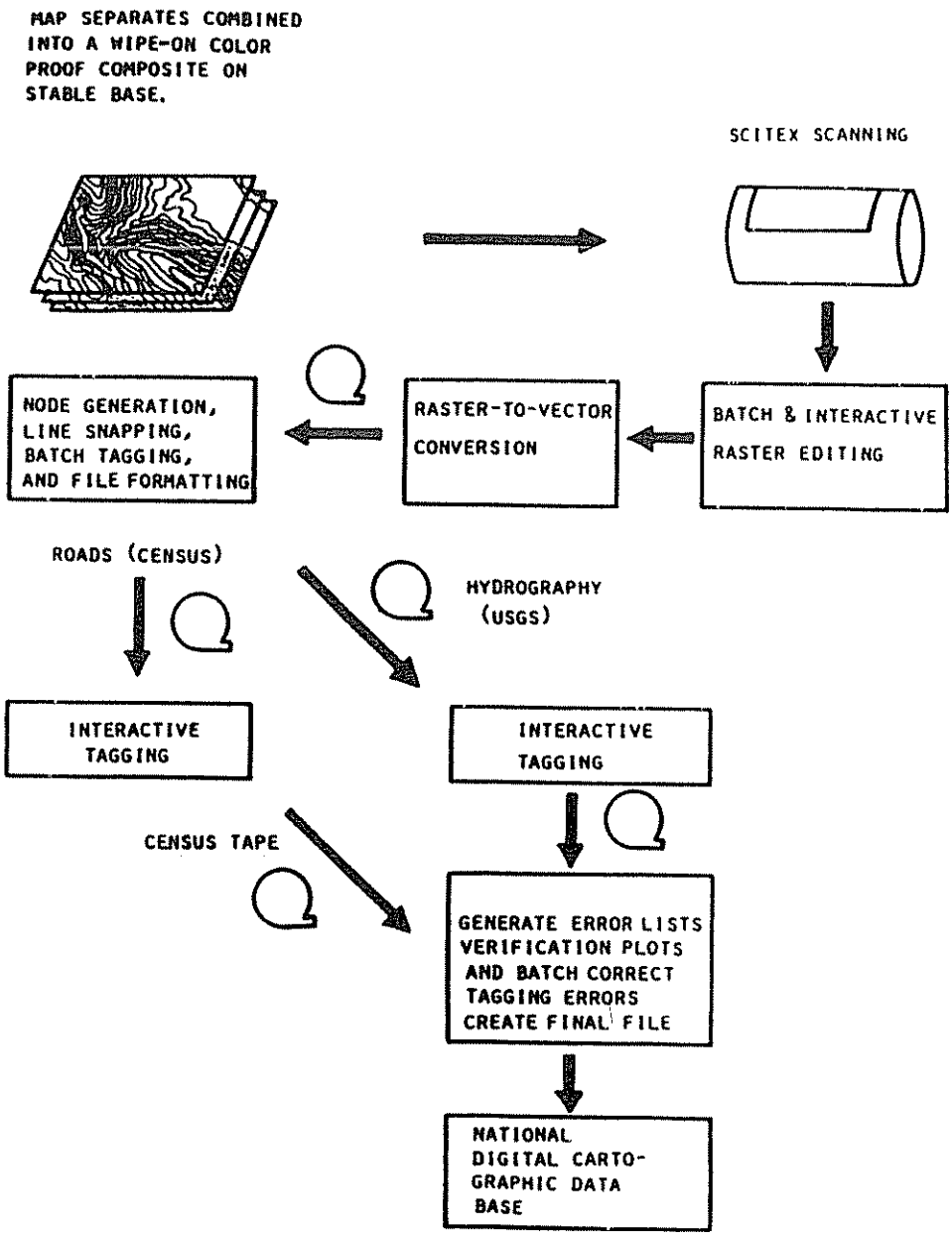
Following scanning the raster data for hydrography are sent to the originating mapping centre. Road information is transferred to the Census Bureau for tagging and structuring.

Raster editing

The following batch and interactive editing procedures are used to process the raster data before vectorization and structuring:

Post-scan cleanup. The first operation performed on all scanned data sets is the deletion of all point features in the raster data base. On the roads overlay this consists primarily of airfield symbols and miscellaneous ticks on the data set neatline. On the hydrographic overlay, springs, wells, and

Figure 63. United States of America: Production work-flow for 1:100,000-scale data base



other point features are deleted. These features are returned to the file during vector editing and tagging of the data. They are deleted during post-scan clean-up because the SCITEX editing and vectorization routines do not handle point features satisfactorily.

Preliminary line skeletonization. Following the deletion of all point features, a preliminary skeletonization, vectorization, and re-rasterization of the file is performed. This is a batch routine that does not require operator attention. The sequence of this operation is:

(*a*) If the data set contains areal features to be processed, the coloured area representing the limits of the features is outlined using the FRAME command;

(*b*) Line features are skeletonized to one pixel in width and converted to vector format using the SCITEX raster-to-vector software;

(*c*) End points of lines at intersections are adjusted using the NODECOR command;

(*d*) The vector-to-raster software re-rasterizes the data at the SCITEX editing station;

(*e*) The original raster file is merged with the re-rasterized file using the PLACE command.

The above batch processing requires from 2 to 5 hours to run depending on the widths of the lines that must be thinned and the overall size of the data file.

Interactive editing. Following the batch processing the operator interactively inspects and edits the data set. This editing involves:

(*a*) Correcting alignment errors due to the skeletonization/vectorization process;

(*b*) Closing any breaks in the linework;

(*c*) Breaking lines that were marked during preparation of the material (this procedure indicates to the structuring software, which is run after the data leaves the SCITEX system, to insert a node).

File segmentation. After editing, a mask is created using the editing system to segment the file. Each file is segmented into 32 7.5-minute subfiles because of current file-size limitations. The mask consists of a set of diagonal points (upper left and lower right corners) for each 7.5-minute section. This mask file is stored for later processing. The software for segmenting the file into larger 15-minute subfiles exists but has not been placed into operation.

Final vectorization. After segmentation, each 7.5-minute section is vectorized and numbered. The number of each subfile represents its position within the overall 1:100,000-scale file. After the file has been vectorized, it is stored on magnetic tape for further processing.

Preliminary File Structuring

At the conclusion of the raster processing, the data files comprise a set of unassociated line strings. For these data to be stored in the NDCDB, the file must be topologically structured and the line strings tagged with appropriate attribute codes. To place the necessary node and area points manually on an interactive editing station would be labour-intensive. To reduce the time required for this process, software was developed that creates the necessary nodes and builds a preliminary topologically structured file from the SCITEX output.

This structuring software originally was developed on an Amdahl 470 V7 computer but recently it has been transferred to a Perkin-Elmer 3230. This transfer enables the basic structuring of SCITEX data to be accomplished in all of the USGS Mapping Centers. The software performs the following tasks: (*a*) node generation and line joining to the nodes; (*b*) clipping of data that extend beyond the established data-set edges; (*c*) assignment of area points denoting areas that fall inside and outside the graph; and (*d*) assignment of attribute codes to all lines. The attribute codes assigned are user-selected to reflect the most common feature class in the file. In the case of hydrography, the code for perennial streams is usually selected; in the case of roads, the code for a fourth-class road is used. More information regarding this software is given by Fegeas and Pearsall (1984).

Tagging and Structuring

USGS operations

The editing and tagging of the files is the most time-consuming and labour-intensive part of the current production process. Each line segment must be checked to determine if the attribute code assigned during the previous process is valid. If not, it must be changed or have another code added to reflect coincidence with another feature or some other situation. The system currently used by the USGS for this purpose is an Intergraph interactive editing system. This system is being used to add all the final attribute tags and any additional structure to the hydrography data sets.

Census Bureau operations

The Census Bureau is responsible for appending the attribute codes to all the road features. As a separate and later operation the Census Bureau will attach names and alternate names to all road features for which names do not appear on the 1:100,000-scale map.

The operation proceeds as follows:

(*a*) The digital road file, received on tape in vector format from the USGS, is loaded into the Topologically Integrated Geographic Encoding and Referencing (TIGER) system on the Bureau's UNIVAC 1100/84. With each digital file a paper copy of the 1:100,000-scale map is provided by the USGS;

(*b*) The USGS attribute coding scheme, Census Bureau procedures, and the paper maps are used in a clerical recording of each road feature. Each feature is carefully marked to show the proper attribute. This operation reduces the terminal time necessary for the data base coding;

(*c*) A portion of the digital file is displayed on a graphics terminal and an operator interactively applies the attribute codes to each feature. The procedure is menu-based (Loikow, 1983), so that a seven-digit attribute code entry rarely requires more than two key-strokes. An acceptable code combination matrix is built into the tagging software to prohibit invalid combinations when multiple attributes apply to a single feature;

(*d*) A quality assurance check is then conducted on the coded files. There is both a computer check for certain automatically detectable logical errors and an interactive manual check of the codes. Depending upon the quantity and types of errors detected, erroneous codes are either fixed on the spot or the file is reprocessed;

(*e*) The coded files are put on tape in the USGS Digital Line Graph (DLG) format and returned to the USGS for inclusion with the other features in the 1:100,000-scale digital data base.

Data structuring and verification

Following the completion of the editing and tagging operation, the data sets, both hydrography and roads, are processed through the Unified Cartographic Line Graph Encoding System (UCLGES). The UCLGES system has been used by the USGS for the past seven years to perform all final data structuring and verification of DLG files. The system performs several logical checks to verify topology and the proper use of attribute codes. Errors are corrected through the UCLGES batch editing routines or the data sets are returned to the producer (USGS or Census) for correction. When a file is completely verified through UCLGES, the files are archived in the NDCDB. For more information see Guptill (1983).

Conclusion

USGS and the Census Bureau have begun a programme to create a National Digital Cartographic Data Base from 1:100,000-scale maps by 1987. The existence of this data base will enable the Census Bureau to support geographic information requirements for the 1990 Decennial Census of Population and Housing and the USGS to support the widespread use of geographic information systems for a host of resource management, area analysis and planning activities. This data base will normally meet the needs of the federal community, but will also serve as a catalyst for the widespread use of geographic information systems in the United States.

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AGENDA ITEM 6

Review of the latest technology and its relationship to policy, economy and development in cartographic data manipulation

(a) *Conventional and digital large-scale topographic map compilation*

CONVENTIONAL AND DIGITAL LARGE-SCALE TOPOGRAPHIC MAP COMPILATION*

Paper submitted by Canada

For hundreds of years man has regarded maps as important documents in his quest to understand and manage his environment. Maps provide the engineer, architect, planner and manager with a wealth of basic, vital information to assist in arriving at the best decision. From the earliest known Babylonian clay tablets to today's digitally-compiled, automatically-produced drawings, maps have been of paramount importance to progress on this planet.

Today, maps are being compiled by all levels of government; by electrical, gas, transportation and water distribution firms; by private mapping corporations; and by the military, for defence purposes. Maps are made in all sizes, shapes, scales, themes and degrees of accuracy. They may be compiled by traditional line-mapping methods, but there is an ever-increasing demand for terrain information to be supplied in digital form.

The basic objective of large-scale map compilation is to portray culture details and land forms accurately, clearly and in a format or scale tailored to the needs of the user. Scale of a conventional map is something that all practiced map users can visualize, usually in the context of street widths, building sizes, contour intervals, and the amount of planimetric information shown thereon.

When a user contemplates digital map data he has no such yardsticks to rely on, because the term *scale*, as applied to digital data, then has no meaning. A digital map user must begin to think in terms other than scale in order to rationalize the information contained in the stored digital data. Of primary concern would be the amount or quantity of planimetric details available in digital form: e.g. are roads digitized on both sides, or shown only as a single centreline? Also of concern would be the accuracy of the pointings and the precision of height determination, both of which (from photogrammetrically-derived data) are functions of platform height.

With conventional line maps we have come to accept relief information as being best represented by contour lines and spot heights. Under digital mapping, the spot height concept is carried one step further, in that the entire stereomodel is blanketed with thousands of spot heights to become what is variously known as a Digital Terrain Model (DTM), a Digital Elevation Model (DEM) or Digital Terrain Elevations (DTE). Although topographic relief data are still being generated by the "stream" method of digitizing traditional pre-determined contour intervals, many mapping organizations today are employing solely DTM methods when compiling a Digital Topographic Data Base (DTDB). Contours at any desired interval can then be called up when required, and plotted by use of an automatic drafting table or drum plotter. Automatic drafting tables have been a boon to cartographers by performing quickly and economically the many routine drafting tasks previously associated with map production.

Because most mapping organizations are staffed with personnel who were trained to produce maps by traditional manual methods, it behooves such agencies to embark on training programmes and policies designed to assist their employees in transition from the conventional to the digital mapping era. In most cases new staff must be hired (often at salary levels considerably higher than current old-technology specialists) and new interdisciplinary groups or teams must be created to deal with the new technology of digital mapping. Most importantly, the directors or owners of map-producing facilities must change their own philosophy of thinking about how maps have been traditionally created; they must direct their energies to appreciating and anticipating the tremendous impact of digital map technology on a society which is becoming increasingly dependent on computer-generated information; they must be prepared to move forward in the knowledge that the production of digital map data requires constant upgrading of instrumentation and technology. The system that is seemingly adequate today could well be obsolete within a few years.

Large-scale topographic maps probably enjoy their greatest application among design engineers, architects, and planners who are associated with municipal corporations. In the field of computerized municipal information management, digital maps are assuming an increasingly important role. Engineering and architectural drawings, taxation records, demographic trends, public transportation routes, fuel and electrical requirements are just some of the elements which are being integrated into a common, homogeneous system. Many progressive municipal corporations have labelled such systems by some variant of the titles Digital Terrain Data Base, or Digital Topographic Data Base (DTDB).

Digital map data for cartographic applications are obtained from three main sources: the first, preferred, and most accurate method is the capture of data from conventional photogrammetric stereomodels, a procedure which requires that the stereoplotting instrument be equipped with encoders that are connected to a recording device.

* The original text of this paper, prepared by Edgar C Anderson, Kenting Earth Sciences Limited, Ottawa, appeared as document E/CONF 77/L.65.

The second, and probably the most widely used, method involves digitizing existing maps or manuscripts by employing a cartographic table digitizer, or a raster scanner. This is perhaps the simplest routine, because it permits the use of standard analog photogrammetric instruments to produce the base map. Accuracy and speed are sacrificed when this method is employed because the table digitizing unit is merely tracing for the second time every feature that was first drawn by the photogrammetrists.

When faced with a large library of costly, relatively up-to-date, conventional line maps some municipalities are embarking on an automatic digitizing program, based on raster scanning techniques. For a black and white raster system, individual film positive overlays are required, thus necessitating a separate scanning routine for each colour shown on the conventional line map. Blue, for example, which usually represents the drainage or hydrographic features, would be scanned and digitized from the original black-line film positive overlay. Similarly, each remaining colour-representing overlay would be separately scanned and digitized.

In the scanning process, the presence of a graphical line on the map is sensed by an optical unit which scans a minuscule area with a resolution as small as 25 microns square. Scanning is done row by row, again at increments as small as 25 microns. A notable disadvantage with this system is that the feature attribute entry, or feature code, must be accomplished off-line, at another time.

A third but somewhat less popular source of capturing digital map data is by the use of 4x or 5x enlarged orthophotos. A metric grid must be superimposed, or passpoints of known value must be clearly visible on the orthophoto. Features to be digitized must first be interpreted in ink on the face of the orthophoto, after which they can be measured directly by a cartographic digitizer unit. Of course, raster scanners cannot be employed with this method because of the nature of the orthophoto image. Another minor disadvantage with cartographic digitizing from orthophotos is that relief information, or z values, cannot be captured simultaneously with xy values; but this problem can be overcome if DTM procedures are instituted at the instant of orthophoto production scanning. Obtaining digital data from good-quality, enlarged orthophotos should generally result in savings of time and money, especially if the orthophotos are being utilized by the client in lieu of conventional line maps. Accuracy of the method should be comparable to that obtained by cartographic digitizing from manuscripts and indeed, when great care is taken at the interpretation stage, the accuracy may even approach that obtainable from directly-digitized stereomodels.

Whichever one of the above three digitizing methods is employed, every feature to be digitized must first be identified with a feature code or "attribute". It is preferable that attribute entry be done simultaneously with the digitizing procedures, although many agencies employ variations of start and end routines for identification coding that are sorted later by an interactive graphics system editor. Under the latter arrangement it is possible to tag those features that have several attributes, e.g. one utility pole might support a postal box, a fire alarm, a bus stop sign, a police call-box, a transformer, a street lamp and an air raid siren.

Attribute entry is normally accomplished by numeric, alphanumeric or menu systems. A fourth, but not yet widely used, voice entry technique is available at high cost from some commercial suppliers.

Numeric entry is likely to be the most widely used of the attribute entry systems because of its basic simplicity and low cost. A numeric keyboard entry device can resemble and appear no more complicated than a hand-held calculator.

Alphanumeric entry is one step up from simple numeric entry with the inclusion of the entire alphabet plus a few other symbols thrown in. But now the keyboard resembles an expanded QWERTY typewriter.

Menu entry is easy to use, and requires less concentration and disruption on behalf of the operator. Because of the relatively small size of the menu panel (or functions keyboard) commands are often limited to a few dozen features. Notable exceptions are the new Wild Avioplot RAP-2, and Aviolyt BC-2, which boast a menu of 64 fields (40 of which are programmable) on their functions keyboards.

Voice entry, as previously noted, is still very expensive. But, like digital watches, the price is bound to come down. Many photogrammetrists consider attribute entry by voice command to be the ultimate system, because the operator is not required to move his hands away from the wheels, nor is he obliged to distract his eyes from the floating mark in the stereomodel. Some difficulty in using today's early versions of voice entry modules is to be expected, mainly because a unit is able to recognize only a limited number of sounds and its "ear" hears and responds best to the same, single voice modulation. When a different operator-voice activates the microphone, the instrument may experience confusion in recognizing the command.

Perhaps the answer might be found by employing some combination of musical tones, where an audio-sensor is programmed to respond positively to sound waves of certain frequencies. Would it then be desirable to train operators to chant or sing a command on key in order to emulate the vibrating frequency of a musical tone? Such an approach would broaden the range of voice commands capable of being recognized by an audio-sensor, but it is doubtful if any serious research is proceeding along such lines.

After the digital data has been captured and stored on tape or disc, the *editing* function is the next crucial step. At this stage, errors are detected and corrected, features are deleted or added, and other data are manipulated to conform with specifications for the end product. The digital data are normally displayed on a cathode ray tube (CRT) for interactive editing, where editors make the required changes before releasing the file to the next production phase.

For *final presentation* purposes, the user may call up any specific area of interest, to be displayed at any scale on his own personal CRT unit. This visual, electronic presentation might yield enough information to satisfy the user's immediate concerns. If he has need for something more permanent, or requires hard-copy editions, then he can choose from several commercially available drafting machines to draw the map by scribing chisels, liquid inks, ballpoint pens, lead pencils, or other synthetic mediums.

Digital data banks, or storage of digits at a central location, offer infinite possibilities for sharing of data by a great variety of potential contributers and users. Conventional line maps, on the other hand, are limited to specific applications where additional overlays must often be constructed to satisfy user requirements. If complex underground electrical information is to be shown, for example, on a drawing which already contains water/sewer installation dimensions, then it would be necessary to manually draw the electrical routings on a separate overlay to avoid confusion between the two diagrams. When a digital data base is employed, the electrical user would call up only the

data required to satisfy his immediate need. The technical advantages and cost-savings available from having access to a digital data base system are now enthusiastically embraced and accepted by prominent cartographers and photogrammetrists. Full enjoyment of the tremendous benefits to be gained from instituting digital mapping procedures is within attainable reach of most organizations. To deny participation in what will surely become the greatest technological advance in the science of map making since the invention of aerial photographs is to deny the space age.

(c) *Conventional and digital charting compilation*

NATIONAL OCEAN SERVICE AUTOMATED NAUTICAL CHARTING SYSTEM AUTOMATED INFORMATION SYSTEM*

Paper submitted by the United States of America

RÉSUMÉ

Avec la mise en place du système d'information automatisé du Service océanographique national aux fins d'établissement de cartes marines assisté par ordinateur, il a fallu modifier les notions et méthodes cartographiques qui avaient été élaborées pour le traitement et la conservation des cartes marines. Comme il arrive souvent dans des projets de mise au point technique, le passage de la planche à dessin à l'exploitation opérationnelle a soulevé des problèmes imprévus. Or, la possibilité d'évaluer ces problèmes et d'apporter les modifications nécessaires est tout aussi importante pour le succès du projet que la conception initiale du système. Grâce à des améliorations constantes, le système d'information automatisé peut maintenant être utilisé à la fois pour l'établissement et la conservation des cartes marines. On examine les notions et méthodes, l'accent étant mis sur certains problèmes rencontrés et les solutions apportées.

RESUMEN

La fase de ejecución del Sistema Automatizado de Información del Sistema Automatizado de Cartografía Náutica del Servicio Nacional de Oceanografía exigió cambios en los conceptos y metodologías cartográficos originales que se habían elaborado para la manipulación de datos y el mantenimiento de cartas náuticas. Como sucede con muchos proyectos de desarrollo, la transición del tablero de diseño al uso operacional ha creado problemas imprevistos. La capacidad de evaluar rápidamente estos problemas y de introducir cambios para solucionarlos es tan importante para la buena ejecución de un sistema como lo es el diseño original del sistema. Debido a su desarrollo continuo, el Sistema Automatizado de Información puede encargarse actualmente de elaborar y mantener cartas náuticas. Se examinarán conceptos y metodologías y se hará hincapié en algunos de los problemas que se han encontrado y en su solución.

The National Ocean Service (NOS) has as one of its primary missions the production and maintenance of approximately 980 nautical charts, comprising approximately 3,000 assorted panels, insets and extensions, and covering the coastal waters of the United States, the Great Lakes and the United States territories.

An NOS study initiated in 1970 concluded that an automated cartographic capability would be essential if NOS were to maintain its suite of charts with current information on natural and man-made changes. Also, the increased throughput of such marine information would not be possible in a timely manner without the use of computer-supported data acquisition, processing, storage, maintenance and interactive graphics. The automated data storage, data maintenance, and interactive graphics associated with nautical chart production is NOS' present concern. NOS has already implemented and made the transition to use of an automated data acquisition and processing capability for hydrographic surveys.

Of the three areas (data storage, data maintenance and interactive graphics), the methods originally conceived for maintenance of nautical charting data have collectively undergone the most significant changes since implementation of the Automated Information System (AIS). These changes have been incorporated in digital data collection techniques supporting the creation of the data base, in new digital data extraction methods required for the maintenance of the data base, and in the hardware used to interactively edit data comprising the data base.

BACKGROUND

The AIS was developed by NOS with the assistance of Technology Development of California and the Planning Research Corporation. The AIS provides on-line disk storage for nautical chart data published by NOS and provides cartographers with the capability of maintaining nautical charts via interactive colour-graphic work stations. The AIS also supports post-maintenance reproduction of nautical charts.

Central site and work station hardware

The central site portion of the AIS contains two model V-76 Sperry UNIVAC computers operating in a master-slave relationship. The system's software allows either computer to act as a stand-alone master in the event of a malfunction of the other. Each computer has 128K memory and is presently configured for dual access to eight 300-megabyte disk drives. Other peripherals supporting each computer include three 9-track tape drives, a card reader, a line printer and an operator's console. The central site computers are networked to the work station computers to support the high speed transmission of data.

* The original text of this paper, prepared by Kirby Gean, National Ocean Service, appeared as document E/CONF 77/L.15. Use of trade names and trade marks is for identification purposes only and does not imply endorsement by the Government of the United States.

Two prototype work stations and one production work station have been implemented. The prototype work stations have been operational for approximately four years. The production work station (the first of six to be installed this year) was certified as operational early this year.

Each of the prototype work stations is driven by a model V-76 Sperry UNIVAC minicomputer with 160K bytes of memory and is supported by two 58-megabyte disk drives for systems software and files, one 300-megabyte disk drive for data storage, a colour vector refresh display screen, a monochrome display screen, a graphic hard copy device, and a digitizing table.

The production work station is driven by a model V-77 Sperry UNIVAC minicomputer with 512K bytes of memory and is supported by a RAMTEK 9400 Raster Display System, three 300-megabyte disks for system software files and data, a graphic hard copy device and a digitizing table. The V-77 minicomputer is capable of supporting multiple work stations.

Data base structure

The AIS data base is nonredundant and geographically oriented. Accompanying attribute information defines how each feature is to be depicted on the various charts. This technique eliminates redundant storage, which in turn decreases the absolute size of the data base. Single feature representation prevents conflicting depictions of features within an area of overlapping charts. Also, when a feature is deleted from a chart through cartographic decision, it is easily deleted from all other charts because it is represented in our data base only once.

The total Data Base Management System (DBMS) used in the AIS allows direct access to records on the disk. To improve the efficiency of the storage and retrieval of data, the Earth's surface has been subdivided into a one degree by one degree unit called a degree block. Each degree block is defined as a master record to the DBMS. Near the shoreline, where the data are more heavily congested, a further refinement is made to the degree block subdivisions. In these areas, a master record represents a unit that is five minutes by five minutes in size, called a cell block.

A variety of data records represents the different types of features. A group of these records is required to represent one feature. A discrete feature (a symbol represented by one co-ordinate) for instance requires a minimum of two records to be stored. The first record, called the base data record, contains information about the feature: origin, feature classification (symbology), and geographic position. The second record in the sequence, called the compilation fact record, delineates which charts the feature is to appear on, how it is to be oriented on each chart, and what alternate symbol is to be portrayed in cases where symbology changes due to scale of the chart.

Lines are similarly represented. The first record contains information about the line—origin, feature classification and geographic position of the beginning of the line. The second record (compilation fact) delineates which charts the entire line or portion of the line appear on. The last record, repeated, contains the actual geographic positions of the line, eight positions per record. Compilation fact records created during editing are inserted in the geographic position record sequence to denote the beginning and end of line segments within the line feature which are either superseded or temporarily turned off (not to be charted) on individual or overlapping chart panels.

Data base creation

The data base is being created by digitizing the suite of NOS published charts. Historical searches supplement the digitization effort by converting to digital form past and current graphic and textual source documents describing navigational aids, landmarks and hazards.

Prior to the collection of currently published information from the chart, 3,200 active hydrographic surveys representing 28,000,000 soundings were digitized to form the nucleus of the data base. These surveys are to be used for chart reconstruction and new chart construction and will also be used to replace soundings previously manually applied to charts and subsequently digitized from those charts. The survey data are currently being used to develop and test automated contouring and sounding selection routines. These routines will be used in the near future to process new hydrographic surveys.

Currently, the charted features for the Gulf of Mexico, the east coast to North Carolina (including Puerto Rico and the Virgin Islands), and the Great Lakes have been collected and loaded into the AIS data base to support automated chart production and maintenance activities.

Data flow/application

New data to be applied to the AIS data base must be converted to digital form. If the data are received in graphic form, they are converted to a machine-readable form on our Intergraph Graphic Design System. If the data are descriptive, they are key-punched and transferred to magnetic tape.

The original design outlined new data application to be performed on the information in the data base in the following manner.

Contemporary source data received by NOS for automated nautical chart production are given a preliminary review to determine charting applicability. If determined to be useful, information specific to the document (date, originator, data type and geographic limits) are key-punched for inclusion in the AIS Source Registry File (SREG) resident on the AIS mass storage. The SREG is an accounting of all documents used for chart maintenance that enter the AIS environment.

The new source document (graphic or textual information) is forwarded to the appropriate compilation team where data from the document are extracted and converted to digital formats. The data are then processed for inclusion into the New Data Holding File (NDHF), a new data repository resident on the AIS mass storage.

The cartographer prepares a retrieval request to extract information from the AIS data base along with new source document information which resides in the NDHF. The data retrieval card deck contains data fields qualifying the data requested by geographic area, specific charts, and data type.

Once the information requested has been successfully retrieved, the cartographer logs onto the work station and registers the largest scale chart upon which the new data falls. The cartographer will create new displays for each chart or portion of the chart requiring edit or the application of new data

After the edit is complete, a senior cartographer logs onto the work station to review the modifications. If the modifications are correct, the reviewer initiates an update to the AIS data base. The modified information is returned to the AIS data base to replace the original data. Any information superseded during the work session is stored on magnetic tape for archival purposes.

The edited data can then be retrieved to tape and subsequently used to prepare reproduction negatives on the NOS/ANCS laser raster plotter.

Problems and new approaches

Initial data base creation

One of the first tasks to be accomplished before implementation of an automated mapping/charting system is the creation of the data base. An early attempt to build the data base by digitally collecting the current depiction of the nautical chart from the original source documents proved to be time consuming and labour intensive.

New approach

Considering that the published nautical chart is a legal document, having undergone intensive edit and review, the decision was made to digitize the entire chart to acquire the data required.

Other than "chart oriented nomenclature", all other data digitized from a larger-scale chart were not recaptured on the next overlapping smaller-scale chart. This saved time and minimized redundancy.

Redundant capturing of data from smaller-scale charts was permitted in cases where linear features were greatly generalized due to extreme scale differences between original source and chart scale. These small-scale charts were digitized in their entirety to avoid a "postage stamp" appearance when larger-scale chart data are plotted on the smaller-scale chart base. Processing software distinguishes between large- and small-scale chart data. Software routines are being developed to generalize linear features without degrading the accuracy of the line, thus allowing a line feature to be applied to all-scale charts, eliminating the need to recapture small-scale generalized linear features.

The approach, that of digitizing existing published information, hastened initial data collection activities and eliminated the labour intensive research and evaluation that would have been necessary had original source information been recaptured.

New data applications to the data base

New data documents entering the AIS were to be collected in their entirety by digitizing graphic information or key-punching textual information.

NOS receives new charting information from approximately 60 sources including Federal agencies, State and local governments, foreign countries, and the private sector. The original concept was to provide the cartographer at the work station with the entire digital copy of the new document from which the cartographer could make evaluations and selections of features for application to the chart. The entire content of the document was to be preserved for future use in making new charts and for litigation research purposes. The original concept specified that the data base content would be document-oriented within the geographic scheme.

It was recognized at the outset that hardware and resources would have to be dedicated to the task of new data collection. Source documents received in high volumes by NOS are diverse in content and format. The task of digitally collecting all the information from these source documents proved to be very labour intensive. Also, to preserve the exact character and content of each source document, extensive review of the digital conversion was required.

The time, resources, and expense involved in collecting and transforming graphic and textual data to digital formats were grossly underestimated. To compound this problem, NOS has recently recognized two other important considerations: (*a*) can NOS digitally capture documents and manuscripts compiled by others outside the Agency, process these data, and guarantee that they represent exactly what the originator of the document intended? and (*b*), should the data base be considered a repository for original documents to be used by the originating office at a later date?

The data entering the data base undergo extensive software processing, point elimination of linear information to reduce storage requirements and elimination of certain non-chartable data specific to the compilation of the original document. Therefore, it has been recommended that the original concept of capturing the entire document and digitally preserving it requires more study. The sheer magnitude of the task of digitally converting documents of varying formats, many with insufficient control or non-standard control, has required extensive set-up time for digitizing and has made it necessary to consider an alternate approach to new data collection.

New approach

The new source document, after being registered and initially evaluated to determine charting acceptability, is forwarded to the compilation team responsible for its application. Team cartographers evaluate the document and determine whether the data are to be digitally collected or immediately applied to the nautical chart and then digitized. Certain factors are considered in this decision:

(*a*) Amount of features on the document;

(*b*) Criticality of the data;

(*c*) Type of control on the document;

(*d*) Scale of document/scale of chart to which the document is to be applied;

(*e*) Availability of resources;

(*f*) Printing schedule of charts to which the document is to be applied; and

(*g*) Estimated time required.

If the data from the document can be quickly digitized or key-punched, the data necessary for chart maintenance are collected and entered into the NDHF. If not, the document is applied to the chart compilation manuscript and these corrections are digitized. The data corrections are identified as originating from the new source document.

Applying data first to the chart manuscript eliminates extensive digitizing set-up time, captures the data after cartographic evaluation, and captures only the data needed for chart maintenance. Most importantly, NOS cannot wait for digitizing and processing functions to be performed on new source documents before evaluating them for critical situations which must be extracted and forwarded for inclusion in the *Notice to Mariners*.

Additional problems associated with new data application

The document approach, that of digitally collecting the entire contents of a document and sending it to the work station for subsequent application, overtaxed retrieval processing and storage capacity at the work station.

In addition, to preserve the integrity of the data base the system will "lock out", or make unavailable to simultaneous update, any portion of the retrieval area previously

retrieved but not updated. The area locked out is the union of the degree blocks within which the new documents fall and the degree blocks covering the area specified by the cartographer. Some documents will lock out very large areas of the data base, making the system very cumbersome for other cartographers.

Resolution

To alleviate the space problem, larger disks were added to the work stations. The large document problem was resolved by effecting software changes to allow partial retrieval of the contents of a document. Prudence on the part of the cartographer in his request for data also helps to keep retrieval areas geographically small. Although more retrievals are required to apply to large documents, prudent scheduling of retrievals circumvents the lock-out problem. This approach somewhat destroyed the original concept of management reporting based on document application and requires a greater awareness on the part of first line supervisors who must now account for individual data records applied. However, this approach has significantly increased throughput. In the future, the new document retrieval approach (total contents or portion of) will be abandoned in favour of automatically retrieving all new data within the geographic window requested for work station edit activity.

Work station enhancement

The work station environment has undergone extensive change—hardware, software, and methodology for data application on the colour screen.

Originally, the work station environment allowed only minimal interaction via the keyboard interface. Early thought assumed that properly evaluated, digitized, and processed data would arrive at the work station clean and error free, be correctly geographically positioned per the control on the original document, and require only minimal editing to apply the data to the current published chart. Limited functions allowed straight-line connections of linear features, rotation and movement of some symbols, and transaction of features to published or archived status; and allowed supporting functions to query the contents of the records.

Methods/software

Preliminary studies indicated that extensive editing would be required of linear features and less editing required for other data types. When the cartographer got on the work station to perform compilation activities, it was found that the work station did not support the cartographer in the manner he/she was accustomed to in the manual application of data.

Production use of the work station provided a more realistic barometer for determining where extensive data editing was necessary. We found that most work station activity centred around maintenance of discrete features and charted nomenclature which supports the feature. Linear data revisions, although not as substantial in quantity, presented problems due to limited capability.

Enhancements

Software enhancements to the cartographic capabilities originally developed include:

(*a*) Complete nomenclature (text) editing (creation, placement, and graphic display);

(*b*) Complete line-editing capability: line creation, joining, closure, deletion, vertex manipulation, segmenting;

(*c*) Capability to edit feature record fields to correct errors introduced during initial data base creation and load processing;

(*d*) Data entry and feature record creation at the work station to by-pass extensive processing of small amounts of data through the NDHF;

(*e*) Bulk editing of features within polygons, qualified by data type, feature classification, charted status, and symbolization.

Other enhancements being developed include the ability to append comment records to features where recording the reasons why a feature was edited in a certain way might clarify post-edit research. Also, a record will be created and appended to any feature moved at the work station. This record will contain the edited position of the feature. The original position as given or captured will be retained for historical reasons.

Central site data base edit capability

Another area of concern is the edit capability, currently being developed, of the data resident on the AIS data base mass storage. There is a need to edit large amounts of data prior to their being sent to a work station. The mass data collection efforts, along with the complex task of processing the information, introduced some errors in the data which, if sent to the work station, would reduce cartographer performance during the editing process. Also, it was recognized that if the cartographer could manipulate the data at the central site he/she could eliminate some tasks formerly thought to be within the jurisdiction of the work station environment.

The one major editing capability desired at the data base mass storage level, above the ability to correct data, is the ability to assign features en masse to a newly designed chart. Presently, features must be assigned to a new chart, one feature at a time, at the work station. The bulk edit function recently developed for editing features at the work station is an improvement, but can only mass edit features that are displayed on the screen.

With central site data base edit capability, a new chart or series of charts can be interactively developed by editing the parameter information files describing geographic chart limits. The data within the new limits can then be assigned *en masse* to the new chart or qualified by specific data types. The new chart would then be sent to the work station for review and enhancement.

Archival system

The original design required an off-line archival library system to store all features which were subsequently removed from the chart during work station edit sessions. This archival file was designed to support cartographic research of past chart maintenance applications eliminating the pick and shovel effort now used in searching through files and drawers to find original source documents.

Features from source documents were to be stored in the active data base if published on at least one chart and stored in the archival file off-line, if superseded. The archival file was to be document oriented. Data written onto the system archival tape during data base update from the work station would, at intervals, governed by the archival tape capacity, be written onto tapes in the library indexed by the document's identification number previously assigned during initial document registry.

The process of updating document indexed tapes, which continually increased in number, was found to be labour intensive. Providing a dumping place for archival features by document identification did not provide the cartographer with all the needed historical information specific to a particular printing of the chart.

New approach

To improve the capability to extract historical information from the archival file, NOS has abandoned the original concept of storing superseded information off-line by document identification in favour of storing data by chart identification.

Graphic recreation of a past printing of a chart will be more easily achieved if corrections applied to a chart are stored in the archival library along with the published representation for each printing of the chart. The listings retrieved in support of the graphic will provide the cartographer with an historical accounting of documents applied and editing performed. NOS is presently developing this capability.

CONCLUSIONS

The importance of post-developmental efforts cannot be overemphasized. The concepts of the AIS geographic-oriented data base are advanced. NOS is attempting to incorporate changes brought about by rapidly advancing technology and cartographer needs for efficient, timely application of marine information.

LESSONS LEARNED FROM NAUTICAL CHART DIGITAL DATA PROCESSING*

Paper submitted by the United States of America

RÉSUMÉ

Il arrive que le traitement des données numériques des cartes marines soit retardé par l'inefficacité du logiciel et le manque de cohérence du matériel utilisé. Ces défauts sont dus parfois à la nouveauté de l'application et à l'absence de techniques ayant fait leurs preuves. Le rapport présente des observations sur les succès enregistrés dans le traitement des données numériques des cartes marines et contient des suggestions pour améliorer la gestion du logiciel et du matériel des programmes connexes. L'évaluation utilisera l'analyse par régression de la documentation sur le traitement des données numériques cumulatives d'environ 350 cartes marines par le National Ocean Service.

RESUMEN

La elaboración de datos digitales para cartas puede tropezar con la ineficiencia de los programas y la inconsistencia del apoyo del equipo de computadoras. Estas dificultades pueden deberse a que se trata de una nueva aplicación y a la falta de técnicas de eficacia demostrada. El objetivo de esta monografía es hacer observaciones sobre los buenos resultados obtenidos en la elaboración de datos digitales para cartas náuticas y sugerir maneras de mejorar la gestión de los programas y del equipo de computadoras en programas conexos. En la evaluación se utilizará el análisis de regresión de la documentación sobre elaboración del Servicio Nacional de Océanos correspondiente a los datos digitales acumulados para 350 cartas náuticas aproximadamente.

The paper will discuss effective ways to process digital geographic position (GP) data using the National Ocean Service (NOS) Automated Information System (AIS) data base as a model. The AIS contains digital portrayal of continuous nautical charts from the Gulf coast of the United States-Mexican border, eastward to the Atlantic Ocean, and northward to Cape Fear. Great Lakes coverage is also loaded. This is 341 charts totalling 4 million records, or approximately 34 per cent of the complete NOS chart inventory.

The discussion will offer a generic view of a digital position data base, including an explicit iterative system life cycle which starts with data capture, develops with data processing rules, and leads to data base load. The focus will be on regression line fit evaluation of AIS data processing to provide suggestions for successful management of software and hardware.

GENERIC VIEW

Any data base requires a data collection mechanism, processing rules, and a storage medium. The AIS captures the bulk of digital data by cursor tracing of source material through a graphic digitizer subsystem. This subsystem is controlled by a PDP 11/70 computer which supports seven double screen work stations, four tape drives, one master console, one card reader, one alphanumeric terminal, one printer and three 300-megabyte disks. This is not the only method of data capture. GP received from published sources may be punched to card, read to magnetic tape, reformatted and entered into the data base.

Processing rules govern data definition, structure, chaining, and control. The AIS representative fraction of each large-scale nautical chart is set between 1:100,000 and 1:105,000. Scales exceeding 1:105,000 are small-scale. This arbitrary division is further subdivided into published and unpublished logical views of data. Processing software differentiates these data by converting feature codes into alphanumeric data base record types. For example, AIS travelling features (features whose length generally exceeds 5 minutes of latitude or longitude) are converted to D2 records. The D2 records are linked together in a data base chain by pointers and assigned to degree block storage units. A degree block is bounded by 1 degree of latitude by 1 degree of longitude. The AIS large-scale linear features, confined to a large-scale chart, are identified as DO records. The DO records are also linked together in a data base chain by pointers but use cells as basic storage units. Each degree

* The original text of this paper prepared by Daniel E. Neumann, National Ocean Service, appeared as document E/CONF 77/L 16. Use of trade names and trade marks is for identification purposes only and does not imply endorsement by the Government of the United States.

Figure 64. United States of America: Chart of digital data base system life cycle

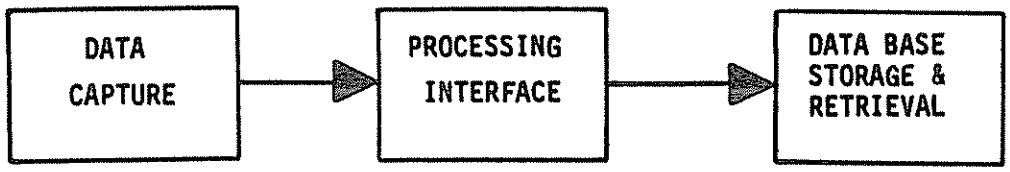
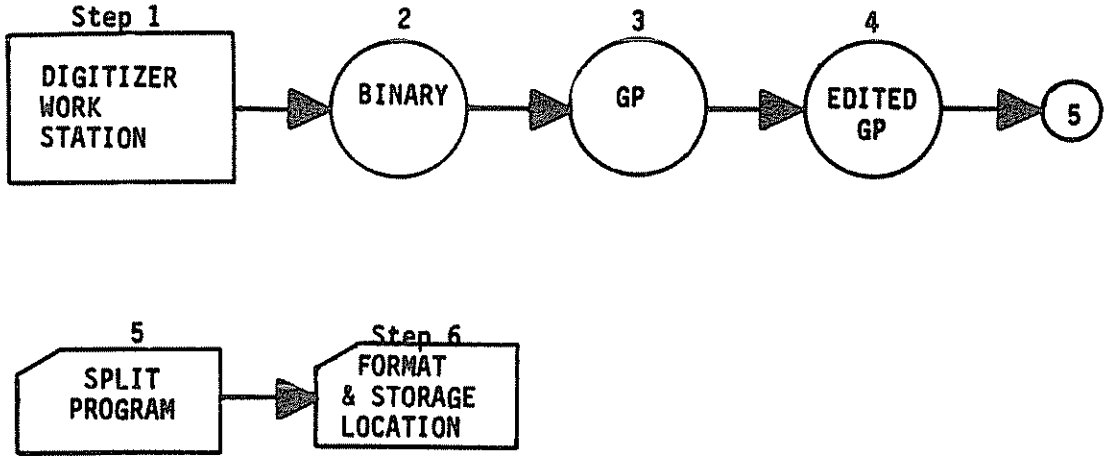


Figure 65. United States of America: Processing interface



block is divided into 144 cells, each 5 minutes by 5 minutes, and organized by 12 rows by 12 columns. Commercial data base management systems integrate these stored data into multiple logical relationships.

The AIS storage medium is actually two data bases: a GP data base and a system data base. The GP data base operates by the rules and procedures just described. The system data base contains files which treat each chart as an entity separate from data to control data base update, modification, and retrieval. The AIS system management personnel use system base feature code files to secure access and flexible graphic portrayal, respectively.

These AIS examples of digital data (capture, processing, and storage) only relate to nautical charts. The generic view used is then a point of departure from which additional data base environments can be conceptualized. Figure 64 illustrates the explicit life cycle within these environments and emphasizes the importance of the processing interface.

Processing Interface

The processing interface is the software which facilitates the expression of multiple relationships between independent data bits. It involves invisible manipulation of heretofore tangible data to determine format and describe content quality. The data can be processed from initial raw input or by supplementing or superseding previously loaded data.

Figure 65 exemplifies a processing interface. Binary data are converted to digital GP data using projection control and added intelligence such as feature name and cartographic code. Editing of these data, splitting them into separate files, and passing them through management controlled reference tables supports integrity, manipulation, and formatting of data, respectively. Raw data plots, magnetic tape dumps, and special edit software identify erroneous data. Post-edit extraneous data elimination permits efficient storage and reduced processing time. Edited and refined data in separate files allows independent interaction with processing tables to create individual record types which when combined form data base chains.

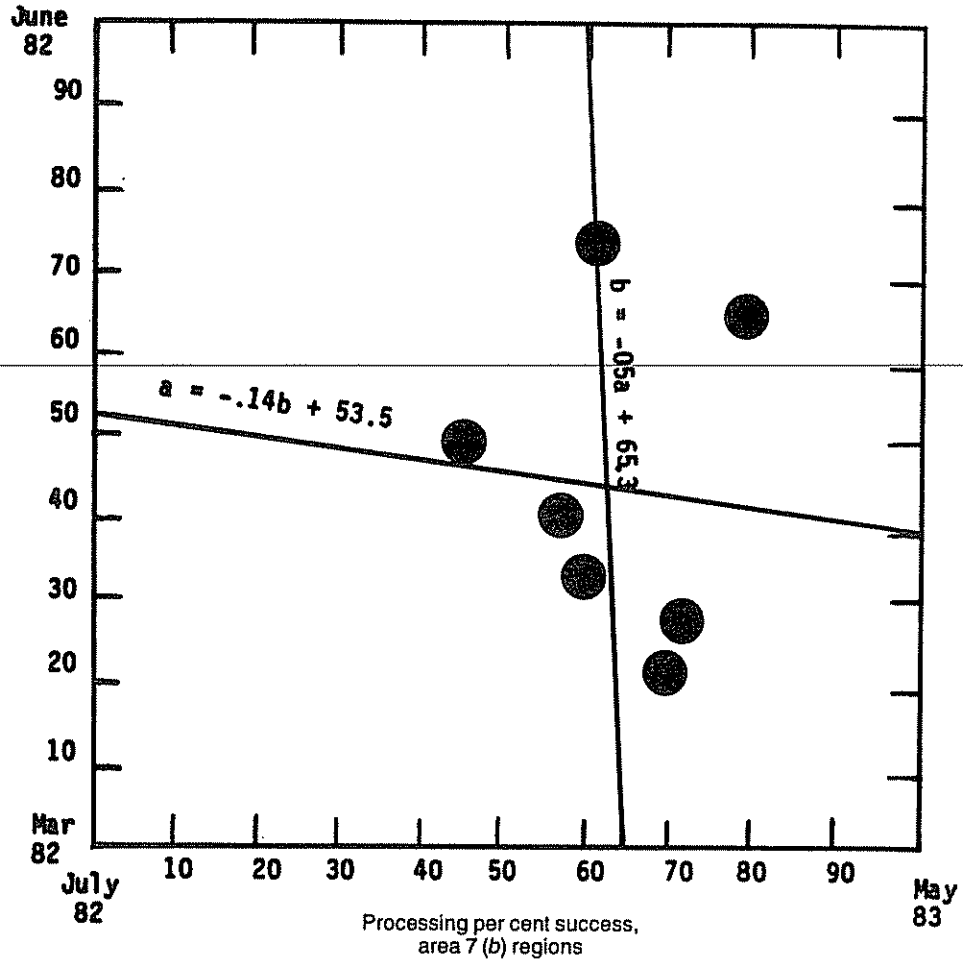
The AIS model uses curve fitting software to recreate curved linear feature facsimiles with a defined set of digitized data points. The AIS system data base tables record the GP outlines of each nautical chart's panels. Digital data are referenced to these windows and organized by cell or degree blocks mentioned earlier. This ensures complete data retrieval for any geographic area or any defined chart.

Again some generic processing guidelines, supplemented by the AIS examples, depict how the processing interface provides accurate, flexible, and complete digital data base coverage in an efficient and timely manner. Some regression analysis of recent AIS processing statistics helps to further develop these objectives.

AIS Processing Analysis

Paired regression analysis, unlike simple graphic presentation, compares sets of data to determine to what extent change in one was or was not reflected by the other's change. This method combines meaningful interpretation of processing success rate trends with visual definition of the system life cycle. Figure 66 shows paired regression line fit

Figure 66. United States of America: Paired variable regression line fit for certification of south-east Atlantic area 3 and Great Lakes area 7 digital data



for data of 107 south-east Atlantic nautical charts with approximately 1.4 million records. The calculations, available upon request from the author, relate to consistent chart numbers, record totals, and regional groupings of area charts for processing management.

The possible values of correlation r range from +1 to −1. The comparison had an r of −.086, which suggests that the processing per cent success rates data sets fluctuated completely independently of each other. The Great Lakes data processing success shows a markedly different trend than that of the earlier south-east Atlantic area. Moreover, a student's "t" test revealed that the independent fluctuation observed had less than a 5 per cent likelihood of change occurrence.

Closer analysis of the positive trend suggested in Great Lakes data processing is presented in figure 67. This analysis is based upon single variable regression line fit for each of the interface processing steps used in Great Lakes data conversion. The computed slopes and their graphical representation provide chronological pictures in which to gauge digital data processing improvement. However, three assumptions were made in the evaluation. First, any relationship that exists is true for the entire processing period. Second, the relationships present can be expressed in linear regression lines. Third, a cumulative positive trend corroborates the trend identified by paired regression line fit.

In the graphs of figure 67, regression line fit for the first two steps indicates a slight downward trend, while subsequent data base formatting of independent files shows continuous improvement. Most important, the overall trend is positive. Discussion of some of the reasons behind this processing success can be beneficial to management of software and hardware in similar endeavours.

Lessons Learned

There were several lessons learned during the processing of south-east Atlantic and Great Lakes digital data. Although this paper primarily concerns itself with software and hardware, there is a learning curve present in the regression graphs. The initial negative results followed by a positive improvement trend reflects training time for detailed personnel and should be developed in another study. Returning to software and hardware emphasis, there were four factors which were equally important. First, different off-site hardware system configurations, which supported digital data processing, were blended together. Secondly, there was improved identification and correction of tape drive problems, magnetic tape irregularities, and job control language errors. Thirdly, modifications were made to processing interface software to increase throughput and processing success rates. Fourthly, rigid documentation was begun to assist problem solving and training.

Figure 67. United States of America: Single variable regression line fit for Great Lakes digital data

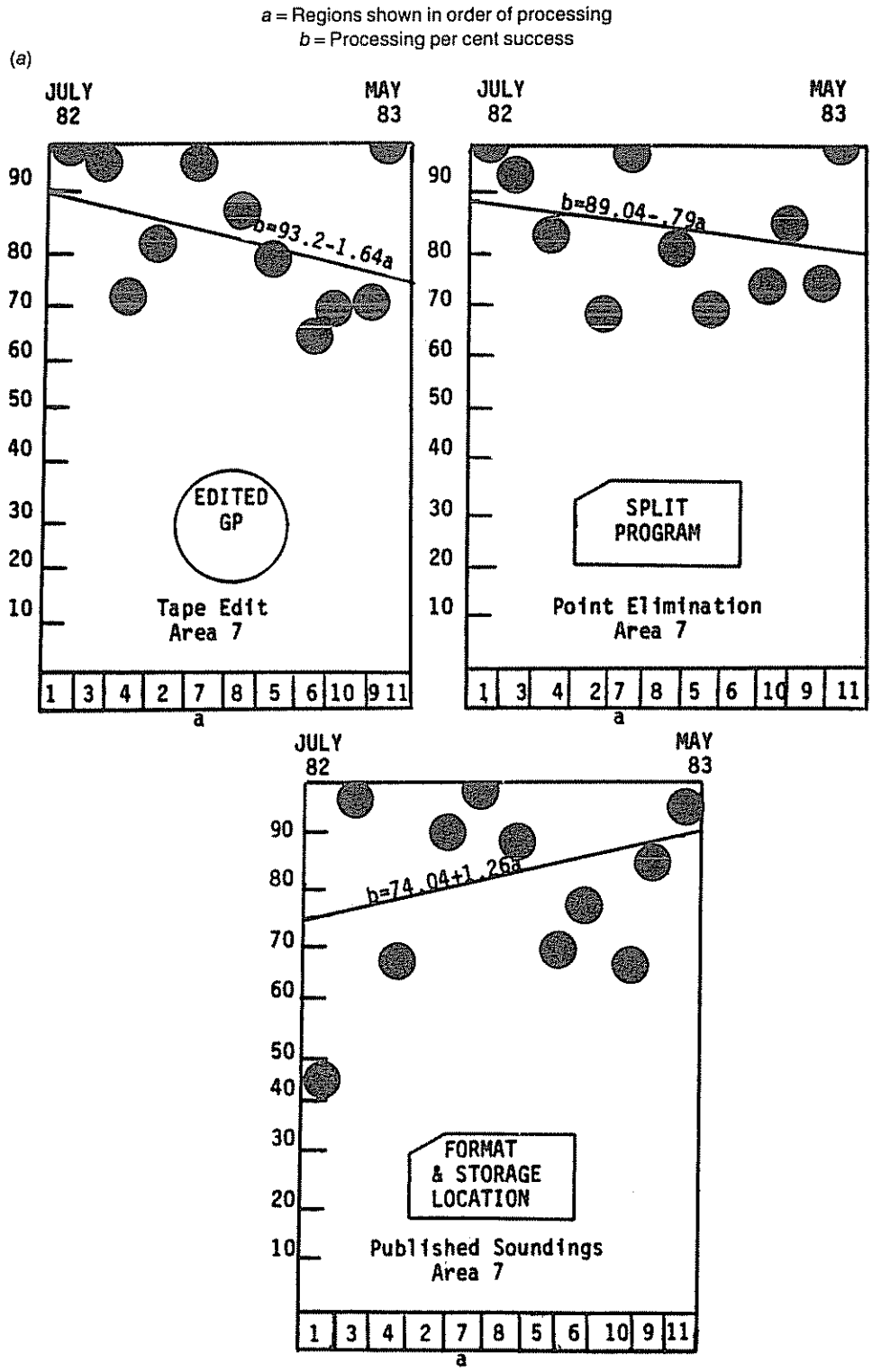
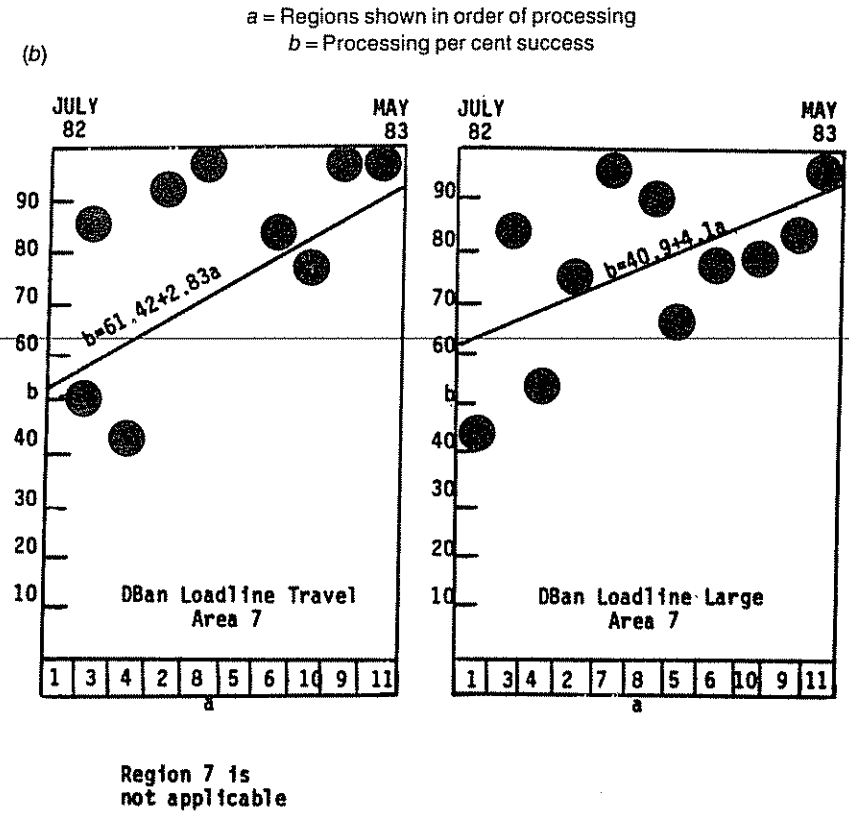


Figure 67 *(continued)*



A UNIVAC 1108 was used for tape edit and file separation. An IBM 360-195 supported formatting of the independent data files. The two configurations, at different physical locations, required multiple transmission lines for card read data input and voluminous magnetic tape transport. System crossover was a problem. It degraded UNIVAC operation more than IBM. Errors detected at the IBM entry of processing necessitated tape re-transport back to UNIVAC for job resubmission. The blend of the two support systems was gradually achieved by first running smaller numbers of jobs in sequence on the UNIVAC to make best use of access time and reduce redundant file and program search. In addition, increased monitoring of completed UNIVAC jobs by dumping output tapes ensured successful IBM entry. At present, there is a conscious effort to use the UNIVAC facility for complete interface processing while reserving the IBM support for auxiliary system data base file, processing table creation, and testing.

UNIVAC tape edit and file separation degradation made quality control measures imperative. Closer monitoring of tape drive calibrations, magnetic tape quality, tape mountings required, tape submission and increased user sophistication in UNIVAC ECL and IBM JCL reduced their cumulative error rates from approximately 10 per cent in south-east Atlantic digital data processing to roughly 3 per cent in Great Lakes digital data processing.

The entire south-east Atlantic and regions 1, 3, and 4 of the Great Lakes used an IBM net structure for running jobs that performed the data formatting and allocation to cell and degree block locations. Each net had two individual jobs cross-referenced to each other. This was problematic. If the first job aborted or completed in error, the second job was invalid even if it executed properly. The IBM system also did not always flush the net identification causing duplication errors in resubmission. After region 4 of the Great Lakes, the nets were eliminated in favour of a combined and concatenated run stream known as a "proc". These procs reduced the amount of JCL required, reduced tape amounts from four to three and relieved the user of file identification by placing them within the proc.

Starting with the south-east Atlantic data verification just prior to data base load, rigid documentation procedures were instituted. Training and interface processing problem solving both benefit from analysis of documented processing statistics. A task force presently preparing an automated compilation manual to supplement the current manual compilation guidelines will be able to use this documentation.

(f) *Conventional and digital cadastral mapping*

LA RÉFORME DU SYSTÈME CADASTRAL QUÉBÉCOIS*

Document présenté par le Canada

SUMMARY

The cadastral system of Quebec province, established between 1867 and 1900, has rendered and continues to render invaluable services in the registration of property rights. However, it has shortcomings that hinder its use; the provincial government has therefore begun to reform it.

The new system, in addition to fulfilling traditional functions more adequately, will provide the basis for property taxes, infrastructure management (water, sewerage, electricity, gas, telephone), administration of by-laws and the establishment of a spaced-based information system.

The present article describes the new system, the technological approach employed (in particular, digital maps on the thousandth scale), the role of government, surveyors' private practices and photogrammetric enterprises, the role of the municipal authorities, the means of financing the reform and its system of management.

RESUMEN

El sistema catastral de la provincia de Quebec, creado entre 1867 y 1900, ha brindado y sigue brindando servicios inestimables en materia de registro de derechos reales. Sin embargo, adolece de lagunas que limitan su utilización; por ello, el gobierno acaba de emprender la reforma.

Además de cumplir más adecuadamente su misión tradicional, el nuevo sistema servirá de base para la tributación inmobiliaria, la gestión de las infraestructuras (agua, desagüe, electricidad, gas, teléfono), la gestión de los reglamentos municipales y la instauración de un sistema de información con referencias espaciales.

El presente artículo describe el nuevo sistema, el enfoque tecnológico utilizado (en particular una cartografía digital a escala 1:1.000), el papel del gobierno, de las oficinas privadas de agrimensores-geómetras y de las empresas de fotogrametría, el papel de las municipalidades, el modo de financiación de la reforma y su sistema de gestión.

Le Québec amorce à l'heure actuelle une réforme fondamentale de son système cadastral. Étalé sur 10 ans, ce programme nécessitera des investissements de l'ordre de 84 millions de dollars (1984), impliquera la création ou la stabilisation de 355 emplois, mettra à contribution plusieurs développements technologiques récents et nécessitera un effort accru de production de la part du secteur privé.

LE SYSTÈME CADASTRAL QUÉBÉCOIS : MÉRITES ET FAIBLESSES

Etabli entre 1867 et 1900, le cadastre québécois a rendu et rend encore d'inestimables services à la collectivité tant au chapitre de la gestion de l'Etat qu'à celui de la protection des droits des propriétaires fonciers. La superficie aujourd'hui cadastrée est de 140 300 km² sur un total de 1 024 200 km², ce qui, en fait, correspond au domaine privé.

Le législateur en l'instituant visait à préciser l'identification des propriétés et à augmenter la sécurité des transactions immobilières. De conception simple, il répondait aux besoins et critères de l'époque. Il était constitué d'un plan illustrant toutes les propriétés désignées par un numéro distinct et d'un livre de renvoi complétant l'information par le nom du propriétaire et les dimensions du terrain. En référence à cet identifiant, une autre organisation enregistrait chaque transaction incluant toute obligation hypothécaire, ou droit réel.

Les arpenteurs procédaient aux mesures et à la confection des documents pour l'identification du morcellement, alors que les notaires établissaient les actes des transactions. La publicité foncière était assurée par le dépôt de copies conformes de ces documents au service du cadastre, au bureau d'enregistrement et à la municipalité concernée. Un mécanisme de tenue à jour avait aussi été prévu au code civil pour l'enregistrement du morcellement subséquent.

Une conjonction de facteurs a cependant entraîné une dégradation du système et de son adéquation aux besoins. Le principal est sans conteste l'inefficacité des mesures adoptées pour son actualisation. Par exemple, l'obligation légale d'enregistrer les opérations foncières ne fut jamais accompagnée de coercition. Comme les frais d'arpentage étaient uniformes, donc relativement élevés en milieu rural, l'application de la loi n'a pas été systématique.

D'autres défauts comme l'imprécision de certains levés initiaux et l'absence d'enregistrement des modifications topographiques ont aussi aggravé la situation.

Avec le temps, ce système a cessé de rendre compte de la réalité du morcellement foncier. D'une part, l'information est incomplète, la moitié seulement des 5 millions de lots étant connue distinctement, soit environ 80% en milieu urbain et 20% en milieu rural. D'autre part, l'image fournie n'est pas conforme à l'utilisation du territoire, dû surtout à l'absence de critère précis de morcellement.

Par ailleurs, la croissance de l'activité économique et l'implication des différents palliers de gouvernement dans l'organisation du territoire, par le biais de lois et règlements relatifs à l'aménagement, ont augmenté de façon critique le volume des requêtes d'officialisation de lotissements (12 000 à 14 000 dossiers maintenant traités annuellement) et élargi le rôle des entités administratives responsables. Les délais pour les usagers sont ainsi devenus difficilement acceptables. Actuellement, le traitement d'un cas simple exige de 2 à 3 semaines et jusqu'à 6 semaines pour un cas plus complexe. Les coûts inhérents à ces délais ne sont pas négligeables.

Il va sans dire que la perte graduelle de précision et d'actualité du cadastre a des conséquences importantes pour l'Etat. C'est en effet un outil de base dont les lacunes rendent difficile, voire même entravent l'application de législations et de réformes importantes.

Enfin, la configuration et les carences du système actuel empêchent l'utilisation maximale de cette banque de don-

* The original text of this paper, prepared by Michel Paradis, Assistant Minister, Ministry of Energy and Resources, Quebec, appeared as document E/CONF 77/L 51

nées et le développement de systèmes d'information à référence spatiale, tant par les municipalités que les compagnies de services publics.

Les objectifs de la réforme

L'évaluation du système cadastral québécois, des besoins actuels et anticipés ainsi que de l'environnement technologique a permis de définir les objectifs de la réforme.

On vise en premier lieu à **reconstituer une image complète et précise du morcellement foncier du territoire.** Pour ce faire, il s'agit, à partir d'une cartographie photogrammétrique de qualité, de procéder à l'identification des erreurs et lacunes, à la correction et au complément de l'information et au regroupement des lots par propriété.

Egalement, afin qu'une intervention lourde comme celle qui est entreprise, ne soit plus requise, il faut **assurer l'actualisation permanente de cette image.** Un mécanisme étanche a été conçu et sera appliqué. Son efficacité dépend, pour une bonne part, comme l'histoire l'a démontré, de l'adaptation des modalités et des frais d'officialisation du morcellement au type de milieu (urbain, rural, forestier).

Il y a aussi une volonté de **faciliter l'accès au système et son utilisation** par la réduction des délais d'officialisation et la décentralisation des opérations d'entrée et de consultation de l'information.

Enfin, il est impératif de **permettre l'utilisation polyvalente de cette banque d'information** par l'élaboration d'un cadre d'ententes et l'utilisation de formats facilitant le transfert.

Les éléments de base du système

Un réseau géodésique complété

Une des qualités essentielles d'un système cadastral est sa précision et l'on ne peut songer à entreprendre des opérations de rénovation sans se doter au préalable d'un canevas suffisamment dense. Le réseau géodésique québécois se compose à l'heure actuelle de quelque 50 000 points planimétriques et repères altimétriques de premier, deuxième et troisième ordre.

La réforme cadastrale nécessite l'addition de 6 000 points aux réseaux de deuxième et troisième ordre et d'environ 6 000 km de réseaux altimétriques. De plus, un réseau de quatrième ordre, d'une densité de 8 à 10 points au km^2, sera établi dans les zones urbaines. Il sera constitué, à terme, de 40 000 points.

L'ensemble de ces repères permet le contrôle de précision des cartes de base, mais aussi le rattachement des relevés de détails pour la rénovation cadastrale et la mise à jour. Enfin, il rend possible la définition en position des infrastructures de l'État, des municipalités et des compagnies de services publics.

Une cartographie topographique adaptée

L'autre élément nécessaire à la réforme est la disponibilité d'une base cartographique de qualité. Elle permet en effet la mise en relation rigoureuse de l'ensemble des thèmes reliés au territoire, y inclus le morcellement. En ce sens, elle constitue un instrument polyvalent et les choix qui ont été faits dans le cadre de la réforme ont dû prendre en compte les programmes existants, la réévaluation des besoins des utilisateurs ainsi que la configuration du morcellement sur le territoire.

C'est ainsi que l'on a été amené à abandonner la production de la carte complète classique à grande échelle au profit d'une carte minimale destinée à couvrir le territoire des agglomérations. Ce concept est apparu à la fois économique et apte à satisfaire la majorité des besoins. Environ 5 000 cartes à 1/1 000 sont requises pour la représentation des milieux urbanisés. Les éléments représentés sont le réseau hydrographique principal, le réseau des voies publiques, les immeubles sous forme simplifiée, les structures visibles des services publics et l'orographie le long des axes routiers.

Par ailleurs, l'ensemble du territoire cadastré sera cartographié à 1/20 000. Il s'agit d'une cartographie topographique où le relief est représenté par des courbes équidistantes de 10 m. Les caractéristiques du marché de ce produit ne permettent pas d'en simplifier le contenu. Environ 1 600 cartes sont à produire ou à numériser.

Une cartographie cadastrale renouvelée et officialisée

Cette cartographie constitue un des aboutissements de la réforme et diverses étapes sont prévues pour y arriver. La première est le report sur des bases cartographiques rigoureuses de l'information cadastrale officielle. Cette opération met en évidence les secteurs où des relevés détaillés s'imposent et ceux où de simples contrôles ou rattachements au réseau géodésique suffisent.

Dans un deuxième temps, le morcellement non officialisé est ajouté en utilisant toutes les sources disponibles : greffe des bureaux d'arpenteurs, archives des ministères, documents municipaux, etc. Au besoin, l'arpentage est fait.

A ce moment, le regroupement des lots par propriété peut s'effectuer, suivi d'une validation en séance publique par les propriétaires. Enfin, le document est finalisé et publicisé. A la très lourde et imprécise description littérale du morcellement se trouve ainsi substituée une description par coordonnées.

La cartographie cadastrale s'effectue, eu égard à la taille des lots, sur une base à 1/1 000 pour le territoire des agglomérations et généralement à 1/20 000 pour le territoire rural ou forestier.

Les choix technologiques

Les objectifs de la réforme, en particulier ceux ayant trait à l'utilisation polyvalente des données, ont guidé nos choix technologiques. Chaque sous-système utilise au maximum les supports et concepts de la géomatique.

La saisie des données

Ces dernières années, les travaux classiques de géodésie ont été effectués de plus en plus à l'aide d'instruments et de techniques évolués : tachéomètre et télémètre intégrés, carnet de notes électroniques programmable. Cependant, la véritable révolution dans le domaine s'amorce par l'usage des satellites en géodésie de positionnement.

Le Québec, pour sa part, s'intéresse activement à la méthode GPS (Global Positioning System). Des tests ont été effectués en fonction des caractéristiques du territoire et des besoins particuliers. Par exemple, pour les secteurs d'accès difficile, la technique de positionnement relatif sera appliquée par méthode héliportée, dès l'an prochain. En milieu urbain, des essais fructueux ont été réalisés en vue de l'implantation du réseau de quatrième ordre. Des points distants d'environ 200 m ont été établis avec une précision supérieure à 1 cm. La méthode sera évidemment mise à contribution dans les travaux reliés à la réforme, dès que la constellation de satellites sera complétée et les coûts devenus compétitifs.

D'autre part, la cartographie topographique prévue au programme de réforme est entièrement numérique. En effet, le Québec, après avoir adopté cette technologie à son contexte particulier, a mis sur pied, il y a plus de trois ans, une structure de production fonctionnelle qui répond aux normes de qualité et de rentabilité.

La chaîne utilisée, basée sur un système graphique interactif, va du captage de l'information en mode numérique sur les photographies aériennes, jusqu'au traçage par table automatique, en passant par un traitement à l'aide de fichiers d'édition.

Le gouvernement utilise actuellement une station reliée à un ordinateur PDP11-70, à des fins de développement et de vérification des travaux effectués par l'entreprise privée. Cette dernière fonctionne à partir de quatre stations de captage et quatre stations d'édition

Le rythme de production annuel est maintenant de 60 cartes pour chacune des échelles mentionnées précédemment : 1/1 000 (version complète) et 1/20 000. D'ici 1986, sept autres stations de captage seront ajoutées au parc d'équipements, en vue de porter la production annuelle à 560 cartes minimales à 1/1 000 et à 1/20 000 Il est à noter que, pour atteindre cet objectif, la période d'utilisation des équipements sera également prolongée.

En ce qui concerne les cartes conventionnelles produites antérieurement, elles seront rendues compatibles par la création de fichiers à l'aide des techniques de numérisation automatique (scanneurs optiques).

Quant aux données du morcellement, l'ampleur des opérations de mise à jour et de complément exige les équipements les plus performants pour les levés de détails. Plus globalement, la constitution d'un réseau de communication informatisé reliant l'ensemble des quelque 250 cabinets d'arpenteurs-géomètres à l'organisation centrale est la solution retenue pour assurer l'actualité et l'efficacité du système.

Le traitement et la diffusion de l'information

L'un des objectifs de la réforme est de favoriser l'utilisation polyvalente de l'information. A cet effet, il était indispensable de mettre en place une organisation qui le permette. Le concept de base géographique nationale (BGN) est au cœur de cette organisation. Cette base est constituée d'un système de référence dense (réseau géodésique), d'une information précise, continuellement tenue à jour et structurée par niveaux de la géographie du territoire (carte photogrammétrique) et finalement d'un ensemble de données sur le morcellement foncier (carte cadastrale) La BGN servira d'assise à la mise en place de systèmes d'information à référence spatiale (SIRS), par diverses organisations, pour des fins de gestion municipale, de planification de réseaux par les compagnies de services publics, etc.

Si des appuis technologiques éprouvés et performants comme des systèmes graphiques interactifs rendent déjà possible la création de SIRS, du moins de petite taille, l'utilisation maximale des produits de la réforme ne peut se concevoir sans l'établissement de liens efficaces et permanents entre ces différents systèmes et la BGN. Il s'agit en fait de créer un réseau de SIRS. L'architecture d'un tel réseau peut varier considérablement, mais le concept le plus élémentaire consiste en une accumulation progressive de SIRS autour d'une base de données centrale qui lui sert de code universel. Le réseau comprend en outre des mécanismes appropriés de communication ainsi que des normes, des protocoles et des procédures qui assurent la compatibilité entre les différentes technologies utilisées, permettent l'identification et la localisation des informations ainsi que l'organisation de leur acquisition physique.

C'est certainement à ce niveau que portent actuellement les plus sérieux efforts de réflexion et de développement. Le problème transcende le strict plan technologique tout en y étant intimement lié.

La gestion de la réforme

La maîtrise d'œuvre

La mise en place et la gestion du système cadastral font partie, au Québec comme ailleurs, de la mission gouvernementale. En conséquence, le gouvernement initie et assure la maîtrise d'œuvre de la réforme. A ce titre, il a défini les objectifs avec la collaboration, il va sans dire, des principaux utilisateurs actuels et futurs. Il établit la programmation, organise le financement, coordonne les opérations, fixe les normes, contrôle les résultats, officialise les documents, en assure la conservation et la diffusion.

D'autre part, il prend en charge le développement que les choix technologiques imposent. Le transfert à l'industrie de l'arpentage et de la photogrammétrie se fait conformément à la politique suivie depuis plusieurs années dans ce domaine.

Le rôle de l'industrie de l'arpentage et de la photogrammétrie

L'entreprise privée est massivement mise à contribution dans la réalisation de la réforme. A titre indicatif, quelque 80% des emplois directs créés le seront au sein de l'industrie. Même si le gouvernement prend en charge la fonction recherche-développement, l'industrie, dans un contexte de production, est appelée à suggérer de nombreuses améliorations aux méthodes à développer des logiciels particuliers, etc. En ce sens, la collaboration entre les deux fonctions doit être des plus étroites.

L'attribution de contrats d'une durée de trois à cinq ans, complétés par des plans de travail annuels, rend possibles les investissements requis.

La participation des municipalités

Comme mentionné précédemment, le gouvernement, en vue d'assurer la rentabilité maximale des investissements, a adopté le concept de base géographique. Dans ce cadre, des ententes sont conclues avec les municipalités locales ou les municipalités régionales de comté (pallier administratif supérieur) par lesquelles le gouvernement remet l'information relative à la base géographique en retour d'une participation à différentes opérations adaptées à leur niveau d'intervention et à l'engagement à constituer un système d'information urbain à référence spatiale.

Ainsi, la municipalité établit et entretient le réseau géodésique de quatrième ordre, assure la mise à jour de la carte photogrammétrique, constitue des cadastres thématiques (fiscal, réglementaire, des infrastructures). Le gouvernement, pour sa part, produit la carte de base et la carte du morcellement foncier, en plus de fournir une assistance méthodologique tout au long du processus.

En ce qui a trait aux opérations directement réalisées, à la connaissance du morcellement et à l'épuration du cadastre, la collaboration des municipalités est également requise. Elles sont invitées à fournir toute l'information dont elles disposent à cet égard et à participer à l'organisation

des séances publiques destinées à l'examen par les propriétaires des documents cadastraux renouvelés.

Le financement

Le plan retenu

Il a déjà été mentionné que les coûts estimés de la réforme étaient de 84 millions de dollars (1984). Le choix du mode de financement a tenu compte à la fois du partage des responsabilités, des bénéficiaires et d'un souci d'efficacité administrative. C'est ainsi que 35 millions de dollars émargeront du budget du programme gouvernemental de levés et cartographie intégrés. Ce programme a en effet des objectifs de production compatibles avec les exigences de la réforme. La différence proviendra à la fois des usagers qui verront augmenter les frais d'enregistrement et les charges cadastrales en retour de l'amélioration du service et de la vente des produits numériques.

Le fonds spécial de la réforme cadastrale

Afin de permettre une gestion souple du programme, tous les argents nécessaires, revenus comme avances de fonds, sont versés dans un fonds spécial de façon à couvrir l'ensemble des dépenses, incluant les salaires. Selon le scénario de financement retenu, le gouvernement investit pour le démarrage du programme, mais à partir de la quatrième année le remboursement de ces sommes débutera. Un surplus net est prévu en fin d'opération.

La réforme du cadastre et la politique de développement de la géomatique

La collectivité québécoise investit quelque 186 millions de dollars annuellement et utilise de 4 000 à 5 000 personnes pour se procurer des informations géographiques nécessaires au bon fonctionnement de ses institutions (ministères, sociétés d'Etat, municipalités, commissions scolaires et compagnies de services publics). Par ailleurs, une enquête approfondie a révélé que la plupart des organismes impliqués procédaient ou s'apprêtaient à procéder à l'introduction des techniques de la géomatique dans leurs opérations.

Dans ce contexte, le gouvernement du Québec a cru bon d'amorcer l'élaboration d'une politique à l'égard de la géomatique, afin de rationaliser le développement du domaine, favoriser le développement de l'industrie privée et faciliter la circulation de l'information à référence spatiale. Cette politique touche autant l'aspect de la formation du personnel, que de la stratégie industrielle ou de la recherche-développement.

Le programme de réforme cadastrale vient s'inscrire et appuyer à la fois la politique, par un investissement majeur dans un projet intégré. Il permet en même temps à l'industrie de s'engager dans le renouvellement de son parc d'équipements, au monde de l'enseignement d'organiser des programmes de formation, à bon nombre de producteurs et d'utilisateurs d'information géographique d'élaborer des systèmes à partir de la base fournie.

CONVENTIONAL AND DIGITAL CADASTRAL MAPPING*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Ce rapport est axé sur l'organisation du cadastre et la façon de l'utiliser comme base de système d'information foncière. Ce système doit être aisément accessible à tous les utilisateurs du cadastre, administrations aussi bien que particuliers. Dans ce rapport, je veux expliquer le système qui vient d'être adopté en République fédérale d'Allemagne et donner une idée de la transformation du plan cadastral classique en carte numérique polyvalente moderne. Mais je voudrais tout d'abord donner un aperçu général du cadastre, ce qui paraît nécessaire pour les remarques qui suivent.

Le cadastre est l'élément essentiel du système d'information foncière. Il a pour but de rassembler des données sur les parcelles et toutes informations supplémentaires s'y rapportant d'une manière ou d'une autre. Cette tâche historique a été confiée au cadastre par la loi.

Pour permettre l'exécution de la tâche définie ci-dessus, le cadastre se composait (et se compose encore) de trois parties : le registre, les plans et les observations. Cette classification s'est avérée utile.

Registre. — Toutes les parcelles d'un secteur sont numérotées de façon à pouvoir être identifiées clairement. Le

*The original text of this paper, prepared by Klaus J. Barwinski, Landesvermessungsamt Nordrhein-Westfalen, appeared as document E/CONF.77/L.10.

RESUMEN

Esta monografía trata de la forma en que está organizado el catastro y de cómo puede utilizarse éste como base de un sistema de información sobre la tierra. Este es un sistema al que pueden tener fácil acceso todos los usuarios del catastro y las oficinas administrativas, así como particulares. El autor explica las características del sistema que acaba de establecerse en la República Federal de Alemania y la transición de mapas catastrales corrientes a mapas digitales modernos, que pueden utilizarse para distintos fines. El autor da una descripción general del catastro como base de las observaciones que figuran a continuación.

El catastro es el componente fundamental del sistema de información sobre la tierra. La finalidad del catastro es recoger todos los datos disponibles sobre las parcelas en que está dividida la tierra y toda la información adicional que de una manera u otra se relacione con ellas. Esta tarea, que ha tenido una larga evolución, se ha asignado al catastro por ley.

Para realizar la tarea arriba descrita, el catastro incluía (y todavía incluye) tres elementos: el índice catastral, los mapas catastrales y las notas tomadas sobre el terreno. Esta clasificación ha resultado ser útil.

Indice catastral. Todas las parcelas de una zona están numeradas de manera que puedan ser identificadas claramente. El índice catastral contiene toda la información descriptiva disponible sobre las parcelas, en un registro de parcelas (Flurstücksnachweis) y en un registro de la pro-

registre contient, classée par parcelle (Flurstücksnachweis) et par propriétaire (Bestandsnachweis), toute l'information descriptive sur les parcelles identifiées chacune par un numéro.

Plan cadastral. — Ces plans comportent les indications suivantes sur les parcelles : limites de la propriété, identification de la parcelle, toponymes, bâtiments, occupation des sols et leur délimitation et éléments topographiques.

Observations. — Les plans cadastraux sont établis à partir des données obtenues lors des levés. Ces données sont consignées dans les notes aussi bien que dans les listes de coordonnées et d'élévation.

Quelques exemples concrets suffisent à faire comprendre comment le cadastre intervient dans la vie des gens et dans l'amélioration des structures foncières : plans de développement, approbation officielle d'un plan, registre des propriétés urbaines, noms de rues et numéros des maisons, transactions foncières, zones inondées, registre des espaces verts.

Les services du cadastre ont utilisé le traitement des donnés dès le début. L'efficacité croissante des ordinateurs permet d'avoir des programmes de plus en plus complexes. Avec les restituteurs, le traitement des données peut également être utilisé pour les documents graphiques et les cartes. Aujourd'hui l'utilisation des ordinateurs est plus simple et plus commode grâce au mode dialogué et aux terminaux alphanumériques et graphiques. Les progrès techniques constants, qui se traduisent par une baisse des prix, font qu'il est maintenant possible d'utiliser des ordinateurs pour toute une gamme d'activités, par exemple pour les levés, la seule condition étant l'existence de programmes appropriés.

Avec la généralisation de cette tendance, les services cadastraux et topographiques de la République fédérale d'Allemagne, en coopération avec les municipalités, ont décidé d'établir un système d'information foncière contenant toutes les données relatives aux parcelles (banque des données immobilières). Toute une série de services devrait être en mesure d'introduire leurs données spécifiques dans le système.

Le système d'information doit garantir que toutes les données requises et réunies par un service peuvent être traitées directement dans le système. Les services cadastraux et topographiques ont donc commencé à construire les programmes pour une partie des systèmes d'information foncière, l'index cadastral.

Il est beaucoup plus difficile de construire un programme pour l'automatisation des plans cadastraux.

Le système de la banque de données immobilières comporte deux parties : la banque de données proprement dite et l'unité de traitement. La banque de données mémorise définitivement toutes les données sur les parcelles, l'unité de traitement assure l'enregistrement, la mise à jour et la recherche de toutes les données emmagasinées dans la banque.

Le système qui fournit toutes les données planimétriques et graphiques est également appelé plan cadastral numérique. Ce système mémorise tous les contours graphiques de tous les objets dans tous les services participants : il n'est

piedad (Bestandsnachweis), clasificada de acuerdo con ese número de identificación.

Mapas catastrales. En estos mapas están indicadas las siguientes características de las parcelas: límites de las fincas, identificación de las parcelas, nombre del lugar, edificios, usos de la tierra, área destinada a los distintos usos y características topográficas.

Notas tomadas sobre el terreno. Las notas catastrales están basadas en los datos obtenidos en los levantamientos topográficos locales. Estos datos se consignan en las notas que se toman sobre el terreno, así como en listas de coordenadas y de elevaciones.

Los ejemplos concretos de la aplicación del catastro que se indican a continuación permiten apreciar los efectos del sistema para los habitantes de una región y para el mejoramiento de la ordenación de la tierra y los bienes inmuebles: planes de desarrollo, aprobación oficial de planes, registro de fincas urbanas, nombres de calles y número de las viviendas, transacciones con inmuebles, determinación de zonas inundadas, y registro de espacios verdes.

Las oficinas catastrales han utilizado métodos de procesamiento de datos desde sus comienzos. La eficiencia cada vez mayor de las computadoras ha permitido elaborar programas cada vez más complejos. Una vez desarrollados los dispositivos trazadores, también se podían utilizar técnicas de procesamiento de datos para la elaboración de gráficos y mapas. Actualmente el uso de computadoras se ha simplificado y la tecnología resulta más accesible gracias a las terminales alfanuméricas y gráficas y las terminales capaces de intercomunicación. La constante evolución de la tecnología ha hecho disminuir los precios, con lo cual resulta posible utilizar computadoras en una amplia variedad de funciones, el único requisito necesario es la disponibilidad de programas adecuados, por ejemplo, de programas para el levantamiento de planos.

Al generalizarse esta tendencia, los organismos catastrales y de topografía y geodesia de la República Federal de Alemania, en cooperación con las autoridades comunales, decidieron establecer un sistema de información sobre la tierra que incluyera todos los datos sobre parcelas (banco de datos sobre inmuebles). Diversos organismos podrían incluir en dicho sistema datos actualizados para sus necesidades específicas.

Uno de los fines del sistema de información es asegurar que todos los datos que se necesiten y obtengan para las actividades de los organismos puedan procesarse directamente por medio del sistema. Por lo tanto, los organismos catastrales y de topografía y geodesia han empezado a elaborar programas para uno de los componentes del sistema de información, a saber, el índice catastral.

La elaboración de un programa para la automatización de los mapas catastrales es una tarea mucho más difícil.

El sistema de programas del banco de datos sobre inmuebles incluye dos partes: el banco de datos y la unidad de procesamiento.

En el banco de datos se archivan en forma permanente todos los datos sobre los terrenos; la unidad de procesamiento se ocupa de registrar, actualizar y seleccionar los datos almacenados en el banco de datos.

El sistema de programas que suministra todos los datos gráficos y planimétricos se denomina también "mapa catastral digital". Este sistema permite archivar todos los esquemas gráficos de todos los objetos de todos los organismos

donc pas limité aux services cadastraux ou topographiques, même si les plans cadastraux en constituent les données essentielles. Ce système est divisé en deux parties, comme la banque de données immobilières : banque de données et unité de traitement. Les deux parties sont liées par une interface spécifique, l'interface uniforme de la banque des données.

Il découle de ce qui précède qu'un plan cadastral numérique comporte trois fichiers principaux : le fichier planimétrique, le fichier par points et le fichier par éléments de mesure.

La méthode décrite plus haut assure la gestion d'un cadastre automatisé en même temps que l'intégration des données d'autres services administratifs concernant les terres et les propriétés foncières. Le cadastre automatisé se prête particulièrement bien à la gestion administrative; d'une part, il doit fournir des données systématiques sur une zone précise et, d'autre part, il est soumis aux lois et règlements applicables au cadastre. En raison de ces règlements, ce système ne peut pas être transféré directement à d'autres pays. Toutefois, la banque des données immobilières pourrait servir de modèle pour un système d'information foncière d'après la définition de la Fédération internationale des géomètres.

participantes, es decir, no está limitado a los organismos de topografía y geodesia o los organismos catastrales, a pesar de que los mapas catastrales proporcionan los datos básicos para el mapa catastral digital. El sistema de programas del mapa catastral digital también está constituido por los mismos componentes que el banco de datos sobre inmuebles: el banco de datos y la unidad de procesamiento

Ambos componentes están vinculados entre sí por medio de una interfaz específica, que se denomina "la interfaz uniforme del banco de datos"

Así, pues, el sistema del mapa catastral digital incluye tres archivos básicos: el archivo planimétrico, el archivo de puntos y el archivo de elementos de medición

El método que se describe más arriba sirve para administrar un catastro automatizado y para integrar los datos sobre otros aspectos administrativos relacionados con la tierra y los inmuebles. El sistema especial del catastro automatizado se presta para la gestión administrativa; por un lado, debe proporcionar datos sistemáticos sobre una zona determinada, y por el otro, sobre todas las reglamentaciones y leyes catastrales. Por esta última razón, este sistema no puede aplicarse directamente en otros países. Sin embargo, el banco de datos sobre inmuebles podría servir de modelo para el sistema de información sobre la tierra, de acuerdo con la definición de la Federación Internacional de Agrimensores.

The significance of surveying and mapping

Generally speaking, the subject of surveying and mapping is not a major public interest. Nevertheless, surveying and mapping documents are important in many fields and activities, both public and private. Lack of them is noticed only in case of need, or where certain information on land and estate is incorrect or incomplete. The more the world population increases, the greater the demands on surveying and mapping. The area of land, as well as the Earth's resources available to mankind are limited and have to be handled economically. We know today that only information on resources and energy allows sensible and necessary planning; we further know that mankind depends more and more on products and resources of the seas. Thus, surveying activities will in future not be limited to the land only, but will extend to the sea.

Surveying and mapping are indispensable means for a thorough and complete inventory of the Earth. All information characterizing the land surface has to be stored, updated where necessary, and made retrievable. Therefore modern surveying and mapping have two important functions:

(*a*) Determination of the shape of the Earth and recording of information of the Earth's surface: this is the task of the national survey, topography and cartography;

(*b*) Registration of parcels, real properties, and information concerning these units: this is a matter for the cadastre.

The present paper concerns organization of the cadastre and how it can be used as the basis of a land information system. It should be noted also that the establishment of a modern surveying and mapping system is not a work carried out once; only a continuous, systematic updating and renewal guarantees its functioning. Comparing different countries, it is obvious that the existence of a qualified surveying system is generally accompanied by a high living standard. Today, more than ever, modern technology offers all prerequisites to survey quickly, to monitor all changes in the surface of the Earth and to produce maps. Therefore modern technologies should be used as far as necessary to create a new surveying and mapping system, which is easily available for all users of the cadastre, administrative offices as well as private persons. The present paper will outline the system, which is newly developed in the Federal Republic of Germany, and give a detailed view of the development of the conventional cadastral map to a modern, multipurpose digital map.

Historical development of the cadastre

The cadastre is the basic component of the land information system. The task of the cadastre is to collect data on parcels and all additional information somehow connected with these parcels. The cadastre was assigned this historically developed task by law.

Only at the beginning of the nineteenth century did systematic surveying come into existence in European countries. Cadastres were established to guarantee a just distribution of land taxes: therefore all parcels had to be surveyed, mapped and recorded in registers. Since this work had to be done hurriedly, all kinds of older documents and maps were used to complete them, along with new surveys. This resulted in very heterogeneous cadastral maps, a fault that is still noticeable today, and thus is mentioned so that such faults may be avoided in future.

Very soon the sole land tax register was also used for other than fiscal purposes, since throughout the period of industrialization the demand for maps was high, since they were needed in the planning of factories, railways and towns. The cadastre gained further specific importance when it became the official document of the property register

(*Grundbuch*); thus, the cadastre became indispensable as reference of ownership. The cadastre in its function as ownership-reference can be dated precisely to the beginning of the twentieth century. Another important functional change was achieved, when in 1934—by way of law—the cadastre was assigned the task of recording evaluation of land. From that time the cadastre could really be called a multipurpose cadastre, since it was the basis for taxation, registration of ownership, and reference of land evaluations.

In the following period, especially after the Second World War, reconstruction work in the Federal Republic made it necessary to use the cadastre as a complete record of buildings, as well as of topography, in order to obtain documentation for regional and urban planning. Thus, the cadastre changed to a planning cadastre.

Content of the cadastre

In order to fulfil the task mentioned above, the cadastre consisted (and still consists) of three parts: the cadastral index, the cadastral maps and the field notes. This classification has proved to be useful and will be explained in detail.

Cadastral index (Buchnachweis). All parcels of an area are numbered in such a way that they can be clearly identified. According to this identification number the cadastral index contains all descriptive information on parcels.

The parcel file (*Flurstücksnachweis*) contains information on:

(*a*) Internal administration (e.g. cadastral office, township, county);

(*b*) Parcel-co-ordinate, blocks of buildings;

(*c*) Location, nature of current use, square measure of parcels;

(*d*) References related to property register of the Office of Census and other administration offices.

