

FOURTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR THE AMERICAS

New York, 23–27 January 1989

Volume II. Technical papers

QUATRIÈME CONFÉRENCE CARTOGRAPHIQUE RÉGIONALE DES NATIONS UNIES POUR L'AMÉRIQUE

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Volume II. Communications techniques

CUARTA CONFERENCIA CARTOGRAFICA REGIONAL DE LAS NACIONES UNIDAS PARA AMERICA

Nueva York, 23–27 de enero de 1989

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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Through accession of the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, the two German States have united to form one sovereign State. As from the date of unification, the Federal Republic of Germany acts in the United Nations under the designation of "Germany".

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PREFACE

The official records of the Fourth United Nations Cartographic Conference for the Americas, held at New York from 23 to 24 January 1989, 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 papers submitted to the Conference by the participating Governments.

These technical papers are grouped according to the agenda item to which they relate. 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 Third United Nations Regional Cartographic Conference for the Americas have been published as E/CONF.77/3 (Sales Nos. E.85.I.14, F.85.V.14, S.85.I.14) and E/CONF.77/3/Add.1 (Sales No. E/F/S.88.I.19).

¹ *Fourth United Nations Regional Cartographic Conference for the Americas, New York, 23-27 January 1989, vol. I, Report of the Conference* (United Nations publication. Sales No. E.89.I.8)

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PRÉFACE

Les documents officiels de la quatrième Conférence cartographique régionale des Nations Unies pour l'Amérique, qui s'est tenue à New York du 23 au 27 janvier 1989, 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. 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 Conférence cartographique régionale des Nations Unies pour l'Amérique ont été publiés sous les cotes E/CONF.77/3 (numéros de vente : E.85.I.14, F.85.V.14, S.85.I.14) et E/CONF.77/3/Add.1 (numéro de vente : E/F/S.88.I.19).

¹ *Quatrième Conférence cartographique régionale des Nations Unies pour l'Amérique, New York, 23-27 janvier 1989, vol. I : Compte rendu de la Conférence* (publication des Nations Unies, numéro de vente : F.89.I.8)

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PREFACIO

Los documentos oficiales de la Cuarta Conferencia Cartográfica Regional de las Naciones Unidas para América, celebrada en Nueva York del 23 al 27 enero de 1989, se publican en dos volúmenes: el volumen I, *Informe de la Conferencia*¹, y la presente publicación, volumen II, *Documentos técnicos*, en el 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. 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 Tercera Conferencia Cartográfica Regional de las Naciones Unidas para América se han publicado con las siglas E/CONF.77/3 (Nos. de venta: E.85.I.14, F.85.V.14, S.85.I.14) y E/CONF.77/3/Add.1 (No. de venta: E/F/S.88.I.19).

¹ *Cuarta Conferencia Cartográfica Regional de las Naciones Unidas para América, Nueva York, 23 al 27 de enero de 1989, vol. I, Informe de la Conferencia* (publicación de las Naciones Unidas. No. de venta: S.89.I.8)

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2. Election of the President.
3. Organizational matters:
 - (a) Adoption of the rules of procedure;
 - (b) Adoption of the agenda;
 - (c) Election of officers other than the President;
 - (d) Organization of work;
 - (e) Credentials of representatives to the Conference;
 - (f) Establishment of technical committees.
4. Country reports and progress made since the Third Conference.
5. Review of the latest technology in cartographic data acquisition, manipulation, storage and presentation, with special emphasis on potential applications in developing countries:
 - (a) Conventional and satellite geodesy, including Global Positioning Systems;
 - (b) Remote sensing for cartography;
 - (c) Topographic and large-scale surveying and mapping;
 - (d) Hydrographic surveying and nautical charting;
 - (e) Cadastral surveying and mapping;
 - (f) Small-scale and thematic mapping, national and regional atlases and the like;
 - (g) Development and application of digital cartographic databases, including digital terrain modelling;
 - (h) Land/geographic information systems;
 - (i) Change detection and map revision;
 - (j) Reproduction and printing.
6. Review of the latest developments related to policies and management of national mapping and charting programmes:
 - (a) Managerial and technical aspects of national programmes;
 - (b) Policies and practices concerning cartographic products distribution;
 - (c) Map specifications;
 - (d) Management and standardization of geographical names;
 - (e) Education, training and research.
7. Technical assistance and transfer of appropriate and affordable technology
8. Future United Nations regional cartographic conferences.
9. Adoption of the report of the Conference.