The ownership file (*Bestandsnachweis*) contains information on:

(*a*) Internal administration (e.g. cadastral office, property register);

(*b*) Owner;

(*c*) All parcels of a certain owner, compiled together with their related parcel identification.

Cadastral maps. These maps depict the following elements of parcels:

Property boundaries
Parcel identification (especially parcel number)
Place names
Buildings
Land uses and their boundaries
Topographical elements

Results of the land evaluation are mapped on a separate overlay.

At present two different kinds of maps exist as cadastral maps:

(*a*) *Inselkarte*: a map showing only the selected isolated area of a named locality (part of a region within natural boundaries);

(*b*) *Rahmenkarte*: a map on which the detail extends over the whole area enclosed by the net line.

After the Second World War, production of the *Rahmenkarte* greatly increased; it has the advantage of being suitable for sheet assemblies. Sheet assemblies of several cadastral maps were used as planning material especially during the reconstruction period after the war. Nevertheless, the application of the *Rahmenkarte* presents problems, because every now and then it happens that important parcels are depicted only at the corners of up to four maps. Most of the *Inselkarte* maps are based on surveys of the last century and, therefore, adaptation problems occur. Another complication is the variety of scales. The scale is generally chosen according to the depicted region. Urban areas should be mapped in scales between 1:250 to 1:500, rural areas at scales between 1:1,000 and 1:2,500. Since the normal method of optical enlargement leads to different symbol sizes and line widths the production of planning material, consisting of several single maps, is problematical. Comparing the cadastral maps of all Federal states it can be noticed that they differ in sheet sizes, e.g. in some states sheets are 50 × 50 cm, because they are easy to handle; in others are found sizes 50 × 100 cm in order to cover a larger area.

Field notes. The cadastral maps are based on the data obtained in local surveys. These data are recorded in the field notes as well as in lists of co-ordinates and heights. The surveying instruments used for cadastral surveys often are self-registering instruments. Without describing further these surveying-activities it should be mentioned that in order to determine survey points various surveying methods are used at present and will continue to be used in future.

Updating

The maintenance of a cadastre is a legally controlled task carried out by the cadastral offices. Keeping the cadastre up-to-date demands a high rate of personnel as well as high costs. Experiences have hitherto shown that changes amount to about 15 per cent a year. Since this figure is relatively high, updating work needs to be well organized. Thus, updating means that:

(*a*) Changes of ownership have to be registered and the cadastral map corrected accordingly;

(*b*) Changes of buildings and streets must be surveyed and the documents of the cadastre corrected as quickly as possible.

To show the extensive and various activities of the cadastre, only one example will suffice: til today we have not succeeded in surveying all buildings in a way necessary for the cadastre. Therefore—and especially for planning purposes—it was necessary to produce a photomap, 1:5,000, providing systematic cover at least for North Rhine-Westphalia (34,000 km²/17 million inhabitants; it is the most densely populated state of the Federal Republic). This photomap exists in addition to the basic map of the Federal Republic (*Deutsche Grundkarte*) 1:5,000.

One further item of information is of interest: in North Rhine-Westphalia, about 80 per cent of the cadastral surveys are carried out by licensed surveyors; consequently, the maintenance and updating of the cadastre is the basic task of the cadastral offices. To record all facts concerning land and real estate and their changes, fundamental control data, vertical and horizontal control data are needed. These data are an unavoidable means to create a homogeneous system in which daily local surveys together with the results of surveys already performed can be embodied without multiple recordings. This task is carried out at the cadastral office, which prepares the collected data and makes them available.

Uses of the cadastre

A few concrete examples show the effect of the cadastre on the people and on improvement of the organization of land and real estate.

Development plans are set up for only parts of a township. They consist of the legal decisions of all urban planning, concerning, for example,

(*a*) The quantity and quality of zoning classification and built-up parcels;

(*b*) The definition of areas reserved for transportation installations.

In addition, development plans must define:

(*a*) Concentration of buildings on parcels;

(*b*) Minimum size of parcels used for construction sites;

(*c*) Whether parcels for construction sites are limited to certain groups of people;

(*d*) Which areas should be used as parks, permanent gardens, cemeteries, sport fields etc.

The cadastral maps function as base maps for development plans passed by the local council.

Official approval of a plan is a prerequisite especially for large-scale road construction and for the construction of railroads, since legal positions as well as the actual local situation have to be altered. It is the aim in approving a plan to arrange the relationship between the legal representative in charge of an official construction project (e.g. a township, private person etc.) and the private persons concerned. The official approval of a plan replaces all necessary administrative procedures of former times.

The urban property roll contains all data on urban property, buildings as well as landed properties. All information and working material for offices concerned with the administration of property or the Office of Census is based on data from the urban property roll. Much of the data necessary for the urban property roll are originally recorded in the cadastral data base.

Street names and house numbers are used as reference, or let us say address, for built-up parcels. Generally this address is more current and better known than the cadastral parcel identification, and it is necessary for mail purposes. The cadastral maps are base maps for these tasks, too. Assembled lists recording the already used names and numbers can be made available.

The granting of land transactions is done to guarantee that only those land transactions can take place that allow the use of the parcel according to the development plan; e.g. if a partition of a parcel is planned, the future boundary is mapped on the cadastral map which is then sent to an approving authority.

Flooded areas are defined as flood protection areas to guarantee the non-noxious draining-off of the flood. Whoever wants to alter, deepen or elevate the land surface of these areas or erect, alter or tear down buildings or plant trees or bushes etc. needs the permission of an approving administration. If there is danger that the demands of flood protection will be neglected, this permission will not be granted.

Green space registers have only recently been established by several town administrations to record all public urban properties that are used as cemeteries, playgrounds, sport fields etc. In addition, the different kinds of plants on these areas are registered. The green space map functions as planning material for further urban green spaces and as basis for the definition of the costs of their maintenance as well as detailed personnel planning. Here again it is the cadastral map that is used as base map for the mapping of green spaces.

Development of data processing

Since the beginning, data processing has been used by the cadastral offices. The increasing efficiency of computers has provided more and more complex programs, which in the beginning were used only for the computation of coordinates and their application in modern surveying methods. But those programs could only be applied in batch mode. After developing plotters, data processing could also be used for graphics and maps. Today the use of computers is simplified and user-friendly by dialogue-mode, alphanumeric and graphic terminals. Meanwhile the operating systems of computers have become very efficient: huge amounts of data are computed in an extremely short time. Continued technical development, resulting in a price decline, makes it possible to use computers in a wide range, the only prerequisite being the availability of adequate programs, e.g., for surveying purposes.

When this tendency became widespread the cadastral and surveying administrations of the Federal Republic of Germany, in co-operation with the communal administrations, decided to establish a land information system containing all data related to parcels (real estate data bank). The cadastre was meant to be the basic component of this land information system. Various administrations were to be in the position of including their specific current data in the land information system. This resulted in a data pool so that each participating administration might directly and constantly use any given data (also those of other administrations) within that pool.

The information system is to guarantee that all data needed and obtained by administration work can be processed directly within the program-system. Any other processing method outside the program system could endanger the updating of data, since the data-flow back to the program system cannot in any case be ensured, and thus the whole land information system could become useless. Data selection outside the program system can only be permitted if it does not have any influence on data within the program system. In 1970 it seemed possible for the first time to realize a land information system. Therefore, the cadastral and surveying administrations began to develop programs for one part of the land information system, for the cadastral index. Parts of this program have been used in some states of the Federal Republic of Germany since the mid-seventies.

A much more difficult task is to provide a program for the automation of cadastral maps. In the beginning of the 1970s this could not yet be realized, but in 1977 the attempt was taken up again. For those programs a preliminary pilot period has begun.

Since the technical prerequisites of computers necessary to develop complex data systems or information systems have improved considerably, and the costs for technical equipment have declined, the realization of a highly complex information system seems possible and the necessary financial means do not seem out of reach.

A real estate data bank

The program system of the real estate data bank consists of two parts: (*a*) the data bank unit; and (*b*) the processing unit.

The data bank unit permanently stores all data on parcels; the processing unit ensures registering, updating, and selecting of all data stored in the data bank. All data on parcels of almost all administrations can be divided into two groups according to the system applied for cadastral data: (*a*) specific data of all necessary representable objects; and (*b*) planimetric data of these objects.

All planimetric data have one thing in common: their reference to land and real estate. All specific data vary according to the administration concerned. For example all data of a parcel within the cadastral index belong to the specific data; the parcel's outline belongs to the planimetric data section. Both data sections are interlinked either via object identification (from planimetric data section to specific data section) or via object co-ordinate (from specific data section to planimetric data section). This conception allows the realization of a real estate data bank step by step, each different administration contributing its specific data section. As mentioned above, the automation of the cadastral index began in 1970 and meanwhile has been completed.

The digital cadastral map

The program system providing all graphic, planimetric data is also called "digital cadastral map" or DCM. The program system stores all graphic outlines of all objects for any participating administration, i.e., it is not limited to surveying administrations or cadastral administrations only, although the cadastral maps provide the basic data for the DCM. The program system of the DCM is divided into the same parts as the real estate data bank, that is, the data bank unit and the processing unit.

Both parts are interlinked via a specific interface, the so-called "uniform data bank interface". This interface ensures the applicability of both parts with different computers.

Many aspects had to be considered in developing an efficient data structure for the data bank; e.g. different demands of users had to be taken into consideration. These demands concern the management and updating of map objects, such as parcels, on the one hand, and, on the other, the production of maps. Seen from an economic angle, unfortunately, the aspects are contradictory.

Concerning the aspect first mentioned above, management and updating all planimetric data of an object stored together by a single procedure seem the most adequate method. As to the second aspect, although many objects have identical outlines or borderlines, e.g. parcels, these lines have to be stored repeatedly according to the number of objects they belong to. As an average value, 3.5 objects were determined to have the same outline or borderline; the maximum were 33 lines of objects sharing a single borderline. But in producing a map, all repeated lines have to be reduced to a single line. The reasons are not only economic, e.g. the very slow working speed of the high precision flatbed plotter, but also the correct representation of these lines or map elements in general. After extensive analysis and research, the line-based model was chosen for storage *inter alia* because map production seemed the main application of the DCM in future.

Stemming from these reflections the digital cadastral map comprises three basic files: (*a*) the planimetric file; (*b*) the point file, and (*c*) the file of measuring elements.

The *planimetric file* is structured according to hierarchical principles. The first level or structuring principle is co-ordinates. Therefore, this file is structured according to geometric criteria without any limitations given by the future sheet-lines. The second level is divided into two sections: (*a*) data referring to lines; and (*b*) data referring to other objects.

In the first section all lines geometrically identical are stored only once. The interpretation possibilities, e.g. as borderline or part of a building etc., and the references to other objects are linked with these data. In the second section are stored the object's name and its date of coming-into-being. Different plotting methods for standard maps can also be stored in this file. The program of the planimetric file provides the possibility of selecting and storing maps of any chosen topic, in any scale or of any chosen window without any pattern previously determined. Data selection according to a given pattern or legend is carried out by the processing unit.

The *point file* contains the horizontal and vertical co-ordinates of the survey points as well as further details concerning these points, e.g. the method of monumentation and the significance of the referred survey points.

The *file of measuring elements* consists of the single measuring elements that are necessary for the computation of vertical and horizontal co-ordinates. In case of new findings or other changes, the insecurities of a co-ordinate transformation can be avoided and the computation can be carried out anew with the stored measuring elements.

All participating administrations storing their data in the same planimetric file use the same data bank. Therefore, the program-system also must comprise elements of data-securing and protection of data privacy. The main tasks of the program-system are:

(*a*) To co-ordinate the processing of all single demands;
(*b*) To respond to all demands;
(*c*) To ensure the consistency of all data.

The user only communicates with the uniform data bank interface, which normally consists of programs of the processing unit.

The processing unit of the DCM consists of the "graphic interactive work station" and a so-called "application managing part", which is designed to help administrations, offices or agencies to carry out their tasks taking into account the fact that an application is normally processed over a longer period and by several operators. The program is controlled according to different possible applications.

The graphic interactive work station, being an independent program system mainly working on mini-computers, has to carry out all technical and graphical tasks necessary for any single application. The work station has its own temporary data base and does not recur constantly to the central data bank unit. The necessary data on a certain area being worked at are made available to the work station via the uniform interface mentioned above. If data are altered at the work station they can be transfered back to the data bank unit.

The graphic interactive work station being designed universally is not limited to application in the field of cadastre; it also provides methods to handle graphic and topographic data. Use in development planning and road construction, as well as in various fields of administration, can be carried out with this work station. In general, its possible uses can be described as follows:

(*a*) Collecting of graphic data and information about the possible interpretations of an object including all geodetic calculations;

(*b*) Updating and management of map elements according to special commands;

(*c*) Applications.

The term "applications" is a collective term that allows map production according to various demands, including:

(*a*) Complete graphic representation by different symbols (dots, lines and coloured areas);

(*b*) Free choice of a plotting or drawing pattern for the presentation of a map in a different way;

(*c*) Free positioning of map lettering;

(*d*) Clearing of other map elements relevant to the positioning of lettering.

In many cases, especially in development planning as well as in cadastral administrations, it will be necessary to overlap a given area with another area in order to determine the sections they both have in common. In addition the representation of certain topics, i.e. specific data linked to map elements, as for example in thematic maps and graphs, should be pointed out.

Working at an interactive work station guarantees the organization of tasks according to the wishes of the user and at the same time under his control, thus ensuring high accuracy and quality.

Real estate data bank and the land information system

The method described above guarantees the management of an automated cadastre as well as the integration of data of other administrative fields referring to land and real estate. The special conception of the automated cadastre is suited for administrative management; on the one hand it has to provide a systematic data covering of a defined area, and on the other, it is subject to all cadastral regulations and laws. Owing to those regulations this system cannot be directly transferred to other countries. Nevertheless, the real estate data bank could be a model for a land information system according to the definition of the Fédération internationale des géomètres (FIG).

In 1978 FIG defined the land information system to indicate that its content should embody all data of landed properties which can form the basis for legal, administrative and economic procedures and which can be useful for planning and development in order to guarantee and improve the actual situation.

CARTOGRAPHIE CADASTRALE EN MILIEU URBAIN ET RURAL

Document présenté par la France

SUMMARY

The compilation of a cadastral map is largely the result of a political and financial decision. The necessary structures must be set up from the outset in order to make judicious use of this economic tool, which is particularly powerful in the hands of national or local authorities. In order to be effective, this system requires a fairly large investment and must be in keeping with local legislation. It should provide a legal guarantee, keep pace with changes and act as a support for regional development. In rural areas, its primary function is in the division and identification of lands. In urban areas, the delineation of lots demands rigorous accuracy.

Photogrammetry is still a favoured means of compiling such maps but it should be used with caution. The fieldwork is especially important when the required accuracy is high (urban areas). There must also be full co-ordination among the various ministries concerned (finance, agriculture, public works, etc.), which can go so far as to require changes in the country's very institutions.

RESUMEN

El establecimiento de un mapa catastral deriva sobre todo de una decisión financiera y política. Desde el principio se deben establecer las estructuras necesarias a fin de utilizar en forma prudente este instrumento económico, que es especialmente eficaz en manos de las autoridades nacionales y locales. Para que sea eficaz, el sistema exige una inversión relativamente considerable y se debe adaptar a la legislación de cada país, debe ofrecer una garantía jurídica, tener carácter evolutivo y seguir siendo una base para el desarrollo regional. En el medio rural, su función principal será en especial la distribución e identificación de las tierras. En el medio urbano, la definición exacta de la parcela de terreno deberá hacerse con todo el rigor necesario.

La fotogrametría sigue siendo un medio privilegiado para el establecimiento de este tipo de mapas, pero su aplicación exige algunas reservas. La labor sobre el terreno sigue siendo indispensable puesto que se exige una gran exactitud en el medio urbano. Deberá existir una perfecta coordinación entre los diversos ministerios interesados, a saber, finanzas, agricultura, obras públicas, etc., que puede incluso llegar a requerir modificaciones en las propias instituciones del país.

Dans de nombreux pays en voie de développement ou d'industrialisation, les responsables chargés de l'aménagement du territoire[1], qu'il s'agisse de décideurs politiques ou de responsables techniques, prennent de plus en plus conscience de l'impératif que constitue une gestion efficace pour :

a) Consolider les structures existantes et rationaliser les pratiques administratives;

b) Maîtriser l'expansion urbaine, souvent incontrôlée;

c) Optimiser les ressources tirées du patrimoine rural.

Très souvent il faut hélas noter que : *a*) l'information concernant l'occupation et l'utilisation du sol, voire du sous-sol, est inexistante ou très parcellisée; *b*) les procé-

* The original text of this paper, prepared by François Brun, National Geographical Institute, appeared as document E/CONF 77/L 34

[1] Ce terme doit être compris dans une acception la plus large possible : aménagement rural, développement régional, urbanisme, etc

dures utilisées pour appréhender et tenir cette information à jour, d'un point de vue tant technique qu'administratif, sont inadaptées et inopérentes; et *c*) les décisions prises ont, par voie de conséquence, un caractère aléatoire.

En d'autres termes, le système d'information nécessaire à l'aménagement du territoire, c'est-à-dire au développement du pays, fonctionne mal ou pas du tout. Ce constat d'inefficacité ou de carence a, entre autres, deux implications qui concernent tout particulièrement notre profession de topographe-cartographe :

1. Le renouveau ou l'apparition d'idées telles que l'équipement de base (géodésique, cartographique, photographique), le cadastre multifonctions ou à buts multiples, la banque de données (géographiques, urbaines, rurales);

2 Le report des besoins et des soucis des gestionnaires et décideurs sur le géomètre ou le cartographe traditionnellement chargés de l'acquisition et de la représentation des données.

De façon tout à fait analogue, les sociétés prestataires de services en informatique actives dans ces pays se voient poser des questions qui débordent considérablement leur champ traditionnel d'action, l'organisation et la gestion administratives. Le problème posé est invariablement de décrire — ce qui implique de localiser — pour mieux les gérer : occupation, utilisation et propriété du sol, voire du sous-sol. Ce phénomène est parfaitement clair en ce qui concerne le cadastre et explique ainsi les pressions qui s'exercent sur les prestataires de services dans ce domaine.

Le cadastre : position du problème

Très souvent, le cadastre est présenté comme étant essentiellement un outil fiscal alors que nombreux sont les pays où l'impôt foncier n'existe pas; on comprend donc leur réticence face à des projets d'inventaire foncier, de rénovation ou de réorganisation cadastrale dont l'unique justification serait l'amélioration de la collecte de cet impôt. De façon à préserver les caractères différents qu'il revêt en fonction de conditions locales, la définition que l'on peut donner du cadastre est celle d'*un inventaire systématique* des propriétés comportant :

— Un aspect technique, la description physique des propriétés;
— Un aspect juridique, la description des droits attachés à ces propriétés en tout ou partie;
— Un aspect financier, la description de la valeur monétaire associée à ces droits;
— Un aspect économique, la description de l'activité économique effectuée sur les propriétés.

De façon très curieuse, ces différentes composantes se retrouvent dans la quasi-totalité des «cadastres» existants même si certaines d'entre elles n'y figurent que de façon embryonnaire.

Les pays vivent dans la plupart des cas une situation foncière ambiguë :

— La législation est incomplète et plusieurs régimes de droit se superposent;
— L'information technique qui avait pu être établie à un moment donné a mal été tenue à jour;
— L'information administrative et juridique est difficilement accessible;
— Les procédures techniques et administratives sont lourdes;

alors que :

— La demande de terrain augmente régulièrement, en particulier sur les centres urbains;
— Les transactions «illégales» se multiplient et les statuts d'occupation deviennent plus précaires;
— Les investisseurs et aménageurs (publics et privés) n'ont pas la possibilité d'intervenir.

Face à cette situation, un système cadastral efficace peut constituer un puissant outil économique allant dans le sens du développement; les avantages qu'il procure, énumérés ci-après, sont extraits d'un rapport de la Banque mondiale sur le sujet (Doebele, 1983) :

— Il fournit aux différents acteurs du marché foncier une information précise et permet ainsi une utilisation plus rationnelle des terrains;
— Il augmente l'offre sur le marché foncier;
— Il réduit les coûts liés aux mutations;
— Il augmente la sécurité de la tenure et permet de mobiliser des investissements publics et privés;
— Il fournit des bases d'information pour l'établissement d'un impôt foncier.

Stratégie pour un cadastre

Les semi-échecs que constituent les pratiques cadastrales dans nombre de pays ou les carences que présentent les systèmes mis en place trouvent leur origine dans l'absence, au départ, d'une approche «système» c'est-à-dire fondamentalement :

— Analyse de la situation et des besoins;
— Définition d'objectifs;
— Définition de produits;
— Réalisation;
— Entretien;
— Vérification des objectifs.

Il faut savoir que ces systèmes sont dans la majorité des cas subis ou transplantés. Subis, ils sont l'héritage de la colonisation où l'objet du cadastre était d'asseoir juridiquement les concessions données aux colons; besoins et objectifs ont changé lors de l'indépendance mais les méthodes n'ont guère varié. Transplantés, ils reprennent *ne varietur* le modèle et la complexité technico-administrative de tel ou tel pays développé avec tous les risques de rejet que cela comporte.

Dans ce cadre, l'Institut géographique national et d'autres partenaires (géomètres et informaticiens) ont mené une réflexion visant à dégager un certain nombre d'idées directrices pour la constitution d'un cadastre que nous qualifierons de «léger» Sa mise en place doit permettre la réalisation d'un certain nombre d'objectifs tout en obéissant à deux impératifs majeurs :

a) *Réaliser un investissement minimal* de façon à faciliter le financement d'une telle opération et à assurer la rapidité de son exécution;

b) *S'adapter aux conditions locales* de façon à s'accommoder des contraintes dues à un système ou des pratiques cadastrales préexistantes et à pouvoir assurer les opérations de maintenance nécessaires par la suite.

Les objectifs à poursuivre sont les suivants :

a) *Il doit offrir une garantie juridique*, l'éventail demeurant ouvert au niveau des choix possibles :

— Ce que l'on garantit (localisation, contenance, surface, limite, valeur, etc.);
— Dans quelle mesure s'exerce la garantie (précision, tolérances, etc.);
— Au profit de qui s'exerce la garantie (propriétaire, occupant, ayant droit);

b) *Il doit avoir un caractère évolutif*, et à ce titre il doit être :

— Actualisable, c'est-à-dire capable de prendre en compte et de refléter les modifications apportées au cours du temps à l'occupation, à l'utilisation et aux droits qu'il décrit;
— Perfectible, c'est-à-dire capable de supporter des améliorations concernant la nature des informations décrites et la précision avec laquelle elles le sont;

c) *Il doit être support du développement*, en fournissant une aide :

— A la programmation de l'aménagement : l'investissement réalisé (et entretenu) doit satisfaire les besoins des aménageurs en matière de connaissance de l'occupation et de l'utilisation du sol;
— A la fiscalité par l'identification des relations entre les personnes et les biens; même si la fiscalité «foncière» n'est pas un des buts initialement retenus, il est indispensable que, à terme, elle puisse être introduite et soit cohérente avec le système mis en place.

En ce sens, le système à mettre en œuvre correspond à une solution qui est optimale lors de son démarrage et doit le rester au cours du temps. Il est par conséquent crucial que l'on se donne, dès le départ, les moyens non seulement d'entretenir mais aussi de faire évoluer l'édifice pour l'adapter aux besoins du pays.

Principes de réalisation

Compte tenu des objectifs et des impératifs mentionnés ci-dessus, il serait illusoire de traiter l'intégralité d'un territoire national de la même façon, tant pour des raisons de coûts que pour des raisons d'adéquation du système aux besoins. Il est donc nécessaire d'effectuer au préalable une typologie des différents milieux à cadastrer; elle peut être caractérisée de la façon suivante :

— Centre ville ou zone d'habitat dense, ancien et stabilisé, cadastré ou non;
— Périphérie urbanisée ou zone d'habitat plus lâche, généralement stabilisé;
— Périphérie en voie d'urbanisation comprenant des zones d'habitat spontané et des zones de lotissements «officiels»;
— Terres agricoles (il peut y avoir lieu de distinguer les terres exploitées collectivement de celles qui le sont de façon individuelle).

Recoupant ces milieux différents, un certain nombre de principes sont à appliquer lors de la phase de réalisation; ils conditionneront les choix, particuliers à chaque milieu, des méthodes techniques à utiliser, de l'organisation administrative à mettre en place et du calendrier de réalisation à suivre. Les choix eux-mêmes ne seront pas détaillés ici; seuls les principes sont mentionnés ci-après :

a) *Nécessité du plan cadastral* ce document a trois fonctions :

i) localisation des parcelles (géographique et postale lorsqu'elle existe);
ii) représentation du développement, en particulier du bâti;
iii) représentation des limites.

Il s'agit d'un document de référence, c'est-à-dire que tout croquis, schéma ou plan comportant un ou plusieurs des éléments indiqués ci-dessus et destiné au public ou à une administration doit être élaboré à partir du plan cadastral et être considéré comme un extrait ou une copie de ce plan;

b) *Nécessité d'un registre unique*, accessible à tous qui soit le seul à garantir les droits et charges afférents à une parcelle ou à une partie de celle-ci;

c) *Utilisation d'un identifiant unique* pour désigner un bien-fonds ou s'y référer;

d) *Mise en œuvre d'un système actif* qui soit donc tenu à jour non seulement d'après les déclarations des propriétaires, occupants, ayants droit mais aussi d'après des enquêtes menées par le «service cadastral» de sa propre autorité;

e) *Réalisation dans le cadre d'un zonage évolutif* tant sur le plan de la matérialisation des parcelles que sur celui des garanties offertes ou des méthodes techniques adoptées;

f) *Réalisation homogène dans le cadre de ce zonage* — Ceci signifie, par exemple, que l'on doit proscrire la non-obligation d'immatriculation qui est très souvent la règle;

g) *Réalisation planifiée*. — Dans ce principe sont en fait réunies deux idées principales;

— La nécessité de «servir» en premier lieu la demande la plus pressante;
— La nécessité d'élaborer un certain nombre d'indicateurs qui permettent de juger quand une modification doit être apportée sur une zone donnée (prise en compte de nouvelles garanties, amélioration de la précision du plan, etc.)

Conclusion

Il ne suffit pas d'intervenir au coup par coup, selon les volontés passagères des pouvoirs politiques, ni selon l'actualité des propositions commerciales ou les verdicts d'une expertise occasionnelle. Il est au contraire nécessaire de bâtir des systèmes complets de gestion foncière, des systèmes au fonctionnement quotidien et continu. Mettre au point des systèmes simples et fiables, et surtout les faire accepter, est parfois difficile, car ils dérangent une culture technique et administrative très répandue. Cela reste cependant toujours possible, que ce soit à cause de la pression exercée par la population sur les pouvoirs publics ou grâce à des actions d'explication et d'information actuellement menées.

On doit également garder présent à l'esprit que de tels projets ne peuvent être viables que s'ils sont économiquement rentables, c'est-à-dire s'ils peuvent dégager très rapidement une marge d'autofinancement; cette marge risque cependant d'être souvent théorique car, d'une part, l'administration maître d'ouvrage subissant les règles de la comptabilité publique ne pourra réaffecter ses recettes et, d'autre part, les bénéficiaires d'une telle opération ne supporteront pas directement les coûts du service qui leur est rendu alors qu'ils le pourraient, et ce pour des raisons politiques.

Référence

W. A. Doebele (April, 1983) Why cadastral systems are important for less developed countries. World Bank report.

(g) *Land Information Systems**

A LAND INFORMATION SYSTEM FOR URBAN AND REGIONAL PLANNING IN THE CITY OF EDMONTON**

Paper submitted by Canada

RÉSUMÉ

L'expansion industrielle et l'accroissement de population qui l'accompagne soulignent la nécessité d'une conception intégrée de la planification et de la gestion de l'utilisation des sols par les administrations urbaines dans la Province d'Alberta au Canada. Le développement des moyens électroniques modernes de levé et de cartographie assistée par ordinateur fournit de puissants outils pour établir la base de positionnement pour ces systèmes d'information foncière. Le document examine la démarche retenue par la ville d'Edmonton et la Province d'Alberta, dans un projet financé conjointement, pour créer un réseau de systèmes d'information foncière géographiquement positionné dans la ville d'Edmonton.

RESUMEN

La expansión industrial y el crecimiento demográfico conexo han destacado la necesidad de que los organismos administrativos urbanos de la provincia de Alberta, Canadá, apliquen criterios integrados en la ordenación y planificación del aprovechamiento de tierras. El desarrollo de medios modernos para realizar actividades de agrimensura electrónica y de levantamiento cartográfico por computadora ha probado ser un instrumento poderoso para establecer la base de determinación de posición de esos sistemas de información de tierras. En este documento se examina el criterio que se ha adoptado en la ciudad de Edmonton y en la provincia de Alberta para un proyecto de financiación mixta encaminado a establecer en la ciudad de Edmonton una red de sistemas de información sobre tierras con determinación geográfica de la posición.

The city of Edmonton, in the province of Alberta, Canada, has grown from a population of 148,000 in 1950, occupying an area of 106 km², to 560,000 in 1983, occupying an area of 700 km². This rapid growth placed heavy demands on the administration to provide the necessary data to plan and implement programmes for the orderly use and servicing of land.

This growth was not unique to Edmonton, since other cities and towns in Alberta were showing comparable growth during this period as the province moved towards industrial expansion. The need for an integrated and uniform approach to collecting and storing land information was recognized by the provincial government, and an urban surveying and mapping programme was commenced in the 1960s. The objectives of the programme were to establish a rigid geodetic survey network, to relate the existing and future individual land units to it and to produce map sheets at scales of 1:1,000 and 1:5,000, as a basis for collecting and storing related land information in a co-ordinate reference system.

The present paper is divided into two parts: the first gives an overview of the urban component of Alberta's surveying and mapping programme. The second briefly describes Edmonton's Geographic Base Information System (GBIS), which used the framework provided by the provincial programme to implement an urban management system. Some of the applications of GBIS to urban and regional planning are discussed.

URBAN SURVEYING AND MAPPING PROGRAMME

Alberta was one of the first provinces in Canada to recognize the need, and accept the responsibility, for providing assistance to urban municipalities in developing a surveying and mapping framework. This assistance is formalized through an intergovernmental agreement which defines the area of coverage and sets out the respective responsibilities of the urban municipality and the province, which are, in summary, for the municipality to:

(*a*) Locate and install survey control markers;

(*b*) Maintain the survey control network in perpetuity;

(*c*) Make ties from the survey control network to the land survey system;

and for the province to:

(*a*) Perform survey measurements on and compute co-ordinates of the survey control markers;

(*b*) Compute co-ordinates of the land parcel corners;

(*c*) Establish a photogrammetric control data base;

(*d*) Produce and periodically revise standard map sheets to cover the municipality, consisting of cadastral (land survey), contour and orthophoto components.

The municipality provides partial funding for the last step. In recent years, several municipalities have opted for the digital compilation of planimetric linework, rather than the orthophoto component. Once the co-ordinates for the survey control markers are published, the area covered by the Agreement is declared a Survey Control Area. The Surveys Act requires that any subsequent land surveys within such an area be tied by survey measurements to the survey control network. This provides the mechanism for ongoing maintenance of the cadastral component of the base mapping system.

The intergovernmental agreements with Alberta's two major cities, Edmonton and Calgary, differ in several key areas from the standard agreement. These cities have significantly greater technical and fiscal resources than the smaller cities and towns of the province, and this is reflected in the level of assistance provided under the urban surveying and mapping programme. The major changes include the deletion of the photogrammetric control data base and the

* See also "Report of the Meeting of the *Ad Hoc* Group of Experts on Cadastral Surveying and Land Information Systems" (E/CONF.77/L.1) discussed under agenda item 5 (*d*).

** The original text of this paper, prepared by C. H. Weir, E. A. Kennedy and R. G. Ritchie, appeared as document E/CONF.77/L.66.

contour and orthophoto components of mapping coverage. In addition, a modified cost and work-sharing approach has been adopted for the production of cadastral mapping.

When both parties have signed the agreement to formalize their respective intents to establish and maintain the urban surveying and mapping system, the work proceeds as described in the following paragraphs.

Survey control

Once the municipality has located and installed the survey control markers, conventional triangulation, trilateration and traversing techniques are used to establish their relative positions and tie the municipal network to existing first- and second-order markers of the national geodetic network in the area. Field procedures are designed to yield positions of the markers to third-order accuracy standards, as defined by the Federal Surveys and Mapping Branch. Additional measurements are made to tie at least one monument in the land survey system to each new survey control marker. The survey field-work is contracted to surveyors in private practice, with limited in-house staff resources being used for reconnaissance and quality control checks on contract returns. The field data is processed through a least squares adjustment program on the Alberta government mainframe computer, an IBM 3033, to produce final co-ordinates for the survey control markers. Subsequent computation provides co-ordinate values for the tie points in the land survey system.

Land survey

A map manuscript is used as the primary source document for the computation of land survey co-ordinates. This manuscript shows all surveyed property boundaries from which stem current title to land and is compiled from such source documents as plans of survey, certificates of title, judges' orders, and gazetteers. The objective of the computations process is to assess the data in the same manner as a registered land surveyor would assess evidence on the ground, and to distribute errors accordingly. Staff survey technologists use a computer system of interactive programs to compute co-ordinates on mainframe CRT terminals, with the co-ordinates previously determined for the tie points and the survey measurements shown on plans of survey as input data. Each co-ordinate point is given a unique code number, which is stored in the computer file and is shown on the map manuscript. The land survey co-ordinates are used for cadastral mapping purposes, and under certain conditions defined by legislation, for the re-establishment of lost survey monuments in the field.

Photogrammetric control

Vertical aerial photography of the municipality (normally at a scale of 1:8,000) is obtained under contract with a private mapping firm. Survey control markers are targeted prior to photography, and serve as the basis for establishing the positions of artificial photogrammetric control points marked on the aerial photos. The controlled photography and co-ordinates of the photogrammetric control points establish a photogrammetric control (or aerial survey) data base, which is used primarily for the production of mapping but is also made available for such special applications as digital terrain modelling or computational analysis projects within the municipality.

Base mapping

The base mapping system for urban municipalities includes cadastral (land survey), orthophoto (or digital planimetric linework), and 1-metre contour components. The Three Degree Modified Transverse Mercator (3TM) projection system is used, with 1:1,000 and 1:5,000 being the standard map publication scales. The 1:1,000 map shows detailed cadastral (figure 68) and, where available, digital planimetric information, while the 1:5,000 maps include various combinations of the generalized cadastral, the contour and the orthophoto components.

Urban base mapping is achieved through a combination of contract and in-house production. The orthophoto/planimetric linework and contour components are supplied by mapping contractors, usually on a project basis, which also include the establishment of the photogrammetric control data base. The cadastral map components are produced by staff cartographic technologists from the co-ordinates previously computed on the mainframe computer, using the Bureau's Geodigital Mapping System (GMS). The GMS consists of a 12-station Intergraph Corporation interactive graphics system and an off-line photo-plotter supplied by the Gerber Scientific Instrument Company. The GMS was acquired with the objective of establishing a provincial digital mapping system composed of several data bases to fulfil large-, medium- and small-scale mapping application requirements.

Programme maintenance

The utility of the surveying and mapping system as a basic framework for land information management is largely dependent on the currency of the data. The urban programme has been designed to have this very critical ongoing maintenance function built in. The municipality is committed to maintaining the survey control network by replacing disturbed or destroyed markers and increasing the network density in urban fringe areas as development occurs. As previously indicated, land surveyors are required by legislation to tie all new land surveys to the control network, which facilitates the Bureau's ongoing revision of land survey co-ordinates. The municipality and the Bureau are jointly committed to periodically revising the mapping coverage, with improved cost efficiency being provided by the existence of the photogrammetric control data base. The GMS has not only enhanced the Bureau's ability to meet the demand for a wide variety of graphical outputs, but has also greatly improved turn-around on map revision.

Products and services

Although the urban surveying and mapping programme is primarily designed to meet the needs of urban administrations, the available products and services are also used widely by such groups as land surveyors, engineers, planners, land developers and computer service bureaus. Survey control products include individual marker identification cards, and co-ordinate listings in hard copy or magnetic tape format. Adjustment statistics are also available for more scientific uses. The standard land survey product is a hard copy or magnetic tape co-ordinate listing, with computer generated line connections to become available within the next year. Although the Bureau's copies of photogrammetric adjustment data and controlled photo diapositives are available to users, a system is currently under development which will provide a more formal service for users of the photogrammetric control data base. This will include access to the on-site point transfer device for transfer of control to the user's own photography, and provision of photogrammetric control point co-ordinates as a hard copy computer printout or on magnetic tape. The standard mapping products are diazo copies of 1:1,000 and 1:5,000 cadastral maps

and lithographed copies of 1:5,000 orthophoto line maps. Digital copies of GMS files of cadastral, planimetric and contour data are also available on magnetic tape. In addition, a service is available for the municipalities to obtain various combinations of the data on film, in a range of scales, at the cost of materials. All products are available at nominal costs, with access restrictions limited to ensuring that users acquire the most current data and use it within normal accuracy limitations.

Program benefits

Some of the major benefits of the programme are the following.

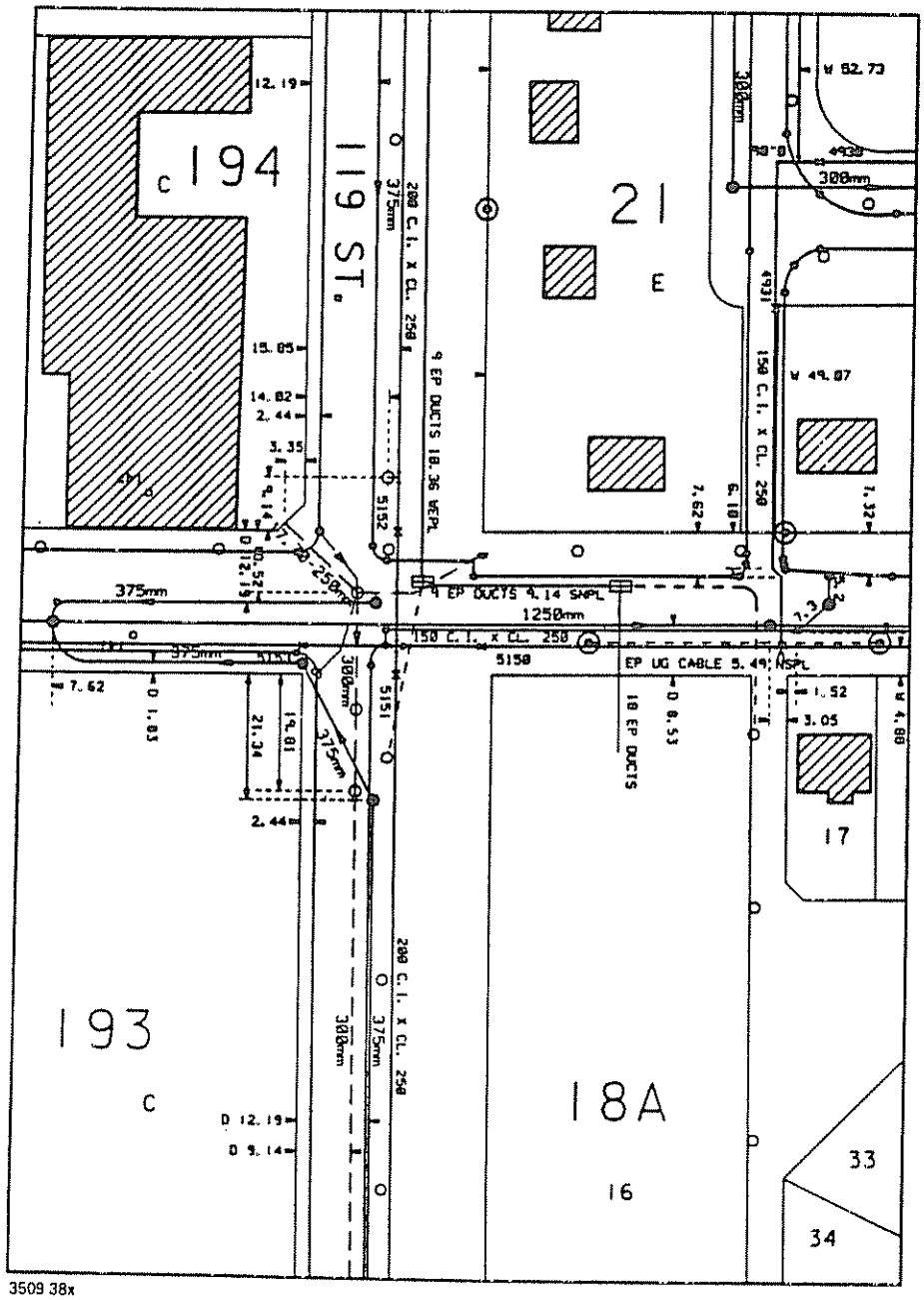
1. The integrated system has the necessary accuracy to be used, not only for planning and land management, but also as an engineering design tool.

2. It substitutes one accurate standardized map base for large numbers of non-standardized urban maps and plans, many of which are often of unknown origin or accuracy.

3. The survey control network provides an accurate, stable framework of points which can be used for the location or relocation of property boundaries and for a large number of municipal engineering and surveying projects in the field;

4. The existence of the mapping data base in digital form provides the basic component required for the devel-

Figure 68. Canada: Portion of 1:1,000 utility cadastre



opment of computerized urban utility, assessment and taxation cadastres.

5. The surveying and mapping system reduces revision costs by establishing the necessary key elements to facilitate ongoing maintenance. Long-term commitment to programme maintenance is ensured by the joint signing of the intergovernmental agreement.

Data conversion and application

The benefits of an accurate, up-to-date digital cadastral mapping system can be more readily seen by providing a brief synopsis of the municipal Land Information System currently being developed at Edmonton.

In 1978, the City Council approved a budget programme for the establishment of a GBIS. This system was to be developed utilizing the framework of the urban surveying and mapping programme developed by the Province of Alberta. The City of Edmonton negotiated with the Province to extend the programme, divide map production responsibilities and agree on cost-sharing arrangements.

This computerized land information system now encompasses a variety of graphical and informational subsystems in various stages of development. These include engineering design, tax assessment, street addressing and land-use and demographic mapping applications. However, the foremost subsystem is the Utility Information System (UIS). This system is being developed in Edmonton's civic Departments of Power, Water and Sanitation, and Transportation; Edmonton Telephones; and the privately-owned gas company, Northwestern Utilities.

Data conversion

One of the most frequent problems in land-related information systems has been the absence of accurate location of data. Consequently, the benefits of precise, positional co-ordinates in a digital cadastral mapping system are numerous. One such benefit for Edmonton is the accurate mapping of utility infrastructure data. The term "infrastructure", as used in the context of Edmonton's land information system, applies to all man-made features of the landscape, including all of the physical plant necessary for the urban community—water, sewer, power, telecommunication facilities, oil and gas pipelines, buildings and transportation networks.

To achieve an accurate and complete picture of the current infrastructure situation in Edmonton, the Engineering Division of the Transportation Department proposed that the basis for a UIS must be the surveyed location of the various utilities. It was recognized that many other important features of the utility, such as material, capacity, installation dates and maintenance records, were vital to the information management process, but only a precise location of physical plant could permit proper correlation of data in an unequivocal manner.

An assessment of city utility records indicated that several of the common errors made in this acquisition and use of survey data were evident. With this in mind, the Engineering Division embarked on new surveying, mapping and record system development projects to acquire and graphically display various types of infrastructure data. These projects are being implemented with a view towards utilizing the various human resources of private industry and the municipal government sector to their maximum potential. One such project, which utilized a combination of aerial mapping and modern ground survey techniques, is described below.

Infrastructure positioning surveying and mapping pilot project

The City of Edmonton designated a 2,400 hectare area (two 1:5,000 map sheets) to which infrastructure data was to be captured. Data included:

(*a*) *Utilities*: the centre point of all outside plant from major utility departments and private utilities;

(*b*) *Curb*: curbface with elevations supplied at the "gutter";

(*c*) *Hydrography*: the ordinary high water mark for all rivers, creeks, ponds, etc ;

(*d*) *Topography*: delineation of contours at 0.5-m intervals or spot elevations in built-up areas;

(*e*) *Buildings*: the outline of commercial and residential buildings.

The specification called for sea level co-ordinates to be published using the 3TM projection with the usual 0.999-scale factor at the reference meridian (long. 114° W). The accuracy of the physical detail was to be within the standard deviation of +/− 10 cm in both the vertical and horizontal directions. This accuracy requirement allowed for land surveyors and photogrammetrists to correlate these various data sets with the cadastral mapping framework.

Aerial photography at the scale of 1:3,000 was to be flown in accordance with the Canadian Association of Aerial Surveyor (CAAS) standards. General specifications in large-scale mapping, aerial triangulation and computer-assisted cartographic mapping were outlined in guidelines prepared by the City of Edmonton and the Alberta Bureau of Surveying and Mapping.

The successful contractor was an Edmonton firm engaged in all aspects of surveying, mapping and land information systems development. Prior to the photogrammetry being performed, the firm prepared a careful inventory of all street hardware known to exist by making composite worksheets from all Edmonton record plans. With these worksheets in hand, a survey technologist then walked each street checking existing hardware and painting targets too small to be visible on the aerial photographs. Hardware not shown on the worksheets but clearly visible in the field was noted and added. Hardware shown on the worksheets, but not visible in the field, was located by using an electronic pin finder. If hardware was not located, this was also noted on the worksheets. Control markers required for triangulation were also targeted at this time.

Aerial photography for the project was performed using an S Wild RC-10 camera and Kodak Double X Type 2424 film on a continuous tone base. Aerial triangulation and numerical adjustment were performed using a Blais Space M adjustment program. The digitizing of street hardware, buildings, curbs, contours and hydrographic features was completed using an analytical stereoplotter. The data were stored on a 9-track magnetic tape with coded identifiers for each set of requested information. These data were then transferred to a digital mapping system where the required linework and data separation routines for interactive graphics production were instituted.

Upon completion of the graphics, the digital data and a check plot were generated and forwarded to the respective city departments for editing. Discrepancies and completeness verification were noted on these plots and returned to the survey firm for corrections. Additional data required to complete the survey was retrieved, utilizing a "total station" survey instrument consisting of a theodolite (electronic distance measuring unit), and digital data recorded

Final corrected data were returned to the city on magnetic tape.

Monitoring and quality control of the project was the responsibility of the Transportation Department of the Engineering Division, City of Edmonton. This project team also consulted an independent survey firm to check two small test areas to validate the accuracy and reliability of the digital data. In addition, city surveyors also performed arbitrary ground survey checks.

In examining the photogrammetric accuracy of the data captured by the survey firm, a data analysis was undertaken. This consisted of an analysis on the aerial triangulation block adjustment results as well as a comparison of photogrammetric "true values" with field survey results. These procedures indicated that the photogrammetric results were highly reliable and within the accuracy specifications of the contract. A comparison of these data revealed that the existing record plans maintained by individual departments within the City of Edmonton were, in most cases, unreliable, with discrepancies of some data up to 10 metres in positional location.

The results of this "pilot project" demonstrated a need for Edmonton to proceed with further projects of infrastructure acquisition and information processing.

However, aside from the benefits of improved positional accuracy, the pilot project revealed other significant findings. The Transportation Department has now made several recommendations for changes to be instituted by the City Survey Office, On-Street Construction Co-ordination Committee and the Roadway Design and Construction Office. These include the following:

(*a*) The preparation of new procedures for the construction of underground utilities, including the requirement to measure and locate all as-built structures before backfilling trenches;

(*b*) New standards for connecting engineering surveys to horizontal geodetic control points and the national vertical data;

(*c*) As-built location plans to be certified through the City of Edmonton's Legal Survey Office;

(*d*) Surface structures to be identified using 3TM coordinates and retrievable through a common data bank or clearing agency;

(*e*) A total review of accuracy standards for the location of each utility;

(*f*) The Cadastral Mapping Office to establish guidelines in co-operation with public works and utility departments that will ensure constant and accurate procedures for the updating of utility maps and common integration standards for correlation with the base map fabric.

With the implementation of these procedural and policy changes within Edmonton, improved safety and operational aspects of construction activities will result. As a consequence, the protection of all life-lines of the urban environment and the provision of responsible space allocation for utilities will be provided. The City of Edmonton has recognized through its travels that many urban centres in the world are looking to computerized land information systems to help to solve problems in urban planning, engineering and decision support. As a pioneer in the field, Edmonton has made some mistakes but, through pilot projects such as the one previously described, has also gained valuable experience. Hopefully, the city will continue to press forward in its endeavours to proceed quickly with the completion of the utility infrastructure system. This process will derive benefits not only in cost savings to be expected from improved administration, planning and engineering design, but also the public relations benefits from being known as a well-run city and the high technological spin-off benefits in both hardware and software development as others look to Edmonton for expertise in this field.

PROPOSED LAND INFORMATION SYSTEM IN THE MALAYSIAN CONTEXT*

Paper submitted by Malaysia

RÉSUMÉ

Le Département de la topographie du Ministère malaisien de l'aménagement foncier et du développement régional est en train de créer un système automatisé d'informations foncières (CALS), projet expérimental devant devenir opérationnel avant le 1er janvier 1985, au Service topographique de Johor Bahru. La mise en place de ce système sera la première étape du programme entrepris par le Département pour automatiser ses activités cadastrales et cartographiques. Le Département se propose également de créer, dans le cadre du cinquième plan de la Malaisie (pour la période 1986-1990), un système cartographique automatisé (CAMS).

Les deux systèmes offriront aux utilisateurs les services d'une banque des données qui contiendra non seulement un registre cadastral, mais également des renseignements sur la topographie de chaque parcelle et sur les services publics et autres renseignements disponibles dans le voisinage. Le

RESUMEN

El Departamento de Estudios Topográficos del Ministerio de Tierras y Desarrollo Regional de Malasia está organizando un sistema de estudio de tierras con ayuda de computadoras y ejecutará un proyecto experimental en el Departamento de Estudios Topográficos de Johor Bahru el 1º de enero de 1985. El sistema de estudio de tierras es un primer intento del Departamento de computadorizar sus actividades catastrales y cartográficas. El Departamento también prevé establecer un sistema de levantamiento cartográfico con ayuda de computadora en el marco del Quinto Plan de Malasia (1986-1990).

Ambos sistemas pondrán a disposición de los usuarios un banco de datos en el que no solamente figuran los terrenos según el catastro sino también información sobre la topografía particular de ese terreno, los servicios públicos y otra infraestructura aledaña. Ambos sistemas se combinan para formar un sistema de información georreferenciada con base terrestre que puede convertirse en el futuro en un sistema de información sobre tierras en gran escala. Las contribuciones de otros usuarios, como las autoridades planifica-

* The original text of this paper, prepared by Abdul Majid Bin Mohamed, Director-General of Survey and Mapping, appeared as document E/CONF.77/L.67

CALS et le CAMS constitueront à eux deux un système d'informations géodésiques au sol, qui pourra par la suite devenir un système complet d'informations foncières. Les données fournies par certains utilisateurs tels que les responsables de la planification, les services publics et les municipalités seront prises en compte dans la mise au point du système proposé, qui sera conçu en fonction du contexte malaisien.

doras, los órganos de servicios públicos y los municipios se tomarán en cuenta en la concepción y el diseño del sistema proyectado de información sobre tierras en el contexto malasio.

Malaysia does not as yet have a Land Information System (LIS) as defined by Commission 3 on Land Information Systems of the International Federation of Surveyors (FIG). It would seem, however, that if Malaysia is to join the ranks of developed countries in the foreseeable future, she will need advanced information systems in order to cope with decision-making and information retrieval at various levels of Government. Indeed, at the International Symposium on Land Information Systems of FIG Commission 3, held at Edmonton, Alberta, Canada, from 15 to 19 October 1984, it was the generally accepted view that "with the growing complexity of urban socio-economic and physical conditions, it is impracticable, if not impossible, to conduct Government business in traditional manual modes." Among the advanced information systems referred to earlier, perhaps the most important is the LIS.

Most countries in Western Europe and North America, and Australia and New Zealand now have developed an LIS, with Sweden being generally recognized as the pioneer. Among the countries in South-East Asia it is known that Singapore and Hong Kong are conducting feasibility studies on the establishment of an LIS. It is also known that Canada is providing technical assistance for a feasibility study on establishing an LIS in Thailand.

The Malaysian cadastre

The Malaysian Cadastre was the result of boundary surveys controlled by a geodetic controlled network carried out in the second half of the nineteenth century. The oldest of these, the Perak System was started in 1888 and covers the States of Perak, Penang and Kedah. It is based on a latitude and azimuth at Taiping, a longitude at Fort Cornwallis in Penang and a base line near Taiping. The records of the Survey Department show that certified plans of cadastral lots were approved as early as 1892 and 1893 in the State of Perak.

In the early 1900s a statutory system of land registration, known as the Torrens system, came into being, providing for a legal guarantee of title for each parcel of land brought into the land register. The legal guarantee includes related land rights.

At present, the following laws relating to land and land tenure, the registration of title to land and their dealings thereof, are in force:

(*a*) National Land Code (Act 56 of 1965) for Peninsular Malaysia;

(*b*) Land Ordnance (Sabah Cap 68) for Sabah;

(*c*) Land Code (Sarawak Cap 81) for Sarawak

All the above laws make it mandatory for surveys to be carried out, and boundary markers planted and co-ordinated, for each and every parcel of land before final titles can be issued

Thus the infrastructure for the setting up of an automated cadastre exists, whereby all the data of the land registry plus the cadastral survey data are stored, including the co-ordinates of control points and boundary markers. This data bank should have the following features: (*a*) quick access; (*b*) large capacity; and (*c*) input availability for further land-related data. The features mentioned above are in essence the salient features of what is commonly known as a multi-purpose cadastre.

Computer-assisted land survey system

The fast tempo of development in the country has tremendously increased work-load on the Survey Department and seriously taxes its ability to respond speedily to demands from users for cadastral base maps at various scales. To cope with the increased work-load and to enable fast retrieval of land information a computer system is required.

The Computer-assisted Land Survey System (CALS) is especially configured to assist a typical Survey Department to meet the above demands. The main objective is to create a cadastral survey data bank and to produce base maps both in digital and graphic forms for the use of decision makers in the public and private sectors.

For a start, CALS is scheduled for implementation as a pilot project for the State of Johor by January 1985. Its specifications and configuration, to meet the work-load and demands of Johor, are detailed in annex I.

Thus it can be seen that besides speeding up the survey examination process from data gathered in the field, CALS also produces both cadastral and large scale town maps, with the possibility of having attributes of land use and public service utilities merged into them. With the land data stored in computerized form, it is possible to speedily update all the registers maintained by the Survey Department, including records of personnel and stock, in its Management Information Systems.

Computer-assisted mapping system

The Directorate of National Mapping, Malaysia, is responsible for the production of maps at all scales for the use of the Ministries of Defence, Agriculture, Forestry, the various planning authorities and other government agencies In addition, the Directorate has also to provide large scale mapping for development agencies, and for the demarcation and survey of the international land and maritime boundaries. The Weights and Measures Act of 1972 makes it mandatory that all current and future mapping be done in metric units. In addition, existing maps are at least 10 years out of date. With the Directorate's responsibility now extended to cover Sabah and Sarawak, its work-load is increased by 151 per cent.

It is proposed that the Directorate introduce the Computer-assisted Mapping System (CAMS) not only to speed up production of the 1:50,000 scale topographic standard mapping series, but also to create a national digital topographic data base. It is projected that with CAMS, the 550 map

sheets needed to cover Peninsular Malaysia and Sabah and Sarawak at a scale of 1:50,000 would take approximately 11 years to complete, at a production rate of 50 map sheets per year. This period corresponds to the map revision cycle, hence ensuring also a balanced map production and revision programme to be established and maintained. At present, the rate of production of 8 standard topographic map sheets per year is grossly inadequate to meet user demands and national objectives. To continue with the manual system would mean a substantial increase in manpower as well as equipment and would not be cost and time effective. The Directorate's studies have shown that CAMS can realize a saving of $21.19 million for the total national topographic mapping programme.

CAMS, although an approved project under the Fourth Malaysia Plan (1981-1985), can be realized only during the Fifth Malaysia Plan (1986-1990) owing to priority being given to CALS. The specifications and configuration of CAMS are as detailed in annex II.

Thus it can be seen that CAMS would not only augment the Directorate's map production capability from 8 to 50 maps per year, but would also create a national digital topographic data base. The challenge of creating such a data base is to find a balance between a reasonable (10-12 year) national coverage and an adequate accuracy to meet most requirements of the immediate future.

Most of the digital coverage will be from the computer-assisted photogrammetric subsystem (CAPS), which will serve as an input into the computer-assisted cartographic sub-system (CACS). As more than 70 per cent of 550 map sheets are yet to be produced by the time CAMS comes on-stream, it is expected that both the geometry and context quality of most of the data input will be of a consistent high quality. Where the input is obtained from digitizing existing maps produced over the years of which the geometry and text quality vary considerably, it may be necessary to digitally reconstruct these inputs to meet modern requirements.

The national digital topographic data base would be able to support a wide range of operational programmes as well as research and development projects in all fields of commercial and executive functions. It will be able to generate thematic maps as well as maps for specialized usage in various disciplines such as geology, land use, forestry, census, utility, etc., that are spatially referenced to the topographic data.

To the data base, additional information of military significance such as key points, road classifications, bridge point loadings, etc., can also be incorporated. The thematic product produced can be enlarged to include infrastructure information, intelligence information, mobility and visibility maps. Command and control applications include communication planning, weapons placement and reconnaissance. Hence a special military map series can be produced, at a rapid response rate, at little additional cost and impact to the normal map production.

Towards a Malaysian Land Information System

FIG, the International Federation of Surveyors, has established a Commission, namely Commission 3, especially to cater for land information systems (LIS) and has adopted the following definition:

> "*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."

The FIG definition is purposely broad and general to accommodate as far as possible all the LIS in existence now. It does not make any references to computers, hardware or software.

The scope of an LIS is so great and varied that it now spans a spectrum of activities ranging from purpose-built small-scale topographic (or cadastral) mapping to the large-scale municipal information system. Common to these is the fact that all the data are based on a uniform spatial reference framework, namely, the Cassini-Soldner (plane rectangular) system or co-ordinates for a statewide parcel-based cadastral system, or on the geodetic network for a national topographic mapping system. For this reason, it has become a logical extension for the surveying profession to be involved in the LIS concept due to the surveyor's involvement in cadastral system and reference frameworks.

It would be appropriate at this point to examine in some detail whether there exists a need for an LIS to be developed, in the Malaysian situation. The development plans carried out by the Government, currently the Fourth Malaysia Plan (1981-1985), have resulted in fast growth areas in both rural and urban sectors. During the past 20 years, the city of

Table 1 Land-related data in custody of various Government offices, Malaysia

Category	*Type of information*	*Government department or agency*
Cadastre and topographic information	Land form, size, and locality	Survey and Mapping Department
Land ownership	Title registration and dealings	Land Office/Registrar of Titles
Land use	Land under forest	Forest Department
	Forest inventory	
	Afforestation scheme	
	Crops and cultivation	Agriculture Department
	Mining	Mines Department
Land capability	Soil suitability	Agriculture Department
	Mineral potential	Geological Survey Department
	Water resources	D I D
Land valuation	Values of land	Valuation Department
Infrastructure facility	Highway	Highway Authority
	Trunk road	Public Works Department
	Local roads, streets, parks	Local government
	Water supply	Waterworks Department
	Electricity supply	National Electricity Board
	Gas supply	Petronas
	Sewerage	Local government
	Telephone	Telecoms

Kuala Lumpur, for example, has grown at an annual rate of 5 to 7 per cent, according to the Town Planning Department. This is more than twice the growth rate of most other towns in Malaysia. The explosive growth rate of the Federal capital has spurred its planners to prepare an elaborate new draft structure plan with the aim of elucidating coherent goals for the future of Kuala Lumpur. Recently, the Prime Minister has announced plans for a twin city for Kuala Lumpur, to be established at Janda Baik, a quiet retreat some 30 km from the city. A tremendous challenge faces planners and decision makers. Intelligent decisions and sound planning can only be based on accurate, timely and comprehensive information, presented in a suitable format. A quick study will show that land-related information is in the custody of more than a dozen government departments and agencies as shown in table 1.

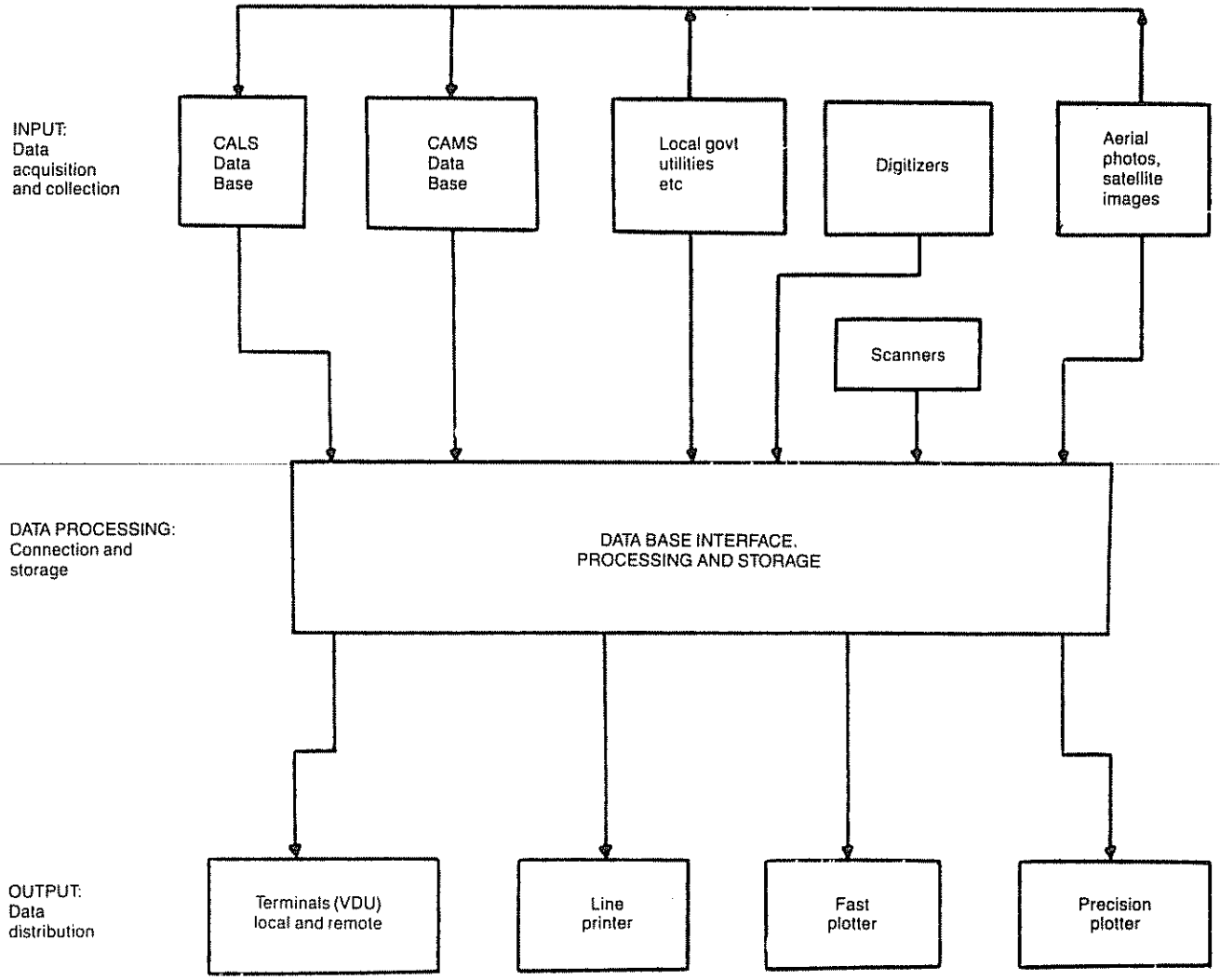
The government departments and agencies mentioned above represent a depository of massive amounts of land related data that would prove impractical, if not impossible, to be manually sorted, processed and presented in a form suitable for use by the user community. Given the above scenario, and the technology that now exists to create and integrate data bases of spatial, topographical, engineering, administrative, economic and resource information, the time is ripe for the setting up of an LIS, which, in its generalized form, would consist of:

(*a*) Data acquisition and collection (input);
(*b*) Data processing, connection and storage;
(*c*) Data distribution (output);

The emphasis is on the inflow and outflow of data to and from the system as shown in figure 69.

The government departments and agencies in table 1 would serve as sources of data input to the LIS. Data from the Survey and Mapping Department will provide the referencing framework to which data with spatial attributes can be tied. CALS would provide a cadastral survey data base at scales of 1:4,000 and mapping data @ 1:2,000. CAMS would provide digital base maps principally at scales of 1:50,000, 1:25,000 and 1:10,000. The 11 registries and 99 land offices in Peninsular Malaysia would provide the legal cadastre data and related land descriptors. Engineering data can be obtained from maps, reports and computer files. Economic and resource information can be obtained from

Figure 69. Malaysia: General view of proposed LIS configuration



thematic maps, reports and files. Other sources of data are from aerial photographic, satellite imageries and manuscripts produced for specialized application. Data that are sensitive in nature, e.g. those that support defence or policy matters, should be provided with a security restriction to prevent unauthorized access, corruption or accidental loss. In general, the data base should have security measures that would also protect it from damage, theft and allow its reconstruction in the event of accidents.

Data base structures and their management are areas of very specialized studies that have come into their own in the LIS. As this area is the domain of the specialists, it would suffice to say at this juncture that in any LIS, the integrity of data and its flow in and out of the system in an organized and efficient manner is of paramount importance.

Just as the input of data is varied, so too would be its output, depending on user needs. The user can have his output displayed on screens (VDUs) on-site or remote, or have it in the form of computer tapes or printed reports from the line printer, or graphically in the form of maps from the fast plotter/precision plotter.

Although at this point it is difficult to imagine that an LIS as comprehensive as the one configured in figure 69 would be set up, it nonetheless serves as a goal to be aspired to. CALS and CAMS, as ongoing development and modernization projects for the Survey Department, would be a computerized information system in their own right, ready to be linked to a future LIS.

Recommendations and conclusions

The public in general and Governments in particular should become aware of the need for, and the potential benefits to be gained by, the implementation of an LIS. Seminars on LIS should be encouraged and their resolutions brought to the attention of the authorities.

If the need for the eventual establishment of an LIS is accepted, then studies need to be made not only on the technological options that are available, but also of the impact of that technology on existing organizations both public and private, and the skills required to manage them.

ANNEX I

CALS: Computer-Assisted Land Surveying System

Configuration of a pilot project

Tender for CALS was invited through advertisement in the NST on 1 October 1983 and will be closed on 30 November 1983. A functional specification (fig. 70) has been put up with a minimum configuration of the computer system as we envisaged it. Of course, the tenderer is at liberty to put up his own proposed configuration as long as it meets with our specific requirement to do the job that we want it to do at a stipulated working rate.

The minimum configuration of the proposed system is made up of the central processing unit (CPU) and its peripherals as per figure 71.

Host computer

Central processing unit (CPU) of 2 megabytes
System console
System manager console
Tape, drives (2 units)
Disk drives (3 units totalling 700ME).

Work station

Visual display units (4 units)
Hard copy printer (1 unit).

Graphic work station

Interactive graphic terminal (4 units)
Digitizer (4 units)
Key board (4 units).

Production station

On line: Line printer
Fast plotter
Off line: Flat bed pen plotter.

Figure 71 shows the proposed configuration.

Cadastral Survey Data Base System (CDS)

CDS involves:

(*a*) Data capture of existing standard sheets and other source documents by digitizing at a graphic work station comprising of graphic monitor, digitizer and key board;

(*b*) Conversion and rectification for distortion, if any, of captured data from standard sheet in imperial unit and format to cadastral map sheet in metric unit and format;

(*c*) Production of a plot of the cadastral map sheet by a fast plotter for verification and editing;

(*d*) Final production of the cadastral map sheet by an off-line flat-bed pen plotter;

(*e*) Production of field diagram by the fast plotter on completion of all interactive works on the screen at the graphic work station. The production of field diagram by this means will only be possible after the completion of the creation of the cadastral survey data bank.

Data capture: graphics

Efforts will be concentrated on data capture of existing standard sheets to develop the cadastral data bank as soon as possible. The standard operational procedure for this will involve the following steps:

(*a*) Graphic recording by digitizing;
(*b*) Processing by computer; rubber stretching to rectify distortion;
(*c*) Numerical data capture of sheet and lot attributes;
(*d*) Production of verification plot of standard sheet;
(*e*) Verification and editing;
(*f*) Processing by computer:
  (i) Converting co-ordinates from imperial unit to metric unit;
  (ii) Resolving junction problems at former standard sheet edges;
(*g*) Input cadastral map sheet attributes;
(*h*) Production of verification plot of cadastral map sheet;
(*i*) Generating mag tape for off-line plotting;
(*j*) Storage.

All the existing Johor standard sheets totalling 647 sheets on 8 chain scale together with other standard sheets of various scales will be digitized at a rate of 4 sheets per day working on two 8-hour shifts. It is envisaged that this process for the creation of the cadastral data bank will take at least one year.

Data capture: numerics

A data bank for certified plans will be created to hold lot and boundary information. Numerical data need only to be captured and hitched to the graphic cadastral data base. With about 33,000 certified plans consisting of approximately 516,000 lots involved, this process will take considerable time to complete the creation of the cadastral data bank.

Production of field diagram

A field diagram can only be produced by CALS when the creation of the CDS is completed. One can then retrieve relevant information from the bank and produce a base on which new information of the lot to be surveyed is added on interactively at a work station.

Work flow

The work flow for CDS is shown in figure 72.

Figure 70. Malaysia: CALS — Computer-assisted land surveying system

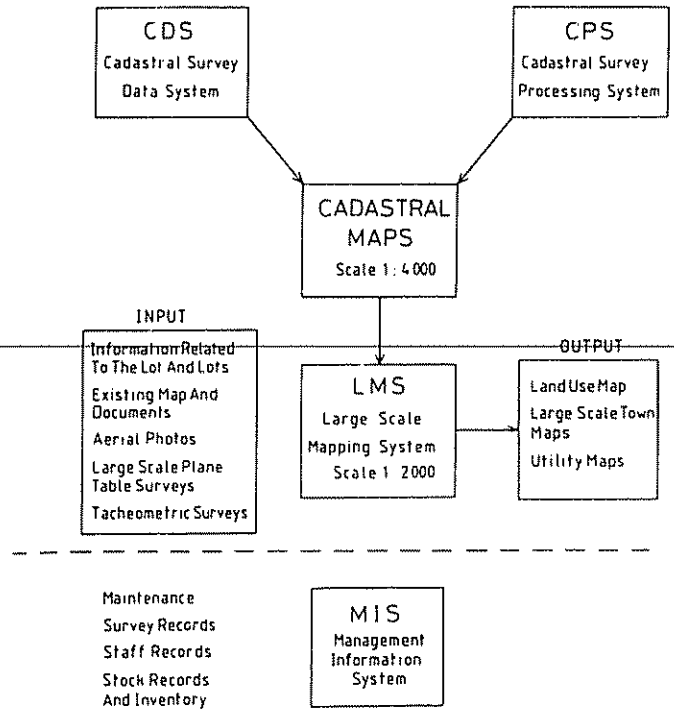
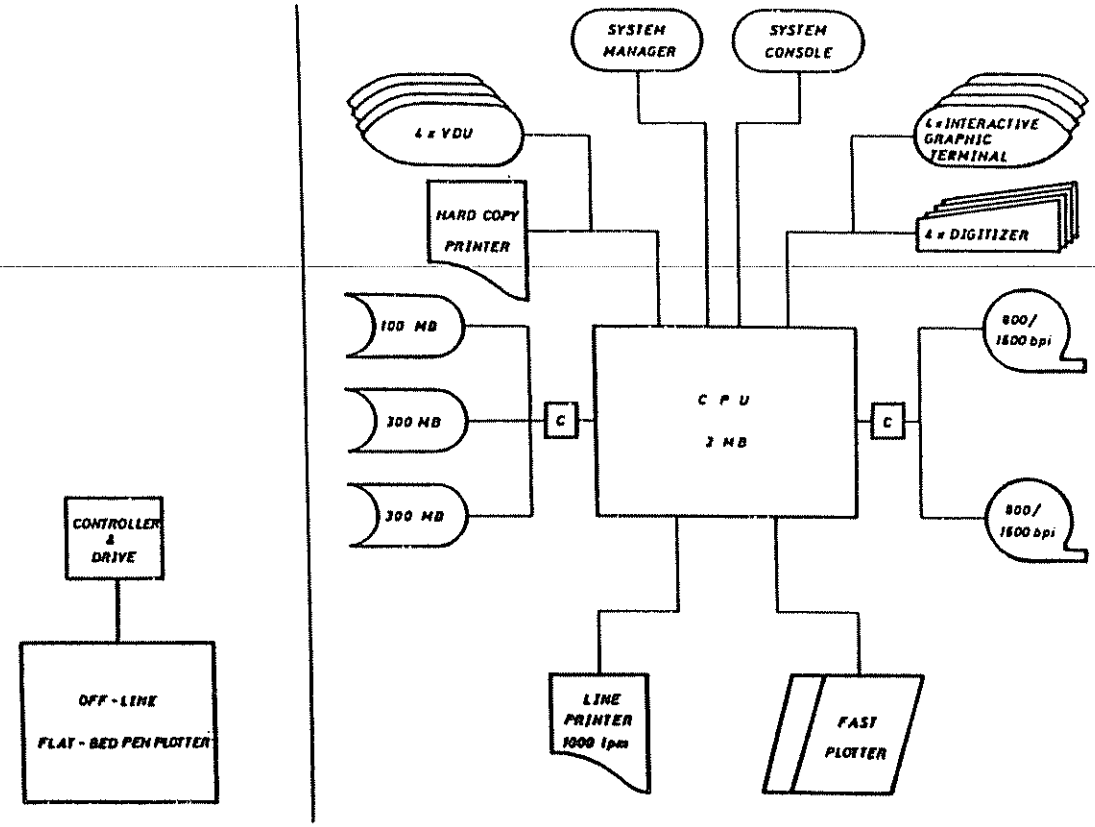


Figure 71. Malaysia: CALS configuration for Johor State Survey Department



CADASTRAL SURVEY PROCESSING SYSTEM (CPS)

CPS involves:

(*a*) Input of survey data from field books;

(*b*) Processing of survey data;

(*c*) Production of final calculation sheets of surveyed lots;

(*d*) Production of certified plan;

(*e*) Updating of the Cadastral Survey Data Base;

(*f*) Production of title plan

The major aspect of CPS is similar to the present existing system However, data capture will be from key to disk CPS will allow boundary information to be adjusted into place on the boundary line according to desired positions This is done interactively on graphic VDU before final production of the CP is made

Once the processing of the surveyed lots is completed, the cadastral survey data base may be updated digitally on command by the operator

The production of a title plan by CALS on a pre-printed title form has not been fully explored At this stage, it is not possible to say whether or not it is feasible to computerize a title plan production However, this aspect of CPS is not crucial to the system as it can be satisfied, for the time being, by the traditional method just as easily and cheaply, with the use of the copying machine

The work flow of CPS is also shown in figure 72

ANNEX II

CAMS: Computer Assisted Mapping System

THE PROPOSED SYSTEM

It is proposed that a Computer-Assisted Mapping System (CAMS) be introduced into the Directorate of National Mapping consisting of three subsystems:

Computer-Assisted Photogrammetric Subsystems (CAPS);

Computer-Assisted Cartographic Subsystems (CACS);

Computer-Assisted Raster Digitizing Subsystem (CARDS)

The Computer-Assisted Photogrammetric Subsystems (CAPS) accepts as input controlled diapositives produced from the aerotriangulation of aerial photography Maps are plotted by capturing map information in digital form at the stereo-plotter. The plotted data are joined and edited interactively to produce ''clean'' map data at a stage ready for field checking

The Computer-Assisted Cartographic Subsystem (CACS) accepts as input the digital map data produced by CAPS Field check data are added to the data to ensure that the map product is current at the time of publication The data are then reduced to final map scale, edited to ensure correctness and then plotted on a high precision plotter in colour-separated negative form The CACS system is also suited to map derivation to smaller scale products and to production of special purpose or thematic maps

The Computer-Assisted Raster Digitizing Subsystem (CARDS) enables existing maps to be converted to digital form for inclusion in the data base This is an important activity to ensure that digital data are available in the meantime while the primary map coverage is being produced (this will be approximately 11 years)

The functions of each of these subsystems are outlined in figure 73. The subsystems are the integral functional elements of the CAMS, providing digital photogrammetric aerotriangulation, stereo-plotting, data base formation, manipulation and map output, together with the conversion of existing maps and plans into the digital data base The characteristics of the CAMS are:

a total turnkey integrated system;

compatible hardware and software in each sub-system;

the ability of each subsystem to operate independently in the event of hardware faults in any of the other subsystems;

the capacity to address the current and near future requirements and the capability of expansion for future needs;

the ability to incorporate other data bases such as utilities, the cadastre, geology, etc , for thematic products

the hardware schematic diagram is shown in figure 74

The CAMS will not replace existing equipment but be adjunct to it. Existing stereo-plotters will be integrated into the CAPS, and CACS will provide mapping output to the existing printing presses The major transition will be in procedures The changes being introduced are illustrated schematically in figure 75

The three subsystems will be installed in purpose-built accommodation and functional work areas

Figure 72. Malaysia: Cadastral survey data base and processing system; work flow

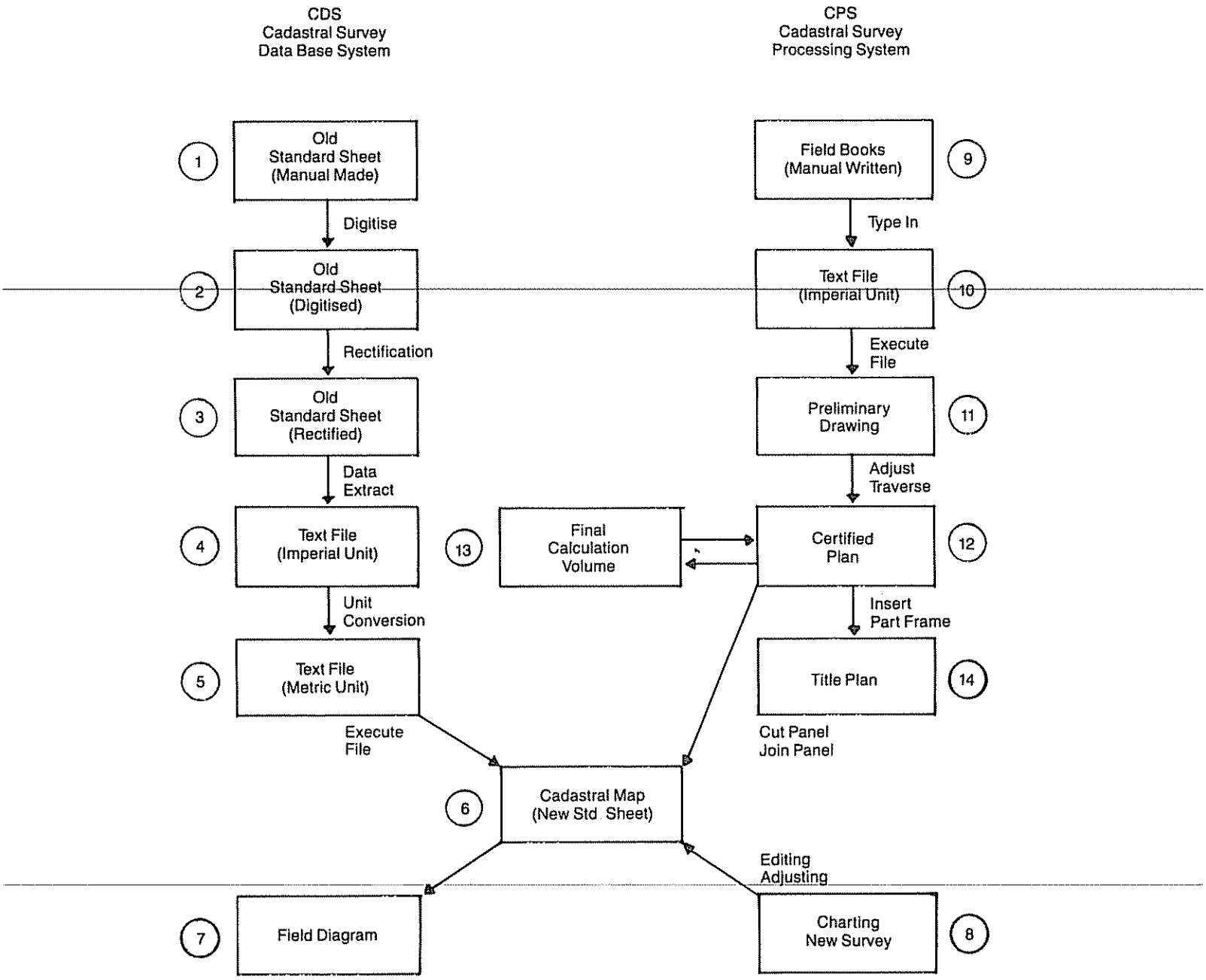
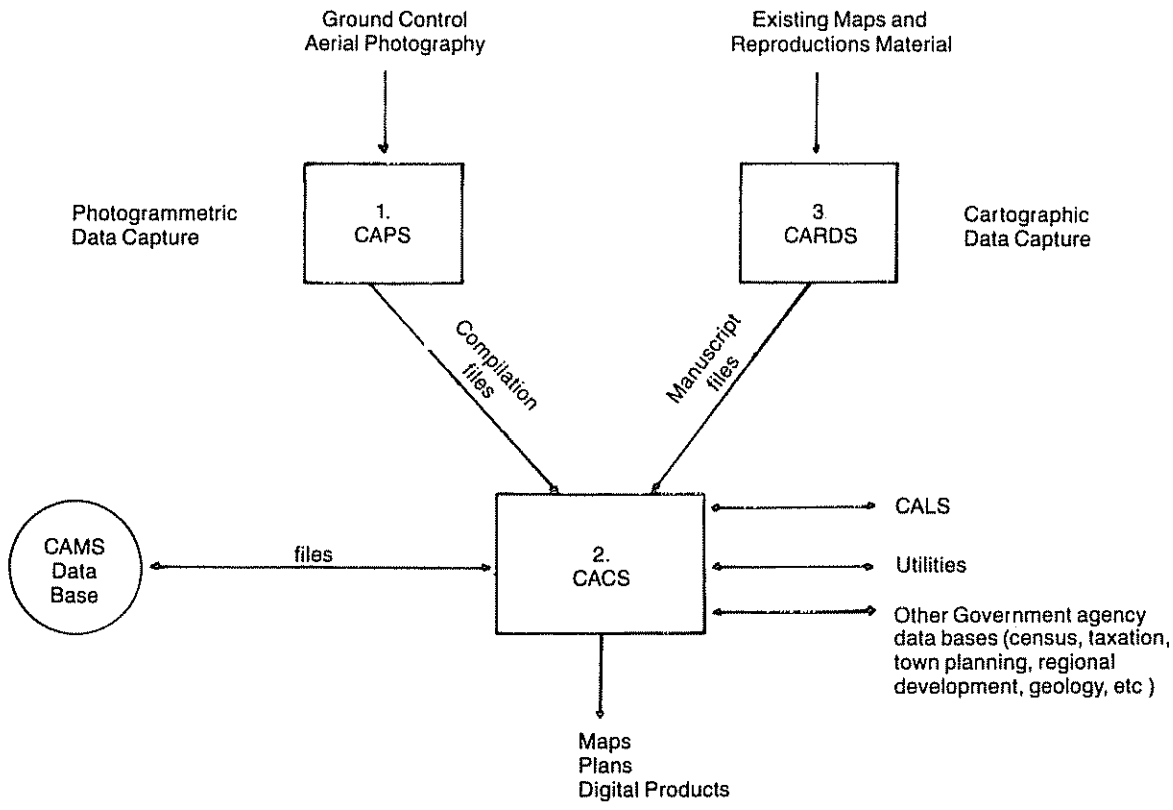
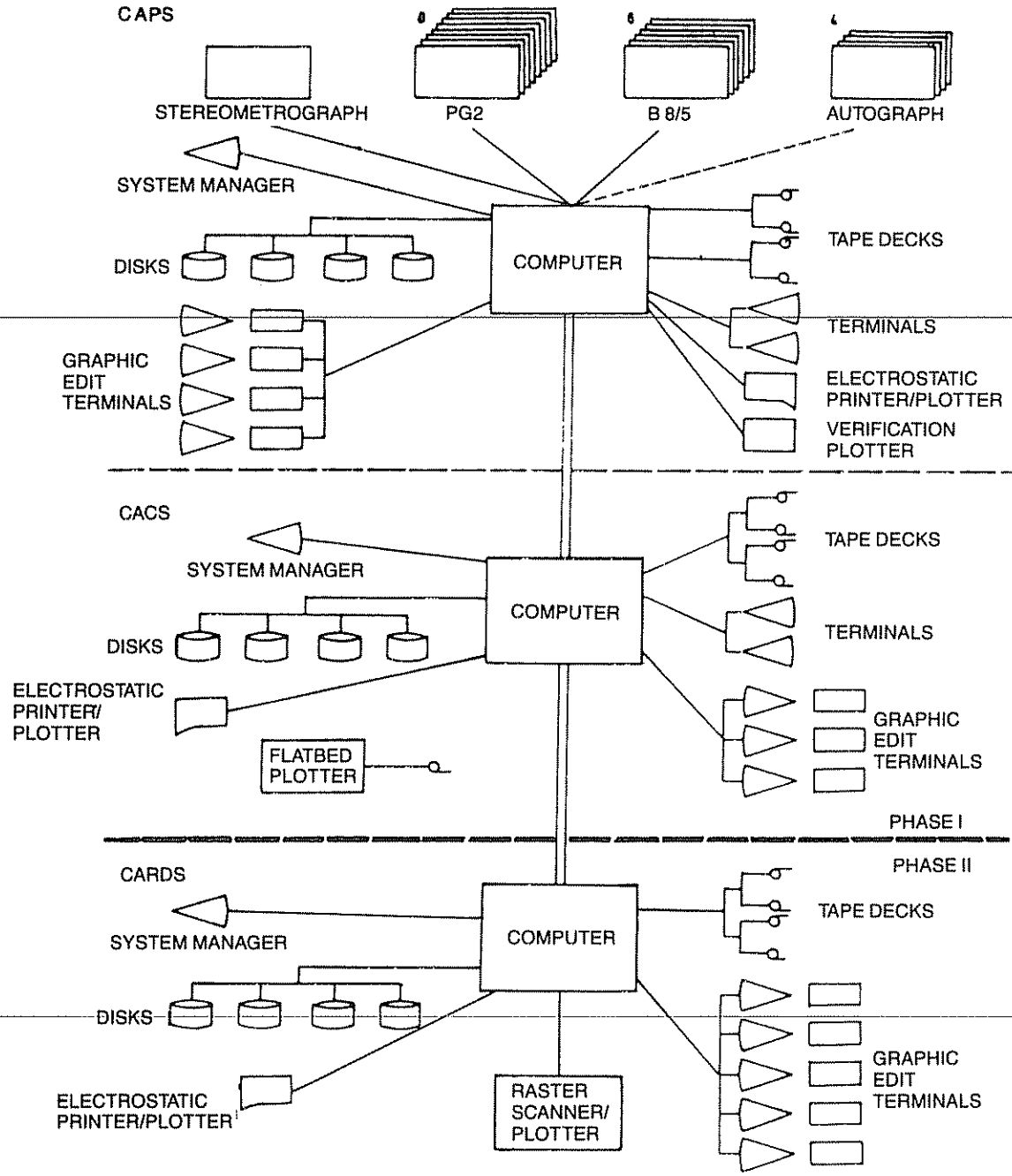


Figure 73. Malaysia: Computer-Aided Mapping System; functional outline



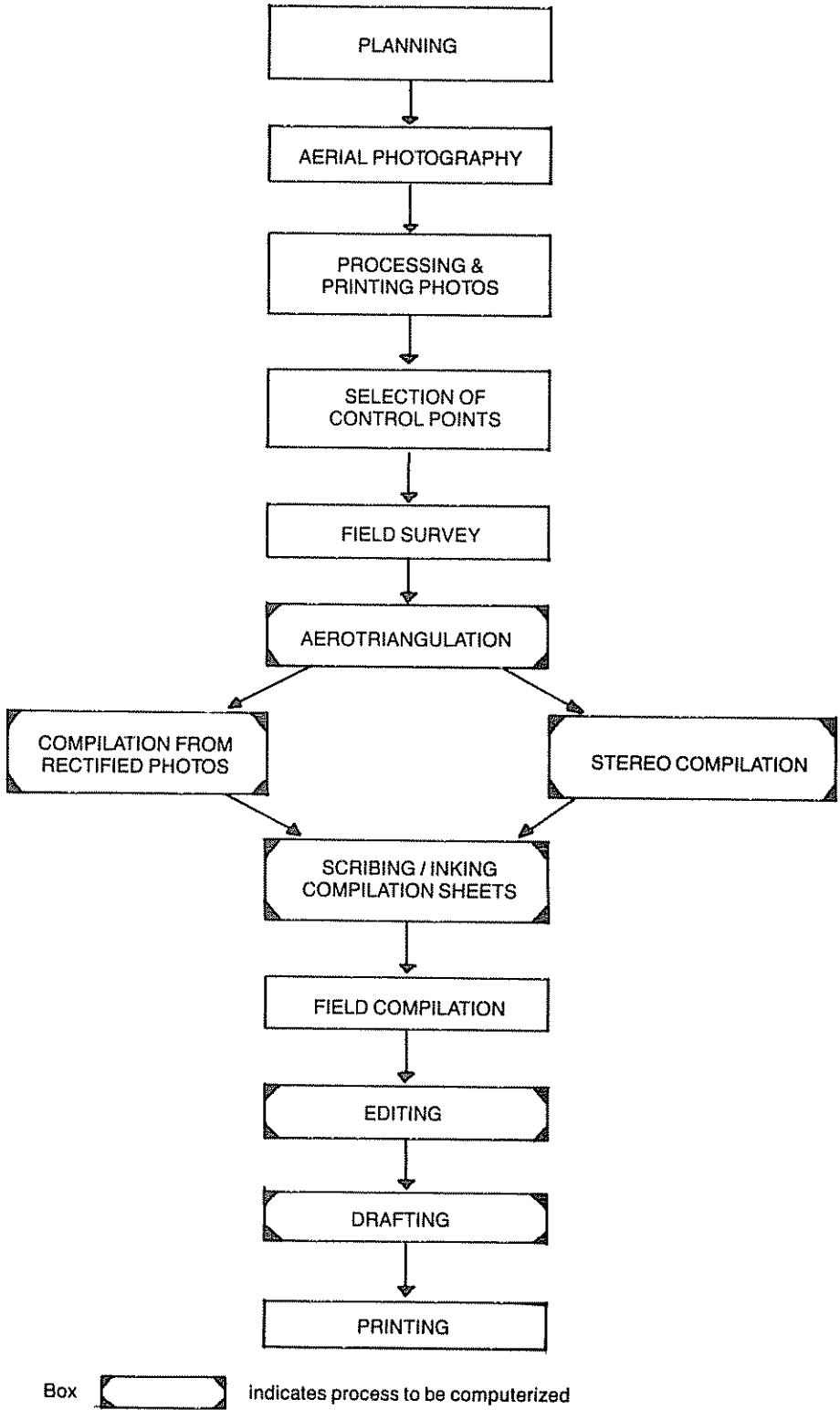
Source. Directorate of National Mapping

Figure 74. Malaysia: Hardware schematic diagram of three subsystems of CAMS



Source Directorate of National Mapping

Figure 75. Malaysia: Production sequence for topographic maps in the Directorate of National Mapping



THE SURVEYOR AND HUMAN SETTLEMENTS*

Paper submitted by the International Federation of Surveyors

RÉSUMÉ

La création d'un établissement humain moderne exige des apports multiples, provenant de particuliers, d'institutions, d'organisations et de groupes interdisciplinaires. Pour leur part, les membres de la FIG ont un rôle majeur à jouer : en premier lieu, dans la prospection, l'étude et le rassemblement d'informations sur les ressources anthropogènes et naturelles de région et dans leur présentation aux habitants, aux pouvoirs publics, aux constructeurs et aux administrateurs des établissements humains au moyen de cartes et de plans; en deuxième lieu, dans la présentation et le traitement des projets de développement qui doivent être soumis à l'approbation des pouvoirs publics, des conseils et des tribunaux; troisièmement, dans la délimitation et la disposition des divers éléments; quatrièmement, dans la conception, la planification et la définition des projets; et cinquièmement, dans la gestion administrative et financière des établissements humains. La définition du terme «géomètre» et les responsabilités professionnelles qui s'attachent à cette fonction varient au sein des organisations membres de la FIG et d'un pays à l'autre. Toutefois, sa formation spécialisée et son expérience des questions de terrains (y compris les terrains recouverts d'eau) donnent au géomètre une mission et des responsabilités particulières dans le domaine des établissements humains. Dans la communication, on se propose d'examiner plusieurs grandes questions — distinctes mais interdépendantes — qui se posent dans ce contexte, en utilisant le terme "géomètre" au sens large, qui recouvre de nombreuses disciplines spécifiques relevant de la topographie et de la cartographie.