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ORDRE DU JOUR

1. Ouverture de la Conférence
2. Election du Président.
3. Questions d'organisation :
 - a) Adoption du règlement intérieur;
 - b) Adoption de l'ordre du jour;
 - c) Election des membres du Bureau autres que le Président;
 - d) Organisation des travaux;
 - e) Pouvoirs des représentants à la Conférence;
 - f) Création de comités techniques.

4. Rapports des pays et progrès réalisés depuis la troisième Conférence
5. Examen des techniques nouvelles en matière d'acquisition, de manipulation, de stockage et de présentation des données cartographiques; une importance particulière étant accordée à leurs applications possibles dans les pays en développement :
 - a) Géodésie classique et par satellite, notamment le Système mondial de localisation;
 - b) La télédétection aux fins de la cartographie;
 - c) Levés et cartes topographiques et à grande échelle;
 - d) Levés hydrographiques et cartes marines;
 - e) Etablissement de levés et de plans cadastraux;
 - f) Etablissement de cartes thématiques et à petite échelle, atlas nationaux et régionaux, etc.;
 - g) Création et exploitation de bases de données cartographiques numériques, y compris la modélisation numérique de terrains;
 - h) Systèmes d'information foncière ou géographique;
 - i) Détection des variations et révision des cartes;
 - j) Reproduction et impression.
6. Examen des faits nouveaux concernant l'organisation et la gestion des programmes cartographiques nationaux :
 - a) Aspects administratifs et techniques des programmes nationaux;
 - b) Politiques et pratiques concernant la distribution des produits cartographiques;
 - c) Spécification des cartes;
 - d) Gestion et normalisation des noms géographiques;
 - e) Enseignement, formation et recherche
7. Assistance technique et transfert de techniques appropriées et abordables.
8. Futures conférences cartographiques régionales des Nations Unies.
9. Adoption du rapport de la Conférence.

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PROGRAMA

1. Inauguración de la Conferencia.
2. Elección del Presidente.
3. Cuestiones de organización:
 - a) Aprobación del reglamento;
 - b) Aprobación del programa;
 - c) Elección de otras autoridades;
 - d) Organización de los trabajos;
 - e) Credenciales de los representantes ante la Conferencia;
 - f) Establecimiento de comités técnicos.
4. Monografías de los países y progresos realizados desde la Tercera Conferencia.
5. Examen de la tecnología más reciente en la adquisición, tratamiento, almacenamiento y presentación de datos cartográficos, prestando especial atención a las posibles aplicaciones en los países en desarrollo:
 - a) Geodesia convencional y mediante satélites, incluidos los sistemas mundiales de determinación de posición;
 - b) Teleobservación para la cartografía;
 - c) Levantamientos y mapas topográficos y en gran escala;

- d)* Levantamientos hidrográficos y cartografía náutica;
 - e)* Levantamientos y mapas catastrales;
 - f)* Cartografía en pequeña escala y temática, atlas nacionales y regionales y similares;
 - g)* Establecimiento y aplicación de bases de datos cartográficos digitales, incluidos modelos digitales del terreno;
 - h)* Sistemas de información geográfica y terrestre;
 - i)* Detección de cambios y revisión de mapas;
 - j)* Reproducción e impresión.
6. Examen de los acontecimientos más recientes relacionados con las políticas y la gestión de los programas nacionales de elaboración de mapas y cartas:
- a)* Aspectos administrativos y técnicos de los programas nacionales;
 - b)* Políticas y prácticas relativas a la distribución de productos cartográficos;
 - c)* Especificaciones de los mapas;
 - d)* Aplicación y normalización de los nombres geográficos;
 - e)* Educación, capacitación e investigaciones.
7. Asistencia técnica y transmisión de tecnología apropiada y asequible.
8. Futuras conferencias cartográficas regionales de las Naciones Unidas
9. Aprobación del informe de la Conferencia.
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AGENDA ITEM 4

Country reports and progress made since the Third Conference

NATIONAL AND CADASTRAL MAPPING IN ZAMBIA*

Paper submitted by Zambia

RÉSUMÉ

La cartographie est un outil essentiel de développement en Zambie, largement utilisé pour la planification comme pour les opérations foncières. La réalisation des levés géodésiques et les activités de cartographie dépendent du Service topographique, qui est chargé d'étudier et d'approuver tous les levés cadastraux effectués par des géomètres du gouvernement ou par des géomètres privés. Les intérêts des géomètres sont défendus par le Surveyors Institute of Zambia.

La Zambie est membre du Centre régional de services de topographie, cartographie et télédétection établi au Kenya et participe à des conférences topographiques régionales et internationales ainsi que dans le cadre du Commonwealth.

Les levés géodésiques servent à la fois à la cartographie nationale et cadastrale. Toutefois, de nombreux levés cadastraux ont été établis à partir de données locales, et la Zambie cherche à améliorer son service géodésique en créant de nouvelles stations et en intégrant les données obtenues par tous les levés. Le Service de cartographie prévoit d'utiliser un système mondial de localisation et cherche à développer ses moyens informatiques.

Parmi les activités de cartographie menées par la Zambie, on peut citer l'établissement de cartes topographiques couvrant l'ensemble du pays, de plans urbains, de cartes urbaines à grande échelle et d'un atlas national. Toutes les nouvelles cartes sont établies à partir de photographies aériennes réalisées aux termes d'un contrat annuel. La création d'un comité national de télédétection a développé l'intérêt des autorités pour les images-satellite. Le tracé des limites cadastrales figure sur certaines cartes à petite échelle, ce qui est utile pour la planification, mais il n'y a pas de lien direct entre les cartes urbaines à grande échelle et les données cadastrales. Les priorités consistent à compléter la série existante, réviser les cartes et intégrer les données concernant la cartographie urbaine et le cadastre.

Les activités de cartographie cadastrale comprennent l'établissement, l'examen et l'approbation de levés ainsi que la tenue à jour des dossiers. La réalisation de ces levés est définie par la loi, et les géomètres doivent obtenir une licence pour pouvoir exercer. Etant donné que 2 500 lopins de terrain sont créés chaque année, que 10 000 lopins n'ont pas encore été cartographiés et que la demande de terrain pour la production agricole est de plus en plus importante, il est urgent d'accroître l'efficacité du système en adoptant certaines mesures administratives et techniques, mais surtout en augmentant les investissements.

RESUMEN

La cartografía constituye para Zambia un instrumento fundamental para el desarrollo y se utiliza ampliamente para la planificación y como parte del proceso de distribución de tierras. El Departamento de Topografía de Zambia es la organización nacional encargada de los levantamientos cartográficos y de control y se ocupa del examen y la aprobación de todos los levantamientos catastrales que realizan el Gobierno y los agrimensores particulares. Los intereses de la profesión topográfica en Zambia están representados por el Instituto de Agrimensores de Zambia.

Zambia es miembro del Centro Regional de Servicios de Reconocimiento. Levantamiento Cartográfico y Teleobservación con sede en Kenya, y participa en conferencias cartográficas regionales, internacionales y del Commonwealth.

* The original text of this paper, prepared by Simon T. Shreeve, Acting Surveyor-General, Martin C. Chitondo, Acting Assistant Surveyor-General, and Tonny L. Mwanalushi, Land Surveyor, Ministry of Lands and Natural Resources, appeared as document E/CONF 81/L. 1

Los levantamientos de control geodésicos constituyen la base común de la cartografía nacional y catastral. Sin embargo, muchos levantamientos catastrales actuales se basan en datos locales y se están desplegando esfuerzos para mejorar el servicio de levantamientos de control mediante una red más densa de estaciones y la integración de todos los levantamientos según un *datum* nacional. El Departamento de Topografía está programando un proyecto relativo al sistema mundial de determinación de posición (EPS) con el fin de ampliar la red y está investigando las posibilidades de contar con una mejor infraestructura de computadorización.

La cartografía nacional en Zambia consiste en una serie de mapas topográficos que abarcan todo el país, junto con planos de calles, mapas urbanos en gran escala y atlas nacionales. Los nuevos mapas topográficos se basan en fotografías aéreas, que se obtienen con arreglo a un contrato anual. El interés en las imágenes obtenidas por satélite se ha visto promovido por la formación de un Comité Nacional de Teleobservación. Los límites catastrales se indican en algunos mapas en pequeña escala, lo que sirve a los efectos de la planificación, pero no hay vinculación directa entre los mapas urbanos en gran escala y los datos catastrales. Las prioridades de la cartografía son la finalización de las series actuales, la revisión de mapas y la integración de los mapas urbanos y los datos catastrales.