RESUMEN

El establecimiento de un asentamiento humano moderno requiere la contribución de muchos individuos, organismos, organizaciones y grupos interdisciplinarios. Los miembros de la Federación Internacional de Agrimensores tienen un papel de importancia que desempeñar: primero, en el estudio, investigación y reunión de información sobre los recursos de una región, tanto naturales como artificiales, y en su representación a ciudadanos, autoridades gubernamentales, administradores y constructores de asentamientos humanos mediante mapas, cartas y planos; segundo, en la presentación y elaboración de estos aspectos para que los aprueben las autoridades gubernamentales, consejos y tribunales; tercero, en la delineación y trazado de numerosos accidentes físicos; cuarto, en la concepción, planificación y diseño de esos proyectos, y quinto, en los aspectos relativos a la gestión, administración y financiación de los asentamientos humanos. La definición del término agrimensor y las responsabilidades profesionales de los distintos agrimensores varían dentro de cada una de las organizaciones afiliadas de la Federación Internacional de Agrimensores y de un país a otro. Sin embargo, la formación especial y los conocimientos de éstos en asuntos relacionados con los suelos, inclusive los suelos cubiertos por agua, les garantizan un lugar y responsabilidad especiales en la construcción de asentamientos humanos. En la presente monografía se procura abordar diversos temas de importancia, distintos pero interrelacionados, que guardan relación con esas responsabilidades, y se utiliza la definición amplia del término agrimensor para que queden comprendidas muchas de las disciplinas específicas existentes en la esfera del reconocimiento topográfico y el levantamiento de mapas.

The establishment of a modern day "human settlement" requires the input of many individuals, agencies, organizations and interdisciplinary groups. Members of the International Federation of Surveyors (FIG) have a major role: first, in the exploration, investigation and gathering of information on the man-made and natural resources of a region and its portrayal to citizens, governing authorities, administrators and builders of human settlements through maps, charts and plans; secondly, in the presentation and processing of developments for approval by governmental authorities, councils and tribunals; thirdly, in the delineation and laying out of the many physical components; fourthly, in the conception, planning, design of these projects; and, fifthly, in the management, administrative and financial aspects of human settlements. The definition of the word "surveyor" and the occupational responsibilities of individual surveyors vary both within each of the FIG member organizations and from country to country. However, the special training and expertise of surveyors in land-related matters (including those lands covered by water), assures them a special place and responsibility in the building of human settlements. The present paper will endeavour to deal with several major, separate but interrelated, topics appertaining to these responsibilities and uses the extended definition of the word "surveyor" to include many of the specific disciplines within the survey and mapping field.

LAND

As professionals (surveyors, cartographers, hydrographers, photogrammetrists etc.), let us for a moment consider the land, its unique nature and the crucial role it plays in the building of human settlements. Land that is usable by mankind is one of our most valuable finite resources and is becoming scarce. The total surface area of our "Space-Ship Earth" is approximately 510 million km² (70 per cent water and 30 per cent land) with the largest part being the Arctic regions, bare mountains, deserts and unproductive forest areas. This leaves less than half the total land surface usable by mankind. Further limitations on the use of this land are imposed by factors such as climate, access to fresh water, topography, fertility of the soil and access to population centres.

Growing populations increase the demand for, and the demands upon, land. The very number of people presently on the earth is creating overwhelming problems with respect to shelter, transportation, food, drinking water, waste management, education, employment, government and all aspects of human existence. In 30 years' time, the world population may double to some 7 or 8 billion people. Land usable by mankind is finite—it will not double. Science and

* The original text of this paper, prepared by C. H. Weir, International Federation of Surveyors, appeared as document E/CONF.77/L.40.

technology can increase productivity and expand the area of usable land, but there are limitations and the cost is high.

In view of the limited supply of usable land, there is a need to conserve and maintain what we have and to reclaim new land for both agricultural and human settlements with a minimum of disturbance to the ecological balance. The challenge must be attacked on many fronts; these include:

prevention of pollution and protection of the environment;

restoration of derelict or damaged land;

control of erosion through reforestation, flood control and appropriate land use practices;

control and reversal of desertification and salinization;

reclamation of waterlogged areas;

landfill sites using solid wastes;

proper land capability assessment programmes to aid in the proper use of the land;

economizing land by fixing appropriate densities.

These are a few areas where we meet the challenge and can help to avert disaster.

Human activities and the forces of nature make this land a dynamic and changing scene. Land becomes the primary element in the exploration of our resources for the benefit of society as balanced or unbalanced, with or against the protection and enhancement of the natural environment. Surveyors all over the world, owing to their affinity with the land, have a larger than normal responsibility and part to play in maintaining an equitable balance.

Land-use control

Thus, with growing populations, the intense competition for land and the need for action point to more control of land use and land-use changes. Such control may be brought about by:

(*a*) Zoning and land use planning being made part of the basic land administrative policy;

(*b*) Legal controls, such as land registration, building and development permits, reallotment and replotting;

(*c*) Fiscal controls, such as property taxes, tax penalties and tax incentives;

(*d*) Creation of public land reserves and land banks;

(*e*) Changes in ownership patterns and separation of land ownership from development rights.

This places an awesome responsibility on the governing authorities as well as the interdisciplinary groups of professionals, including surveyors and all those who aid in establishing and managing these systems. However, to be effective, it also requires the involvement of the public, including those who have not traditionally participated either in the planning or in the decision-making processes. Control then becomes a co-operative effort.

The improvement of the quality of life for all the citizens of the world is the primary goal of every human settlement policy. However, in striving to achieve this objective, increased demands are placed upon the land. Increasing the standard of living for the most part means an added requirement for land, such as:

(*a*) Increased need for recreational areas, parks, hiking trails, resorts, summer houses, playgrounds etc.;

(*b*) Higher energy standards requiring land for coal mining, reservoirs behind dams, right-of-way for transmission lines etc.;

(*c*) More and higher standards of transportation facilities, airports, highways;

(*d*) Additional shelter, infrastructure and services.

Projecting this phenomenon into the future: does it mean a lowering of expectations, particularly in the more industrialized countries? This is more than a planning problem; it becomes a community and a world problem, particularly when the underdeveloped nations are brought into the picture.

Public participation

Land-use control usually implies a decline of individual property interests through government or state intervention via planning processes embedded in land management institutions. Regardless of the political milieu, the legitimacy of government intervention lies in the supposition that it is required in the greater public interest. Professionals involved in urban and rural land-use development and control have come to recognize that their actions require the input and support of the public. Public participation is required to identify and achieve the goals and objectives for the nation, region or particular locale. Public participation is not simply the transfer of information from independent decision-makers to the public; rather, it is the dynamic continuous process of integrating the many interests and values in the decision-making process regarding all aspects of human endeavour. To be effective, public participation requires four fundamental conditions:

(*a*) A credible, open and honest process;

(*b*) Provision of adequate information;

(*c*) Opportunity for meaningful dialogue and bargaining;

(*d*) Recognition of the interests of the disadvantaged.

The active participation of affected interests allows for the identification and priorizing of the public's values regarding natural resources, aesthetics, economics, development etc; the imaginative generation and comprehensive evaluation of alternatives and the support for and, thus, easing of the implementation programme. However, this requires public involvement in all phases of the programme, from project initiation through to the monitoring of impacts. Public participation allows and requires the professionals and decision-makers to achieve an equitable balance between technological or scientific fact and individual values and perceptions. In a field as complex as human settlements, public participation must be an integral part of the planning process and is an indispensable element in many parts of the world. Within the survey and mapping community, the planning process, while varying from country to country, has some primary aspects which we should address.

Planning

Many conferences all over the world are dealing with the complex aspects of human settlements. The present Conference will no doubt address problems encountered in the planning process and offer solutions. All the members of FIG are involved in planning, some more, some less. What is "planning" in the world today?

Planning is an international activity involving both private and public sectors. Within a country, there are levels of planning ranging from national policies regarding regional economic development to local neighbourhood design. Planning is multidisciplinary, involving diverse professions that offer their own unique expertise and perspective to the planning process. It has evolved from a simple concern for

community health standards to economic, social, environmental and cultural policies, and programme development. Planning has a broad scope and few human activities are not affected by the process. Planning attempts to effect a rational allocation of resources (land, mineral and human) in response to national and local goals, objectives and values.

Ideally, the planning process should be proactive not reactive; adaptive and dynamic not restrictive and static. Decisions should be based upon the best available information and a full understanding of the impacts or consequences of alternatives. This process is seen by many to involve six major stages:

Identification of goals and objectives;
Collection and analysis of information;
Generation of viable alternatives;
Evaluation of the alternatives;
Implementation of the "best" alternative;
Monitoring of the consequences of the action.

Few would disagree that this process is rational, but of late, professionals in many disciplines have recognized the inherent difficulties with this process. Further, it has been acknowledged that planning has not been a panacea for all of society's problems. This is a function of numerous factors, including the rapid growth and distribution change in population, phenomenal technological changes, an increasingly complex society, the lack of basic land and social information and of environmental impacts and, perhaps, undue emphasis on the economic and efficiency objectives. The issues facing the professions are contradictory and serious. A concerted co-operative effort is required to meet the challenges of building human settlements in our environment.

To a varying extent, all nations confront both urban and rural area crises. In rural areas, problems include the reduction of soil productivity, the loss of productive acreage, the difficulty in providing basic infrastructure and social services to a dispersed population, and the fierce competition, at times, between conflicting land uses for finite resources.

Many urban areas are facing major fiscal and population problems. Owing to the massive immigration pressures, even minimal shelter and servicing standards have not been attained in many cities of the world, nor have employment opportunities been generated to meet the demand. These problems are extreme in developing nations but even Western society is now feeling the effects. For instance, the North American dream of owning a home, to many, is just that, a dream, due to the escalating services and material costs and high interest rates.

Planning has adequately addressed concerns relating to physical planning, i.e. building design, lot size, road standards, infrastructure etc., but is still wrestling with major social problems. Through higher levels of education, a pervasive media, organized groups are calling for a re-evaluation of society's goals and a new perspective on land and, in particular, the environment. It has become obvious that more and better readily available information, new techniques and, perhaps, new objectives are required. In this area, the surveying and mapping community have an important role to play and must actively pursue the matter of supplying information. Planning, if dynamic and adaptive, can respond to changing societal demands and yet respect the limitations imposed by the environment. Planners acknowledging uncertainty by proceeding with care and monitoring their actions can ensure the reduction of impacts and also maximize benefits.

Surveyors and mappers throughout the world play a varying and significant role in the planning process. An important role is to provide accurate up-to-date information and communicate this information to the decision-makers in a concise and comprehensive manner. This role is of greater importance as the scale of the problems increases. The reduction of uncertainty by increasing knowledge of biotic and abiotic systems and the monitoring of programmes should be a major responsibility of the survey profession. Better solutions or programmes require better information and techniques upon which to base decisions. Surveyors with "hands on" experience with land management have a legitimate role in the multidisciplinary planning process. Science and technology, while freeing man from many burdens, has yet to resolve all problems and, in some cases, has added to the load. However, new technology has particularly allowed the surveyor to gather and disseminate land-related information much more accurately and efficiently to all those involved in building human settlements. Surveyors and mappers must continue to use new technology resources but must also continue to temper them with a strong social conscience.

Land Information Systems

Effective land-use planning and control measures cannot be implemented unless the public and all levels of government have access to adequate information. Comprehensive information on land capability, characteristics, tenure, use and legislation should be collected and continuously updated so that all citizens and levels of government can be assisted in determining the most beneficial land-use allocation and control. Thus, land-related information becomes increasingly important to the orderly, fair and intelligent use and development of the land. In the past, land-related information was gathered, stored, updated and distributed on a manual basis in registers, books, plans and maps. With modern technology, these activities are now being computerized and automated throughout the world.

The development and maintenance of computerized land information systems is receiving major attention by private, industrial and governmental agencies all over the world. The variety of systems is great and includes fiscal systems, legal land registration systems, development control systems, facilities management systems, utility network systems, urban and rural planning information systems, land resources systems, demographic and social data systems and the basic geographic or co-ordinate systems. Of primary importance in building effective, efficient and compatible land information systems are:

(*a*) The existence of an easily accessible common reference framework;

(*b*) Constructive action by government in co-ordinating existing land-related functions;

(*c*) Standardization of procedures and terminology, and funding;

(*d*) High priority in allocation of funds;

(*e*) Active involvement by the decision-makers.

The precise definition of a Land Information System is somewhat elusive and has been defined by the International Congress of Surveyors (FIG) as follows:

"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 which also facilitates the linking of data within the system and with other land-related data."

This is a wide definition. The contents of a Land Information System comprise all land-related data and may include geodetic survey data, cadastral data, data on natural resources, data on man-made installations, environmental data, economic and socio-political data, etc. It must be emphasized that it is not practical, and most likely impossible, to contain all land-related data and serve all activities from one technical system. Therefore the information must be contained in many systems, each having their own functional and technical aspects. In addition, the Land Information System is an interdisciplinary subject involving surveyors, cartographers, photogrammetrists, engineers, lawyers, planners, administrators, decision-makers and other users and suppliers of land-related data.

The decision-makers (i.e. managers, administrators, politicians, tribunals, councils etc.) are the key element in the use, organization, development and effectiveness of land information systems. Their questions must be answered and their problems solved. If they are not interested, success is unlikely and probably there would be no need for the system. Therefore, decision-makers must be involved from the beginning in the use of the systems, particularly as they start to replace their largely intuitive or rule-of-thumb methods with a reliance on information obtainable from the various information systems. Information selected from one or more information systems can be used for modelling and developing scenarios or alternatives in preparation for management decisions. Thus, referring back to the FIG definition, "a land information system is a tool for legal, administrative and economic decision-making", we can easily understand the importance of the systems to management decisions made in the building of human settlements.

Surveyors have an important role to fulfil in the building of land-related information systems. The traditional double function of providing the common reference framework and the collection, updating and analyses of different types of land-related information assigns them a primary role. However, the surveyor's application of technology, systematic approach to problem solving, concern for accurate current data, and traditional role within the land management team allows the surveyor to fulfil a larger responsibility. This is the responsibility of owning, managing and maintaining land-related information systems. It is important that educational institutions recognize this future responsibility and provide courses and practical training in land-related information systems.

The surveyor and his role in several phases of the building of human settlements has been summarized. The surveyor's role in the land management side of human settlements and his part within the land management team is considered below

Land management

Management is an organized response to a perceived threat, conflict or problem. Land management can range in scale from the individual farmer and his holdings to a state or national agency responsible for a particular resource or activity (e.g. state fisheries, forests etc.). Land-use control and planning are elements of land and resource management. Building upon the identification of elements, the manager attempts to determine the system mechanics or the cause-effect linkages. Assuming that these linkages are known, the manager can then judiciously manipulate key or primary elements to produce the required end result. Although this process appears straightforward and simple, this, of course, is not the case. Difficulties exist owing to the fact that not all elements have been identified; that the individual system mechanics are, to a great extent, still a mystery and that knowledge of the inter-relatedness of natural systems, one with another, is deficient. This high level of uncertainty leads to a trial and error approach and requires an extensive monitoring programme. Faced with the data complexity and uncertainty, increased scale of problems and ever-changing societal goals, land and resource managers, be they resource specialists, planners, civil servants, or politicians, have a critical and difficult task.

There is an increasing demand from society to consider interdisciplinary approaches to the resolution of land management decisions. No longer can single disciplines determine the events which affect land management decisions. As an example, foresters must consider the impact of their practices on wildlife, water resources, soil conservation and forest regeneration, to name a few. Other environmental managers face similar situations, and none of them can effectively plan without adequate land information. Continued increasing government intervention and regulation in the many approval stages of subdivision development, urban renewal, land use zoning etc., have not only increased the requirement for more complete land information, but have also necessitated the need for someone to guide the decision-makers through the maze. This leads us to the concept of the "land management team". In the present context, the land management team is defined as that group of professionals whose principal occupation or function is associated directly with the management, administration, definition, tenure, use and development of land. This group would include, but not be limited to, surveyors, planners, engineers, lawyers, architects, developers, land economists, land administrators and others whose area of interest within their profession deals specifically with the land.

Surveyors have always been members of the land management team. According to the FIG Statutes, the surveyor is defined as:

> "a professional man who identifies, determines the boundaries of, measures and values public or private land property, whether urban or rural, and whether on the surface or below, as well as works executed thereon; and who arranges for the registration of property, and settles questions of ownership connected therewith. The surveyor also studies, plans and is responsible for land development and town and country planning. He deals with the technical, legal, economic, agricultural and social aspect of the aforementioned "

This FIG definition gives the surveyor an extensive role as a land manager. Any surveyor professionally fulfilling the role as envisaged in this definition can easily be the leader of the land management team.

Thus far, in this paper, the role of the individual surveyor in the building of human settlements has been briefly considered. Lastly, let us consider the function of the international organization to which he belongs.

Role of the International Federation of Surveyors

The FIG has an important function to fulfil in the ongoing world-wide debate on the building of human settlements. The professional responsibilities of the individual surveyor within the FIG family, and the aims of the FIG ordain that the organization take an active role. The main aims of the FIG as stated in Article 1 of the Statutes are as follows:

(*a*) To group the national associations or organizations of surveyors of all countries with the object of exchanging views on matters of general interest to the profession;

(*b*) To organize liaison between the various affiliated associations;

(*c*) To make known information on the social conditions prevailing amongst professional surveyors in individual countries so that each may take advantage of the improvements attained;

(*d*) To encourage, subsidize and disseminate the results of professional research, and discoveries useful to surveyors, in the scientific, technical, legal, economic and social spheres;

(*e*) To co-ordinate professional training in accordance with new methods;

(*f*) To foster relations with the appropriate authorities and the exchange of surveying personnel between different countries.

These aims include a general coverage devoted to increasing the surveyor's knowledge by promoting education, encouraging research and development, and sponsoring publications and conferences. The exchange and dissemination of new technical, scientific and professional knowledge of surveying and mapping techniques and practical experience allow the profession to be more competent and up-to-date and better serve society on a world-wide basis. With respect to the items mentioned in this paper such as land, land-use control, planning, land management, information systems, and the many elements in the building of human settlements, FIG concentrates efforts along the following lines:

1. On a world-wide basis, FIG should continue its role in promoting both the advancement of land-related information systems and their use in the building of human settlements. Co-operative programmes for the exchange and dissemination of new techniques and practical experience should be developed with its sister organizations, the International Cartographic Association, the International Society of Photogrammetry and Remote Sensing, and the International Association of Geodesy. It should also continue its support and participation in the United Nations cartographic conferences and other United Nations initiatives such as the Kawasaki Seminar on Information Systems for Urban and Regional Planning. The co-operative programmes should particularly include the developing countries and give special consideration to their problems in establishing land-related information systems.

2. Within FIG, the nine commissions are developing co-operative programmes covering all aspects of the development of land information systems. Commission 3, whose special mandate is Land Information Systems, is acting as a clearing house and a co-ordinating group to avoid excessive overlap of efforts. Land Information Systems is an interdisciplinary subject and can be considered from the professional, educational, technical, functional and management point of view, thus involving all nine commissions within the FIG family.

3. FIG, through its nine commissions and member associations, is making an effort to communicate with the university and technical educational institutions on the academic requirements needed by surveyors to fulfil their role in the building of human settlements. Survey educational programmes, while including the usual scientific and technical aspects, should also concentrate on preparing the surveyor for the following: integration of his contribution to the planning process; the interdisciplinary approach to building human settlements; development of land information systems; his role in the management team; and his need to be knowledgeable in the economic, social and political aspects of human settlement problems.

FIG is actively pursuing its aims in many ways, as illustrated by the many symposiums and congresses being sponsored and supported throughout the world. However, considering the ongoing world-wide debate on the building of human settlements, special effort by the FIG in the above three areas will hopefully constitute a significant contribution to building human settlements in many parts of the world.

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(h) *Map revision techniques*

SCANNER-AIDED REVISION OF THE TOPOGRAPHIC MAP 1:25,000*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Le "Bayer. Landesvermessungsamt München" (Service cartographique du Land de Bavière à Munich) a procédé à

RESUMEN

La "Bayerisches Landesvermessungsamt München" (Oficina de Topografía del Estado de Baviera en Munich) ha ensayado si puede mejorarse la revisión del mapa topográfico a escala de 1:25 000 utilizando un sistema de explorador adaptado a las exigencias cartográficas. Un sis-

*The original text of this paper, prepared by Gerfried Appelt, Bavarian State Survey Office, Munich, appeared as document E/CONF.77/L.11.

des essais en vue de déterminer si on pouvait améliorer la révision de la carte topographique au 1/25 000 en utilisant un système de scanneur adapté aux besoins de la cartographie. Un système à balayage linéaire décompose l'image de la carte en minuscules éléments appelés «pixels». Au cours de ce processus optoélectronique, un ordinateur repère les couleurs des pixels balayés sur la carte et les met en mémoire sur disques magnétiques. Les méthodes de traitement numérique permettent d'effectuer différentes opérations sur l'image ainsi emmagasinée, par exemple :

a) Modifier l'échelle ou modifier indépendamment la direction de l'axe ou de la circonférence (transformation affine);

b) Eliminer les taches parasites (poussière);

c) Teinter et tramer des zones déterminées;

d) Développer ou réduire des lignes;

e) Définir et placer tout signe conventionnel de lieu ou de ligne;

f) Placer des signes conventionnels sur des lignes numérisées ou codées en différentes couleurs;

g) Fabriquer des «caches effaceurs» pour les écritures;

h) Corriger la partie agrandie de la carte grâce à un moniteur couleur interactif;

i) Visionner des documents photographiques, en positif ou négatif, en lecture normale ou réfléchie.

Les scanneurs destinés à la cartographie sont fabriqués par les sociétés HELL de Kiel (République fédérale d'Allemagne) et SCITEX de Herzlia (Israël). Pour des raisons de coût, seul le système HELL a été testé.

Dans le travail de révision des cartes, on utilise les orthophotocartes au 1/10 000. Jusqu'à présent, on obtenait les manuscrits de révision en comparant les orthophotocartes aux cartes originales existantes. On tenait à jour les cartes topographiques en effaçant à la main les détails à éliminer et en dessinant à la main les nouveaux éléments cartographiques. Les écritures et signes conventionnels de lieu sont portés sur la carte par montage manuel.

Si on utilise un scanneur pour la révision des cartes topographiques, on commence par analyser les cartes originales existantes, puis on stocke les données sur disques magnétiques. Pour l'instant, on établit les manuscrits de révision en comparant les orthophotocartes aux cartes originales. Il s'agit, d'une part, de feuilles dessinées à l'échelle 1/10 000 sur lesquelles on recouvre les détails cartographiques à supprimer et, d'autre part, de feuilles sur lesquelles les éléments linéaires (routes par exemple) ou les zones tramées sont délimitées par différents codes-couleurs. Ces derniers servent à déterminer la signature ultérieure. Tant la suppression des détails cartographiques désuets que la transformation des manuscrits de révision correspondant aux différents codes-couleurs sont effectuées grâce à des programmes de traitement de l'image.

Par généralisation et à partir de la version ainsi obtenue de la carte révisée, comprenant le nouveau système routier, les constructions sont dessinées sur un manuscrit de révision supplémentaire de détail et reportées sur l'image de la carte révisée après balayage.

Les nouvelles écritures sont produites par photocomposition, montées sur une feuille et introduites sur la carte après balayage.

tema de barrido línea por línea descompone la imagen del mapa en elementos diminutos, los denominados pixeles. Durante el proceso de barrido óptico-electrónico, un computador detecta los colores de los pixeles del mapa sometido al barrido y los almacena en pilas de discos magnéticos. Mediante métodos de procesamiento digital de imágenes, la imagen almacenada puede someterse a ciertas operaciones, por ejemplo:

a) Cambios de escala, cambios independientes en las direcciones axial y circunferencial (transformación afín);

b) Eliminación de puntos no deseados de la imagen (polvo);

c) Colorido y filtrado de zonas destacadas;

d) Ampliación o reducción de líneas;

e) Definición y colocación de cualquier símbolo de localidad o de línea;

f) Colocación de símbolos de línea en líneas digitalizadas o en líneas codificadas en colores diferentes;

g) Obtención de "filtros de despeje" para la rotulación;

h) Corrección de la sección ampliada del mapa mediante el supervisor de colores interactivo;

i) Exposición de material fotográfico, en positivo o negativo, en lectura normal o invertida.

Los sistemas de explorador para las necesidades cartográficas son producidos por HELL en Kiel, República Federal de Alemania, y por SCITEX en Herzlia, Israel. Habida cuenta de los costos, sólo se ensayó el sistema de HELL.

La base de la revisión de los mapas consiste en fotos en proyección ortográfica en escala de 1:10.000. Hasta ahora, el borrador para la revisión del mapa se obtenía comparando las fotos en proyección ortográfica con los originales de mapas existentes. Los mapas topográficos se mantenían actualizados borrando a mano los objetos que debían eliminarse y dibujando a mano los nuevos elementos del mapa. Los símbolos de localidad y la rotulación se insertaban en el mapa mediante montaje manual.

Durante la revisión de mapas topográficos con auxilio de un explorador, los originales de mapas existentes se someten primeramente a un barrido y los datos se almacenan en pilas de discos magnéticos. Los borradores para la revisión se siguen obteniendo mediante la comparación de fotos en proyección ortográfica con originales de los mapas. Estos consisten en dibujos en hojas a escala de 1:10.000, en que se pasa pintura sobre los objetos del mapa para eliminarlos, y de otras hojas en que los elementos lineales (por ejemplo, caminos) o las zonas destacadas se delinean en colores de código diferentes. Los colores de código sirven para determinar la signatura posterior. La eliminación de objetos obsoletos en los mapas y la transformación de los borradores para la revisión sometidos a barrido correspondientes a los códigos de color se llevan a cabo mediante programas de procesamiento de imágenes.

Por generalización, y en relación con la versión ya obtenida del mapa revisado con el nuevo sistema carretero, se dibujan los edificios en un borrador de revisión de detalle adicional y se agregan a la nueva imagen de situación luego del barrido.

El nuevo rotulado se obtiene mediante composición fotográfica, montaje sobre una hoja e inserción en el mapa luego del barrido.

L'expérience a donné les résultats suivants :

a) On ne constate pas de baisse de la qualité graphique des cartes;

b) Le stockage numérique des cartes permet d'opérer un nombre illimité de corrections sans perte sur le plan de la qualité;

c) Il faut moins d'heures de dessin manuel et aussi moins de clichés et de copies;

d) Le temps de travail est réduit;

e) Une révision assistée par scanneur coûte de 20 à 40% de moins que la révision par la méthode manuelle actuelle.

On peut encore améliorer la méthode de mise à jour des cartes en complétant les programmes existants par de nouveaux programmes qui permettraient :

a) D'introduire des données externes, par exemple grâce à un numériseur autonome;

b) D'insérer des écritures obtenues hors ligne à l'endroit précis où elles doivent être situées sur la carte révisée.

Le "Bayer. Landesvermessungsamt" a acquis en automne 1984 le Chromographe Scanneur CTX330 de la société HELL qui sera équipé en 1985 de composants permettant le traitement de l'image par balayage numérique récurrent. Cet appareil est actuellement utilisé pour tramer les photographies aériennes et pour séparer les couleurs pour l'impression offset quadrichrome.

El resultado del ensayo fue el siguiente:

a) No se reconoce una disminución de calidad gráfica del mapa;

b) El almacenamiento digital del mapa permite un número ilimitado de correcciones sin desmedro de la calidad;

c) Se reduce el número de horas de dibujo manual y el número de exposiciones y copias fotográficas necesarias;

d) Se reduce el tiempo de trabajo;

e) Los costos de la revisión con auxilio de explorador son un 20 a un 40% menores que los de la revisión mediante el método actual de trabajo manual.

Es posible un mayor perfeccionamiento del método para mantener actualizados los mapas si los programas existentes se complementan con programas relacionados con:

a) Entrada de datos externos, por ejemplo, mediante un digitalizador fuera de línea,

b) Inserción de la rotulación obtenida fuera de línea y su ubicación exacta en el mapa revisado.

En el otoño de 1984 la "Bayerisches Landesvermessungsamt" adquirió el *Scanner Chromograph* CTX 330 de HELL, que en 1985 se complementará con los componentes para el procesamiento de imágenes por cuadrícula digital. Actualmente se utiliza para el filtrado de fotos aéreas en semitonos y la obtención de separaciones de colores para la impresión offset en cuatro colores.

Revision of an existing large-scale map series is important in order to keep its value and satisfy demands for up-to-date maps. This task however is laborious and time-consuming, since large numbers of official topographic maps need revision at intervals of five to ten years. Updating involves adjustment to changed drawing keys and new working methods, and all effort must be made to preserve the graphic quality of the maps.

In the Federal Republic of Germany map originals have been revised almost exclusively by manual drawing or scribing. For more than 10 years tests have been made to substitute manual methods by digitizing, interactive processing on a display and subsequent drawing or scribing by means of an automatic drawing machine. Since many data are to be acquired for revision by manual digitization, the computer-aided working method has yielded no shorter working time or lower costs than the current practice. Scanner-systems have been offered for the past four years. In combination with a computer and programs for digital image processing they seem to be qualified for the technical production or revision of a map series. Therefore, in 1983/84, the Bavarian State Survey Office tested whether a scanner with adequate periphery might accelerate the revision process of the *Topographic Map 1:25,000*. The results of these tests are described below.

Map compilation and current working methods

Topographic Map, Series 1:25,000 consists of adjoining sheets, using the colours black for situation; blue, hydrography; brown, contour lines; green, forest areas. The map originals generally are copies on a plastic foil named "Astralon". Transparent photographic enlargements of each quarter of a map-sheet to the scale of 1:10,000 are produced, in which the alterations are picked up by comparing them with orthophotos of the same scale. Details that cannot be clearly recognized on an orthophoto have to be identified by local visit. Alterations, e.g. newly constructed roads, settlements and houses are delineated in different colours on the transparent enlargement at 1:10,000. Then, photographic reductions to the scale of 1:25,000 are produced, and mounted on a combined whole map-sheet. This assembly is copied in a red colour on an Astralon-foil. It is used as a basis for the manual updating of the black, blue, brown or green Astralon originals by erasing and ink drawing. The changed lettering, set on film, is stuck onto these transparent originals. Revision of the situation and hydrography foil follows the sticking in of lettering. To clear the originals of details, touched by the added names, the application of lettering is underlaid. Local symbols, e.g. sports grounds or water-towers, are mounted as small film-cuts.

For the presentation of water areas by a dot screen, the water area-mask is fitted with the altered water-outlines. Water-outlines and water-area are combined by a copy on Astralon by screening the water area. In total, 15 photomechanical copies, 9 multicoloured copies (Cromalin) and 4 photographic reductions are produced.

Scanner specifications for application to cartography

During line-by-line scanning with an optical system consisting of 3 colour filters and photomultipliers, scanners decompose the image of a map into tiny elements, so-called pixels, whose colour characteristics are digitally stored. By digital image processing methods the scanned map image can be modified by programs.

Such a scanner has to meet the following technical demands:

scan and record size, at least 60 × 60 cm;

resolution, at least 40 lines/mm;

scanning and recording time, maximal 60 minutes;
colour identification, at least 10 colours;
recording of the scanned data on magnetic disks;
interactive processing of map sections on a colour display;
program-controlled producing of symbols and screened areas.

Moreover, it should allow:

data input by off-line digitizer;
exposure of lettering on any line.

The most important demands can be satisfied by the following scanner-systems:

(*a*) HELL TDP 500 HELL Company, Kiel, Federal Republic of Germany;

(*b*) SCITEX Response 250 of SCITEX, Herzlia, Israel.

In view of the costs, the test on the scanner-aided revision of the *Topographic Map 1:25,000* at HELL at Kiel was possible during a stay of four days only. The HELL TDP 500 scanner-system for cartographic application consists of the following components:

Chromagraph CTX 330 Scanner and Recorder:

With Operator console and colour computer carriage;
Size 100 × 112 cm, maximum 40 lines/mm;
Processing time, about 40 minutes;
Identifying up to 15 colours;
Scale variation from 10 to 400 per cent;

Process computer R 30 of Siemens:

Magnetic disk storage 300 Mb.

Combiskop Colour Monitor, 512 × 512 dots:

with digitizing board 40 × 40 cm;

magnetic tape station 1,600 respectively 6,250 bpi operatable;

line-film processor.

After scanning an original, the software of the system is able to modify the map image as follows:

(*a*) independent scale conversion in axial- and circumference direction (affinitive transformation);

(*b*) positive or negative recording, normal-reading or reversed reading recording;

(*c*) expanding or reducing of lines;

(*d*) colouring and screening of outlined areas;

(*e*) cleaning by removing isolated image dots (e.g. blemishes caused by dust);

(*f*) geometric defining of any line symbol or local symbol and its exactly located representation by means of a digitizing board or by an interactive display;

(*g*) coding of any line symbol by characteristic colours; for locating the line symbol exactly, it is sufficient to delineate the run of a line with a specific colour;

(*h*) placing of scanned names, producing masks for clearing the map content and positioning the lettering on the interactive display;

(*i*) joint output on one film of map elements of the same colour;

(*j*) interactive manipulation on the colour monitor Combiskop in an enlarged and coloured represented map section;

(*k*) interactive correction of half-tone images, e.g. hill shading.

Further programs are planned for:

smoothing of lines;
external data input (e.g. off-line digitized lines, lettering);
symbol rotation;
transformation and fitting of map sections;
placing of local symbols, whereby the position is determined by coloured dots on a scanner-copy.

Plan of new working method

The existing originals of the *Topographic Map 1:25,000* are drawings or copies of each printing colour on a foil (scale 1:25,000). The updating of the map is based on orthophotos (scale 1:10,000). At first, transparent photographic enlargements of the four sections of the *Topographic Map* are produced at scale 1:10,000. They are adjusted to the orthophotos on a light-table. The stated alterations are delineated by tracing on revision copies. For each quarter of a map-sheet (scale 1:10,000) these copies consist of:

(*a*) "Eliminating masks" covering all those map details that are to be deleted;

(*b*) "Map supplements", showing on one or two foils the new map objects of the situation (without buildings), hydrography, forests and, perhaps, contour lines. All these map objects are coded by lines or areas in different colours and exactly located;

(*c*) "Detail supplements", which will be explained below.

If necessary, vague objects in the orthophotos are to be identified by making local inquiry.

For map revision the original foils of each printing colour have to be scanned on scale 1:25,000 and the digital image stored. Then the four "eliminating masks" are scanned, and, after scale change and transformation, the map is erased at those parts that are to be deleted on the digitally stored image.

Later, the "map supplements" are scanned, reduced to scale 1:25,000 and transformed. Definite symbols are assigned to coloured lines or areas on each foil by program (e.g.: red line = double lined road, blue area = an area outlined and filled with a dot screen of 25 per cent. The exact geometric definition of the map symbol as well as its appointment to one of the four printing colours are readable in a particular storage.

The result of the digital image processing (old map original minus "eliminating masks" plus "map supplements") is exposed on film by means of the recorder at scale 1:25,000. This is the first black colour version of the revised map for roads, hydrography and forests; it has to be examined in regard to a necessory retouching, in particular, the joints of new and old roads, the crossings of roads and waters. The retouching is performed by interactive corrections of enlarged map sections on the colour monitor Combiskop. While doing this, road run bends or discontinuities may be smoothed by digitizing the characteristic road line as a vector and representing it by the road symbol.

The retouched first version is recorded on film at scale 1:10,000 for the extraction of new buildings from tne orthophoto. Since it shows the new roads and can immediately be compared with the orthophoto, it is possible to pay attention to the displacement of buildings caused by the width of road symbols. In the "detailed supplements", the buildings are drawn at an enlarged scale in black colour on a foil in a generalized mode. Also, embankment edges along new roads are coded with coloured lines. Instead of manual drawing, transfer sheets can be used. The outlines of areas, represented in the map by a screen (e.g. gardens, meadows, vineyards), are coded in different colours and drawn on a second transparent foil.

Both foils are scanned, reduced to the scale 1:25,000 and transformed. The scanned buildings are inserted into the stored digital image of the situation. Colour coded map symbols for the embankment edges and screen areas are converted by program into map symbols and also added to the digital map image.

Now the second version is recorded. It is taken to design the new lettering. The changed names, set on film, are stuck onto different foils according to the different printing colours.

Next, the mounted lettering is scanned. A digital image of a "clearing-off mask" for the situation is produced by expanding the black lettering. On the digital image the situation is cleared by using this mask, and then the black lettering is added to the situation. The blue and brown names for hydrography and contours are added to the corresponding digital images.

As a third version of the revised map, a film of every printing colour is recorded, and a four-coloured Cromalin proof is produced for examination and correction of the total work. Errors are corrected sectionally by interactive revision on the colour monitor. Eventually, the new map originals for each printing colour are recorded as a film; they are the originals for producing the printing plates for the circulation run. The digital image of the *Topographic Map 1:25,000* is output on a magnetic tape and filed for the next map revision. Thus, the quality of map image can be conserved forever, no matter how often the map-sheet will be revised in future.

Conclusion

The scanner-aided revision of a *Topographic Map 1:25,000* was tested on the basis of a quarter map-sheet. The test shows the following results:

(*a*) The resolution of the Scanner-Recorder Chromagraph CTX 330 with 40 lines/mm, scanning and recording the map image, is sufficient also to reproduce fine-line symbols or names. Sometimes the fine lines with a 0.1 mm line width appear like light saw-teeth on the photographic film. But this is not perceptible on the printed map;

(*b*) For storing and interactive processing of *Topographic Map 1:25,000*, size about 50 × 60 cm, a magnetic disk with approximately 300 Mb is needed;

(*c*) Eight different colours applied to the updating copy were differentiated automatically without difficulty;

(*d*) Smallest blemishes of the scanned copies, like scrapers, dust or creases, could be deleted by a cleaning program;

(*e*) Scale changes and joining the different scanned parts of the map presented no difficulties, since the scanner original was already mounted in correct orientation on the scanner drum. Thus, time-wasting operations to transform the scanned data were avoided;

(*f*) The conversion of coloured lines in the "map supplement" into map symbols shows little bends or deviations from the straight-line run caused by the coloured lines drawn with a broad overhead projection pen and without ruler. The use of fine lines would yield a smoother road run. Better, too, would be the smoothing of scanned lines by a computer program;

(*g*) The recording of new map originals on a photographic film shows a good resolution, a high contrast and density;

(*h*) "Clearing off" the black situation relevant to the position of black lettering was tested by one name and shows a good result.

On the basis of these test results the cost benefit ratio of the described scanner-aided map revision was estimated. It was supposed that, in addition to the basic equipment above described, two colour monitors Combiskop are used for interactive processing simultaneously. The investment rate of DM 2.5 million was deducted over a period of six years, and the manual drawing work was done at approximately DM 40 an hour. Moreover, it was considered that the decrease in quality by the copying process necessitated the complete renewal of the map originals after five map revisions in manual mode, whereas there were no quality losses using scanner-aided map revision by means of digital image storage.

Supposing a map-sheet with numerous supplements, scanner-aided map revision may be about 20 to 40 per cent less expensive than manual map revision. The saving results from the considerable reduction of manual drawing and the smaller number of copying processes, with a corresponding saving in work and material. Moreover the shortening of processing time is advantageous for the revision of topographic maps. Additional cost-reduction is possible by data input by means of an off-line digitizer or by writing a program for using the scanner as photo-typesetter. In this case, by means of an off-line digitizer the names, place and size are acquired and stored on a magnetic disc for transmission to the scanner system.

In view of the good results of the test, and notwithstanding the limited financial means, the Bavarian State Survey Office bought a Scanner-Chromagraph CTX 330 with an operating console and colour computer carriage. At present it is used for screening half-tone aerial photos and producing colour separations for four-colour offset-printing. In 1985, additional needed components of a complete cartographic system are to be purchased and installed for use in the scanner-aided revision of *Topographic Map 1:25,000*.

TECHNIQUES DE RÉVISION DE LA CARTE DE BASE*

Document présenté par la France

SUMMARY

The National Geographical Institute maintains a base map at scale 1:25,000, which comprises 2,016 sheets covering

RESUMEN

El Instituto Geográfico Nacional de Francia mantiene un mapa base a escala 1:25 000, que consta de 2 016 láminas que cubren el territorio de Francia. Se revisan según un ciclo promedio de nueve años.

El proceso de revisión requiere sucesivamente las operaciones siguientes: fotografía aérea a escala 1:30 000,

* The original text of this paper, prepared by Michel Michot, National Geographical Institute, appeared as document E/CONF 77/L 37. See also document E/CONF 77/L 31.

France's metropolitan territory Revision is done every nine years on an average.

The following successive operations are required: aerial photography at scale 1:30,000, topographic operations in the work station and in the field, and cartographic drawings.

The setting up of a topographic data base is currently being studied. Based on digital plotting of aerial photographic coverage at scale 1:30,000 and supplemented by field observations, it will enable any graphic material to be issued on demand, particularly the 1:25,000-scale map.

Revision of the base map of the two French Caribbean departments, Martinique and Guadeloupe and dependencies, is in progress.

operaciones topográficas de taller y luego sobre el terreno, dibujo cartográfico.

Las láminas más antiguas (levantamientos directos y primeros levantamientos fotogramétricos) no se revisan sino que se renuevan totalmente.

Se está estudiando una base de datos topográficos que, establecida a partir del trazado digital de la cobertura fotográfica aérea a escala 1:30.000 y de las labores finales sobre el terreno, permitirá entregar cualquier resultado gráfico cuando se solicite y en particular el mapa a escala 1:25.000.

Se está llevando a cabo la revisión del mapa base de los dos departamentos de Francia en el Caribe, a saber, Martinica y Guadalupe y dependencias.

L'Institut géographique national français (IGN) entretient pour son territoire métropolitain et pour certains de ses départements d'outre-mer (DOM) une carte de base au 1/25 000.

Il entretient également deux séries topographiques dérivées de la carte de base : une carte au 1/50 000 et une carte au 1/100 000.

Spécifications de la carte de base

Commencée dès le début du XXe siècle, la carte de base ne fut achevée qu'en 1980.

Obtenue par levés directs, elle était éditée au 1/20 000, en noir. Après la seconde guerre mondiale, les levés photogrammétriques avec complétement sur le terrain supplantèrent rapidement les levés directs. La carte fut éditée en trois puis quatre couleurs et, en 1956, apparut pour les besoins de l'OTAN une version au 1/25 000

En 1964, il fut décidé de ne conserver pour tous usages, civils et militaires, que l'échelle du 1/25 000.

Les spécifications de la carte, qui avaient été définies en 1922, montrèrent à la même époque de nombreux inconvénients :

a) Mauvaise adaptation au 1/25 000 de signes conventionnels prévus pour le 1/20 000;

b) Mauvaise adaptation de ces signes aux procédés modernes de rédaction (tracé sur couche, pelliculage) et à une révision fréquente dont la nécessité apparaissait alors;

Des études aboutirent aux spécifications modernes recherchées, qui furent celles de la carte de base au 1/25 000 type 1972.

Les principales caractéristiques en sont :

a) Adaptation quasi parfaite aux procédés modernes de rédaction;

b) Signes conventionnels du réseau routier adaptés à une révision facile;

c) Nombre restreint de signes ponctuels assorti d'un large usage de désignations et abréviations;

d) Représentation satisfaisante du relief montagneux par combinaison des courbes de niveau, d'un dessin structural du rocher et d'un estompage oblique.

Programmation de la révision

La France métropolitaine a une surface de 551 000 km^2. Elle est couverte par 2 016 feuilles au 1/25 000 de dimensions géographiques 0,20 x 0,20 grade soit 20 (nord-sud) x 14 km environ (est-ouest).

Le cycle moyen de révision est de 9 ans. En fait, selon l'importance économique et touristique de la zone couverte par une feuille, le cycle prévu varie de 5 à 15 ans.

Une unité spécialisée d'information cartographique entretient pour chaque feuille un dossier évolutif, grâce à une liaison permanente avec les services techniques et touristiques nationaux, régionaux et privés. Des valeurs pondérées données à tout renseignement permettent d'établir à partir d'un logiciel le programme de révision théorique pour une année donnée. Dans le cadre d'un comité d'utilisateurs, ce programme est modifié pour tenir compte de demandes de révision plus hâtives exprimées par le Ministère de la défense ou un service technique.

Chaque programme annuel de révision porte le millésime de l'année pendant laquelle sera effectuée une intervention sur le terrain (voir plus loin). Il est établi suffisamment à l'avance pour qu'une couverture photographique aérienne au 1/30 000 en noir et blanc soit effectuée l'année précédente sur les feuilles à réviser.

Phase topographique de la révision

Toute modification doit être traitée lors de la révision. Il est en effet prévu qu'une feuille de la carte de base au 1/25 000 se présente après révision telle qu'elle serait après une réfection complète, avec les mêmes qualités géométriques. Les conditions dans lesquelles s'effectue actuellement la révision permettent de satisfaire de très près à ces critères de qualité.

La *phase topographique* est fondée sur l'exploitation de la couverture photographique aérienne au 1/30 000.

L'*investigation* consiste à détecter par examen stéréoscopique les zones à reprendre entièrement et les détails isolés à supprimer, ajouter ou modifier.

La *restitution* (mise en place géométrique des éléments nouveaux) est assurée principalement sur appareil de 2e ordre (Planitop de Zeiss). Deux autres procédés sont également utilisés :

a) Superposition de la carte et de la photo aérienne redressée, facette par facette, dans un appareil de restitution simplifié dit révicarte (fabrication IGN). Ce procédé n'est applicable qu'en régions de faible relief;

b) Superposition de la carte et d'une orthophotographie. Ce procédé est surtout utilisé en zone de planimétrie dense ou fortement modifiée (remembrement rural). Dans les deux procédés, l'examen simultané d'une deuxième photographie permet la vision stéréoscopique de la photographie ou orthophotographie superposée à la carte.

L'*intervention sur le terrain* permet au topographe réviseur :

a) De consulter les services techniques et administratifs locaux;

b) De parcourir en voiture, plus localement à pied, la feuille à réviser. Il met en place les détails non visibles sur les photos aériennes ou postérieurs à celles-ci (à condition, dans ce dernier cas, que leur importance et leur future pérennité le justifient);

c) D'actualiser la toponymie

Pour une feuille au 1/25 000 (250 à 300 km^2), la phase topographique nécessite environ, sans l'encadrement :

a) 450 heures de travaux en atelier;

b) 3 ou 4 semaines d'intervention sur le terrain.

Phase cartographique de la révision

La phase cartographique de la révision utilise les procédés modernes de rédaction et reproduction :

— Tracé sur couche et pelliculage;

— Photogravure et copie sur plastique

La minute de révision utilisée par le topographe comporte la planimétrie ancienne en rouge. Les suppressions sont effectuées une seule fois, par ce topographe, qui ajoute ensuite en vert la planimétrie nouvelle. Une succession judicieuse d'insolations sous filtre vert et d'alourdis permet d'obtenir une couche gravée de la planimétrie ancienne à conserver. La planimétrie nouvelle est reportée sur cette couche par procédé diazoïque puis gravée manuellement.

Les trois autres planches-mères : orographie, hydrographie et végétation ne nécessitent généralement que des opérations cartographiques plus simples. Toutefois, environ 20 % des planches de végétation sont totalement refaites.

A l'occasion de la révision :

— Les feuilles rédigées antérieurement à 1972 sont rapprochées le plus possible des spécifications du *type 1972*;

— Le format de certaines feuilles est étendu afin de tenir compte du tracé des côtes et des frontières et de l'intérêt de situer sur une feuille unique des agglomérations ou sites touristiques importants;

— Les feuilles couvrant des régions touristiques reçoivent une surcharge touristique et sont alors éditées en 6 couleurs au lieu de 4

Pour une feuille au 1/25 000, la phase cartographique nécessite environ, sans l'encadrement, 720 heures de travaux de rédaction et laboratoire

Réfection totale : base de données topographiques

Environ 10 % des feuilles de chaque programme annuel de révision ne sont pas seulement révisées mais totalement réfectionnées. Il s'agit des feuilles issues des levés directs ou des premiers levés photogrammétriques. Lors de la restitution, l'altimétrie fait l'objet d'un enregistrement numérique qui permet entre autres, après correction, la sortie automatique de la planche orographie.

La constitution d'une base de données topographiques est en cours d'étude (voir E/CONF.77/L.31: communication de D. Piquet-Pellorte, de l'IGN). Cette base prévoit la restitution numérique complète altimétrie et planimétrie de la couverture photographique aérienne au 1/30 000 et un complétement sur le terrain plus étoffé, enregistré par poste interactif. Elle permettra toute sortie graphique à la demande, la sortie principale restant la carte de base au 1/25 000 sous une présentation vraisemblablement voisine de sa présentation classique actuelle, à laquelle sont habitués les utilisateurs. Il est prévu de sortir à partir de 1990 au moins 60 feuilles par an, soit 3 à 4 % du total.

Simultanément, et au moins jusqu'à la fin du siècle, la révision classique telle que décrite plus haut sera poursuivie pour les feuilles non programmées en restitution numérique avant plusieurs années.

Martinique, Guadeloupe, St-Pierre-et-Miquelon, Guyane

La carte de base des deux départements français de la Caraïbe — Martinique et Guadeloupe et dépendances — a été établie au 1/20 000 entre 1951 et 1957. Seule la carte de la Guadeloupe a été révisée en 1969, sans intervention sur le terrain.

La révision de la carte de la Martinique est en cours : la prise de vues aériennes a été effectuée en 1982 et l'intervention sur le terrain en 1983. Les feuilles révisées seront éditées prochainement (3e trimestre 1985), après réduction au 1/25 000 et reprise complète de la rédaction.

La révision de la carte de la Guadeloupe est également programmée. Après une prise de vues aériennes en 1984, l'intervention sur le terrain a lieu actuellement (janvier à mai 1985). Les feuilles révisées seront également réduites au 1/25 000 et reprises complètement en rédaction. Leur édition est prévue en 1987.

La révision de la carte de base au 1/20 000 de l'archipel français de St-Pierre-et-Miquelon, éditée en 1957, est envisagée pour 1987 ou 1988. La carte sera également réduite à l'échelle du 1/25 000.

La carte de base du département de la Guyane est établie au 1/50 000. Elle comporte 125 feuilles dont 59 sont actuellement éditées. La révision, dans les mêmes conditions techniques que pour le 1/25 000, n'a concerné actuellement que 5 feuilles dont 7 en cours.

BASE DE DONNÉES TOPOGRAPHIQUES*

Document présenté par la France

SUMMARY

The National Geographical Institute, with a view to modernizing its output after consultation with users, is studying the question of setting up a topographic data base. This will facilitate, for the purposes of revising the base map, the editing and updating of the 1:25,000 and 1:50,000 maps; it will also make possible the preparation of larger-scale graphic documents covering local communities, especially in connection with drawing up a topo-cadastral document. Some principles and conditions for carrying out this operation are briefly described and a short survey of ongoing research and experiments is given.

RESUMEN

El Instituto Geográfico Nacional, a fin de modernizar su producción, luego de consultar con los usuarios, está estudiando el establecimiento de una base de datos topográficos. Esta base de datos permitirá, de conformidad con la renovación de los mapas base, editar y luego actualizar más fácilmente el levantamiento de mapas a escala 1:25 000 y 1:50 000, por una parte, y, por la otra, elaborar documentos gráficos en escala más grande para la colectividad local y contribuir en especial a levantar un documento topográfico a nivel territorial. Se describen brevemente algunos principios y condiciones de ejecución y se consigna una breve reseña de las investigaciones y experimentos que se están llevando a cabo.

Une enquête auprès des usagers a fait apparaître au niveau des collectivités locales et des aménageurs un besoin de documents topographiques à plus grande échelle que la carte de base au 1/25 000 et la nécessité d'un document topo-foncier regroupant la figuration du parcellaire et des principaux éléments topographiques sans pour autant exiger une précision relevant des grandes échelles. En conjonction avec le désir de moderniser sa production, ceci a conduit l'Institut géographique national (IGN), dans le cadre de la réfection de la cartographie de base du territoire national, à entreprendre une étude pour la constitution d'une base de données topographiques.

L'accroissement de précision dû à l'enregistrement numérique, d'une part, les possibilités de dessin automatique liées à l'informatique, d'autre part, permettent de proposer une description topographique du territoire plus fine que la cartographie au 1/25 000 actuelle. Sans remettre en cause les échelles d'édition 1/25 000 et 1/50 000, ce sont des sorties graphiques à l'échelle du 1/10 000 (voire du 1/5 000) qui sont proposées et la possibilité pour toutes les administrations de disposer de données topographiques numériques dont la précision de localisation est de l'ordre de 1 à 2 m.

Description de la base

Les données seront issues d'un levé photogrammétrique numérique sur appareil de premier ordre, exploitant tous les détails topographiques d'une certaine pérennité et complété sur le terrain pour les zones couvertes, l'identification des détails et le relevé des données administratives et de toponymie.

Dans ces conditions, la résolution, la finesse d'identification et la précision des données contenues dans la base dépendent essentiellement de l'échelle de prise de vues, et c'est cette échelle qui sert de référence pour définir le contenu de la base.

Contenu

Dans les zones urbaines ou sensibles (5 à 10 % du territoire), l'échelle de prise de vues sera le 1/15 000 ou le 1/20 000 (à expérimenter) permettant une meilleure description du bâti et de la voirie (précision de localisation : 0,5 à 1 m).

Dans les zones rurales, l'échelle de prise de vues sera le 1/30 000 correspondant à la couverture nationale courante (précision de localisation : 1 à 2 m)

Organisation

L'organisation de la base permettra l'extraction des données par zone (définie par un polygone quelconque) avec des critères de sélection sur la nature et les caractéristiques des éléments topographiques

Réalisation

La phase d'études et d'expérimentation permettant de fixer exactement le contenu, de mettre au point les méthodes d'acquisition, de définir les structures informatiques et de développer les principaux outils d'utilisation de la base (mise à jour, extraction de données, cartographie numérique) devrait durer jusqu'en 1990.

La phase de première mise en production pour un volume réduit devrait commencer en 1986 pour atteindre un régime de croisière de 10 feuilles au 1/50 000 par an vers 1988-1990.

Après une phase d'accroissement progressif de la production, le rythme de croisière d'environ 40 feuilles au 1/50 000 par an devrait être atteint vers 1995.

Ceci conduit à la constitution complète de la base dans un délai d'un peu plus de 30 ans.

Relai avec la production actuelle

Le rythme de renouvellement de la carte de base qui est actuellement de neuf ans (130 feuilles au 1/50 000 par an dont 10 en réfection et 120 en révision) ne sera absolument pas modifié.

La constitution de la base se situe dans le cadre de la réfection de la carte et commencera donc par se substituer à la production classique de ce type de travaux.

Lorsque les capacités de production de la base excéderont 10 feuilles au 1/50 000 par an, la révision classique diminuera d'autant. Enfin, à partir de 1990-1995 se mettra en place une chaîne de révision de la base dont la production sera au prorata de l'étendue de la base.

* The original text of this paper, prepared by Daniel Piquet-Pellorce, National Geographical Institute, appeared as document E/CONF 77/L 31. See also document E/CONF 77/L 37.

ETAT DES RECHERCHES

Un premier essai portant sur 280 km² dans une zone rurale a été conduit : définition du contenu, mise au point d'une codification, étude méthodologique de saisie, restitution photogrammétrique numérique de prises de vues (1/30 000), dessin automatique des documents de terrain pour le complètement, analyse méthodologique pour le complètement sur le terrain et exécution. Les résultats sont encourageants et seront complétés par un essai sur 560 km² en zone urbaine et rurale avec plusieurs prises de vues 1/30 000, 1/20 000 et 1/14 500.

Parallèlement sont menées une réflexion approfondie sur la structure informatique des données ainsi que le développement d'outils informatiques tels que : poste interactif graphique de correction et de mise à jour, poste de restitution assistée, poste interactif graphique d'aide à l'édition numérique.

REVISION OF NATIONAL MAPPING SERIES: EXPERIENCE IN GREAT BRITAIN*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Au cours des 40 années qui se sont écoulées depuis la seconde guerre mondiale, de nombreux pays ont entrepris de vastes programmes systématiques de cartographie. L'auteur regrette quelque peu que, bien souvent, la tâche continue de révision et de conservation ne soit pas abordée avec le même enthousiasme et les mêmes moyens que l'entreprise initiale. Particulièrement à une période où les ressources se font rares, cela pourrait faire réfléchir les responsables de l'allocation de crédits, d'autant plus qu'inévitablement les cartes sont de plus en plus périmées et de moins en moins adaptées aux besoins. Il serait difficile de démontrer qu'il faut recommencer les programmes d'établissement de cartes. L'intérêt des utilisateurs risque également d'en souffrir.

Le manque d'importance accordé à la révision se reflète dans le nombre réduit d'ouvrages consacrés à la question. Les services topographiques et cartographiques ont tendance à s'intéresser surtout aux manuels et publications sur les techniques et les méthodologies d'établissement des cartes initiales et il y a donc peu d'ouvrages sur la révision.

RESUMEN

Durante los cuatro decenios transcurridos desde la Segunda Guerra Mundial, numerosas naciones han emprendido amplios programas sistemáticos de cartografía. El autor lamenta que en numerosos casos no se haya abordado la labor permanente de revisión y mantenimiento con igual entusiasmo y nivel de recursos que la labor inicial. Ello puede provocar, sobre todo en una época de recursos escasos, una actitud más reticente por parte de quienes asignan los recursos, ya que, inevitablemente, los mapas quedan cada vez más anticuados y son menos útiles para el logro de sus fines. Sería difícil abogar nuevamente por el establecimiento de programas cartográficos. También se vería afectado negativamente el interés de los usarios.

El poco hincapié que se ha hecho en la revisión queda demostrado por el escaso número de trabajos publicados sobre ese tema. Los profesionales que se ocupan de hacer levantamientos y elaborar mapas han tendido a concentrarse en la preparación de libros de texto y monografías sobre técnicas y metodologías para los trabajos iniciales de cartografía, lo que ha dado como consecuencia que se disponga de poco material en la esfera de la revisión.

The Ordnance Survey is responsible for almost a quarter of a million different maps of England, Scotland and Wales. Considerable experience of revision policies and techniques has been gained. The paper covers two themes. The first concerns current revision practice and the second attempts to draw out some threads of experience and lessons learned during the past 40 years.

MAP COVERAGE OF GREAT BRITAIN

Great Britain (England, Scotland and Wales) has been mapped at a very diverse range of scales. Each locality is mapped at one of three scales, known as "basic scales", that is, at the largest scale of mapping for that locality:

(a) *1:1,250 scale* (¼ km² units). This scale is used for the major urban areas. It is a monochrome series without contours but has spot heights and bench-mark information. There are 53,315 maps in the series;

(b) *1:2,500 scale* (1 km² units). This scale depicts other urban and developed areas including all cultivated land. The series is monochrome without contours as above. There are 157,987 maps in the series;

(c) *1:10,000 scale* (25 km² units). This scale is employed for mountain and undeveloped areas. The sheets are in two colours and are contoured. In all there are 4,205 sheets in the series.

Map detail at the first two scales is in its correct plan position to plottable accuracy and no generalization is introduced.

All areas depicted at 1:1,250 and 1:2,500 are also covered by a 1:10,000 scale derived map series which is both generalized and contoured. Revision of this series (some 6,000 maps in total) inevitably lags behind the revision of the basic scale components. The next scale of national coverage is at 1:25,000 which is a multicoloured map, again derived from the basic scales. The next smaller scale is at 1:50,000 with some 204 sheets comprising national cover. For these, a separate revision procedure is adopted, although some material is derived from relevant large-scale mapping.

The scale of mapping is not final and unchanging. In areas where major topographic development takes place, new mapping at the next larger basic scale is produced by

* The original text of this paper, prepared by Peter W. Wesley, Ordnance Survey of Great Britain, appeared as document E/CONF 77/L.27

a resurvey. This then becomes the basic scale for that locality.

The body of basic scale mapping managed by The Ordnance Survey is known as the National Mapping Archive. The mapping is produced to a complex specification to meet a wide spectrum of user needs. The specification and content are kept under continuous review by The Ordnance Survey and its several user consultative committees. It is to this very valuable archive of mapping that the present paper relates.

Evolution of Ordnance Survey revision policy and practice

Extensive large-scale map coverage, principally at 1:2,500 scale, has existed in Great Britain since 1896. Systematic revision on a cyclic pattern began in 1891, being eventually completed in 1914. The second cycle commenced in 1904 but this was never completed. During these early experiences, materials and techniques evolved quite rapidly as increasing thought was applied to the revision task.

The concept of cyclic revision can be seen in retrospect to have failed quite seriously. The Governments of that era were both able to, and chose to, withdraw the resources essential to perform the sequential cycles of revision, thus forcing The Ordnance Survey to extend or omit a cycle, in turn leaving more and more revision work to accumulate for future survey. Cyclic revision was inflexible and could take no real account of differential rates of change. This led to "out of turn" requests for revision which served only to postpone scheduled revisions, and thus large blocks of maps fell more and more out of date. The only advantage of the cyclic concept was the facility it afforded for systematic derived mapping but this was much outweighed by the ease with which programmes were postponed or abandoned.

From 1914 the mapping became increasingly out of date, consequently failing to meet user needs. In 1935 Government established a committee of enquiry into The Survey which became known as the Davidson Committee. Its major conclusion was:

> "There is no question that what is required by government authorities, and by the public, is a map which represents the relevant facts as they are on the day when the map is required for use. The governing factor is not therefore the age of the map but the extent to which the facts shown on it have changed since the date of its publication. . . .
>
> "It is therefore apparent that the only practical system which will fulfil the requirements of the users of large scale plans is one which has for its object the recording on the map of topographical changes as soon as possible after they have taken place on the ground."

Follow-up action to the Davidson Committee recommendations by The Ordnance Survey led to the scales of mapping outlined above. The basic scales were designed to support conveyancing and local and central Government requirements. Continuous revision was felt to be the only means of meeting the revision objective above. The production of systematic mapping is both expensive and time-consuming. Mapping represents a "snapshot" taken at the time of its production. Without a disciplined revision strategy, as topographic and cultural change takes place, this valuable national asset will deteriorate. Its restoration will be more expensive and possibly politically less acceptable than ongoing revision and maintenance.

Through a series of developments between 1948 and 1980 The Ordnance Survey has evolved an integrated revision policy. The Government of the United Kingdom has initiated several reviews of The Survey's national mapping and revision procedures in the half century since the Davidson Committee. The most recent review (OSRC 1979) accepted the Davidson dictum but felt that there was a clear need to interpret the meaning of "as soon as possible". The review concluded:

> "A major responsibility for Ordnance Survey, as the national mapping agency, must be to ensure the maintenance over time of the national geodetic and topographic survey. It follows that Ordnance Survey must seek to give proper weight to what may be termed the archival and contingent requirements of the nation, and that more immediate user needs (even though financially rewarding) do not necessarily have overriding priority."

Modern policy for revision of basic scales mapping

The Ordnance Survey, as the national survey, can avoid duplication of effort and other wastage of precious resources only if it aims to meet user needs for up-to-date mapping in Great Britain. The very largeness of map scales, with their implicit minuteness of detail, means that they are much more liable to change than small-scale maps. The latter deal only with leading features which are themselves less easily and frequently disturbed.

Ordnance Survey modern policy for the revision of basic scales mapping (1:1,250, 1:2,500 and 1:10,000 scales) is stated thus:

> "Topographic change will be surveyed and recorded on basic scales mapping as soon as possible after it has taken place on the ground. In formulating the programme for revision due account will be taken of user needs, economy and efficiency of survey, availability of resources and the Department's longer term responsibilities for the maintenance of the content and accuracy of the national archive of survey information. To this end topographic change is separated into Primary and Secondary categories, and its survey is undertaken either by Continuous Revision (CR) or Periodic Revision (PR)."

Primary change is that which is of the first importance in maintaining the currency of the archive. For such change wider user interest and reliable knowledge about its occurrence can be assumed.

Secondary change is all other topographic change, which is nevertheless important to the survey in maintaining the long term integrity of the archive. Such change may attract less immediate user interest and it is unlikely that reliable intelligence of the change can be collected.

Continuous revision is the survey of primary change which can be undertaken as an economic survey task on its own, together with such secondary change that is economic to survey at the same time.

Periodic revision is the survey of all other change which by virtue of being scattered, or in some other way uneconomic to survey on its own, can be left until the mapping of an area as a whole can be surveyed to bring it up to full specification.

The overall survey of primary and secondary change and the integrated policy of continuous and periodic revision thus constitutes the maintenance over time of the national topographic survey archive.

Modern operation of the revision system

Having firmly adopted the concept of continuous revision, the Ordnance Survey's post-war mapping programme rapidly expanded. Concurrent with this programme, an ever increasing proportion of total resources available had to be dedicated to revision. Highly mobile map makers were formed into resident revision teams as extensive areas were mapped. This eventually led to a national network of some 200 offices, a number which has only recently been reduced in a modern rationalization. The field offices are managed by a hierarchical structure based on a handful of region offices.

To manage successfully continuous revision, an information system of intelligence (information about topographic and cultural change) is essential. The Survey has evolved a rigorous system of collecting and managing data derived from local government development planning consents and building control procedures. An information system is essential both to allocate national resources and to schedule revision on a daily basis.

The Survey's basic scale archive is essentially a graphic survey. Stable based copies (Master Survey Drawings (MSDs)) of the last published edition of each map are held in local field offices. Revision is compiled by simple graphic techniques using alignments, intersected alignments and short taped distances, which are plotted directly in ink onto the MSD by the revision surveyor. Previously surveyed detail serves as control for revision in all but extensive areas of revision where instrumental or photogrammetrically derived control is employed. These techniques have led in the past to the need for rigorous quality control until surveyors have become very experienced.

The continuous revision practice enables the Survey to market facsimile copies of its stable based revision MSDs. This service has in turn enabled the Survey to postpone the fair drawing and printing of its revised maps until they are significantly altered by change or have become physically damaged. Clearly, if large-scale revision information is surveyed soon after change occurs on the ground, then it is inappropriate to delay publication in some form or other. Two revision services are offered: one via field offices where yesterday's survey is available and a periodic revision service (based on microfilms), through a network of commercial agents.

The complexity and value of the revision task has led to the development of a Computer Management Information system based on a work-recording system for some 800 survey staff involved. Revision work currently costs about £30 million per annum.

A computer model to predict patterns and trends in topographic change is being developed. This will assist the Survey to plan and manage the task.

Lessons from revision experience

Revision must be tailored to local circumstances

Just as map scales, coverage, content and specification are the result of cultural, political, geographical, historical and socio-economic influences, so must any revision strategy be constrained by or have to be developed to reflect these same influences. This is a major argument for tailoring revision arrangements to a particular nation's needs. Revision strategies require more thought than the original mapping programme if only because they must endure longer.

National resources

It is likely to be more difficult to convince government resource managers of the need to invest resources in the surveying and mapping sector on a continuing basis for revision after the initial mapping programme has been completed. This may be made even more difficult when the initial mapping has been achieved, with minimal commitment of domestic resources, by aid donors or through joint programmes.

The penalty for neglect of revision of national mapping series accrues quite rapidly. User needs become progressively less well served, and eventually the mapping agency may be discredited as the mapping fails to meet its purposes.

Methods for revision

If the revision task is left to accumulate to serious proportions eventually necessitating resurvey, the use of more simple revision survey techniques may be precluded. The Survey's experience with piecemeal continuous revision has led to the development of very cost-effective "low technology" methods for revision, based largely on technician surveyors' well-developed topographic skills but with minimal instrumentation. The lesson here is that if revision is tackled in a timely and continuous fashion, expensive high technology solutions are not necessary. Topographic change (the cause of revision) is generally piecemeal in location and occurrence, and such change can be efficiently controlled by, or tied in to, existing original detail already on the map. Scarcer instrumental or photogrammetric resources can thus be reserved for larger areas of topographic change which are not economically supplied by these simpler techniques.

Stability of staff

The adoption of the method of continuous revision, with its implicit stability, has enabled the Survey, even in these troubled economic times, to retain a reasonably consistent level of resources. The commitment of resources has to be reasonably constant. This has led to a remarkable degree of domestic stability for staff, which in turn has led to lower overall costs and increased staff contentment in a profession which is normally seen as itinerant. A further benefit has been that staff have tended to identify with a locality and thus develop better user liaison, better intelligence about topographic change and greater job satisfaction, which has manifested itself, in turn, in good morale.

Publication of revision

The revision method employed must be related to the more important uses to which the map series are to be put. The Ordnance Survey's basic scale maps serve many uses but the three most prominent are:

(*a*) to support and service the business of conveyancing and registration of title to landed property;

(*b*) to plan and record physical planning and development control within the wider responsibility of local government and administration;

(*c*) to enable the national utilities to plan and record their services for gas, water, electricity and telecommunications.

The continuous revision method avoids large accumulations of unsurveyed change. It also leads to ready access by users of up-to-date topographic information. Change is not only surveyed soon after it occurs but is made available to users. The Survey, in its continuous revision methodology, has moved away from periodic fair drawing and litho-

printing of revised map editions adopted in the past. Now facsimile copies of surveyors' working documents are available quite literally one day after survey is completed in the field. The former service is supplied from the 150 local Survey offices and is a further benefit of the stability arising from continuous revision. It is a prompt and up-to-date service much appreciated by users. The mapping is always kept within touch of the situation on the ground and hence the national mapping authority has been able to meet unusual developments without undue stress, e.g. the oilfield support developments in Scotland, the extension of title registration in rural areas etc.

Special customers for mapping and revision information can have a major influence on the revision strategy adopted. Her Majesty's Land Registry (HMLR) in the United Kingdom is a good example of this effect. Such influence may bring benefits but may also serve as a constraint on programmes, resources etc.

Degradation

There is a need to plan the revision strategy with considerable care to minimize the inevitable degradation that revision can cause. The Ordnance Survey has adopted a succession of techniques and materials as technology has evolved with time. Certain features have been retained and major considerations throughout have been:

(*a*) to use stable materials that minimize distortions;

(*b*) to avoid at all costs the successive redrawing of map information that is not subject to change;

(*c*) to maintain rigorous quality assurance on revision.

The need for economy in continuous revision

The Survey has switched from a pre-1939 policy of cyclic revision, which had failed quite badly, to the present strategy of a combination of continuous revision and periodic revision as described in an earlier part of the paper. Continuous revision, however, has its dangers. It is easy to be idealistic in pursuit of perfection. The Survey has learnt to impose the discipline of "economic working" on its revision operation. For economic survey a sufficient amount of revision work must exist in one location to justify the positioning costs of the surveyor. Where it is not economic to undertake continuous revision, then the "safety net" of periodic revision eventually comes into play to ensure that all maps are brought up to date to full current specification periodically.

Intelligence system

Resources cannot be mobilized for revision without reliable knowledge of the location and nature of changes to the map, so a system for acquiring this information is essential. This aspect is, of necessity, taken very seriously by the Survey, and effort is dedicated to it in each Survey office. All planning and development proposals are monitored and a project to develop a computer model of topographic change as a strategic planning tool is in hand. Without good intelligence, resources cannot be applied to the task with any degree of precision. User needs will not be met unless an intelligence system is created and maintained.

Longer-term view needed

Countries which have embarked on long-term mapping programmes should budget for and plan to initiate revision well before the mapping is completed. Resources, once secured, should be balanced between mapping and revision, with the ratio changing from mapping to revision as the programme develops.

REVISION: A LOOK AHEAD

The most significant aspect of the future concerns the major project upon which the Survey is embarked to convert to and store all the maps in the archive as digital data. Essential to this project is the development of digital field revision methods. This is bringing with it major technological and management problems. The digital revision system will enable either graphics to be produced on automatic plotters or digital data to be supplied to those users seeking such data. It is planned that as a minimum the quick response of the current revision strategy will be matched but the variety of presentations will be even greater.

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AUTOMATION OF THE DEFENSE MAPPING AGENCY'S BROADCAST WARNINGS: A SIGNIFICANT MILESTONE IN MARINE COMMUNICATIONS

*Paper submitted by the United States of America**

RÉSUMÉ

Le présent document donne un aperçu du sous-système des avis radiodiffusés du Système automatisé d'avis aux navigateurs (ANMS). Une fois l'avis diffusé, le texte du message est mis en mémoire dans l'ordinateur de l'ANMS en vue de sa publication ultérieure dans la section 3 du

RESUMEN

En esta monografía se presenta una reseña del subsistema de alertas radiodifundidas del Sistema de Aviso Automatizado a la Gente de Mar. Una vez que se transmiten las alertas radiodifundidas, el texto de cada mensaje se incorpora en la computadora del sistema para imprimirse posteriormente en la sección 3 de la publicación semanal *Notice to Mariners*. Además del control de la manipulación y la impresión de mensajes, la computadora permite a los buques en alta mar y a los usuarios a distancia consultar en la base de datos el texto de los mensajes de alerta radiodifundidos

* The original text of this paper, prepared by Maurice Harding and Morris F. Glenn, Defense Mapping Agency, appeared as document E/CONF.77/L.17. Use of trade names and trade marks is for identification purposes only and does not imply endorsement by the Government of the United States.

bulletin hebdomadaire *Notice to Mariners*. En plus des possibilités de traitement et d'impression des messages, l'ordinateur permet aux navires en mer et à d'autres utilisateurs éloignés d'interroger à distance la base de données pour obtenir le texte des avis diffusés par la Defense Mapping Agency. Il s'agit là d'un progrès important vers l'automatisation du Service mondial d'avertissements de navigation.

del Organismo de Cartografía de la Defensa. Esta automatización es un importante avance en todo esfuerzo futuro para automatizar el Servicio Mundial de Alertas a la Navegación.

The Defense Mapping Agency (DMA) has had an important role in the broadcast of "Navigational Warnings to Mariners" since 1908. That year the parent organization, the United States Navy Hydrographic Office, began issuance of hydrographic warnings three times daily from eight stations on the Atlantic Coast and seven stations on the Pacific Coast (one of these being in Alaska). This system was amended over the years and today the United States participates in the Worldwide Navigational Warning Service (WWNWS). It is not the purpose of the present paper to discuss the WWNWS, but to describe the in-house automation of DMA's broadcast warnings in support of WWNWS goals. The automation of DMA's message handling, printing and global query capability is an important advancement in the field of marine communications for any co-operative global automation of WWNWS. Two recent papers provide an excellent overview of WWNWS and DMA's role in that service; namely:

(*a*) "The Worldwide Navigational Warning Service" by J. E. Ayres and J. P. Lyall, presented at the International Symposium on Ship Operations in New York City in November of 1981;

(*b*) "The Broadcasting of Navigational Warnings on the High Seas" by Mitchell Kalloch, presented at the Technological Interchange Week sponsored by the DMA Inter-American Geodetic Survey from May 14-19, 1979.

Reference to these documents will answer all questions concerning the international considerations of DMA's participation in the WWNWS service, the history of our Broadcast Warnings programme and the specific details of the entire manual procedure which DMA has since automated.

Overview of DMA's broadcast warning system

The United States Navigational warning broadcasts consist of radio transmissions in the forms of NAVAREA IV, NAVAREA XII, HYDROLANT and HYDROPAC: these are broadcast to all ships without regard to nationality or purpose. The other 14 NAVAREA of the world are handled generally by other nations with extensive communication facilities.

The NAVAREA IV broadcast covers the waters contiguous to North America from the Atlantic coast eastward to longitude 35°W and between latitudes 7°N and 67°N. The NAVAREA XII broadcast covers from the Pacific coast westward to about 180° and the ocean area between latitude 67°N and the equator. The HYDROLANT broadcast covers those water areas outside and eastward of the NAVAREA IV area; and the HYDROPAC broadcast covers those water areas outside and westward of the NAVAREA XII area.

All messages are consecutively numbered annually commencing 1 January and remain in force until cancelled. These warnings, which are normally broadcast on the next two schedules after receipt by the transmitting station, contain information considered vital to safe navigation.

Broadcast particulars, including schedules, are listed in Radio Navigational Aids, Pubs. 117A and 117B, and are corrected in the weekly *Notice to Mariners*. Separate numerical lists of each series of messages issued during the past six weeks (and still in force) are broadcast every Wednesday.

Copies of NAVAREA IV and HYDROLANT messages are printed in the Atlantic edition of the *Daily Memorandum* while copies of NAVAREA XII and HYDROPAC messages are printed in the Pacific edition of the *Daily Memorandum*. The *Daily Memorandum* makes available to the mariner and hydrographic organizations each working day copies of the previous day's messages. It is designed to fill the time gap between the radio broadcast and the receipt of the weekly *Notice to Mariners*.

The following are some examples of subject matter contained in warnings issued by the Defense Mapping Agency Hydrographic/Topographic Center;

(*a*) Casualties to major and outlying aids to navigation; for example, primary lights, lightships, large navigational buoys (LANBY's), approach or sea buoys etc. Local broadcasts should be monitored for information concerning inshore, harbour, and inland waterway aids that may not affect offshore navigation;

(*b*) Establishment of new aids that could affect the safety of offshore navigation or alterations of an established aid, where the change might be confusing;

(*c*) Floating dangers, such as drifting mines in or near sea lanes or large derelicts adrift on the high seas. Following the end of the "Ice Season", all reports of ice below 50° North Latitude which endanger the North Atlantic Shipping Lanes are broadcast. Trees, timbers, or drifting buoys do not normally constitute a danger for ocean-going ships and are not broadcast on the long-range systems, but are promulgated on short-range or local broadcasts;

(*d*) New or amended shoal depths or changes in hydrography;

(*e*) Dangerous wrecks, obstructions, etc;

(*f*) Marine, air or submarine disasters and searches for survivors. This type of information is normally broadcast over the long-range navigational warning system, as well as the local broadcast in order to achieve the widest possible dissemination. Reports of overdue ships and aircraft are also normally broadcast;

(*g*) Selected exercises and hazardous operations conducted by units of the armed forces. More specifically, exercises or operations employing the use of flares, searchlights or pyrotechnics that may be mistaken for distress signals; night firing exercises; darkened ship exercises; submarine exercises, missile launches; space missions; and nuclear tests are normally broadcast. Such warnings are purely

cautionary and are not intended to obstruct the right of innocent passage upon the high seas;

(*h*) Unexploded ordnance at depths of less than 100 fathoms is broadcast, when it constitutes a definite danger to shipping.

(*i*) Mobile drilling rig operations at sea. Such rigs may be encountered in operation or in transit anywhere in the world. The on-site drilling location and transit through established sea lanes is broadcast if known. Also, vessels engaged in seismic operations often detonate explosives and tow extremely long cables;

(*j*) Malfunctions, scheduled off-air time for maintenance, and other information concerning electronic aids to navigation including: marine radiobeacons (marker radiobeacons are not broadcast), LORAN-A, LORAN-C, Navy Navigation Satellite System and OMEGA;

(*k*) The presence of large unwieldy tows in congested waters;

(*l*) Notification of special changes or events. For example, alteration or suspension of mandatory traffic separation schemes or activation of a new buoyage system.

Section III of the weekly *Notice to Mariners* includes the text of each message issued during the week, except those cancelled prior to publication. A quarterly summary of all the effective broadcast warnings is included in Section III of *Notice to Mariners*, numbers 13, 26, 39, and 52.

The Automated Notice to Mariners System

There are several published articles that will provide readers with details concerning the Automated Notice to Mariners System (ANMS) hardware specifications and the capabilities of the initial chart Corrections Subsystem. In particular, refer to a paper by Morris F. Glenn presented at the 12th International Hydrographic Symposium, held at Monaco in April 1982, entitled "Chart corrections via global communications". This paper and several others are reprinted in a DMA/HTC Navigation Department pamphlet entitled "Automated Notice to Mariners System" dated 5 March 1982 (available from DMA upon application).

The present ANMS hardware is a combination of three commercially available systems: Prime 400 computer and peripherals; Imlac PDS-4 intelligent terminals and peripherals; and a Photon Pacesetter Mark III typesetting machine. The intelligent terminals provide the man/machine interface to load the broadcast warnings data into the ANMS computer controlled and managed files. Intelligent terminals were utilized because they were already a part of the ANMS chart corrections system. Also, they provide a capability to plot a hard copy of the information shown on the screen display, and a simplified data entry procedure which could be aided by preprogrammed computer function keys. The Prime computer is the heart of the ANMS and manages all data files, data processing and data communications (see figure 76). It also creates the print tape in a special format to drive a Photon typesetter. The resultant hard copy can be easily formatted into sequential pages which are camera-ready for making press plates. Once the data base is built or corrected via an Imlac terminal, the computer can generate an extract of broadcast warning information within minutes, and the contents will be completely up-to-date. The three hardware units are combined to form a powerful publications management system collectively called the ANMS.

Although the hardware is important, one might say the real heart of the ANMS is the specially developed applications software. The Chart Corrections Subsystem software took over four years to develop and it consists of about 45 individual programs. They operate under the Prime system software, PRIMOS, and are written in COBOL. The intelligent terminal is connected to the Prime computer via a 9600 baud line and is in continuous communication with the ANMS data files which are stored on the Prime disk units.

The Broadcast Warning Subsystem was the second software system to be installed on the ANMS. The first *Daily Memorandum* produced by the Navigation Department completely on the ANMS computer was No. 20 of 1 February 1982. The Broadcast Warning Subsystem shares the overall design concept of the Chart Corrections Subsystem (i.e., data is loaded to Prime disk files via the Imlac terminal as a print tape is created by the computer to drive the Photon typesetter). In addition, the data base containing all active Broadcast Warnings is maintained by the Prime System and query software allows access over global communications links in the same manner as chart corrections.

The Prime computer now supports up to 64 interactive time-shared users. However, as the number of on-line users increases, the response time for all users will decrease. Another major system consideration in view of the importance of meeting extremely strict departmental production schedules, is to ensure the existence of some reasonable back-up capability. There are many important reasons to maximize response time, e.g., remote users may be paying long distance communications rates for their connect time, and data entry personnel need rapid response time to utilize effectively the Imlac terminals. The most important system planning consideration is to provide a back-up production capability for vital DMA publications and ANMS master data files.

The solution to the overall system problem of improving response time, providing production back-up, and back-up for on-line files, is to network the present ANMS CPU with a second CPU (this item is in the DMA 1984 equipment procurement programme). This final hardware acquisition, which is planned to complete the ANMS hardware configuration, will provide two CPU's operating in a computer network to share on-line data files, split the processing workload, and essentially provide a complete back-up capability for all system hardware, files and software. In addition to copies of all master files resident on a separate disk device, this configuration will make it immaterial which disk contains the master file; a benefit of a networked system. If one CPU becomes inoperative, the second CPU can be used to complete the query or data processing task. Even if the on-line disk is disabled, the task can be easily completed by use of back-up files.

Currently, the ANMS automation plan assumes a two processor environment that will allocate the data processing tasks as follows: the present CPU will handle routine production input/output, manage on-line Chart Corrections, support Broadcast Warnings and List of Lights weekly work-files, and automatically schedule ancillary tasks to support production; the second CPU will handle remote data base queries that can be generated from anywhere on the globe on a 24-hour basis. The second CPU will also handle all batch processing necessary to produce:

(*a*) Annual volumes of *Lists of Lights*;

(*b*) Periodic summary of *Corrections* volumes;

(*c*) Daily back-up of work files;

(*d*) Periodic back-up of master files;

(*e*) New navigation publications which are planned for addition to ANMS;

(*f*) Future projects, such as processing graphics.

The increased computer capability is not considered an optional feature when so many important and highly time oriented publications are involved. Banks, airlines and other business establishments have pioneered the redundancy concept of computer operations and this capability is now offered by most modern computer manufacturers. Also, by use of widespread international standards such as the CCITT X.25 which supports computer to computer or computer to terminal communications via packet switching software, computers marketed by many vendors may be connected into a single computer network. This is an important design concept when one considers the global nature and impact of the Chart Corrections, Broadcast Warnings and List of Lights data.

In addition to a world-wide geographic distribution of users, DMA has numerous co-operative agreements with United States agencies and foreign Governments for the exchange of hydrographic data. Without such exchanges, DMA would be unable to produce its navigational publications in a timely, accurate and comprehensive manner. Conceptually, the new hardware configuration of the ANMS advances the time when computers will perform a major role in the exchange and dissemination of international hydrographic information.

Broadcast warning automation plan

All ANMS automation has included the capability to utilize new digital techniques and incorporate United States Navy communications systems into our query links as they become available. Future ANMS goals involve interfacing the system with all new global communications systems, new international hydrographic reporting methods which may be developed (between national hydrographic offices and major shipping companies), and international programmes to automate the WWNWS.

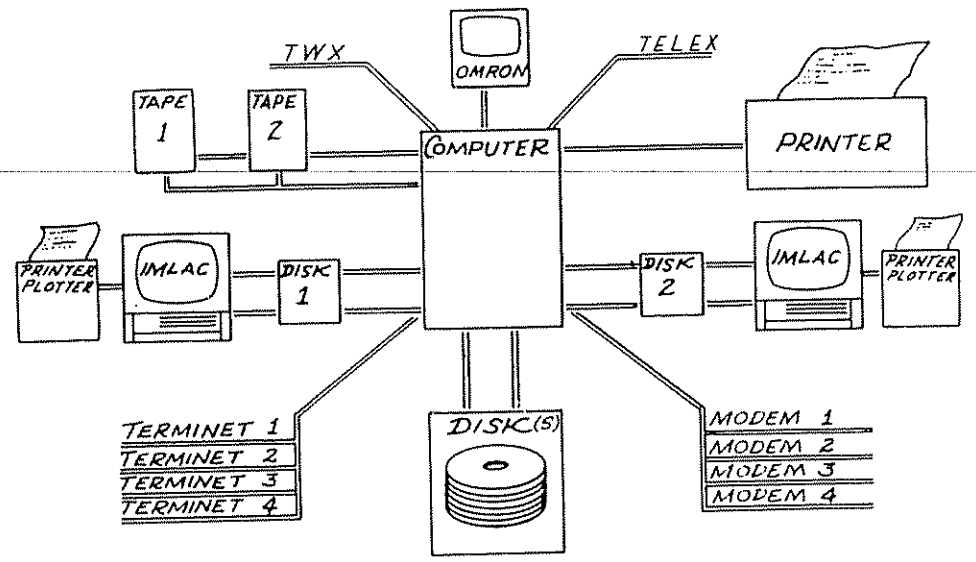
The Broadcast Warning Subsystem was essentially modeled after the original Chart Corrections Subsystem of the ANMS. As noted earlier, the nature of the initial software effort was research and development, because there were no other comparable systems available that DMA could use to develop specific designs. In addition to the existing Chart Corrections Subsystem software, all ANMS start-up hardware was already installed and its operational capability was well established and clearly demonstrated. Thus, the design constraints around which the Broadcast Warning Subsystems were developed, compared to most other software efforts, were exceedingly specific. Fortunately, the need for a phased development plan which allowed the addition of other publications to the system was anticipated during the original ANMS system design. So, all hardware and software specifications were written accordingly. Since chart correction data were only the first of several data sets to be automated on the ANMS, use of the software to allow input of data for other publications was an important stepping stone in ANMS development. Even though the particular specifications of the input were subject to change, the operational parameters required to load the other publications were presumed to remain the same.

General description of the Automated Broadcast Warning Subsystem

The Broadcast Warning Software has been divided into five separate areas for discussion purposes in this paper: Data Entry, Daily Memo, Weekly/Quarterly Print, Queries and Reports, and Maintenance Utilities. The Broadcast Warning Subsystem is referred to as BW in this text for purposes of brevity.

The flow charts, figure 76(*a*)-(*e*), provide the best overview of the Automated Broadcast Warning Subsystem.

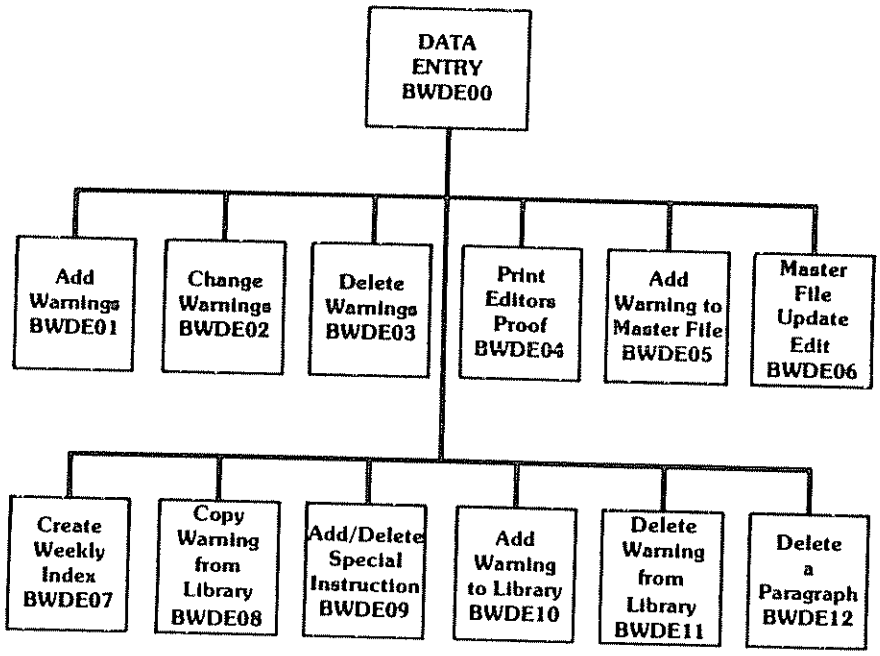
Figure 76. United States of America: Functional diagram of Automated *Notice to Mariners* System



NOTE: Broadcast warnings data are loaded via one of the two IMLAC terminals. All data are stored on disk files under the control of the Prime 400 computer. A magnetic tape is output to drive a typesetting machine for printing the Daily Memo and Weekly/Quarterly notice. Proof plots are output on two printer/plotters attached to the IMLAC data input stations or on a high-speed line printer controlled by the computer. TWX, Telex and a variety of modems allow remote access to the master data file.

Figure 76 (*continued*)

(a) *Flow chart for data entry*



(b) *Flow chart for Daily Memo*

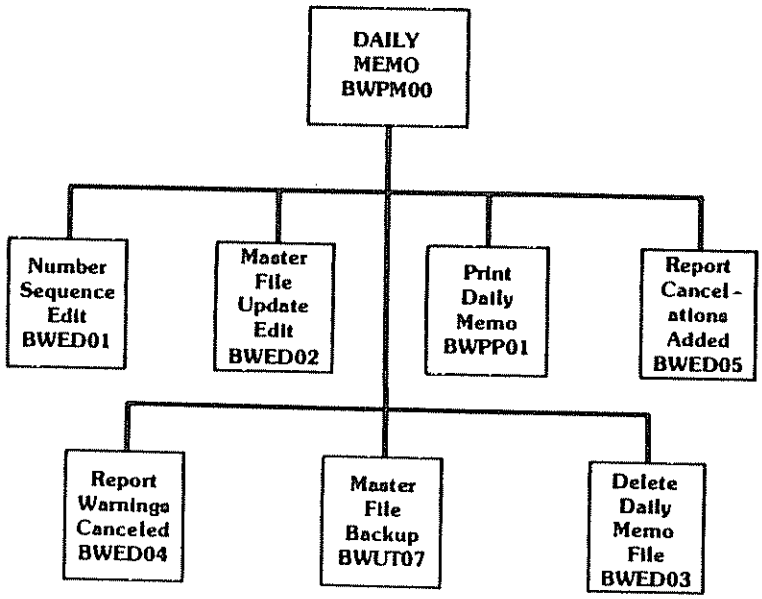
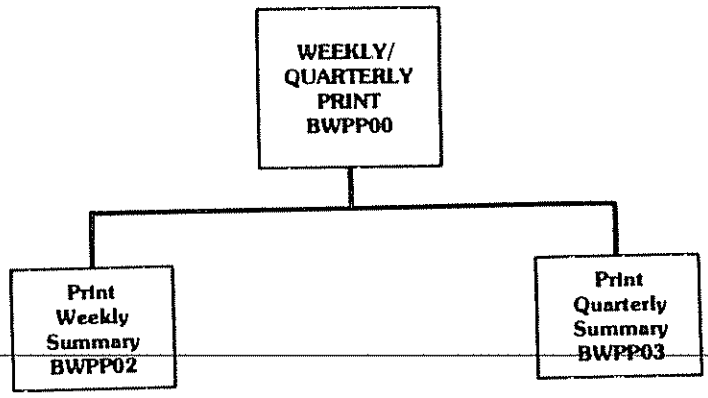


Figure 76 (*continued*)

(c) *Flow chart for Weekly/Quarterly print*



(d) *Flow chart for Queries and Reports*

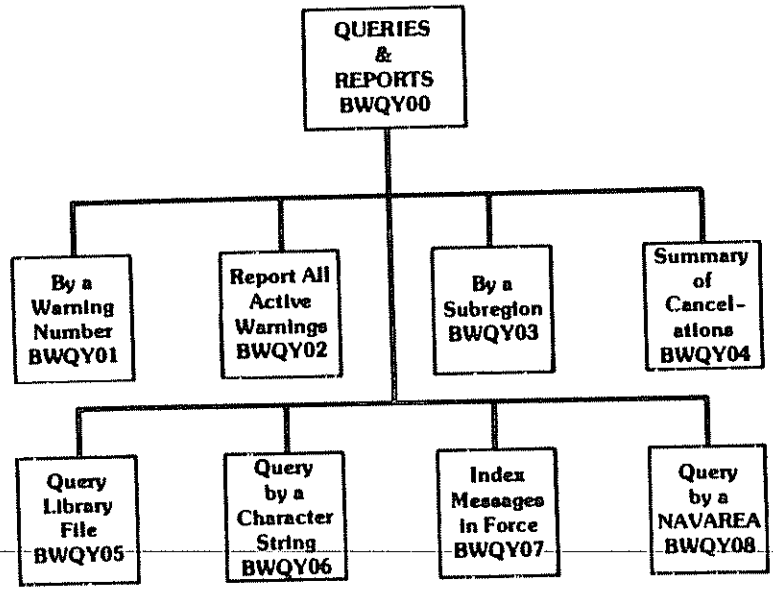
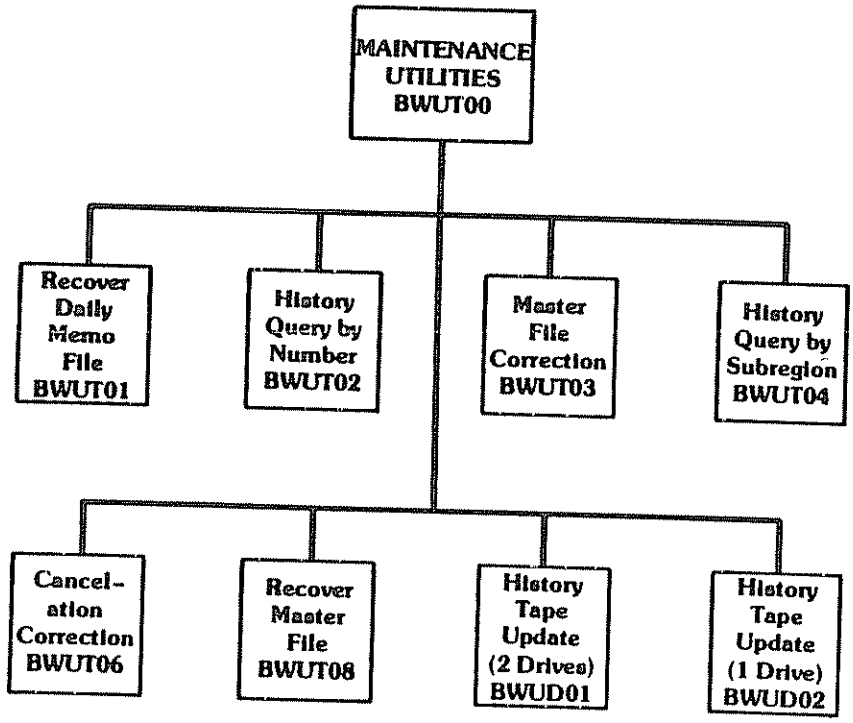


Figure 76 (*continued*)

(e) *Flow chart for maintenance utilities*



To prepare the reader to understand better the software as shown in three detailed diagrams, we should identify the terminology used in the flow charts as follows:

(*a*) The six character program identification numbers are coded with:

Character 1 and 2 = System ID (always BW)
Character 3 and 4 = Program Function
DE = Data Entry
UD = Update
PP = Photon Print
ED = Edit
QY = Query
UT = Utility
Character 5 and 6 = Unique Program Indicator
00 = Menu or calling program
01-99 = Assigned program number

As noted earlier, the Broadcast Warning Subsystem is comprised of five functional areas (runfiles). This arrangement aids future expansion or enhancement of the subsystems. They are:

1. #BWENTRY: Data entry;
2. #BWMEMO: Daily Memo print run;
3. #BWPRT: Weekly/Quarterly print runs;
4. #BWQRY: File queries and reports;
5. #BWUTIL: Systems maintenance utilities.

After a user has successfully logged onto the ANMS in-house production system for Broadcast Warnings, any of the five modules and the applications programs may be invoked.

Data entry (figure 76(*a*))

When the user selects DATA ENTRY, a segmented runfile (#BWENTRY) is generated which includes the applications programs and the required system libraries to load messages onto the computer. The reader should now refer to the flow diagram in figure 76(*a*) which lists all the included application programs that may be used (12 programs are shown in the figure). Functionally the purpose of each program is as follows:

(*a*) Add Warning. Program allows computer entry and an on-line edit of the DMA's Broadcast Message text from the hard copy (taken directly from message form). This entry creates the Daily Memo and Cancellation files;

(*b*) Correct Warnings. Program allows computer operator to correct data previously entered on Daily Memo file;

(*c*) Delete Warning. Program will delete an entire warning on the Daily Memo file. If the Master file has been updated, the message will also be deleted from the update;

(*d*) Warning Proof copy. Program will generate proof copy of message data as entered;

(*e*) Master File Update. Program allows the operator to add new Warnings to Master file (or cancel a message);

(*f*) Master File edit. File will output an Edit List of any warnings that date prior to the last warning and any skipped numbers on the Daily Memo file;

(*g*) Weekly Summary. Creates the Weekly Summary of Messages that are in force;

(*h*) Other programs. Several other programs, mainly of interest to DMA operators, will not be discussed in this general presentation.

Daily Memo print runs (figure 76(*b*))

A segmented runfile is generated that includes the applications programs and the required system libraries comprising the Daily Memo print module. The figure shows the software to accomplish the Daily Memo printing run processing.

Weekly/Quarterly print run (figure 76(*c*))

Another segmented runfile is generated that includes the application programs and required system libraries comprising the Weekly/Quarterly print module. A photo tape is written to produce the typeset output of these publications.

Queries and reports (figure 76(*d*))

In-house operator queries may be made to the master file as follows:

(*a*) By warning number (if the message has been cancelled but still on system, the system will output to the user the time and date of cancellation and provide a reference check of the message that cancelled it);

(*b*) For all active warnings (user can get active warnings for all subregions or for one subregion);

(*c*) By subregion (numbers of these subregions may be found on the chart in the front of the weekly *Notice to Mariners*);

(*d*) For all warnings on library file (an in-house program to retrieve the text of long library messages that will be rebroadcast each week so the operator will not have to retype the text);

(*e*) By character string (to allow query on key words in the message, i.e., for Platform, Drill Rig, etc.);

(*f*) For an index of all messages (user must specify the area to get this information data base report extracted);

DMA has made two special query programs available to mariners. These programs may be invoked by users of ANMS telecommunication links.

To use Broadcast Warnings routine (QB11 which is BWQY03 in BW software) enter:

1. The world "subregion" (available from chart on page "v" of any *Notice to Mariners*).
2. The date back to which broadcast warnings (in force) are needed.

To use our program to query for broadcast warnings affecting a NAVAREA (QB12 which is BWQY08 in BW software), enter:

1. The NAVAREA number, code, or type in HELP.
2. HELP gives the following information.

VALID CODES AND AREAS ARE:

CODE	*AREA*
12	NAVAREA XII
P	HYDROPACS
4	NAVAREA IV
A	HYDROLANTS

Again, the user has option to enter NAVAREA, CODE or HELP for AREAS and CODES.

(Above text is an example of a remote terminal's print-out.)

3. Once code or NAVAREA is entered, the computer asks for starting date by day, month, year (e.g., 12 February 1983).

NOTE: Figure 77 provides an example of a print-out obtained from a remote BW Subsystem Queries. Interested parties should write the Navigation Department, DMAHTC, Washington, D.C., 20315 to request an ANMS communications users' identification number and *Users' Manual*.

Utilities (figure 76(*e*))

These programs, written to assist the DMA operator in managing the subsystem, provide data processing recovery programs, history file query programs and other software of a purely technical nature.

Data files

The following files are created to automate the Broadcast Warnings:

(*a*) Daily Memo file (has all Warnings published in Daily Memorandums and after the print run is processed, the system deletes all entries on this file);

(*b*) Broadcast Warning master file (contains all active warnings. Cancelled warnings are flagged and remain on the file until transferred to the History Tape Program when it is run. Then, they are deleted from master file);

Figure 77. United States of America: Operation of the Automated *Notice to Mariners* Query System and print-out obtained

Instructions to user

1. Dial 202-227-3352 and connect telephone to your machine
2. Press any key, and then press the return key. Computer should respond "LOGIN PLEASE"
3. Type in "LOGIN ANMS"
   Computer will respond "PLEASE ENTER YOUR USER-ID NUMBER"
4. Type in ID (number to be assigned to each user)
   Computer will respond
   "WELCOME TO THE AUTOMATED NOTICE TO MARINERS SYSTEM"
   "OK, SEG NUMBER ANMS"
   "THIS IS THE CHART CORRECTION SUBSYSTEM"
   "ENTER JOB TO RUN. MENU TO REDISPLAY MENU"
5. At this time, type in the word "MENU" in order to view the list of programs available for your use
   Now you can operate one of the programs
6. Type in "MP01" if you wish to send a message to the defense mapping agency or
7. Type in "QS37" if you wish to find some chart correction information or
8. Type in "QB11" if you wish to get Broadcast Warning information
9. In order to interrupt a long listing, press the "CTRL" key and the letter "S" at the same time
10. To get off the system after a program is completed, type in "SIGN OFF"

Figure 77 *(continued)*

Example of print-out
(underlined entries are typed in by user)

```
Example of print-out (underlined entries
are typed in by user.)

LOGIN PLEASE
FR ! LOGIN ANMS

PRIMOS Version 18.2
ANMS   (8) LOGGED IN AT   18:00 040682

Please Enter your User Identification
672

WELCOME TO THE AUTOMATED NOTICE TO MARINERS SYSTEM

OK, R *ANMS

ENTER JOB TO RUN OR MENU TO DISPLAY PROGRAM MENU
OB11

EXTRACT EFFECTIVE BROADCAST WARNINGS BY SUBREGION

Please Enter Subregion Number
12

OPTIONS:
  1  All Effective Warnings
  2  All Effective Warnings from a Selected Date

Please Enter Option Number (1 or 2)
2

Enter Starting Date as:
DD MONTH YEAR   (EX: 5 JUNE 1982)
25 MARCH 1982

.....

                    AUTOMATED NOTICE TO MARINER                    4/06/82
                  BROADCAST WARNING QUERY SYSTEM
          EXTRACT ALL EFFECTIVE BROADCAST WARNINGS FOR SUBREGION 12
                        FROM 25 MARCH 1982

NAVAREA IV

879/82(GEN)    OMEGA
  Polar cap anomaly, PCA, in progress since 300800Z March.
  (COGARD  ONSOD  301415Z  MAR 82)                          (30 Mar 1982)

902/82(12)     VIRGINIA.    GUNNERY.
  1.  Gunnery/pyrotechnic exercises 0100Z to 0400Z daily 6 to 12
  April in area bound by:
    37-15N.  75-30W.,  37-15N.  75-00W.,  37-03N.  75-00W.,
    37-02N.  75-08W,  37-04N.  75-26W,  37-08N.  75-30W
  2.  Cancel this message 120500Z April.
  (FACSFAC VACAPES 011945Z APR 82)                          ( 1 Apr 1982)

903/82(12)     VIRGINIA.    GUNNERY
  1  Gunnery exercises 1540Z to 0540Z daily 7 and 8 April in area
  bound by:
    36-48N.  75-30W,  36-47N.  74-30W,  35-30N.  74-30W.,
    35-30N.  74-57W,  35-54N.  75-30W.
  2.  Cancel this message 080640Z April.
  (FACSFAC VACAPES 011945Z APR 82)                          ( 1 Apr 1982)
```

(*c*) Cancellation file (contains records of messages to be cancelled. Entries to this file are made at the time a self-cancelling message is entered into the system. Previously entered messages may also be cancelled. The Master File Update program will access this file and add the date, time and reference message to any record being cancelled by the current message).

SUMMARY

The automation of the Broadcast Warnings has involved more than computer specialists and programmers. There has been an intensive effort to include marine information specialists to ensure the user orientation of the final software.

The goals of the Broadcast Warnings Automation effort which have been developed in this paper can be summarized as follows:

(*a*) To automate the production and publication of the Daily memorandum as well as production of the Weekly/Quarterly output;

(*b*) To provide mariners with an on-line data base of up-to-date Broadcast Warnings via global communications links;

(*c*) To provide rapid, digital data management tools, to replace antiquated in-house data handling methods, to replace extensive space consuming manual file storage and slow manual publication set-up methods.

The software developed by this effort is a major advance towards DMA's long-term goal of achieving a totally automated weekly *Notice to Mariners*. Although it builds upon earlier software, the new Broadcast Warnings software will make the remaining automation steps easier and less costly. Therefore, some credit must be given to the synergistic effect of each of our completed ANMS phases. The next phase will complete the text oriented, data entry capabilities. Research and development efforts, which are planned but are not now programmed, will address graphics. The impact of DMA's automation of the Broadcast Warnings will extend beyond the actual publication of hard copy Daily Memorandums and Part III of the Weekly/Quarterly Notice. Presumably, this automated subsystem will be a model for later automation efforts which may be undertaken by other nations operating Broadcast Warning systems. Also, it will provide a means to interface with new developments in automation of shoreside message handling and transmission of Broadcast Warnings to ships at sea. The annex, entitled "Milestones in Marine Communications", is provided as a summary of developments in marine communications including our automation of Broadcast Warnings.

ANNEX

Milestones in marine communications

1899 The American liner *St Paul* was the first vessel to receive a wireless message.

1906 The radio telegraph distress signal, SOS, was adopted as the international call for help at sea.

1908 Hydrographic Office began issuance of hydrographic warnings three times daily from eight stations on the Atlantic coast and seven stations on the Pacific coast (one of these being in Alaska).

1912 The luxury liner *Titanic* sank with a loss of 1,503 lives, and the tragedy inspired regulations requiring increased radio transmitting power as well as 24-hour manning of radio rooms for passenger ships.

1922 First ship-to-shore, two-way voice communications took place between a shore station in New Jersey and the *SS America*, while it was 400 miles at sea.

1929 High seas radio telephone service became available for public use.

1965 First commercial communications satellite, Early Bird, was placed in operation.

1981 Exxon tanker, *ESSO Kagoshima* (6ZWE), was the first ship to make an at-sea query via MARISAT to Defense Mapping Agency (DMA) Automated *Notice to Mariners* (ANMS) computer for chart corrections information.

1982 On 21 January, DMA Broadcast Warnings were added to DMA's computer data base for use of ships at sea via satellite communications. INMARSAT began operations on 1 February. Operations were initiated by leasing commercial capacity on existing MARISAT satellites.

(i) *Thematic mapping*

ECONOMICAL MAINTENANCE OF A NATIONAL TOPOGRAPHIC DATA BASE USING LANDSAT IMAGES*

Paper submitted by Canada

RÉSUMÉ

En raison de la relative exiguïté de la base d'imposition, de l'étendue du territoire et de la diversité de son relief, la gestion de sa base nationale de données topographiques pose au Canada d'importants problèmes économiques et techniques. Cette base de données comprend : 1) une série de 918 cartes au 1/250 000 partiellement révisée; et 2) une série incomplète qui comprendra 13 150 cartes au 1/50 000.

RESUMEN

Debido a su base de contribuyentes relativamente reducida y a su vasta y variada superficie, el Canadá encara importantes problemas económicos y técnicos para mantener su base nacional de datos topográficos. En esa base de datos figuran: 1) una serie parcialmente revisada de 918 mapas en escala de 1:250 000, y 2) una serie incompleta en que figurarán 13 150 mapas en escala de 1:50 000.

Desde hace tiempo se reconoce la permanente necesidad de revisar esas bases de datos. En 1978, los autores llegaron a la conclusión de que el procesamiento cerebral de las imágenes LANDSAT por un intérprete experimentado podía

* The original text of this paper, prepared by Alan F. Gregory and Harold D. Moore, Gregory Geoscience, Ltd., Ottawa, appeared as document E/CONF.77/L.48.

La nécessité de réviser ces bases de données se fait sentir depuis longtemps. En 1978, les auteurs sont arrivés à la conclusion que le traitement d'images LANDSAT par des spécialistes de la photo-interprétation pourrait répondre à la plupart des besoins en matière de détection de variation et de révision des cartes.

Au titre de contrats passés avec le Service de cartographie du Ministère de l'énergie, des mines et des ressources du Canada, la Gregory Geoscience Limited a mis au point et exécuté un programme opérationnel de détection des variations en vue d'établir des cartes au 1/50 000 et de réunir les informations nécessaires à la révision des cartes au 1/250 000. On utilise un projecteur exclusif (Projection compositor PROCOM-2) pour reporter une image LANDSAT récente sur une carte topographique au 1/50 000. Les résultats obtenus à ce jour montrent que l'erreur moyenne de positionnement des détails va de 50 à 100 m. Le programme de 2 700 cartes couvrant une superficie d'environ 2 000 000 km² (soit environ le double de celle du Venezuela) a été mené à bien en neuf mois, compte tenu d'un certain nombre d'inspections sur place. Le coût moyen de ce programme combiné de détection des variations et de révision des cartes s'est établi à 21 cents par km (soit 210 dollars canadiens pour une carte au 1/50 000). Le Service de cartographie se charge ensuite de la production des cartes révisées.

En ce qui concerne la gestion économique d'une base nationale de données topographiques, nous sommes arrivés aux conclusions suivantes :

1. Ces techniques peuvent être utilisées dans d'autres régions tempérées, moyennant des dépenses minimes de formation et d'investissement;
2. Une adaptation s'impose dans le cas de régions présentant des contrastes très marqués, comme les zones arides et la forêt tropicale;
3. Ces techniques peuvent utiliser les images fournies par d'autres satellites sans modification du système;
4. Ces techniques peuvent être adaptées à des échelles plus grandes dans le cadre de l'utilisation de photographies aériennes;
5. Ces techniques demeureront pendant quelques décennies un élément essentiel des systèmes opérationnels de cartographie.

satisfacer la mayoría de las necesidades de detección de cambios y revisión de mapas.

En virtud de una serie de contratos de la División de Topografía y Cartografía del Departamento de Energía, Minas y Recursos del Canadá, *Gregory Geoscience Limited* ha desarrollado y aplicado un programa operacional para detectar cambios en los mapas cartográficos de escala 1:50.000 y suministrar información para la revisión de los mapas de escala 1:250.000. Se usa un componedor de proyecciones patentado (PROCOM-2) para registrar una imagen LANDSAT reciente en un mapa topográfico de escala 1:50.000. Hasta la fecha, la experiencia indica que el error medio en la ubicación de los accidentes topográficos es de 50 a 100 metros. El programa actual de 2.700 mapas representa una superficie de aproximadamente 2 millones de kilómetros cuadrados (aproximadamente dos veces la superficie de Venezuela) y se terminó en nueve meses, incluida la verificación selectiva sobre el terreno. El costo promedio de este programa combinado de detección de cambios y revisión de mapas fue de 21 centavos por kilómetro cuadrado o 210 dólares por mapa de escala 1:50.000. Los mapas revisados son producidos ulteriormente por la División de Topografía y Cartografía.

Con respecto al mantenimiento económico de una base nacional de datos topográficos concluimos lo siguiente:

1. Estas técnicas pueden traspasarse con un costo de capacitación y de capital mínimos, para usarse en otras partes templadas del mundo;
2. Pueden requerirse modificaciones de las técnicas para usarlas en zonas con contrastes muy grandes entre sí, por ejemplo, zonas áridas y bosques tropicales;
3. Las técnicas pueden permitir utilizar imagenes de otros satélites sin que haya cambios en el sistema;
4. Las técnicas pueden adaptarse a escalas más amplias recurriendo a la fotografía aérea;
5. Las técnicas permanecerán como un componente esencial de los sistemas operacionales de la cartografía en los próximos decenios.

Cartographic and other applications of satellites were first considered by the United Nations and its member States over 15 years ago (United Nations 1970, 1971). At that time, meteorological satellites were operational and the potential utility of space data for completing and updating national topographic data bases had been recognized. Now, in 1985, geodetic positioning satellites are a global fact of life although cartographic applications of space data have grown more slowly.

Within that time frame, Canadian development of practical applications of space data was left largely to a diverse group of potential users, both public and private. Geodetic and topographic applications receive strong technical and administrative support from the Surveys and Mapping Branch of the Department of Energy, Mines and Resources. On the other hand, many organizations are involved with research into thematic mapping from space data, primarily from LANDSAT data produced by the Canada Centre for Remote Sensing. The principal geometric control for such mapping is the Canadian national topographic data base.

While the need for continued revision and maintenance of national data bases is well known, there has been little progress until recently towards this essential, but seemingly mundane task. For example, at an international symposium in 1978, R. E. Moore (1978, p. 4) re-emphasized the need to develop and implement a simple, economic system for detecting areas of change and for updating maps with acceptable accuracy. The present paper reports on one system that has been operating successfully in Canada since 1980 and which might be adapted to other areas of the world with minor expense.

The Canadian context

Diversity in terrain and density of population

As the second largest country in the world, Canada faces monumental economic and technical challenges in completing and maintaining a national topographic data base. The lands and freshwaters that are represented in this data base cover 10 million km^2, i.e. about one sixth larger than Brazil, 5 times larger than Mexico and 46 times larger than Guyana. The Canadian terrain is extremely varied and ranges from temperate rainforest on the Pacific coast through rugged mountains, semi-arid steppes, fertile prairies and vast boreal forests to the woodlands and farmlands of eastern Canada and the treeless expanses of the Arctic tundra. Much of the land is rocky or mountainous and is exposed to a harsh, cold climate. About 8 per cent of the land is covered by permanent water bodies, ranging from the Great Lakes to small ponds; but, in addition, there are large areas of marsh, wooded swamps and intermittent lakes.

Canada has a relatively small population, just over 25 million, of which 90 per cent live in a zone about 300 km wide along the boundary with the United States of America. Over half of these people are concentrated in the towns and cities of southern Ontario and southern Quebec. North of the populated zone, the country is uninhabited or sparsely inhabited, except near scattered small resource developments and centres of government.

The technical challenges of maintenance

The National Topographic series of 918 maps at scale 1:250,000 is currently the most detailed data base containing topographic information for all of Canada. These maps, which were published over a 23-year period ending in 1970, provide the only information for much of northern Canada. Traditional methods of photointerpretive revision were based on arbitrary cycles that reflected anticipated change. Almost three quarters of these maps are in a "remote" class with a revision cycle of 30 years. In areas of resource development, changes take place much more rapidly; for example, within a few years, hundreds of kilometres of road may be built, millions of tons of soil and rock may be removed and millions of hectares of land may be flooded by reservoirs. Thus, by the early 1980s, many of the 1:250,000 maps were out of date, while some older maps did not meet the most recent cartographic standards.

The technical challenges for 1:250,000 mapping were first, to identify those maps which required revision, and next, to complete the revision accurately.

The National Topographic Series of 13,150 maps at scale 1:50,000 present more detailed information than the 1:250,000 maps. However, only 76 per cent of these maps had been produced by the end of 1984. Much of the completed mapping represents the ecumene, the area of concentrated human activity. These maps are candidates for revision almost as soon as they are published. Such revision is in competition with the primary mapping that is essential for completion of the series.

The technical challenges for 1:50,000 mapping, then, were (*a*) to identify those areas where primary mapping had highest priority; (*b*) to identify other areas where revision was required; and (*c*) to complete either mapping or revision, as warranted

The economic challenges of maintenance

Until recently, revision of maps in Canada was completed at three levels of complexity and cost: (*a*) overprinting of changes on extant maps; (*b*) amendment of extant cartographic bases and reprinting; and (*c*) recompilation to produce a completely new map. Where single maps required minor revision, the most economical approach was overprinting. Amendments and recompilations, as well as primary mapping, were completed by photogrammetric methods using aerial photography. The most economical approach to such revision was based on the completion of large blocks of maps so as to average the costs of photography and ground control over many maps. In the past, aerial photography was acquired systematically over large areas of the country. However, this approach has become increasingly expensive, and related costs have become a factor that limits the maintenance programme.

In view of the continuing climate of economic restraint and of the urgent need to revise many of the published maps, maintenance of the Canadian topographic data base faces two economic challenges: (*a*) to develop funding for maintenance when a direct economic or social benefit is difficult to demonstrate, and (*b*) to effect a significant reduction in the cost of maintenance so that the programme can be accelerated.

A Canadian response to the challenges

Over the past twelve years, the authors and their associates at Gregory Geoscience Limited have used LANDSAT and collateral data to prepare maps for a wide variety of themes at scales ranging from 1:15,000 to 1:2,000,000. In 1974, a contract was begun to assess various remote sensing techniques for mapping mine wastes on behalf of the Canada Centre for Mineral and Energy Technology. In 1976, a national inventory was completed of mine wastes, using LANDSAT-MSS and -RBV images projected onto 1:50,000 topographic maps (Moore, Adams and Gregory, 1977). The experience of that broad programme led to a proposal to the Surveys and Mapping Branch that the technique should be assessed and developed for the detection of change and revision of topographic maps. At the same time, a start was made in the development of specialized projectors, both multiband and single-band, which eventually became PROCOM systems (Gregory, Moore and Turner, 1982). The single-band system (PROCOM-2) projects one image to register on a map and has become the basic tool for using LANDSAT images to maintain the national topographic data base.

In 1978, the Surveys and Mapping Branch initiated a sequence of contracts which assisted Gregory Geoscience Limited in assessing digital and cerebral (using the eye and brain of an experienced mapper) processing of LANDSAT data for change detection and map revision. The most accurate and economical method of change detection at scales 1:250,000 and 1:50,000 was cerebral processing using the PROCOM-2. This was true also for revision of 1:250,000 maps (Moore, 1982). However, LANDSAT-MSS data alone did not provide enough detail for the accurate revision of 1:50,000 maps. These accuracies were assessed independently by the Surveys and Mapping Branch using new, 1:80,000 aerial photography. Proto-operational programmes were then implemented with the continuing support of the Surveys and Mapping Branch in order to develop costs for systematic mapping and to assess techniques of verification. All of these techniques are now in use to meet the current

requirements for maintenance and, with new types of data in particular, have potential for systematic use at larger scales.

Operational maintenance

To be operational in the Canadian context, any new programme of maintenance must, for reasons previously outlined, be accurate, economic and compatible with the existing data-base and mapping system. The following sections outline the current techniques that are used to assist in maintaining the Canadian data base using LANDSAT-MSS images, the PROCOM-2 and experienced interpreters. Further details may be found in the relevant manual (Moore and others, 1982).

Selecting and ordering images

The initial selection of LANDSAT images is a procedure that is critical to the success of the maintenance programme. The selection is made from a computer listing by experienced interpreters. They consider such factors as spectral characteristics and temporal variations for features in the map area (Moore and others, 1982) as well as cloud cover and image quality. Because of these variables, one image per map may be inadequate for revision. On the other hand, many will be expensive for large areas. Thus, costs are minimized by selecting only images that are optimal for interpretation in the specific map area. Optimal data may include seasonal enhancements to delineate features that are not detectable at other times, e.g. snow enhances narrow-cut lines in boreal forest. In a few cases, it may be preferable to request special digital enhancements rather than standard LANDSAT products.

Further, because of a common lag of four to six weeks between selection of images and delivery, operational programmes require that most of the data be selected well and in advance of the programme, otherwise serious delays may be experienced.

Feature discrimination

The detection and identification of a feature represented in a LANDSAT scene is based on standard photointerpretive procedures, particularly those that emphasize shape, pattern, association, spectral characteristics and seasonal variations. With respect to the varied geographic regions of Canada, we have compiled interpretive keys (Moore and others, 1982). While initially these keys are important, they are soon replaced by the practical experience that is fundamental to the operational programme. In addition, knowledge of many relevant variables must be acquired. Specific to the area are geographical factors (especially climate, topographic relief, vegetation and forests, soils and rocks, erosion and human activities) and seasonal factors (such as snow cover, haze and cloud, drought, intermittency of water bodies, cropping and harvesting patterns, solar elevation, shadow). Further, image factors (such as dropped pixels, line shifts, dust, scratches) must be recognized under high magnification and excluded from analysis.

Operational change detection and revision

The techniques for change detection and revision are essentially the same except that, in the former case, there is less concern for accuracy in positioning and completeness of identification of the map features. The steps noted below outline the procedure for revision. Steps marked with an asterisk are omitted for change detection. Relevant details may be found in the manual (Moore and others, 1982).

1. Organize LANDSAT images in files representing the specific map areas, with appropriate notation for overlap;
2. Superimpose LANDSAT image on appropriate 1:50,000 topographic map using PROCOM-2; where 1:50,000 maps are not available, enlargements of 1:250,000 maps may be used;
3. Register projected image to each sub-area of map (e.g. UTM grid square) with, as warranted, local rescaling and registration to features in or adjacent to the sub-area;
4. Conduct systematic grid search for change in each sub-area using map features as internal calibration;
5. Delineate all changes on map in pencil, identify from LANDSAT image where possible and mark each change with small adhesive labels;
*6. Verify as many unidentified changes as possible using available documents and publications;
*7. Transfer all change information to the 1:250,000 map from the appropriate set of 16 maps at 1:50,000 and plan for airborne field verification;
*8. Verify remaining unidentified features using observations and photographs made from light aircraft in the map area;
9. Complete revision information on each 1:50,000 map by incorporating appropriate verifications;
10. Complete supplementary listings of changes and images;
11. Perform independent quality control on revision using the same LANDSAT data to find errors of omission, commission, positioning or classification;
12. Complete cartography of change in ink according to specifications of contract.

Steps 1 to 10 are usually completed by the interpreter who worked on the specific map area. This is particularly valuable in broadening personal interpretive experience and in confirming that experience with verification.

Revision of 1:250,000 topographic maps

The 16 revised large-scale maps (1:50,000) that comprise each 1:250,000 map are delivered to the Surveys and Mapping Branch. The Branch's standard procedures are then followed to reduce those maps to compilation scale and to prepare the final manuscript incorporating other relevant information, e.g. legal boundaries, names, surround, etc. The maps are then published at 1:250,000 by the Branch.

Change detection for conventional revision of 1:50,000 topographic maps

The change maps are less precise versions of the revision as noted above. They are used by the Surveys and Mapping Branch to assign priorities for revision of 1:50,000 maps. At present, such priorities are used to guide acquisition of aerial photography so that the 1:50,000 maps can be revised by conventional photogrammetry.

Some conclusions from practical experience

This discussion is based on numerous projects, both research and application, that have been completed by Gregory Geoscience Limited using LANDSAT images and PROCOM systems (or their predecessors). Over the past 12 years, such projects have ranged from mineral exploration through agriculture and forest depletion to land use, including detection of relevant changes. The following ex-

amples represent some of the operational-type programmes that have been implemented using LANDSAT images as the principal data:

(*a*) Weekly maps of snow and ice cover for north-western Canada (approximate scale 1:20,000,000) with forecasts of future cover in two weeks time (about 200 maps, break-up to freeze-up, 1975 to 1977);

(*b*) National inventory of mine wastes and revegetation (217 maps at 1:50,000 plus 399 data sheets);

(*c*) Forest depletions and access roads (40 maps at 1:15,840);

(*d*) Land cover and land activity (25 maps at 1:50,000);

(*e*) Wetlands and peat bogs (40 maps at 1:50,000);

(*f*) Geology (100 maps at scales between 1:50,000 and 1:250,000) by integration with geophysical data.

By far the largest operational programme is that providing information on change detection and map revision for the Surveys and Mapping Branch. In total, the work performed for the Branch includes:

(*a*) Revision information for about 2,320 maps at 1:50,000 to be compiled into 145 maps at 1:250,000.

(*b*) Change detection for another 2,682 maps at 1:50,000.

Excluding overlap, these 5,000 maps represent an area of about 3.7 million km^2 (over 1/3 of Canada) and required about 2,000 LANDSAT images (colour composites primarily, but also single MSS bands and RBV).

This broad and intensive Canadian experience has resulted in a number of conclusions that may be applicable in other countries also:

1. *The systematic analysis of standard LANDSAT images by an experienced mapper using the PROCOM-2 is an economical method for detecting change on topographic maps at scale 1:50,000 and for providing accurate information at 1:50,000 for the revision of 1:250,000 maps.*

For a combined programme of change detection and map revision in Canada, the average operational cost is $ Can .21 per km^2 or about $210 per 1:50,000 map. The cost of providing revision information for 1:250,000 maps varies greatly ($500 to $16,000) with the amount of change. The average cost for revision information is about $5,000 per 1:250,000 map, including field verification but excluding compilation and production of the published map. A significant benefit/cost ratio (at least 10:1) has been achieved for such maintenance relative to previous photogrammetric methods.

2. *All significant and major features that appear on Canadian topographic maps at scale 1:250,000 can be detected, identified and plotted with acceptable accuracy for either change detection or map revision using the techniques outlined above.*

The nominal 80-m "resolution" (IFOV) of LANDSAT is not as severe a limitation for maintenance of topographic maps as might first appear. Interpretive keys have been established for numerous point, line and area features that have land and water associations. Up to eight classes of roads are consistently identified with field experience. Features as small as clearings along an aerial cableway or a bridge across a river may be detected, although aerial verification is required to define their precise nature. Very small features, such as isolated cabins in the forest or communication towers on rock outcrops may be missed unless systematic and more expensive field searches are made.

3. *The accuracy of positioning for features plotted from LANDSAT images that are registered to the topographic map at scale 1:50,000 meets the Canadian standards for 1:250,000 maps.*

Accuracy of positioning has been verified in two ways: (*a*) direct comparison between independent revisions by photogrammetry from aerial photographs (Fleming, 1980, 1981) and by LANDSAT techniques as outlined here; and (*b*) by comparison of LANDSAT revision information at 1:50,000 with maps that were revised subsequently by photogrammetric methods at the same scale. Both assessments suggest that the standard for 1:250,000 maps (90 per cent of errors less than 125 metres) was consistently met. Current evidence shows that many features are plotted as accurately from LANDSAT as from aerial photographs (i.e. relative error = 0) while the average observed error is of the order of 50 m to 100 m.

4. *The PROCOM-2 system for maintenance of the topographic data base utilizes available mapping skills and experience with minimum requirements for special training, capital investment and operating costs.*

Accurate mapping can be completed by a variety of resource specialists (e.g. photointerpreters, geographers, geologists, foresters etc.) who have become familiar with the principles of LANDSAT interpretation and who have been selected for their personal mapping skills. The initial capital cost for PROCOM-2 is of the order of $13,000, depending upon options, while operating costs are primarily those of periodically replacing lamps and fan belts. Salaries, overhead and field expenses should not be overlooked. The recent programme operated with three PROCOM-2 systems, which ran about 11 hours a day for a staff comprising one project director, three team leaders, seven interpreters and two cartographers.

5. *Experience with semi-arid areas and overhanging deciduous trees in Canada suggest that special techniques of image selection, digital processing and/or field verification may be required to adapt the Canadian experience to countries with deserts or rainforest.*

Where abundant topographical and cultural detail is lacking (as control for local registration), it may be necessary to obtain geometrically-corrected-images. For areas of low contrast (e.g. arid conditions), special digital processing, such as contrast stretch, may be useful. The problem of tree canopies that overhang roads and small features may be overcome by appropriate selection of seasonal data (as in Canada) and/or development of systematic techniques for field verification.

6. *Limited experience with aerial photographs (diapositives) and other satellite data and simulations suggest that similar techniques can be used for systematic mapping at other scales than those reported here.*

The techniques have been tested with aerial photographs enlarged to scales of 1:500 for mapping right-of-way along roads and with thematic mapping (TM) images and other satellite images that are not yet available for systematic use. We conclude that, where primary control does not have to be developed across the map, these techniques will be a useful adjunct to maintenance of the topographic data base as well as to many types of thematic mapping.

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CARTES DES SOLS*

Document présenté par la France

SUMMARY

Land development requires the prior gathering of knowledge about soils and their use, and, more generally, about the environment. Automated cartography enhances the value of such inventories: it enables them to be updated and, in particular, provides the opportunity for studying the interactions among several parameters by means of models designed by specialists in the disciplines concerned. Three projects under way at the National Geographical Institute of France are presented as illustrations.

RESUMEN

La ordenación del suelo requiere la reunión de datos edafológicos, el aprovechamiento de tierras y, más en general, el medio ambiente. Estos inventarios adquieren más interés gracias a la cartografía automatizada, puesto que permite actualizar los datos y ofrece además la posibilidad de estudiar la interacción de varios parámetros mediante un modelo computadorizado elaborado por especialistas procedentes de las respectivas disciplinas. Se presentan como ejemplos tres proyectos que actualmente lleva a cabo el Instituto Geográfico Nacional de Francia.

La cartographie classique d'un inventaire relevant de l'une des disciplines des Sciences de la Terre se fait habituellement en trois étapes : recueil des données, mise en forme et représentation graphique; il s'agit d'un échange entre le spécialiste et le cartographe, dont l'utilisateur final est généralement exclu. L'utilisateur est passif, et, si les cartes ne lui conviennent pas parfaitement, il n'a d'autre solution que de ne pas les utiliser, il ne peut pas revenir aux données de base.

Ce que l'on demande en pareil cas à l'automatisation, ce n'est pas en premier lieu de réduire les coûts et les délais de fabrication, mais c'est d'abord d'accroître la disponibilité des données. Les deux dernières étapes du processus classique sont modifiées en conséquence : d'une part, la mise en forme porte sur les données et sur les logiciels de traitement de ces données, d'autre part, les requêtes de l'utilisateur viennent s'ajouter au fur et à mesure de leur élaboration à la production graphique initiale.

Dans cette perspective, l'Institut géographique national de France a constitué une chaîne de cartographie thématique automatique, dont les traits essentiels seront présentés au long de quatre parties :

a) Une description sommaire du processus de rédaction;

b) Une énumération des produits de base et des produits dérivés;

c) La présentation de trois inventaires;

d) L'exploitation qui est faite de deux de ces inventaires pour fournir des outils d'aide à la décision.

LE PROCESSUS DE RÉDACTION

La première étape du processus de rédaction est la numérisation des données. Elle est effectuée en deux temps : saisie de la description géométrique en mode maillé («*raster mode*») sur un scanneur automatique, puis allocation d'attributs sémantiques aux entités géométriques individualisées, qu'il s'agisse d'objets ponctuels, linéaires ou zonaux, au moyen d'un poste de travail interactif. L'obtention des typons de la quadrichromie se fait par traitement simultané des fichiers géométrique et sémantique et adjonction d'un fichier de légende numérisé au préalable. Une épreuve d'essai précède l'impression.

LES PRODUITS DE BASE ET LES PRODUITS DÉRIVÉS

La carte sur papier est un produit de base, mais ce n'est pas le premier; le premier produit est le fichier. Il doit être correct à la fois dans son contenu (données justes et contrôlées) et dans sa forme (données structurées), sans quoi une utilisation ultérieure est impossible, ce qui réduit no-

* The original text of this paper, prepared by Jean-Philippe Grelot, National Geographical Institute, appeared as document E/CONF 77/L.35.

tablement l'intérêt de recourir à un processus informatisé. Le dernier produit de base est un tableau de données statistiques indiquant les résultats d'un planimétrage sur l'ensemble de la coupure : surface des zones, longueur des lignes, nombre de points, ceci pour chaque classe d'attribut.

Les produits dérivés sont généralement obtenus par ajout de données complémentaires soit sous forme de cartes numérisées, soit sous forme de modèles de traitement lorsque plusieurs attributs entrent en jeu. Ainsi, on calcule le planimétrage pour chaque unité administrative en numérisant ces dernières. On obtient des cartes analytiques en sélectionnant au moyen d'un critère approprié (par exemple, prairies de plus de 5 ha). En groupant les fichiers de cartes voisines, on dresse des cartes de synthèse par changement d'échelle et agrégation des classes de la légende, afin de passer d'une vue locale à une vision régionale. Enfin, en croisant différentes données thématiques, on établit des cartes d'interaction (par exemple, prairies comprises entre 400 et 500 m d'altitude).

Présentation de trois inventaires

La première opération réalisée par l'IGN au titre d'un contrat passé avec un organisme gouvernemental français porte le nom d'*Inventaire du littoral*. Le littoral français est soumis à des pressions contradictoires — tourisme, industrie, agriculture, protection de l'environnement — et les pouvoirs publics ont décidé de se doter d'un outil de surveillance basé sur une cartographie au 1/25 000 de l'occupation du sol. L'opération porte sur 147 coupures au format AØ, révisées tous les cinq ans. Les produits initiaux sont les fichiers, les cartes au 1/25 000, des statistiques communales et des cartes de synthèse régionale au 1/100 000.

La deuxième opération est plus complexe dans son aspect cartographique. Il s'agit de la *Carte des sols de la région Centre*, région céréalière située au sud-ouest de Paris. Cinq informations pédologiques sont répertoriées : développement du profil, texture, intensité de stagnation de l'eau, charge caillouteuse, substrat. 45 coupures au 1/50 000 doivent être levées en une dizaine d'années. La variété des produits est plus grande; aux fichiers, aux cartes et aux statistiques s'ajoutent des documents conçus comme des illustrations pédagogiques, qui sont des synthèses calculées à partir des données initiales et dont chacune a un objectif propre : carte des textures superficielles pour expliquer les techniques de labour et d'ensemencement, carte des contraintes liées à l'excès d'eau pour délimiter les grands programmes de drainage, carte des réserves utiles potentielles en eau et carte des aptitudes agricoles complétées par les facteurs limitants pour choisir les types de culture et les zones à irriguer. Toutes les valeurs calculées au moyen des modèles élaborés par les pédologues de la région sont conservées dans les fichiers et donc disponibles pour toute utilisation.

L'IGN engage actuellement une phase d'expérimentation afin d'établir une *carte nationale d'occupation du sol* sur l'ensemble du territoire, à l'échelle du 1/50 000. La difficulté majeure d'une telle opération réside dans le choix d'une légende unique pour les 1 100 coupures de la série. Aussi a-t-il été décidé de constituer une classification globale, dont certaines rubriques pourront être décomposées si les circonstances locales justifient cette opération. L'ordinateur procédera aux regroupements nécessaires lors de l'édition, mais les fichiers conserveront toute la richesse de la nomenclature fine. Des statistiques communales seront calculées.

Exploitation des inventaires

En ajoutant des données ou des modèles à ces inventaires, on les fait passer de l'état d'archives statiques à celui de systèmes d'information dynamiques, à l'aide desquels l'utilisateur final fabrique des outils d'aide à la décision.

Pour l'*Inventaire du littoral*, ces outils sont constitués lors de la mise à jour. Le photo-interprète utilise la carte initiale et la prise de vues aériennes récente pour rédiger une maquette de mise à jour qui est numérisée et combinée au fichier initial pour produire un fichier actualisé. De ce fichier sont dérivées :

a) La carte et les statistiques actualisées (il s'agit d'une simple mise à jour);

b) La carte des modifications, qui décrit l'état actuel des zones dont l'occupation a varié entre les deux levés;

c) Les cartes et statistiques d'évolution, qui indiquent à la fois ce qui a changé et aux dépens de quel type d'occupation s'est effectuée la mutation.

Les nombreuses classes de la légende font que le nombre de cartes d'évolution est gigantesque. Une première solution qui s'offre est de choisir *a priori* quelques évolutions-types et de publier les 147 coupures correspondantes. Mais l'utilisateur ne peut alors intervenir, et il est douteux que le choix soit partout adéquat, tant les contrastes régionaux sont forts. Aussi est-il proposé de calculer, pour chaque commune, une «matrice d'évolution». L'examen de ces matrices, qui peut être fait interactivement sur ordinateur, permet à l'utilisateur de choisir la carte d'évolution qui lui paraît significative et dont il a réellement besoin. Au cartographe de concevoir ensuite la représentation graphique appropriée.

A l'intérieur des terres, même si les pressions sont moins fortes que sur le littoral, les programmes d'urbanisation ou d'implantation de grandes infrastructures sont en conflit avec l'agriculture. Pour éviter de soustraire à cette dernière les meilleures terres, le législateur a imposé de dresser une carte de valeur des terres agricoles au 1/50 000 sur l'ensemble du territoire français. En région Centre, nous utilisons les données pédologiques, que nous complétons par l'occupation du sol, le zonage des agrosystèmes, les pentes, etc., pour constituer une base de données qui fournit non seulement la carte imposée, mais également des données statistiques pour étudier en détail l'occupation des sols en fonction de leur valeur agricole issue des données physiques et économiques.

Conclusion

Ces opérations n'ont pu être menées à bien que par l'emploi de moyens informatiques relativement puissants. Mais les résultats obtenus ne sont pas seulement dus à ces moyens. Nous les devons avant tout à la rencontre et à la mise en commun de compétences intellectuelles : les aménageurs, les pédologues, les agronomes extérieurs à l'IGN dont la connaissance du terrain et la réflexion ont guidé le choix des données et la constitution des modèles de traitement; les informaticiens que nous sommes nécessairement et qui ont transcrit ces réflexions en programmes informatiques; et aussi les cartographes que nous essayons de rester, qui apportent leur connaissance de l'information géographique, de son organisation et de sa transcription graphique. Cette transcription graphique reste fondamentale : le décideur, souvent sensible au fait que la carte a été faite «par ordinateur», ne l'utilise que s'il est séduit par elle, d'abord en trouvant ce qu'il cherche, ensuite en étant accroché par son

aspect esthétique. Le cartographe n'est pas un simple technicien des arts graphiques; il est et doit rester, avec et peut-être malgré l'ordinateur, celui qui communique une information géographique. Ceci est la condition *sine qua non* pour que se développent les systèmes d'information géographique, rencontres entre le milieu physique et humain, les spécialistes, les cartographes et les décideurs, systèmes indispensables pour définir et gérer une politique de développement, mais dont les potentialités ne sont pas suffisamment connues et utilisées.

CARTOGRAPHIE STATISTIQUE*

Document présenté par la France

SUMMARY

The knowledge of population phenomena is a decisive factor in defining a development policy. An overall view is insufficient: the geographical distribution of the population must be known. With the digital encoding of census results, automated cartography is the most favoured way of disseminating information needed by geographers and planners. This tool must be well known, however, and the financial arrangements must be made during budgetary preparations for the census.

RESUMEN

El conocimiento de los fenómenos demográficos es un factor determinante para definir un programa de desarrollo. Su aspecto mundial no basta: es preciso estar al tanto de la distribución geográfica de la población. Gracias a la codificación digital de los resultados censales, la cartografía automatizada es un medio sumamente eficiente para dar a conocer las informaciones que necesitan los geógrafos y las autoridades encargadas de la planificación. Sin embargo, es preciso conocer bien este instrumento y estudiar los aspectos financieros durante la preparación del presupuesto del censo.

En 1979, l'Institut géographique national de France s'est doté d'un système de cartographie automatique dans le but de produire des cartes statistiques à un coût et dans des délais réduits. De six années d'expérience et de collaboration avec les services statistiques de plusieurs ministères français peuvent être tirés un bilan et quelques réflexions sur l'avenir prochain de la cartographie censitaire; les expériences menées sur des pays étrangers seront également évoquées.

Les données statistiques

Les données statistiques sont chaque jour plus nombreuses, plus précises et plus fiables. Parmi cette masse de chiffres, la cartographie ne prend que ceux rapportés aux échelons géographiques les plus fins, tels les communes ou les cantons, et couvrant une grande portion ou la totalité du territoire national.

Cette limitation peut paraître importante, mais elle laisse tout de même place à un vaste champ d'activités : les principales sources utilisées en France sont les recensements généraux de la population et de l'agriculture et les données de démographie médicale.

Le recensement général de la population

Visant à obtenir une connaissance chiffrée des phénomènes démographiques et sociaux ainsi que de l'état du parc des logements, le recensement général de la population est une opération menée à intervalles assez réguliers, ce qui permet de suivre de façon satisfaisante l'évolution de nombreux phenomènes. Les derniers recensements ont eu lieu en 1968, 1975 et 1982. Il est à noter que les recommandations internationales préconisent un recensement tous les dix ans.

L'unité géographique de base, qui sert à la saisie des données, est le district de recensement, tout entier compris dans une commune, et dans un îlot (ou bloc de maisons) si la commune est découpée en îlots; il contient au maximum 800 personnes et est confié à un agent recenseur. Trois types de questionnaires sont distribués : le bulletin individuel concerne la situation sociale propre de chaque individu; la feuille de logement répertorie les personnes occupant le logement; enfin le bordereau de maison renseigne sur le type de construction.

Le dépouillement du recensement commence par le comptage des questionnaires recueillis : cette opération, appelée dénombrement, permet de déterminer la population globale des différentes circonscriptions administratives du pays et d'établir des statistiques rapides sur l'évolution de la population et du nombre de logements entre les recensements.

La population légale ainsi déterminée sert notamment à fixer le découpage des circonscriptions électorales et le nombre d'élus, à guider les programmes d'équipements scolaires et sociaux, à fixer le montant des subventions.

La connaissance des caractéristiques des populations recensées (sexe, âge, état matrimonial, activité professionnelle, etc.) et des logements qu'elles occupent (dimensions, équipements, etc.) est subordonnée à l'analyse des renseignements contenus dans les questionnaires. Ceci fait l'objet de l'exploitation statistique, réalisée en priorité sur un échantillon au 1/4 déterminé par tirage systématique d'une feuille de logement sur quatre.

Le recensement général de la population a une autre fonction, qui résulte de l'exploitation statistique : il sert à établir des bases de sondages qui permettent de mener de nombreuses enquêtes durant la période intercensitaire.

Le recensement général de l'agriculture

Le recensement général de l'agriculture est moins fréquent mais plus détaillé que celui de la population; les derniers ont eu lieu en 1970 et 1980.

Le questionnaire est rempli par un enquêteur, d'après les renseignements que lui donne le chef de l'exploitation agricole. Les questions sont multiples, plusieurs d'entre elles sont communes à tous les pays de la Communauté économique européenne. Ces questions sont regroupées en cinq

* The original text of this paper, prepared by Jean-Philippe Grelot, National Geographical Institute, appeared as document E/CONF.77/L.35.

rubriques : identification et statut du chef d'exploitation, utilisation du sol au cours de la campagne agricole précédant le recensement, cheptel, matériel et équipement, famille du chef d'exploitation.

Les résultats sont publiés selon plusieurs regroupements géographiques, en particulier par commune, par canton et par région agricole (le découpage du territoire en 700 régions agricoles environ répond au désir de réunir dans une même entité les terres ayant même vocation agricole)

L'inventaire communal

Mené en 1979, l'inventaire communal a pour but de recenser les équipements et services implantés sur le territoire de chaque commune et, si certains n'existent pas, les déplacements effectués par la population pour les trouver dans une commune voisine : ainsi apparaissent des pôles d'attraction.

Le questionnaire, envoyé à une commission communale présidée par le maire, est divisé en une douzaine de chapitres : généralités sur le territoire communal; la chasse et la pêche; l'aménagement de la commune; l'eau, l'assainissement, les ordures ménagères, la pollution; l'enseignement; les services et les commerces; les transports; les services de santé; la vie sociale et l'animation; les sports et les loisirs; la capacité d'accueil et éventuellement le tourisme.

La démographie médicale

Le Ministère de la santé recense les quelques 100 000 médecins en exercice, en indiquant s'ils sont généralistes ou spécialistes, libéraux ou salariés. Ainsi peut être étudiée de manière qualitative et quantitative l'offre de soins en précisant sa répartition géographique, ce qui doit guider la politique de formation médicale et d'implantation des jeunes praticiens.

Les données géographiques

Afin de diversifier la gamme des représentations graphiques, deux fichiers de base ont été constitués : l'un de points caractéristiques (représentations ponctuelles ou linéaires), l'autre des limites de communes (représentations zonales).

Le fichier des chefs-lieux (localisation de la mairie) et des centroïdes (centre visuel de la commune) a été numérisé d'après la série de cartes au 1/250 000; les coordonnées sont arrondies à l'hectomètre.

Le fichier des limites de communes a été numérisé sur scanneur automatique après assemblage et réduction photographique de six planches dessinées au 1/500 000 d'après une schématisation des 36 450 communes de France. L'affectation du code géographique officiel de la commune à chacun des polygones a été faite en partie automatiquement à partir du fichier des centroïdes et des chefs-lieux, en partie manuellement.

Pour adapter les fichiers de base à l'échelon géographique cartographié, deux types d'extraction sont utilisables. Le premier procède par agrégation en conservant l'intégrité du territoire : on a ainsi obtenu un fichier des 3 500 cantons, un fichier des 96 départements, un fichier des 22 régions de programme, ainsi que des fichiers plus spécifiques tel celui des secteurs sanitaires ou encore des régions agricoles.

La seconde extraction procède par sélection d'entités administratives (régions ou départements), suivie éventuellement des agrégations indiquées précédemment.

Des formats standards ont été définis et ont conduit à généraliser automatiquement le fichier initial, pour couvrir une vaste gamme d'échelles allant du 1/500 000 au 1/5 000 000.

Les mises à jour sont effectuées sur les seuls fichiers de base; les fichiers dérivés sont alors reconstruits au fur et à mesure des besoins. Ces mises à jour consistent soit en regroupements de communes, soit au contraire en éclatements de communes qui avaient auparavant fusionné, soit enfin en création de communes nouvelles par assemblage de parcelles d'anciennes communes.

Le processus de rédaction

L'IGN ne réalise pas, à l'heure actuelle, de cartes statistiques pour son propre compte : il agit en tant que prestataire de service au profit d'un client. Dès lors, le choix des thèmes cartographiés est fait par le commanditaire, à qui sont proposés les représentations cartographiques.

Choix statistique

Lorsque le thème de la carte est fixé, il faut procéder à une exploitation statistique pour déterminer les seuils des classes ou les paramètres qui vont associer les données aux variables visuelles.

Cette détermination n'est jamais faite dans l'absolu. En effet, des contraintes peuvent être imposées, comme la taille minimale d'un symbole ponctuel, ou bien l'emprise relative des classes d'une représentation zonale, ou encore si l'on dresse une série de cartes, la volonté de pouvoir comparer et donc d'avoir des seuils identiques pour plusieurs variables. Il faut procéder par itération et pressentir l'effet visuel en fonction de la distribution de la donnée.

Choix de la représentation

Pour cartographier une grandeur absolue, on dispose de représentations en signes ponctuels :

a) cercles, carrés, ou cercles partitionnés, dont la surface totale est proportionnelle à la variable statistique; en cas de superposition, le plus petit symbole, cerné d'un anneau blanc, vient effacer le plus grand;

b) Semis de points en nombre fixé par la valeur de la donnée, les points sont répartis aléatoirement à l'intérieur de la surface correspondante.

Une densité ou une proportion sera traduite par une représentation zonale; éventuellement, des hachures peuvent être utilisées.

Enfin, des relations de commune à commune (flux d'échanges, attractions) peuvent être représentées par des traits dont la largeur est modulée par la donnée statistique.

Rédaction cartographique

A partir des fichiers de base et des fichiers de données statistiques, un traitement informatique met en place les symboles et les trames retenus; la légende est ajoutée interactivement sur une console graphique. La confection des planches d'impression est assurée par un restituteur à laser de haute définition.

Les écritures sont ajoutées manuellement avant la confection de l'épreuve d'essai.

Quelques réalisations

En collaboration avec les grands organismes statistiques français, l'IGN a, en six ans, confectionné plus de 150 cartes nationales et environ autant de cartes régionales ou départementales.

Les principales réalisations ont utilisé les données des recensement généraux de la population et de l'agriculture et les statistiques de démographie médicale.

Travaux réalisés avec l'INSEE

Après un essai de 50 cartes sur la région Rhône-Alpes en 1979, l'IGN et l'Institut national de la statistique et des études économiques (INSEE) ont entrepris en 1980 et 1981 la coédition de deux fascicules d'une vingtaine de cartes présentant les principaux résultats du recensement de la population de 1975 sur l'ensemble du territoire. L'unité élémentaire cartographiée est la commune ou le canton. Une carte administrative et une carte physique viennent compléter ces ouvrages.

Quelques mois après le recensement de 1982, les premières estimations sont parues sous forme de tableaux chiffrés accompagnés de 17 cartes synthétisant les données de dénombrement et leurs évolutions depuis les derniers recensements; l'unité élémentaire cartographiée est le département. Des données plus précises ont conduit à l'établissement de 30 autres cartes plus détaillées.

Travaux réalisés avec le SCEES

Le Service central d'enquête et d'études statistiques (SCEES) du Ministère de l'agriculture a publié des cartes départementales et régionales montrant quelques résultats du recensement de l'agriculture.

A la suite de ces travaux, il a confié à l'IGN la réalisation de six cartes nationales qui, outre leur intérêt propre, sont conçues comme des documents promotionnels destinés à faire connaître ce recensement.

Travaux réalisés avec le Ministère de la santé

Depuis 1979 et tous les deux ans, le Ministère de la santé fait réaliser, par l'IGN, une série de 12 à 16 cartes nationales représentant par canton ou par secteur sanitaire le nombre d'habitants par praticien, libéral ou salarié, généraliste ou spécialiste pour les dix spécialités qui comptent le plus fort effectif.

D'une série à l'autre, on peut comparer l'évolution de la densité mais aussi de l'implantation géographique des médecins, ce qui intéresse directement l'établissement de la carte sanitaire.

Il est envisagé d'étendre cette cartographie à celle de l'infrastructure hospitalière et de l'ensemble des personnels médicaux.

Les succès et les infortunes

Incontestablement, les cartes publiées constituent un succès technique, de par la finesse des représentations cartographiques et des détails géographiques lisibles même à très petite échelle. En cartographie classique, ce type de travail est maintenant inconcevable, car il engendre des coûts et des délais prohibitifs. L'apport de la cartographie automatique est ici essentiel, en particulier parce qu'elle réduit drastiquement les temps de fabrication. On est parvenu à un stade où la conception cartographique demande plus de temps que la réalisation proprement dite, ce qui valorise d'ailleurs le rôle du cartographe.

L'attrait esthétique des cartes est un atout important. A cet égard, les possibilités qu'offre l'automatisation sont décisives, puisque pratiquement aucune limite technique ne vient freiner l'imagination du concepteur. Il peut ainsi véritablement jouer avec les représentations et les couleurs.

Les documents ainsi produits apparaissent comme des cartes destinées à un large public : elles apportent une information statistique, certes résumée, sous une forme agréable qui accroche le lecteur. Cependant, force est de constater les problèmes posés par la diffusion de tels produits.

Les causes en sont multiples. On peut citer le manque d'habitude du public, le format des cartes qui oblige à les consulter en les déployant sur une table; mais le frein principal est lié à la nature même de la cartographie de données statistiques.

En effet, toute carte est simplificatrice, dans la mesure où l'on est contraint de grouper les données en classes, ce qui masque des variations et au contraire accentue des disparités lorsque deux valeurs proches sont situées de part et d'autre d'un même seuil. Pour cette raison, nombre de statisticiens se méfient de la cartographie statistique, d'autant qu'une mauvaise détermination des seuils peut totalement fausser la réalité.

Un autre handicap vient de la vétusté des données. Si l'information statistique se périme rapidement, le manque de données rapportées à un niveau géographique fin impose de recourir à des résultats datant de 3 à 5 ou même 10 ans. Quand bien même les phénomènes cartographiés ne subiraient que des évolutions lentes, on ne peut diffuser largement des cartes qui paraissent dater d'un autre âge.

Vers l'avenir

Face à ces problèmes, l'avenir apportera des solutions qui s'esquissent dès aujourd'hui.

Tout d'abord, la télématique améliorera, en la décentralisant, la tenue à jour des fichiers qui auront pu être constitués.

Elle permettra de diffuser, à un public certes restreint, des cartes sur écran qui rendront familière l'utilisation de cette présentation de l'information statistique.

Des périphériques graphiques produiront des épreuves d'essai couleurs à très bas prix, ce qui facilitera les études et le choix d'un seuillage : actuellement, les essais successifs sont excessivement onéreux, ce qui conduit à se limiter à la cartographie de thèmes «sûrs».

Enfin, l'existence de fichiers géographiques et de logiciels de cartographie permet de publier simultanément les tableaux chiffrés et les cartes. Ceci est sans doute un atout décisif, puisqu'il s'oppose au vieillissement constaté jusqu'à présent. Ou peut souligner à cet égard la publication des premiers résultats du recensement de 1982, pour laquelle une quinzaine de cartes a été réalisée en quelques jours.

Expériences hors France

L'IGN a conduit deux expériences de cartographie postcensitaire dans deux zones extrêmement différentes, l'une en Italie du Nord, l'autre au Cameroun (province Centre-Sud).

Après recueil des informations auprès des autorités locales, les répertoires géographiques ont été dessinés puis numérisés, tandis que les données statistiques étaient structurées pour que les fichiers forment un ensemble cohérent. Après vérification de la numérisation, quelques cartes ont été établies automatiquement à des échelles diverses. Cependant, ces expériences n'ont pas eu de suite.

Les principales raisons, semble-t-il, sont, là comme ailleurs, la vétusté des données (de l'ordre de 5 ans) et le financement de ce type d'opérations. Il apparaît en effet que

les opérations de recensement, étalées sur plusieurs années, requièrent l'élaboration d'un budget pour les différentes phases — préparation précensitaire, collecte, dépouillement, publications. Il est extrêmement difficile de modifier ce budget pour y inclure par exemple l'édition de cartes, en remplacement ou en supplément d'autres publications. Il faut donc inclure, lors de la préparation budgétaire un chapitre «cartographie» dans la partie dévolue aux publications.

Conclusion

Dans une société où l'information se répand sous forme d'images, la cartographie statistique doit prendre une place plus importante dans la diffusion des résultats de recensements. Les moyens techniques existent, mais un effort de formation reste à faire, tant auprès des détenteurs de données que des lecteurs-utilisateurs et des planificateurs.

AERONAUTICAL CHARTS*

Paper submitted by the International Civil Aviation Organization

Specifications for aeronautical charts

Article 37 of the Convention on International Civil Aviation calls for each contracting State of the International Civil Aviation Organization (ICAO), of which there are 153 at present, to secure the highest degree of uniformity in all matters where such uniformity would facilitate and improve air navigation and to adopt, and amend from time to time as may be necessary, international standards and recommended practices for aeronautical charts as contained in annex 4 (Aeronautical Charts) to the Convention.

Chart specifications were developed with a view to ensuring production of aeronautical charts of the type required by international aircraft operations. The availability of certain types of charts having adequate uniformity of content and/or presentation, contributes to the *safety*, regularity, and *efficiency* of international air navigation. Specifications have been developed for 13 such types of charts; these specifications represent the minimum internationally agreed requirements.

To amplify and illustrate the specifications of annex 4, guidance material, including sample charts, is published in the ICAO Aeronautical Chart Manual (document 8697). It is essential to safety that the chart information, which can be subject to frequent change, be kept up-to-date; the Chart Manual contains guidance on how this may be achieved.

Requirements for aeronautical charts

Mandatory charts

ICAO Convention, annex 4, contains the specifications for 13 types of aeronautical charts for which an international need for uniformity has been established. The production of five of these charts is mandatory because they cover the most critical phases of international air navigation. They are:

(*a*) The *Instrument Approach Chart* and the *Landing Chart* which are required to be made available for all aerodromes used by all types of international civil aviation. The first chart is required when instrument approach procedures have been established for the aerodrome;

(*b*) The *Precision Approach Chart* which is required for all precision approach runways at aerodromes used by international civil aviation;

(*c*) The *Aerodrome Obstruction Chart, Type A*, which is required to be made available for aerodromes regularly used by international *commercial* air transport where there are significant obstructions in the take-off flight path areas. This chart will provide the data necessary to enable an operator to comply with operating limitations such as maximum take-off weight limitations;

(*d*) The *World Aeronautical Chart*, 1:1,000,000, which is required to be made available for all areas except that the obligation to produce this type of chart is modified to permit a choice, as determined by regional agreement, of either the Aeronautical Chart, 1:500,000, or the Aeronautical Navigation Chart, Small Scale, when operational or chart production considerations so dictate.

Establishing the need for other charts

For the safe performance of air operations it is essential that a current, comprehensive and authoritative source of navigational data be made available at all times, and aeronautical charts provide a convenient medium for supplying this information in a manageable, condensed and coordinated manner. All segments of aviation make reference to them for air traffic control, planning and navigation purposes, and it is of prime importance to place current and accurate charts in the hands of these users quickly. States should note a need for, and assign appropriate priority to, the production of:

(*a*) *Radio navigation charts* for all areas where international civil aviation operations occur;

(*b*) *Terminal area charts* where a need is established for information to be furnished to the pilot to facilitate the transitional phases of flight in highly congested areas between en-route and final approach, and between take-off and the en-route phase;

(*c*) *Aerodrome charts* for those international aerodromes where the complexity of the aerodrome movement area and terminal facilities make a Landing Chart inadequate as a means of facilitating ground movement of aircraft to and from runways and apron, and of showing the major flight operation facilities at the aerodrome;

(*d*) *Aeronautical charts (ICAO 1:500,000) and Aeronautical Navigation Charts (Small Scale)* when operational requirements for visual navigation or chart production considerations indicate a need for these charts either as a substitute for or to supplement the *World Aeronautical Chart* (ICAO 1:1,000,000);

(*e*) *Aerodrome obstruction charts, Type B*, where a need exists for a chart to assist in the determination of critical heights, e.g. for circling procedures for use in the event of an emergency during take-off or landing, and of obstruction clearing and marking criteria;

* The original text of this paper appeared as document E/CONF 77/L.71.

(*f*) *Plotting charts* which are a useful adjunct to provide a means of maintaining a continuous flight record of the aircraft position by various fixing methods and dead-reckoning, and maintain an intended flight path. These charts would be appropriate to major air routes over oceanic areas and sparsely settled areas flown by international commercial air transport;

(*g*) *Visual approach charts* to provide the pilot with a graphic presentation of the approach to an aerodrome by visual reference. These charts may be required for aerodromes where radio aids are lacking, and for international aerodromes with limited navigational facilities, when no adequate charts of the aerodrome and its surroundings are available at 1:500,000 or larger scale.

Revised specifications and new charts

Revisions will be made to all of the existing charts this year and as a result of a study on charts to be used in the cockpit, one chart, the *Landing Chart*, will be dropped in favour of expanded specifications for the *Aerodrome Chart* and the *Instrument Approach Chart*.

New chart specifications are to be added to annex 4 for the following charts:

(*a*) *Obstacle Chart, Type C*, which will provide data on obstacles within a radius of 45 km (24 NM) from the aerodrome; the data will be used for the determination of emergency procedures during take-off or landing;

(*b*) *Standard Departure Chart, Instrument (SID)*, which will portray established standard instrument departure routes from an aerodrome;

(*c*) *Standard Arrival Chart, Instrument (STAR)*, which will portray established standard instrument approach routes to an aerodrome;

(*d*) *Aerodrome Ground Movement Chart*, which will portray detailed information for the ground movement of aircraft from the runway to the parking positions on the apron; and

(*e*) *Aircraft Parking/Docking Chart* which will portray details of the parking positions for aircraft on the apron; including visual docking guidance systems.

Priorities

In the production of aeronautical charts, it is desirable to assign priorities to the various chart series particularly where they are not produced within the department responsible for civil aviation. It is not, however, feasible to expect that each State could follow a uniform system in this respect, since most administrations attempt to produce, first, those charts that are within their production capabilities.

Certain difficulties in assigning priorities may arise where a government department, other than that responsible for civil aviation, is charged with the production and publication of aeronautical charts. This is particularly so when the same department is responsible for supplying the entire national requirements for maps and charts, in addition to aeronautical charts. It is imperative that the requirements for aeronautical charts be adequately anticipated and assigned an appropriate priority within the national charting programme. It is important that the many economic benefits which accrue to a State from its participation within the international civil aviation community be recognized and that aeronautical charts be given the requisite priority. When these charts are produced within, or are directly under the control of the department of civil aviation, the aviation needs are better known and appreciated, and it is much easier to make rapid assessments and adjustments to programmes to meet emergency situations, a factor which is very common in the field of aeronautical charts.

Relations with chart users

The users of aeronautical charts are primarily aircrew and general aviation pilots, airline flight operations personnel, air traffic control personnel, pre-flight briefing officers at aerodromes as well as other departmental and airline units indirectly involved in flight operations planning and technical libraries. Arrangements must also be made to ensure prompt distribution of the finished product to all those whose needs initially established the requirement for it.

Technical assistance

ICAO renders technical assistance to developing countries in the form of projects funded by the United Nations Development Programme (UNDP), trust funds and other funding sources such as the World Bank and the European Fund for Development. Projects cover a wide range of activities, designed to meet country and regional needs as seen by Governments in consultation with ICAO. ICAO's assistance can include training in cartography through fellowship programmes offering specialized training at civil aviation schools. Assistance is also available to procure equipment, comprising new or replacement components to improve the physical requirements.

Any State requiring further information about technical assistance in the fields of cartography should contact the accredited ICAO Regional Office or a UNDP office.

Aeronautical Chart Catalogue (Doc 7101-MAP/565)

ICAO also produces an Aeronautical Chart Catalogue which lists all current aeronautical charts notified by States as being available for aerodromes and areas of interest to international civil aviation.

Conclusion

The speed, volume and complexity of modern air navigation demand, for reasons of safety of human life and property, that accurate and up-to-date aeronautical charts be available promptly to all users. The most elaborate system of aids and procedures for air navigation would be of little value, unless aircrew and those in the various aviation ground services who would assist them, have the means to do so through the medium of the prescribed aeronautical charts, which are specialized tools expressly designed to facilitate this purpose. Complete reliance on charts produced by non-State agencies is not in keeping with the obligation imposed on States by annex 4 to the Chicago Convention in assuming responsibility for the production of the prescribed charts in the internationally agreed form.

Documents mentioned can be obtained from the Document Sales Unit of ICAO.

AGENDA ITEM 7

Review of the latest technology and its relationship to policy, economy and development in cartographic data depiction

(a) *Conventional and digital map and chart production and publishing*

CURRENT DIGITAL CARTOGRAPHIC ACTIVITY AT THE UNITED STATES GEOLOGICAL SURVEY*

Paper submitted by the United States of America

RÉSUMÉ

Au cours des dernières années, un nombre croissant de spécialistes a étudié activement les concepts, les instruments et les techniques qui entrent en jeu dans la mise au point et dans l'utilisation de systèmes de données spatiales informatisées concernant les sols, les ressources, les cultures et les phénomènes connexes. Pendant plus de 20 ans, la recherche et l'expérimentation devaient suivre le pas des progrès technologiques. Aujourd'hui, la plupart des promesses qui avaient été faites il y a 20 ans peuvent être réalisées.

La Division cartographique nationale du Service des levés géologiques s'emploie activement à adopter des techniques informatisées à l'appui de ses activités de collecte des données cartographiques et géographiques de diffusion auprès des utilisateurs du Gouvernement fédéral, des Etats, des pouvoirs locaux et des services publics des Etats-Unis. Les premières études du Service géologique ont montré qu'il était nécessaire de structurer, au plan topologique, les données cartographiques numériques et qu'il était souhaitable de prévoir les nouveaux concepts dans les systèmes d'information géographique. Le Service géologique par le truchement de son équipe des applications numériques a défini les données planimétriques comme des graphiques linéaires numériques et les données altimétriques comme des modèles numériques d'altitude et a créé la capacité de numériser, de gérer et de distribuer ces données. Parmi les activités de collecte et de diffusion des données cartographiques et géographiques numériques, on peut citer au premier chef l'élaboration de bases de données numériques consistant de données de catégorie de base concernant les diverses séries des cartes topographiques du Service géologique. La production de données à partir de cartes au 1/24 000, au 1/100 000 et au 1/250 000 est en cours; elle est terminée dans certains cas. Ces données numériques constituent un cadre utile pour la liaison entre d'autres ensembles de données, sur les ressources et la gestion par exemple, et pour l'automatisation des opérations de cartographie.

Le Service géologique ayant présenté en 1980 une demande de crédits en vue de faire face à l'accroissement de

RESUMEN

En los últimos años un grupo creciente de especialistas se ha dedicado activamente al estudio de los conceptos, la instrumentación y las técnicas necesarias para desarrollar y utilizar sistemas de datos espaciales computadorizados relativos a la tierra, sus recursos, cultivos y fenómenos conexos. Durante más de dos decenios, la investigación y experimentación relativas a estos sistemas han tratado de mantenerse a la par de los progresos de la tecnología. Actualmente, muchas de las promesas de hace 20 años pueden ser hoy realidad.

La División Nacional de Cartografía del Servicio Geológico de los Estados Unidos se ha esforzado para adoptar técnicas de computadora en apoyo de su labor de reunir y distribuir datos cartográficos y geográficos para los usuarios de los gobiernos federal, estatales y locales y del público en general de los Estados Unidos. En las deliberaciones del Servicio Geológico se determinó muy pronto la necesidad de dar una estructura topológica de datos cartográficos digitales así como la conveniencia de prepararse para los nuevos conceptos de sistemas de información geográfica. Mediante un equipo de aplicaciones digitales, el Servicio Geológico de los Estados Unidos definió los datos planimétricos como gráficos de líneas digitales (DLG), y los datos de elevación como modelos de elevación digitales (DEM), y desarrolló la capacidad de dar forma digital a esos datos y ordenarlos y distribuirlos. Entre los esfuerzos para reunir y distribuir los datos cartográficos y geográficos en forma digital ocupa un lugar primordial el establecimiento de bases de datos digitales consistentes en datos de categoría básica sobre varias series de mapas topográficos del Servicio Geológico de los Estados Unidos. Actualmente se elaboran datos a partir de mapas en las siguientes escalas:1:24 000, 1:100 000, 1:250 000 y 1:2 000 000; parte de la producción se ha completado ya. Estos datos digitales son útiles como marco de referencia para vincular otros conjuntos de datos, como los datos sobre recursos y ordenación y para automatizar la elaboración de mapas.

En 1980, en respuesta a un pedido que se hacía en el presupuesto del Servicio Geológico de los Estados Unidos de que se atendiesen las necesidades crecientes de datos cartográficos digitales del Gobierno Federal, la Oficina de Políticas Científicas y Tecnológicas efectuó un estudio al

* The original text of this paper, prepared by Rupert B. Southard, United States Geological Survey, appeared as document E/CONF.77/L.23

la demande de données cartographiques numériques au niveau fédéral, l'Office de la politique scientifique et technologique a procédé à une étude. Selon les conclusions de cette étude, l'établissement d'une base nationale de données cartographiques numériques est justifié, le Service géologique doit centraliser le programme correspondant et la demande de produits numériques est suffisante pour soutenir un programme autonome. Une loi portant création d'un fonds autorenouvelable ayant été proposée, le Congrès a invité le General Accounting Office à réunir plus d'informations sur les activités cartographiques informatisées au niveau fédéral. Dans son rapport, celui-ci a fait état de chevauchements indésirables dans les programmes et recommandé que l'Office of Management and Budget et le Département de l'intérieur prennent des mesures énergiques en vue de satisfaire les besoins fédéraux en matière de données. Par la suite, le Service géologique a été chargé de diriger les activités de coordination des programmes de données cartographiques numériques au Département de l'intérieur et dans le gouvernement en général. Un des principaux aspects de ce travail consiste à définir des normes nationales applicables aux données cartographiques numériques. Dans ce contexte, le Service géologique a rédigé sept chapitres du *U.S. Geological Survey Circular 895*, lequel décrit les problèmes, les hypothèses et les optiques dans ce domaine, énonce les normes actuellement utilisées par la Division cartographique nationale, décrit l'action du Service géologique en vue de définir des normes nationales. Cette action, si elle aboutit, aura des effets pour les utilisateurs au niveau des Etats et au niveau local et elle facilitera l'accès aux bases de données numériques nationales automatisées et en accroîtra l'utilité.

respecto. En ese estudio se llegó a la conclusión de que se justificaba una base nacional de datos cartográficos digitales que el programa necesario debía centralizarse en el Servicio Geológico de los Estados Unidos y que la demanda de productos digitales era suficiente para que el programa se mantuviese por sus propios medios. En respuesta a un proyecto de ley en que se proponía establecer un fondo rotatorio, el Congreso pidió a la Oficina de Contabilidad General de los Estados Unidos que efectuara un estudio para obtener más información acerca de las actividades de elaboración de mapas mediante computadoras del Gobierno Federal. En ese informe se señalaron los inconvenientes resultantes de la duplicación de programas de elaboración de mapas mediante computadoras y se recomendó que la Oficina de Administración y Presupuesto y el Departamento del Interior adoptasen medidas enérgicas para atender a las necesidades de datos del Gobierno Federal. Posteriormente se encomendó al Servicio Geológico que encabezara los esfuerzos para coordinar los programas de datos cartográficos digitales en el Departamento del Interior y en todo el Gobierno Federal. Para esta coordinación es esencial el establecimiento de normas nacionales para los datos cartográficos digitales. En cumplimiento de esta misión, el Servicio ha elaborado siete capítulos de *U.S. Geological Survey Circular 895* (Circular 895 del Servicio Geológico de los Estados Unidos). En esta circular se describen los programas, los supuestos y los enfoques relativos a las normas sobre datos cartográficos digitales, se exponen las normas que usa actualmente la División Nacional de Cartografía y se reseñan los esfuerzos del Servicio Geológico para definir las normas *nacionales*. El éxito de esta tarea beneficiará a los usuarios de los Estados y a los usuarios locales, y contribuirá a aumentar la disponibilidad y utilidad de las bases nacionales de datos digitales automatizados

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The United States Geographical Survey (USGS) considers the development of a national digital cartographic data base, at several levels of detail, to be a natural outgrowth of its mission to map the United States in graphic form. The improvements in computer technology in recent years, coupled with the availability of large amounts of completed mapping, have prompted USGS to increase its efforts to build digital data bases of map base categories such as hydrographic features, transportation systems, boundaries, and the land net (public land survey system); categories that have been so useful in graphic form in the past to fashion the framework for other studies like geology, soils, and land and forest management. To the extent feasible, these data bases will be multipurpose in design and available to Federal, State, and local users.

The mission

A requirement for more government attention to digital cartography was noted by the Office of Management and Budget of the Federal Mapping Task Force in the report of the Task Force for 1973. In the years following that study, USGS developed plans for an extremely large data base to consist of the information level of detail shown on 1:24,000-scale maps with an estimated content of about 10^{14} bits of data. Early USGS deliberations identified the need for topologic structuring of data and the desirability of anticipating the emerging concepts of geographic information systems (McEwen, 1983).

In 1977, a digital applications team was formed to develop a prototype capability to digitize, manage and distribute cartographic data (1:24,000 scale), to incorporate topological structure for those data, and to identify a complex set of attribute codes for the high level of information contained on a quadrangle map. The team defined planimetric data as digital line graphs (DLG) and elevation data as digital elevation models (DEM). Data files categorized in accord with these early definitions are still being produced.

Early contributions to the digital cartographic data base came from the land use/land cover mapping programme, which has been under way in the USGS since the early 1970s. Digital data from that programme began to be produced in 1973 because of the requirements of natural resource managers. The Geographic Information Retrieval and Analysis System (GIRAS) was developed at that time to manage the land use/land cover digital data. Knowledge and experience with the requirements for topological structure and attribute coding came from the designers of GIRAS.

In the late 1970s, USGS also began work on a Geographic Names Information System (GNIS) with the objective of building a digital data base of all the names used on the 1:24,000-scale topographic map series. Also, in 1979, USGS began to collect data for a national small-scale digital cartographic data base using as a source the 1:2,000,000-

scale sectional base maps from the *National Atlas of the United States of America*. Work on the first phase of this project has since been completed.

In 1979, USGS was funded to include digital mapping in the National Mapping Program, and other agencies' needs for digital cartographic data were addressed. As a result of this new direction, digital cartographic and geographic data were considered standard products of the National Mapping Program, and procedures for distribution were developed to enhance public availability of data. In the early years the following data types were produced:

(*a*) DEM data, meeting 7-metre root-mean-square error accuracy;

(*b*) Topologically structured DLG data for boundaries and the public land net (1:24,000-scale);

(*c*) Land use/land cover data at 1:250,000 and 1:100,000 scales;

(*d*) 1:2,000,000-scale DLG data;

(*e*) Geographic names data from the 1:24,000-scale map series.

A strong in-house research capability was developed to address the multitude of problems facing the National Mapping Program in its implementation of digital technology (USGS, 1983a).

In preparation for the 1980 budget, USGS requested an increase in funding to establish a digital cartographic programme, and the OMB considered the justification for such a programme. A study was conducted in concert with the Office of Science and Technology Policy (OSTP)(Donelson, 1980), which reached the following conclusions:

(*a*) A national digital cartographic data base was justified;

(*b*) The requisite programme should be centralized in the USGS;

(*c*) There was sufficient demand for digital products to support a self-sustaining programme.

Important aspects of the OSTP study were evidence of a strong requirement for universal standards and for uniform coverage, leading to a conclusion that only the Federal Government could establish and promulgate universal standards and provide uniform coverage in the creation of a national data base. In support of the recommendation for a self-sustaining programme, a bill was introduced in the 97th Congress to establish a revolving fund in the Department of the Interior to make available financing for the production and distribution of digital cartographic data by USGS under the direction of the Secretary of the Interior. Thus far, Congress has not acted on this or any subsequent similar legislation; however, annual funding has continued for digital cartographic activities. In support of the proposed legislation the United States General Accounting Office was requested to conduct a study to develop further information on computer-mapping activities in the Federal Government. Their report (United States General Accounting Office, 1982) cited undesirable effects of duplicative computer-mapping programmes and recommended vigorous actions by OMB and the Department of the Interior to be responsive to Federal data requirements.

In October 1982 the Secretary of the Interior moved quickly to effect co-ordination of production, storage, access and distribution of digital cartographic data of United States land areas. He gave lead-agency responsibility to USGS. To carry out this responsibility, USGS chairs the Interior Digital Cartography Coordination Committee. The committee meets regularly, and constructive discussions are held among the agencies on their programmes, plans, expenditures, requirements for digital cartographic data production, and equipment available by type and location.

Co-ordination of Federal Activity

In a further important development, on 4 April 1983, the Director of OMB issued a memorandum to the heads of executive departments, establishments, and independent agencies on the subject, "Co-ordination of Federal digital cartographic data programs". The purpose of the memorandum was to initiate a process to bring about the co-ordination of digital cartographic activities of Federal agencies. It established an interagency co-ordinating committee, to be chaired by the Department of the Interior, which was to consist of representatives of at least the following departments and agencies:

- Department of Transportation
- Department of Defense
- Department of Agriculture
- Department of Housing and Urban Development
- National Aeronautics and Space Administration Agency
- Department of Commerce
- Department of Energy
- Department of State
- Department of the Interior (Chair)
- Federal Emergency Management Agency

A steering committee was formed of representatives from these agencies. The Environmental Protection Agency was later added to the steering committee.

An organizing meeting for the Federal Interagency Co-ordinating Committee on Digital Cartography (FICCDC) was held on 27 May 1983, and was attended by 57 representatives from 23 Federal agencies. The next few meetings were involved with collecting information from the various Federal agencies to constitute the first annual report to OMB, which was delivered in October 1983 (FICCDC, 1983). The report concentrated on three goals:

(*a*) Development of a systematic approach for elimination of duplication and waste within Federal digital cartographic activities;

(*b*) Improvement of communication throughout the Federal Government concerning digital cartographic activities;

(*c*) Determination of necessary co-ordination mechanisms.

To best serve the needs of the FICCDC, the steering committee established working groups for reports, requirements, standards, technology exchange and applications. The working groups contributed to the development of a comprehensive questionnaire aimed at yielding an understanding of current capabilities, types of work being performed, kinds of data collected and standards being used. This questionnaire was sent to all Federal agencies and the responses to that questionnaire formed the basis for the second annual report to OMB (October 1984). The task of co-ordinating Federal digital cartography is a complex one. The agencies involved are taking a straightforward professional approach to solving a difficult common problem, and early results are encouraging.

Data Standards for Digital Cartography

There is a clear and well perceived need throughout the community for digital cartographic data standards. In recognition of the urgent requirement for standardization of data elements and representations thereof, a memorandum of understanding between the National Bureau of Standards and the USGS was signed in 1980, giving USGS the lead-agency responsibility for standards to be used in automated

earth-science systems, including digital cartography. As required by the terms of this agreement, and further mandated by assignments of the digital cartography leadership role in the Department of the Interior and in co-ordination with the other Federal agencies, the National Mapping Division (NMD) is developing and maintaining cartographic and geographic data elements and their standards for representation for use in the Federal community.

In line with this effort, USGS has produced seven chapters of *USGS Circular 895* (USGS, 1983b). This circular describes problems, assumptions, and approaches relating to digital cartographic data standards, sets forth the standards currently being used by NMD, and outlines USGS efforts to define *national* standards. The seven chapters are:

A. Overview and USGS activities
B. Digital elevation models
C. Digital line graphs from 1:24,000-scale maps
D. Digital line graphs from 1:2,000,000-scale maps
E. Land use and land cover digital data
F. Geographic names information system
G. Digital line graph attribute coding standards

The intent of these standards is that they be treated as draft documents, and that users throughout the broad community should comment substantially on the impact such standards would have on their work. It is of extreme importance that the user community be fully involved, and it is for this reason that NMD is actively supporting the work of the National Committee for Digital Cartographic Data Standards (Moellering, 1983).

The National Committee was established in 1982 and operates under the auspices of the American Congress on Surveying and Mapping. The Committee is structured into a steering committee and has working groups on (*a*) data organization, (*b*) data set quality, (*c*) features and (*d*) terms and definitions. Membership comes from Federal, State, and local governments, private enterprise and academia.

It is the stated goal of the Committee to provide a professional forum for public agencies and professional individuals to state their views, assessments, and proposals concerning digital cartographic data standards. The Committee has been requested to review the standards set forth in *USGS Circular 895*. After appropriate review, these standards will be submitted to the National Bureau of Standards for consideration as Federal Information Processing Standards.

Base map data as the framework

As expected, there is a growing demand for digitized base map data to form a reference for relating various other themes and data sets. In this regard, USGS has been digitizing base map categories from its various map series. The following list sets forth the types and scales of digital cartographic data presently in the National Digital Cartographic Data Base (Starr and McEwen, 1983).

Series	*Product (data type)*
1:24,000	Digital Elevation Model
	Digital Line Graph
	Land net
	Boundaries
	Transportation
	Hydrography
	Geographic names
1:100,000	Digital Line Graph
	Transportation
	Hydrography
1:250,000	Digital Line Graph
	Land use/Land cover (polygon)
	Census tracts
	Political boundaries
	Hydrologic units
	Federal land ownership
	Composite (grid cell)
	Digital terrain data (1° × 1° blocks produced by DMA)
1:2,000,000	Digital Line Graph
	Boundaries
	Transportation
	Hydrography

Of particular note in the above list is the work being undertaken in concert with the Bureau of the Census in which USGS is digitizing transportation and hydrography data from the 1:100,000-scale maps. This work is being done in preparation for the 1990 census, and USGS is digitizing these two categories for the entire conterminous United States with a required completion date of the middle of fiscal year 1987. Census will combine additional features and data and automatically produce enumerator maps for the 1990 census. It is a massive production project, and it will tax the resources and the ingenuity of both agencies to deliver the desired products on time to meet the required objective.

The products of the multipurpose GNIS data base (Orth, 1980) are proving to be of great value. In GNIS there are five distinct data bases, as follows:

(*a*) *National Geographic Names data base*: the primary data component of GNIS, which consists of descriptive information for all named features found on the maps of the topographic map series;

(*b*) *Topographic Map Names data base*, which contains descriptive information pertaining to the official names of the individual map sheets in the USGS topo map series;

(*c*) *Generic data base*, which is structured to serve as a research tool and as a depository for descriptive text information for GNIS (includes 61 feature categories);

(*d*) *National Atlas data base*, which contains descriptive information pertaining to the geographic names found in the index of the *National Atlas of the United States of America;*

(*e*) *Board on Geographic Names data base*, which lists all domestic geographic names decisions rendered by the Board on Geographic Names since 1892.

Conclusion

Much of the early work by USGS in digital cartography has been to serve Federal requirements in automating the mapping process. The earliest decisions by USGS to move more definitively into digital cartography were motivated by the proliferation of data being digitized by both government agencies and private industry from USGS maps, and the resulting knowledge that much of this digitizing was single purpose. Some of the same data were being digitized over and over again. The National Mapping Program is dedicated to reducing duplication to the extent possible, and it is building a national digital cartographic data base to make available to a variety of users a large amount of base data at nominal cost using standards that are communicated and well understood.

Two major national data bases are now complete and are serving the country well; these are the 1:250,000-scale dig-

ital terrain data produced by the Defense Mapping Agency and the 1:2,000,000-scale data base from the National Atlas. The soon-to-be-completed (1987) 1:100,000-scale data base for transportation and hydrography will be a welcome addition to the national data base. The 1:24,000-scale DLGs and DEMs, where they exist, are meeting requirements all across the country, and these data bases are continuing to grow.

It is most important now for users to communicate their needs and what they like and don't like about the national effort. Every effort will be made to heed these signals, with the intent of making the programme as responsive as possible.

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CARTOGRAPHY 1985: STATE-OF-THE-POSSIBLE*

Paper submitted by the International Cartographic Association

RÉSUMÉ

Il n'est pas facile à l'heure actuelle de faire le point des connaissances en cartographie. Les énormes progrès réalisés dans la collecte des données et dans l'automatisation des techniques cartographiques permettent maintenant d'avoir recours à au moins deux groupes de techniques. La présente communication traite de ce qu'on pourrait appeler "le futurible" de la cartographie et comporte trois parties : acquisition de données; stockage et traitement de l'information; recherche et présentation de l'information. Sous plusieurs aspects, cette discipline apparaît comme encore perfectible. L'International Cartographic Association souhaite vivement collaborer dans ce sens avec d'autres organisations internationales et nationales.

RESUMEN

En la cartografía contemporánea no resulta simple determinar el estado actual de la técnica. Debido a que simultáneamente están en curso la revolución en materia de reunión de datos y la relativa a la introducción de la tecnología de computadoras a la cartografía, actualmente se utilizan al menos dos grupos diferentes de tecnologías. En el documento se analizan las posibilidades actuales en materia de cartografía en tres capítulos, relativos a la adquisición de datos, el almacenamiento y manejo de datos, y la presentación y recuperación de la información; y se ponen de manifiesto diversas necesidades de la disciplina. La Asociación Cartográfica Internacional está muy dispuesta a trabajar con otras organizaciones internacionales y nacionales con el objetivo de satisfacer esas necesidades.

It is difficult, but at the same time interesting, to try to capture the essence of a body of knowledge at one instance in time. Cartography has evolved over the past 5,000 years from a cottage craft or art with no technology to a highly sophisticated science with a highly sophisticated technology. This is neither surprising nor rare. Further, as with many other disciplines, many levels of cartography continue to be practised, and through the years cartography has not dispensed with previous technologies as it has matured. People still draw spatial depictions of important relationships, crude maps, in the sand with sticks or with their fingers, or on the backs of napkins in restaurants, while at the same time information from satellites is processed through a computer to direct peripheral equipment to make an image of a spatial relationship. Admittedly, some technologies have fallen from use, but in most cases we know about them, find them unsatisfactory or uneconomical for current purposes.

History teaches several important lessons in this respect. In the history of cartography at least two patterns of activity can be identified. The first pattern shows that throughout history the cartographic discipline has responded to two types of innovations. The availability of new data suited to cartographic purposes has generally resulted in an increase in the development of new conceptual methods for manipulating and displaying that data. In the same manner the discovery of new technological innovations suited for cartographic purposes has generally resulted in the use of these technological innovations for the production of "better" maps. New data and new technological innovations usually preface an increased utilization and production of maps.

The second identifiable pattern of activity is that these innovations have normally come from outsiders to the car-

* The original text of this paper, prepared by Joel L. Morrison, President, International Cartographic Association, appeared as document E/CONF 77/L.56.

tographic discipline. An innovation is brought into the discipline from another discipline and initially a number of the outside practitioners carry the innovation beyond its cartographic usefulness and then leave the cartographic discipline as abruptly as they entered. For example, in the late eighteenth and nineteenth centuries many new thematic mapping methods were developed by statisticians and medical professionals who were concerned with the spatial spread of communicable diseases. Most of these individuals returned to their chosen professions, but their newly supplied methodologies were adopted by cartographers and today are some of our most common thematic mapping procedures.

Fortunately, cartography has usually taken the best and discarded the worst and has steadily improved on each innovation that has come forth. It is not surprising then that at any given time the discipline has several data sources and several usable technologies operating. It is not the purpose here to follow this second identifiable pattern of activity. Therefore, further discussion will be limited to the efforts of the current innovations in data and technology on cartography.

Finally, it must be recognized, as with life in general, that the pace of activity or rate of change in the discipline of cartography has increased throughout history. The frequency of innovation has increased dramatically or at least that is the prevailing impression. Furthermore, we are experiencing a time when both types of innovation, data, and technology are being introduced simultaneously into the discipline. Therefore, the situation may be, in fact, unique.

The major innovations that the discipline of cartography has experienced can be summarized as follows within the history of Western civilization. Data revolutions number at least three. The consequences of each are readily apparent. The first data revolution came about as a result of man's learning to accurately measure the earth. The rise of cadastre-type maps, of Ptolemy's list of the latitudes and longitudes of cities, and, finally, the rise of the portolan chart in Western Europe were some of the direct results of the incorporation of new, more accurate, data sources about the physical characteristics of the planet into the discipline. The second data revolution dates from the end of the eighteenth century and the beginning of the nineteenth, when censuses first began to be conducted and data about man's activities on the Earth were thus for the first time recorded. The cartographic results of this second data revolution were primarily the development of thematic mapping methodologies, which were used to map non-physical data distributions.

The third cartographic data revolution is currently in progress. It is the ability to capture and analyse highly accurate data about the Earth and some of man's activities on it by electronic means. The results, of course, are only partially known at this time. But it is certain that they include the ability to map more accurately distributions and relationships of Earth phenomena, some of which have never before been mapped (e.g., surficial temperatures using thermal sensor data).

Major technological innovations are equally important in cartographic history. One is the invention of the printing press. This resulted in the capability of producing multiple copies of maps easily and that in fact meant that more of the human race could have accurately made available maps than ever before. A second major technological innovation was photography. This innovation allowed the cartographer to bring the field into the laboratory on one hand and to more accurately reproduce the map itself on the other. Finally, today there is a third major innovation; the use of computer technology in cartography. Again the results are only partially apparent. It is certain, however, that new cartographic products are now possible and that the full extent of this innovation is uncharted as yet.

Cartography today is in the midst of simultaneous revolutions in data collection and map production. The consequences are considerable, and it is only by relating the historical antecedents that the state of cartography today can be appreciated. The direct consequences of the two revolutions are the emergence of an independent identity for the discipline, a thorough definition and redefinition of all of the terms and methods used in the discipline, the creation of new methodologies and products and the short-term increase in the separation between those cartographers who use computer-assisted technology and those who continue to use a manual or photomechanical technology. Cartography is becoming a pluralistic discipline. No longer is it limited to one technology and one product line. The very definition of the word map is being redefined. The remainder of this paper will concentrate on the state-of-the-possible in cartography today.

What is meant by "state-of-the-possible"? Where is cartography today, and where is it going? Certainly today many technological processes are in use in this science. Not only is new technology being invented and introduced, but the older technologies are still being improved. It is, therefore, difficult to view cartographic technology as a single topic. The technology used by the United States Geological Survey is not the same as that used by Rand McNally, nor that used by a county assessor's office in the middle of the State of Iowa. At the same time each of the above organizations is doing its job in what it believes to be a cost effective and efficient manner, which means that each is improving the technological processes that it is employing. This means that there is no single state-of-the-art in cartography today, but rather states-of-the-art.

It is quite appropriate that cartography can offer differing technological levels to its practitioners. Each nation or bureau has a different set of needs and economic priorities not to mention constraints imposed upon it from other sources. Whereas there may be an inexpensive supply of labour in one place, it may be absent in another. There may be places where there is a scarcity of highly trained personnel. The ability to maintain equipment also varies extensively from place to place. Replacement parts may be impossible to obtain in some areas. Finally, other constraints extraneous to cartography itself can also cause change. For example, a change in leadership or economic conditions may force a reduction in the number of employees available within a nation to do cartographic work, or it may foster the change and acquisition of new technological equipment. Therefore, it is appropriate for a group of cartographers to discuss innovations and improvements in all technologies when they convene.

To assess what is the state-of-the-possible in cartography today and try to forecast where it may be headed, it seems most convenient to divide the field into three major areas: data acquisition, data storage and manipulation, and information presentation and querying.

Data acquisition

As already stated, there is at present a revolution in data acquisition. Capabilities exist for capturing data by remote methods, from various altitudes, using various sensors sen-

sitive to specified bands of the electromagnetic spectrum. The combinations are many, and the stage of development has not yet been reached where a single sensor system is dedicated to the acquisition of a single data distribution; yet that would seem to be a logical step forward from the present position.

To date, sensors have been used to collect images that simultaneously include a variety of data distributions. For world-wide coverage, data have been collected by the series of LANDSAT satellites. Many experiments and studies performed by cartographers throughout the world have utilized LANDSAT imagery successfully. The first three LANDSAT imaging systems collected data with ground resolution of about 80 m using a multispectral scanning system. A thematic mapper sensing system was added to LANDSATs 4 and 5. This TM system yields data with a ground resolution of 30 m; and this is world-wide coverage which, theoretically, is available every 18 days for any area of the world, to any interested user. So today the state-of-the-possible for easily available comparable world-wide data collection by satellite is the LANDSAT system

Soon to be available will be data collected by the French satellite system named SPOT. It is presently scheduled for launch in October of 1985 and will yield data with ground resolution of 10 m. Although there are some significant differences between LANDSAT and SPOT, namely, the possibilities for stereo-coverage from SPOT, the finer resolution of the imagery, and the use of multiple-linear arrays instead of the movable scanner systems of LANDSAT, the similarities are of more cartographic importance, namely, world-wide continuous coverage with high resolution

Looking farther into the future is merely speculation at this point, but the trends are evident: a trend toward higher resolutions and in general a trend toward more cartographically friendly (i.e., useful for mapping purposes) data collection.

For data collection for specific purposes (i.e., non-world-wide coverage), there is an impressive array of sensors available for the cartographer to choose among. Many distributions, for example, the varying temperatures of water currents in a stream, have been cartographically captured by the use of specific film/filter combinations, or by specific band width scanning systems. The future will bring further refinement of such capabilities permitting data acquisition for even more specific purposes. The cartographer will increasingly realize that his job is not simply data collection but that he bears a major responsibility to transform that data into meaningful information for others. An image is one cartographic product that is like an unabridged dictionary or natural prairie—everything, as it exists, is shown on the photo. A map on the other hand is a cartographic product which has digested the data and manipulated it into a more usable form. It is a specialized dictionary or a cultivated field, where deletions have been made and enhancements have been specifically tailored to draw attention to a specific message.

In the area of local data collection efforts, there is a choice of several highly precise sensors mounted in aircraft. The future holds additional gains in the precision and accuracy of these efforts by allowing the employment of even more refined sensors. As the resolution of imagery from spacecraft approaches that available through aircraft, it would seem probable that a combination of world-wide or national general coverage from spacecraft would be combined with high resolution specific mission imagery from aircraft. At some future time, it may be that urban areas or regions may wish to have stationary satellites that cater to the needs of that region. Such satellites could provide the dual functions of monitoring change and also of keeping an up-to-date data base capable of being queried by individuals on the ground.

Imagine driving in your automobile and querying the data base contained aboard a satellite on the best route to get from your present position to your destination in an urban area. Your daily commuting route could be planned by such a data base before you left home in the morning, taking into account road construction and traffic conditions.

For data that cannot be remotely sensed—population, income and other socio-economic data—we are now in the era of the use of highly sophisticated sampling questionnaires. The statistical science of sampling has enabled the collection of highly accurate data with a relatively modest investment of resources. The future will find more of this type of data collection and an increasing amount of data being collected and tied to geographical position. The trend is for cartographers to know the details of spatial distributions more precisely, to be able to analyse these distributions to a greater degree and to display the essence of these distributions more exactly. This knowledge will be increasingly needed as planning models and forecasting models are refined. The future will lead to even more detailed psychological profiles of individuals who are selected as representative of the population in a given area. This trend will increase abilities to plan and to predict physical and human interactions.

Data storage and manipulation

In the arena of data storage and manipulation, the technologies used today in cartography vary widely. Whereas, in data acquisition, for the most part, the data are not personally collected by the cartographer, so that every cartographer has available roughly the same data, in the area of data storage and manipulation the processes the cartographer applies to the data depend upon the technology available. Many maps are still compiled manually. Some are compiled using a combination of plotted output from a data base with manual additions. Some are compiled entirely utilizing computer-assisted technology. Since most new data today are being stored in digital form, it makes these data readily available for reuse or multiple use. The same is not true of manual compilation. Manual compilation for the most part is map specific and must be redone for each map.

Cartographers work today with data in different forms: images, maps and digits. (Digits can represent data in one of two forms: vector or raster.) Cartographers must be able to convert from each form to each of the other forms, and this requires the following processes: digitizing, plotting, vector to raster and raster to vector conversions, and photographic manipulations. These storage forms for cartographic data, images, maps and digits (raster or vector), present differing problems for the cartographer. The conversion of images to digits is done through a process called scan digitizing. The conversion of maps to digits may be done by line-following digitizing, or by scan digitizing of the separation plates of a map and the converting of the resulting raster data to vector data. The conversion of digits to either images or maps is called plotting, and its particular form and the equipment needed depend upon whether the digital record is in raster or vector form. Finally the conversion of maps and photos to each other and to themselves is usually done via some photographic process. In some cases manual tracing is used in conjunction with enlargement or reduction by a mechanical machine, and occasion-

ally, if precision is not required, simple processes like xerography can be used.

Storage of cartographic data as images or maps is a library function calling for a cataloguing system that facilitates users to access an actual photo or map. Storage as digits is done on a variety of media, including magnetic tape or paper tape, floppy diskettes, hard disks, or laser disks. Images or maps can also be stored on video disks. There are at the present time two major concerns about the storage of digital data. One concern is the sheer volume of data, which is immense. The second concern is for the best logical arrangement to place the data on the storage medium. This latter question has opened an entirely new area of concern for cartographers: data structures. The structuring of cartographic data is important not only for its efficient storage but also for its eventual efficient use.

Today, the state-of-the-possible for cartographic data storage therefore is of two principle types: analog and digital. The processes necessary to convert from one to another are available, and currently the most perplexing problems appear to be the determination of the best storage structure for digital data and the handling of the immense magnitudes of these data.

The future will see increasing use of digital storage. Most major mapping agencies in the developed countries are converting their analog maps and images into digital records. The ability to transfer easily between different modes of digital storage will enhance this trend. Once cartographers experiment with and determine the preferred ways to structure the digital data, we can expect an even greater use of digital storage. The future will see improvements in the ability to store the immense quantities of cartographic data in readily accessible digital form. Archiving and updating that data will become major problem areas as will the detection and elimination of errors in the data.

Today the manipulation, as well as the storage of cartographic data, is technology-dependent. In the world of computer-assisted cartography, the current emphasis is on the creation of geographic information systems (GIS). A GIS is a package of analysis and presentation processes that allows the cartographer to create useful information by combining data from a digital cartographic data base with other statistical, socio-economic, and thematic data. At present, comprehensive GIS are not widely available but much work is being expended on the development of GIS. Several GIS are in existence which are outgrowths of the specific needs of their developers. A comprehensive generic GIS probably will not be forthcoming until the data structuring problem has received more attention and until more comprehensive data bases are available. The contents of a generic GIS are rather straightforward however, and most of the capabilities that such a GIS should possess are already available in one form or another, although they are not always compatible with one another.

On the manual technology side, the manipulation of cartographic data makes use of the statistical processing of data and often the more sophisticated uses employ processing by computers. The cartographic manipulations themselves may still be done manually with the aid of a wide variety of dimensionally stable materials and photographic processes. In the future, great advances are not foreseen in the present manual cartographic manipulation techniques, but rather refinements of them. The trend would seem to be toward the increasing use of computer-assisted GIS manipulation and away from the manual manipulations.

Information Presentation and Querying

In this area the effects of computer technology have been the least. In the early stage of computer use in cartography, the quality of the presentation of information was considered substandard to that of the manual technology. The author held the thesis that it would be impossible for cartographers to take full advantage of the potentials of computer technology until they had demonstrated conclusively that the high quality of manual production of topographic maps could be replicated by computer technology. This has only been recently accomplished and, therefore, it is too soon to look at the use of new capabilities resulting from the use of computer technology, as we have not as yet taken full advantage of the capabilities.

It is clear that computer technology does offer a wider spectrum of map products than does the current manual technology. Taylor has recently summarized the situation as follows: "The greatest educational challenge facing cartography does not lie in teaching or learning new techniques, but in creating a radically new conception of our discipline" (Taylor, 1984). He is correct in this assessment. Once cartographers change their conception of the limits of their field, a vast array of cartographic products will come into use that are not available or are not used today.

There are many questions for which people consult a map for answers. Using computer technology, the questions may in some cases be posed directly to the data base and the answer given directly to the person by the computer without the necessity of a map. In other cases the map that is necessary is much more simplified than any printed map which the user has available to consult. In both of these cases the actions involved are concerns of the cartographic science. In short, cartographers will no longer have as their end product a printed map on a sheet of paper that must serve a variety of users for a variety of purposes. Once the presentation and querying of cartographic data bases are made easy for map users they will undoubtedly prefer to receive their needed information through some product other than a printed map sheet. Specific cartographic products will exist to answer each specific query. This will be a tremendous change for some, and the demand for printed paper maps can be expected to continue for some time.

The state-of-the-possible in information presentation and querying is today not much different from what it was 25 years ago. There are experimental or prototype systems available, but no comprehensive widely used computer technology-based system is available that compares to walking into the nearest bookstore and purchasing a printed map sheet of the area of interest. As yet the computer technology does not exist that is the equivalent of an atlas, or a road map, or a tourist brochure. Yet the work on a computerized road map that can be installed in an automobile is advanced, and prototype systems are now available. The full-scale use of these systems awaits the creation of the necessary data bases, however. Perhaps within the United States and several other nations we are five years away from a large-scale adoption of video-map displays in automobiles. From a cartographic point of view let us hope that the incorporation of this cartographic product into automobiles at least equals that of the CB radios of a few years ago. Cartographers can aid these developments by playing a major role in the development and creation of the data bases necessary to support such systems.

The future will bring many changes. There will be the capability to have video-map displays at critical points in cities for visitors to consult. In the lobby of the United

Nations building there should be available information packages playable on video terminals for each of the Member nations of the United Nations. Such packages should contain maps illustrating the geography, history, and culture of the Member nation. Hotels should have information guides that include street plans of where sites are located with respect to one another within the city. It is even conceivable that hand-carried terminals could be available to interact with stationary satellites above a city to keep an individual informed where he is located in the urban complex. It is certainly possible for a person to wear a tracer to which the sensor could respond and thus always know his location relative to the city. Of course, individuals must retain the right to turn that sensor on and off at will.

Needs of the Cartographic Discipline

These last statements do not represent the state-of-the-possible today. Printed maps, atlases, and images as planning tools are still, and will be, needed. Perhaps the major need in cartography today is one of education and training. Not only must cartographers be trained to use the new technology as appropriate, but the vast number of citizens of the Earth must be educated to think spatially, and to realize the usefulness of cartographic information. A comprehensive programme of education and training in cartographic basics is vital. We cannot, owing to the numerous technologies now being employed in cartography and to their rapid change, educate and train via technology dependent processes. The basics of cartography must be part of every citizen's education. Curricula in map use must be available for the ordinary citizen through the public school systems of each nation. Specialized curricula for cartographers must also be designed. But once again, because of the increasingly rapid changes in technology, these curricula must be technology independent until the cartographic basics are well understood. Continuing education and training for the cartographic professional must also be emphasized, because it is impossible today to train an individual in cartography techniques that will enable that person to be gainfully employed for the next 40 years without some form of retraining.

A second need for the discipline is its recognition as an independent science. This can only be accomplished through a two-stage approach. First, the practitioners of cartography must thoroughly understand the cartographic science and believe in it and, second, by solidly executed research, development, and production programmes, the cartographic science must gain the respect of its other sister sciences. This is a long-term goal.

Finally, a change in attitude on the part of many practitioners in the discipline is needed to decrease the reliance on tradition and to enable the more rapid incorporation of changes in technology and data collection into current cartographic practice. Cartography is a conservative discipline with a long and often glorious history. Cartographers can be justly proud of its accomplishments but they cannot ignore the current developments or refuse to take advantage of them. To do so would cause the discipline of cartography, as presently known, to become an anachronism and allow other disciplines to take over its rightful place among the sciences.

In pursuing these needs, there are several encouraging signs. Since the 1950s there has been a rapid rise in the number of professional cartographic societies and in the number of professional journals devoted to cartographic subjects (Wolter, 1975). Some may say that there is even an over-abundance of cartographic meetings. On the international level, the 25-year-old International Cartographic Association (ICA) has established a firm foundation and is willing to lead and to co-operate with the other international organizations in furthering the cartographic science.

The ICA now has 62 member nations and two affiliates. There are 14 standing commissions, *ad hoc* commissions, and working groups within the ICA covering such diverse subjects as tactual and low vision mapping, thematic mapping from satellite remote sensing, map use and the history of cartography, to name only four. ICA has a policy to transfer technology to the third world and has held five seminars to date in China, India, Indonesia, Kenya, and Morocco. ICA has recently published the first volume of a basic manual on cartography, and the second volume is scheduled for printing. The purpose of this two-volume manual is to address the cartographic basics in a manner understandable to potential cartographic technicians. ICA has also sponsored or encouraged the publication of other basic works for cartographic scientists, including the *Multilingual Dictionary of Technical Terms in Cartography*, and a *Historical Glossary of Cartographic Innovations to 1900*.

There is much that can be done. ICA, in co-operation with the United Nations, could promote cartography throughout the world. For example, the African Association of Cartography (AAC), declared 1986 as the Year of Cartography in Africa. ICA offered to assist the AAC in some of these activities. Many organizations are already preparing to celebrate in 1992 the 500th anniversary of the discovery of the Americas by Christopher Columbus. Although many may dispute the "first" aspect of Columbus' voyages, no one can dispute that his voyages did begin the systematic European settlement and exploitation of the two American continents. As such, much land was added to world maps and the event was of major importance in cartography. Perhaps a World Cartographic Year should be planned for 1992. ICA and the United Nations, with help from other international organizations, could plan activities to raise the cartographic consciousness of all the citizens of the world. The help could be enlisted of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council of Scientific Unions (ICSU); and of regional associations such as AAC, the Organization of American States (OAS), and the Pan-American Institute of Geography and History (PAIGH). On another scale, the United Nations in co-operation with ICA and others could embark on a comprehensive training programme that would keep cartographic practitioners technologically current regardless of the technology they currently employ. ICA is willing to discuss such initiatives with other world organizations at any time.

Conclusion

Maturing is difficult. We are maturing not as cartography, but as a science. The transition from a cottage craft (art) to a rigorous science employing sophisticated technology has been accomplished. It remains only to continue the rigorous pursuit of our science and to explore and explain its many helpful contributions to mankind. It is an exciting time to be associated with cartography. Cartography remains a science small in its number of participants, yet vitally necessary in the world of the late 20th century. We have the data collection innovations and the technological innovations necessary to take a quantum step forward in the history of our discipline. Let us not miss this opportunity, or worse

yet, allow others with no appreciation for the long history of cartography to take the lead in the profession.

How may the state-of-the-cartographic-art be characterized in 1985? It is vibrant. The technologies used are rapidly changing, and capabilities never before possible are being realized. A professional identity for cartographers is emerging, and the realization that we are all interconnected on this planet and that cartography plays a vital role in enabling us to live together, both with nature and with other cultures, means that a golden age of cartography may be beginning. Let the United Nations, ICA, UNESCO, UNEP, ICSU, and other international organizations join together to foster world cartographic consciousness for use in the betterment of man and his planet.

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AGENDA ITEM 8*

Review of the latest developments related to policies and management of national mapping and charting programmes

(a) *Matters related to the establishment of national programmes*

MANAGERIAL AND TECHNICAL ASPECTS OF DIGITAL MAPPING AND AUTOMATED CARTOGRAPHY**

Paper submitted by Canada

RÉSUMÉ

L'auteur examine les facteurs qui influent sur la décision de s'engager dans la cartographie numérique ainsi que les attributs importants des banques de données topographiques. Il décrit l'organisation d'une unité de cartographie numérique, en suppute la rentabilité et explique l'influence que les banques de données topographiques exercent sur l'acquisition, l'emmagasinage et la diffusion de l'information.

RESUMEN

El autor examina los factores que influyen en la decisión de iniciarse en la cartografía digital, así como los atributos importantes de las bases de datos topográficos. Describe la organización de una unidad de cartografía digital, examina su rentabilidad y explica la influencia que ejercen las bases de datos topográficos sobre la adquisición, el almacenamiento y la difusión de la información.

Developments in the last decade in computer technology, particularly in the field of computer graphics, have opened new vistas to the mapping community. These developments have far-reaching implications, with effects on the collection, storage, display and use of topographical information that are not yet fully appreciated.

Digital mapping and computer assisted cartography are today recognized as an integral part of mapping activities at every level of responsibility, be it the basic national topographic mapping, detailed engineering maps of urban areas, cadastral and land information systems and utility digital data bases, or terrain data for communication, hydro or other engineering projects needing terrain information for computer studies.

Today, an increasing number of users demand terrain data in digital form in addition to or in place of the traditional graphics. In the traditional approach, the graphic manuscript or the reproduction negatives are the principal archival storage of the terrain information. In digital mapping, the graphic manuscript is replaced by a digital data file, and the graphic data base is replaced by a topographic digital data base.

Digital mapping technology has the potential to greatly facilitate the use of terrain data by many other professions that are employing geo-referencing principles for the presentation and analysis of their own data, and are overlaying information peculiar to their disciplines upon a topographic map (or a skeleton of it) to display an almost infinite variety of themes. The use of "digital maps" in mathematical modelling for engineering and other applications is increasing steadily.

These professional users of digital terrain data cover a number of disciplines in which geographically referenced terrain information plays an important role in engineering design, in land related information systems and in the decision making process.

The impact of digital mapping is beginning to change a number of well entrenched philosophies and practices, and is forcing the photogrammetrist as well as the cartographer to re-examine the entire concept of collecting, disseminating, displaying and storing terrain information.

Some look upon these developments as a new challenge and exciting opportunity. Others consider them a necessary evil. The difference between *digital mapping* and *computer-assisted cartography* should be underlined. They are two separate, but related, activities and it is important that the distinction between them should be fully understood so that new concepts can be developed and formulated that are applicable to the digital era.

Digital mapping is a system for collecting, classifying, storing, retrieving and managing of terrain data in digital form in a manner that is not tied specifically to a single application and that facilitates the use of this digital data for a multitude of applications. Digital terrain data do not have a scale as a map has.

Computer-assisted cartography, on the other hand, is a system for producing graphics from the data contained in the "digital map" by means of computer-assisted carto-

* For other papers covering matters related to the establishment of national programmes, see also country reports listed under agenda item 4.

** The original text of this paper, prepared by J. M. Zarzycki, Director, Topographical Survey Division, Department of Energy, Mines, and Resources, Ottawa, appeared as document E/CONF.77/L.49.

graphic methods employing proper symbolization to provide a clear and pleasing visual representation of the terrain.

Decisions regarding digital mapping

Every manager, whether at the national, provincial or municipal level, is faced today with a difficult but important decision: to what degree, or whether at all, one should enter the field of digital mapping. Three basic questions must be asked:

What are the advantages of digital mapping in the operation in question?

What should be the scope of the digital mapping activity?

How should the required level of digitization be implemented?

A textbook answer to these questions will not be given here, but some light may be shed on the entire problem of digital mapping and computer assisted cartography, based on the experience of developing and implementing digital mapping at the Topographical Survey of Canada. In this agency, digital topographic maps are now routinely produced and a digital topographic data base created which eventually will cover the entire Canadian land mass.

Digital mapping is here to stay and is going to have an increasingly important impact on everything cartographers do. The decision therefore is when the digital mapping field should be entered and for what purpose. No one should employ modern technology simply for its own sake without a careful study of the costs and an analysis of the resulting benefits to the organization and the users of terrain information. One should not be mesmerized by the computer, and expect that the computer will solve all problems and provide answers to complex questions by the simple touch of a button. Such blind reliance would only lead to disappointments and disillusionment, for a computer has only as much intelligence as we are capable of putting into it. In some applications computers perform superbly, in others they are very inept. A human looking at a map immediately perceives the spatial relations between features; for example, that a river is close to a road, or a church is next to a school, or that a certain house is above a given elevation. But, as soon as a map or aerial photograph is digitized, all relationships between features are destroyed. The computer is not capable of recognizing or interpreting these relationships, unless, in addition to the terrain data, we include topological information and introduce complex data structure with the associated extensive software. Simple digitizing of topographic features will result in digital data suitable only for production of primitive graphics and not a digital data base capable of satisfying a multitude of analytic and graphic applications.

One of the fundamental considerations when setting out on the road of digital mapping is the philosophy to be followed by the organization, which must be the acquisition of either (*a*) terrain data in digital form for the purpose of creating a digital terrain data base; or (*b*) cartographic representation in digital form for the purpose of producing graphics by means of computer-assisted cartography.

Approach (*a*) will result in a very flexible digital mapping system, which, in addition to the creation of a geographically referenced digital data base, will permit production of a multitude of graphical products by means of computer-driven plotting tables or cathode-ray tubes. But before such a system operates efficiently, it requires the incorporation of a sophisticated taxonomy of topographical features, topological structuring, an efficient reference system for all data, and a file structure that provides for extensive data-base management operations.

The structure and sophistication of the total system will determine the degree of usefulness of the collected data. The structure and composition of data base management systems are being investigated and vigorously discussed by mapping experts and computer scientists in production agencies and in academia. Although great progress has been made in understanding these problems, a fully satisfactory solution has not yet been achieved. Much still remains to be done.

Since it is not feasible to foresee all possible applications of digital data, the data is *ipso facto* collected without prior knowledge of all subsequent possible users. Therefore, digital data must be classified, collected, and stored in such a manner that their eventual use is not tied specifically to a single application. The data must be stored in files so that they can be retrieved in an orderly manner, based on the knowledge of the data content and data organization of the files. In addition to these files, functions are needed for the user to define, in terms of a logical model, the data elements required and the particular association between these elements. The digital file and these functions comprise a digital data base. Such a system cannot be acquired by simply purchasing one of the commercially available digitizing instruments but must be assembled with the various components being joined by specially tailored hardware and software systems.

Approach (*b*), although less costly and simpler to implement, will not result in the creation of a digital data base capable of serving users who need terrain data in digital form, but it will give a computer-assisted drafting capability. It is often not fully appreciated that the simple digitizing and encoding of terrain data for subsequent drawing by a computer-assisted drafting table will not satisfy the need of most users of digital data.

In the author's view, the approach to follow is (*a*), that is, to create a digital terrain data base capable of satisfying the needs of the users of digital data by providing a foundation for a geographically referenced information system and the capability of generating a variety of graphic products.

Digital data acquisition

The input to a topographical data base comes basically from two sources: (*a*) digitization of existing graphics; or (*b*) direct digitization from air photography by photogrammetric instruments.

The choice between one and the other method depends very much on local conditions and requirements. A country that has accurate, up-to-date maps at different scales would most likely opt for digitizing of existing graphics by employing manual digitizers, semi-automatic line followers or raster scan techniques combined with vectorizing software.

The development of interactive graphic data collection and editing systems makes the digitization of photogrammetric instruments a practical proposition. It gives the stereo-plotter operator unrestricted access to the digital data of the stereo-model he is compiling, and of the surrounding stereo-models that have been compiled by him or others. The operator may view the digitized features at any scale on a CRT and perform any necessary corrections or editing. He can tie in adjacent stereo-models and make any required changes to the digital data that he normally would make on a pencil manuscript in the graphical compilation mode.

The accuracy of the topographical data acquired by graphical map making methods and then subsequently digitized is always constrained by the compilation scale. However, this is not the case when terrain data is digitized directly in the stereo-plotter. Whereas in the traditional mapping process the original graphic manuscript compiled photogrammetrically at a given scale is the limiting factor covering the accuracy of topographic data, in digital compilation, the accuracy of the data is limited only by the scale of the photography and the visual acuity and manual dexterity of the photogrammetric operator. The accuracy of the digital data is independent of the map scale. There is no displacement of features to avoid crowding and no slippage of the scribing tool in following a difficult line. The digital data compiled photogrammetrically is always of a higher accuracy than on the resulting graphics. Thus, maps at several scales can be automatically drawn from the same photogrammetrically acquired digital data, and the graphic accuracies that are standard for each scale are maintained on the final products.

Implementation of Digital Mapping System

One of the common mistakes managers make when starting on the road to digital mapping is that they expect too much, too fast, which leads to disappointment and disillusionment. It should be realized that there is unlikely to be a "turn-key" system available which will totally satisfy the needs of an organization. Buying a digital mapping system is not the same as buying a stereo-plotting instrument which can be put to work the day after it is installed and calibrated.

While the capabilities and potentials of digital mapping systems are not difficult to perceive, there is a nearly universal ignorance of the processes and time requirements for the design and implementation of a truly effective production system. The start-up phases of a digital mapping system will require, in addition to training of personnel (which takes approximately six months) the definition, development and implementation of application software and procedures. In addition, it is very important that the change in the overall philosophy of the organization is vigorously fostered and implemented, so that energy is not directed into trying to emulate current manual practices. Every effort must be made to develop procedures that take full advantage of the power of digital technology.

Present cartographic specifications were influenced by the abilities of the human draughtsman and limitations of manual methods. Over the centuries, the cartographic conventions have evolved from artistic portrayal of the terrain to a more technical or scientific representation of the Earth's surface. Digital maps are a step in this evolution. New specifications must be devised to take full advantage of the opportunities of digital technology, but they must also satisfy the prime objective of making a map that will portray the terrain with clarity and fidelity.

The implementation of a digital production system requires several commitments and adjustments by a traditional organization. The primary requirements are listed below:

1. The production supervisors must be highly motivated to digital methods and must be capable of comprehending the potential capabilities of the method and initiating changes to exploit the system.

2. The production staff, while being motivated, must also be capable of adapting to changes, not only on entry to digital methods but subsequently as techniques are modified.

3. Planning and programming must be adjusted to exploit the peculiar features of the digital system.

4. Quality control and specifications must be adjusted to accept the consequences of digital approaches, such as data densities, and should take count of, and exploit, the capabilities of digital systems, for example in the drawing of close spaced lines, smaller yet more complicated symbols etc.

5. An ambience which is sound and suitable must be provided in support of the digital equipment and operation. The lack of adequate space, climatic control etc., can result in particularly disastrous consequences during the start-up and evaluation phases.

6. Supervisors must be able to detect and solve technical problems which may require software modifications, refinements or development of new software. Problems which appear during early stages of production result from situations and conditions that could not be foreseen and depend a great deal on the specific input and product expected, as well as the decision taken as to the design of the system.

7. A high level of skilled maintenance must be available in order to assure problem-free operations.

After a digital mapping system has undergone a running-in period (which could last approximately six months) it must go to a phase which I would call "tooling for production" or "pilot production". At this stage, the digital mapping section operates in a production environment and undertakes compilation of different types of terrain to test and ascertain the capabilities of the system. Operational processes are improved and software is enhanced during this phase. This is the "shakedown" period of the total digital mapping system.

Successful operation of a digital mapping unit will be better assured when the total integrated system approach to management is practiced. It is essentially a carefully considered, meticulously executed master plan for a coordinated design, development and integration of many elements that constitute the end product. Any diversion, however small, from the established procedure and master plan may render data useless, cause the system to crash, or require costly manual intervention.

The development, implementation and operation of a digital mapping system is a joint effort between the photogrammetrist, cartographer and computer scientist. However, the conceptual design and management of the system must be in the hands of the map maker and not the computer scientist. The computer scientist is an essential member of the team, but he must be subservient to the professional map maker.

Economics of Digital Mapping

The performance of the digital mapping system is often measured *vis-à-vis* traditional manual methods with little regard being given to the value of the digital topographic data base from which, in addition to digital applications, a number of graphic products can be produced on demand. Evaluation of the cost and efficiency of digital mapping must take into account the value of the digital data in addition to the graphical products derived from it.

The cost-effectiveness of sophisticated digital mapping systems employed exclusively for the purpose of producing graphics by means of an automated drafting table, and disregarding completely the value of digital data, is question-

able at best. The actual or perceived savings in manpower cannot, at present, offset the substantial cost of capital equipment.

Graphical outputs can be produced semi-automatically by other simpler means. We have on the market several "intelligent" drafting tables which can be attached to stereo-plotting instruments in place of the older-type tables. This innovation reduces significantly a number of manual drafting operations at large map scales, and although such machines will not produce the quality of product of a sophisticated digital mapping system, they are considerably less expensive and simpler to put into production.

The economic viability of a sophisticated digital mapping system which produces a digital data base for the purpose of disseminating digital terrain information, providing a foundation for a geographically referenced terrain system and for production of a multitude of graphics, depends on the value we put on the digital data. The value of this data is not difficult to perceive, but it is difficult to quantify.

In terms of the process to be used in acquiring digital data, in the case where new compilation is needed it is more economical to collect the topographical data directly on the stereo-plotting instrument than to first compile conventionally and then digitize the resulting graphical manuscripts.

Need for Standardization

Rapid explosion of digital mapping technology and, particularly, relatively easy access to a growing number of digitizing instruments have created, in some countries, a proliferation of digital data collected at different levels of government, utilities and private companies, without much thought being given to a common standard which would facilitate exchange of digital data.

Ideally, the same topographical feature, whatever it be—a road, house, property boundary or telephone line—should be digitized only once by whatever organization has the first need for these data. They should then be supplied to other users. Certainly, such an ideal situation will not exist, despite best efforts on everyone's part. However, in the digital area, duplication of effort can be substantially reduced if there is good will on the part of all concerned. A uniform digital data base which would satisfy the needs of all organizations is not feasible, nor is it required in order to achieve the objective of exchanging digital terrain data. What is needed, however, is a national standard for the exchange of digital terrain data which will facilitate communication between distributed data bases. The standard should cover the following three aspects:

(*a*) Classification (taxonomy) of topographical features;

(*b*) Standards for quality evaluation of digital topographic data;

(*c*) EDP standards as applied to digital topographic data.

Of all these, the taxonomy of topographical features is most crucial. For example, it is essential to know how a road is defined — by the centre line, the width of the pavement, or the right-of-way. Should the width of the pavement be an attribute or a separate feature? Does the right-of-way belong to the road or to the cadastral data? Is the ditch along the road a part of the road feature or does it belong to the drainage feature? These questions must be settled before a meaningful exchange of digital topographic data can take place. In Canada, preparation of national standards for the exchange of digital topographic data is now in progress. A draft of these standards is now available.

Implications of Digital Mapping and Computer-Assisted Cartography

The rapid development of computer technology (particularly computer graphics) and the automated digitizing of existing graphics have already made a great impact on the cartographic profession, and they offer new avenues and opportunities to those engaged in providing and managing terrain information. These developments have far-reaching implications which will affect the acquisition, storage, display, dissemination and use of topographical information.

In the traditional approach, the graphic manuscript or the reproduction negatives are the principal archival storage of the terrain information. In digital mapping the graphic manuscript is replaced by the digital data file, while the graphic data base is replaced by the digital topographic data base. Digital mapping technology has the potential to greatly facilitate the use of terrain data by the many other professions that are employing geo-referencing principles for the presentation and analysis of their own data. Practitioners in such disciplines overlay information peculiar to their field upon topographic maps to display an almost infinite variety of themes. The use of digital maps in such work is greatly on the increase. The use of digital terrain data in mathematical modelling for applications such as communications, transportation, hydrography and remote sensing is increasing rapidly.

When we speak of a map at a given scale, we intuitively form a mental concept as to the accuracy and content of the terrain information on that map. However, in terms of digital data, "scale" becomes meaningless. We have to develop and get used to a new concept applicable to the digital environment which would be equivalent to the concept of "scale" in the graphical environment. This new concept would include standards of geometric accuracy, precision and level of topographical content of digital data.

Traditionally, terrain elevation is represented by contours. This type of relief depiction is well understood by most map readers, but for computer applications the relief is best represented by a digital elevation model (DEM). It could then be argued that the digital topographic data base should contain DEM information and not contours. Contours at different intervals could be automatically generated on demand from the DEMs.

In digital mapping, at medium and small scales, two basic types of digital files should be considered: (*a*) the Position File; and (*b*) the Representation File. The Position File contains edited and checked data collected directly in digital form on photogrammetric instruments or from large-scale plans where the position and shape of features are not distorted by cartographic representation. In this file all topographical features are recorded in their true geographical positions, without regard to cartographic symbolization.

The Representation File is created by the cartographer for each scale of map from the Position File. A computer-assisted interactive graphic system permits the cartographer to displace or delete features, select the proper symbols, then issue appropriate commands for the automatic drafting of colour separation negatives.

Since the geometric accuracy of terrain data is contained in digital data, the positional accuracy of the graphics could be of secondary importance. One can foresee that in the future, maps will be printed and distributed in a different manner than today. The production of printing plates directly from digital representation files would eliminate most, if not all, of the photomechanical processes. The distribution of digital topographic data would have to make adjustments

to cope with the digital era. It should be completely clear that dissemination of terrain information in digital form will be quite different from selling of printed maps. The type of data to be provided, format and the extent of pre-processing as part of the user's services will affect the type of staff needed, the size of the organization and the cost of distributing digital terrain data. The almost unlimited flexibility of digital data may result in user demands for very specific information and a greater variety of data than is commonly the practice with graphical data bases. Organizations, or even individuals, could interrogate regional digital topographic data bases and view a map displayed in a CRT in their office, or at home. They may even have the ability to produce the map of the areas of their interest in monochrome or in colour.

The technology to accomplish this is now available. We can now see on our television screen our favourite movies displayed from video tape and will shortly be able to do shopping in our living rooms, watching and examining items we wish to purchase. Items will be displayed on our TV screen at our command. It may not be long before topographical maps could be displayed on a television screen or CRT for study in our homes before taking a vacation trip, or in our office for technical studies.

The managers of mapping organizations should react positively to the new opportunities offered by digital mapping technology and adjust their organizations accordingly, in order to take full advantage of this powerful new tool.

METROLOGICAL LABORATORIES AS AN INDISPENSABLE TOOL IN THE ACTIVITIES OF THE NATIONAL GEODETIC SERVICES*

Paper submitted by Poland

RÉSUMÉ

Cette communication traite des mesures géodésiques pour lesquelles un calibrage des instruments de mesure est particulièrement important ainsi que des erreurs d'observation dues à l'emploi d'instruments n'ayant pas été contrôlés et testés. L'importance de ces problèmes pour les services géodésiques nationaux, chargés de superviser divers travaux géodésiques dans le pays, est soulignée. D'où la nécessité pressante d'établir des laboratoires métrologiques nationaux dûment équipés pour contrôler et tester des instruments géodésiques (théodolites et niveaux), gravimètres, télémètres et mires de nivellement de haute précision. On propose l'organisation d'un tel laboratoire comportant plusieurs ateliers spécialisés : mesure du temps (fréquences), gravimétrie, contrôle des théodolites, des niveaux et des télémètres, atelier équipé de comparateurs pour examiner les mires de nivellement de haute précision et autres étalons. L'équipement de base d'un tel laboratoire est énuméré. On signale aussi que l'organisation des laboratoires métrologiques doit coïncider avec l'organisation du service spécialisé de maintenance des instruments utilisés en géodésie et topographie.

Il est indiqué dans la communication que chaque pays doit posséder ses propres étalons (de longueur, de temps, de fréquence, de pesanteur, etc.) ainsi que des bases nationales pour le calibrage des télémètres, des gravimètres et pour l'essai sur le terrain d'autres instruments géodésiques; de même, on mentionne l'expérience du GEOKART dans l'organisation de tels laboratoires et dans la formation du personnel indispensable pour un service fiable de maintenance dans les laboratoires métrologiques.

RESUMEN

Se han examinado en el documento las mediciones geodésicas que requieren una calibración especial de los instrumentos de medición, así como los errores de las observaciones geodésicas resultantes de la utilización de instrumentos con los cuales no se han realizado investigaciones y ensayos. Cabe destacar que estos problemas revisten gran importancia para los servicios geodésicos nacionales que se encargan de supervisar todo tipo de labor geodésica en el país. Por lo tanto, es necesario establecer laboratorios metrológicos nacionales dotados de dispositivos que se puedan adaptar para efectuar investigaciones y ensayos de instrumentos geodésicos, teodolitos y niveles, gravímetros, telémetros y miras de alta precisión. También se propone la organización de algunos cursos prácticos especializados, por ejemplo, cursos prácticos sobre tiempo, frecuencia, gravimetría, ensayo de teodolitos, niveles y telémetros, comparadores para realizar investigaciones de miras y otras cintas de alta precisión. Se consigna la lista del equipo básico con que debe contar este tipo de laboratorio. También se señala que la organización de los laboratorios metrológicos debe coincidir con la organización de servicios especializados de mantenimiento de los instrumentos utilizados en la práctica geodésica.

Se indica además que cada país debe poseer sus propias normas nacionales, por ejemplo, normas de longitud, tiempo, frecuencia, miligalios, etc. Deben determinarse además las bases nacionales necesarias para la calibración de telémetros, gravímetros y la investigación sobre el terreno de otros instrumentos geodésicos. Se menciona además la experiencia adquirida por GEOKART en la organización de este tipo de laboratorios y en la enseñanza del personal profesional respecto de los elementos indispensables para la labor de mantenimiento autónomo en los laboratorios metrológicos establecidos.

It is indisputable that geodetic measurements are best performed with tested and properly maintained equipment. As examples of the most important sources of systematic errors of geodetic networks, deformation of networks, errors of scales, errors of point determination etc., one can point to linear measurements performed by means of uncalibrated distance meters, angular measurements taken with untested theodolites, levelling measurements carried out with un-

* The original text of this paper, prepared by Janusz Sledzinski and Boguslawa Kalinowska-Sledzinska, Geodetic and Cartographic Export Enterprise, appeared as document E/CONF 77/L 46

comparated measuring rods, gravimetric measurements performed by means of uncalibrated gravity-meters or astronomical measurements taken with improperly tested clocks etc. Such errors considerably decrease the quality of the network, or they disqualify it.

The above facts are generally understood. However, not enough attention is paid to the problems connected with permanent and periodical maintenance as well as with the testing of geodetic equipment. Owing to lack of metrological laboratories, field measurements are often performed with uncontrolled and uncalibrated instruments that take into consideration only a few, approximate corrections, which are specified by the producers and not updated in time. This becomes important when geodetic networks are established over areas without any geodetic background, when the early detection of systematic errors resulting from the use of untested instruments is impossible. The results of measurements of elements of the same network measured with different, untested instruments are characterized by considerable systematic differences. It should be stressed that many observed differences between particular parts of the network, as well as closure errors of polygon and chain loops, can be explained by the lack of proper testing of measuring instruments.

The present paper points to the necessity for organizing proper metrological laboratories in each country. Such laboratories should be equipped with devices for maintenance and testing of commonly used geodetic instruments and they should maintain national metrological standards. Main errors resulting from the use of untested instruments are also described as well as the principal laboratory work needed to ensure their proper working conditions.

Examination of theodolites and levelling instruments

Theodolites and levelling instruments are still the basic geodetic instruments; however, much new specialized equipment has lately been invented which, developed over a long period of time and equipped with numerous additional devices, makes field-work easier (digital displays, self-levelling devices, laser devices etc.). Still, the principles of angular measurements with the use of theodolites as well as the principles of geometric levelling remain the same. Nowadays instruments should fulfil basic geometric conditions, and they should be periodically maintained and examined for use in field-work. Only well maintained and tested instruments will ensure high accuracy, and this is especially true when the equipment is used in difficult geographical and climatic conditions, such as deserts, areas covered with dust, areas of high humidity etc. In such conditions it is necessary to perform very careful periodic testing of theodolites and levelling instruments.

It has been stated that even theodolites of high quality are characterized by considerable random as well as long and short periodic errors of graduation of the circle, which influence the results of measurements. Standards of geodetic instruments do not always correspond to the standards published by their producers, a fact that is another reason for establishing quality control of new or used instruments.

Periodic maintenance of instruments includes the cleaning of internal optics and lubrication of mechanical parts, their regulation and adjustment and replacement of used-up parts. Testing of an instrument aims at determining the errors of mechanical and optical parts (for example, determination of the systematic errors of optical micrometers, circular division, inclination, self-levelling compensators etc.) as well as checking the real achievable accuracy of particular instruments. As a result of the testing, classification of an instrument within a proper class of accuracy should be obtained.

In order to maintain and test instruments, it is necessary to organize a laboratory equipped with indispensable stands and pillars, allowing the performance of all activities connected with maintenance and testing. Organization of such a laboratory should be done keeping in mind complete service for geodetic instruments. Different types of instruments of different producers require various auxiliary devices for maintenance and testing, and this should be considered during organization of the laboratory.

The laboratory should be in a place that would permit proper conditions to be maintained (stability of temperature, tidiness, anti-dust protection etc.), and it should have necessary maintenance equipment and important spare parts. There should be a sufficient number of independent pillars and devices for testing optical and mechanical parts, such as equipment for determination of the errors of graduation of the theodolite circles, equipment for electronic and mechanical determination of angles, targets for testing geometric properties of theodolites (collimation and inclination), collimators, testers for levels, testers for self-levelling instruments etc.

It is also necessary to elaborate detailed programmes of periodic maintenance and testing of theodolites and levelling instruments of different types as well as the methods to be used in such investigations.

Testing and calibration of distance meters

In the classical triangulation networks linear measurements were performed only for the determination of the length of baselines giving the scale of the triangulation network. Subsequently, new concepts of linear-and-angular as well as trilateration networks were developed; linear measurements were the most important ones in such cases. This was possible as a result of the development of numerous electromagnetic, optical and radio distance meters; the basic principles of their work utilize measurements of time, which is necessary for passing the measured line by a wave of specified frequency.

Particular types of distance meters utilize different frequencies; their stability influences the accuracy of measurements. Deviations of the real frequency from the nominal value cause systematic errors, which then cause the scale changes of the established geodetic network. Therefore, during testing and calibration of distance meters particular attention should be paid to testing the frequency.

Development of a method utilizing the distance meters resulted in all previously applied classical methods of baseline and basic network measurement (for example measurements with Invar wires, parallactic measurements of baselines etc.) becoming less important. In some cases, however, even these classical, inefficient methods are still applied. Their place has been changed.

Establishing the scale of geodetic networks is one of the most important tasks of practical geodesy, which should be solved during the establishment of the national and continental networks and obtained by measuring some elements of the networks by means of various methods based on different physical principles. Satellite methods are mainly applied for this reason nowadays (Doppler and sometimes laser methods), and also linear terrestrial measurements performed by means of well calibrated distance meters. Ele-

ments measured by satellite methods usually concern long lines fastening and clasping smaller fragments (segments, areas) of the network, the linear elements of which were measured by means of distance meters. For continental networks the method of very long base-line interferometry (VLBI) can also be applied, which utilizes radiation coming from extra-galactic sources. The final scale of the network is obtained during the joint adjustment of all observations, satellite and linear measurements carried out by means of distance meters.

Calibration of distance meters influences the proper scale of the geodetic network. Each distance meter should be tested and calibrated before measurements, as some years ago each measuring tape or Invar wire had to be comparated. Two methods of distance meter calibration can be applied:

(*a*) Comparison of distance meter frequency with standard frequency;

(*b*) Control measurements of specially designed field baseline.

In the first case the standard frequency can be obtained by means of a high quality laboratory standard frequency generator or by receiving signals from a strong radio station the carrier frequency of which is sufficiently stable. A condition of high stability of the frequency must be fulfilled in this case. The most convenient situation occurs when each country has its own such radio station. If the stable frequency of the country's central radio station is ensured, that frequency may be considered to be the national standard of frequency. Surveyors then have the possibility of testing the frequencies of their distance meters directly in the field before and after field measurements; it increases accuracy of linear measurements. Application of this method is possible within the receiving area of signals from the radio station and requires utilization of special electronic devices for field comparison of basic frequency of the distance meter with the received standard frequency. Where there is difficulty in organizing a national frequency standard by means of the national radio station, foreign radio stations of the international time service can be used. Utilization of such radio stations has the disadvantage that calibration is limited to certain periods for receiving signals (usually at night) and reception can be influenced by local disturbances.

Calibration of distance meters by baseline relies upon comparison of results obtained with the distance meter with the known length of the baseline. The specially designed baseline is composed of segments, the lengths of which are suitable for particular distance meters; this allows determination of other parameters, such as: additive constant, scale factors, corrections of the phasemeter etc. The test baseline should be established in a suitable area; its total length as well as the lengths of its segments should be suited to the distance meters that are to be compared. Pillars of the baseline should be equipped with specially designed centring devices. The length of the national baseline and all its segments should be determined with an accuracy not lower than 10^{-6} with the use of all possible instruments, such as tellurometers, geodimeters, as well as by classical direct methods (Invar wires).

In countries where a national baseline is used for comparation and calibration of distance meters the two above-mentioned methods are obligatory.

In organizing the comparation and calibration of distance meters the following activities are to be recommended:

(*a*) Organization of a laboratory equipped with a good generator of standard frequency;

(*b*) Ensuring the stability of the carrier frequency of the central national broadcasting station and accepting this frequency as the standard of the national frequency;

(*c*) Supplying the field groups with devices for comparing frequencies of distance meters with the standard frequency of the selected radio station;

(*d*) Establishment and measurement of the national test baseline;

(*e*) Elaboration of methods for comparation and calibration of distance meters.

Comparation and testing of the measuring rods for precise levelling

It is obvious that one of the most serious errors of precise levelling is caused by utilization of uncompared and untested measuring rods. Unfortunately, not enough attention is generally paid to the problem of the comparation of the rods; in many cases geodetic services are forced to neglect the comparation corrections even in measurements of the national levelling networks owing to lack of proper comparators. Experience proves that length corrections of particular Invar rods with respect to their nominal length (comparation corrections) can be equal even to 50 μm/1m. Neglecting such corrections implies large systematic errors dependent on measured height differences. Measurement of height difference equal to 300 m is, in this case, charged with the systematic error equal to 1.5 cm!

It should be considered that the value of comparation correction is influenced by several factors. One of them is the value of tension of the Invar tape of the rod on a wooden frame. This value should also be tested and regulated. Differences in tension with respect to values specified by producers sometimes reach the value of 5-7 kG. Considering the fact that the change of 1 kG of the tension implies the change of the 1-m segment of the rod equal to 4 μm, the total error caused by this factor can amount even to 30 μm.

The next factor that should be considered is the relation between the length of the measuring rod and the changes of temperature. Many experiments, carried out also in Poland, show that the temperature coefficients of the Invar rods can vary within the range 0,9-3,0 μm/1m/1°C. It means that the length of the 1-m segment of the rod can vary up to 90 μm for the change of temperature equal to 30°C. This is particularly important when using rods in the tropics and at different periods of the year.

It should also be stated that the length of the levelling rod varies for horizontal and vertical positions of the rod. The length difference of a 1-m segment of the rod is equal to 10 μm, depending on vertical or horizontal position of the rod. This is the reason for the need to compare rods in the vertical position, since they are used in such a way during field-work. This requirement is not generally fulfilled. The rods are comparated by means of horizontal comparators, which results in considerable systematic errors. At present, in Poland and in several other countries the measuring rods are comparated in their working, i.e. vertical position.

Only the most important factors causing systematic changes in length of the rods for precise levelling are mentioned above. It should also be added that considerable value can be reached by time variations of the length of the rod, as well as errors of the graduation of the rod, errors of a plane of the rod foot, errors of frame warping etc.

The rods for precise levelling should be periodically comparated and tested. Comparation of the rods aims at deter-

mination of the so-called "average meter" of a rod in the vertical position, and investigation of the rod graduation aims at determining the systematic and random errors of the rod scale. The value of the tension of the rod spring should also be tested and regulated. The rods should be comparated at least twice a year, before and after measuring periods. Temperature coefficients of the rods should also be determined periodically, but not so often, perhaps every three years.

Accuracy of comparation of measuring Invar rods used for precise levelling should be equal to 5-7 μm. In order to reach such accuracy, it is necessary to equip the laboratory with a proper horizontal-and-vertical comparator, suited for rod comparation in various temperatures and for determination of the temperature coefficients of the rods. Such a comparator should allow examination of the graduation scale of the rod; that is, it should be possible to measure any selected segment of the investigated rod.

Two types of comparators are presently used for comparation and testing of precise levelling rods. The first type is a traditional, 2-m vertical-and-horizontal optical comparator, installed on a solid laboratory wall, equipped with four horizontal and two vertical microscopes and with one movable microscope allowing the testing of any selected fragment of the rods. Such a comparator allows comparison of the rods with respect to the basic length standard, which should be also kept at the laboratory. The second type of comparators includes interferometric laser devices; in this case, the known length of the stabilized laser light is the length standard. Principles of the working of such devices utilize interference of the laser light passing through the interferometric system consisting of mirrors and prisms, the one of which is mounted on the rod moving along the determined path. Such a comparator requires exact adjustment, as well as electronic and optical maintenance, and it is much more expensive than the classical one. For this reason such comparators are not recommended at centres where it is impossible to ensure permanent optical and electronic maintenance. The optical, microscopic comparator allows sufficient accuracy of comparation and testing of rods to be obtained that its use is easier and "safer"; therefore, metrological laboratories should be equipped first of all with such devices.

Summarizing the problems mentioned above, it can be stated that a laboratory of comparation and testing of precise levelling rods should be equipped with:

3-m microscope, horizontal-and-vertical comparator (seven microscopes: four fixed and one movable horizontal microscopes and two vertical microscopes) with equipment for testing rods in various temperature conditions;

one 1-m basic Invar standard (or the national standard);

two 1-m Invar standards of the second order;

a dynamometric device for testing and regulation of the tension of Invar rods.

It is also necessary to develop complete methodology of the comparation and testing of high precision levelling rods and determination of the temperature coefficients of the rods.

Calibration of gravity meters

The necessity for utilizing gravimetric data in geodesy is obvious. The gravity values or gravity anomalies are required primarily in the following fields of geodesy and geophysics:

(*a*) Calculation of the horizontal geodetic control networks. One of the most important stages of such calculation concerns the proper projection (reduction) of geodetic observations from the Earth's surface onto a reference surface (usually an ellipsoid), for which all further calculations are performed. The following values must be known at this stage:

(i) Deflection of the vertical, usually determined by the astrogeodetic and gravimetric methods;

(ii) Distances between the geoid and the reference ellipsoid (height of the geoid, undulation of the geoid), determination of which requires the gravimetric data (anomalies of gravity);

(*b*) Calculation of heights of the precise levelling benchmarks in a certain adopted height system. It is impossible to calculate the heights of precise levelling bench-marks without the use of measurements of the gravity along the lines of precision levelling. So the gravimetric network should be correlated with the high precision levelling network;

(*c*) Research of mineral resources. Gravimetric measurements are required for preparation of maps of Bouguer's anomalies. The gravimetric method is one of the most efficient geophysical research methods (besides magnetic, seismic or geoelectric ones). In many countries utilization of gravimetric methods allows the detection and location of valuable deposits of resources.

Absolute gravimetric measurements are carried out with the use of free-fall, or the more advanced method of "two stations", which is very expensive and requires laboratory conditions; for this reason, they can be performed to establish reference points in only a few places on a continent (or country). For the needs of relative measurements of the gravity (measurements of the differences of gravity) pendulum devices and gravity-meters of various types are used. Principles of their work rely upon utilization of the elastic properties of various bodies. Measurements with the use of gravity-meters are fast and efficient, but the results are expressed in the units of the scale of the gravity-meter, so they require periodical testing and scaling, which rely upon determination of the value of one interval of the scale. This can be performed at the laboratory, using the so-called inclination method, or by measuring the known value of difference of the gravity between points of the field gravimetric baseline. Usually both methods are applied: that is, the value determined at the laboratory by the inclination method is checked by means of measurements of the gravimetric baseline.

Differences of the gravity used for geodetic and geophysical (research) purposes should be known with the accuracy of 0.05-0.1 mgal. In order to obtain such accuracy it is necessary to perform periodical testing of gravity-meters and to determine the so-called equation of the gravimetric scale. Measurements performed by means of uncalibrated gravity-meters cause considerable systematic errors in gravimetric networks, which cannot be tolerated. Such errors are undetectable even with the analysis of closures of the network loops. The calibration of gravity-meters should be carried out in the same areas where they are to be used for the fieldwork. The basic national gravimetric network, which is later densified with the networks of lower orders and the national gravimetric baselines, realizes the national unit of a milligal, the maintenance of which requires periodical repetition of gravimetric measurements. The national gravimetric baseline, determined from the adjustment of the

whole gravimetric network of the country, is the standard of the national unit of milligal, which should be periodically tested and kept, similarly to the conditions for keeping the length standard at the laboratory.

Considering the above problems, it is clear that national geodetic services should pay attention to the testing and calibrating of gravity-meters. The following steps are necessary:

(*a*) Organization of the gravimetric laboratory equipped with:

(i) devices for the calibration of gravity-meters by the inclination method;

(ii) devices (room) allowing determination of the equation of the gravity-meter by means of measurements in various temperatures;

(*b*) Establishment of the national gravimetric baseline (baselines), utilizing the highest possible differences of gravity (meridional location, utilization of natural height differences);

(*c*) Elaboration of methodology for testing and calibration of gravity-meters, as well as methods of periodical maintenance of the national unit of a milligal.

Conclusion

From the above discussion, it follows that the taking of proper geodetic measurements requires the organization of a permanent metrological service to keep all utilized instruments in satisfactory working state. Each national geodetic service should be supplied with a well organized metrological laboratory, which includes: the laboratory of length with the geodetic comparator, the laboratory of angles, the laboratory of time (frequency) and the gravimetric laboratory. All instruments and tools used for production work should undergo periodic control and testing. This is particularly important for theodolites and levelling instruments, precise levelling rods, distance meters and gravity-meters. National baselines for distance and gravimetric measurements should be established in each country. Each geodetic service should develop efficient testing methodologies. It should be emphasized that good results of geodetic measurements cannot be obtained without such metrological service; the cost of organization of the service is negligible in comparison with the cost of all geodetic works. It can be stated that the quality of geodetic works has been considerably increased in the countries that have organized such services.

The organization GEOKART is widely experienced in the field of organizing metrological laboratories and workshops in Poland and abroad, and it is ready to help geodetic services in setting up complex metrological laboratories and in the establishment of the control baselines. GEOKART is also ready to prepare and immediately sign agreements, in the framework of which all documentation concerning organization of the laboratories, equipment and methodology of testing can be delivered on a very convenient basis.

ORDENACION DE LA CARTOGRAFIA EN ESPAÑA*

Documento presentado por España

SUMMARY

In Spain, there are many bodies of the public sector carrying out cartographic studies for their own purposes, either directly or by entrusting them to private enterprise. In many cases, this is done without co-ordination, resulting in the duplication of surveys and the consequent waste of resources. The new State structure, by creating autonomous communities, contributes to this dispersion and lack of uniformity in the studies.

The purpose of the new Cartographic Regulation Act is to achieve effective co-ordination of the cartographic work done by public bodies through the establishment of the National Cartographic Plan, the Central Cartographic Registry and the Cartographic Standard for the different scales.

RÉSUMÉ

Il existe en Espagne une multitude d'organismes publics qui soit font directement soit font faire par des entreprises privées des travaux cartographiques pour leurs propres besoins. Très souvent, la coordination nécessaire fait défaut, ce qui entraîne des doubles emplois dans les levés et un gaspillage de ressources. Avec la création des communautés autonomes, la nouvelle structure de l'Etat favorise cette dispersion des efforts et ce manque d'homogénéité dans les travaux.

La nouvelle loi relative à l'organisation de la cartographie a pour objet d'assurer une coordination effective des travaux cartographiques exécutés par les organismes publics, en établissant un plan cartographique national, un registre central de cartographie et une norme cartographique pour les différentes échelles.

En relación con el punto 8 del programa provisional, el Gobierno de España desea presentar a la Tercera Conferencia Cartográfica Regional para América la siguiente comunicación, por considerar puede ser de interés, para algunos países, conocer los problemas existentes en España en el campo de la cartografía oficial (denominando así la que se realiza por distintos organismos de las Administraciones Públicas) y cuál ha sido la solución que se ha estimado más idónea para resolverlos.

Antecedentes y problemática del sector

Al ser la cartografía un instrumento indispensable para el desarrollo de múltiples actividades del quehacer humano, ha existido desde muy antiguo la tendencia por parte de diversos organismos públicos a proporcionarse directamente la cartografía que consideraban necesaria para sus propios fines.

Si nos remontamos al siglo XVIII, a finales del cual la cartografía empezó a hacerse con un cierto carácter sistemático, observamos que la actividad cartográfica respondía

*The original text of this paper appeared as document E/CONF 77/L 4

principalmente a unas necesidades sentidas por los estados mayores de los ejércitos y, por ello, era una función militar en la práctica totalidad de los países. En España, el primer organismo encargado de la realización de dicha cartografía fue el Depósito de la Guerra.

El desarrollo industrial del siglo XIX fue imponiendo, cada vez más, la necesidad de la cartografía también para aplicaciones civiles. Esta demanda era atendida en mayor o menor medida por los organismos cartográficos militares existentes, y en algunos países que tardaron más en iniciar sus labores cartográficas, lo hicieron encargándoselas a organismos civiles. En España, a partir de 1870, en que se creó, aunque con otra denominación, el Instituto Geográfico Nacional, fue este centro cartográfico el que recibió el encargo de formar y conservar el mapa topográfico nacional a escala 1:50.000 subsistiendo, sin embargo, el referido Depósito de la Guerra, que colaboró en la formación de este mapa y mantuvo sus competencias en lo que se refiere a cartografía de interés militar, así como en lo que concierne a las fronteras con otros países.

En 1923 se estableció que la coordinación de ambos centros cartográficos se haría a través de un órgano, el Consejo Superior Geográfico, creado a tal fin, en el que además de los dos organismos citados tendrían entrada representantes de otros departamentos interesados en la ejecución o en la utilización de trabajos geográficos o topográficos.

En el transcurso del tiempo la demanda de cartografía para grandes proyectos de obras públicas, planes de regadíos, de concentración parcelaria, de urbanismo, etc., así como los catastrales a efectos de fiscalidad, fue incrementándose en tal proporción, que era prácticamente imposible satisfacerla con la prontitud que requerían los usuarios de dicha cartografía. Por ello resultó prácticamente inevitable que diversos organismos se procuraran directamente la cartografía que necesitaban, realizándola por sí mismos o encargándola a empresas privadas del sector que proliferaron en razón a esta demanda.

El resultado fue que, si bien existía una cierta coordinación, no siempre efectiva, a través del Consejo Superior Geográfico en cuanto a escalas medias (1:25.000-1:50.000), para mayores escalas la confusión, duplicidad de trabajos, falta de normativa técnica que permitiera la utilización de trabajos encargados por un organismo, por otro distinto, y consiguiente despilfarro de fondos públicos y del esfuerzo técnico del Estado, ha sido la tónica general durante muchos años. Y ello no porque faltara un consenso general en cuanto a la necesidad de coordinar los trabajos cartográficos, de realizar aquellos que más convinieran a los intereses nacionales y de que respondieran a unos requisitos técnicos que los hiciera aptos para su posterior utilización con carácter general, sino porque faltaba una norma legal de suficiente rango que posibilitara la efectividad de las competencias coordinadoras que se asignaban al Consejo Superior Geográfico. La Ley de 18 de marzo de 1944 que regulaba las funciones del Consejo se ha mostrado, a través de los 20 años transcurridos, inoperante e insuficiente para coordinar la cartografía desarrollada por las Administraciones Públicas, como lo demuestra el hecho de que pese a su larga vigencia no ha logrado evitar la deteriorada situación del sector a que antes nos referíamos.

Esta situación aún podría complicarse más, al aparecer en escena servicios cartográficos de las Comunidades Autónomas recientemente constituidas. De no ordenarse adecuadamente la actividad cartográfica oficial, los distintos organismos autónomos podrían realizar o encargar la realización de la cartografía básica de sus territorios con criterios y calidades muy diversas, que podrían dar lugar a nuevas repeticiones de trabajos, a una falta de homogeneidad en los levantamientos y a una mayor dispersión de recursos.

Solución prevista

Ante la situación que, a grandes rasgos, acaba de esbozarse y dada la imposibilidad manifiesta de realizar, en un tiempo razonable y mediante un solo centro cartográfico específico, que sería el Instituto Geográfico Nacional, todos los trabajos de cartografía que la demanda exige, mientras se desaprovechaban otros medios y posibilidades existentes, se ha optado por una solución que, reservando al organismo citado la responsabilidad de la formación y conservación de las series cartográficas que se consideran fundamentales, permita la concurrencia de otros centros cartográficos y aun diversos organismos en la realización de cartografía básica y derivada a otras escalas, bien por sí mismos o a través de terceros, siempre y cuando los trabajos realizados reúnan los requisitos de calidad técnica que se establezcan, estén coordinados de manera que se eviten duplicidades y puedan ser utilizados con posterioridad por los diferentes servicios de las Administraciones Públicas.

Con esta finalidad, el Gobierno de España ha remitido a las Cortes un Proyecto de Ley de Ordenación de la Cartografía que afirma la competencia de la Administración del Estado en materia cartográfica, que ejercerá a través del Instituto Geográfico Nacional, en lo que se refiere a las redes nacionales geodésicas y de nivelaciones y la formación y conservación de las series cartográficas que se consideran fundamentales, y mediante el Instituto Hidrográfico de la Marina en lo que hace a la cartografía náutica básica.

Asimismo y para cualesquiera otras producciones de cartografía básica o derivada, el Proyecto de Ley refuerza la función coordinadora que, en España, corresponde a la Presidencia del Gobierno y que se desarrollará a través de un órgano colegiado de coordinación y planificación —el Consejo Superior Geográfico— de carácter mixto (Administración del Estado, Autonómicas y Local) y de unidades técnicas operativas de gestión y control de calidad (el Instituto Geográfico Nacional y el Instituto Hidrográfico de la Marina) incardinados en los Ministerios de la Presidencia y de Defensa.

Los instrumentos previstos en el Proyecto de Ley al servicio del objetivo de coordinación efectiva de la cartografía producida por los entes públicos son:

a) El Registro Central de Cartografía, al que se confía la misión de formar y mantener al día un inventario de la producción cartográfica realizada por las Administraciones Públicas, constatando que la cartografía de servicio público se adecua a la norma cartográfica que le sea de aplicación y confiriéndole carácter de cartografía oficial en ese caso. La inscripción en el Registro será obligatoria para toda la producción de cartografía básica y para la cartografía derivada correspondiente a las series de ámbito nacional producidas por organismos del Estado.

Se encomienda asimismo al Registro Central de Cartografía el mantenimiento de un archivo donde consten las líneas de las divisiones administrativas y sus variaciones acordadas por las administraciones competentes

Igualmente se responsabiliza al Registro Central de la formación y conservación del Nomenclátor Geográfico Nacional.

b) El Plan Cartográfico Nacional, que la Administración del Estado establecerá a propuesta del Consejo Superior

Geográfico y que necesitará la aprobación del Consejo de Ministros.

El Plan, de vigencia cuatrienal y desarrollado en programas operativos anuales, coordinará las actuaciones de las distintas Administraciones Públicas para dar respuesta adecuada, ordenadamente y dentro de las limitaciones que impongan los recursos disponibles, a toda la demanda nacional en materia de cartografía oficial.

El Plan no podrá incluir trabajos de ejecución de cartografía que ya figure inscrita en el Registro, salvo los de actualización que el Consejo Superior Geográfico, a propuesta de algún organismo en él representado, considere necesario.

c) La Norma Cartográfica estatal para las diferentes escalas que, redactada por una Comisión de expertos en el seno del Consejo Superior Geográfico y una vez obtenida la aprobación ministerial, será de obligado cumplimiento para la producción de cartografía básica y derivada realizada por organismos del Estado.

Se considera que los instrumentos y mecanismos que contempla el Proyecto de Ley son necesarios y suficientes para ordenar y racionalizar un campo de actuación pública que en la actualidad es confuso, gravoso para el Estado e incumple su función específica.

A continuación se reproduce el Proyecto de Ley:

Proyecto de Ley de Ordenación de la Cartografía

Artículo 1°

Es objeto de la presente Ley, la ordenación de la producción cartográfica del Estado. Tendrá carácter de cartografía oficial la realizada con sujeción a las prescripciones de esta Ley por las Administraciones Públicas o bajo su dirección o control.

Artículo 2°

A los efectos de la presente Ley, la cartografía oficial se clasifica en básica, derivada y temática.

Artículo 3°

Uno. Es cartografía básica, cualquiera que sea la escala de su levantamiento, aquella que se realiza de acuerdo con una norma cartográfica establecida por la Administración del Estado, y se obtiene por procesos directos de observación y medición de la superficie terrestre. La norma cartográfica será establecida por Orden del Ministro de la Presidencia tratándose de cartografía terrestre o por Orden del Ministro de Defensa en el caso de cartografía náutica.

Dos. La norma cartográfica correspondiente a cada serie cartográfica especificará necesariamente el dátum de referencia de las redes geodésica y de nivelación, el sistema de proyección cartográfica y el sistema de referencia de hojas, para la cartografía terrestre, y, además, por lo que respecta a la náutica, el dátum hidrográfico al que estén referidas las sondas.

Tres. Además de lo establecido en el apartado anterior, la Norma Cartográfica contendrá cuantas especificaciones técnicas sobre el proceso de formación del mapa sean necesarias para garantizar que éste refleja la configuración de la superficie terrestre con la máxima fidelidad posible según los conocimientos científicos y técnicos de cada momento.

Cuatro. La cartografía básica será objeto de aprobación oficial, a propuesta del Consejo Superior Geográfico, por el mismo órgano de la Administración del Estado competente para establecer la norma aplicable.

Artículo 4°

Uno. Cartografía derivada es la que se forma por procesos de adición o generalización de la información topográfica contenida en cartografía básica preexistente.

Dos. La Administración del Estado establecerá la norma cartográfica a que habrá de atenerse la formación de cartografía derivada para las series que hayan de cubrir todo el territorio nacional. El establecimiento de dicha norma se hará por Orden del Ministro de la Presidencia, si se trata de cartografía terrestre, o por Orden del Ministro de Defensa, si se trata de cartografía náutica.

Tres. La cartografía correspondiente a estas series nacionales será objeto de aprobación por el procedimiento establecido en el apartado cuarto del artículo anterior.

Artículo 5°

Uno. Cartografía temática es la que, utilizando como soporte cartografía básica o derivada, singulariza o desarrolla algún aspecto concreto de la información topográfica contenida en aquéllas, o incorpora información adicional específica.

Dos. Los organismos públicos responsables de la realización y publicación de cartografía temática establecerán sus propias normas cartográficas, sin perjuicio de que puedan recabar para tal fin el asesoramiento del Consejo Superior Geográfico.

Tres. La cartografía temática sólo será objeto de inscripción obligatoria en el Registro Central de Cartografía en los supuestos en que, por razones de interés nacional, así lo acuerde el Ministro de la Presidencia, previos el informe del Consejo Superior Geográfico y, tratándose de cartografía temática militar, la aprobación del Ministro de Defensa.

Artículo 6°

Uno. Es función de la Administración del Estado:

a) A través del Instituto Geográfico Nacional:

1. El establecimiento y mantenimiento de las redes nacionales geodésica y de nivelaciones.
2. La formación y conservación de las siguientes series cartográficas:
   - Las series cartográficas básicas a escala 1:25 000 y derivada a escala 1:50.000 que constituyen el Mapa Topográfico Nacional.
   - La serie cartográfica básica a escala 1:5.000, que integrará el Mapa Nacional Topográfico Parcelario, como base geométrica principal del Catastro Polivalente.

b) A través del Instituto Hidrográfico de la Marina: la formación y conservación de la cartografía náutica básica.

Dos. Cualesquiera otras producciones de cartografía básica o derivada que se realicen por los distintos organismos de las Administraciones Públicas conforme a sus propias necesidades cartográficas y recursos disponibles, serán coordinadas a través del Plan Cartográfico Nacional.

Tres. El ejercicio de las competencias referidas en el presente artículo y la ejecución de los correspondientes trabajos podrá realizarse mediante acuerdos de cooperación entre los distintos órganos de las Administraciones Públicas. Los acuerdos de cooperación que se celebren para la formación y conservación del Mapa Topográfico Nacional se realizarán preferentemente con los órganos cartográficos del Ministerio de Defensa.

Artículo 7º

Uno. La Administración del Estado, a través del Instituto Geográfico Nacional, formará y conservará el Registro Central de Cartografía, cuyo régimen jurídico y de funcionamiento se establecerán reglamentariamente.

Dos. Todas las producciones de cartografía básica y de cartografía derivada correspondientes a series nacionales, realizadas por las distintas Administraciones Públicas, serán presentadas, una vez aprobadas, para su inscripción en el Registro Central de Cartografía.

Tres. La cartografía oficial registrada será de uso obligatorio por todas las Administraciones Públicas para la formación de nueva cartografía derivada o temática. El régimen económico correspondiente a la utilización de cartografía oficial registrada será establecido por acuerdo entre la Administración responsable del Registro Central de Cartografía y los organismos productores de aquélla, con sujeción a las bases generales que al efecto se establezcan en desarrollo de esta Ley, a propuesta del Consejo Superior Geográfico.

Cuatro. En el Registro Central de Cartografía se inscribirán, igualmente, las delimitaciones territoriales establecidas y sus variaciones, acordadas por las administraciones competentes. Corresponde asimismo al Registro Central de Cartografía la formación y conservación del Nomenclátor Geográfico Nacional, en el que se registrarán las denominaciones oficiales de los municipios, entidades de población y formaciones geográficas, así como sus variaciones, debidamente aprobadas.

A los efectos del párrafo anterior, la inscripción tendrá carácter obligatorio y será requisito previo a la inclusión de dichas alteraciones de líneas y denominaciones en la cartografía oficial.

Artículo 8º

Uno. Para atender las necesidades de los servicios de la Administración del Estado, el Ministro de la Presidencia, a propuesta del Consejo Superior Geográfico, elevará al Consejo de Ministros, para su aprobación, un Plan Cartográfico Nacional, de vigencia cuatrienal, que, dentro de las disponibilidades presupuestarias, será desarrollado en programas operativos anuales y que podrá ser revisado durante su vigencia con arreglo al mismo procedimiento.

Dos. Los programas de inversiones públicas que contengan recursos destinados a producción cartográfica no podrán incluir proyectos que no se correspondan con los objetivos del Plan Cartográfico Nacional, salvo razones de urgencia apreciadas por el Gobierno.

Tres. El Plan no podrá contener previsiones de nueva ejecución de cartografía que figure ya inscrita en el Registro Central de Cartografía, salvo las de revisión o actualización de la misma en los supuestos autorizados por la normativa que al respecto se establezca.

Cuatro. Para garantizar la unicidad técnica y la coordinación de los trabajos cartográficos, lo dispuesto en el apartado anterior será de aplicación a todas las Administraciones Públicas en orden a sus propios planes y programas de producción cartográfica.

Para la ejecución de dichos planes y programas, en lo que se refiere a cartografía básica y derivada, se precisará certificación del Registro Central de Cartografía acreditativa de que aquélla no ha sido realizada. Los referidos planes y programas serán coordinados con el Plan Nacional a través de la representación de dichas Administraciones en el Consejo Superior Geográfico.

Artículo 9º

Uno. El Consejo Superior Geográfico es el órgano superior, consultivo y de planificación del Estado en el ámbito de la cartografía. La composición de dicho órgano colegiado, en el que podrán integrarse, a iniciativa de sus respectivos órganos de gobierno, representaciones de las Administraciones autonómica y local, se determinará reglamentariamente.

Dos. El Consejo Superior Geográfico ejercerá las funciones de coordinación y asesoramiento necesarias para la formación, revisión y ejecución del Plan Cartográfico Nacional.

Tres. El Consejo Superior Cartográfico propondrá las Normas Cartográficas para la ejecución de la cartografía básica y derivada a los órganos de la Administración del Estado competentes para su aprobación. Asimismo, informará, a instancia de los organismos interesados, las normas de cartografía temática elaboradas por los mismos.

Cuatro. El Consejo Superior Geográfico será consultado en los procesos de elaboración de cuantas disposiciones afecten a la producción cartográfica oficial.

Disposiciones adicionales

Primera

Las personas físicas o jurídicas privadas que produzcan para sus propios fines cartografía básica o derivada podrán obtener su aprobación e inscripción en el Registro Central de Cartografía. Una vez inscrita, dicha cartografía privada adquirirá validez de cartografía oficial ante los organismos de las Administraciones Públicas.

Segunda

Lo dispuesto en la presente Ley se entiende sin perjuicio de la aplicación de la normativa vigente en materia de secretos oficiales y zonas de interés para la defensa nacional.

Disposición transitoria

Uno. En el plazo de un año desde la entrada en vigor de esta Ley, los distintos Ministerios, órganos de gobierno de la Comunidades Autónomas, Diputaciones, Ayuntamientos y Entidades Estatales Autónomas, presentarán al Consejo Superior Geográfico un inventario detallado de sus respectivas producciones de cartografía básica junto con la norma cartográfica aplicada en cada caso. En los seis meses siguientes, el órgano competente de la Administración del Estado resolverá, a propuesta del Consejo, acerca de las producciones que estime convalidables, a la vista de la norma aplicada, y recabará de los organismos productores las correspondientes reproducciones de las mismas para su inscripción en el Registro Central de Cartografía.

Dos. El Consejo Superior Geográfico quedará constituido con arreglo a su nueva composición dentro del plazo de seis meses contados a partir de la entrada en vigor de esta Ley. Hasta dicho momento, mantendrán transitoriamente su vigencia el artículo 12, apartado dos, del Real Decreto 2761/1977, de 28 de octubre, y los Reales Decretos 2894/1980, de 4 de diciembre, y 105/1984, de 25 de enero.

A STRATEGIC PLAN FOR NATIONAL MAPPING ACTIVITIES*

Paper submitted by Sweden

RÉSUMÉ

Le Service topographique national de la Suède a formulé un plan stratégique pour les activités cartographiques nationales. Le programme décennal proposé vient d'être adopté par le Parlement et son application exigera un accroissement des ressources de l'ordre de 30 %.

L'exposé décrit brièvement le processus de planification et la nouvelle politique en matière de cartographie. On notera qu'une attention particulière a été accordée à la cartographie assistée par ordinateur.

RESUMEN

El Servicio Nacional de Agrimensura de Suecia ha formulado un plan estratégico para las actividades nacionales de elaboración de mapas. El programa decenal propuesto ha sido aprobado recientemente por el Parlamento. La ejecución del programa requerirá un aumento aproximado del 30% en los recursos financieros.

En el presente documento se informa brevemente del proceso de planificación y del contenido de la nueva política de elaboración de mapas. Se concede especial atención a la elaboración de mapas mediante métodos digitales

In Sweden, official mapping is carried out by three governmental agencies: the National Land Survey (NLS), the Geological Survey and the National Administration of Shipping and Navigation. In addition to these, a number of other authorities, municipalities and private companies produce maps and geographical data bases. Forestry mapping is an example of medium-scale mapping carried out by many different producers. The current tendency is that an increasing number of organizations are engaged in collecting, storing and using geographical data.

Among national map series produced by the NLS are the *Economic Map* at the scale of 1:10,000 or 1:20,000, the *Topographic Map* at 1:50,000 or 1:100,000 and general maps at 1:250,000, 1:500,000 and 1:1,000,000.

The NLS also has responsibility for the fundamental geodetic networks, aerial photography and the handling of digital data related to these products. Together with a number of larger urban authorities it is also responsible for cadastral activities.

In addition to these activities, which are financed by the Government, NLS also carries out mapping at a variety of scales and other services on a repayment basis.

THE PLANNING PROCESS

In Sweden during the second part of the 1970s, there was increasing criticism of the inefficient organization of land information collection and dissemination and the negative, national economic effects of this situation. There was clearly a feeling, not fully supported by facts, that many authorities were engaged in producing the same products with considerable overlapping, and that total mapping costs could be reduced through a more rational planning of the national mapping.

A review committee was appointed in 1978, which submitted a report in 1981. The Committee proposed that the official mapping resources should be concentrated on base maps and other base materials (such as the collection and collation of aerial photography). The final derived products should to a greater extent be the economic responsibility of the users.

However, the reaction to this proposal showed clearly that few were in favour of such a policy. At the same time map-users stressed the need for better and more up-to-date maps as well as an aerial photography programme extended to include new altitudes, etc.

NLS also argued that it would be too costly to administer a system in which many users would contribute to the financing of land information, and proposed that a thorough examination of the demand for land information should be made as the base for a long-term plan regulating the tasks of NLS. In February 1983 the Ministry of Housing and Physical Planning instructed NLS to formulate a programme for national mapping for the 10-year period 1985-1994.

The result was a report, published in June 1983, the main proposals of which are presented below. It was stated that funds should be increased by 30 per cent to guarantee a mapping standard in the future that would meet the combined demands from several different sectors. The economic benefits to be gained from the use of maps, orthophotos and other geographical information for all users were shown to exceed the costs for the suggested map production. The possible gains within each main sector (transport, defence, local mapping, forestry and farming, tourism and education) were evaluated, and the share to be borne by each Ministry was calculated. Financing was mainly cleared through an agreement between six other ministries.

The long-term plan has now been approved in Parliament, and the NLS budget has been adjusted to make implementation possible.

THE IMPORTANCE OF AN INTEGRATED APPROACH

Earlier, the official mapping activities at NLS focused mainly on the production of printed maps, and the handling of information was organized to suit the requirements of map production. In recent years a broader approach has been adopted. Responsibility is not only limited to map production. It also includes methods for handling basic geographical data in order to rationalize the activities of other users and producers of land information.

From a general point of view, the system through which NLS collects, stores, treats and presents land information is built up in the following way:

NLS collects land related data by observations in the field (1) in connection with mapping or geodetic activities, etc., and from different types of aerial photography (2). These two activities are integrated. Data is also collected by the National Road Administration, the Forest Administration, the National Environment Protection Board and other agen-

* The original text of this paper, prepared by Ulf Andersson and Hans Fredrik Wennström, appeared as document E/CONF 77/L 72

cies (3). These data can be stored either by the administration in question or the NLS.

The data collected can be used by NLS in feature separations for the official maps. The information can also be stored in special map data bases. The use of data base techniques makes possible a flexible presentation in different scales and permits the selection of contents adapted to specified user requirements. Users often wish to combine the "map information" with other special information, which will also be possible.

This approach has increased the importance of a closer co-operation between NLS, as the producer of official maps, and other institutions. An important part of the work with the strategic plan for the mapping activities has, therefore, been to carefully examine how to establish and make this co-operation rational and efficient.

The 10-year programme

A short summary of the new 10-year programme for the official mapping activities is given below.

Geodetic activities. National retriangulation was carried out during the period 1968-1982, and has been computed in 12 separate blocks. A final computation of the whole network to give a unified co-ordinate system for all 3,800 stations is being carried out.

During the next decade no extension or densification will be carried out; instead the very limited resources available will be used to maintain the existing stations. The network configuration is an area network with side lengths of 30 km densified to 10 km.

In 1980 a programme for the remeasurement of the national levelling network was started. Motorized levelling techniques are being used. The field-work is programmed to take 17 years, and will engage almost all available resources during the 10-year period.

The geodetic archives containing co-ordinates and station descriptions will be computerized, and data-base techniques will be introduced.

Participation in international geodetic activities and projects within the sphere of geodetic sciences will continue. This includes satellite geodesy and studies of land uplift.

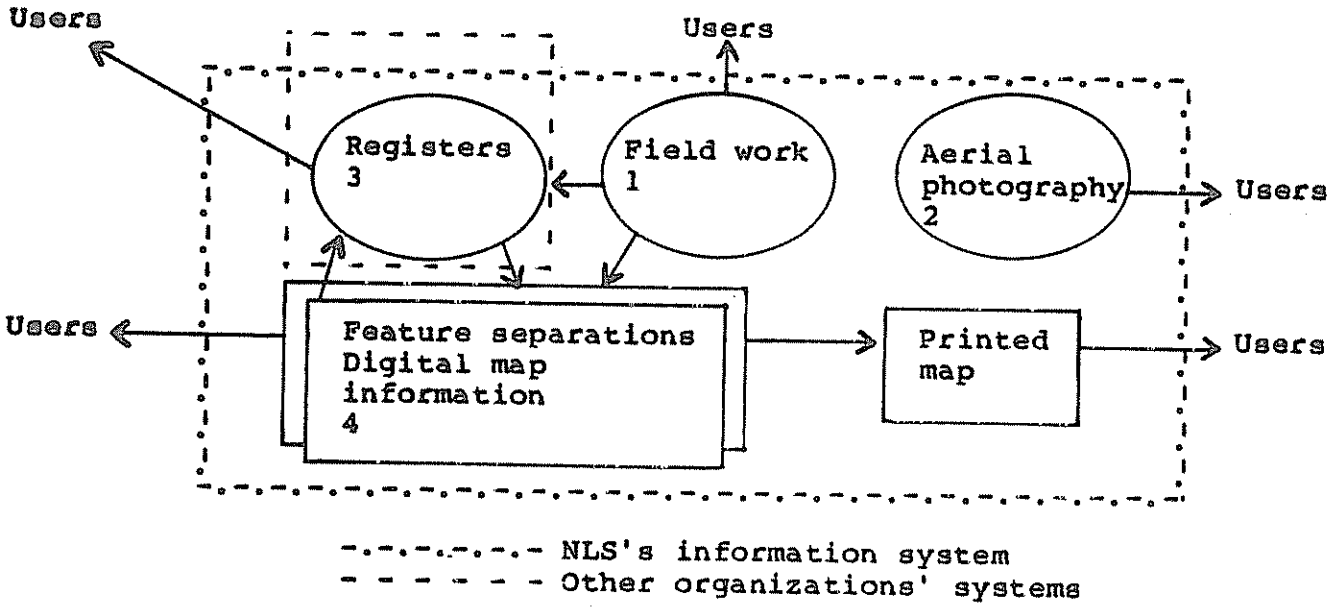
Terrain elevation data bases. During the latter part of the 1970s a national terrain elevation data base was proposed as a means of speeding up the production of orthophotos and making possible other applications such as visibility studies and correction of satellite imagery. Initially some areas were covered by a data base with elevations registered for a 100 × 100 m grid. This base met the requirements for forestry mapping, and could be used for the production of orthophotos at a scale of 1:20,000. However, orthophoto production for the most important national map series, the 1:10,000 *Economic Map*, requires a 50 × 50 m grid. The highest priority will, therefore, be given to the establishment of a national terrain elevation data base based on the denser 50 × 50 m grid, so that all types of maps with regional or nationwide coverage can be produced from orthophotos over the 1:10,000 to 1:50,000 scale range. The data base is now programmed to be completed by 1989. Today's coverage is about 45 per cent of Sweden.

Aerial photography. Since the 1930s the 1:10,000 *Economic Map* series has been produced using an air photo background. Controlled photo mosaics were used until 1967 when orthophoto technique was introduced. The standard altitude used for the aerial photography is 4,600 m which gives a negative scale of 1:30,000. During the 1970s an altitude of 9,200 m was used for forestry mapping purposes. Photographs from an altitude of 3,000 m is also of interest for detailed photo-interpretation within forestry and municipal planning sectors.

A few years ago the programme was increased to include IR-colour photography. The main use of this type of photography is in geological and vegetation mapping.

Up to now only the 4,600-m programme (with an interval of 5 or 10 years between re-photography) and the IR-colour programme have been government financed. However, as the interest in aerial photography is great it has been pro-

Figure 78. Sweden: National Land Survey information system



posed that the activities, which are financed by the Exchequer, should be increased to include:

(*a*) Re-photography every 5 or 10 years from 4,600 m;

(*b*) Re-photography every 4 to 5 years with superwide angle lenses from 13,200 m;

(*c*) Extension of the IR-colour photography coverage to be nationwide;

(*d*) Some areas to be photographed from 3,000 m to facilitate improved photointerpretation;

(*e*) Photography of some areas where the scale of orthophotos is to be 1:20,000 from 9,200 m.

Thus, no less than four different flying altitudes will be required:

3,000 m (medium, e.g. between low and standard)
4,600 m (standard)
9,200 m (high)
13,200 m (extremely high)

Orthophoto mapping. The production of orthophoto maps is of great importance, not only for the official mapping programme, but also for other users of land information, e.g. for forest maps. The production rate will therefore be speeded up, so that new orthophotos can be made available on a 10-year cycle. This will mean almost a doubling of the area to be annually covered.

NLS has produced some test sheets at a scale of 1:50,000 based on orthophotos from photography taken from an altitude of 13,200 m. These tests have been successful, and the orthophoto maps at scale 1:50,000 have been very well received also among regional planners and local government authorities. NLS is considering inclusion of this type of orthophoto in the new topographic mapping production programme.

Economic Map at 1:10,000 or 1:20,000. At present 80 per cent of Sweden is covered by maps at 1:10,000 (11,600 sheets) or 1:20,000 (1,100 sheets), each with a 50 × 50 cm format. The average age of a sheet is about 15 years. The oldest maps, which have not yet been replaced by new orthophoto-based editions, date from 1947.

As the geometry of the older maps is poor, it is not possible to combine old separations with modern photomaps or new separations. Therefore, it is of primary importance to bring the whole set of maps up to a better geometric standard, which will, in future, facilitate wider use of map material. A question of primary importance in this connection is whether future maps will be based on feature separations or on map data base techniques.

NLS has proposed that some 5,900 sheets should be produced within the 10-year period, i.e. half of the series. This will entail the production of completely new sheets, as it has proved too costly to re-use material from the old editions. This is due not only to the poor geometric quality of the old sheets, but also to the fact that both map contents and conventional signs have been changed since the first series was published. Also, the combining of separations is nowadays more complicated, as old separations do not correspond to new ones in content.

The re-mapping programme is planned to take about 10 years and will significantly improve the geometric quality of the 1:10,000 series, as the use of digital techniques will be combined with storing some parts of map contents in data bases. An experimental series of maps at 1:10,000 for the county of Gävleborg (600 sheets) is in the process of being produced with computer-assisted techniques.

The printing in four colours of the maps at 1:10,000 will be discontinued, and instead a series at 1:20,000 will be printed. The sheets at 1:20,000 will be produced by photographic reduction from the 1:10,000 scale. Usually, six sheets will be combined into one new 1:20,000 sheet.

The *Economic Map* series is, on an annual basis, kept up to date by the regional organization of NLS. The updating has hitherto been carried out in the same manner as for standard map revision, by partially redrawing the map with standard symbols and with a high positional accuracy. New methods will be used for regular minor revision. Simplified symbols will be used and new buildings and new roads will be drawn without complete resurvey. A complete revision will be made when new orthophotos are made.

Topographic Maps. The present topographic map series was published during the years 1953-1979. The general scale is 1:50,000 but for the sparsely settled mountain areas the 1:100,000 scale is used.

During the latter years the demand for new details to be included in topographic maps has increased. Among the new features that are requested is a more detailed road and vegetation description.

The proposals for a new topographic mapping policy occupy a major part of the report. The most important recommendation is that the mapping programme for the future should include both 1:50,000- and 1:100,000-scale maps based to a large extent on a common data base. In this way information can be better selected and distributed for different purposes. The 1:100,000 map will focus attention on road information, whereas the 1:50,000 maps will contain the more detailed classifications of terrain, vegetation and hydrography.

The revision rate for the present type of map at 1:50,000 will now be slowed down. Instead, maps at 1:100,000 will be produced to serve as an up-to-date source of information on the road network. These sheets will be based on material from the 1:50,000 series.

In the long term there is also an interest in features that the present maps do not show, e.g. in a totally new vegetation depiction with information on forest clear-cuts, different types of forest and their age status. It may also be necessary to show where the terrain contains boulders or large rock outcrops, etc. It is suggested that a new 1:50,000 map series should be produced to specifically meet this type of demand. After some years of development work it should be possible to produce the new series rapidly. The present intention is that the map should be a combined topographic and thematic map for vegetation and ground surface elements.

The present demand for up-to-date maps will be met by the "shorter" map series at scale 1:100,000. The new map will be produced in the following way:

(*a*) Roads will be digitized, normally from aerial photographs taken from 13,200 m;

(*b*) Roads will be scribed in flat-bed plotters and be saved for future use, also at the 1:50,000 scale;

(*c*) New text will be produced using digital photo-setting methods;

(*d*) Built-up areas and some other map elements will be drawn from manuscripts made by photointerpretation;

(*e*) Contours, hydrography and vegetation will be taken from existing 1:50,000 maps reduced to 1:100,000.

Consequently, most of the information will either be taken from a data-base information system common to both the 1:50,000 and 1:100,000 scales, or from already existing 1:50,000 map material reduced in scale.

The new series has been programmed to take 10 years to complete.

Vegetation mapping. The mapping programme will in the future also include vegetation mapping. This type of map has up to now been produced on a repayment basis and financed jointly by many different users. The vegetation maps are at the same scale as the topographic maps, e.g. 1:50,000 or 1:100,000.

Cadastral mapping. Cadastral maps at larger scales (1:2,000-1:10,000) are produced by regional or local government and municipal authorities at different scales. For non-urban areas economic maps are used (the separations showing real-estate subdivision, the administrative divisions, roads, etc). The cadastral maps suffer serious deficiencies, owing to the poor geometry of the older maps and because of the poor state of the original source material. In future the mapping activities of the NLS will include a programme for the replacement of many of these cadastral maps. This will, to a large extent, be done at a newly established map unit in Kiruna in the northern part of Sweden. A variety of source materials and methods will be used. Other land survey offices will also be able to purchase services from this unit.

General maps. A new series at a scale of 1:250,000 was produced during 1972-1980. At present the series is being revised and converted to new sheet-lines.

Computer-assisted mapping at NLS

Computer-assisted mapping has been in use at NLS for more than fifteen years. The new mapping techniques were introduced for the production of certain separations for the official and large-scale maps such as grids and some map symbols. With time, the use of computer-aided mapping has expanded to include other details. At first, the aim was to try to make standard map production more economically viable. Later on, however, the demand for digital map data from various customers has also stimulated faster development towards the use of digital methods for mapping.

The demand for digital map data for different purposes and at different scales has made it desirable to introduce a co-ordinated system for computer-aided mapping that can meet a wide range of requirements. The software development for such a general system was started at NLS in 1976 and the system AutoKa has been developed further to include a very wide range of software to handle data capture, data bases and presentation of computer-stored information.

The AutoKa system is used both for official mapping production and production of maps on a repayment basis for a wide range of consumers. The latter maps are usually at larger scales, such as urban maps at scale of 1:400-1:2,000 and forestry maps at scales 1:10,000 and 1:20,000.

Nation-wide data bases

Around 1975 the build-up of a series of nation-wide data bases was started both at the University of Lund and at NLS. Some of the bases are now completed; some are still under construction. The University data base is now, step by step, being replaced by new data captured during ordinary map production at NLS or from modern maps.

Nation-wide data bases which have been completed or are in the process of being established include:

Data base	*Stage*
Terrain data elevation	
500-metre grid	Complete
50-metre grid	Complete 1989
General map data base	
1:250 000	Half complete
1:500 000	Half complete
1:1 million	Complete 1984
Aeronautical map information	Complete
Boundaries of densely built-up areas	Complete

As mentioned above, NLS has, in connection with the production of the *Economic Map* and the *Topographic Map*, stored some parts of the map information in map data bases. However, it will be many years before the data bases cover the whole of Sweden.

Terrain elevation data base. The main purpose of the base is to serve as an information source for the production of orthophotos at scales between 1:5,000 and 1:50,000. Elevation data can also be used for other purposes, such as:

(*a*) Production of contours;

(*b*) Computing of cross sections, i.e. for intervisibility studies;

(*c*) Correction of remote sensing data;

(*d*) Correction of gravimetric measurements;

(*e*) Terrain representation in flight simulator systems;

(*f*) Different cartographic applications, such as slope mapping and automated hill shading;

(*g*) Perspective drawings.

General map data base. Experience has shown that the demands placed on map products differ widely depending on the scale. This is also the case with data bases. The demands on these bases are also quite different, for example in making separations for general maps as compared with making thematic maps. This, together with the fact that it will take considerable time to capture all the map information, has resulted in the development of a system comprising different data bases:

1:250,000
1:500,000
1:1 million

The contents of the *General Map* data base are:

Administrative boundaries
Boundaries for densely built-up areas
Hydrology
Roads and railroads
Power transmission lines
Elevation information
Map symbols
Text

The 1:1,000,000 base has recently been completed. The other two bases will follow successively. The remaining work mainly consists of collection of data for minor roads and for the detailed hydrology.

Studies are now in progress concerning the build-up of data bases for local and regional authorities as an information source in connection with physical planning, registration of planning regulations, statistics, etc. In this project the NLS is working together with the county admin-

istration in two counties in southern Sweden as well as a number of municipalities in these counties.

Aeronautical map information. Aeronautical charts are subject to relatively short updating intervals. An aeronautical information system has therefore been developed in co-operation with the Swedish Air Force. This system contains at all times current aeronautical information concerning Sweden as well as parts of neighbouring countries. The system is used to produce and revise separations for charts at a scale of 1:250,000.

Important steps in the strategic planning

The planning work has been successfully completed. There are some specific aspects of the work that should be of interest.

NLS has, as the national surveying and mapping authority, responsibility for increasing effectiveness and rationalizing production activities. This entails, amongst other things, the development of solutions and products at NLS that are better adapted to stated requirements and cheaper for map users than would have been the case if every individual user had produced his own map. Much time and energy was, therefore, spent on documenting the needs for mapping and map products in Swedish society. It was considered important to analyse, together with different users, the need for maps, aerial photographs and other map products and to identify rationalization and other gains that would result from the availability of such products. It was also considered important to listen to users and, as far as possible, adapt products and plans to their needs.

The goal was to convince decision makers that maps are important planning tools and that allocating increased resources to mapping would lead to significant rationalization and savings in a wide range of activities.

Following up

The decision now taken by the Government means that the framework for mapping activities has been established. The exciting task of implementation is about to begin. Expectations from all map users are high. The remaining planning work includes more detailed planning as to what should be done to different products, when and where. NLS has decided to carry out the strategic planning as a running plan, which will be evaluated and up-dated annually.

It also remains to specify the contents and design of some products and also to further consolidate the co-operation between NLS, other authorities and the municipalities in order to simplify the collecting of information, etc. Other fields to work with include modifying the production line at NLS, with regard to both technical and personnel requirements.

These are stimulating and demanding tasks, and their successful accomplishment can only be achieved by careful team-work and co-operation.

SYSTEMATIC MAPPING PROGRAMMES IN THE COMMONWEALTH COUNTRIES OF THE CARIBBEAN: A REVIEW*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Les activités cartographiques des pays des Caraïbes appartenant au Commonwealth, qui ont été menées à bien avec l'assistance du Royaume-Uni au cours de la période à l'examen, ont permis d'établir un nombre satisfaisant de cartes et de diazocopies à buts multiples à grande échelle. Les travaux d'établissement de cartes à petite échelle sont également assez avancés et reflètent l'importance croissante qu'un grand nombre de pays accordent au secteur important du tourisme.

Pour maintenir les activités cartographiques raisonnablement à jour dans les secteurs clefs et à un bon niveau de préparation dans les secteurs où l'évolution est plus lente, il faut assurer une bonne gestion et une affectation appropriée des ressources (tant humaines que financières). L'auteur examine la question des ressources requises et de leur utilisation efficace en se référant à des projets récemment réalisés par la Direction des services cartographiques d'outre-mer du Service de cartographie du Royaume-Uni (Overseas Surveys Directorate, Ordnance Survey — anciennement Directorate of Overseas Surveys).

RESUMEN

Los países caribeños del Commonwealth, la mayor parte de los cuales ha recibido asistencia del Reino Unido durante el lapso del presente examen, disponen actualmente de buenos mapas topográficos y mapas impresos mediante compuestos binitrogenados en gran escala y para fines múltiples. El levantamiento cartográfico en pequeña escala está también bastante actualizado y refleja en muchos de los países un creciente hincapié en el turismo como industria de importancia.

El problema de mantener el levantamiento cartográfico convenientemente actualizado en zonas claves y preparado en zonas donde se producen cambios de manera más lenta requiere una buena gestión y la asignación de recursos financieros y de personal. Se examinan los recursos necesarios y su utilización eficiente con referencia a recientes proyectos realizados por el Overseas Surveys Directorate, Ordnance Survey (anteriormente Directorate of Overseas Surveys).

Until the end of the Second World War, the mapping of what are now Commonwealth countries in the Caribbean region was sparse. There were many reasons for this, and the mapping of most of the less developed countries in the area was in a similar state (1). The need for accurate, reliable mapping then was recognized; with funds made available through British government development schemes, in 1946

* The original text of this paper, prepared by L. J. Howells, Overseas Surveys Directorate, Ordnance Survey, appeared as document E/CONF.77/L.45.

the newly-formed Directorate of Overseas (formerly Colonial) Surveys started mapping work in Antigua (1:25,000), Barbados (1:10,000) and Jamaica (1:50,000), initially using photography of the United States Air Force, and survey control emplaced by the military. The first of many subsequent field parties started control surveys in Guyana the same year (2).

Between 1949 and 1969 the Directorate evolved into a special unit of the British Ministry of Overseas Development, now the Overseas Development Administration, of the British Foreign and Commonwealth Office. Its resources became part of the British aid programme to developing countries. Work in this period was mainly directed to the establishment of new control for topographical mapping in a number of the smaller Commonwealth countries of the region and for basic mapping, which varied in scale from 1:10,000 in Barbados to 1:25,000 in the Bahamas and in the eastern Caribbean islands.

In the next decade survey control work was observed in the Bahamian sister-islands, Turks and Caicos Group, Barbuda, Caymans, Grenadines, Bermuda, Trinidad and Belize. Maps at 1:10,000 scale were produced for most of these countries from air photography, although difficulties were experienced in obtaining the photographs because of cloud cover in Guyana and over the more mountainous islands. Most of the air photography was obtained by British private sector companies on contract, but the Royal Air Force also made a significant contribution in the period 1961-1966. The British Directorate of Military Survey also carried out field-work in the region over the same period.

In the 1970s a change of emphasis occurred. Previously, most of the mapping had been produced for general development purposes, subject to constraints on available resources, but with the aim of national coverage of general purpose maps. In this period emphasis was placed on mapping for special projects. New funding for DOS operations, in common with other British aid procedures, was allocated on a project basis. Special projects met a growing requirement for large-scale mapping in support of specific schemes, including the project on Regional Cadastral Survey and Registration (British Virgin Islands, Cayman Islands, Anguilla and Antigua), other land registration projects (Belize, Montserrat, Guyana), property valuation and agricultural development.

Since the Second United Nations Regional Cartographic Conference for the Americas was held in 1979, the main direction of British aid, through the Directorate's activities, has been to revise and extend large-scale mapping and to revise and reconstruct smaller-scale mapping in support of specific projects and to foster tourism. Details are given in the country report of the United Kingdom to the present Conference.

Extension and maintenance of mapping

Although it is obvious to both users and the survey and mapping community that out-of-date maps progressively lose their value, the importance of systematic revision has not, so far, been sufficiently appreciated by most Governments.

Annexes I and II summarize the current situation of mapping and air photography. Most of the countries have, during the last few years, had their mapping revised and extended in areas with significant change, using air photography, photogrammetric plotting and local field completion through a number of aid projects. Generally, large-scale mapping has been made available as positive transparencies, rather than as printed sheets, to facilitate revision and allow production, on demand, of sheets containing the most up-to-date information available. The scene is thus set for the implementation of sound revision practice.

The Ordnance Survey of Great Britain has had long experience of map revision and has developed procedures of continuous revision which are very successful. Their important features are discussed in a separate paper submitted to the present Conference (E/CONF.77/L.27), but include:

(*a*) Establishment of a system for gathering, systematically and continuously, information (intelligence) of change which will need to be recorded on maps;

(*b*) Actual updating of large-scale maps on a continuous basis, so that the permanent resources allocated for the purpose can be efficiently employed in particular locations;

(*c*) Simple, cheap, graphic methods of revision based on sound control;

(*d*) A system for ensuring that users have access to the revised maps as soon as possible after the survey of change has been completed;

(*e*) Revision of smaller-scale maps related to the amount of change which has taken place and not to any given time interval.

In recent years the Directorate, through its Regional Survey Officer in the Caribbean, has placed great emphasis on the need to convince ministers, and senior officials in Governments of the region, of the necessity for making resources available to keep existing mapping maintained as far as possible up to date, particularly at large scales and in urban and other fast developing areas.

The extent of the large-scale task

Following the completion of a joint mapping project of the Governments of the United Kingdom and St. Kitts and Nevis, the opportunity is taken here to analyse future requirements. In this project some 160 km^2 of mapping at scale 1:2,500 was revised between 1982 and 1984, initially from air photography flown in 1981/82.

The field completion, that is, the survey of features built since the date of the air photography or obscured by vegetation etc., plus addition of names, took 13 United Kingdom technician surveyor-months. Local counterpart amounted to approximately 12 man-months (which included training). Thus, the overall rate per surveyor was some 6.5 km^2 per month, or nearly 80 km^2 per year (part of some of the sheets, however, was areas of sea). Up to September 1984, 2,113 house units (all surveyed features were quantified relative to a detached house with fences) were added in 21 man-months, an average rate of 100 house units a month.

On completion of this project, it is estimated that 24 "active" maps, each covering 2 km^2, would be required by local government needs to be kept fully revised. These covered areas including the small township of Basseterre (5 maps) and developing areas to the south-east covering another 16 sheets on St. Kitts; a total of 3 maps were in similar areas on Nevis. The survey section in St. Kitts is part of the Government's Central Housing and Planning Authority (CHAPA) and thus has easy access to applications and approvals for building etc. Records of approximate locations of new building/alterations/demolitions may be made on dyeline paper copies of the recently revised maps in the active category. When approximately one week's work has been accumulated in an appropriate location (i.e., when there are 20-25 housing units to survey), the surveyor-in-

charge should instruct a technician to revise the area. The master transparencies of the maps in the area should then be updated from this survey exercise by a trained draughtsman.

It is estimated that this work will take one local surveyor/technician about two months every year. It is also recommended that periodically (say, once a year) revision should be undertaken of other urban areas; at the most this work should not take a competent technician more than one month if the work is properly planned and monitored. On a longer time scale, for revision of minor detail and of areas where the rate and importance of change do not warrant continual attention, multipurpose air photography of the developed parts of the country could be used to check that all the maps are being kept reasonably up to date (or, if not, the size of the task to bring them to this state). Such photography would also be valuable for archival, census, agricultural, and forestry purposes and for crop surveillance.

Assuming that staff competent in revision by simple graphical methods and supervision by a responsible surveyor/manager are available, then the annual cost of fieldwork and fair drawing should not be more than about $US 600 (1984 salary rates). The cost of a multipurpose air photographic contract might be of the order of $42,000 (spread over, say, 10 years), although this could be reduced if the countries of the area were to co-operate in a joint contract to cover several islands once in, say, 10 years, because American and European air survey companies might then be willing to open a subsidiary company in the area for such a purpose.

In Dominica, a similar project for revision and extension of large-scale mapping is also in progress. A separate mapping unit in the small Lands and Survey Department has recently been set up. The unit will comprise a professional surveyor, who will have other duties, but will provide management, and one or two technicians who have been trained in revision by the simple graphical survey means used by Ordnance Survey. The correction of the dyeline transparencies will be entrusted to a trained draughtsman. Diazo paper prints, from these master transparencies, will supply demands (often made at short notice) for up-to-date maps.

Based on these models, the amount of resources to keep each country's developing areas up to date, and to maintain the National Survey framework as a parallel task, is not large. One problem that has arisen in the past is that emphasis has been placed solely on the execution of property surveys for Government and for private purposes. It is accepted that such government work must have a high priority but government surveyors are not generally well paid. If they obtain a licence to do private surveys, they are often allowed to undertake private sector surveys outside official working hours. Many, of course, leave Government altogether to take up private practice. Without government recognition of mapping needs, property surveys become completely dominant, while maintenance of the survey control framework and the mapping is neglected altogether.

Other Caribbean countries have introduced, in recent years, systems of land registration which are dependent on up-to-date large-scale mapping to support and maintain the Registry Index Maps which define property boundaries. The consequences of lack of maintenance in these countries will be particularly serious. But in all the smaller Commonwealth countries of the Caribbean, the cost of maintenance of the large-scale national mapping archive is a small price to pay, not only in support of land registration but to have maps generally up to date and available for politicians, administrators and planners and for such purposes as defence, security and service undertakings, as well as development. Of course, given that Governments have been convinced of the economic benefit, it is up to surveyors and cartographers to use the resources they have been given to the best possible effect and to use appropriate technology, which will keep costs to a minimum.

Revision at medium and small scales

For smaller scales and multicoloured mapping it seems improbable that all island countries can justify investment in equipment and trained manpower that very likely would not be fully utilized in the maintenance of quite small numbers of maps. If this is the case the available options will include combinations of:

(*a*) Limited revision capability in local departments;
(*b*) Further aid projects;
(*c*) Contract work commissioned by the Government;
(*d*) Regional co-operation.

As with large-scale mapping, knowledge of change and the extent to which change has affected the value of existing maps is an essential pre-requisite to any consideration of whether any particular map, or series of maps, merits revision. This knowledge can only be acquired locally, and most sensibly by the establishment of a formal system for recording change on a set of existing maps or components of maps at the survey department. The resources for this, and the accurate survey and recording of changed detail, will usually not be great. Methods can be adapted to available instruments and skills and the work involved can usually be integrated with other tasks, such as surveys for construction and of property boundaries, provided that the requirements are clearly set out and made known to the staff concerned.

The later stages of production will frequently pose more problems since the work-load will frequently be too small to justify the heavy investment represented by the purchase of expensive items such as a process camera and multicolour printing presses. The craft skills necessary for small-scale cartography may be expensive to acquire and difficult to maintain in the absence of sufficient work to ensure continuous practice.

The development of intelligence systems and the maintenance of survey data concerning changed detail are, however, within the scope of most departments and must be considered a regular task which will both reduce the cost of subsequent reproduction and provide justification for periodic expenditure through direct contracts and/or aid projects to complete the production of new editions.

Governments should be aware that resources must be set aside for reprinting, revised editions and, eventually, reconstructed maps (3). Whether this cost can be met from local resources or must be added to the many competing demands for development aid will be a decision that can only be made locally, but it should not be forgotten that medium- and small-scale maps are a source of revenue through sales to the public and generally, in the region, to visitors and tourists. With attention to pricing policy and to copyright or royalty revenue and to the quality of the maps, so that they are attractive in both content and appearance, much—perhaps all—of their cost can be recovered so that their availability for administrative and developmental purposes costs very little.

If local resources remain inadequate to meet the many and varied demands for recurrent expenditure, further sur-

vey and mapping aid projects may be the only possible solution. It is, however, only rarely that projects to deal with maintenance of mapping will rate high enough in competition for priority either within local governments or with donor Governments, to be included in programmes—that is, until the lack of updating has drastic effects on administration and development. By that time it is probable that, quite apart from the inconvenience and even danger of using inadequate maps, much more must eventually be spent, and on re-survey rather than revision. Certainly very careful preparation and presentation of proposals will be necessary, in which the hard facts of recorded change from a local intelligence system will be a vital ingredient.

No Government can, or would wish to, plan on the basis of a permanent need for aid funding, and many may see disadvantage in reliance on external contracts for national mapping. There is an alternative offering an efficient solution through regional co-operation. By working in co-operation with one another, the high costs of aerial photography associated with positioning and demurrage in an area with a fickle climate and of the capital equipment necessary for the production of multicolour maps could be spread and minimized.

It is a fact that while maps, when they exist, are often taken for granted, neither survey nor mapping is cheap. They are, however, essential elements of the infrastructure of a modern State for which spatial information becomes more important. Maintenance will be neglected unless the need is continually emphasized. Failure of maps to supply the information needed, accurately and when needed, is not spectacular, in comparison to the collapse of a bridge or the breakdown of a central electricity plant, but it does have serious effects. Departments will not fulfil their duties unless both the role of maps and the resources required to keep them up to date are properly represented to their Governments through adequate, but not extravagant, planning for future needs.

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Annex I

MAPPING OF COUNTRIES WITHIN THE CARIBBEAN REGION: BY SCALE, 1984

Country	Area (Sq. miles)	Population 1980 (E) = Estimated (thousands)	1:25,000 (or larger)	1:5,000 1:10,000 (S) = Scheduled	1:25,000 (and 2" to 1 mile)	1:50,000 (and 1" to 1 mile)	Country maps scale (S) = Scheduled
			(percentage cover)				
Anguilla	35	7	100	—	100	100	1:50,000
Antigua and Barbuda	108	70(E)	20	100	100	100	1:100,000
Bahamas	5,380	170	5	10	100	75	1:2,500,000
Barbados	166	244	80	100	25	100	1:50,000
Belize	8,866	145	5	5	—	100	1:750,000
Bermuda	21	55	100	100	100	—	1:75,000
British Virgin Islands	59	11	70	20	100	100	1:63,360
Cayman Islands	100	15(E)	30	60	100	100	1:150,000
Dominica	290	75	5	100(S)	100	100	1:122,500
Grenada	133	105(E)	5	15	100	100	1:150,000
Guyana	83,000	760(E)	5	10	15	100	1:2,200,000
Jamaica	4,400	2,096	10	15	100	100	1:250,000
Montserrat	39	12	40	60	100	—	1:25,000
Saint Kitts and Nevis	101	44	20	10	100	100	1:50,000
Saint Lucia	238	115	15	5	100	100	1:50,000
Saint Vincent and the Grenadines	150	98	5	50	100	100	1:200,000(S)
Trinidad and Tobago	1,980	1,059	10	90	100	100	1:475,000
Turks and Caicos Islands	166	7	5	100	100	100	1:200,000

Annex II

AERIAL PHOTOGRAPHY OF COUNTRIES WITHIN THE CARIBBEAN REGION

Country	1. Contact scale larger than 1:15,000		2. Contact scale 1:15,000 to 1:35,000		3. Contact scale smaller than 1:35,000	
	% cover	Date of latest A/P	% cover	Date of latest A/P	% cover	Date of latest A/P
Anguilla	95	Feb. 1982	100	Jan.-Feb. 1956		
Antigua and Barbuda	45	Mar.-Apr. 1968	100	Mar. 1968; Mar. 1966		
Bahamas	95	Mar.-Apr. 1958; Dec. 1958-Feb. 1959	100	March 1958		
Barbados	100/30	Jan. 1951/Dec. 1972				
Belize	5	1968	80	1975		
Bermuda	100	1981	90	1962		
British Virgin Islands	80	Jan. 1969	45	Feb.-Mar. 1981		
Cayman Islands	100	Jan.-Feb. 1971	100	Jan.-Feb. 1971		

Annex II (*continued*)

AERIAL PHOTOGRAPHY OF COUNTRIES WITHIN THE CARIBBEAN REGION

Country	1 Contact scale larger than 1:15,000		2 Contact scale 1:15,000 to 1:35,000		3 Contact scale smaller than 1:35,000	
	% cover	Date of latest AIP	% cover	Date of latest AIP	% cover	Date of latest AIP
Dominica	25	1982; 1984	40	1982; 1984		
Grenada	25	Mar -Apr 1977	100	Jan 1951		
Guyana	5	Oct 1972	10	Nov. 1975	10/10	Nov 1981/Oct 1983
Jamaica	90	1953-1954	100	1968	100	1979-1980
Montserrat	90	Feb -Mar. 1982	100	Feb -Mar. 1982		
Saint Kitts and Nevis	90	Dec 1981-Mar 1982	100	Jan -Feb 1956		
Saint Lucia	60	Jan -Apr 1981	100	Jan 1951		
Saint Vincent and the Grenadines	50	Jan -Apr 1981	80	Jan -Feb 1981		
Trinidad and Tobago	40	Feb -Mar. 1969	95	Jan -Mar. 1969		
Turks and Caicos Islands	100	Feb 1969	100	1980-1981		

Source: Overseas Surveys Directorate.

(b) *Map specifications*

INFORMATION ON ACTIVITIES RELATED TO CARTOGRAPHY*

Paper submitted by the International Organization for Standardization

The International Organization for Standardization (ISO) brings to the attention of the participants of the Third United Nations Regional Cartographic Conference for the Americas two international standards as follows:

1. ISO 3166 "Codes for the representation of names of countries" gives an internationally agreed alpha and numeric coding system for countries
2. ISO 6709 "Standard representation of latitude, longitude and altitude for geographic point locations".

Activities carried out by two ISO technical committees listed below could also be of interest.

1. ISO/TC 97 "Information processing systems"
   This committee covers the whole area of computing and information processing systems. Work on the establishment of data bases and networking information could be facilitated by reference to ISO International Standards in this field.
2. ISO/TC 42 "Photography"
   This committee has projects on aerial photography and film speeds that may well be of use to experts in air surveying.

For more detailed information on ISO activities and publications please contact:

International Organization for Standardization (ISO)
1, Rue de Varembé
Geneva
Switzerland

(c) *Geographical names***

LA COMMISSION DE TOPONYMIE DU QUÉBEC ET LA NOMENCLATURE GÉOGRAPHIQUE OFFICIELLE***

Document présenté par le Canada

SUMMARY

The Commission on Toponymy, set up under the Charter of the French Language on 26 August 1977, is the body which co-ordinates all toponymic work in Quebec. To this

RESUMEN

La Comisión de Toponimia, constituida por la Carta de la Lengua Francesa el 26 de agosto de 1977, es responsable de la nomenclatura geográfica del Quebec. La Comisión está encargada del establecimiento de normas y reglas ortográficas para la denominación de lugares; la compilación y el registro de los nombres de lugares; la creación y la normalización de la terminología geográfica; la oficialización de los nombres de lugares, y la difusión de la nomenclatura geográfica oficial. La Comisión aconseja al Gobierno con respecto a toda cuestión de toponimia.

* The original text of this paper appeared as document E/CONF.77/L.74

** See also "Information on activities related to cartography" (E/CONF.77/L.74), submitted by the International Organization for Standardization, discussed under agenda item 8 (b).

*** The original text of this paper, prepared by François Beaudin, former President of the Commission de toponymie du Québec, appeared as document E/CONF.77/L.64

end, the Commission was entrusted with the mandate of establishing norms and orthographic rules to be followed in respect of place names, compiling and keeping a record of names, establishing and standardizing geographical terminology, making place names official, distributing the official gazetteer and giving advice to the Government on any question concerning toponymy which the Government might submit to it.

In order to ensure the implementation of its decisions and of the rules and recommendations that it formulates, the Commission has just published the *Guide à l'usage des cartographes*, which contains all the basic toponymic rules and at the same time describes their specific application in cartography. It deals with aspects of Quebec toponymy and transborder toponymy that concerns Quebec. Other sections concern map titles, historical toponymy, the identification of sources and the compilation of index gazetteers.

Para asegurar la ejecución de sus decisiones y las reglas y recomendaciones formuladas por ella, la Comisión acaba de publicar un "Guide à l'usage des cartographes", que contiene las reglas toponímicas de base y que, al mismo tiempo, describe sus aplicaciones específicas a la cartografía. Trata de la toponimia del Quebec, y de la toponimia que toca al Quebec y el extranjero. Otras secciones tratan de los títulos de cartas, la toponimia histórica, la identificación de los orígenes y la compilación de índices para diccionarios geográficos.

Mandat de la Commission

La Commission de toponymie a été constituée par la *Charte de la langue française* adoptée le 26 août 1977. Succédant à l'ancienne Commission de géographie, elle devenait alors responsable de la nomenclature géographique du Québec.

La Commission s'est vu confier un vaste mandat et une autorité de dernier ressort en matière toponymique.

Ainsi, la Commission doit :

a) Etablir les normes et les règles d'écriture à respecter dans la dénomination des lieux;

b) Procéder à l'inventaire et à la conservation des noms de lieux;

c) Etablir et normaliser la terminologie géographique en collaboration avec l'Office de la langue française;

d) Officialiser les noms de lieux;

e) Diffuser la nomenclature géographique officielle du Québec;

f) Donner son avis au Gouvernement sur toute question que celui-ci lui soumet en matière de toponymie.

La Commission peut :

a) Donner son avis au Gouvernement et aux organismes de l'Administration sur toute question relative à la toponymie;

b) Réglementer les critères de choix des noms de lieux et la méthode à suivre pour dénommer des lieux et en approuver la dénomination;

c) Dans les territoires non organisés, nommer les lieux ou en changer les noms;

d) Avec le consentement de l'organisme ayant une compétence concurrente sur les noms de lieux, déterminer ou remplacer le nom de tout lieu d'un territoire organisé.

La Commission de toponymie est donc l'organisme dont le Gouvernement du Québec s'est doté pour réaliser le vœu des Conférences des Nations Unies sur la normalisation des noms géographiques, à savoir que chaque pays se dote d'une instance responsable de l'inventaire des noms de lieux, de leur traitement, de leur normalisation et officialisation et de leur diffusion.

Responsabilité de l'Administration

Etant donné que «les noms approuvés par la Commission au cours de l'année doivent faire l'objet de publication au moins une fois l'an à la *Gazette officielle du Québec*» (art. 127 de la Charte), il s'ensuit que «dès la publication à la *Gazette officielle du Québec* des noms choisis ou approuvés par la Commission, leur emploi devient obligatoire dans les textes et documents de l'Administration et des organismes parapublics, dans la signalisation routière, dans l'affichage public ainsi que dans les ouvrages d'enseignement, de formation ou de recherche publiés au Québec et approuvés par le ministre de l'éducation» (art. 128 de la Charte).

Collaboration de la Commission à l'exercice de cette responsabilité dans le domaine cartographique

Dans le but d'aider les cartographes du Québec à faire face à la responsabilité que le législateur leur a imposée, la Commission a voulu bâtir un outil qui leur permette de le faire aisément.

Elle a donc publié un *Guide à l'usage des cartographes* qui leur indique comment la toponymie doit être écrite sur les cartes et quelle toponymie doit être utilisée.

Vous trouverez en annexe I la table des matières de ce guide. L'annexe II comporte un extrait du chapitre 5 de ce guide.

Invitation aux autorités cartographiques à l'étranger

La tenue de cette présente conférence est l'occasion pour nous de rappeler que le territoire du Québec constitue 9% du territoire des Amériques.

Ce seul fait légitime déjà notre présence ici à cette conférence.

Mais il faut de plus ajouter que, sur ce vaste territoire de 1 667 926 km^2, dont 1 315 134 km^2 de terre ferme et 200 099 km^2 en eaux intérieures, la toponymie reflète la présence d'une population à plus de 80% francophone, mais aussi celle d'une population anglophone, en plus de celle des Amérindiens (8 langues et de nombreux dialectes) et Inuit.

De plus, nombre d'entités du territoire ne sont pas encore nommées. (Sur environ 500 000 lacs, un peu plus de 50 000 portent un nom officiel.)

Enfin, la juridiction de la Commission porte également sur les noms de voies de communication (plus de 21 300 sont maintenant officialisés sur un ensemble d'environ 80 000).

Pour toutes ces raisons, c'est 8 000 à 12 000 nouveaux noms qui sont rendus officiels par notre Commission, *chaque année*.

Il y a donc, tant de la part des autorités cartographiques nationales que de la part des grandes firmes productrices de cartes et d'atlas, une attention particulière à apporter à la toponymie du Québec qui est actuellement soumise à une normalisation systématique, et cela à un rythme considérable.

Enfin, il n'est pas prévu que ce rythme diminue avant de nombreuses années, compte tenu du territoire à couvrir.

Dans ce contexte, il est important de savoir que notre organisme a publié le *Répertoire toponymique du Québec* en 1979 et que depuis cinq numéros spéciaux de la *Gazette officielle du Québec* sont venus augmenter de 50% la nomenclature géographique officielle du Québec, qui se chiffrait à plus de 102 000 toponymes et odonymes.

Les diverses autorités cartographiques nationales et les firmes productrices de cartes sont donc invitées à se procurer les ouvrages qui ont été mentionnés précédemment auprès de la Direction générale des publications gouvernementales, Direction de la commercialisation, Case postale 1005, Québec (Québec) G1K 7B5.

Les futures publications et le Service de l'implantation

En terminant, si les producteurs de cartes ne réussissent pas à trouver réponse à toutes les questions qu'ils se posent sur la toponymie du Québec dans les ouvrages que notre organisme a publiés, ils sont invités à faire deux choses.

Premièrement, pour être tenus au courant de nos futures publications, ils devraient demander d'être mis sur la liste d'envoi des dépliants publicitaires annonçant ces publications.

Ils peuvent le faire en écrivant à :

Commission de toponymie du Québec
Service de l'animation et de la diffusion
220, Grande Allée Est
Québec (Québec)
G1R 2J1

Deuxièmement, si des points restent obscurs, les producteurs de cartes peuvent adresser des demandes de renseignements par correspondance à :

Commission de toponymie du Québec
Service de l'implantation
220, Grande Allée Est
Québec (Québec)
G1R 2J1

Conclusion

L'effort que le Gouvernement du Québec a accompli dans le domaine de sa toponymie depuis huit ans ne doit pas rester dans l'ombre des rayons de bibliothèque, mais il doit se répercuter dans toute la production cartographique qui couvre son territoire.

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5. — Documents annexes

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5.1.1 Toponymie québécoise

5.1.1.1 Toponymie officielle

Québec (Province) Commission de toponymie. *Répertoire toponymique du Québec*. Québec : Editeur officiel, 1978. XVII, 1199 p.

Numéros de la *Gazette officielle du Québec* qui complètent le *Répertoire toponymique du Québec*

Québec (Province) Assemblée nationale *Gazette officielle du Québec. Répertoire géographique du Québec*. (Partie 1, Avis juridiques) n° 31A (8 août 1977) [2] p., p. 7469 à 7730

Québec (Province) Assemblée nationale *Gazette officielle du Québec. Répertoire toponymique du Québec*. (Partie 1, Avis juridiques) n° 40A (7 octobre 1978) [2] p., p. 12 227 à 12 434

Québec (Province) Assemblée nationale. *Gazette officielle du Québec. Répertoire toponymique du Québec* (Partie 1, Avis juridiques) n° 31A (2 août 1980) p. 8181 à 8251

Québec (Province) Assemblée nationale *Gazette officielle du Québec. Répertoire toponymique du Québec* (Partie 1, Avis juridiques) n° 32A (8 août 1981) p. 8789 à 8930

Québec (Province) Assemblée nationale *Gazette officielle du Québec. Troisième supplément au Répertoire toponymique du Québec* (1978). (Partie 1, Avis juridiques), n° 51A (18 décembre 1982) p. 9343 à 9590.

Québec (Province) Assemblée nationale *Gazette officielle du Québec. Quatrième supplément au Répertoire toponymique du Québec* (Partie 1, Avis juridiques) n° 50A (17 décembre 1983) p. 5727 à 6014.

5.1.1.2 Guides toponymiques

Québec (Province) Commission de toponymie *Guide toponymique du Québec*. Québec : éditeur officiel, 1979. 45 p.

Québec (Province) Commission de toponymie *Guide toponymique municipal* Québec : Commission de toponymie, 1979. 118 p.

Québec (Province). Commission de toponymie *Guide à l'intention des éditeurs et des rédacteurs de manuels scolaires* Québec : Commission de toponymie, 1983. 37, [4] p.

Québec (Province) Commission de toponymie *Guide des noms d'entités* (à paraître en 1984)

Québec (Province) Commission de toponymie *Guide des noms d'entités de nature administrative* (à paraître en 1984)

Québec (Province) Commission de toponymie *Guide odonymique* (à paraître)

CARTOGRAPHY AND GEOGRAPHICAL NAMES*

Paper submitted by the United States of America

RÉSUMÉ

La question des noms géographiques revêt une importance croissante. Qu'on se place sur un plan théorique ou qu'on considère leur rôle dans l'identification des lieux, les toponymes jouent un rôle important. Le processus de création des toponymes est complexe et fait intervenir, entre autres disciplines, la géographie, la linguistique et la cartographie. On s'intéresse depuis longtemps, au niveau international, à la normalisation des noms géographiques, une large place étant faite aux programmes nationaux. L'Organisation des Nations Unies cherche activement à promouvoir les activités nationales dans ce domaine. S'il y a lieu de se féliciter des progrès accomplis dans le monde entier dans la mise sur pied de programmes nationaux de ce type, beaucoup reste à faire. Ce document montre qu'il est utile d'établir des liens structurels entre les services cartographiques et les autorités toponymiques de chaque pays. Ainsi aux Etats-Unis, le Service géologique et l'Agence cartographique de la défense (Defense Mapping Agency) fournissent un appui au Conseil des noms géographiques et, en retour, font appel à ses services. Ces liens s'avèrent importants et utiles. Le document contient également une liste de questions à étudier si l'on cherche à créer ou renforcer des services de normalisation des noms géographiques nationaux.

RESUMEN

El campo de la toponimia va aumentando en importancia Ya sea desde el punto de vista académico, o como elementos para la identificación de lugares, los nombres geográficos desempeñan una función importante Los procesos necesarios para producir nombres son complejos y requieren la aplicación de conocimientos geográficos, lingüísticos, cartográficos y de otras disciplinas. La atención internacional se ha centrado desde hace mucho tiempo en las ventajas de uniformar los nombres, y se ha hecho mucho hincapié en los programas nacionales. Al respecto, las Naciones Unidas han hecho grandes esfuerzos para promover la labor nacional de toponimia. Aunque en todo el mundo se han logrado adelantos encomiables en el establecimiento de esos programas locales, todavía queda mucho por hacer. En esta monografía se señala el valor de establecer vínculos organizacionales entre los organismos cartográficos nacionales y las autoridades toponímicas. En tal sentido, se señala el hecho de que, en los Estados Unidos, el Servicio Geológico de los Estados Unidos y el Organismo de Cartografía de Defensa prestan apoyo a la Junta de los Estados Unidos sobre Nombres Geográficos y reciben beneficios de ella. Se reconoce que esta vinculación mutua es importante y útil. En esta monografía también se proporciona una lista de temas que deberían examinarse en cualquier intento de crear o fortalecer organismos nacionales para uniformar los nombres geográficos.

There is good evidence that the study of geographical names plays an increasingly important role in many applications throughout the world. On the one hand, a growing number of people are interested in geographical names from perhaps an academic level and pursue the development of etymology of names. They may focus on very small areas and deal with the evidence of past cultural and linguistic factors. A study of names can also deal with migrations of peoples on a continental or even transoceanic scale who leave traces of their successive occupancy on names of natural features. These and other concerns offer interesting and, for some, vital clues as to national origins and can be used to identify historical legacies of settlement and ethnic development. Various organizations provide outlets for the research of experts involved with this aspect of geographical names. For example, the International Congress on Onomastic Sciences (ICOS) supports continuing forums for the presentation of research papers and related discussions dealing with the subject. In the United States, the American Name Society plays a similar role. (Both organizations, however, also embrace interests in names of all kinds, not only in geographical names.) A review of the literature of these bodies will readily indicate the professional contributions being made to a study of geographical names

ROLES OF GEOGRAPHICAL NAMES

While such efforts fill a needed purpose, there are other significant aspects of place names. Perhaps the most significant level can be classified as "general communications". Here names play a vital part in enabling people to communicate with each other as individuals or as groups and to place themselves or things in a locational context for identification purposes.

The matter of identification may seem simple, but it is complex. At one level, it is simple because where people and things are on the earth (or elsewhere) is obviously important if there is any need to engage in useful dialogue, conversation, or any other kind of communication about living and non-living things. This simple aspect of names can be further illustrated as follows. A botanist doing research of a particular plant's distribution is interested in knowing where new samples have been located. This information may permit him to find heretofore unknown distributional patterns of the plant. In another instance, there is the requirement that personal mail be delivered to the right place. If the name of the town (or country) is not known or is incorrectly spelled, the mail might not be delivered even despite the presence of coding systems.

These kinds of communications may have to depend on that marvellous human invention, the map. Discounting the kinds of maps that are not seen or utilized by the human eye and brain, no map has value without at least a minor degree of identification that involves geographical names. This identification could be no more than a title on the sheet (presumably referring to a feature on the map face), but depending on the intended use, identification could require the names of thousands of features and places. As differing maps covering the same part of the earth (or other area) are utilized, there is an obvious requirement that the same place depicted on the sheets have the same names.

* The original text of this paper, prepared by Richard R. Randall, Defense Mapping Agency, appeared as document E/CONF.77/L.21

Process of standardizing names

These aspects are clear and forthright. What remains complex is the process of assuring that geographical names are standardized—correctly and consistently spelled, officially recognized, and accurately located on a map, chart, or other medium. This process is often taken for granted, but anything more than a casual study of this process will reveal the many steps involved.

One important step is to select features for naming, a process depending on scale and purpose of the map. Another step is to find the correct name. An entire parade of steps is now involved. First, a source is needed, and if found, must be corroborated or proven to be sound. Possible errors or inaccuracies must be corrected. One name from two or more available names has to be selected. Recent name changes must be traced and updated. Accurate positional date and placement on the map have to be assured. The correctness of associated terminology has to be proven. All of these steps, in turn, require a rational process and an organizational capability to carry out the process. While many of these details can be conducted from within an office environment, in some places of the world, field-work is vital. As larger-scale mapping progresses, features previously not mapped become evident, and experts have to travel to the field to find the name. This action may require techniques involving linguistics, air photointerpretation, and even diplomacy to ensure that local citizens provide the correct name of an unnamed feature.

All of these factors are well known to this audience, but they should be mentioned because they have been the ongoing concern of many nations; they also have been the concern of the United Nations for a number of years. Those closely occupied with national and international programmes involving geographical names—most of which have proceeded under the term "standardization of geographical names"—are increasingly aware of several areas that need attention. There is hardly a need any longer to promote the concept that names are important to cartography.

Benefit of linking cartography and names programmes

What now should be emphasized is a more specific matter. With the knowledge that more and more nations are establishing programmes to standardize names—which can be credited in large part to international efforts implemented by the United Nations—it seems wise to identify the benefits that will arise if national cartographic agencies actively support these programmes. Such support exists in many nations already active in names work, since in many cases it is the map that requires consistent names information. Among other nations, perhaps the relationship is not seen or is less direct.

Professor Ormeling, past president of the International Cartographic Association and one who has been active in United Nations names programmes, has repeatedly stressed the importance of bringing cartography programmes and geographic names work closer together. At the Eleventh Conference of the United Nations Group of Experts on Geographical Names, held at Geneva in October 1984, the participants affirmed the value of establishing greater collaboration between national agencies involved with cartography, and hence with names. During that meeting, considerable attention was given to United Nations and national names work. Regardless of the agenda topic—training courses for the benefit of nations seeking to create names authorities, national progress in the publication of gazetteers, international co-operation in automated data processing to help assure standard specifications to facilitate the interchange of names information—it was clearly evident that such activities were moving ahead with gratifying results where national cartographic organizations were also involved. No matter what the level of effort is, it appears more and more evident that national names programmes best flourish and fulfil stated requirements when they are elaborated in conjunction with national cartographic agencies. This is not to suggest that names should be seen only as an element essential to a cartographic product, nor is there any idea that programmes of names standardization should be designed only to serve map production. The production of names within a country should serve many national applications—education, economic planning and development, tourism, the press, postal services, transportation—and, consequently, should keep the needs of the relevant users in mind.

While viewing cartographic needs as a primary reason for national programmes of names production, it is important to understand that names work cannot be relegated to a secondary level of significance. Instead, work on names should have a status equal to the requirement it should fulfil. Accordingly, cartographic agencies and cartographers should recognize the importance of a good names programme and of the scope of activities required to provide names to all users.

As indicated, the United Nations Group of Experts on Geographical Names has been active in attempts to encourage nations to create national names agencies. It sponsored a names training course in Indonesia in 1983. A future edition of the United Nations periodical, *World Cartography*, will be dedicated to geographical names. And a manual is being prepared to provide detailed guidelines on the establishment and functioning of national names authorities. The United States fully supports these efforts and anticipates that members of this conference will be interested in the cited publications. Meantime, there follows below a list of elements that could provide a general set of guidelines for any nation interested in creating or strengthening a names standardization body. They are presented with the hope that there will be a growing movement among national cartographic agencies to be more closely involved with names programmes.

General guidelines in creation of names authority

1. *Goals*

(a) *Cartographic support*: support for mapping and charting programmes of national agency;

(b) *Other requirements*: provision of names to other users through gazetteers or lists of names;

(c) *Co-operation*: participation in international names co-operation.

2. *Structure*

(a) *Legal basis*: appropriate legal backing and financial support to make decisions and to promulgate lists of names in official documents;

(b) *Membership*: committee or commission with members from cartographic and other user-producer organizations;

(c) *Staff*: permanent technical staff to provide research and administrative support to committee, to maintain names

files, and to produce gazetteers and related names documentation.

3. *Functions of a national names agency*

(a) *General*: establishment of procedures and policies for considering names questions and developing production programs.

(b) *Field collection*:

(i) Work with national and local (provincial or other) authorities to obtain or confirm names;

(ii) Use of tape recorders and systematic methods of obtaining names information orally and in writing;

(iii) Use of maps and aerial photography.

(c) *Office processing*:

(i) Establishment of office area for research, study, and files;

(ii) Maintenance of files of names to serve stated requirements.

(d) *Production of names*:

(i) Provision of names to meet cartographic production;

(ii) Issuing of lists of names as names are approved.

(iii) Publishing of gazetteers for major regions or entire national areas according to programmed schedule.

(e) *Inquiry services*: provision of answers to questions from various sources for names data.

4. *International co-operation*

(a) *Border areas*: work with adjoining nations to resolve names questions.

(b) *Information exchange*: exchange of names information with other countries;

(c) *United Nations programmes*: making certain that participants in United Nations names programmes represent or have co-ordination with the national cartographic organization.

Emphasis should be placed on the last item concerning participation in United Nations programmes. When people involved in United Nations names programmes also are involved or have knowledge of national cartographic programmes, their representation can assume a greater degree of authority than would otherwise be possible.

The experience of the United States in cartographic and geographic names programmes suggests that goals of both areas are well served by collaboration and interdependence. While the principles, policies, and procedures of the United States Board on Geographic Names, and its structural ties to the United States Geological Survey and the Defense Mapping Agency for staff, administrative, and publication support may not be precise models for other countries, there is evidence that these factors play an important role at both the national and the international level.

GEOGRAPHIC NAMES INFORMATION SYSTEM*

Paper submitted by the United States of America

RÉSUMÉ

Le Service géologique des Etats-Unis a mis au point le Système d'information sur les noms géographiques (GNIS) compte tenu des besoins essentiels en ce qui concerne les noms géographiques et leur normalisation, leur utilisation et leur diffusion à l'échelon national. Il est possible d'extraire, transformer, combiner et analyser les informations contenues dans le Système pour satisfaire les besoins d'une large gamme d'utilisateurs, aussi bien pour la recherche que pour les applications. Les applications et l'utilisation des informations du Système sont diverses : planification des transports locaux, planification régionale, commercialisation, sélection et analyse des sites, préparation aux situations d'urgence, recherche généalogique et solution de problèmes exigeant l'emploi et l'analyse de noms géographiques.

Pour l'instant, on distingue deux phases dans la mise au point du Système. La phase I consiste à rassembler environ 2 millions de toponymes obtenus directement à partir de cartes topographiques à grande échelle publiées par le Service géologique. Pour que le Système automatisé soit aussi pratique et efficace que possible, il faut y ajouter des noms de détails ne figurant pas sur les cartes topographiques, notamment d'autres noms importants pour les chercheurs et les utilisateurs, par exemple les noms historiques et les variantes. La phase II consiste à rassembler systématique-

RESUMEN

El Sistema de Información sobre Nombres Geográficos fue establecido por el Servicio Geológico de los Estados Unidos para atender importantes necesidades nacionales en lo que respecta a los nombres geográficos y su normalización, aplicación y difusión. La información del sistema puede ser recuperada, manipulada, ordenada y analizada para atender las necesidades de una gran gama de usuarios, ya sea para fines de investigación o para su utilización. Las aplicaciones y los usos de la información del sistema son variados e incluyen actividades como la planificación del transporte local, la planificación regional, la comercialización de productos, la elección y análisis de sitios, la preparación para casos de emergencia, la investigación genealógica y la solución de problemas que exigen la utilización y el análisis de nombres geográficos.

Hasta ahora se han identificado dos fases de recopilación de datos para el sistema. La fase I abarca cerca de 2 millones de nombres geográficos recopilados directamente de los mapas topográficos de gran escala publicados por el Servicio Geológico de los Estados Unidos. Para que el sistema automatizado de información sobre nombres pueda usarse eficazmente es necesario agregar los nombres de los lugares geográficos no registrados en los mapas topográficos, incluidos otros nombres de importancia para investigadores y usuarios, como nombres históricos y variantes de los nombres. La fase II consiste en la recopilación sistemática de nombres a partir de otras fuentes, incluidos mapas, cartas y textos, así como fuentes históricas. La información re-

* The original text of this paper, prepared by Roger L. Payne, United States Geological Survey, appeared as document E/CONF.77/L.25

ment des noms obtenus d'autres sources, notamment des cartes et des textes, ainsi que de sources historiques. Chaque toponyme est accompagné d'informations sur la nature des détails, l'emplacement (Etat et Comté); les coordonnées géographiques exprimées en degrés, minutes et secondes, les cartes correspondantes du Service géologique, l'altitude, la situation du nom à l'échelon fédéral, les variantes, les codes bibliographiques et, dans certains cas, des notes et descriptions historiques. Les autres informations — population, municipalité, étendue et codes de données — ne sont pas encore complètes.

Les produits du Système sont disponibles sous plusieurs formes. Pour les Etats pour lesquels la phase II est terminée, les dossiers sont publiés comme volumes de la publication professionnelle n° 1200 du Service géologique, *The National Gazetteer of the United States of America*. Ces volumes contiennent des variantes de noms renvoyant aux noms officiels, de même que des noms provenant de sources diverses. Les informations de la phase I sont disponibles sous forme de publications provisoires avec une reliure en spirale et de microfiches. Pour des recherches spéciales et des analyses de noms, une version informatisée interactive — ou en ligne — peut être consultée au siège du Service géologique ou dans ses centres d'information. On peut également obtenir les données sur bande magnétique.

Le Système est conservé par la Division cartographique nationale du Service géologique. Chaque centre cartographique régional compile et édite les nouvelles données et corrections relatives aux noms, qui sont communiquées électroniquement au personnel du GNIS, qui procède à un dernier contrôle avant de les introduire dans le Système. L'United States Board on Geographic Names (Conseil pour les noms géographiques) transmet directement au Système les informations relatives aux solutions trouvées en cas de contradictions entre les noms au niveau fédéral. Le bon état et la fiabilité du Système sont garantis par une série de contrôles, de façon à ce que tous les utilisateurs puissent extraire et utiliser les données sans risques.

lativa a cada nombre geográfico incluye el tipo de característica geográfica, la ubicación por Estado y condado, las coordenadas geográficas expresadas en grados, minutos y segundos, la cobertura en los mapas del Servicio Geológico de los Estados Unidos, la elevación, el estatuto federal del nombre, las variantes del nombre, las claves bibliográficas y, en algunos casos, apuntes y descripciones históricos. Se agregan también, aun cuando en forma no completa todavía, otras categorías de datos, como población, clasificación urbana y rango, y claves de datos.

La información del sistema se pone a disposición de los usuarios mediante diversos medios. Los archivos estatales en los que se ha completado la fase II de recopilación se publican como volúmenes del documento profesional 1200 del Servicio Geológico de los Estados Unidos, *The National Gazetteer of the United States of America*. Esos volúmenes contienen las variantes de los nombres oficiales con remisión a éstos, así como nombres procedentes de diversas fuentes. Publicaciones provisionales que recogen la información obtenida en la fase I pueden ser consultadas por los usuarios en forma de libros de hojas sueltas y microfichas. En el Servicio Geológico de los Estados Unidos y en sus oficinas de información puede consultarse una versión interactiva o en línea para investigaciones especiales y análisis de nombres. La información del sistema puede obtenerse también en forma de cinta magnética.

El Sistema de Información sobre Nombres Geográficos está a cargo de la División Nacional de Cartografía del Servicio Geológico de los Estados Unidos. Cada centro cartográfico regional recopila y da el formato adecuado a los datos sobre nuevos nombres y sus correcciones, que se transmiten electrónicamente al personal del sistema para su comprobación final antes de darles entrada en el sistema. La Junta de Nombres Geográficos de los Estados Unidos transmite directamente al sistema información concerniente a las resoluciones adoptadas respecto de nombres que difieran en fuentes federales. Una serie de comprobaciones y cotejos permite garantizar la integridad y certeza de la información, de modo que todos los usuarios puedan recuperar y utilizar los datos con entera confianza.

The Geographic Names Information System (GNIS) was developed by the United States Geological Survey (USGS) to meet major national needs regarding geographic names and their standardization and dissemination. Information in the system can be retrieved, manipulated, arranged and analysed to meet the needs of a wide variety of users for either research or application. Primarily, GNIS was designed to:

(*a*) Assist in establishing uniform geographic name usage throughout the Federal Government in co-operation with the United States Board on Geographic Names;

(*b*) Provide an index of names found on Federal, state and other maps;

(*c*) Eliminate duplication in time and money spent by government agencies, industry and institutions to organize similar data files for specific needs;

(*d*) Provide an interface for integrating data from other systems for multidisciplinary use;

(*e*) Provide for standardization of data elements and their coded representation for use within the information processing community;

(*f*) Meet Federal public information requirements prescribed by law.

System development

The GNIS is currently composed of five data bases: the National Geographic Names Data Base; the USGS Topographic Map Names Data Base; the Generic Data Base; the National Atlas Data Base; and the Board on Geographic Names Data Base.

Research and initial compilation of data for the GNIS was begun in 1968, and test data were collected and completed for Massachusetts. In 1976, geographic names data for Kansas and Colorado were collected as a pilot project to determine the feasibility of compilation on a national scale. After analysis and favourable evaluation of this pilot project, geographical names data for the remaining States and territories were compiled from 1978 through 1981. The initial compilation, or Phase I, is now complete, and the system includes most named features on all of the maps in the USGS topographic map series except roads and high-

ways, communication towers and triangulation stations. As maps with the largest scale available were used during the initial compilation, the majority of the names were compiled from 1:24,000-scale, 7.5-minute topographic maps. When there were no published 7.5-minute maps or advance copies with names available, 15-minute maps were used; when there was no coverage by either series of maps, 1:250,000-scale maps were used.

After the initial compilation, the geographical names in each state were edited by comparing the computer file with the accumulated records of the United States Board on Geographic Names (BGN). This edit was a comparison of names on a one-to-one basis, which is a precise method of finding and correcting errors. When the initial edit of the geographical names in a state was completed, the corrections were made, and other information such as variant names and BGN data were added.

Optimum use and effectiveness of the automated names system requires that the names of features not recorded on topographic maps be added, as well as other names of importance to researchers and users, such as historical and variant names. The systematic collection of names from other sources, including maps, charts and texts, as well as historical sources, is termed Phase II.

Products

A standard format product is available with each name listed as a 132-character line of information designed to provide at least some information from most of the locative data elements. An alphabetized listing of all of the names in a particular state or territory is also available in the form of spiral-bound alphabetical listings, microfiche and magnetic tapes. Specialized searches may be tailored to the individual needs of the user. Results of specialized searches are usually provided as computer print-outs or magnetic tapes but may also be obtained in the form of spiral-bound books or microfiche. An interactive or online version to retrieve, arrange, manipulate and analyse information is available for use at USGS headquarters and its regional mapping centres. A special, more formal publication is the *National Gazetteer of the United States of America*, published as U.S. Geological Survey Professional Paper 1200. The geographical names in each state and territory will be published as separate volumes in the gazetteer series when Phase II compilation and edit have been completed.

Maintenance

The GNIS is maintained by the USGS National Mapping Division. Each regional mapping centre compiles and formats new name data and minor corrections, which are electronically transmitted to the GNIS staff for a final check before the data are entered. BGN transmits information directly to the system concerning the resolution of geographical names found to be in conflict on Federal sources. A series of checks and balances assures integrity and security so that all users can retrieve and use data with confidence.

The maintenance schedule is on a continual basis, and flexibility is built into the system for any needed maintenance adjustment. All users have retrieval capability, but only the GNIS managers have the capability to alter, add or remove information. GNIS is maintained at the USGS National Centre by the Branch of Geographic Names, and the system resides and operates on an Amdahl V7 computer.

Description of the data bases

A record consists of a name and its associated data, but, because names may be duplicated, each record is given a unique eight-digit number. The first two digits of this number identify the file and the remaining six digits identify the specific record within the data base.

Record content

One of the most important concepts in GNIS is the nature of the data or what kind of data are present. The following tables list an abbreviated form (label) of the data elements in each of the five data bases and their meanings, followed by a detailed explanation of each data element. To properly search and retrieve information, the user must be thoroughly familiar with the contents of the system, as well as the commands.

Data elements

National Geographic Names Data Base

The National Geographic Names Data Base is the primary and largest data base in GNIS and contains 57 files representing each state, territory and the District of Colombia. Each state file contains, as a minimum, the names compiled from the USGS topographic map series, but many state files contain information from other source materials. Eventually, all state and territory files will contain information from other sources.

The following data element descriptions are designed to provide the necessary information for understanding and retrieving data. Table 1 lists each data element and the appropriate abbreviation used when retrieving data.

Table 1. Labels and data elements from the National Geographic Names Data Base

Label (Abbreviation)	*Data element*
BIBLIO	Bibliographic code
CENCODE	Census place code
COUNTY	County name
DESCR	Description
DESIG	Type of feature
ELEV	Elevation (Ft)
FIPS 55	FIPS 55 place code
HEADS	Source of feature (LATLONG)
HIST	Historical note
LATLONG	Geographic coordinates
LOC	State/County FIPS code
MAP	GNIS map number
MAPNAME	Map or chart name
NAME	Feature name
NUMBER	ID number
POP	Population (1980)
QUAD	USGS quadrangle code
SIZE	Size
SPDESIG	Special designator (Detailed)
SPEC	Special codes
STATUS	Federal status
STR	Section, township, and range
TAG	Sort according to BGN rules
VAR	Variant name(s)

BIBLIO: a variable-length alphanumeric coded entry that references the exact source for each name in the state or territory that was not compiled from the USGS topographic map series in the *initial* compilation. The first two characters of the code are the alphabetical Federal Information Pro-

cessing Standards (FIPS) state code, followed by a hyphen and an M or a T corresponding to "map" or "text", respectively. The M or T is followed by one or more digits that are a specific reference to a fully documented and annotated bibliographic entry describing the source material and relative worth of the source from which that name was obtained. If the source used is an atlas or text, the code will be followed by a slash (/) and a specific reference to a map or page in the source. The complete bibliographic entry is located in the Generic Data Base. The absence of a code indicates that the name was compiled during Phase I (1978-1981) from the most current, largest scale USGS topographic map. Information in this element will be added as each volume of the gazetteer series (Professional Paper 1200) is published.

CENCODE: a four-digit numeric field that represents the place code as assigned by the Bureau of the Census. This code is available only in the populated places file.

COUNTY: the variable-length upper- and lower-case name that represents the primary civil division (county level) in which the primary co-ordinate of the feature is located. Unlike the data element LOC, which indicates all counties in which a feature is located, this element contains only the county in which the primary co-ordinate (centre or mouth) is located.

DESCR: upper- and lower-case text that defines the situation, or relative position to nearby features and to at least one close, well-known feature, usually a major town or city. Distances are provided, as well as the names of all major and minor civil divisions associated with the feature. The data element is active only in the Alaska and Massachusetts files at this time.

DESIG: a variable-length totally lower-case alphabetical element that is designed to group similar features into broadly designated categories to facilitate search and retrieval. These categories can be altered only by approval from the GNIS data base manager. The Generic Data Base contains a cross-reference for every generic thus far encountered in the compilation of the National Geographic Names Data Base.

ELEV: a variable-length field containing up to five characters that give, in feet, the height above or depth below sea level of the highest or lowest point respectively. The entry is present only if a published elevation was directly associated with the feature. Generally no interpolation was made, and metric conversion will be accomplished at a later date. Negative elevations are preceded by a minus sign. The Alaska file contains some ranges of elevations separated by a hyphen, in addition to the single elevation entry. States and territories that have been completed through Phase II contain interpolated elevations for populated places, locales and summits; some other features compiled during Phase II may have interpolated elevations. Data in this field are left justified and therefore *must* be treated as decimal data when sorting.

FIPS 55: a five-digit numeric field that contains the place code of populated places as assigned by the National Bureau of Standards. The codes are available only in the populated places file.

HEADS: a fixed-length alphanumeric field provided to indicate the source of linear features. The format is identical to that of the geographical co-ordinates in LATLONG; however, there can be only one source co-ordinate. The source co-ordinate corresponds to the last entry in the data element MAP unless the source co-ordinate is not within the state, in which case no corresponding map number is provided. The source of a linear feature is not always indicated by the name placement on the map; therefore, the guideline applied was that the source of linear features not properly identified by name placement, textual description, or any other indicative variable should be taken to the source of the longest, straightest drain. This guideline is in accordance with the policies of BGN.

HIST: a variable-length upper- and lower-case text that provides as much information as is available from all known reputable sources about the physical and cultural history of a named feature. In addition, special attention is given to name origin, if known, and detail is provided for background research. At present, the element is active only in the Alaska and Massachusetts files, with some information provided in state files that have completed Phase II compilation.

LATLONG: an entry that contains the official geographic co-ordinates in a variable-length alphanumeric field with each co-ordinate compressed and fixed at 15 characters. Latitude and longitude are to degrees, minutes and seconds, and each is followed by a one-letter directional. If the degrees of longitude are less than 100, a leading zero is required. The first co-ordinate in this element is termed the primary co-ordinate. In the case of areal features, this co-ordinate represents the approximate centre of the feature, while the primary co-ordinate of linear features represents the mouth. The mouth is where the feature joins another feature, ends in a delta or in an alluvial fan, or no longer has a discernible channel or trough-like characteristics. All subsequent co-ordinates in this element are termed secondary co-ordinates and are designed to associate the feature with each 7.5-minute topographic map on which it is located. The required location of the secondary co-ordinate is simply anywhere on the feature and on the topographic map with which it is associated. Strict guidelines were established as to the point where each kind of feature is digitized (see Generic Data Base below), and the geographic co-ordinates are accurate to within 5 seconds of latitude or longitude. An exception occurs with large populated places or cities. The guideline for digitizing areal features requires the co-ordinate to be taken in the centre, but the location of the centre of a large city is somewhat subjective. Additional guidelines were suggested for determining the centre of large populated places, such as the location of the city hall or town hall, main post office, main library, central business district, or main intersection. The primary co-ordinate corresponds to the first number in the data element MAP and the entry for the data elements QUAD and MAPNAME. All subsequent co-ordinates correspond on a one-to-one basis, with the entries in the data element MAP. An exception occurs if the primary co-ordinate is outside the state, in which case no corresponding map number is provided. Also, multiple co-ordinates for linear features are in order from mouth to source, while multiple co-ordinates for areal features are generally from the centre outward.

LOC: a variable length alphanumeric field that contains one or more five-digit FIPS codes referring to the state and county. The first two digits refer to the state or territory, and the last three refer to the county, parish, municipality, or other civil division. Codes for all counties in which a feature is located are present with multiple entries separated by a blank. Multiple county codes are ordered from mouth to source for linear features, and generally from the centre outward for areal features. All codes are numeric except where the state or territory borders a foreign country, where the appropriate two-character alphabetical FIPS code is used; for example, CA for Canada, MX for Mexico, UR

for the Soviet Union, UK for the United Kingdom, and WS for Western Samoa.

MAP: a variable-length four-character alphanumeric entry with leading zeros, if appropriate, that refers to each USGS topographic map (published or planned). This data element includes all topographic maps associated with the feature, and multiple entries are separated by a blank. If Phase II has been completed, it is possible that the feature may be shown, but not named, on the topographic map. Entries found outside the bounds of topographic map coverage are properly coded with the map series from which they were taken; for example, entries from National Ocean Service charts outside the border of any topographic map are coded NOS CHART 12345 (using the appropriate five-digit number). The GNIS four-digit numbering system begins in the north-west corner of each state or territory and continues from west to east while progressing latitudinally southward. Note that no map number is provided for the primary co-ordinate, secondary co-ordinate, or the source co-ordinate, if they are not within the state. The final entry in this element is the map on which the source co-ordinate is located. The first entry corresponds to the first entry in LATLONG and the entries in MAPNAME and QUAD, with subsequent entries corresponding on a one-to-one basis to the subsequent co-ordinates in LATLONG.

MAPNAME: the variable-length upper- and lower-case entry that represents the map name exactly as it appears on the USGS topographic map. The element contains only one map name or the map name on which the primary co-ordinate is located and differs from the data element MAP, which contains all topographic map numbers on which the feature is located. As in the data element MAP, if the feature falls completely outside the bounds of USGS topographic map coverage, a reference to the source map is present. The entry in this data element corresponds to the coded entry in QUAD and to the first entry in LATLONG and MAP. If the primary co-ordinate is located outside the state or territory, the name of the map, followed by a blank and the two-character alphabetical state FIPS code, are recorded.

NAME: a variable-length upper- and lower-case alphanumeric entry that indicates the official geographic name and, in many cases, the generic or type of feature. Some entries are followed by a space and an asterisk which indicate that there is a diacritical mark somewhere in the name. This arrangement is temporary and will soon be replaced by the appropriate diacritical mark and the removal of the asterisk. In some cases the generic may be in the first position, and followed by the specific name. In this case, if the feature is a physical feature the generic is reversed; for example; Mount Saint Helens becomes Saint Helens, Mount. Names with a false generic are not reversed; for example, Mount Olive, which is a populated place and not a mountain, remains Mount Olive. Some names are followed by a parenthetical entry which provides additional information about the name; for example, Gold Town (historical site), Seven Springs (flowing), Big Flat (mud). Unedited geographical names may have a number symbol (#) or some other special character preceding the name, which indicates a problem with the name that will be resolved during the first edit. Also, the Alaska file contains some names with a blank preceding the name. This indicates that the longitude is east even though a W is present. The proper directional will be applied during the first edit.

NUMBER: an eight-digit number that is the unique identifier of each feature and its associated information. The first two digits correspond to the state numeric FIPS code. This is the only data element that must exist for each record and is for GNIS internal use.

POP: the population of all named features in the feature class category of populated place and, if applicable, locale. The data element is active only in the populated places file but will be activated in the individual state files at a later date. The data element will also be expanded to include ranking of populated places.

QUAD: a fixed-length alphanumeric field that contains eight characters of the USGS topographic map coding system. The first five digits represent the degrees of latitude and longitude of the particular 1° latitude × 1° longitude square in which the map is located, followed by a hyphen and a specific alphanumeric code identifying one of the 64 7.5-minute cells in the 1° × 1° square. The rows of the square are coded A through H, and the columns are coded 1 through 8, each beginning in the south-east corner of the 1° × 1° area. The only entry is the code for the 7.5-minute topographic map on which the primary co-ordinate of a feature is located. If the primary co-ordinate is located outside the state or territory, the coded entry will be for the first map in the state or territory on which the feature is located.

SIZE: a short variable-length phrase that gives the length of linear features and the width of areal features in English units. This element is active in the Alaska and Massachusetts files, and the element is being utilized in the compilation of Phase II data.

SPDESIG: a variable-length data element that is a further refinement of the broad categories in DESIG. Special information is provided allowing more sophisticated search and retrieval of information, based upon categories and subcategories of information relating to types of features. For example, all places where airplanes and helicopters land are coded "airport." Privately owned airports have special information to allow search and retrieval on a subcategory. Another example is the differentiation of public and private recreation facilities. Information regarding whether populated places are incorporated or not may be found in this data element. Other information includes ownership of public land such as Federal, state, or municipal. This element is active in states and territories that have completed Phase II compilation.

SPEC: a special numeric reference code that relates to specific characteristics of the named feature such as source material; language of origin; unusual characteristics; number of words in the name; whether descriptive, associative, or comparative; or any other known characteristic of the name. This data element is currently available in the Massachusetts file only.

STATUS: an entry that provides the Federal standing of each name in the data base. Entries indicate whether the name is official according to the policies of BGN; has had special research and consideration by BGN (BGN YEAR); is official by an act of Congress (US YEAR); is administrative according to Federal, state, or local organizations (ADMIN); or is unofficial (UNOFF) and not within the purview of the BGN or any other administrative body.

STR: a data element that identifies the appropriate section, township and range in which the feature occurs, as well as the principal meridian with which it is associated. The township and range system was established in the late eighteenth century to systematically divide Federal lands. The original 13 states and Vermont, Tennessee, Kentucky, West Virginia, Maine, Texas, Hawaii, part of Ohio and all territories are not included in the township and range system. The

element is active only in the Arizona file and is being added as state files complete Phase II compilation.

TAG: a special fixed-length numeric code that consists of the first two digits of the FIPS code for the state or territory, followed by consecutive numbers in increments of one hundred to facilitate sorting. These special codes enable the sorting rules of the BGN to be applied. Data from this element should be used only with the SORT command. The element is active only in states or territories that have been completed through Phase II.

VAR: a variable-length upper- and lower-case field containing any other current name, former name, or former spellings of the current official name. If more than one variant is present, they are arranged alphabetically and separated by a comma and a blank. In addition, if BGN has rendered a formal decision for what is now a variant, the year of that decision is given in parenthesis following the variant name with which it is associated. A variant obtained from a source other than BGN is followed by a code in parenthesis that is a reference to a complete annotated bibliography of the source. The code may also be followed by a map or page number if the variant was obtained from an atlas or a text. All complete annotated bibliographies reside in the Generic Data Base.

USGS Topographic Map Names Data Base

The USGS Topographic Map Names Data Base contains 57 separate files; the 1:24,000-scale topographic map names for each state and territory represent 56 of the files and a separate file contains information about 1:100,000- and 1:250,000-scale quadrangle maps.

The following data element descriptions are designed to provide the necessary information for understanding and retrieving data. Table 2 lists each data element and the appropriate abbreviation used when retrieving data.

TABLE 2. LABELS AND DATA ELEMENTS FROM THE USGS TOPOGRAPHIC MAP NAMES DATA BASE

Label (Abbreviation)	*Data element*
APPNAM	Assigned or approved names
COORD	LAT/LONG (SE corner)—Quad size (Minutes)
FIPS	State Alpha FIPS code
HIST	Former quadrangle name(s)
MAP	GNIS map no
NAME	Quadrangle name
NUMBER	ID number
QUAD	USGS quadrangle code
SCALE	Quadrangle scale
STATE	Quadrangle state(s)
XNAME	7.5 × 15 minute map name
250	Quadrants 250000 series

APPNAM: a variable-length field that represents the assigned or approved name of a 7.5 × 7.5-minute area that has not yet been mapped in the 7.5-minute topographic map series.

COORD: contains an 11-character code that represents the latitude and longitude of the south-east corner of the cell, or the north-east corner of the cell in American Samoa and the south-west corner of the cell in Guam. The coordinates are to degrees and minutes followed by the appropriate directional, with quadrangles ending in 30 seconds rounded down to the next minute as shown on each topographic map. Also, longitude of less than 100° is preceded by a leading zero. The file for 1:250,000- and 1:100,000-scale maps differs somewhat in that the directional precedes the co-ordinate, and the co-ordinate is followed by a slash and the dimension of the mapped area in minutes; for example, "/60 × 120" follows the co-ordinate. The co-ordinate that identifies the map is the corner co-ordinate closest to 0° latitude and 0° longitude. Note that while the format of the state and territory co-ordinates is fixed, the format for 1:250,000- and 1:100,000-scale maps is variable because the dimension in minutes of latitude and longitude may vary.

FIPS: a numerical element that contains the five-digit FIPS code for states and territories. This element is active only in the 1:250,000- and 1:100,000-scale map file.

HIST: data presented are of variable length and include any information of historical significance regarding the map, especially former names.

MAP: a four-digit number assigned to each 7.5-minute cell in each state and territory. Overedge maps are divided into two complete 7.5-minute maps with valid numbers, and 7.5-minute cells totally in water are also assigned valid numbers. The numbering system begins with the number 1 in the north-west corner of each state and territory and increases consecutively by moving from west to east while progressing latitudinally southward. This numbering system was designed specifically to code geographical names to individual topographic maps. Since the geographical names were compiled on a state-by-state basis, each state's numbering system begins with number 1, thereby creating controlled redundancy in the numbering system. Some 15-minute maps and 1:250,000-scale maps have numbers depending upon whether a state was completely covered by 7.5-minute published topographic maps at the time of Phase I compilation of the National Geographic Names Data Base. The beginning number for 15-minute maps and 1:250,000-scale maps varies from state to state. Maps in the 15-minute and 1:250,000-scale topographic map series are present only if they were needed for geographical name compilation. Complete coverage of the 1:250,000-scale maps may be found only in a separate file; however, complete 1:62,500-scale coverage does not exist in any GNIS file.

NAME: a variable-length entry that represents the full name of the 7.5-minute cell exactly as it appears on the published topographic map. Some 7.5-minute cell names are followed by a space and an asterisk, which indicates that the name has a diacritical mark somewhere in the name. The appropriate diacritical will be added at a later date. Some entries will contain the word "SEE" followed by a 7.5-minute cell name. This is necessary because each state or territory is divided into equal 7.5-minute cells (except Alaska), and many 7.5-minute maps are published as overedge maps, which means that small portions of land outside the normal 7.5-minute bounds of the map are included. Overedge areas are treated as a separate 7.5-minute cell, with no approved name, and must be referenced to the main 7.5-minute map which portrays the overedge area. In addition, some special 1:24,000-scale maps are designed to show oddly shaped areas, such as Isle Royal in Michigan. These areas have also been divided into as many 7.5-minute cells as necessary with each cell name a reference to the main map, except the south-east corner 7.5-minute cell which bears the actual name of the main map. Also, some entries contain the reference "(ALL WATER)", which indicates that the particular 7.5-minute cell is completely water. Maps may not have been published for 7.5-minute areas in which case the word "SEE" is present followed by the name of the appropriate 15-minute published quadrangle and the indicator "15'" is present. In the absence

of a published 15-minute quadrangle, the reference will read SEE followed by the name of the appropriate 1:250,000-scale quadrangle and the indicator 250K.

Note that in the individual state and territory files, all available 15-minute or 1:250,000-scale quadrangles are *not* present. Those that are present are there only because there was no larger scale coverage at the time Phase I of the National Geographic Names Data Base was compiled. A complete listing of the names of 1:100,000-scale and 1:250,000-scale quadrangles may be retrieved from a separate file, but there is no complete coverage of the 15-minute series in any GNIS file.

NUMBER: an eight-digit number that is the unique identifier of each entry (quadrangle name) and its associated information. The first two digits correspond to the state numeric FIPS code. This is the only data element that must exist for each record in each file. The first two digits of the eight-digit entries for the QUADNAM file are 00. This element is for use by GNIS staff.

QUAD: contains the first eight characters of the USGS code for each 7.5-minute quadrangle in the United States. The entire United States (except Alaska and outlying areas) is divided into areas of 1° latitude × 1° longitude, each containing 64 7.5-minute quadrangles. The rows within each area are coded A through H, and the columns are coded 1 through 8, each beginning in the south-east corner of the 1° × 1° area. The first five characters are the same for each of the 64 quadrangles within the area and are determined by the geographic co-ordinates (degrees) representing the south-east corner of the 1° × 1° area. These five digits are followed by a hyphen and the appropriate row-column designation. This is not the complete quadrangle code, but it is sufficient to identify the 7.5-minute topographic map.

SCALE: indicates the ratio of units on the map to units on the Earth, and identifies the particular series to which the map belongs. In the state and territory files the entry is fixed at two numbers. Seven entries are possible: 20, 24, 25, 62, 63, and 88. The 20 represents metric topographic maps in Puerto Rico. The 24 represents 7.5-minute 1:24,000-scale maps in English units, and the 25 represents either 7.5-minute or 7.5 × 15-minute maps in metric units at a scale of 1:25,000. The 62 represents 15-minute maps at a scale of 1:62,500, and 63 is used (mostly) for 1:63,360-scale maps in Alaska. The 88 identifies maps in the 1:250,000-scale series in the state and territory files and was used because the field was limited to two characters. The scales in 1:250,000- and 1:100,000-scale file are six digits, either 100000 or 250000.

STATE: the entries in this element are of two types. One type is used in the state and territory files and is the two-character alphabetical FIPS code. The other type, used in the 1:250,000- and 1:100,000-scale file, is the state abbreviation from the *Government Printing Office Style Manual* as shown on topographic maps. The *Style Manual* abbreviations contain periods, and multiple state entries are separated by a hyphen.

XNAME: a variable-length element for the names of maps in the USGS 7.5- × 15-minute map series. Since the 7.5- × 15-minute map generally spans the same area as two 7.5- × 7.5-minute maps, the eastern half, containing the south-east corner co-ordinate, contains the name of the 7.5- × 15-minute map, while the western half contains the word "SEE", followed by the name of the 7.5- × 15-minute map.

250: the entries are of variable length and are limited to the 1:100,000-scale maps in a separate file. The information contained in this element associates the 1:100,000-scale map name to the appropriate quadrant of the 1:250,000-scale map. The entry consists of the 1:250,000-scale map name followed by the appropriate directional; NE, SE, NW, or SW.

Generic Data Base

The Generic Data Base is designed for use as a research and reference tool as well as a depository of reference information for GNIS. It contains the 62 broad feature categories of the National Geographic Names Data Base, definitions of those categories, and their cross-references to all types of features found on topographic maps and other sources. The data base also contains detailed information concerning unusual features, such as specifically where they are found, how they are used and, if possible, why they were applied in such an unusual manner. Other information includes a reference to abbreviations used on topographic maps and definitions of cartographical, geographical, and linguistic terms. Also included is the complete bibliography of all source material (in addition to USGS topographic maps) used in the compilation of the National Geographic Names Data Base.

The following data element descriptions are designed to provide the necessary information for understanding and retrieving data. Table 3 lists each data element and the appropriate abbreviation used when retrieving data.

TABLE 3 LABELS AND DATA ELEMENTS FROM THE GENERIC DATA BASE

Label (Abbreviation)	*Data element*
ABBREV	Standard abbreviation
BIBLIO	Annotated bibliography of source materials
DEF	Feature class definition
DESIG	GNIS feature class
HIST	Generic source, type, and use
NUMBER	ID number
PRIME	Primary co-ordinate location
SOURCE	Source co-ordinate necessary
WORD	Generic shown on map

ABBREV: contains the standard abbreviations used on USGS topographic maps, and includes all valid geographical, cartographical and linguistic terms and definitions necessary in researching geographical names.

BIBLIO: contains the complete annotated bibliographical entry for all source material other than USGS topographic maps used in geographical names compilation. Also, contains the code for the bibliographical entry used in the data element BIBLIO in the National Geographic Names Data Base.

DEF: provides the GNIS definition of each of the broad feature class categories contained in the data element DESIG. It provides the basis for classifying broad categories of features.

DESIG: a variable-length lower-case element that is designed to group similar features into broadly designated categories to facilitate search and retrieval of feature types. The entries in this data element correspond to the same entries throughout the system.

HIST: contains unusual generics or words. Each entry lists the map on which the generic is used, how it is used, to what it refers specifically, the general category in which it is located, reason for use (if discernible), and other pertinent information that would aid in research or application.

The same generic may refer to different types of features throughout the country. All unusual references to the same generics are listed together no matter how diverse the feature types.

NUMBER: an eight-digit number that is the unique identifier of each feature and its associated information. This number is for internal use and is the only data element that must exist of each record in each file.

PRIME: contains lower-case entries that specifically state where the primary co-ordinates of features in the National Geographic Names Data Base are to be digitized.

SOURCE: contains the lower-case word "yes" if the generic or feature class indicates a linear feature, thereby requiring that a source co-ordinate be digitized.

WORD: a variable-length upper- and lower-case entry that represents the generic or type of feature. It identifies a specific type of feature and may precede or follow the substantive or proper part of the name. This data element serves multiple purposes because it provides a relationship and reference from a feature type to the broad category of terms used to classify names in the National Geographic Names Data Base. It is also a record of all generic or unusual words encountered in all source material used in the compilation of other data bases. This data element provides a means of discovering and researching subtle differences in feature types.

National Atlas Data Base

The National Atlas Data Base is designed to be the basis of an abridged version of the entire National Geographic Names Data Base as well as national topical files. One file represents entries found in the index of the USGS *National Atlas of the United States of America* and is maintained primarily for historical purposes. Other files include a national file containing most known populated places and localities, as well as an abridged version of the National Geographic Names Data Base, which includes, among other categories, the well known physical and cultural features of the United States. The data elements are similar to those of the National Geographic Names Data Base (see table 1).

Board on Geographic Names Data Base

This data base contains information representing the investigations and decisions of the Domestic Names Committee of BGN. The Board was created in 1890 and established in its present form by Public Law in 1947. The Board is authorized to establish and maintain uniform geographical name usage throughout the Federal Government, and it also currently maintains a close working relationship with about 30 states. The staff of BGN researches the background of geographical names that are determined to be in conflict on Federal sources or are controversial in nature. The results of the research are promulgated in a quarterly report, and these decisions are binding for Federal usage. Most state and local usage follows the recommendations of the Board.

Each entry in this data base may also be found in the National Geographic Names Data Base; however, the entries contain the reference and associated detailed information researched and promulgated by BGN. The data base contains all of the activity of the Board from 1890 through the first quarter of 1959. The remainder of the data base is scheduled for completion in 1985. The data elements are similar to those of the National Geographic Names Data Base (see table 1).

INFORME DE LA PRIMERA REUNION REGIONAL DE LA DIVISION DE AMERICA LATINA DEL GRUPO DE EXPERTOS DE LAS NACIONES UNIDAS EN NOMBRES GEOGRAFICOS*

Documento presentado por la Secretaría

CAPITULO I

ORGANIZACIÓN DE LA REUNIÓN

Mandato

La Primera Reunión Regional de la División de América Latina del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos se celebró en La Habana, del 10 al 14 de diciembre de 1984, de conformidad con la resolución 7 de la Primera Conferencia de las Naciones Unidas sobre la Normalización de los Nombres Geográficos.

Participantes

Asistieron a la reunión representantes de los siguientes países: Argentina, Colombia, Cuba, Ecuador, España, México y Nicaragua. Estuvo representada la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (UNESCO). Asistió también como invitado el Sr. Dirk Peter Blok, Presidente del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos. Como observadores estuvieron presentes representantes de Panamá y Checoslovaquia.

Ceremonia de apertura

El Sr. Emilio Lluis Rojo, Presidente de la Comisión Nacional de Nombres Geográficos de la República de Cuba, dio la bienvenida a los representantes, exhortándolos a trabajar en aras de lograr la normalización de los nombres geográficos de la región.

El discurso de apertura estuvo a cargo del Sr. Ydelís Velázquez García, Vicepresidente del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos y Presidente de la División Regional de América Latina. En su discurso, el Sr. Velázquez destacó que esta Primera Reunión obedece fundamentalmente al mandato de la Primera Conferencia de las Naciones Unidas sobre la Normalización de los Nombres Geográficos, celebrada en Ginebra en 1967, sobre todo, a la necesidad que existe de participar en la uniformación de los nombres geográficos por los países latinoamericanos miembros de la División.

La reunión acuerda incluir el discurso de apertura como un documento de trabajo.

* The original text of this paper, prepared by Ydelís Velázquez García, President of the Latin American Division of the United Nations Group of Experts on Geographical Names, appeared as document E/CONF 77/L 41

Aprobación del reglamento

En la primera sesión plenaria de la reunión se analizó el reglamento, el cual tiene como finalidad establecer el procedimiento que permita la continuidad de los trabajos de la reunión. En este punto, la delegación de Nicaragua propuso interrelacionar los artículos 2 y 9 y sugirió que la secretaría hiciera la verificación de poderes. El Sr. Velázquez señaló que dicha propuesta es factible de aceptarse; sin embargo, consideró que, con el objeto de que exista una participación lo más amplia y democrática posible, sería la propia asamblea la que conformaría la Comisión. Estuvo de acuerdo con ello la delegación de Nicaragua. Finalmente se aprobó el reglamento.

Mesa de la reunión

La reunión eligió la siguiente Mesa:

Presidente: Ydelís Velázquez García (Cuba)

Vicepresidente: Alberto Martínez Barbosa (Colombia)

Relator: Gilberto Salinas Mendoza (México)

Verificación de poderes

La Comisión de Verificación de Poderes, compuesta por Hilda Sisalema Hidalgo (Ecuador), Adolfo Castrillo Quijano (Nicaragua) y Marta Martínez Samalea (Cuba), comunicó que las credenciales de todos los representantes eran válidas. La reunión aprobó su informe.

Aprobación del programa

La reunión aprobó el programa provisional preparado por el Comité Organizador.

Organización de los trabajos

El Sr. Velázquez propuso trabajar en sesiones plenarias, lo cual fue aceptado por la reunión.

La reunión estableció un Comité de Redacción, presidido por Luis Clarasó de la Vega (Argentina), e integrado por Cesáreo Sanz Alonso (España) y Gloria Amengual Rodríguez (Cuba).

Documentación

En la reunión se presentaron informes nacionales y documentos técnicos, los cuales aparecen en la lista del anexo.

Trabajos de la reunión

La reunión celebró cinco sesiones plenarias y una sesión de trabajo de los jefes de delegaciones. Los trabajos de la reunión se resumen en el capítulo II y las recomendaciones en el capítulo III.

Sesión de clausura

A la sesión de clausura, celebrada el 14 de diciembre de 1984, asistió el Sr. José Ramón Fernández Alvarez, Vicepresidente del Consejo de Ministros y Ministro de Educación de la República de Cuba.

El representante de Nicaragua, a nombre de las delegaciones asistentes, agradeció a la Comisión Nacional de Nombres Geográficos de Cuba la organización de este evento.

El Sr. Dirk P. Blok, Presidente del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos, también hizo uso de la palabra, destacando los resultados de la reunión.

Las palabras de resumen estuvieron a cargo del Dr. Antonio Núñez Jiménez, Viceministro de Cultura de Cuba.

CAPITULO II

Resumen de los trabajos de la reunión

El Presidente sometió a la consideración de los presentes el documento "Principios básicos para las actividades de la División." El delegado de Colombia expresó la conveniencia de que tal instrumento debía constar de dos partes: Procedimiento y Reglamento. Después de diversas intervenciones, se determinó mantener el documento en su forma actual para el análisis por todos los países miembros de la División, tanto los presentes como los ausentes, los que remitirán al Presidente sus observaciones en un plazo prudencial que permita ponerlo en práctica a partir de la próxima reunión.

Se procedió a informar sobre la Reunión del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos efectuada en Ginebra del 15 al 23 de octubre de 1984.

Hizo uso de la palabra el Sr. Dirk P. Blok, refiriéndose a los antecedentes del Grupo de Expertos desde su creación, en 1967, hasta la fecha y destacó los problemas de la transcripción y romanización. Recordó al colega guatemalteco Francis Gall como uno de los miembros más activos en esta materia en la Organización de las Naciones Unidas y ponderó la capacidad del trabajo del actual Presidente. Se complace del apoyo que ha recibido la idea de uniformar los nombres geográficos por los países de esta División, evidenciando el deseo de que a través de esta organización participen aquellos países que hasta el momento no forman parte de la misma.

La sesión del 11 de diciembre de 1984 se dedicó al informe de las distintas delegaciones. Argentina hace una exposición dando a conocer que desde hace cinco años se han iniciado las actividades relacionadas con la uniformación de los nombres geográficos de su país, habiéndose finalizado el trabajo correspondiente a las Islas Malvinas.

Le siguó el delegado de Colombia, quien presentó el informe correspondiente, señalando la gran labor que ha realizado, de tiempo atrás, el Instituto Geográfico Agustín Codazzi sobre la Toponimia, particularmente en la publicación del *Diccionario de nombres geográficos de Colombia* y brindando al mismo tiempo asesoría a los países miembros de la División de América Latina interesados en la elaboración de este tipo de diccionarios. Por otra parte, anunció que se está adelantando la organización del Comité Nacional Permanente de Nombres Geográficos, lo cual se espera concluir en el primer semestre de 1985.

Hizo uso de la palabra la delegación de Cuba, dando a conocer la situación actual de los nombres geográficos en el país.

España procedió a dar su informe, haciéndose énfasis en las dificultades vencidas por el Comité Nacional de Nombres Geográficos y el Gabinete de Toponimia del Instituto Geográfico Nacional, debido fundamentalmente a las diversas lenguas que se hablan en el país, y destacó la importante colaboración actual de las Comisiones de Toponimia de las comunidades autónomas.

En un detallado informe, México habló de las diversas actividades toponímicas encaminadas a rotular su cartografía a escala 1:50.000 y las dificultades que, debido a la orografía y a la diversidad de lenguas, han encontrado para el desarrollo de esta labor.

Nicaragua, al aceptar la asesoría de Colombia para la elaboración de un diccionario geográfico, expresó su decisión de preparar para la Segunda Reunión un informe de las actividades para uniformar los nombres geográficos en ese país.

Checoslovaquia agradeció la invitación para asistir como observador a esta reunión y explicó en detalle los trabajos que se han hecho en su país en los últimos 40 años.

Finalizados los informes de las distintas delegaciones, Cuba procedió a presentar un conjunto de trabajos de carácter técnico.

En la sesión del 12 de diciembre de 1984 se expusieron por Cuba diversos trabajos. España intervino con un trabajo sobre el tratamiento de la toponimia en su país.

En la misma sesión del 12 de diciembre de 1984 se efectuó una reunión de trabajo de los jefes de delegaciones, con objeto de intercambiar opiniones sobre aspectos fundamentales del funcionamiento de la División. Asisten los Sres. Jorge Santiago Casal (Argentina), Alberto Martínez (Colombia), Emilio Lluis Rojo (Cuba), Cesáreo Sanz (España), Gilberto Salinas (México), Adolfo Castrillo (Nicaragua) y Jorge E. Ruiz (Panamá). También concurren el Sr. Ydelís Velázquez, Presidente de la referida reunión y de la División de América Latina.

Cuba explica que el objetivo de la reunión de contacto es analizar un conjunto de ideas que se han ido expresando por las distintas delegaciones y que son muy útiles para el trabajo futuro de la División, por lo que es conveniente precisarlas y llegar a un consenso al respecto.

México manifiesta que es necesario precisar un conjunto de aspectos que posibiliten el desarrollo de la actividad, establecer programas que precisen metas objetivas, por intermedio del actual Presidente de la División; esto, con independencia de la cooperación y asesoría que puedan brindar otros países.

Colombia, con el fin de facilitar la operatividad de la División para desarrollar su objetivo fundamental propone: establecer una Secretaría *Pro-tempore* hasta la próxima reunión regional de la División, la cual quedaría a cargo de Cuba para aprovechar su experiencia y darle continuidad a su labor desplegada al frente de la Presidencia del Grupo Latinoamericano. Además, tres puntos focales: en Colombia, para Sudamérica; en México, para Centroamérica, y uno en Cuba para el Caribe y España, a fin de cooperar con la secretaría *pro-tempore*. Crear un Centro de Documentación e Información Regional de Nombres Geográficos, para lo cual Colombia ofrece preparar y enviar a los países miembros de la División un estudio preliminar. Reitera el ofrecimiento de asesoría en la elaboración de diccionarios de nombres geográficos, para lo cual enviará la información pertinente a Nicaragua y a México, países que aceptaron tal ofrecimiento. Propone que todas las ideas en las que haya consenso deben ser objeto de recomendaciones de la Primera Reunión.

España señala que es necesario mantener una información multilateral a través de una secretaría *pro-tempore*, que pudiera estar en Cuba, quizás hasta la próxima reunión, para hacerla rotativa con el objetivo de que no sea una carga demasiado fuerte para un solo país. También desea que el nombre de España aparezca en el de la División para que no dé la idea de un país invitado.

México aclara que es necesario proponer metas precisas, establecer una secretaría, y también una comisión permanente que posibilite el desarrollo de las metas que adoptemos; por medio de las comunicaciones pudiéramos intercambiar los criterios, y así se daría trabajo y obligación a todos los integrantes de la División.

Argentina declara que tal vez lo más acertado sería que al final de la reunión se deba aprovechar para precisar con los gobiernos qué es lo más conveniente, si crear una secretaría *pro-tempore* o una comisión permanente; esto habría que proponerlo por medio de una recomendación.

Nicaragua manifiesta que su país está de acuerdo con que Cuba desempeñe una secretaría *po-tempore*, pero es preciso definir las metas a alcanzar que sean de interés común a toda Latinoamérica. Un primer paso sería identificar aquellos países que tienen autoridades nacionales, y tal vez Cuba, por conducto de los Ministros de Relaciones Exteriores, pueda recabar esta información. Es conveniente recopilar las ponencias más importantes de carácter metodológico y publicarlas para su distribución; esto demostraría las ventajas de participar en este tipo de reunión.

Panamá entiende que es muy importante lograr el intercambio entre los países, a través de un centro o secretaría que lo facilite.

Cuba señala que pudiera aceptar la secretaría *pro-tempore*, pero que es conveniente que los países presentes se comprometan al esfuerzo común. Es imprescindible contar con el apoyo de todos para que la organización de la Segunda Reunión sea positiva, que asistan la mayor cantidad de países de la División.

El Sr. Ydelis Velázquez señala que la Presidencia de la División debe tener un término de cinco años, para que facilite el trabajo.

España manifiesta que es conveniente que los gobiernos ratifiquen las recomendaciones de la reunión. A lo que el Sr. Ydelís Velázquez responde que habría que buscar una solución para que los gobiernos se adhieran a las recomendaciones que adopte la reunión.

Colombia destaca que sería un alto honor acoger la Segunda Reunión, pero no está autorizado para ofrecerla porque no tiene el mandato del Gobierno de Colombia para ello.

España señala que debe adoptarse una recomendación precisando que, a partir de la Segunda Reunión, los países que aspiren a organizar la reunión siguiente presenten la solicitud oficial de su Gobierno.

Se acuerda por consenso elaborar un documento que recoja las precisiones a que se ha llegado en la reunión de contacto sostenida por los señores jefes de delegaciones, para conocimiento de la sesión plenaria siguiente.

En la sesión del día 13 se sometió a la plenaria de la reunión el documento resumen con las recomendaciones que tuvieron el consenso de los jefes de delegaciones. Después de discutirse este documento se acordó que el mismo fuese incluido en el informe final.

El Presidente somete a la consideración de la reunión el proyecto de plan de trabajo de la División de América Latina entre la Primera y Segunda Reunión. Se convino en cambiar el término "plan de trabajo" por "guía" y adoptarlo como

una recomendación para que los países den su criterio a la secretaría *pro-tempore*.

Se sometió a la consideración de la reunión un proyecto de programa provisional para la Segunda Reunión. Después de varias intervenciones, se acordó que dicho proyecto sea anexado al informe final para consideración ulterior de los países miembros de la División.

CAPITULO III

Recomendaciones sobre el trabajo y para el desarrollo futuro de la División de América Latina

Exhorta a los gobiernos a la creación en cada país de una autoridad nacional encargada de la normalización de los nombres geográficos en apoyo a las recomendaciones de la Conferencia de las Naciones Unidas sobre la Normalización de los Nombres Geográficos.

Trabajar en aras de obtener los principios fundamentales que rijan la labor del grupo regional, con vistas a su adopción en la Segunda Reunión de la División de América Latina.

Solicitar a Cuba que ejerza una secretaría *pro-tempore* de la División, hasta tanto se definan y establezcan los mecanismos requeridos para la organización de la actividad de normalización de los nombres geográficos en la región.

Crear puntos focales para facilitar y apoyar la labor de coordinación de la referida secretaría *pro-tempore*. Dichos puntos estarían en Colombia para Sudamérica, México para Centroamérica y España para el Caribe.

Establecer y mantener actualizado un directorio de las instituciones nacionales dedicadas al estudio de los nombres geográficos.

Solucionar los problemas de uniformación de los nombres geográficos de interés común a la región a través de la División.

Promover la programación de cursos de distintos niveles y seminarios en toponimia, factibles para las diferentes disciplinas relacionadas con esta materia.

Solicitar de los países interesados en obtener la sede de la Segunda Reunión de la División, que realicen las gestiones pertinentes para oficializar su interés durante el primer semestre de 1985. El otorgamiento de esta sede se determinaría por la secretaría *pro-tempore* en consulta con los puntos focales.

Establecer a partir de la Segunda Reunión el procedimiento más adecuado para determinar la sede de futuros eventos.

Promover el establecimiento de un Centro de Documentación e Información Regional de Nombres Geográficos. Para tal fin, Colombia ofreció a la secretaría *pro-tempore* un estudio preliminar sobre el particular. Solicitará además a los restantes países de la División el envío de sus consideraciones al respecto.

Solicitar al Grupo de Expertos de las Naciones Unidas en Nombres Geográficos que hagan llegar al Consejo Económico y Social la necesidad de estudiar la posibilidad de asignar fondos a las divisiones que lo requieran para la realización de determinados proyectos en la normalización de nombres geográficos. Además, identificar posibles fondos de financiamientos nacionales e internacionales, como el de las agencias especializadas del sistema de las Naciones Unidas o el Programa de las Naciones Unidas para el Desarrollo (PNUD), para proyectos específicos.

Desarrollar relaciones bilaterales y multilaterales de cooperación entre los países miembros de la División.

ANEXO

Lista de documentos presentados en la reunión

1. Principios básicos para las actividades de la División de América Latina del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos
2. Informe sobre la Reunión del Grupo de Expertos de las Naciones Unidas en Nombres Geográficos, efectuada en Ginebra, Suiza, del 15 al 23 de octubre de 1984
3. Informe Nacional de la República de Colombia
4. Informe Nacional de la República de Cuba
5. Experiencia del Grupo de Trabajo del Ministerio de Educación en la uniformación de nombres geográficos
6. Informe sobre el tratamiento de la toponimia en la cartografía española
7. Informe Nacional de los Estados Unidos Mexicanos
8. La importancia de los nombres geográficos en la sociedad actual
9. Importancia y significación de la uniformación de los nombres geográficos en la rama de las comunicaciones, especialmente en correos y telégrafos
10. La reducción de los exónimos, introducción al tema
11. Apuntes Lingüísticos para la Uniformación de los Nombres Geográficos
12. Experiencias del Grupo de Trabajo para los Nombres de Países
13. Información sobre la experiencia del trabajo de investigación de los nombres geográficos marítimos y costeros
14. Procedimiento específico de uniformación de los nombres geográficos para el trabajo de gabinete de litonimia y nesonimia
15. Consideraciones lingüísticas acerca de la nesonimia
16. Términos náuticos en la toponimia cubana
17. Los términos genéricos en el estudio de los nombres geográficos Aplicación de métodos estructurales y clasificación numérica en litonimia
18. La litonimia en el contexto físico-geográfico e histórico de la Isla de la Juventud
19. La oronimia en Cuba
20. Consideraciones metodológicas para el establecimiento de los nombres geográficos de las principales unidades del relieve
21. Método para la uniformación de los lugares habitados
22. Relación de ciudades de la República de Cuba
23. Metodología aplicada a la selección de los ríos que se estudiarán en la primera etapa investigativa
24. Aspecto geográfico de la toponimia del distrito físico-geográfico La Habana—Matanzas
25. Sistema de cómputo para los nombres geográficos
26. Proceso automatizado de los nombres geográficos
27. Las lenguas amerindias: un tesoro preterido
28. Toponimia. Glosario
29. Estructura, funciones y organización de la Comisión Nacional de Nombres Geográficos
30. Organización, estructura y funciones de los Grupos Técnicos Asesores
31. Proyectos para la preparación de las directivas toponímicas para cartografía en los países miembros de la División de América Latina
32. Proyecto de plan de trabajo de la División de América Latina para el período entre la Primera y Segunda Reunión
33. Proyecto de programa provisional para la Segunda Reunión
34. Informe de la delegación argentina
35. Informe de la delegación de Nicaragua

(d) *Training and education**

CURRENT DEVELOPMENTS IN TRAINING AND RESEARCH AT THE INTERNATIONAL INSTITUTE FOR AEROSPACE SURVEY AND EARTH SCIENCES**

Paper submitted by the Netherlands

RÉSUMÉ

Le rapport présentera les faits récents survenus à l'Institut international des levés aérospatiaux et sciences de la terre, qui sont résumés ci-après.

On est en train de concevoir et construire des programmes de formation de photogrammétristes et cartographes. Ceux-ci devront être employés dans les services topographiques et cartographiques outre-mer pour former la première génération de personnel, sous la supervision d'instructeurs qualifiés.

Un nouveau cours d'un an sur les systèmes d'information foncière débouchant sur un diplôme d'études supérieures est en cours de préparation à l'intention de ceux qui seront chargés de concevoir, mettre en place et administrer de tels systèmes. On définit les objectifs du cours et on examine les conditions d'admission. Les principales disciplines sont énumérées et commentées. Le premier cours sera offert en octobre 1985, en coopération avec le Département de géodésie de l'Université technique de Delft et d'autres services spécialisés. Ce cours sera axé sur le cadastre et la publicité foncière. On prévoit que d'ici 1986 deux autres sections seront ajoutées, sur les systèmes de gestion des données concernant les zones urbaines et rurales respectivement.

Un nouveau cours de cartographie marine sera donné à partir d'octobre 1985 à l'intention de personnes ayant une formation universitaire et une vaste expérience dans d'autres domaines de la cartographie. Ce cours d'une durée de cinq mois sera donné en coopération avec l'hydrographe de la marine royale néerlandaise. Les personnes n'ayant pas de formation universitaire et ayant moins d'expérience peuvent être admises à suivre les cours de technologue (C3) et de technicien (C4) de la cartographie en février 1986. Après avoir suivi ce cours qui durera neuf mois et demi, les étudiants pourront être admis au cours de cartographie marine. Le rapport contient une description du programme de ce cours.

On y trouve également un aperçu des résultats de l'examen du programme de maîtrise de cartographie. A l'avenir on pourra être admis directement à suivre ce programme qui comportera deux parties. La deuxième partie permettra à l'étudiant de se spécialiser dans l'un des quatre domaines ci-après : préparation et graphisme; visualisation de l'information spatiale; technologie des bases de données, cartographie automatisée et GIS; et télédétection au service de la cartographie.

Le cours de traitement des données de télédétection a été révisé et élargi pour tenir compte de deux filières de traite-

RESUMEN

El documento informará sobre la evolución reciente en el Instituto Internacional de Levantamiento Aéreo y Ciencias de la Tierra, que puede resumirse como sigue:

Se están diseñando, reuniendo y construyendo conjuntos de materiales de capacitación para operadores fotogramétricos y dibujantes cartográficos. Se tiene el propósito de que esos materiales sean utilizados en establecimientos extranjeros dedicados a la realización de levantamientos y la elaboración de mapas para la capacitación inicial del personal bajo la supervisión de instructores locales calificados.

Se planea un nuevo curso de postgrado de un año de duración en materia de sistemas de información sobre las tierras, destinado a personas que hayan de administrar el diseño, la ejecución y el mantenimiento de un sistema de ese tipo. Se han definido los objetivos del curso, y se han examinado las condiciones que deben reunir los participantes. Se han enumerado y explicado los principales grupos de materias que ha de abarcar el curso. El primer curso se impartirá en octubre de 1985 en cooperación con el Departamento de Geodesia de la Universidad de Tecnología de Delft y otros expertos catastrales. Ese curso se centrará en los temas del catastro y la inscripción. Se espera añadir para 1986 otras dos materias al curso, sobre sistemas de administración de datos municipales y rurales, respectivamente.

En noviembre de 1985 se ofrecerá un nuevo curso sobre cartografía marítima a personas que hayan tenido una formación académica previa y considerable experiencia en otras formas de cartografía. El curso durará cinco meses y será impartido en cooperación con el Hidrógrafo de la Marina Real de los Países Bajos. Las personas que carezcan de formación académica y que tengan menos experiencia pueden ser aceptadas para iniciar en febrero de 1986 los cursos normales de tecnólogo cartográfico (C3) y técnico cartográfico (C4). Tras seguir esos cursos durante nueve meses y medio, los estudiantes pueden inscribirse en el curso de cartografía marítima. Se ha definido y descrito el programa de estudios para este curso.

Se incluye un breve informe sobre los resultados del examen del programa de licenciatura en cartografía. En el futuro, podrá ingresarse directamente en ese programa, que constará de dos partes. La segunda parte permitirá al estudiante especializarse en uno de los cuatro grupos de materias siguientes: reunión de datos y diseño gráfico; elaboración de presentaciones gráficas de información espacial; tecnología de bases de datos, cartografía mediante computadora y sistema de información GEO (GIS), y teleobservación para la cartografía.

El curso sobre elaboración de datos obtenidos mediante teleobservación se ofrece ahora en una forma revisada y ampliada a fin de reconocer dos líneas de elaboración: la elaboración de imágenes digitales y el reconocimiento de configuraciones. El curso dura tres meses y consta de tres fases. La primera trata de los conceptos físicos, matemáticos y estadísticos necesarios. La segunda se ocupa de las co-

* See also "Background information on the International Federation of Surveyors" (E/CONF.77/L.12), discussed under agenda item 9.

** The original text of this paper, prepared by Gerald McGrath, International Institute for Aerospace Survey and Earth Sciences, Enschede, Netherlands, appeared as document E/CONF.77/L.3.

ment : traitement numérique des images et reconnaissance des formes. Il s'agit d'un cours de trois mois qui comporte trois phases : la première est consacrée aux notions de physique, mathématiques et statistique nécessaires. La deuxième porte sur les corrections à apporter aux données des capteurs numériques, le traitement des images, la reconnaissance des formes et la base des données. La dernière phase concerne des projets pratiques.

Des travaux de recherche-développement sont en cours pour affiner la série de programmes USEMAP. Il s'agit de numériser les calques thématiques établis lors de l'interprétation des photographies aériennes, de permettre une surimposition des calques et de rendre possible la production de cartes dérivées. Un programme complémentaire a pour but l'automatisation du traitement numérique des calques grâce à un scanneur électronique et au logiciel approprié.

La recherche menée à l'Institut sur les modèles numériques d'élévation a été concentrée sur la collecte de données photogrammétriques et l'évaluation de la qualité. On utilise pour cela les notions de fonction de transfert et d'analyse spectrale. Le rapport décrit des travaux récents sur une méthode d'acquisition semi-automatique des données à des échantillonnages composites, sélectifs et progressifs. On évoque la recherche en cours sur les systèmes entièrement numériques de production, de modèles numériques d'élévation et l'utilisation de ces modèles pour l'ombrage automatique du relief et la restitution numérique.

La commercialisation de l'information cartographique est un domaine qui présente un intérêt croissant pour des raisons qui sont identifiées dans le rapport, qui indique les principaux aspects de la commercialisation de cette information auprès du public. La formation du nouveau groupe de travail de l'Association cartographique internationale (ACI) sur l'entreprise cartographique et les liens avec l'Institut sont expliqués.

rrecciones que hay que aplicar a los registros digitales de detección, la elaboración de imágenes, el reconocimiento de configuraciones y las bases de datos. La fase final está dedicada a proyectos prácticos.

El Departamento de Investigación y Desarrollo está refinando la serie de programas sobre USEMAP. Esos programas tienen por objetivo digitalizar las transparencias temáticas preparadas durante la interpretación de fotografías aéreas, permitir la superposición de varias transparencias y hacer posible la generación de mapas derivados. Un objetivo complementario consiste en la automatización de la digitalización de transparencias (ADIOS) mediante el uso de una cámara de exploración electrónica y programas de computadora apropiados.

La investigación en el Instituto sobre modelos digitales de elevación (DEM) se ha concentrado en la reunión de datos fotogramétricos y la evaluación de la calidad. En esta última se han utilizado los conceptos de función de transferencia y análisis espectral. Se describe la labor reciente sobre un método de adquisición semiautomática de datos, que incluye el muestreo compuesto, selectivo y progresivo. Se hace referencia a la investigación reciente sobre un sistema totalmente digital para la generación de DEM y para utilizar los DEM para el sombreo automático del relieve y el monotrazado digital.

La comercialización de la información cartográfica es una esfera que suscita interés y atención crecientes por razones que se señalan, y se indican los principales aspectos de la comercialización de esa información en el sector público. Se explican la formación de un nuevo Grupo de Trabajo de la Asociación Cartográfica Internacional sobre la empresa cartográfica y su relación con el Instituto.

The purpose of the paper is to report upon recent developments at the International Institute for Aerospace Survey and Earth Sciences (ITC), which is one of 17 institutes in the Netherlands that provide international education. ITC also has long-established functions in the fields of research and consultation. The former efforts are well known through reports on research findings in the *ITC Journal*, professional journals in almost a dozen disciplines and books published by ITC staff; the latter activity is less publicized but nevertheless firmly established. It remains as a vital function of the Institute, and at present there are consultancies with 13 countries on diverse topics. What follows is concerned primarily with international education, and to some extent with active research at the Institute.

Development of training programmes in photogrammetry and cartography

Evidence had been accumulating for some years to indicate that arrangements were lacking in some countries for adequate training of qualified school leavers wishing to enter mapping establishments. Accordingly, proposals were drawn up by the Departments of Photogrammetry and Cartography for the development of training packages. These would be designed:

(*a*) For use in survey and other departments overseas into which educationally qualified former students of secondary or high schools are accepted without prior training in mapping;

(*b*) To be administered by qualified instructors of the appropriate department, if necessary in the local language after translation from the original Engish;

(*c*) To be self-contained and self-supported with instructional materials in the forms of lessons on theoretical and practical subjects, practical exercises, equipment and materials.

These conclusions were reached after careful consideration of two alternative courses of action. The first is to provide an appropriate course at ITC. The arguments against so doing are by no means new: the financial costs to the host and overseas Governments of sending new and untried employees for training outside their own country, the "social cost" to the individual employee of being away from home and family for a period of up to a year, and the added difficulty of having to master a technical subject in a second or third language. The second alternative is to establish such a training programme in a post-secondary educational institution within the overseas country. This is desirable but it cannot always be achieved. There must be a sustained demand for the training of students at or above the level of enrolment that will make the offering of the programme cost-effective. This means that a training programme cannot be expected in every country experiencing the need; and

though an offering by a regional centre has much to commend it, such centres are insufficient in number, are distributed less than optimally, and are not always open to nationals of adjacent or nearby countries.

Recent reports by Paresi and de Lange (1), and by van Elzakker and Oxtoby (2), provide explanations of the progress achieved to March 1984. Work on the development of the two training programmes continues, though progress will be governed by further funding. Both general and detailed statements of objectives have been prepared for both training packages, and circulated respectively in April and September for comment by overseas mapping establishments. For the cartography training package, the statements have been accompanied by extracts from a sample teaching unit, on the subject of scale, so that recipients may understand the form that lessons on theory may take. Departments or establishments which are interested in either or both of these training packages, but have not already been contacted, are requested to write to the Institute for further information.

Commencement of a course on land information systems

The phases of data collection, manipulation and presentation have been traditional fields of teaching and research at the Institute since its inception in 1952. A significant number of the Institute's staff are at present actively engaged in teaching and research associated with the surface of the land, the processes which shape the surface, the cover and use of the land, urban and rural settlements, and the subsurface geology, mineral resources and geophysics. The integration of such information about the land is also a well-established interest of the Institute. It is within this context, and in co-operation with the Department of Geodesy at Delft University of Technology and other cadastral experts, that a new one-year post-graduate diploma course will be offered in October 1985 which should be beneficial to students from developing countries. Provision may be made for suitable candidates to extend the programme by six months for research and the writing of a thesis, leading to the Master of Science degree.

The overall aim of the course is to prepare participants for their anticipated task, that is, the management of design, implementation, and maintenance of a cadastre and Land Information System (LIS). The specific objectives are to provide instruction in the following subjects:

(*a*) Establishment of a cadastral system, national or municipal for legal, fiscal and other purposes;

(*b*) Upgrading or improvement of a cadastral system;

(*c*) Creation and development of a municipal management information system;

(*d*) Expansion of an existing cadastral system into a multipurpose cadastre or large-scale LIS, embracing two or more of title registration, valuation and assessment, administration and social services, census services, utilities and services, and transportation;

(*e*) Establishment of a rural, regional or national medium- or small-scale Geographic Information System (GIS) for development planning, decision-making and monitoring change.

The factors that have influenced the selection of objectives for the course to commence in October 1985 are:

(*a*) The need to strengthen the existing legal cadastre in connection with continuing agrarian reform and expanding rural development;

(*b*) Forecasts of accelerated urbanization, particularly in the developing countries, and the associated problems of planning and managing the urban environment;

(*c*) The rapidly growing requirement to install or to improve means of valuing and taxing land.

The first course will, therefore, concentrate upon the cadastre and registration.

Participation in the course will not be restricted to persons with degrees in surveying engineering or a cognate discipline, though much of the educational preparation in these fields will be particularly relevant to the course. Others who share interests in land and its management include lawyers engaged in the administration of lands and in conveyancing, officers of agricultural and development banks, valuers, tax officials, administrators and managers in central, local and urban governments, those responsible for the planning and management of utilities, development economists, and Treasury officers. It is expected that the course participants will come from a variety of disciplines and functional environments.

It is expected that by 1986 two other streams will have been added to the course, on municipal and rural data management systems respectively. There is, however, a common structure which is reflected in the major subject areas of the syllabus and is set out below.

1. *Preparatory subjects.* It is recognized that because of the heterogeneous backgrounds of the participants expected to enrol, some time must be allowed for review and, where necessary, reinforcement in mathematics, computer programming, land surveying, photogrammetry and cartography.
2. *Introduction*
3. *Discussion of the problem area*
4. *Environmental factors.* These are considered with regard to the political, legal and juridical, cultural, socio-economic, technological and institutional domains.
5. *Information required by the problem area*
6. *Data required to derive the information needed*
7. *Technology.* This subject will comprise about 40 per cent of lectures and 55 per cent of practical exercises in the course, and will be centred upon data gathering techniques, mapping techniques and the presentation of information, data base technology, and data into information processing.
8. *Human, financial and equipment resources required*
9. *An overview of existing cadastre/land information systems*
10. *Application to practical problems.* This will deal with a systems approach to the statement, analysis, and solution of problems concerned with land information.
11. *Case studies.* These are examined in static and dynamic modes, and drawn in part from developing countries.
12. *Final project.* This approach has been used successfully in the Department of Cartography at ITC since its inception as a means of integrating all aspects of the course, and will be introduced into the cadastre/land information systems course for the same purpose.

The course will consist of formal lectures and seminars, literature study, writing, and practical exercises. Ample op-

portunity will be allowed for participants to visit organizations in the Netherlands, and elsewhere in Western Europe, that are engaged in projects involving the collection, processing and management of land information.

A NEW COURSE IN MARITIME CARTOGRAPHY

The long-standing role of a small number of hydrographic departments in the charting of distant waters is well known. The United Kingdom was an early contributor to systematic charting of in-shore and oceanic waters in many parts of the world, and was joined much later by the United States, the USSR and Japan. It has been established that under the pressure of changing circumstances—the search for shallow water hydrocarbons, tow-out surveys, the charting of routes for VLCCs and general bathymetric surveys—the United Kingdom Hydrographer has had to concentrate his resources upon the North Sea and domestic coastal waters. Most national hydrographic offices have resources barely sufficient for the charting of national, but rarely international, waters. Canada has had a national responsibility for charting since the turn of the century, though in the 1960s and 1970s it contributed to several surveys in distant waters under Canadian aid programmes. Some hydrographic departments have been founded more recently, for example in Australia, Fiji, India, Malaysia, New Zealand, Pakistan, Sarawak, Singapore and South Africa. Yet there is a consistent complaint that continental shelves are surveyed poorly by modern standards for the purpose of charting. A report in 1983 from Australia indicated that almost two thirds of its waters have only been surveyed by random lines of echo-soundings or early lead-line soundings, or have not been surveyed at all; and one from Canada stated that less than 50 per cent of its waters in which there is commercial maritime traffic are surveyed to modern standards, while the percentage in Arctic waters is less than 20. To the shortfall illustrated above has been added the consequences of the United Nations Convention on the Law of the Sea, signed in December 1982 and undergoing slow ratification by the signatory countries. This confers the right upon coastal States to declare specific maritime zones of national jurisdiction, provided that the delimitation is founded upon baselines and scientifically gathered supporting data. Consequently the added work-load in hydrographic surveying and charting is heavy, and will fall particularly upon States which do not yet have hydrographic offices.

It is with this background, and in the spirit of resolution 19 of the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific (1983), that the Hydrographer of the Royal Netherlands Navy and ITC will cooperate in offering a new course in maritime cartography. Two types of students are anticipated:

(*a*) Technologists and technicians who have received formal training in cartography, have considerable experience in topographic and thematic mapping, and must be prepared for new duties in maritime cartography;

(*b*) Those who have not had such training, are relatively inexperienced, but are to be assigned to new duties in maritime cartography.

A small number of applicants from the first group will be accepted to commence a five-month course in November 1985. The course will consist of the following sections:

1. *Introduction to navigation*: a three-week period of instruction covering:
   (*a*) The maritime environment;
   (*b*) The use of the sea;
   (*c*) The use of various types of charts in planning and navigation;
   (*d*) Position fixing at sea;
   (*e*) Other instruments used for navigation;
   (*f*) Subjects related to navigation;
   (*g*) Other hydrographic publications.
2. *Introduction to hydrographic and oceanographic surveying*: instruction for three weeks on:
   (*a*) The aims and purposes of surveys;
   (*b*) Requirements;
   (*c*) Positioning systems;
   (*d*) Sounding;
   (*e*) Detection and investigation of obstructions;
   (*f*) Tidal reduction;
   (*g*) Tidal streams and currents;
   (*h*) Sounding selection for fair sheets;
   (*i*) Automation in surveying.
3. *Maritime cartography*: instruction for six weeks, to include:
   (*a*) Introduction;
   (*b*) The IHO, its technical resolutions, and international chart specifications;
   (*c*) Compilation, construction and production of charts;
   (*d*) Automation;
   (*e*) Legal aspects;
   (*f*) Chart revision;
   (*g*) Hydrographic management.

There will be practical exercises in all sections, and visits to a hydrographic vessel and a shore establishment.

4. *Final project*: instruction of two months' duration. The student is provided with an opportunity to integrate his knowledge of theory and practice by compiling and producing a hydrographic chart to proof stage. This project will be given close supervision.

Students in group 2, above, will be accepted in a 15-month course consisting of:

(*a*) Lectures and practical exercises of 9½ months' duration, presented in the standard post-graduate (C2), technologist (C3) and technician (C4) courses given in the Department of Cartography at ITC;

(*b*) Maritime cartography course (sections 1, 2 and 3 above);

(*c*) Final project of two months' duration (as in section 4 above).

OTHER DEVELOPMENTS AT THE INSTITUTE

1. *Master of Science programme in Cartography*

A major review has been undertaken of the M.Sc. programme in Cartography. The setting for this is the changes in the nature of the discipline, which can be expected to multiply and be accelerated during the coming 10 years. Of particular importance are the role of, and emphasis upon, the printed multicolour map as a static medium for spatial inventory and display; the continuing need for investigation into the design and production of permanent and ephemeral graphic displays; the increasing significance of raster-based data collection, manipulation and analysis, and its effective integration into semi-automated digital mapping and computer-assisted cartography; the gradual coalescence of re-

mote sensing and cartography, partially through exploring and applying the techniques of image processing; and the application of computer-assisted cartography and remote sensing to information systems concerned with spatial data.

The essential features of the revised M.Sc. programme are as follows:

(*a*) A qualified student with a suitable first degree may be admitted directly to the M.Sc. programme, which will last 25 months.

(*b*) Part I of the programme will concentrate upon building a basic but sound theoretical and practical knowledge of all aspects of cartography, along the lines of the present and well-known post-graduate diploma course. Part I will require a 12-month period of study. It must be completed successfully, and in the process the student must demonstrate the potential for further study, before permission may be given to proceed to Part II of the programme.

(*c*) Part II of the programme will contain two sections. The first will consist of a series of lectures, seminars and practical exercises, and will last 5½ months. There will be a compulsory core of subject matter which is central to cartography, that is, the nature and transmission of spatially related information to actual or potential users. This will be accompanied by teaching in the design, conduct and reporting of investigations; computer programming; and the fundamentals of managing human, physical and financial resources.

The student must then choose one of four specializations, and will concentrate upon his choice for three months. The specializations are:

(i) Compilation and graphic design of maps in analog or digital form;

(ii) Production of spatial information displays;

(iii) Data base technology, computer-assisted cartography, and Geographic Information Systems (GIS);

(iv) Remote sensing for cartography.

(*d*) The second and final section of Part II will occupy the remaining time. It will require the student to undertake a piece of independent research under supervision, and to report upon this in the form of a thesis. This will be examined and defended in the customary manner.

2. *Course in remote sensing data processing: image processing and pattern recognition*

In the processing of digital remote sensing data the purpose of the processing is to extract information from the data.

Two lines of processing are distinguished:

(*a*) Digital image processing is directed towards image correction, image enhancement and the extraction of features for presenting information and further visual interpretation;

(*b*) Pattern recognition is a large collection of classification and discrimination techniques implemented with analytic, statistical or heuristic decision rules. The input for pattern recognition is not confined to remote sensing data, and in practice an increasing proportion of the input comes from existing data bases.

The course is three months in length, commences in January, and is directed towards persons who need insight into the actual working of data processing for remote sensing. It may have direct application in the work environment or to university level teaching, or may prepare the individual for specifying and using future data processing hardware and software.

The course is revised each year in view of the rapid developments in the "parent fields" of image processing, pattern recognition, artificial intelligence, and data base systems which are applicable to data processing in remote sensing.

The course has a three-phase structure:

First phase: three weeks of refreshing a relevant subset of physics, linear algebra and statistics, supported by a computer laboratory equipped with microcomputers and colour graphics.

Second phase: six weeks on the subjects of:

(*a*) Sensor corrections, atmospheric corrections;

(*b*) Geometric corrections, georeferencing, map transforms;

(*c*) Image processing, specifically:

(i) Radiometric feature extraction, colour coding;

(ii) Spatial feature extraction, filters, and enhancement;

(*d*) Pattern recognition, including:

(i) Feature extraction, training a classifier, prior probabilities, cost/benefit;

(ii) Statistical, heuristic, logical and sequential decision rules;

(iii) Per sample (pixel) classification;

(iv) Object detection/classification, using spatial features;

(v) Multi-source and multi-date classifications, use of models;

(vi) Applications from artificial intelligence, and an introduction to expert systems;

(*e*) Data bases:

(i) Image data bases, theme data bases, and digital elevation models;

(ii) Data base systems; hierarchical, network and relational;

(iii) Data normalization, reformatting, raster versus vector format, compression and decompression.

Third phase: four weeks for practical projects. The students usually bring tapes with them from various sources of remote sensing data. They apply the techniques learned in the course in a familiar context, and produce enhanced images, classification "maps", and corresponding statistics and reports.

In the second and third phases, 50 per cent of the available time is devoted to "hands on" exercises with the powerful interactive image processing system of ITC. This includes one graphics and three colour work stations. Some time is also spent on the cartographic interactive graphic design system. The microcomputer laboratory remains available throughout the course for the development of concepts and teaching support. The central VAX computer can be used by those who wish to develop software in a special image processing environment utilizing a subset of PASCAL.

3. *Further refinements to USEMAP and the coming of ADIOS*

The antecedents and early history of USEMAP (Urban Survey Experimental Method for Analysing Photodata) have

been described by de Bruijn, as have its two major applications:

(*a*) In teaching, where it is used in conjunction with the interpretation of aerial photography;

(*b*) In research and consulting as an aid in urban and regional analysis and planning.

There are three essential features:

(*a*) Interpretation of characteristics on aerial photographs such as land use, soils or forestry;

(*b*) Direct digitizing of the results of interpretation expressed as points or polygons, and transformation into grid cells of a size selected by the user;

(*c*) A series of software components for the analysis and display of the input, the former consisting of routines for the comparison and/or combination of mapped data, and for the generation of maps to depict derived data.

Recent application of USEMAP to a land-use study in the Netherlands (3) using grid cells of 100×166 m proved the effectiveness of the software in indicating the relative sensitivity of rural areas to future urbanization. In addition, a part of the study was repeated with 50×50 m cells to test the effects on cartographic presentation, planimetry and data processing procedures, and to determine the problems which may arise with higher resolution systems. The higher resolution permits smaller minimum sizes of land use to be classified, improves the depiction of boundaries between classes of use and deals more satisfactorily with linear features. Nevertheless, it tends to emphasize weak geometric correlation between successive maps in studies of land-use change.

It is this refinement in grid cell resolution, and developments in both hardware and software for image processing, that have prompted the design of new software, known as USEMAP III, by the Computer and Urban Surveys Departments of the Institute. The major considerations in the design are:

(*a*) Ease of user interaction with the system;

(*b*) A data base which can be shared and expanded;

(*c*) Creation of efficient and flexible geo-operators which will function upon maps and statistical tables for studies in spatial analysis and planning to match the special requirements of users in these fields;

(*d*) Ability to accommodate a variety of data input procedures.

The central features of this new software are GIPSY (Grid Image Processing System) and MUMAS (Multi-User Interactive Map Administration System), both written in PASCAL-2 for the DEC RSX-11 operating system.

ADIOS (Automatic Digitizing of Interpretation Overlays System) is a development project on which work was begun in 1984. The purpose is to automate the digitizing of the monochrome transparent overlays at large and medium scales which result from photographic interpretation. This will be extended later to experiments with colour filtering during digitizing, and with automatic recognition of hand-written coded attributes. The two elements of the proposed system are, first, an electronic scanning camera incorporating CCDs which provides high resolution imaging and digitized video output. The second is the writing of suitable software for the interactive assignment of attribute codes at a colour screen to polygons that have been digitized; interactive editing of the results on the screen; and rescaling and resampling into the USEMAP data base. It is hoped that the various developments will be completed by the end of 1985.

4 *Research and development efforts on digital terrain modelling*

Although the concept of a digital terrain model was developed more than 25 years ago, it was only during recent years that public and private survey and mapping organizations have proceeded to its broad application. Several countries have started to set up a country-wide digital elevation data base. Major fields of application are, at present, civil engineering (including transportation, power and water supply), photogrammetry and cartography (orthophotoproduction, digital topographic mapping, slope mapping and map revision) and defence (aircraft and vehicle simulators, guidance systems). Elevation data are mainly acquired by photogrammetric means and by digitizing contour lines on maps. A wide variety of data processing and display software exists, developed by research institutes, instrument manufacturers and production organizations.

Research and development at ITC has been focused on photogrammetric data collection and quality assessment of digital elevation models (DEM). Quality assessment is of vital interest for both planning and validating DEM. The concepts of transfer function and spectral analysis have been utilized to make theoretical assessment possible [(4), (5), (6)]. For regular grid DEM tools have been developed to operational maturity. An extension to cover incomplete grids (progressive sampling) has been conceived.

A method of semi-automatic data acquisition has been introduced in composite sampling [(7), (8), (9)]. Composite sampling is designed primarily for large-scale applications of DEM, and allows for a time efficient collection of precise and comprehensive terrain relief data. In selective sampling, which is a manual operation, distinct morphometric relief features are digitized. Subsequent progressive sampling, which requires a feed-back loop interfacing of the stereoplotter with a computer, supplements the morphometric data by collecting elevation data at grid intersections. The density of the initial coarse grid is increased progressively based on a near real-time analysis of the data already collected. The resulting grid of variable density is adapted locally to the fluctuations in the terrain. The prototype system which was built is in the stage of refinement, while further attention is being given to making the procedure for selective sampling more systematic. Two manufacturers of analytical plotters already offer a software module for the acquisition of DEM based on the composite sampling approach. The concept of progressive grid densification (or hierarchical grid data structuring) and thresholding the second differences at each level can also be applied to compress DEM data efficiently (10).

A topic of current research is the generation of DEM automatically by an all-digital system [(11), (12), (13)]. The investigations concern digitizing images, the strategies and techniques of off-line pre-processing, image matching, post-processing, and the theoretical tools for assessment of performance. Experiments are also being carried out with an all-digital stereo-photogrammetric system designed at ITC.

Finally, two projects can be mentioned which are related to data presentation and to the application of DEM. Software has been developed for automated relief shading of a quality acceptable to cartographers (14). Secondly, digital mono-plotting (15) utilizes DEM for digital mapping from single photographs. This technique is applicable to new mapping, to revision of existing data bases, and to thematic mapping.

5. *Marketing cartographic information*

The increased concerns of a number of Governments about (*a*) the expenditures, services and products of surveys and mapping organizations, (*b*) the benefits that may accrue to users of the services and products and (*c*) the substantial capital costs of acquiring digital systems for collecting, processing, and presenting spatial information have combined to encourage a renewed interest in the marketing of cartographic information. This is a subject upon which little public attention has been focused in the recent past, but it can be anticipated that this will change.

There are four principal aspects of marketing cartographic information in the public sector:

(*a*) Defining the market and its segments for present and future services and products, identifying the actual and potential users, determining the benefits that may accrue, and valuing those benefits;

(*b*) Developing the market with an extensive range of mechanisms so that the full potential may be realized;

(*c*) Distributing the products and delivering the services in an efficient and cost-effective manner;

(*d*) Pricing the services and products in such a way that government policy on cost recovery is fulfilled while the market needs and potential are realized.

The contributions of the Institute to this subject have been modest to date, and have been confined to the first aspect noted above. This has been changed during the past year with the appointment of a staff member who undertook in 1983 a supply-side study of the Canadian market for non-digital cartographic information, and a demand-side study of one segment of the market; organized and convened in 1984 an international symposium on the subject (16); and was elected Chairman of the International Cartographic Association's Working Group on the Cartographic Enterprise.

The Working Group was created by the 7th General Assembly of ICA during its meeting at Perth, Western Australia, in August 1984. Its terms of reference are:

(*a*) To enlist the participation of a variety of cartographers actively involved in the public, private and educational sectors of the cartographic enterprise in a variety of countries, to:

(i) Define market demands for cartographic information in both analog and digital forms;

(ii) Define the types of management information needed to meet the demands for cartographic information;

(iii) Investigate the relationships between the definition of policy on the cartographic enterprise and its effects on the market for cartographic information;

(*b*) To publish a special ICA publication in 1987 on the findings.

It is hoped that the programme of inquiries to be launched by the Working Group will receive the co-operation and support of Governments engaged in the generation and provision of spatially related information to a wide variety of public and private sector users.

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PROPOSALS FOR LONG- AND SHORT-TERM TRAINING COURSES IN THE FIELD OF GEODESY*

Paper submitted by Poland

RÉSUMÉ

On examine dans cette communication différents types de formation universitaire à long terme et de formation professionnelle à court terme en entreprise dans le domaine des levés et de la géodésie. On signale que la société GEOKART/Pologne est prête à organiser à l'étranger de courts stages thématiques dans l'entreprise et à assurer une formation pratique en cours d'emploi dans toutes les branches de la géodésie et de la cartographie.

RESUMEN

En el documento se examinan diversos tipos de capacitación en la esfera de la topografía y la geodesia, mediante cursos de larga duración a nivel universitario y cursos breves de capacitación profesional en el empleo. Se señala que la organización GEOKART de Polonia está dispuesta a organizar en el extranjero cursos temáticos de capacitación en el empleo, de corta duración, así como cursos de capacitación en el empleo sobre temas relativos a todas las ramas de la geodesia y la cartografía.

The education of professional technical staff is a matter of importance to national geodetic services. Fast economic development creates a high demand in all countries for topographic and thematic maps, necessary to the realization of development projects. In order to meet this demand many countries are making considerable efforts to train, in a short time, new specialists capable of adapting and utilizing new methods of surveying and production of modern maps. It is often stated that nowadays modern, complicated instruments are much easier to acquire than the well-trained technical personnel able to utilize all the advantages of this equipment.

Apart from technicians and field-workers national survey services also need highly educated technical administrative staff, able to plan and organize the work, ensure the conditions of proper implementation and direct the course of the operations. The education of professional geodetic staff, engineers and Ph.D.s, is expensive and requires a very long time; it is a necessary process, however, in order to achieve the self-sufficiency of surveying enterprises and organizations in their everyday routine work. The education of these personnel can, and should, be performed at high schools, technical universities and universities. This method of education, being the "normal" way of becoming a professional, should be considered first of all by anyone who wants to obtain development and progress in geodesy and surveying.

Not every country, however, can afford to acquire professional technical staff in this "normal" way. The fast economic development of some countries requires their surveying services to deliver cartographic products in a very short time. Therefore besides normal education, immediate emergency training must be applied in order to make up at least partially for the shortage of urgently needed qualified staff; that is to say, on-the-job and in-service training, which up to now has not been sufficiently utilized.

Geodetic works in developing countries are often carried out by foreign companies and international organizations. This gives them the opportunity of transferring a good deal of their technical experience to the host countries, especially as regards the application of new technologies. The situation should not be tolerated in which host countries gain no profit from cartographic contracts as regards the practical training of their national technical staff. In other words, the realization of geodetic and cartographic works by foreign executors should always be combined with the transfer of technology. Every contract should contain clauses concerning in-house training of national personnel. Such an approach is necessary for the strengthening of national survey departments and institutions as well as for ensuring further self-dependent activities by national surveyors and geodesists, undertaken in operations formerly executed by foreign experts.

But the "in-house", "on-the-job" or "in-service" training should not be combined only with contract works. Such training can also be performed by special experts and instructors from foreign surveying institutions and organizations well experienced in the practical development of technical personnel.

Such training can have variants. Special training courses can be created with the more capable students assigned directly to working field-groups led by experienced foreign specialists, or forming special operating parties working under the supervision of highly qualified instructors (these parties could themselves execute various important jobs).

The importance of carrying out in-house, on-the-job or in-service training has already been confirmed in practice. An example of very good results of applying these kinds of training can be provided by many years of GEOKART's activities in Afghanistan as executing agency of the United Nations Development Programme (UNDP) project: "Strengthening of the Afghanistan Geodetic and Cartographic Head Office". GEOKART—the Organization for Surveying and Mapping of Poland—is in a position to state that after several years of extensive in-house training in most important fields of geodesy, surveying and cartography, the surveying service of Afghanistan has become to a great extent capable of performing important tasks connected with the requirements of the national economy. The same line of conduct is followed at present, and will continue in the future, in performance of all foreign contracts in all countries.

It should also be noted that GEOKART has close and fruitful co-operation with technical universities in Poland as well as with many national, highly specialized geodetic enterprises. As a result of such co-operation GEOKART is able to acquire professors, lecturers, instructors and experienced engineers representing various geodetic specializations, which are able to teach and train technical staff abroad and in Poland, on different levels

* The original text of this paper, prepared by Janusz Sledziński, Organization for Surveying and Mapping (GEOKART), appeared as document E/CONF.77/L.54

Various kinds of training are mentioned below; they can be organized for foreign clients by GEOKART itself, or with its effective assistance.

1. Long-term training

The following variants of this kind of training can be considered:

1.1 training on the level of secondary technical school;

1.2 training on engineering-university level;

1.3 post-graduate university training courses;

1.4 doctoral university training.

All of these training courses are given by secondary geodetic technical schools (1.1) or technical universities (1.2 - 1.4). GEOKART is ready to help participants to arrange all necessary formalities, supply educational instruments etc.

Secondary training lasts for five years (1.1) and its participants acquire the title of technician in geodesy after completion. Training on the university-engineering level (1.2) lasts for five years, and participants acquire the title of master of technical science (M.Sc Eng.) in one of the following specializations:

basic measurements (geodetic networks, geodetical astronomy, gravimetry);

engineering and industrial geodesy;

rural geodesy;

photogrammetry;

cartography;

mining geodesy.

Post-graduate studies (1.3) are organized according to the requirements of organizations and enterprises, and their topics are adjusted to the needs of the users. As typical topics, the following can be mentioned:

applications of remote sensing;

modernization of geodetic networks;

use of the Earth's artificial satellites for geodetic and geodynamic purposes;

use of the gravimetric measurements for geodetic purposes and geophysical research works;

methods of designing and updating of cadastres etc.

Graduates of high schools (masters of technical science or equivalent) can be participants of these post-graduate studies. Such studies usually last 6-12 months and the participants, after passing special tests, obtain certificates issued by the technical university. Post-graduate studies can be organized as theoretical and practical training courses. If the participants wish it, GEOKART can organize practical training at specialized geodetic enterprises. In the case of a sufficient number of foreign participants, lectures of such training can be delivered in English or in French.

Doctoral university studies are organized individually for particular participants. The scientific council of the relevant department of the university opens the procedure, determines the subject of the dissertation thesis and designates the professor-scientific adviser, who in individual discussions and consultations with the student determines the detailed programme of his studies. The doctoral studies are completed by public discussion of the dissertation thesis. Such studies last for two to four years, according to the educational level of the participant and the intensity of his work.

It should be noted that the language of training in 1.1 and 1.2 is Polish. For foreign students, special courses in the Polish language are organized; they last one year and include also some supplementary knowledge in mathematics and physics, preparing the participants for their university studies. Many trainees from all over the world participate yearly in such courses.

2. Short-term training

The organization GEOKART proposes the following kinds of short-term training:

2.1 thematic in-house training courses in particular countries;

2.2 practical training for foreign engineers and technicians in Polish enterprises and institutes;

2.3 on-the-job training (supervision and training);

2.4 complex on-the-job training, execution of work by joint GEOKART and local staff groups.

These types of training will be briefly discussed below.

Thematic training courses (2.1)

GEOKART can organize short-term (up to two months) in-house training courses on the following topics:

theoretical backgrounds of the establishment of the geodetic horizontal networks;

satellite techniques in the establishment of geodetic control networks; use of the satellite Doppler technology;

spherical and practical astronomy; astronomical methods of determining position and azimuth in various geographic latitudes;

gravimetry: relative methods of determination of gravity; maps of anomalies; geodetic use of the gravimetric measurements;

precise levelling: technology of the measurement, height systems and calculation;

investigation and comparation of standards and high precision levelling rods;

preparation of basic maps and their updating;

cadastral survey, establishment of the cadastral system for urban areas, inventory surveys of underground installations.

All these training courses will be conducted by experienced engineers and organized on a non-commercial basis.

All costs of organization of the training courses, costs of the release of lecturers from their home universities as well as costs of preparation of the training programmes and short lecture notes will be covered by GEOKART. It is expected that institutions wishing to organize such in-house training courses will cover only the two-way travel costs from Poland to the host country and costs of subsistence and insurance of lecturers and instructors as well as some *per diem* pocket money in their own country.

The outlines of several such training courses organized by GEOKART are presented below as examples. It is also possible to organize training courses on other subjects according to the wishes of the foreign institutions and organizations.

Astronomical determinations

Duration of the course: 2 months (150 hours)

1. Basic information on spherical astronomy (systems of co-ordinates, diurnal and annual motions of the Earth, time systems).

2. Reduction of the astronomical co-ordinates; calculation of ephemerids.

3. Astronomical instruments and accessories.

4. Determination of the latitude, longitude and astronomical azimuth.

5. Pre-processing of observations

Doppler survey

Duration of the course: 2 months (150 hours)

1. Satellite methods in the process of establishing geodetic networks.

2. Doppler TRANSIT system and methods of positioning.

3. Execution of Doppler observations

4. Processing of observations.

5. Utilization of Doppler observations jointly with other elements of the geodetic network.

Gravimetry

Duration of the course: 2 months (150 hours)

1. Absolute and relative gravimetric measurements.

2. Gravity-meters; field measurements

3. Gravimetric reductions.

4. Gravimetric anomalies; maps of anomalies.

5. Use of the gravimetric data for calculation of the horizontal control network.

6. Height systems: use of gravimetrical data in high-precision levelling.

7. Gravimetry in geophysical research of mineral resources.

Practical courses (2.2)

GEOKART is ready to organize for foreign engineers and technicians practical training in all branches of geodesy, cartography, remote sensing, gravimetry and geodetic astronomy. This can be organized at enterprises and research institutes in Poland. Detailed programmes, level, and duration of such courses are always adjusted to the requirements of the foreign participants. They can be organized either as theoretical and practical sessions (lectures, practical exercises) or as practical work only. The participants of the courses can obtain certificates, with specification of the range and level of training issued by GEOKART.

On-the-job training (2.3)

GEOKART is ready to send its specialists and experts to the interested countries; they could supervise and train local technical staff during execution of the everyday field and laboratory geodetic work. The fields of training, range and duration can always be adjusted to the requirements of the participants. It should be noted that GEOKART has wide experience in organizing such training courses. GEOKART's experts have been working for many years in Afghanistan under a UNDP contract, and their work was appreciated both by the United Nations authorities and by the Afghan colleagues.

Complex on-the-job training (2.4)

It should be underlined here that on-the-job training is the most effective and economical kind of training; it has two major advantages: it allows the simultaneous performance of practical work and training of specialists. Execution of complex geodetic measurements on selected areas is the most effective form of such practical training. Field measurements can be performed by local staff in close co-operation with GEOKART's experienced specialists. Taking an area of approximately 200 × 200 km, the short list of works that could be performed for this area would include:

(*a*) establishment and measurement of about 10 Doppler points;

(*b*) connection of the Doppler points by the geodimeter traverses and establishment of the geodetic network;

(*c*) astronomical measurements (astronomical longitude and latitude, astronomical azimuth);

(*d*) precise levelling along the geodimeter traverses;

(*e*) establishment of about 10 points of the gravimetric network of the first class;

(*f*) gravimetric measurements along the levelling lines.

The advantage lies in the speedy execution of specified practical work for selected areas; and at the same time, the training of technical personnel capable of quickly adopting advanced technologies. It is also possible to organize training in the planning and organizing of geodetic works, as well as the geodetic supervision of works. Such training can be continued until the local personnel becomes self-sufficient and self-reliant.

The above-mentioned topics of training should be considered only as examples. It is possible to carry out specific types of work (e.g. only gravimetric works, Doppler measurements, levelling measurements etc.). Other kinds of activity, such as laboratory work, field data processing, computations, creation of the data bank, map production etc., can also be included in the training programmes.

The above briefly described proposals for various kinds of training will be of interest to those who would like to develop their professional qualifications. All who would like to participate in some of the long- and short-term training courses are requested to contact GEOKART at Warsaw, which is ready to impart further information and conclude immediately the respective agreements concerning professional training of technical staff.

INTERREGIONAL UNITED NATIONS COURSE ON THEMATIC CARTOGRAPHY*

Paper submitted by the Union of Soviet Socialist Republics

RÉSUMÉ

Le Cours interrégional des Nations Unies sur la cartographie thématique s'est tenu à Moscou et à Dushanbe du

RESUMEN

El Curso Interregional de las Naciones Unidas sobre Cartografía Temática se celebró en Moscú y Dushanbe del 6 de septiembre al 10 de octubre de 1983. Representantes de 23 países asistieron a este curso y participaron en conferencias, seminarios y trabajos prácticos. El objetivo prin-

* The original text of this paper appeared as document E/CONF.77/L.59.

6 septembre au 10 octobre 1983. Les frais de conférences, de participation aux séminaires et aux travaux pratiques ont été assurés à des représentants venant de 23 pays. L'objectif principal de l'instruction dispensée était de mettre les participants au courant des nouvelles techniques utilisées en cartographie et de leur montrer comment l'information tirée de cartes thématiques est utilisée dans la planification économique et sociale.

cipal de la enseñanza fue familiarizar a los participantes con las nuevas tecnologías empleadas en cartografía y mostrarles cómo se utiliza en la planificación social y económica la información proveniente de los mapas temáticos.

From 6 September to 5 October 1983, the United Nations Interregional Course on Thematic Cartography was held at Moscow and Dushanbe, Union of Soviet Socialist Republics.

Representatives from 23 countries attended from Africa, Asia and America: Afghanistan, China, Democratic Yemen, Ethiopia, Guyana, Iraq, Jamaica, Jordan, Kenya, Lao People's Democratic Republic, Mongolia, Nepal, Nicaragua, Nigeria, Somalia, Sudan, Syrian Arab Republic, Thailand, Uganda, United Republic of Tanzania, Viet Nam, Yemen and Zambia.

Most of the participants in the course represented the mapping departments of government bodies responsible for topographic surveying and mapping. The Soviet geodetic service co-operates with some of these bodies (Afghanistan, Democratic Yemen, Ethiopia, Lao People's Democratic Republic, Mongolia, Nicaragua, Viet Nam and others) or provides technical support for their activities in surveying and mapping.

At the official opening ceremony in the conference hall of the Leningradskaya Hotel at Moscow, the chief of the Cartographic Section of the Department of Technical Co-operation for Development of the United Nations Secretariat, M. De Henseler, took the floor, addressing to participants his greetings.

The course was organized according to the programme produced by the Department of Technical Co-operation for Development. Its objective was to inform students about modern achievements in thematic mapping, the technologies used for charting and the application of thematic cartography data to social and economic planning. In accordance with recommendations of the Department, the detailed programme was arranged to include lectures, practice sessions, discussions and visits to scientific institutions, universities and enterprises engaged in thematic mapping. Besides the Soviet lecturers, scientists from abroad participated in the course.

Lectures were devoted to four main topics:

(*a*) General questions of thematic mapping;

(*b*) Aerospace and other methods used in thematic and complex cartography. This was the most comprehensive part of the programme and included remote sensing and photogrammetric processing of photos from space, determination of space data parameters, methods employed for application of space-photo information to thematic mapping, as well as principles and methods of interpretation for the purposes of complex mapping of natural resources. Some lectures were devoted to scientific and technical planning of thematic maps and their mathematical and cartographic bases; socio-economic mapping; mapping for students and tourists; and complex mapping of oceans, lakes, reservoirs and shelves, and of the Moon and other planets; and maps related to the standardization of geographical names;

(*c*) Technology of charting and printing of thematic maps, questions of storage and acquisition of cartographic information, current developments in the technologies of compilation, copy preparation and printing of multicolour geographic maps etc ;

(*d*) International co-operation in the field of thematic mapping and environmental remote sensing. Experience in international co-operation within the Intercosmos programme in the field of Earth remote sensing from the Saliut-6 orbital spacecraft.

Technical excursions were made to the Moscow Institute of Geodesy, Air Survey and Cartographic Engineers, Moscow State University and the Central Science and Research Institute of Geodesy, Air Survey and Cartography.

During the studies some practice sessions were held on thematic and geologic interpretation of space photos.

Participants also were able to use Soviet mapping instruments, materials and technologies for copy preparation.

Exhibitions and movies on course subjects were useful supplements to theory.

During the discussion periods, the representatives of some countries reported on the development of thematic mapping and training in their countries. In their leisure time, participants, the majority of whom were visiting the Soviet Union for the first time, enjoyed Moscow and Dushanbe sightseeing trips, theatres, exhibitions and museums.

The United Nations Interregional Course in Thematic Cartography has served to strengthen international co-operation in cartography.

(e) *Map and chart sales and distribution policies and practices**

DISTRIBUTION OF MAPS AND AERIAL PHOTOGRAPHS: EXAMPLE OF A *LAND* SURVEY ADMINISTRATION**

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Les Länder étant indépendants à l'intérieur de la République fédérale d'Allemagne, leurs services topographiques exercent leurs fonctions indépendamment les uns des autres. Il n'y a donc pas d'uniformité absolue dans la diffusion des cartes topographiques officielles et des photographies aériennes, qui sont les unes et les autres le résultat d'une activité nationale. Jusqu'à présent, on a réussi à éviter des divergences excessives dans les travaux de levé et de cartographie en République fédérale d'Allemagne surtout grâce à un organisme qui fonctionne au niveau fédéral — l'Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) [groupement des services topographiques des Länder de la République fédérale d'Allemagne].

Tous les services topographiques ont des réseaux de diffusion des cartes qui relèvent à la fois du secteur public et du secteur privé. En République fédérale d'Allemagne, les entreprises privées — grossistes, détaillants et libraires — ont un rôle à la fois utile et économiquement important aux côtés des services de diffusion des cartes des Länder. Grâce au vaste réseau de librairies, les cartes sont diffusées d'une manière efficace et dans l'intérêt des consommateurs.

L'information des utilisateurs en ce qui concerne les publications et éditions nouvelles est un élément important de ce système. Les renseignements cartographiques officiels sont mis à jour périodiquement et des éditions nouvelles sont publiées, mais il faut en informer régulièrement l'utilisateur. Des articles de presse, la diffusion de spécimens publicitaires et de fiches d'information, ainsi que l'organisation d'expositions se sont révélés utiles à cette fin. La principale source d'information sur toutes les cartes publiées par le service topographique d'un Land est le catalogue des cartes, avec ses index des feuilles et ses cartes spécimens.

RESUMEN

Dado que los estados de la República Federal de Alemania son entidades federales independientes, los organismos de topografía y geodesia desempeñan sus funciones en forma totalmente independiente. Por esa razón, la distribución de mapas topográficos y fotografías aéreas oficiales, a pesar de ser productos basados en levantamientos nacionales, no es totalmente uniforme. Hasta la fecha ha sido posible evitar disparidades demasiado grandes en los levantamientos topográficos y las actividades cartográficas en la República Federal de Alemania, gracias a la existencia de un órgano a un nivel superior al de los estados, el Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) (Comité de Trabajo de los Organismos de Topografía y Geodesia de los Estados de la República Federal de Alemania).

El sistema de distribución de mapas de todos los órganos de topografía y geodesia tiene características que son propias tanto del sector público como del privado. En la República Federal de Alemania, la empresa privada representada por los mayoristas, minoristas y libreros desempeñan, junto con el servicio estatal de distribución cartográfica, una labor útil y económica. La vasta red de librerías existente en la República Federal de Alemania asegura la eficacia de la distribución de mapas y permite satisfacer las necesidades de los usuarios.

Un componente importante del sistema de distribución de mapas es la información sobre nuevas publicaciones y ediciones destinada a los usuarios. La información contenida en los mapas topográficos oficiales se actualiza cada tanto a intervalos predeterminados y luego se publican nuevas ediciones, mientras que los usuarios deben recibir información sobre las nuevas publicaciones en forma continua. Los artículos sobre el tema publicados en periódicos, la distribución de muestras publicitarias, las circulares informativas y las exposiciones cartográficas han resultado útiles para este fin. La principal fuente de información sobre todos los mapas confeccionados por los respectivos organismos estatales de topografía y geodesia es el catálogo de mapas, que incluye índices y muestras de mapas.

The German Basic Law gave the Federal Republic of Germany the form of a federated State; that is, not only the Federal Government but the individual *Länder* represent independent political entities. The Basic Law defines the limits of the competencies of both Federal Government and *Länder*: any matter that must be ordered or regulated uniformly in the general interest comes under the Federal Government, with the *Länder* being responsible for all other matters. Therefore, official surveying and mapping, hence the national survey, have fallen to the individual *Länder*.

Survey organization is regulated differently in the various *Länder*. Apart from differing organizational forms, surveying comes under the competency of different *Land* ministers, e.g. the *Land* Minister of the Interior, the *Land* Minister of Finance, the *Land* Minister for Economy and Technology. However, all organizational forms have one thing in common: production of topographic maps is the task of the *Land* survey administrations.

The duties of the *Land* survey administrations are defined in the law of the respective *Länder*. The Survey Adminis-

* See also "Status of hydrographic surveying and nautical charting world-wide" (E/CONF 77/L.12), discussed under agenda item 5(*e*).

** The original text of this paper, prepared by K.-H. Bastian, Survey Administration of the Rhineland-Palatinate, appeared as document E/CONF 77/L.9.

tration of the Rhineland-Palatinate has the following duties, according to the Survey Act of 1969:

(*a*) Establishment, maintenance and revision of the vertical and gravitational control survey net;

(*b*) Recording of geographic data, topographic features and terrain forms of the Earth's surface of the *Land* at scales 1:5,000 and 1:25,000;

(*c*) Continual recording of the topographic changes in the Earth's surface;

(*d*) Preparation and publication of the topographic *Land* map series at scales 1:5,000, 1:25,000, 1:50,000, 1:100,000 and of official topographic map series at scales 1:200,000 and smaller, as well as their revision;

(*e*) Preparation and publication of special maps;

(*f*) Central evaluation of surveys conducted by the survey and cadastre administration

In fulfilling these duties, the survey administrations of the *Länder* act completely independently of each other. In order to retain the largest possible degree of uniformity in surveying and mapping, for example, in the design of map series covering more than one *Land*, in 1948, the Working Committee of the Survey Administrations of the *Länder* of the Federal Republic of Germany (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV)) was founded.

AdV is a non-governmental committee of all the *Länder* administrations of the Federal Republic of Germany and of Berlin (West) that are responsible for cadastre and surveying; in this body the different administrations can discuss questions related to surveying, mapping and cadastre. The outcome of these deliberations is written down in the form of recommendations for the various administrations.

The fruitful work of AdV has ensured a large degree of uniformity in official surveying and mapping. An example for this co-ordinated method are the sample sheets used to produce official topographic maps.

User information on the results of the national survey

For the user, the results of the national survey are documented primarily in aerial photographs and maps.

Aerial photographs

The aerial photograph as a universal source of information is of special importance in the various tasks facing public administration and the state sector of the economy. Apart from the areas of cartography, land consolidation, property cadastre, forestry and road construction, aerial photographs are increasingly coming into use for inventories, planning, environmental protection control, and also as a basis for scientific investigations. In order to increase the utility of aerial photographs above and beyond their immediate purposes for other uses, the following must be done:

(*a*) Aerial survey projects conducted for surveying, planning, inventory and control purposes must be registered centrally and co-ordinated;

(*b*) Photographic flights carried out must be recorded and the aerial photographs produced should be collected at a central agency.

The *Land* survey administrations are charged with the registration of photographic flights and the documentation and archival storage of all aerial photographs produced by order of *Land* administration offices.

The Survey Administration of the Rhineland-Palatinate, for example, records all photographic flights of the current year and all those planned for the coming years in a general map, published annually. An appended index contains further details on the aerial photographs.

The general map and the index are available *gratis* to all agencies interested in the aerial photographs. They also constitute the basis for the aerial photograph records for the whole of the Federal Republic of Germany, which is published by the Institut für Angewandte Geodäsie, Frankfurt am Main. Furthermore, the register is published annually in the State *Gazetteer*.

Since 1960, for example, the Survey Administration of the Rhineland-Palatinate has collected and stored all aerial photographs produced at its order and entrusted to it for safekeeping. The aerial photograph archive contains photos at varying scales. With the exception of a few small areas the entire area of the *Land* has been covered several times, at regular intervals of about five years, by means of photographic strips at a scale of approximately 1:34,000. For some other areas aerial photographs at lower scales, e.g. 1:12,000, 1:6,000 or 1:4,000, are also available.

Reproductions of the aerial photograph negatives in the archive can be ordered from the survey administrations of the various *Länder*, with distinctions being made between air-photo prints, enlargements and single-photograph rectifications. Reproductions are on photo-paper with either matt or glossy surface, but are also available as negatives, slides or as screened positives suited for heliographic printing. (To avoid unnecessary queries, exact details of the area, e.g. through marking on a map or a sketch, are desirable.)

Air photo prints are copied from the original negatives and have the format 23 × 23 cm. Since the aerial photographs are taken in the direction of flight with a longitudinal overlap of normally 60 per cent, the prints of two consecutive air photos can be viewed three-dimensionally in the overlap zone using a stereoscope. The height division of the terrain can be seen (third dimension). In addition, the possibility of extracting more information from the air photos using stereoscopic vision is increased, which means that air-photo prints are particularly suited for interpretation of aerial photographs.

Air-photo enlargements are eminently suited for teaching and demonstration purposes. Details of the photo are clearly recognizable in the enlargement.

Single-photograph rectifications present, with the same image content, a better accuracy to scale. During rectification the aerial photograph undergoes not only a change in scale (enlargement) but also an additional optical reforming. The air photo is fitted as nearly as possible onto a map, or points of which the situation is known (control points). On sufficiently level terrain, single-photo rectifications attain the positional accuracy of a map. However, if there is a large disparity in terrain height the air photo cannot be transferred exactly, by means of single-photo rectification, to a uniform scale, due to its special geometric characteristics (central projection).

Official topographic map series

The official topographic map series are available for the whole area of the Federal Republic of Germany, with few exceptions. The maps at scales 1:25,000-1:100,000 are revised and published by the *Land* survey administrations in a predetermined five-year cycle, with exact area divisions for the whole Federal Republic of Germany. The maps at

smaller scales are prepared by the Institut für Angewandte Geodäsie. Owing to the set revision cycle of these map series, the user is not dependent on information whether or which maps are available.

In the cases of the German Basic Map 1:5,000 (*Deutsch Grundkarte* (DGK 5)) and the Aerophotographic Map 1:5,000 (*Deutsche Grundkarte Luftbildkarte* (DGK 5L)), the situation is considerably different. This map series does not cover the whole area of the Federal Republic of Germany and in Rhineland-Palatinate, for example, is not of a uniform, recent date. For this reason the Survey Administration of Rhineland-Palatinate publishes a general map annually, in which the areas covered by the DGK 5 and DGK 5L are marked. Whereas the DGK 5 revision cycle varies considerably, the DGK 5L is an information source of continually recent date.

Special maps

Publication of special maps with different themes and different sheet lines requires continuous user information on the available supply of maps.

Information on new publications is normally announced in

(*a*) the press (by presentation of new maps before publication date at a press conference);

(*b*) information sheets;

(*c*) announcement in the State *Gazetteer;*

(*d*) annual delivery of copies of new publications announced in the news sheet to all bookshops and dealers;

(*e*) exhibitions;

(*f*) samples for wholesalers.

The map register provides all the information on all available maps.

Map registers

Map registers are available at all *Land* survey administrations and are revised when necessary. These are available *gratis* to all interested map users.

Within the framework of AdV, the *Land* Survey Administration of Hesse publishes a collection of map registers as a review of all maps of the official *Land* survey administrations of the Federal Republic of Germany.

The map registers contain details on the official maps prepared and published by the *Land* survey administrations.

In view of the great number of maps on the market it is not always easy for the user to find the map most suitable for his need. The map registers contain details, such as scale, types of edition, folded or not, number of colours and prices. Also the choice of map is facilitated by sheet indices for each map series on which the sheet names and numbers are visible, as well as by small map extracts from the map series in question.

An important factor of the map registers is the indication of delivery conditions. These give uniform, concrete conditions of contract between the *Land* survey administration and the individual map user. In particular, the delivery conditions contain statements on posting of maps, claims, conditions of payment, discount rates and prices, proprietary rights and place of performance.

Organization of map distribution

All maps published by the *Land* survey administrations are brought to the user via a two-tier distribution system, the components of which are the map distribution agency of the *Land* survey administration and private booksellers. In some *Länder* special distribution agencies have been set up in addition, normally at cadastral offices.

In the Rhineland-Palatinate, cadastral offices are supplied to a certain extent with new publications and editions of their area. Orders which go beyond the stocks of these distribution agencies are passed on directly to the *Land* Survey Administration of Rhineland-Palatinate.

The distribution agencies within the official institutions cannot take over map distribution completely. In the Federal Republic of Germany wholesalers, retailers and bookshops provide a useful service for map distribution purposes. The wide network of bookshops ensures an effective map distribution service within the reach of the citizen. However, the sale of national survey maps in bookshops (which work on a profit basis) requires that the *Land* survey administrations allow the booksellers an adequate profit margin for the product "topographic map".

The retailers receive a quantity discount in the range of 30 to 60 per cent, depending on the number of maps ordered. The discount rates are derived from the basic prices given in the map registers. The prices quoted in the map register are recommended prices and are not binding on the bookseller, who therefore has the opportunity of selling maps at less than the officially recommended prices if his sales figures are sufficiently high with respect to an adequate selling-price calculation.

The distribution agencies at the cadastral offices must adhere to the prices given and can give only the quantity discount rate stated in the conditions.

Conclusion

The combination of private and State distribution of the map series produced by a *Land* survey administration ensures a permanent wide-coverage distribution. In addition, State agencies needing maps for their work can be supplied without reliance on a private agency. Experience in the Federal Republic of Germany has shown that this two-tier distribution system ensures efficient, consumer-oriented availability of maps and aerial photographs produced by the official survey administrations of the *Länder*.

AGENDA ITEM 9

Technical assistance and transfer of technology

SURVEYING AND MAPPING ACTIVITIES IN CENTRAL AND SOUTH AMERICA AND THE CARIBBEAN*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

En premier lieu, l'auteur évoque les projets en matière de levés et d'établissement des cartes exécutés par la République fédérale d'Allemagne en coopération avec les pays d'Amérique et des Caraïbes. La coopération dans ce domaine a commencé il y a 20 ans.

L'auteur analyse ensuite cette coopération, en relevant soigneusement les effets négatifs et positifs. Il traite en particulier des difficultés qui peuvent surgir lors de l'établissement d'un cadastre et montre comment certains groupes d'intérêts essaient continuellement d'user de leur influence politique en vue d'empêcher l'établissement d'un cadastre, qui par nature est déjà un système d'information portant sur la propriété. L'auteur souligne que, malgré les antagonismes qui peuvent naître au cours de l'établissement d'un cadastre, les pays donateurs devraient lui apporter leur plein appui, car il peut fournir une contribution inestimable à l'aménagement du territoire des pays bénéficiaires. Il note par ailleurs la tendance à abandonner le terme «cadastre» au profit du terme «système d'information foncière». Il ne faudrait pas cependant renoncer au principe du cadastre. Il faudrait définir avec plus de clarté la relation entre le système d'information et les opérations de levé et d'établissement des cartes. Ceci permettrait de redonner toute son importance au cadastre. L'auteur fait également observer que, dans de nombreux cas, les travaux de levé et d'établissement des cartes ont été entrepris parce qu'ils étaient nécessaires à la réalisation d'autres projets.

L'auteur accorde une importance spéciale aux activités de formation et de perfectionnement dans le domaine des levés et de l'établissement des cartes parce qu'elles contribuent essentiellement au développement d'un pays. Il mentionne en particulier la Escuela de Topografía, Catastro y Geodesia (ETCG) du Costa Rica et montre comment un établissement de ce genre peut cristalliser de nombreuses activités liées à toutes sortes de projets portant sur les levés et l'établissement de cartes dans le cadre de la coopération technique entre pays bénéficiaires et donateurs.

En matière de transfert des techniques, il est important d'utiliser des méthodes et procédés modernes qui permettent d'exécuter les travaux de levé et d'établissement des cartes de façon ordonnée et économique. A cet égard, il convient de veiller à adapter les techniques modernes utilisées à la

* The original text of this paper, prepared by Johannes Nittinger, appeared as document E/CONF.77/L.8.

RESUMEN

El autor se refiere, primero, a los proyectos llevados a cabo por la República Federal de Alemania en cooperación con los países del continente americano y la región del Caribe en la esfera del levantamiento de planos y la cartografía. Esta cooperación comenzó hace 20 años.

El autor examina estas relaciones de cooperación y analiza cuidadosamente sus consecuencias negativas y positivas. Se refiere, en particular, a las dificultades que pueden surgir al establecer un catastro y muestra cómo ciertos grupos de partes interesadas muchas veces procuran ejercer su influencia política a fin de evitar el establecimiento de un catastro que, básicamente, es un sistema de información que contiene datos sobre los bienes inmuebles. El autor señala que, a pesar de las controversias que puedan surgir al establecer un catastro, los países donantes deberían apoyar plenamente la idea, ya que el catastro puede hacer una contribución inestimable a la ordenación de la tierra en los países receptores. También señala que hay una tendencia a reemplazar el término "catastro" por el de "sistema de información sobre la tierra". Opina, sin embargo, que la institución del "catastro" no debería abandonarse. Sugiere además que se defina más claramente que hasta ahora la relación entre los sistemas de información y las actividades cartográficas y el levantamiento de planos. De este modo se pondrá nuevamente de relieve la importancia del catastro. También señala que en muchos casos el levantamiento de planos y las actividades cartográficas han sido necesarios para la realización de otros proyectos.

El autor asigna especial importancia a la formación y a la capacitación avanzada en la esfera de los levantamientos y la cartografía porque contribuyen de manera fundamental al desarrollo de un país. Menciona, en particular, la Escuela de Topografía, Catastro y Geodesia (ETCG) de Costa Rica y muestra cómo una institución puede convertirse en el núcleo de muchas actividades en todo tipo de proyectos de levantamiento y cartografía en la esfera de la cooperación técnica entre los países receptores y donantes.

En cuanto a la transmisión de conocimientos técnicos, es importante utilizar métodos y procedimientos que permitan la realización de actividades de levantamiento topográfico y cartografiado en forma continua y económica. En estos casos, es necesario asegurarse de que las técnicas modernas que se utilicen puedan adaptarse a las circunstancias imperantes en el país (nivel de capacitación, disponibilidad de personal y posiblidades financieras).

situation du pays (niveau de formation, questions de personnel et possibilités de financement).

L'auteur exprime l'espoir que la coopération efficace qui existe depuis 20 ans entre la République fédérale d'Allemagne et ses partenaires de la vaste région constituée par l'Amérique du Sud, l'Amérique centrale et les Caraïbes pourra continuer dans les années à venir.

El autor expresa la esperanza de que la fructífera cooperación iniciada hace 20 años entre la República Federal de Alemania y la vasta región de América Central y del Sur y el Caribe pueda continuar en los próximos años.

Twenty years have passed since the Federal Republic of Germany, within the scope of technical aid and by various contacts between survey institutions of both regions, began to assist South and Central America and the Caribbean in different kinds of surveying and mapping projects. It is interesting to learn how during these 20 years these activities have affected the development of surveying and mapping in this region.

The present report is not concerned so much with the transfer of technical know-how, which often is the focus of attention at United Nations conferences, but with the effects of such a co-operation as they have become apparent in the course of time. This does not only include positive developments but also leaves room for critical considerations that may have resulted.

Technical co-operation with the Americas and the Caribbean

Co-operation with the Americas

A survey and cadastral project "Central America and Panama", 1965-1974.

Production of a map 1:10,000 for Nicaragua as of 1976.

Realization of a pilot study on the evaluation of aerial photographs and interpretation methods for the Managua region in Nicaragua.

Establishment of a school for surveying and mapping ("Escuela de Topografía, Catastro y Geodesía (ETCG)") at the national university of Heredia (UNA) in Costa Rica, 1974-1982.

Cartographic project for the Sudene area (Brazil) for the improvement of water supply and distribution conditions, 1972-1976.

Planning project in Recife (Brazil) as consequence of a study for Porto Alegre, since 1980.

Training project at the University of Curitiba, Brazil, since 1981.

Training project at the University of Recife, 1978-1982.

Cadastral project Curitiba as of 1983, carried out by the *Land* of Baden-Württemberg, Federal Republic of Germany.

Training projects at the universities of Maracaibo and Mexico (not carried out within the scope of technical aid).

Cartographic project in Peru, since 1982.

Co-operation with the Caribbean

Survey and cadastral project for an extensive water management project in the Gonaïves plain, Haiti, as of 1975.

Planning and survey project for Port-au-Prince, Haiti, since 1976.

Training measures for personnel from the Caribbean at the ETCG.

Other aids in technical co-operation

Numerous individual contacts between German survey experts and experts from the Americas and the Caribbean resulted in an extensive exchange of experience to which the seminaries attached to the Carl Duisberg Society (Carl-Duisberg-Gesellschaft) and the German Foundation for International Development (Deutsche Stiftung für Internationale Entwicklung) contributed. In this connection the work of the Advisory Group for International Development in Surveying and Mapping (Beratungsgruppe für Internationale Entwichlung im Vermessungswesen (BEV)) must also be mentioned since it made a basic contribution to the promotion of contacts between survey institutions and experts. Nearly all of the projects were initiated by BEV.

Analysis of the technical co-operation in cadastral work

The survey and cadastral project "Central America and Panama," which was supplemented by the regional school project ETCG, was an extensively laid out project. In 1965, an economic community still existed for Central America which supported the establishment of a multipurpose cadastre for Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. The results of the primitive tax cadastre (tax-mapping system) by no means satisfies the countries of the region, which therefore looked for new technical ways for establishing a more suitable cadastre. In view of the many years' experience European countries had with the cadastre, the countries of Central America turned towards the Federal Republic of Germany for assistance in establishing modern, fast procedures.

The first orthoprojectors were available and automated data processing had already been introduced into surveying and mapping. It was obvious that these new techniques should be put to use. All countries of Central America were supplied with instruments in such a manner that, with the aid of orthophoto techniques and electronic data processing (EDP), a cadastre could have been set up in an acceptable period of time and with sufficient accuracy. But the initially high expectations were not realized for the following reasons:

(*a*) Political developments had weakened the influence of the economic community. As a consequence of contrary political opinions, the countries of Central America had cut themselves off from each other: i.e., they went their own way with respect to the cadastre.

(*b*) Partnership contributions of the countries differed considerably. Those countries providing optimal partnership contribution were concentrated upon: hence, Nicaragua and El Salvador became the leading countries in the establishment of a cadastre.

(*c*) The national geographic institutions, which also were involved in realization of the cadastre lacked the middle management needed for such a complex undertaking. For this reason the suggestion of the German experts to

found ETCG was accepted. With the training of technicians and engineers ETCG has contributed greatly to the fact that the intention to establish a multipurpose cadastre was not abandoned.

(*d*) Central America was under the influence of North America. The United States Agency for International Development had been working for quite some time on the setting up of a cadastre in Central America. It took some time before the experts reached co-ordination of their efforts. It would have been more expedient if this co-ordination had been agreed upon at higher level before the project was started. The tax-mapping system advocated by the North Americans, which is based on sketches derived from aerial photographs, was abandoned by consent between North American experts and those of the Federal Republic.

(*e*) As pointed out earlier, in some countries revolutionary events brought work on the cadastre to a standstill. However, in those countries where a cadastre already existed, it was of great help in land reform. It also became evident that securing cadastral records was of great importance in order to prevent their loss in times of war or during natural occurences (earthquakes).

(*f*) At times, it was difficult to secure the services of suitable experts

(*g*) Adoption of the cadastral laws was delayed considerably because actions of pressure groups prevented the legislative bodies from treating the matter speedily. Influence of the experts of the Federal Republic of Germany on the adoption of the law was not great, although the draft for the law had been prepared by them.

(*h*) Development aid organizations of the Federal Republic expected that in a short period of time more tangible results ought to have been obtained or that the time for realization of a cadastre project ought to be shorter. Because of this opinion the experts were always under a certain pressure of time.

In spite of these critical remarks on the cadastral projects, some success has been achieved:

(*a*) Because of the "radiation effect", those countries that at first had approached the establishment of a cadastre only reluctantly began to concern themselves with the matter. They recognized the advantages such a cadastre offers and prepared themselves for a higher partnership contribution;

(*b*) Because of the training offered at ETCG, the national geographic institutions now had well-trained personnel at their disposal which took care that the establishment of the cadastre was started;

(*c*) It was recognized that with a cadastre many aspects of administration can be organized more efficiently. The *registro* can be maintained in a more simple way; it could even be automated like the cadastre (in some countries, cadastre and *registro* were even combined in one department). The tax administration can fall back upon the data of the cadastre; the self-assessment procedure, with its well-known shortcomings, can be abolished. Planning authorities can work with faultless data. Banks were willing to grant secured credits to property owners. Statistical offices can make use of the reliable information of the cadastre. This increase in information the cadastre owed entirely to orthophotos with their multitude of data and to the automation of the cadastre which facilitated the transfer of information to other departments;

(*d*) It was recognized that the cadastre is not only important for the levying of a land tax, which most of the time could not be levied from the small property owner for social reasons, but also can lead to juster taxation on the large landowner. In industrial countries, the land tax plays only a small part. Because of the rapid development from agrarian to industrial economies, in third world countries this tax will not gain the importance that it used to have in the former agrarian countries with a slower pace of development. In spite of this, the property owner always fears that with the establishment of a cadastre the land tax could be increased, though actually it leads to a juster tax levy.

Technical co-operation in cartographic projects

Cartographic projects are not as sensitive as are cadastral projects because political difficulties are less to be feared. The production of topographic maps (ranging from 1:50,000 to 1:250,000) may serve purposes such as the following:

(*a*) Agricultural and water management measures;

(*b*) Physical planning measures, expert reports on land planning, regional planning etc ;

(*c*) Discovery of resources;

(*d*) Representation of traffic routes and settlements;

(*e*) Representation of topography.

For the production of such map series the orthophoto technique has been applied; but it should be realized how fast technical development progresses considering that use of satellite images is already being discussed, at least for maps at scale 1:100,000. The most recent technique should always be applied, not only in industrial countries but in less developed countries as well. As far as possible, the *dernier cri* should be considered for countries of the third world, since what was looked upon as modern in topographic mapping 20 years ago, is now antiquated. Still, while a newer method may lead to a faster and more economic result, this does not mean that a critical attitude towards older procedures is justified since every period of time has its methods. The mania for the latest procedure is understandable but must not always be put into practice. It often happens that a new method cannot be combined with an older procedure; this does not mean that the chosen conception should always be discarded because there is a more modern technique.

Past techniques will be in demand as long as personnel and technical equipment do not permit the application of more recent techniques.

At present, tests are being made to discover whether the map 1:100,000 can be produced by means of satellite images. It is very likely that the results of such tests will later also be applied in countries of the third world.

Whether the results of these tests can be used for the cartographic project, mentioned earlier, in Peru would have to be investigated more closely. It should, however, be borne in mind that with high altitude photography the same results can be obtained as with satellite images. The decision whether the one or the other method should be applied depends entirely on economic aspects, training level of personnel and financial means to acquire personnel and equipment.

Importance must be attached to the interpretation of aerial photographs: for this reason the study for the area of Managua was made. Training must include interpretation of aerial photographs so that their wealth of information can be fully utilized.

As regards the cartographic projects, the partnership contributions of the third world countries have been of eminent importance, since without them the planned programme of tasks could not have been fulfilled. In some cases it would be worth considering (see Haiti project) whether the production of topographic maps should be left to the donor country to ensure that for the execution of subsequent measures the maps would be available in time. Training of the personnel from third world countries can take too long; hence the maps are not available and the project that prompted the survey cannot be carried out. This delay in the execution of the project is then attributed to the surveying. The personnel from third world countries should be trained so that they can expeditiously do the work on their own, but if it is seen that the training takes too long a time, firms from industrialized countries must be entrusted with the performance of the work, the project-related advanced training of the local personnel being continued nevertheless.

Training and advanced training measures

On the occasion of the Second United Nations Regional Cartographic Conference for the Americas, held in Mexico in 1979, attention was already drawn to ETCG. It has turned out that the training given, particularly at the middle level, has been of decisive importance in the establishment and maintenance of a cadastre. There have also been objections to this training to the effect:

(*a*) That training at the highest level would be more expedient, because the trained personnel could then take over the further training of personnel at the middle level;

(*b*) That technicians and engineers who have been subjected to training, would aim at the highest training level. It was claimed that the trend towards the highest training level would exist in the third world countries just as in industrialized countries and that the glut of university graduates was not to be prevented.

However, the consequence of these criticisms should not be that training of the middle management is neglected. Criteria should be set up to determine which personnel can be admitted to the highest training level.

Co-operation between universities of the Federal Republic of Germany and foreign universities, initiated by the Academic Exchange Service of the Federal Republic of Germany (Deutscher Akademischer Austauschdienst (DAAD)), resulted in training measures which, among other places, were carried out in Curitiba and Recife. In Curitiba, training for the Bachelor's degree was to be used as basis for the training of the licenciate and the doctoral candidate. In Recife, it was more the question of deepening and enlarging the training of the Bachelor. At ETCG, efforts are being made to extend the training of the technician and engineer (Bachelor) by licentiation. In many cases the universities are responsible for the extension of training possibilities. Most of the time it is not possible to meet the requirements for individual training levels.

The direct contact of the universities in the Federal Republic of Germany with universities in South and Central America (Maracaibo and Mexico) resulted in a co-operation which aimed at placing geodetic training on a higher level. It is particularly worth mentioning that in Maracaibo training has been raised to the level of training in the Federal Republic (Dipl. Ing., licentiation and doctorate) by the dispatch of lecturers from the Federal Republic. The costs for this extended training have been borne by the Government of Venezuela.

A number of courses in remote sensing, photogrammetry and cadastre have been held in Mexico.

This shows that quite a range of training and advanced training measures have been carried out in this region. The most effective assistance for a third world country is still training and advanced training at all levels, because knowledge thus acquired cannot get lost regardless of all political disturbances; for this reason utmost attention should be paid to it.

Information system and surveying and mapping

In surveying and mapping it has recently become fashionable to publish articles, hold lectures and have numerous discussions on the establishment of information systems (more precisely, land information systems (LIS)). With the introduction of EDP into surveying and mapping the view is gradually gaining ground that the multitude of information on the surface of the Earth can be combined in order to furnish all political, administrative and legal institutions with a solid basis for making decisions on the execution of projects and environmental measures. Although some definitions of LIS do already exist, not one of them is so far totally satisfactory. What decisively matters is what the user of the LIS thinks of this interdisciplinary product. Here, too, the initiator would have to say what requirements must be met and also declare what costs he is ready to pay for setting up the LIS. However, these questions can only be answered when, on the basis of an existing pilot project, there can be recognized

(*a*) what such an LIS looks like;

(*b*) how the question of cost is settled;

(*c*) what organizational measures must be taken to set up an LIS.

Here and there it is to be noticed that the word cadastre is being replaced by the designation "land information system". One should, however, bear in mind that the countries of the third world, in particular, want the cadastre. The concept of cadastre has become established. Furthermore it would be worth investigating whether the cadastre, as multipurpose cadastre, is not an LIS already. It is always pointed out that the cadastre could only be a basis for an LIS; but the question is justified as to whether the cadastre fulfils the criteria of a land information system.

For each country a different LIS may exist. If a country does not yet have a cadastre, it can set up an information system via topographic maps or even via satellite images. This means that, depending on the conditions existing in the various countries, there are information systems at different levels. With the aid of the cadastre, a so-called large-scale information system can be established that contains many individual data. The cadastral and survey works represent, in any case, a basic reference system for the allocation of information on the surface of the Earth.

But it should also be investigated to what extent the cadastre and the topographic map series already are an information system. To this must be added that surveying, with its "information systems", has already solved the problem of updating.

The problematic nature of LIS has been mentioned because development aid organizations of the Federal Republic of Germany tend to replace the word "cadastre" by "land information system", being of the opinion that the ancient word cadastre should be discarded. Moreover, there are associations connected with the word cadastre which render the realization of a project difficult. However, the problems are not solved with a change of words. In surveying, too,

some seem to think that the word cadastre is no longer up to date.

The setting up of an LIS is not merely a matter of computer technique. It should also be borne in mind that the establishment of information systems does not at present meet with favourable preconditions because of data protection.

The reason for making these remarks on land information systems is that the third world countries are confronted with these problems and that expectations have been awakened which possibly cannot be fulfilled.

Technical co-operation with the Caribbean

Because of the numerous projects in progress in the Americas, the survey activities of the Federal Republic of Germany have had an effect upon the Caribbean, too. First, some countries of the Caribbean approached the Federal Republic of Germany with the request to make possible the training at ETCG of Caribbean Spanish-speaking personnel. This request was fulfilled and scholarships were granted. Of interest is how the Federal Republic became involved in the Haiti project of 1945. There, an extensive water management project was being carried out in the Gonaïves plain with assistance from the Federal Republic. The engineering surveying work in the field had been arranged for by construction firms. After the project had been going on for several years, it was suddenly noticed that a cadastre was needed because (*a*) the status of ownership rights was unknown, and (*b*) the property boundaries and other data (area, etc.) had in many instances not been properly recorded.

One of the reasons why these data were needed was to establish the just distribution of costs for the water supplied to the properties. A cadastral office had been set up by the Haitians; however, it was only with the help of the Federal Republic that the cadastral work could be carried out efficiently as to instrumentation and organization. From that time on it became possible to establish the cadastre corresponding to the course of construction.

Regrettably, the cadastral surveys could not make use of the work carried out in engineering surveying. New terrestrial cadastral surveys had to be made. The proposal of the Federal Republic to apply photogrammetric methods had been disapproved because of the small size of the project area. At a later time, however, the aerophotogrammetric coverage could be realized when aerial photographs were taken of Port-au-Prince.

This project very clearly shows how surveying and mapping—in this case the cadastre also—were brought in to serve another project (on water management). It must be attributed to the project initiator that some measures in surveying and mapping were started too late so that delays and disagreements in the course of the project had to be accepted.

The production of orthophoto maps 1:1,000 of Port-au-Prince, in 1976, was also instigated by another project. Originally it had been planned to produce maps only for the planning of a by-pass, but the town planners (United Nations experts) decided in favour of orthophoto map production for the entire city area because it had proved impossible to prepare a reasonably dependable land-use plan on the basis of existing records. Moreover, there was uncertainty in Port-au-Prince, too, as to the status of property rights. For this reason a planning and cadastral project was carried out with the assistance of the Federal Republic of Germany, in the course of which the orthophoto maps were to be used for:

(*a*) Carrying out planning tasks;
(*b*) Establishing a cadastre;
(*c*) Recognizing and reducing erosion risks;
(*d*) Improving sewerage;
(*e*) Recording buildings.

Firms from the Federal Republic of Germany produced the orthophoto maps in a very short time. As soon as the maps were available, many Haitian institutions made immediate use of them. In short: the maps sold like hot cakes! That the maps had been produced so quickly by firms from the Federal Republic had been an advantage. In Nicaragua, too, in the same year, this method stood the test in the production of the map 1:10,000. This proceeding may draw the criticism that the map production was not handled via a Haitian institution, but the training of the personnel, the establishment of a department and the procurement of the instruments and equipment would have taken so much time that the task, so important for development policy, could not have been started within the next few years.

It had also been planned to use the orthophoto maps for immediate establishment of the cadastre, but here, too, there was a longer delay which could not be attributed to the experts from the Federal Republic of Germany. They had drawn up the cadastral law and submitted it to the Haitian government departments in time, but certain property owners did not agree with the law, fearing that in the course of the cadastral activities it would come to light that they had not acquired their properties lawfully. It turned out that many irregularities had happened during recording of the sales contracts.

It was nearly six years before the President signed the cadastral law. Only then the establishment of a cadastre could be commenced. Although the draft law of the Federal Republic of Germany had been accepted in the main, authorship should be awarded to the Haitian Government.

It is unfortunate when a donor country does not support a cadastral project because of eventually arising difficulties. The organization of land is an important prerequisite in a country's development, particularly an agricultural country. Land is a precious good for the countries of the third world. However, the organization of land, adapted to the country's specific conditions, cannot be avoided. There is no need for the donor country to do all the work, but based on its experiences it should show how such a task can be carried out without delay and in an economic manner. It must suggest organizational measures by means of which a cadastre can be set up, with the greatest possible efforts being made by the recipient country.

The establishment of a cadastre shold not be turned down by a donor country because the task is considered to be too political or too sensitive. Other projects, carrying even more political dynamite, are supported nevertheless.

Conclusion

The above report shows how the Federal Republic of Germany has for many years co-operated with the countries of a large region in surveying and mapping. Based on its own experiences in special fields of surveying and mapping, the Federal Republic has assisted these countries by word and deed in the development and extension of their surveying and mapping services. Cultural ties with these countries have also developed during this engagement of many years' standing; there has been a give and take on both sides. The

question has not always been to carry out spectacular projects. Whenever new methods have been used, attention has always been paid to the practical application of the new procedures. The report has also shown how co-operation can be improved upon in the future.

It is to be hoped that the Federal Republic of Germany will in times to come continue to co-operate with the continent of North and South America and the Caribbean in the field of surveying and mapping, as it has done for the last 20 years.

MONITORING AND EVALUATION OF PROJECTS FOR LAND REGISTRATION*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Tous les pays en développement de la région souhaitent de plus en plus voir s'établir des systèmes plus efficaces, simplifiés et moins coûteux de tenue d'états des droits fonciers, en vue d'améliorer la production agricole, d'accroître les revenus de l'Etat, de promouvoir la mise en valeur des ressources naturelles et de réduire l'injustice sociale.

Le document expose les procédures que l'Overseas Development Administration du Gouvernement britannique applique pour identifier, étudier, suivre et évaluer les projets. Il met l'accent sur le fait que, bien que les géomètres et les administrateurs fonciers débattent souvent de questions techniques et des améliorations qui peuvent être introduites grâce à l'adoption de techniques de pointe, il faut que les responsables locaux et les organismes donneurs d'aide soient convaincus des avantages économiques que ces modifications pourraient apporter afin que ces projets soient jugés suffisamment prioritaires pour être incorporés dans les programmes d'investissement dans les limites des ressources limitées disponibles.

Il est nécessaire que les propositions de projets soient élaborées avec soin et il est essentiel pour la mise en œuvre et le succès des futurs projets que l'on procède avec le concours d'observateurs neutres non spécialisés à l'examen et à l'échange de données sur les avantages économiques que le pays a retirés de l'exécution de programmes antérieurs.

RESUMEN

En todos los países en desarrollo de la región hay un interés creciente por establecer sistemas mejores, más simples y más baratos de mantenimiento de registros de propiedad de las tierras encaminados al mejoramiento de la producción agrícola, la recaudación de rentas fiscales junto con el mejoramiento de la economía natural y el alivio de la injusticia social.

En la monografía se reseñan los procedimientos de la Administración de Desarrollo de Ultramar del Gobierno británico para la determinación, estimación, supervisión y evaluación de proyectos. Se recalca el hecho de que, aunque los agrimensores y los administradores de tierras debaten a menudo puntos técnicos y mejoras que pueden obtenerse de técnicas avanzadas, es necesario convencer a los gobiernos locales y a los donantes de asistencia de los beneficios económicos que se obtendrán antes de que esos programas reciban la prioridad necesaria para su inclusión en los programas de gastos con cargo a los limitados recursos disponibles.

Es necesario elaborar cuidadosamente las propuestas de proyectos. Para que la aplicación de propuestas futuras tenga buenos resultados son muy importantes el estudio y el intercambio de información sobre los beneficios que se han obtenido de programas anteriores en lo que respecta al mejoramiento de la economía nacional, así como una evaluación de observadores neutrales no técnicos.

Throughout Central and South America and the Caribbean, there has been steadily increasing concern to improve existing systems for recording land tenure and to record formally rights in land which currently depend on custom, tenancy at will, squatting and invasion of unoccupied land. This effort is aimed at a number of objectives, perhaps the most important of which are:

(*a*) To improve productivity of land through better management. In the larger countries this mainly applies, properly, to agricultural production, but there are analogous situations even in urbanized areas where well-managed land can develop a property market which brings in capital to stimulate other types of development. Frequently, development is stultified by lack of knowledge of who owns, or has rights over, the land and the extent of these interests;

(*b*) To generate revenue through various forms of taxation which can be applied both to recurrent expenditure and to further development. Although land tax as such is frequently politically unacceptable, forms of taxation on real estate, such as rates, are increasingly important to central revenue, and some form of tax based on holdings of agricultural land can be seen as an alternative or supplement to income tax that is more easily and accurately administered and can also be manipulated to encourage productivity;

(*c*) To alleviate social injustice, especially in South America where open conflicts result from an influx of peasant farmers into large and often undeveloped estates.

Little can be done to advance towards these objectives without a comprehensive and accurate record of ownership of rights in land and some categorization of the use to which land is put. But the main drive stems from an increasing realization that farmers will not invest in improved land use, better farming methods and crop varieties that contribute to national economic growth, unless they have the security of tenure conferred by legal title. In many countries, too, it is highly relevant that agricultural credit programmes are blocked because farmers do not have proper documents to support their claims for use of land as collateral.

It is significant that the World Bank is now placing considerable emphasis on land-related projects, including "titling"—usually referred to in Britain as land registration. A recent paper (8) gave the rationale for this attitude.

* The original text of this paper, prepared by B. E. Furmston, Ordnance Survey of Great Britain, appeared as document E/CONF 77/L. 28

Although the Bank announced support for "land reform" activities, including financial and technical aid with cadastral surveys, registration of land titles and similar services in a sector paper published in 1974/75, only three projects approved between 1975 and 1981 were actually so related. This has been attributed to the considerable political and technical difficulties encountered in the wide-ranging projects for land reform considered in the 1960s and to the fact that titling and cadastral operations were still lengthy processes which were very costly and did not fit well within Bank project procedures.

New technologies and new approaches have dramatically reduced the time and the cost required to establish a reliable cadastre, or register of rights in land although both time and cost remain substantial. Nevertheless, the Bank now considers that costs up to about US$ 10 per hectare result in cost-effective investment.

The Bank has recently approved some projects with a new approach based on specific limited objectives rather than difficult nation-wide land reform. These projects, and others now in preparation (for example, in Brazil, Cameroon, the Philippines and Tunisia), put emphasis on land titling and the establishment of an extended and reliable cadastre. In the region, USAID has also approved the substantial project for land registration in Saint Lucia for which operations have just started.

The Overseas Surveys Directorate of Ordnance Survey has experience of land settlement and land registration programmes in a number of countries, these being generally within the Commonwealth and carried out against a background of British aid. The words used to describe particular activities sometimes differ not only between languages, but between organizations and it may, therefore, be useful to define some of those in general use in Britain, and in the present paper.

Project identification refers to the preparation of proposals, often in connection with a "shopping list", for discussion with potential aid donors. Such discussion may take place at various levels, ranging from informal technical contacts to the formal presentation of a project to an identification mission. The outcome, if favourable, is likely to be the approval in principle and within a broad financial budget of a project for inclusion in a future programme subject to detailed appraisal.

Project appraisal is used to describe the costing and scrutiny of project proposals leading to their consideration for funding. It may frequently involve the modification of original proposals in both informal and formal consultation with those asking for assistance. The aim will usually be to clarify objectives and to match both objectives and methods of implementation to the available resources. At the end of appraisal, decisions will follow on whether a particular project is deserving of support and whether (and when) specific resources can be made available.

Project monitoring concerns the management and overseeing of a project in progress with the aim of meeting objectives within allocated resources.

Project evaluation, within the British Overseas Development Administration, is the term reserved for post-project analysis and is an assessment of the realization of the project. The objective is both to compare actual costs and benefits to those projected earlier and to record lessons that may have been learnt and can be applied to the appraisal of any future projects of the same nature.

Programmes for reform of the administration of land tenure may vary widely depending on the existing law, whether this should be changed, the existing pattern of rights in land and the improvements being sought—for example, whether settlement of new land is involved or the better use of land which is already occupied.

Few land administrators, especially among those who have any experience of the operation of a deeds registry, or who are concerned with access to information held in such a registry, would now contest the view that registration of title, in which it is the land parcel that is the fundamental unit of reference, is far superior to registration of deeds. Reference to *land registration*, therefore, may be taken to mean registration of title.

If there is "new" land available an objective may be to allocate this land to new owners or tenants. This process of *land settlement* may, as in Brazil and the transmigration programmes of Indonesia, involve the clearance of forest and the opening of new areas for development or, as in Kenya and Zimbabwe, the repurchase and re-allocation of existing estates. In either case the process is likely to require land-use planning, the demarcation of new boundaries and their survey, as well as land registration.

Other programmes seek to improve the use, and therefore the output, of land that is already occupied. This may be sought through better security of tenure where rights in land have been obscured through the deterioration of existing record systems, or where rights are recognized only by a customary system vulnerable to change at short notice or where no legal or customary rights exist, but share-croppers or squatters may have established some equitable right that it is wished to recognize (of course, in other cases it may not be desirable to perpetuate the stay of squatters on land that would be better used for other purposes). In these cases, a system of *adjudication*, to establish claims or determine conflicting claims will be required, based on special legislation.

Fragmentation may be a problem where individual owners possess small parcels of land that may be better managed by a process of consolidation (remembrement). In other cases, individuals may have rights only in single parcels which are too small to provide a living. Such cases may well arise from laws and customs of inheritance. Correction by legislative action may involve control of subdivision or some form of redistribution of land. Such more radical solutions involve *land reform*.

Whatever the nature of the programme the land may be allocated on the basis of communal, co-operative, clan, family or individual tenure with the rights vested in either groups of people or in one individual. Tenure may be unrestricted or specific conditions may be imposed, for example related to development or to the execution of acceptable agricultural practices or to the fulfilment of some financial obligation. The terms *ownership* and *title*, when used in the present paper refer to ownership of rights and title to rights, which may include many varieties of conditional tenure and which may be shared with other members of a group as well as individual absolute ownership of, and freehold title to, land.

General points

Proposals for rural land administration programmes usually originate from departments and institutions actively engaged in such administration. Most, and perhaps all, of the organizations from which support must be sought (including the treasury or finance department of the same Government) are more greatly concerned with the benefits to be gained from the proposed programme, in relation to the costs in-

volved, than with any of the technical or administrative aspects. The first necessity is, therefore, for those engaged in land administration to be able to show those in charge of financial resources that the benefits of new programmes outweigh costs and, because resources are always limited, that the proposal should have greater priority than alternative calls on the same resources. There is no lack of literature that describes existing systems of land registration and cadastre, the evolution of such systems and land information systems in general, and describes or debates the merits of particular technical methods of surveying and recording rights in land. A most useful list of 145 references up to 1981 is contained in Kent's article in *Surveying and Mapping* (1), but few of these address the fundamental question—why should any Government spend money in developing new or better systems of rural land registration? More debate on this issue resulting in assistance for those compiling projects would be of great value.

The importance of land as the basic natural resource is generally recognized. It is now better appreciated that land is often quite fragile, that its fertility and its suitability for growing particular types of vegetation is extremely variable and that it can, for all practical purposes, be destroyed—in short, that there is a fine balance between conservation and exploitation. But, whereas such broad statements may be accepted, they are far from sufficient to convince a financier or an economist. In making a case for a land registration programme on grounds of development, or financial return, it will usually be found that both costs and benefits are particularly difficult to quantify with any degree of accuracy and certainly both are far more difficult to assess than in, say, a case for a canning factory or a mineral development. Kent (1) notes that "claims regarding the potential benefits of these programs far outweigh those actually realised" and "Typically, from two to four times more time is required to complete a given program than was originally anticipated". If such an assessment is implanted in the minds of those carrying out appraisals, it is all the more difficult to counter on subsequent occasions.

Because the ownership of land is an emotive subject, and because no sysem of land registration and, indeed, few land administration programmes, will succeed without the active support of the people involved, public relations and the communication of information to the public are important aspects of most land programmes. Land reform often has a political background, but whether the background is political (ideology) or political (dealing with public policies) there is often pressure for speed of execution. This can become dangerous ground for the professional surveyor or land administrator. The introduction of effective, and lasting, systems must not be hasty, but its speed must be realistic. There are illuminating examples of cases where a Government, exasperated by the apparent inability of a survey department to execute cadastral survey quickly enough, has simply bypassed its professional advice and resorted to other expedients, with results which have required work to be, or planned to be, re-done. Even such duplication may be seen as part of the price that must be paid for public support of the programme. Clearly, the ideal is for the technical expert to recommend a system which is both effective (though it may not be ideal) and speedy enough to satisfy the needs of the users, whether they be officials, the general public or both. In this it is often the case that "the best is the enemy of the good".

Many projects—certainly including programmes of adjudication and initial registration—will need an injection of expertise and of manpower, as well as funds, for an initial period of implementation. Attention must be paid to the need to maintain the systems that have been introduced long after the period has passed. Such maintenance must be within the capability, and the resources, of a realistic level of future recurrent budgets. Maintenance (in which is included the continued operation of a registry, revision of mapping, agricultural extension services, marketing facilities and so on, as appropriate to each scheme) is frequently more difficult to administer than initial implementation if only because its needs are sporadic in volume, space and time.

Those with direct experience will know that it is particularly difficult to quantify the time, and therefore the cost, needed to implement a programme of land registration, where adjudication is an element, and of land settlement, where new and undeveloped land is involved. Even where local practice and custom is thought to be well understood, it is impossible to know in advance the number and complexity of problems that may arise when demarcation and adjudication actually commence, and the extent to which disputes may be carried through the system of petitions and appeals necessary to show that decisions are fair. Estimates formed on the basis of studies and replies given by landowners to hypothetical questions posed in advance of an actual adjudication exercise may not prove to be reliable when the same persons realize that the programme itself will result in an irrevocable record. Settlement in heavily forested areas may expose deficiencies in earlier topographical surveys and land resource surveys simply due to the difficulty of travelling through, and observing the actual ground under, heavy vegetation.

At the same time, the success of the programme will depend on the acceptance of its results, whether these be confidence in the security of title offered by a new registration system to a landowner or mortgagor, or in the ability of a settler to obtain the fair standard of living he will no doubt have been promised from his new property. Time and trouble *must* be taken to achieve this confidence or the programme will fail. It will, therefore, normally be wise to undertake pilot programmes in any area where new attitudes, as well as new physical conditions, may be encountered, and it will also be wise to allow for a substantial review of procedures, costs and production rates at some mid-point in the programme when there is still sufficient time and resources available to effect any necessary changes.

Project identification

Projects may be put forward during a formal identification mission or on an *ad hoc* basis. Given that the major proportion of available funds is likely to be absorbed by the presentation of some formal package, however, *ad hoc* requests are only likely to be considered if their scope is fairly small. For large programmes, where aid funds or development finance is required, early informal discussion may be quite wide-ranging and may cover much the same ground as the appraisal stage.

In the procedures of the British Overseas Development Administration (ODA), identification amounts to the consideration of a project against priorities expressed by the overseas Government concerned, these usually having been collated by a central department (perhaps a Ministry of Finance or of Economic Planning) and against the available resources. If this consideration leads to a favourable view, the project may be accepted in principle and fitted within a broad programme of expenditure, but it will then be subject to appraisal before any final agreement is reached.

The maxim that "time spent in reconnaissance is seldom wasted" applies. A project, whatever its nature, has more chance of success if proposals are well presented and objectives, costs and benefits analysed at an early stage.

Project appraisal

In the context of the British aid programme, the aims of appraisal are to ensure that the projects accepted for funding are conceived as an effective contribution to development in the recipient country, have the best possible chance of being successful (that is, that their objectives will be achieved) and that their cost and timing can be contained within the available resources. The greatest emphasis falls on justification (economic analysis of costs and benefits) and on viability (assurance of realistic objectives and cost-effective technical specifications and methods).

For land registration programmes, whether these involve the recognition and registration of existing rights, or the allocation of new rights through settlement, a valuable guide to their viability was given by H. West in his paper "The role of land registration in developing countries" (2). In this he lists conditions essential for success, such as:

(*a*) Landowners and others must generally understand and support the introduction of registration;

(*b*) Actual or potential land values must be high enough to warrant the expense to landowners (and to government);

(*c*) Property rights and property boundaries must be clearly recognizable and definable;

(*d*) Survey and registry staff of requisite ability must be available;

(*e*) Government must appreciate (and accept) the expense and duration of the operation.

To those should be added a further condition that enabling legislation which, as Dr West states, must be simple, intelligible and fully adapted to local circumstances, must have been enacted before any adjudication or registration can be contemplated. If a programme includes the preparation of this legislation, then there must exist the political will to bring this forward and to implement it once enacted. Experience suggests that there will frequently be opposition to any such legislation from groups, which may include both surveyors and lawyers, who see new systems as inimical to their interests, especially if they involve the simplification of survey requirements and legal formalities (which are often desirable). In fact, such opposition may be overcome as, for example, in a number of Caribbean islands for which projects to introduce land registration systems were financed by ODA between 1970 and 1980. Warren records (3) that "It is gratifying that the legal profession, once so vocal in expressing its doubts about the introduction of Land Registration is now almost unanimous in its acceptance" and, indeed, many of those who first expressed doubts have found that the increased volume of transactions in the islands has more than compensated for the simplification of the legal procedures, and thus the wasteful litigation which once took place.

Beyond these conditions there are undoubted benefits, although perhaps difficult to relate to specific development, to the private individual and to government. Again, based on Dr West's analysis, these include:

(*a*) Benefits to the individual:

(i) greater confidence and security, encouraging the investment, by landowners, of capital and effort to improve the use of land;

(ii) more expeditious and reliable and cheaper dealing in land, together with a reduction in the possibility of loss, fraud or mistake;

(iii) easier access to credit;

(iv) reduction in the quantity of disputes and litigation over land rights;

(*b*) Benefits to the State and to local government:

(i) removal of constraints to development caused by uncertainty in knowing the rights of the State and of individuals in land parcels;

(ii) provision of a reliable base for an inventory of land resources;

(iii) provision of a reliable record for administrative purposes including, where appropriate, the raising of revenue through rent of leaseholds and property taxes, environmental control through planning measures and as a basis for a wide variety of incentives to develop the produce of the land;

(iv) in the case of land settlement, increased production linked to improvements in farming methods (for example, by mechanization, irrigation), to a new or improved ability to produce particular crops for food or for sale or simply the offering of land to the landless as in the transmigration programmes of Indonesia and in Brazil.

It is immediately obvious that the economist will find it difficult to quantify many of these benefits in terms of cash—usually the only common denominator available to assess either the merits of an individual programme or the relative merits of quite different types of development projects which may be competing for the same funds.

In a study of the Caribbean Regional Cadastral Survey and Land Registration Project carried out in 1974 (4), benefits were quantified for a number of islands. All have individual characteristics, of course, but then so do any prospective areas to be considered for new programmes. The approach of the study thus serves to illustrate at least some of the quantification which may be achieved and perhaps some of the limitations. None of the three island groups considered relied on agriculture to any significant extent for revenue and the major quanitifiable benefits were considered to be:

(*a*) a reduction in conveyancing costs—very small in Turks and Caicos, but significant in Antigua;

(*b*) a reduction in litigation costs—relatively high in Cayman Islands;

(*c*) cheaper credit at an increased volume—small, but in all three groups.

It is, however, interesting to note that almost 10 years after the report was written, although it concluded that the benefits stemming from the establishment of registration of title would be small, revenue from stamp duty on land transactions in the Cayman Islands, which at the time had risen from $CI 217,000 in 1970 to $CI 500,000 in 1974, reached almost $CI 6,000,000 in 1983 (5). It is true that land on the islands has its own attractions, regardless of registration, but secure title is known to be an attraction to foreign investment, and even if only a small percentage of the pull is due to land registration, the return in increased government revenue must represent a sound investment of the total cost of the original programme of some £550,000 sterling.

An important element—sometimes even the main justification for a land registration or land settlement pro-

gramme—is to right social injustices or create new social opportunities through land reform. However, while there may be gains in social stability there should be economic gain in addition—there is little point in resettling people in a new area without improving their economic prospect and through that, the economy as a whole. Studies have shown that conversion of "family lands" and lands farmed by squatters or sharecroppers to individual tenure can greatly increase production, but some arbitrary increase in production or in family income from sales of produce must usually be assumed which, set against the increased expenditure (for example, on better seed and fertilizer), forms the basis for the analysis of potential benefit in cash figures.

It is not the purpose of this paper to weigh the merits of particular technical methods (which in the present context may be taken to include land registry administration as well as land survey adjudication). It will certainly be part of the appraisal process for those concerned, to be satisfied that the proposed methods are sound, cost-effective and suited to the terrain, the climate, the resources and the local customs and practices of the particular area. It is equally certain, however, that methods found satisfactory in one country, or even in one area of a country, may not be wholly appropriate in another location. Much advice and literature can be found, but a good overview is given by the report of the meeting of the *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping convened at the United Nations in New York in 1972 (6). Since that time, there have been considerable advances in computer based digital systems, but these are not always appropriate in developing countries and their availability, as a tool, can easily be assimilated in the general principles set out in the report presented to the United Nations Regional Cartographic Conference for Asia and the Far East in 1973.

Appraisal should aim to set out clear objectives and targets against which the implementation of a programme can be monitored. Where costs and times have been developed on assumptions extrapolated from other programmes, it is particularly important that these should be easily identified. If such assumptions do not prove to be valid, corrective action will almost certainly be needed at an early stage of implementation

Project monitoring

Many early development projects, of all kinds, were simply allowed to proceed, without adequate oversight to ensure that the right work was being done, that cost-effective methods were being used in line with the resources available and that the specified objectives were kept fully in mind. Some undoubtedly failed and others tended to develop along lines which were not the original intention. The worsening world economic situation has made all funding authorities, whether the Government seeking improvement, donor Governments, international agencies or private sector financiers, take much more care to see that money going into any project is well spent and making an effective contribution to the desired aim.

The essence of monitoring is that it is an influence outside the management of the project itself. The project manager, and his team implementing the project, remain responsible for operations within the timetable, financial budget and specifications that are the outcome of appraisal, and the project manager must exercise that role. However, no appraisal can be faultless, and land administration programmes are among those where it is both impossible to anticipate all problems and their solutions and probably unhelpful even to try to do so. Even the law governing the implementation of adjudication and registration will usually be capable of interpretation in the light of circumstances. Indeed, it is better that this should be so and that many details of its administration should be controlled by ministerial or departmental regulation or by a developing system of "case law" and precedent. Otherwise even small amendments to interpretation will have to be referred to a Parliament or equivalent legislative authority, which is rarely able to operate sufficiently quickly. The establishment of precedent, which will set the scene for future action, does therefore need to be watched and this, naturally, is particularly important in the early stages. Monitoring acts as an early warning system if implementation reveals deficiencies in policy or underestimation of time and cost—and the sooner these are known and corrective action taken, the better.

A difficulty with many land administration projects is that their benefits—or indeed their drawbacks—may not become evident for some time, and the institutions and practices introduced are, by their nature, intended for very long-term use. It is frequently implicit that benefit is sought from encouraging a settler, or a new freeholder, to invest on the basis that he can pass the resulting improvements to his children, and his children's children. The emphasis on short-term profit which, in a stark interpretation, drives the private sector is not the best motive on which to rely to ensure that really long-term development is foreseen and its effect taken into account at implementation stage. This is not to imply that government officials should not be cost-conscious; it is a necessary part of their service that they should be so, and be fully conscious that it is the taxpayers' money with which they are entrusted. Nor does it imply that the private sector is so wedded to short-term gain that it is ignorant, or neglectful, of the long term interest. But the need is for an understanding of the necessity to employ the best of both approaches and for the monitoring agency to correct any malign bias to either side. A number of possible relationships exist for the employment of outside expertise as contractors and consultants from both public service and private sector. There is, however, much advantage in consultants' being familiar with government machinery. The ultimate responsibility for any guarantee of title will inevitably rest with the State and its administration. The exercise of that responsibility must be an integral part of the arrangements for maintenance of the system. In ODA, monitoring may be undertaken by consultants, but it is an important role of the professional advisers who are maintained both at headquarters in London and in development divisions in key locations. These advisers form a multidisciplinary team, able to travel to project areas and to draw on each other's expertise. The role is in some ways close to that of the on-site resident engineer in civil engineering, usually emplaced by consultants to monitor and approve the work of contractors during construction, but need not be quite so closely involved. Whoever carries out the monitoring function must certainly be knowledgeable and experienced in the work being done. It is not enough simply to keep a check on expenditure without also paying attention to the results achieved to date and the progress made towards the stated objectives.

Most schemes introducing new tenure systems will involve the training of those who will remain in permanent administrative posts. There are many advantages in such local personnel taking an active part from the outset, although there are limits to which training can be given alongside production work. It is better to start with only that number who can be properly supervised by experienced

project staff and to build later on that initial strength even if this extends the time-scale of the project. In Indonesia much effort has been wasted through deficient surveys without adequate supervision and quality control.

Much of the work of monitoring will be done by the study of progress reports and maps and by the comparison of cost and cash flow against estimates or budgets, but it is also essential that visits be made to the area, both to the administration being established, and to the ground. The systems introduced will stand or fall by the service they give to the local community, whether this is newly created or one which existed previously. It is their acceptance, which will depend on the benefits they perceive, on which the success or failure of the whole project will depend and this cannot be judged without direct contact

Certainly, of all development, implementation must be carried through, even if this means that the scope of the project must be reduced to meet a shortfall of resources. To leave a particular settlement area inadequately developed or without adequate services is to court failure, while the partial introduction of land registration to a particular area will serve only to intensify problems of title and of occupation. It must be better to concentrate such resources as are available on the completion of the project within an area that can be fully covered than to overreach in a wider area, and this is something to which the project monitor must pay particular attention

Evaluation

Project evaluation, that is, examining completed projects to measure their success, is a process to which increasing attention has been paid in recent years, no doubt stimulated by the economic climate. Its importance in ODA has been increasingly recognized and has recently been underlined by the organization of a Conference, with international attendance, in 1983. In the Proceedings (7), the role of evaluation was set out succinctly by R. A. Browning as:

(*a*) to learn lessons from past aid activities;

(*b*) to ensure, as far as possible, that projects have a good chance of being successful by feedback of observations into future appraisals;

(*c*) to assure those interested in development, not least the taxpaying public, that funds used for overseas development are well spent;

(*d*) to help those involved in the teaching of development studies

In ODA evaluations have usually been made by economists, although outside consultants and advisers from elsewhere within ODA are now increasingly called in to augment the staff of the Evaluation Department. It is not intended to argue the merits of the discipline of economics as a basis for evaluation. This is certainly sometimes challenged by other professionals and holders of technical qualifications in other fields closer to the technical background of particular projects. It is, however, increasingly clear that in a time of scarce resources any profession or technical discipline needs support from assessors who are perceived as "neutral" with no interest in promoting the interests of any particular professional group and no identification with a user pressure group.

Other funding organizations, including the World Bank and USAID, have been more meticulous in evaluation earlier perhaps, but there seems to be a general trend to the realization that many useful projects aiming at long-term benefits require time to settle down before those benefits can be properly evaluated. Such a trend must be welcomed in relation to land registration projects. Not only do the benefits increase in the longer term, but they are also very dependent on the understanding of both owners and tenants, on the one hand, and government itself, on the other, of the uses to which the new, accurate, comprehensive and reliable record which has been created may be put. This understanding can take time to develop

Land registration has been evaluated only once—and that somewhat informally—by ODA. This formed part of the review undertaken in connection with mid-term appraisal of the project which had been initiated for the Cayman Islands and for Antigua and concerned registration in Turks and Caicos. The conclusion was that Turks and Caicos had, in the first six years of the register, gained benefits that far outweighed the costs, given the assumptions made concerning the extent to which the existence of the new register had influenced events. Even so, the report was cool towards the completion of registration for the whole area of the Cayman Islands and the determination of the local Government was crucial to the completion of that project, as originally conceived. Events now seem to have proved that it was the Government that was right.

A few more evaluations have been carried out of integrated rural development projects, some in conjunction with the World Bank who were involved in joint funding. The conclusions drawn from these investigations (7), which are most closely related to settlement and registration, confirm the principle that settlement and registration projects need to be carefully constructed to take account of local conditions and of local practices and customs. If these are not already well understood more baseline research is indicated before a project is formulated. This may also indicate that a pilot project is advisable in which implementation procedures and the impact on those who are expected to benefit, can be assessed before extending the scheme to wider areas. In respect of registration and settlement, however, any pilot area must be such that the new systems can operate as a self-contained unit and that they do not become confused at their perimeter with other systems, to their detriment.

It is worth noting that benefits may follow which were not foreseen by project appraisal. An evaluation of the Lilongwe Land Reorganisation Scheme, later known as the Lilongwe Land Development Project, in Malawi, was carried out by the World Bank in 1979. The report reviewed the original objectives of the project, one of the principle aims being to increase the output of two particular crops. It concluded that the project had been successful and commented that any visitor to the area could hardly fail to appreciate the beneficial changes that had taken place. Neat, tidy, productive family holdings with a new air of purpose and of better social and economic conditions give an unmistakable sign of success. Yet the output of those particular crops had fallen, not risen, and the benefits had developed in ways not foreseen at implementation.

Land registration of family holdings was one input to the project along with road construction, the emplacement of bunds to control rainfall run-off and the introduction of better farming methods, fertilizer and marketing. Survey and registration of family holdings (family rather than individual tenure was appropriate to the social background in the area) inevitably followed after the other agricultural elements of input and indeed is not yet complete for the whole project area. It is not, therefore, possible even to try to assess the benefit arising from this particular input. Yet the lesson to be learned is that benefits may flow from the

injection of capital development in unforeseen ways. It may be that the benefits of land registration will prove to be more closely associated with preserving the gains that have been made, rather than in initiating those gains. But, if this is so, this is still a valuable step. Too many projects have a tendency to slide back once the major phase of input is over and the enthusiasm generated by the intense activity of implementation cools to longer-term levels.

No functional sector of development should be afraid of evaluation. If its results do not show a positive benefit after an informed and properly based study, then there is need to think again about the inputs that have been recommended. There must be feedback from the results and stimulation of new ideas.

Conclusion

Land settlement projects usually arise from population pressures that are clear for all to see and cannot be denied. It will usually be the case that the questions posed in appraisal, and indeed in implementation, are not so much "why?" or even "when?", but more where and how the most benefit may accrue to the community at large, and the best value for money, can be obtained.

The benefit of land registration, however much it is appreciated by those engaged in land administration, is often less obvious to the general public (excepting, of course, those directly gaining title and occupation of land in the process). In principle, at least, the "where" and the "how" are accepted by land administrators even though there may be argument about detailed implementation and debate (which may be eternal) about the equation of cost and accuracy. It is the "why?" which lurks in the mind of the economist and the non-technical appraiser, and "why now?".

Its aim will be a simple and inexpensive system cutting out waste of resources, but "the introduction and maintenance of an authoritative record of land rights is undoubtedly expensive; success will require perseverance and determination on [a] government's part, because it may be some time before any benefits begin to be apparent" (2). Conviction of the value of rational and stable land tenure and of its effective administration will come only from communication with those outside the immediate circle of surveyors and land administrators. There is a clear need to foster contact and debate involving general administrators, economists and the financiers of international agencies as well as technical and professional surveyors. Such interaction can serve only to improve the quality of project appraisal, monitoring and evaluation, which in turn will foster and improve the prospect of these vital development projects.

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REPORT ON CARTOGRAPHIC ACTIVITIES IN THE AMERICAS*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Le présent document fait le point des travaux de topographie et de cartographie terrestre et marine des pays et mers de la région des Amériques, exécutés par les organismes gouvernementaux britanniques depuis la deuxième Conférence cartographique régionale des Nations Unies pour l'Amérique.

La Direction des services cartographiques d'outre-mer a exécuté des travaux topographiques et cartographiques dans 15 pays de la région, au titre du programme d'aide du Royaume-Uni. Le Département de l'hydrographie a continué de mettre à jour les cartes marines des zones dont il s'occupe dans la région, tandis que la Royal Navy a mené à bonne fin un certain nombre de levés dans la région des Caraïbes et des Antilles. Il existe un rapport des activités entreprises dans chaque région et une liste des cartes terrestres et marines exécutées par les organismes britanniques

RESUMEN

Este documento es una reseña de la contribución de los organismos gubernamentales del Reino Unido a los trabajos topográficos, levantamientos cartográficos y preparación de cartas de los países y mares de América desde la Segunda Conferencia Cartográfica Regional de las Naciones Unidas para América.

La Dirección de Estudios Ultramarinos realizó trabajos de cartografía y topografía en 15 países de la región como parte del programa de ayuda del Reino Unido. El Departamento de Hidrografía continuó con sus trabajos de actualización de las Cartas de Navegación del Almirantazgo en las partes de la región de que es responsable y la Royal Navy llevó a cabo varios estudios en el Caribe y las Indias Occidentales. Se describen las actividades realizadas en cada país y se enumeran los mapas y cartas preparados por los organismos

* The original text of this paper appeared as document E/CONF.77/L.61

The report is an account of the contribution to the surveying, mapping and charting of the countries and seas of the Americas made by agencies of the Government of the United Kingdom between 1 January 1979 and 31 December 1984. This covers the period since the last United Kingdom report, presented at the Second United Nations Regional Cartographic Conference for the Americas, held at Mexico City, 3-14 September 1979.[1]

United Kingdom government agencies

The main contribution to cartographic activities in the Americas was made by the following government agencies.

(*a*) Directorate of Overseas Surveys (DOS) of the Overseas Development Administration (ODA), Foreign and Commonwealth Office;

(*b*) Directorate of Military Survey (DMS), Ministry of Defence;

(*c*) Hydrographic Department, Ministry of Defence.

Merger of DOS with the Ordnance Survey

In April 1984, DOS ceased to be part of ODA and merged with the Ordnance Survey of Great Britain, the British national mapping agency, to become the latter's Overseas Surveys Directorate (OSD). OSD continues the role of DOS; it carries out work within the overall United Kingdom government aid programme to the region funded by ODA; it also undertakes projects for international aid organizations and is able to perform some repayment tasks on contract.

TOPOGRAPHICAL SURVEYING AND MAPPING

Topographical surveying and mapping projects were undertaken by DOS in collaboration with local survey departments in the following countries of the region:

Anguilla	Dominica	Saint Lucia
Antigua and Barbuda	Grenada	Saint Vincent and the Grenadines
Barbados	Guyana	
Belize	Jamaica	Turks and Caicos Islands
British Virgin Islands	Montserrat	
Cayman Islands	Saint Kitts and Nevis	

In Jamaica a joint project was established in which production of the revised 1:50,000 map series was shared between DOS and the Survey Department, both working to an agreed specification.

The majority of projects were to:

(*a*) Revise and extend large-scale mapping for the development of specific areas, town planning or current and future schemes of land registration;

(*b*) Revise and reconstruct smaller-scale mapping in support of specific projects, general administration or tourism.

DMS produced a map of Trinidad in collaboration with the Lands and Surveys Department.

Activities of the Directorate of Overseas Surveys

The main DOS activities in relation to these projects, and generally in the field, were as follows.

Air photography

Contracts with commercial firms were arranged to obtain air photography for parts of Anguilla, Belize, British Virgin Islands, Dominica, Guyana, Jamaica, Montserrat, Saint Christopher and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and the Turks and Caicos Islands (DOS also arranged air photography of Bermuda, but not as part of a mapping project.)

Computing

The adjustment of the whole of the survey network of Saint Vincent and of Dominica was undertaken and work continued on integrating new traverses with older work in Anguilla, the British Virgin Islands, Jamaica, Saint Lucia and the Turks and Caicos Islands.

Field survey

DOS field survey parties operated in Anguilla, the British Virgin Islands, Dominica, Guyana, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and the Turks and Caicos Islands at various times during the period. They established ground control for mapping projects, undertook field revision and completion and control densification for cadastral and development projects. The DOS parties worked with, and often trained, local survey department staff. Management of the field programme was the responsibility of a regional survey officer based in ODA's Development Division in Barbados. He also liaised with Governments and survey departments in the region and provided technical advice on request. Under a reorganization, this post was abolished at the end of 1984, but contact will be maintained by regular visits from OSD headquarters.

Map production

New or revised topographical series maps were produced for 15 countries in the region at scales from 1:1,000 to 1:250,000. These maps are listed in Annex I. When larger-scale mapping was undertaken, monochrome reproduction material was sent to the country concerned for local printing on demand.

Details by country

Details of the topographic surveying and mapping undertaken for each country are given in the final section of the present paper.

Papers submitted to the Conference

The United Kingdom is presenting two papers dealing with aspects of topographic mapping and surveying; these are entitled "Systematic mapping programmes in the Commonwealth countries of the Caribbean" (E/CONF.77/L.45) and "Revision of national mapping series: experience in Great Britain" (E/CONF.77/L.27).

CADASTRAL SURVEYING AND MAPPING

The Caribbean Regional Cadastral Survey and Registration Project

The project, sponsored by ODA, operated in the region until 1980 when the work in Antigua was completed. Its aim was to establish modern systems of land registration, suited to each territory, and to train local counterpart staff to operate the system once it had been set up. Considerable back-up support was provided by DOS in seconding staff to the project team, establishing control frameworks and preparing photographic enlargements, mosaics and large-scale mapping as required.

Land registration projects: Belize and Montserrat

Separate projects, supported by ODA funding, were undertaken in Montserrat and Belize. Assistance was provided by DOS by seconding staff and undertaking mapping fieldwork.

The United Kingdom is contributing to the present Conference a paper entitled "Monitoring and evaluation of projects for land registration" (E/CONF/77/L.28).

HYDROGRAPHIC CHARTING AND SURVEYING

Navigational charts

The total world coverage of Admiralty Charts contains about 3,400 sheets. The whole series is distributed through a world-wide agency system and is maintained by information promulgated in Admiralty *Notices to Mariners*. In areas where the United Kingdom is, or until recently has been, the responsible hydrographic authority—that is, in home waters, waters of some Commonwealth countries and certain areas like the Persian Gulf, the Red Sea and parts of the Caribbean—the Admiralty Charts afford detailed cover of all waters, ports and harbours. These make up about 30 per cent of the total series. The other 70 per cent are compiled mainly from information given on published foreign charts and the Admiralty versions are designed to provide charts for ocean passage and landfall, and approach and entry, usually under pilotage, to the major ports.

The series contains charts on many different scales, but they can be divided into six major classes, excluding the very small-scale "Route planning" and "Ocean passage" charts on scales of between 1:3,500,000 and 1:10,000,000.

Classification	
Coast approach or landfall identification	1:1,000,000
Coasting	1:300,000-1:200,000
Intricate or congested coastal waters	1:150,000-1:75,000
Port approach	1:100,000-1:75,000
Harbours or anchorages	1:50,000 or larger
Terminal installation	1:12,500 or larger

Admiralty nautical charts in the Americas

In the Americas, out of a total Admiralty Chart coverage of approximately 600 charts, about 100 are in areas where the United Kingdom is the primary hydrographic authority. These areas include Bermuda, the Bahamas, Jamaica, Belize, the Cayman Islands, parts of the Leeward and Windward Islands, Barbados, and Trinidad and Tobago. Also included are areas adjoining certain other countries with little or no charting capabilities of their own.

Since the last report on this subject, the Admiralty Chart series has been continuously updated for essential information gleaned from all available sources, particularly foreign Government charts, and surveys by ships of the Royal Navy. In the period January 1979 to October 1984, in addition to regular *Notices to Mariners*, publications have included 160 new editions and 62 new charts in the Americas. Details of these are given in annex II.

Hydrographic surveying

Hydrographic survey effort in British areas of interest in the Caribbean and West Indies has concentrated on important harbours and anchorages, in passages between the islands and on the off-shore banks.

Surveys were conducted in the Virgin Islands, the Turks and Caicos Islands and in Barbados. An extensive area was completed in the Yucatan Channel and the Nicaraguan Rise. Details of surveys completed since the last report are given in annex III.

OTHER MAPPING

Thematic mapping

DOS produced a number of thematic maps to accompany reports of ODA's Land Resources Development Centre. Eighteen slope maps of Jamaica at scale 1:12,500 were produced for the Carib Pine Inventory Project in 1981; and 3 swamp maps of the Cayman Islands at scale 1:25,000 were completed in 1982. Geological maps of Barbados and Bolivia were also produced. Those of Barbados, at scales 1:10,000, 1:20,000 and 1:50,000, were produced in collaboration with the island's chief geologist. Work on the Bolivian multi-coloured map series at 1:100,000 and 1:250,000 continued throughout the period. These maps illustrate the work of the joint British Geological Survey and Government of Bolivia survey of the Pre-Cambrian Shield.

Tactical pilotage charts

One sheet at 1:500,000 scale covering part of Guyana was produced by DMS.

Miscellaneous

Print laydowns of United States photography were prepared of La Mosquita region in north-east Honduras for an ODA land resource inventory, and mosaics were made of the Chaco Indian Settlement Scheme in Paraguay.

Moving map displays for Harrier, Jaguar and Tornado aircraft were produced by DMS for a number of flying training areas in Canada.

TRAINING

Training in cartography, photography, printing, land survey, survey management and hydrography was provided in the United Kingdom for trainees from the region holding United Kingdom technical co-operation scholarships or United Nations fellowships. Training was provided both in government departments and in polytechnic schools and universities.

Training by DOS

Practical training in the field was provided by DOS survey parties in Anguilla, the British Virgin Islands, Dominica, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and the Turks and Caicos Islands. (In Jamaica, teams of surveyors were trained both in modern techniques and in the organization and logistics of field operations.) Practical technical training in cartography and photogrammetry was given at DOS headquarters to 11 trainees drawn from Antigua, Belize, the British Virgin Islands, the Cayman Islands, Jamaica, Saint Lucia and the Turks and Caicos Islands.

SECONDMENTS

Senior DOS staff were seconded to the British Virgin Islands and the Cayman Islands to head their respective survey departments. Others went to Montserrat and Ecuador.

GEOGRAPHICAL NAMES

The United Kingdom participated in the Fourth United Nations Conference on the Standardization of Geographical Names in 1982 and in the Eleventh Session of the Group of Experts on Geographical Names in 1984.

RESEARCH AND DEVELOPMENT

Advances by the United Kingdom in the fields of satellite geodesy, remote sensing and digital mapping continued during the period and were applied, as relevant, to surveying and mapping in the Americas. The United Kingdom's National Remote Sensing Centre (NRSC) came into being in 1980. The Centre provides facilities for research into, and development of, image processing, analysis and interpretive techniques; supplies remote sensing data and imagery; pro-

vides education and training facilities in remote sensing; and acts as a focal point for the development of remote sensing techniques and their application.

Topographic surveying and mapping by country

Anguilla

The 1:2,500 map coverage of the island is being revised from air photography flown in 1982 and 1984. A DOS field party worked with, and trained, counterpart staff in field completion of the sheets and in ground revision of the unphotographed areas: 14 sheets have been published. The revised maps are being used to update the 1:25,000 sheet, which has proved popular with both administrators and tourists.

In 1982, the Lands and Survey Department and DOS worked together to break down the control network, checking existing points and establishing new ones where required for future development.

Antigua and Barbuda

Revision of the 1:2,500 series covering Antigua was completed in 1982, followed in 1983 by the 1:5,000 series. A revised edition of the 1:50,000 Antigua sheet and a new country map showing Antigua and Barbuda at scale 1:100,000 were published in 1980.

Barbados

The 1:1,250-scale mapping of Bridgetown and of Grantley Adams International Airport was completed by 1979. Mapping of the environs of Bridgetown and of Speightstown at 1:2,500 was completed by the end of 1981. Reconstruction of the 12-sheet 1:10,000 map series is currently in progress, using air photography obtained under Canadian technical co-operation in 1982.

Belize

The Royal Air Force obtained 1:25,000-scale air photography of central Belize in early 1979 for a land resource study being undertaken by ODA. Large-scale photography of the towns of Corozal and Orange Walk was obtained later in the same year. The latter was required for the land Registration Project, which included the establishment of control by a DOS field party, the rectification and enlargement of air photographs of a pilot area and the plotting of 22 maps of Orange Walk at scale 1:1,000. All the sheets were completed by 1982.

The first photomap, a 1:50,000 sheet of Ambergis Cay, was published in 1980. The 1:250,000 3-sheet series of the whole country was revised, recast in 2 sheets and published in 1980. A small 1:750,000-scale map derived from the latter was published in 1982.

Bermuda

DOS assisted the Government of Bermuda in letting and monitoring a contract for air photography (1981) and mapping (1983). By the end of the period, the 1:2,500 series covering the island had been published.

British Virgin Islands

In 1980/81, an adjustment was completed of the survey network on Anegada. Air photography at scales 1:35,000 and/or 1:12,500 was obtained of all islands in the group (except Anegada) in 1981.

Work is in progress on 1:2,500-scale revision and on new mapping of parts of Virgin Gorda, Beef Island, Tortola and Jost Van Dyke. Additional mapping control was established jointly by the Survey Department and DOS. Field completion of the shelf will be the responsibility of an Ordnance Survey surveyor whose task is also to train local staff. The 1:25,000 series has been revised and was being printed at the end of 1984. A 1:63,360 tourist map derived from the 1:25,000 series was published in 1982.

Cayman Islands

A multicoloured photomap at 1:50,000 for use by visitors was produced in 1979; a numbered limited edition was prepared specially for signature by the Governor.

Dominica

Height and plan adjustment of the whole survey network of the island was completed. Revision and new mapping at 1:2,500 of parts of the island are in progress, ground control and field completion being undertaken by a joint OSD/survey department team. The remaining areas, mainly mountainous, are being mapped at 1:5,000 and 1:10,000.

A revised edition of the single-sheet 1:50,000 map of the whole island was produced in 1982, followed by a small derived map at 1:125,000.

Grenada

Two revised 1:25,000 sheets covering Grenada were published in 1979, and a tourist map at 1:50,000 derived from these was also published in 1979. A small-scale map showing Grenada and the Grenadines was printed in 1980.

Guyana

The 1:2,500-scale mapping programme was completed by 1980. Work continued on the 1:10,000 scale rectified photomosaics of the coastal belt; 361 sheets originally planned were completed by 1982, and a further 50 sheets are now in progress. Mosaics at 1:5,000 scale were prepared of the Tapakuma area in 1982. These were urgently required for a major ODA/World Bank development project.

A total of five air photography contracts were let in the period in order to obtain cover of an area that is rarely cloud-free. Adequate cover has now been obtained to complete both the 1:10,000 mosaic programme and the reconstruction of the 1:50,000 mapping of the coast lands. The later is being carried out as a joint project between the Guyana Lands and Survey Department and OSD.

Jamaica

The DOS field party in Jamaica continued to establish a dense network of survey points throughout the island and to train local department surveyors in all aspects of the work so that, when the DOS team withdrew in mid-1981, it was able to hand over the continuation of the project to the Department.

A joint project with the Jamaica Survey Department to reconstruct and revise the 1:50,000 map series of the island was launched in 1979. A mapping specification was agreed in 1980, and air photography at 1:50,000 scale of some 10,000 sq km was obtained in 1979/80; cover of the Blue Mountain area was not achieved. By the end of the period the first 6 of the 20 sheets had been published.

Montserrat

The mapping commitment to the Land Registration Project was completed in 1981 when the last of the 1:1,250 sheets of selected villages were produced. Earlier, six sheets

of the 1:5,000 series were revised and printed. A revised edition of the 1:2,500 sheet covering Plymouth was published in 1981. Air photography at 1:20,000 was obtained of the whole island in 1982 and some areas were also photographed at 1:12,500-1:13,500 scale. The photography was required for mapping at scales 1;2,500 and 1:5,000, which is now in progress.

A tourist map at 1:25,000 with an inset map of Plymouth at 1:5,000 was produced in 1983.

Saint Kitts and Nevis

A single-sheet, hill-shaded map at 1:50,000 of the islands was published in 1979: it has tourist information in the text.

During 1981/82 1:12,000-scale air photography was obtained of both Saint Kitts and Nevis for a new programme of revision and new mapping at 1:2,500.

DOS field parties working with local government staff provided training, extended the original survey framework established in 1955 and carried out field completion of the new maps.

Saint Lucia

The DOS field party, which was in the country at the start of the report period, continued work on densification of the existing survey framework and established control for 1:2,500 mapping of selected areas. Additional air photography at 1:12,500 scale was flown in 1981. Field completion of the new maps was carried out by a joint DOS/survey department team, and all sheets, both new and revised, were published by 1984. Revised editions of the three sheets of the 1:25,000 series were published in 1981 and a tourist map at 1:50,000 was produced in 1982.

Saint Vincent and the Grenadines

An overall adjustment of all surveys for which DOS held data was completed early in the period and a list of final co-ordinates issued for 1,177 points.

Work on the revision of the 1:2,500 mapping continued. The task had nearly been completed by the end of the period. This mapping is required for property valuation and other purposes.

In early 1981 the outstanding 1:12,500 photographic cover required for the large-scale mapping programme was achieved on Saint Vincent, and the islands of Mustique, Bequia, Union and Prune were also photographed. In addition, 1:25,000-scale air photography of the whole of Saint Vincent was obtained. Plan and height control for the 1:2,500 programme was provided by a DOS team. Much of the field completion and revision was undertaken by a joint field party consisting of one Ordnance Survey surveyor and surveyors from the Lands and Survey Department.

Revision of the 1:5,000 and 1:10,000 mapping of the Grenadines was also undertaken and completed in the period. The 1:25,000 maps of Saint Vincent were revised from the new 1:25,000-scale photography. Those of the Grenadines were revised and prepared for publication as part of a new 1:50,000 series. A tourist map of Saint Vincent was published at the end of 1984.

Trinidad and Tobago

The Directorate of Military Survey produced a joint operations graphics sheet at 1:250,000, covering Trinidad. Source material was provided by the Lands and Surveys Department, Trinidad.

Turks and Caicos Islands

Air photography at a scale of 1:25,000 was obtained of part of the group in 1980; cover of the whole group was completed in 1981. This photography was required to revise 14 of the 1:10,000 maps covering the islands and to produce a new photomap edition of the 1:25,000 series.

A DOS field party was set up in 1980 to strengthen the main control framework, increase control density in developing areas and to provide additional control for the 1:10,000 and 1:25,000 mapping. The field-work was completed by late 1981 and the results of the survey were incorporated in an adjustment of the survey network to give a homogeneous set of co-ordinates for the islands.

Most of the 1:10,000-scale maps had been published by the end of the period.

A new administrative and tourist map at 1:200,000 scale was published in late 1984.

NOTE

[1] See *Second United Nations Regional Cartographic Conference for the Americas, Mexico City, 3-14 September 1979*. vol. II, *Technical papers* (United Nations publication, Sales No. E/F/S 82 I 14). Document E/CONF.77/L.34.

ANNEX I

Topographical maps of the Americas published by the Directorate of Overseas Surveys, January 1979 – December 1984

Country	*Scale*	*DOS Series number*	*Date*	*Remarks*
Anguilla	1:2,500	043	1979-	Ed 2 and 3
Antigua and Barbuda	1:100,000	993	1980	Ed 3 country map
	1:50,000	406	1980	Ed 7 and 8 Antigua
	1:5,000	106	1983	Ed 2 Antigua
	1:2,500	006	1979-82	Ed 1 and 2 Antigua
Barbados	1:2,500	018	1979-81	Ed 1 Bridgetown and Speightstown
	1:1,250	0018	1979	Ed 1 Bridgetown and Grantley Adams Airport
Belize	1:750,000	958	1982	Ed 4 country map
	1:250,000	649/1	1980	Ed 1 whole country
	1:50,000	4499P	1980	Ed 3 and 4 Ambergis Cay photomap
	1:1,000	0049	1981	Ed 1 Orange Walk

ANNEX I (*continued*)

Country	*Scale*	*DOS Series number*	*Date*	*Remarks*
British Virgin Islands	1:63,360	446	1982	Ed 1 whole group tourist map
Cayman Islands	1:50,000	428P	1979	Ed 1 visitors' photomap
Dominica	1:125,000	998	1982	Ed 2 country map
	1:50,000	451	1982	Ed 3 and 4 whole island
Grenada	1:150,000	995	1980	Ed 3 country map
	1:50,000	442	1979	Ed 3 tourist map
	1:25,000	342	1979	Ed 4 Grenada
Guyana	1:10,000	240M	1979-82	Ed 1 coastal areas controlled photomosaics
	1:5,000	140M	1982	Ed 1 environs of towns
	1:2,500	040	1980	Ed 1
Jamaica	1:50,000	1	1982-	Ed 1
Montserrat	1:25,000	359	1983	Ed 6 tourist map
	1:5,000	159	1979	Ed 2
	1:2,500	059	1981	Ed 3 Plymouth
Saint Kitts and Nevis	1:50,000	443	1979	Ed 1 and 2 tourist map
Saint Lucia	1:125,000	945	1982	Ed 2
	1:50,000	443	1979	Ed 1 and 2 tourist map
	1:10,000	2943	1983	Ed 1
	1:2,500	045	1980-84	Ed 1 and 2
Saint Vincent and the Grenadines	1:50,000	417	1984	Ed 6 and 7 Saint Vincent tourist map
	1:25,000	317	1983	Ed 5 and 6 Saint Vincent
	1:10,000	217	1983	Ed 1 Grenadines
	1:5,000	144	1983	Ed 2 Grenadines
	1:2,500	017	1980-	Ed 1 and 2 Saint Vincent
	1:2,500	044	1983	Ed 1 and 2 Grenadines
Turks and Caicos Islands	1:200,000	609	1984	Ed 2 tourist map
	1:10,000	209	1983-84	Ed 3 and 4

ANNEX II

The Americas: New admiralty charts and new editions

Chart No.	*Title*	*Scale*	*Published*
NORTH AND CENTRAL AMERICA			
New charts			
2753	New York: Raritan Bay to Newark Bay	1:20,000	April 1984
2580	Long Island Sound: Chimon Island to Execution Rocks	1:50,000	April 1984
2756	New York Harbour: Coney Island to New York City	1:20,000	April 1984
2626	Bay of Campeche	1:312,000	January 1984
3851	Ship Shoal to Pensacola Bay	1:500,000	October 1983
3380	Plans in the Gulf of Mexico	Various	October 1983
3382	Mississippi River: South-West Pass to New Orleans	1:100,000	October 1983
2849	Columbia River: Lord Island to Vancouver and Portland	Various	May 1983
2839	Columbia River from the entrance to Lord Island	1:50,000	May 1983
2603	Delaware River: Delaware Point to Little Tinicum Island	1:40,000	May 1983
2604	Delaware River: Philadelphia and Camden	1:15,000	May 1983
2605	Delaware River: Philadelphia to Trenton	1:20,000	May 1983
1081	San Pedro Bay including Los Angeles and Long Beach Harbours	1:12,000	May 1983
1082	Approaches to San Pedro Bay	1:20,000	May 1983
2988	Ports in the Gulf of Honduras	Various	April 1983
3857	Southern approaches to the Mississippi River	1:150,000	March 1983
3858	Pass à Loutre to Dauphin Island	1:150,000	March 1983
3849	Brazos Santiago to Galveston Bay	1:500,000	March 1983
3850	Galveston Bay to Ship Shoal	1:500,000	March 1983
3852	Pensacola Bay to Tampa Bay	1:500,000	March 1983
3853	Tampa Bay to Key West	1:500,000	March 1983
925	Approaches to Vancouver	1:25,000	March 1982
922	Burrard Inlet, Vancouver Harbour	1:12,500	March 1982
3856	Louisiana offshore oil port	1:60,000	February 1982
1944	Ports on the west coast of Mexico	Various	November 1980
660	Harbours on the west coast of Central America	Various	April 1980
659	Ports on the west coast of Central America	Various	August 1979

ANNEX II (*continued*)

Chart No.	*Title*	*Scale*	*Published*
New editions			
2807	Plans on the coast of South Carolina and Georgia: approaches to Savannah, approaches to Brunswick	1:50,000	October 1984
315	Goose Island to Quebec	1:81,000	September 1984
318	North Traverse and South Channel: south-west portion	1:50,000	September 1984
319	Quebec Harbour	1:18,000	September 1984
421	Montreal Harbour	1:18,000	September 1984
1960	Plans on the west coast of Central America	Various	September 1984
2865	Cape Romain to Cape Canaveral	1:500,000	September 1984
2604	Delaware River: Philadelphia and Camden	1:15,000	August 1984
3056	Bahia Rosario to San Diego Bay	1:364,000	August 1984
303	Saint Pierre and Miquelon	1:110,000	July 1984
2034	Northumberland Strait	1:300,000	July 1984
3204	New York: lower bay and approaches	1:50,000	June 1984
975	Galveston Bay to Calcasieu Pass	1:200,000	June 1984
2890	Approaches to Narragansett Bay and Buzzards Bay	1:100,000	May 1984
2563	Approaches to Delaware River	1:150,000	May 1984
1097	Key Biscayne to Lower Matacumbe Key	1:145,800	February 1984
1098	Lower Matacumbe Cay to Boca Grande Cay	1:145,000	February 1984
1300	Approaches to the Panama Canal	Various	January 1984
2861	Delaware Bay to Cape Hatteras	1:500,000	October 1983
2891	Cape Cod Canal and approaches	1:27,500	September 1983
513	Isla Roatán to Puerto Cortés	1:250,000	August 1983
2806	Charleston Harbour	1:37,500	July 1983
660	Harbours on the west coast of Central America	Various	July 1983
590	San Pablo Bay including Carquinez Strait and Suisan Bay	1:50,000	June 1983
2492	Bay of Fundy to Block Island	1:677,000	May 1983
352	Bay of Fundy: Sheet 1, outer portion	1:258,000	May 1983
3204	New York: lower bay	1:50,000	April 1983
374	Plans in the Gulf of Mexico	Various	April 1983
3684	Ports on the coast of Florida	Various	March 1983
1063	San Pedro Channel	1:100,000	February 1983
373	Plans in the Gulf of Campeche	Various	January 1983
2831	Plans in the Gulf of Mexico	Various	December 1982
2805	Port Royal Sound and approaches	1:50,000	December 1982
522	Belize Harbour	1:40,000	October 1982
1427	Seattle Harbour and approaches: Tacoma harbour	1:25,000	September 1982
592	San Francisco Bay: southern part	1:50,000	September 1982
959	Approaches to Belize City	1:125,000	September 1982
1797	Ranguana Cay to Columbus Cay including Glover Reef	1:125,000	August 1982
1051	Puerto Angel to Puerto Lazaro Cardenas	1:720,000	July 1982
2564	Delaware River	1:80,000	July 1982
2626	Bay of Campeche	1:290,000	July 1982
422	Quebec to Montreal	1:125,000	June 1982
2580	New York Harbour: upper bay, Hudson River and East River	1:50,000	May 1982
2885	Plans on the coast of California	Various	May 1982
311	Halifax Harbour	1:12,000	April 1982
319	Quebec Harbour	1:18,000	April 1982
320	Bedford Basin	1:18,000	April 1982
3124	Yaquina River to Cape Disappointment	1:200,000	April 1982
2881	Key West and approaches	1:50,450	March 1982
2941	Juan de Fuca Strait and approaches	1:150,000	February 1982
3981	Cape San Blas to Ship Shoal	1:750,000	February 1982
1516	Boston Harbour	1:25,000	February 1982
591	San Francisco Harbour	1:50,000	December 1981
392	Gulf of Mexico	1:2,280,000	December 1981
1082	San Pedro Bay including Los Angeles Harbour	1:24,000	November 1981
1651	Nova Scotia, Prince Edward Island and part of New Brunswick	1:725,000	November 1981
2848	Chesapeake Bay: Wolf Trap to Smith Point	1:100,000	October 1981
2856	Chesapeake Bay: Cove Point to Turkey Point	1:100,000	October 1981
2530	San Diego Bay to Cape Mendocino	1:200,000	October 1981
2846	Chesapeake Bay: Smith Point to Cove Point	1:100,000	October 1981
2864	Cape Hatteras to Cape Romain	1:500,000	September 1981
2666	Grand Banks of Newfoundland	1:500,000	September 1981
235	Davis Strait and south-east part of Baffin Bay	1:800,000	September 1981
3980	Ship Shoal to Brazos Santiago	1:750,000	July 1981
975	Galveston Bay to Calcasieu Pass	1:200,000	May 1981
2516	Gulf of Saint Lawrence	1:1,000,000	April 1981
2710	Delaware Bay to Florida Strait	1:1,500,000	March 1981
1225	Gulf of Campeche	1:1,000,000	March 1981

ANNEX II (*continued*)

Chart No.	*Title*	*Scale*	*Published*
2670	Cape Breton to Delaware Bay	1:1,500,000	February 1981
1947	Admiralty Inlet and Puget Sound	1:139,000	February 1981
1551	Approaches to Saint John Harbour	1:25,000	December 1980
1792	Port Townsend and Kilisut Harbour	1:24,320	November 1980
3982	Key West to Cape San Blas	1:750,000	October 1980
318	North Traverse and South Channel: south-west portion	1:50,000	September 1980
315	Goose Island to Quebec	1:81,000	September 1980
2850	Approaches to Baltimore	1:40,000	August 1980
3122	Redding Rock to Cape Blanco	1:200,780	June 1980
3125	Grays Harbour	1:40,000	May 1980
3138	Plans in south-east Alaska	Various	February 1980
2839	Columbia River: from the entrance to Harrington Point	1:40,000	January 1980
525	Boca Grande Key to Dry Tortugas	1:146,000	January 1980
2818	Hampton Roads and Elizabeth River	1:37,500	January 1980
1227	Portsmouth Harbour to Boston Harbour	1:100,000	December 1979
2843	Chesapeake Bay Entrance	1:100,000	November 1979
1897	Plans on south coast of Vancouver Island: Esquimalt Harbour, Victoria Harbour	1:7,500	November 1979
3120	Bodega Head to Abalone Point	1:200,540	November 1979
3363	Prince William Sound: eastern portion	1:175,000	October 1979
337	Yarmouth Harbour	1:12,000	September 1979
2940	Cape Disappointment to Cape Flattery	1:200,000	September 1979
778	Point Conception to Point Pinos	1:256,400	September 1979
229	Point Pinos to Bodega Head	1:201,000	September 1979
2942	Bonilla Point to Lennard Island including Barkley Sound	1:100,000	June 1979
2488	Portland Harbour	1:24,000	June 1979
1717	Port Angeles	1:10,000	June 1979
2487	Plans in the Gulf of Maine	Various	June 1979
2489	Nantucket Sound: eastern part and approaches	1:100,000	May 1979
1050	San José to Puerto Angel	1:720,000	May 1979
2897	Tampa Bay	1:80,000	April 1979
3060	Plans in the Golfo de California: Mazatlán Harbour and approaches: Bahia de Guaymas and approaches	1:37,500	April 1979
1082	San Pedro Bay including Los Angeles Harbour	1:24,000	March 1979
421	Montreal Harbour	1:18,000	March 1979
2456	Nantucket Sound, western part: Buzzards Bay and approaches	1:100,000	March 1979
922	Vancouver Harbour: Burrard Inlet	1:36,250	March 1979
320	Bedford Basin	1:18,000	January 1979

CARIBBEAN AND WEST INDIES

New charts

481	Serpent's Mouth	1:75,000	October 1984
502	Plans in Barbados	Various	October 1984
456	Approaches to Kingston Harbour	1:40,000	June 1984
1414	Bonaire	Various	May 1984
489	Approaches to Nevis	1:50,000	October 1983
487	Saint Kitts to Saint Eustatius	1:50,000	October 1983
483	Gulf of Paria	1:100,000	September 1983
2065	Saint John's Harbour to Parham Harbour	1:25,000	April 1983
454	Kingston Harbour	1:20,000	September 1981
256	Western approaches to Jamaica	1:200,000	May 1980
255	Eastern approaches to Jamaica	1:200,000	May 1979

New editions

1220	Gulf of Honduras and Yucatan Channel	1:1,000,000	August 1984
1074	Grassy Bay	1:6,000	June 1984
332	Great Sound including Hamilton Harbour	1:12,500	June 1984
334	Bermuda Islands	1:60,000	June 1984
1315	Saint George's Harbour with the Narrows and Murrays anchorage	1:6,200	June 1984
868	Bermuda: Five Fathom Hole, the Narrows and Murrays anchorage	1:17,500	June 1984
867	Bermuda, north and south channels: approaches to Grassy Bay and Ireland Island	1:17,500	June 1984
703	Punto San Juan to Cabo San Roman	1:300,000	March 1984
1277	Punta de la Garita to Isla Fuerte	1:200,000	August 1983
360	Bermuda Islands and off-lying banks	1:200,000	April 1983
2485	Approaches to Barbados	1:100,000	March 1983
478	Ports in Puerto Rico	Various	July 1982

ANNEX II (*continued*)

Chart No.	*Title*	*Scale*	*Published*
335	Ireland Island, north and south basins	1:2,445	July 1982
1525	Lago de Maracaibo	1:300,000	March 1982
517	Trinidad to Cayenne	1:1,500,000	November 1982
482	Harbours and anchorages in the Gulf of Paria	Various	October 1981
410	Ports and anchorages on the north coast of Cuba	Various	May 1981
3867	Cuba: western sheet	1:500,000	December 1980
444	Bahia de Cienfuegos	1:24,480	December 1980
3197	Bahia Nuevitas	1:40,360	September 1980
1524	Plans in Lago de Maracaibo	Various	August 1980
1315	Saint George's Harbour with the Narrows and Murrays anchorage	1:6,200	August 1980
1529	Golfo de Venezuela	1:300,000	March 1980
332	Great Sound including Hamilton Harbour	1:12,500	February 1980
1073	Hamilton Harbour	1:6,020	December 1979
411	Ports and anchorages on the north coast of Cuba	Various	September 1979
2434	Approaches to Bahia de Cartagena	1:100,000	May 1979
258	Ports and anchorages on the south coast of Jamaica	Various	March 1979

SOUTH AMERICA

New charts

529	Recife to Cabo São Tome	1:750,000	November 1984
528	São Luis to Recife	1:500,000	November 1984
504	Porto de Natal and approaches	Various	August 1984
520	Cayenne to São Luis	1:500,000	May 1984
3979	Ponta Dos Três Irmãos to Cabedelo	1:300,000	March 1984
3978	Cabedelo to Maceió	Various	March 1984
3977	Maceio to Aracaju	Various	March 1984
3695	Roca Pearse to Isla Cutler	1:30,000	October 1983
544	Canal de Santa Catarina	Various	October 1983
2799	Ports on the coast of Colombia and Ecuador	Various	January 1983
3971	Cabo de São Tome to Rio de Janeiro	1:300,000	November 1982
3972	Rio Doce to Cabo de São Tome	1:300,000	September 1982
3976	Aracaju to Ponta Açu da Torre	1:300,000	March 1982
3076	Ports on the coast of Chile	Various	December 1981
1331	Approaches to Bahia Blanca	Various	November 1981
3755	Bahia Blanca	Various	November 1981
3975	Ponta Açu da Torre to Ilhéus	1:300,000	September 1981
3974	Ilhéus to Ponta Corumbau	1:300,000	September 1981
3973	Ponta Corumbau to Rio Doce	1:300,000	April 1981
397	Porto de Belém and approaches	Various	May 1980
535	Bahia de São Marcos	1:75,000	December 1979
3959	Approaches to Rio Para and Rio Amazonas	1:500,000	April 1979
519	Georgetown and Demerara River	1:50,000	April 1979
231	Approaches to Porto de Paranagua	1:50,000	February 1979

New editions

3561	Buenos Aires and Colonia to Nueva Palmira	1:100,000	September 1984
550	Porto de São Francisco do Sul	Various	August 1984
3077	Plans on the coast of Chile	Various	August 1984
397	Porto de Belém and approaches	Various	August 1984
1289	Islas Guaitecas to Bahia San Pedro	Various	June 1984
1314	Ports and anchorages in Chile	Various	April 1984
3092	Salaverry to Punta Ayangui	Various	March 1984
630	Canal Smyth to Canal Señoret	Various	December 1983
586	Rio Guayas and approaches	Various	August 1983
560	Approaches to Estero Salado and Puerto Maritimo de Guayaquil	Various	August 1983
19	Ports and anchorages on the coast of Brazil	Various	November 1982
534	Entrances to rivers in French Guiana and Suriname: approaches to Cayenne; Fleuve Maroni (entrance)	1:75,000	September 1982
539	Puerto Santa Cruz to Cabo Pilar	1:1,750,000	June 1982
1749	Montevideo to Buenos Aires	1:250,000	June 1982
541	Baia de Guanabara	Various	October 1981
3079	Plans on the coast of Chile	Various	May 1981
561	Cabo Pilar to Golfo Coronados	1:750,000	April 1981
530	Cabo de São Tome to Rio Grande	1:1,750,000	February 1981
557	Mar del Plata to Comodoro Rivadavia	1:1,750,000	February 1981
556	Tramandai to Mar del Plata	1:1,750,000	November 1980
558	Isla Leones to Estrecho de Magallanes	1:1,750,000	October 1980
534	Entrances to rivers in French Guiana and Suriname: approaches to Cayenne; Fleuve Maroni (entrance)	1:75,000	September 1980

ANNEX II (*continued*)

Chart No.	*Title*	*Scale*	*Published*
2259	Plans on the coast of Colombia	Various	June 1980
531	Plans on the coast of Argentina	Various	April 1980
3958	Cabo Gurupi to Tutoia	1:500,000	April 1980
99	Entrances to rivers in Guyana and Suriname	Various	January 1980
3957	Tutoia to Fortaleza	1:500,000	November 1979
1683	Approaches to Angra Dos Reis	Various	June 1979

ANNEX III

Hydrographic surveys completed by H. M. survey ships in American waters 1979-1984

Area	*Scale*	*Ship*	*Year*
LEEWARD ISLANDS			
Virgin Bank, Virgin Islands	1:50,000	*Hydra*	1982
West Anegada, Virgin Islands	1:10,000	*Hydra* and *Fawn*	1982
Necker I Passage, Virgin Islands	1:25,000	*Fox*	1982
Norman I to Virgin Gorda, Virgin Islands	1:25,000	*Fawn*	1982
WINDWARD ISLANDS			
Bridgetown Harbour and approaches, Barbados	1:12,500	*Hecate*	1980
Speightstown, Barbados	1:15,000	*Hecate*	1980
Oistins Bay, Barbados	1:12,500	*Hecate*	1980
North-eastern approaches, Barbados	1:100,000	*Hecate*	1980
BAHAMA ISLANDS			
Turks I to Caicos Bank	1:75,000	*Hydra* and *Fawn*	1981/82
South Caicos Bank	1:75,000	*Fawn*	1982
Clearsand Road anchorage, Caicos Bank	1:37,500	*Fawn*	1982
CENTRAL AMERICA/CARIBBEAN			
Yucatan Channel	1:200,000	*Bulldog*	1980/81
Nicaraguan Rise and Alice Shoal	1:200,000	*Fox* and *Fawn*	1983
BERMUDA			
South Basin, Ireland Island	1:2,400	*Bulldog*	1981

BACKGROUND INFORMATION ON THE INTERNATIONAL FEDERATION OF SURVEYORS*

Paper submitted by the International Federation of Surveyors (FIG)

RÉSUMÉ

Ce document contient des renseignements généraux sur les buts et la structure administrative de la Fédération internationale des géomètres (FIG). On peut se procurer des exemplaires de la constitution de la FIG et des documents concernant la Fédération auprès du Secrétaire général à l'adresse suivante : P.O. Box 5458, Postal Station «E», Edmonton, Alberta T5P 4C9 (Canada).

RESUMEN

En el presente documento de antecedentes se consigna una reseña de los fines y la estructura administrativa de la Federación Internacional de Agrimensores. Pueden obtenerse ejemplares de la constitución y las publicaciones de la Federación en la Secretaría General, P.O. Box 5458, Postal Station "E", Edmonton, Alberta, Canadá, T5P 4C9.

The International Federation of Surveyors was founded on July 18, 1878 in Paris by delegates of seven national professional organizations (Belgium, France, Federal Republic of Germany, Italy, Spain, Switzerland and the United Kingdom of Great Britain and Northern Ireland.) Its membership in 1984 is made up of 51 professional organizations from 47 countries. The objectives of the Federation are set out in Articles 1, 2 and 3 of the Statutes, as follows:

Article 1

The principal aims of the Federation are as follows:

(*a*) To group the national associations or organizations of surveyors of all countries with the object of interchanging views on matters of general interest to the profession;

(*b*) To organize liaison between the various affiliated associations;

* The original text of this paper, prepared by C. W. Youngs, International Federation of Surveyors, appeared as document E/CONF 77/L 39

(*c*) To make known information on the social conditions prevailing amongst professional surveyors in individual countries so that each may take advantage of the improvements attained;

(*d*) To encourage, subsidize and disseminate the results of professional research and discoveries useful to surveyors in the scientific, technical, legal, economic and social spheres;

(*e*) To coordinate professional training in accordance with new methods;

(*f*) To foster relations with the appropriate authorities and the exchange of surveying personnel between different countries.

Article 2

The Federation shall abstain from any interference in questions of a political or religious nature and from intervening in racial disputes.

Article 3

The Federation shall realize the above mentioned by organizing or encouraging:

(*a*) International Congresses;

(*b*) Meetings of Commissions;

(*c*) Periodical meetings of delegates of the national associations constituting the Permanent Committee of the Federation;

(*d*) Lectures, exhibitions and experiments to demonstrate methods or instruments;

(*e*) A periodical bulletin specially edited with a view to recording the proceedings of meetings and the administrative, technical and professional work of the Federation;

(*f*) The circulation or interchange amongst members of literature from any source of interest to the profession;

(*g*) The creation, within national associations, of bureaux of information and employment for teachers, practitioners, probationers or anyone desirous of information on the possibilities of study, work, periods of residence or holidays.

Membership in the Federation is made up of National Associations or Organizations of professional persons whose main occupation falls within the following definition.

"The Surveyor is a professional person who identifies, determines the boundaries of, measures and values public or private landed property, whether urban or rural, and whether on the surface or below, as well as works executed thereon; and who arranges for the registration of the property, and settles questions of ownership connected therewith. The Surveyor also studies, plans and is responsible for land development and town and country planning. He deals with the technical, legal, economic, agricultural and social aspects of the aforementioned."

The administrative organs of the Federation are the General Assembly, the Permanent Committee and the Bureau. The professional and scientific work is carried out in nine different technical commissions and the *Office international du cadastre et du régime foncier* (OICRF). A General Assembly (reunion of member associations) is held every three years, during an International Congress, which is hosted by a member association. This will change to a four-year cycle commencing in 1988. The Permanent Committee (Administrative Council), which consists of the Bureau, the chairmen of the nine commissions and representative of the member associations, meets annually and gives policy direction to the Bureau. The Bureau consists of a President, three Vice Presidents, a Secretary General, a Treasurer and a Congress Director. Its purpose is to carry out the decisions of the Permanent Committee.

The technical and scientific work of the Federation is carried out by the nine commissions, which prepare the exchange of information on the progress and experiences within different fields of interest of the Federation. The commissions are structured as follows:

Group A: Profession, organization and activities

Commission 1: Professional practice, organization and legal systems
Commission 2: Professional education and literature
Commission 3: Land information systems

Group B: Surveys and mapping

Commission 4: Hydrographic surveying
Commission 5: Survey instruments and methods
Commission 6: Engineering surveys

Group C: Land administration

Commission 7: Cadastre and rural management
Commission 8: Urban land system: planning and development
Commission 9: Valuation and management of real estate

OICRF, as a functional part of the Federation, observes the following tasks:

(*a*) To collect documentary material on existing cadastral and land registry systems; to categorize and store them;

(*b*) To make comparative studies of the material collected and to publish its results;

(*c*) To furnish information and advice on the diverse cadastre and registry systems for the purposes of study and for countries who intend to establish such systems or may improve them.

The Federation supports member associations by co-sponsoring conferences and symposia of national and international interest. Examples of these are listed below.

Evaluation of Control Networks under the aspects of Stochasticity; held at the University Centre, Aalborg, Denmark, from 7 to 9 July 1982, sponsored by Den Danske Landinspektorforening, the Aalborg University Centre, and the Hochschule der Bundeswehr, Munich.

Information Systems in Surveying; Geodätentag Vienna, 1982; held at Vienna, from 1 to 4 September 1982, sponsored by the Deutsche Verein für Vermessungswesen (DVW) and the Osterreichische Verein für Vermessungswesen and Photogrammetrie (OVW).

International Joint Symposium of FIG, IAG, ICA, ISM and ISPRS on Education in Geodesy Resolutions; held at the Technical University, Graz, Austria, from 27 to 29 September 1982.

International Seminar on Information Systems for Urban and Regional Planning; held at Kawasaki City, Japan, from 3 to 6 October 1984, sponsored by the City Government of Kawasaki and the United Nations Centre for Regional Development.

International Symposium on Land Information Systems; held at Edmonton, Alberta, Canada, from 15 to 19 October 1984, sponsored by the Canadian Institute of Surveying

Colloquium on Surveying and Mapping Education; to be held at the University of New Brunswick, Fredericton,

Canada, from 11 to 14 June 1985, sponsored by the Canadian Institute of Surveying and co-sponsored by FIG, ICA, ISPRS and IAG

II Symposium on Digital Cartography; to be held at Plovdiv, Bulgaria, from 8 to 12 October 1985, sponsored by the Scientific and Technical Union of Surveying and Land Management in Bulgaria and co-sponsored by FIG, ISPRS and ICA.

The official languages of the Federation are French, English and German. Proceedings of the Congresses and records of the General Assembly and Permanent Committee meetings are published by FIG in bulletins.

Close co-operation is maintained through a Joint Board with the International Society for Photogrammetry and Remote Sensing (ISPRS), the International Cartographic Association (ICA), the International Association of Geodesy (IAG) and the International Society for Mine Surveying (ISM).

Copies of the Statutes of FIG and documents concerning the organization at the following address: P O Box 5458, Postal Station E, Edmonton, Alberta, Canada T5P 4C9.

UNITED NATIONS TECHNICAL CO-OPERATION ACTIVITIES IN SURVEYING, MAPPING AND CHARTING, WITH SPECIAL EMPHASIS ON THE AMERICAS*

Paper submitted by the Secretariat

STATUS OF UNITED NATIONS TECHNICAL CO-OPERATION ACTIVITIES IN SURVEYING AND MAPPING AS AT 31 DECEMBER 1984

The technical co-operation activities reported in this paper are limited to those executed by the Department of Technical Co-operation for Development of the United Nations Secretariat. They include activities financed from the regular budget, as well as those funded by extrabudgetary sources (United Nations Development Programme (UNDP), cost sharing by recipient Governments and third parties and trust funds). Surveying and mapping activities by other executing agencies of the United Nations system (Food and Agriculture Organization of the United Nations, International Labour Organisation, World Health Organization, etc.) are not reported since, essentially, they are considered application-oriented support activities for other aspects of technical co-operation (irrigation schemes, water supply projects, etc.). In the majority of cases, those activities lack the element of "institution-strengthening" and their impact is therefore of a more transient nature.

As of 31 December 1984, technical co-operation activities in surveying and mapping were under execution in Bhutan (three projects), Burundi, the Cayman Islands (United Kingdom of Great Britain and Northern Ireland), Ethiopia (two projects), Fiji, Jamaica, the Lao People's Democratic Republic, Madagascar (two projects), Nepal, the Philippines, Saudi Arabia, Trinidad and Tobago and Viet Nam.

The projects under execution cover the fields of geodesy, topographical surveying, photogrammetry, mapping, cartography (in the narrower sense of the term), map reproduction, hydrography and cadastral registration and cadastral surveying. Of the ongoing projects, 10 are of medium or large scale and are aimed directly at the strengthening of national mapping and survey organizations and their attendant training and ancillary facilities.

In addition to the ongoing projects, advisory missions and preparatory activities for future projects were undertaken to and for Abu Dhabi (United Arab Emirates), Chile, Iraq, Jordan and Qatar.

The strategy applied for all projects is in line with the general development strategy of UNDP: emphasis is placed on increased self-reliance of the recipient Government organizations. To achieve this goal, formal and on-the-job training of national personnel at key as well as operational levels is being recognized as the most important factor, to which all other project actions are generally subordinate.

Technical co-operation projects related to cartography are playing an increasingly pivotal role in the economic, social and cultural development of the recipient countries and in the implementation of a vast variety of specialized development projects. If such projects, aimed at the institutional strengthening of national mapping organizations, are to be successful, it is first and foremost necessary to achieve an adequate balance between the major elements of which they are composed: expertise for the transfer of technology, on-the-job training and formal training abroad of national counterpart personnel; equipment for training, for the transfer of technology and for carrying out production at a minimum and balanced level; and subcontracts covering elements which are either beyond the present technical capacity of the recipient organization or which are required on an urgent basis. The elements of a project should themselves be in harmony and should also harmonize with the objectives of the project and the priorities set in the overall development strategies of the recipient Governments.

In the context of a balanced distribution of project components, it has been noted that the high unit costs of certain types of equipment (particularly computer-assisted systems) make it increasingly difficult for new projects to achieve a level of balance acceptable to some donors (particularly UNDP). It is expected that this problem, created by the relative dominance of the equipment component, will continue and will become even more pronounced. At the same time it is also expected that these difficulties will contribute to the introduction of new and more flexible forms of project co-funding with investment-oriented donors (for example, the World Bank, third-party cost sharing, etc.).

"New dimensional" aspects of technical co-operation are becoming increasingly more manifest in ongoing projects: sub-contractual arrangements with national cartographic institutions have proved to be a viable alternative; long-term assignment of groups of experts to the same project is the exception rather than the rule. On the other hand, short-term consultancies in very specialized fields and the use of

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* The original text of this paper appeared as document E/CONF.77/L.13.

highly qualified national professionals in the function of national project co-ordinators is much more visible. This changing aspect of project implementation, however, requires more direct involvement of the headquarters of the respective United Nations executing agency in the monitoring of the projects.

The ongoing cartographic projects are generally well on schedule. The lengthy and complex process of nominating national candidates for fellowships abroad appears to be better understood by recipient Governments and has led to a marked improvement of the implementation rate of this project element. Some cases of extensive damage (in transit) to highly sensitive equipment have demonstrated that the elements of *force-majeure* and flexibility must be given their due share in the design of the projects.

Besides the backstopping activities for technical co-operation projects, the Cartographic Section, Natural Resources and Energy Division of the Department of Technical Co-operation for Development, has also organized two major conferences (Fourth United Nations Conference on the Standardization of Geographical Names, held at Geneva in 1982, and the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific, held at Bangkok in 1983). Three seminars, organized in co-operation with national counterpart institutions, covered the following topics: topographic and hydrographic surveying (Dubai, 1983); thematic cartography (Moscow, 1983); and methods and techniques of land organization in rural areas (Berlin (West), 1983). Three expert group meetings on the subject of geographical names were convened at New York in 1981 and at Geneva in 1982 and 1984, and an expert group met to discuss cadastral surveys and land information systems in Berlin (West) in 1983.

Publication of the United Nations series *World Cartography* (in English and French) was continued on a regular basis and the Cartographic Section of the Department has continued to monitor the publication of the *International Map of the World on the Millionth Scale*, although the latter activity is of less importance now since this series has by and large been completed. The focus of attention has now shifted to larger-scale topographic base map series.

United Nations technical co-operation activities in the Americas region since the Second United Nations Regional Cartographic Conference for the Americas

The level of involvement of the United Nations system in technical co-operation in surveying and mapping in the Americas has regrettably remained low, as compared to Asia and Africa, since the Second United Nations Regional Conference was held in Mexico City in 1979. As of late, there are some hopeful signs that more countries of the region intend to make use of the potential contribution of the United Nations system in this respect.

A large-scale project aimed at strengthening the national cartographic potential has successfully been completed in Guyana (GUY/71/001: Establishment of a Topographic Division). Under this project, with a total UNDP and third-party cost-sharing contribution of about $US 2 million, 310 expert man-months have been provided in the fields of project management, land surveying, photogrammetry, cartography, map reproduction and computer applications. Equipment worth over $US 500,000 was procured. Fellowships totalling 60 man-months were implemented. It was found that on-the-job training and direct transfer of technology were more effective than formal training abroad, because of the difficulty of retaining highly trained nationals in the financially not very attractive national civil service.

In Trinidad and Tobago, a large-scale project (TRI/74/006: Assistance in Surveying and Mapping), with a total UNDP contribution of slightly over $US 500,000, was concluded in 1982 and provided 58.5 man-months of expertise in surveying, cartography and photogrammetry. Fellowships abroad, totalling 69 man-months, supplemented intensive on-the-job training. The equipment component of slightly over $US 100,000 was a relatively modest one, reflecting the Government's ability to provide the Lands and Surveys Division essentially with all the equipment required. This ability is also reflected in the matching contribution in kind of the Government to the project, which eventually totalled the equivalent of $US 1,720,000 in local currency. This project has also met its objectives.

In the context of a regional physical planning project in Honduras, aerial photography and large-scale topographic mapping were provided for about 1,200 km^2. The work, at a total value of slightly under $US 1 million, had been subcontracted to expatriate mapping companies, but was field and office checked by the national mapping organization in a concerted effort in close co-ordination with the United Nations. As a result of these efforts, it was determined that the capacity of the Instituto Geográfico Nacional is in urgent need of being strengthened, so that it can cope with the ever-increasing demands put upon it in relation to cartographic needs for the development policy actively pursued by the Government of Honduras. A project outline for the necessary strengthening of the Instituto Geográfico Nacional has been prepared and hopefully will be implemented as soon as funding for the project can be secured.

Small-scale projects are currently under execution in Jamaica and the Cayman Islands (United Kingdom of Great Britain and Northern Ireland). In Jamaica, the Government has requested the assistance of the United Nations for topping-up the salaries of locally recruited expatriate land surveyors who have been contracted to fill vacant key positions in the Lands and Survey Department (JAM/84/002: Assistance to the Survey Department, Phase II). It is expected that this project, which has been carried out for some years under Phase I, will be continued into 1986. The project in Cayman (CAY/82/005: Fellowship in draughtsmanship) is essentially limited to one fellowship abroad but contains an element of consultancy, which has yet to be implemented.

The only large-scale project currently being implemented in the Americas again concerns Trinidad (TRI/79/008: Hydrographic Surveying). The project, which is expected to last well into 1986, shows at present a financial contribution from UNDP of slightly under $US 1.5 million. The main elements of the project are the construction and the equipment of a 25-metre survey launch, expected to be commissioned in mid-1985, as well as attendant activities of training, transfer of technology, etc., resulting in the creation of a small but well-equipped hydrographic unit.

A request by the Government of Chile for assistance in the establishment of an integrated cadastre is now being followed up by an advisory mission. The mission could result in the formulation of an important project.

Finally, mention must be made of the important role that the learning institutions of the Americas have always played in the formal training of national counterparts from projects all over the world. The pre-eminent role of Ohio State Uni-

versity (United States of America) and the University of New Brunswick (Canada) in no way diminishes the outstanding contribution of many lesser-known institutions in this respect. The United States and Canada have always been excellent sources for high technology equipment, although the competitive position of the former has of late been somewhat impaired by the high exchange rate of the United States currency.

It is to be hoped that the participation of surveying and mapping specialists of the Latin American and Caribbean subregion in conferences, seminars and symposia, organized under the auspices of the United Nations, which has hitherto been somewhat limited, will show a marked increase in the future. The United Nations Secretariat will assist interested organizations and individuals in this respect in any possible way.

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Litho in United Nations, New York
88-40832—December 1988—2,525
ISBN 92-1-002051-0

04200

United Nations publication
Sales No. E/F/S.88.I.19
E/CONF.77/3/Add.1