La cartografía catastral entraña el levantamiento catastral, su examen y aprobación y el mantenimiento de registros. Los levantamientos están regidos por la legislación y existe un sistema de concesión de licencias a los agrimensores. Con la producción anual de 2.500 parcelaciones, un atraso de 10.000 parcelas y una demanda creciente de asentamientos para incrementar la producción agrícola, es imperiosamente necesario mejorar la producción, en parte con cambios administrativos y técnicos, pero principalmente con una mayor inversión.

SUMMARY

Mapping in Zambia is a basic tool of development, which is widely used for planning and as part of the process of land delivery. The Survey Department is the national organization in charge of control surveys and mapping. It is responsible for the examination and approval of all cadastral surveys carried out by government and private land surveyors. The interests of the land survey profession are represented by the Surveyors Institute of Zambia.

Zambia is a member of the Kenya-based Regional Centre for Services in Surveying, Mapping and Remote Sensing and participates in regional, Commonwealth and international mapping conferences.

Geodetic control surveys form a common base for national and cadastral mapping. However, many existing cadastral surveys are on local datums, and it is an ongoing task to improve the control survey service by densifying the network of stations and integrating all surveys on the national datum. The Survey Department is planning a global positioning system (GPS) project to extend the network, and improved computerized facilities are being sought.

National mapping in Zambia consists of series of topographic maps covering the whole country, together with street plans, large-scale township mapping and national atlas sheets. All new topographic mapping is based on aerial photography for which there is an annual contract. Interest in satellite imagery has been fostered by the formation of a National Remote Sensing Committee. Cadastral boundaries are shown on some small-scale maps and this is of value for planning purposes, but there is no direct link between large-scale township mapping and cadastral data. Mapping priorities are completion of existing series, map revision and integration of township mapping and cadastral data.

Cadastral mapping involves cadastral surveys, their examination and approval and the maintenance of records. Surveys are regulated by law, and a system of licensing of land surveyors prevails. With annual production at 2,500 parcels of land, a backlog of 10,000 parcels and a growing demand for settlement to increase agricultural production, there is urgent need to improve production, partly by administrative and technical changes, but mainly by increased investment.

The Republic of Zambia is bounded by Angola, Zaire, the United Republic of Tanzania, Malawi, Mozambique, Zimbabwe, Botswana and Namibia and lies between 8° and 18° south latitudes and 22° and 34° east longitudes. It has an area

of 752,618 square kilometres and a population estimated in mid-1987 as 7.3 million.

Mapping is a basic tool of development in Zambia. National small-, medium- and large-scale topographic maps

are widely used for economic and urban and rural and land-use planning, engineering projects, agricultural development and tourism. Cadastral mapping is an essential part of the process of land delivery and planning and making land available on title.

The Zambia Survey Department is part of the Ministry of Lands and Natural Resources and is the national organization responsible for control surveys, production and revision of national mapping, surveys for title to land and all cadastral records and the dissemination of all survey- and map-related data, including aerial photography (Shreeve, 1987).

The Survey Department has its headquarters in Lusaka and regional offices in Lusaka town, Livingstone, Kabwe, Ndola and Kasama. There are 15 professional staff and 90 technician cartographers, surveyors and photogrammetrists.

Field offices have electronic distance measuring instruments and supporting equipment for both control and cadastral surveys. There are some 20 four-wheel drive vehicles and lorries for field-work. Headquarters has fully equipped cartography, photogrammetry and photo-reproduction sections. Use of programmable calculators and personal computers is well established. (Shreeve and Malik, 1986)

The departmental budget for 1988 is some 5.2 million kwacha (\$US 600,000) covering staff pay, operating funds and capital projects. In addition, aid grants for equipment and materials, aerial photography, training, consultancy, personnel and map printing are received from Sweden (valued at \$US 700,000 in 1988); for training, personnel, map printing and consultancy from the United Kingdom; and for training from the Netherlands.

The main problems faced by the Department are the low or non-availability in Zambia of materials, equipment and services, including map printing facilities, essential to the Department's operations; shortages of residential and office accommodation and of transport; and difficulties in recruiting technician staff.

Other departments and organizations with a role in survey and mapping in Zambia include the Department of Town and Country Planning, the Department of Agriculture (land-use planning and demarcation of land) and the National Housing Authority. Private survey firms are engaged in cadastral and engineering surveys.

Basic training in land survey is provided at degree level by the University of Zambia in Lusaka and at diploma or certificate level by the Zambia Institute of Technology in Kitwe. In-service courses are run by the Survey Department, but training is supplemented by courses abroad for cartography, photogrammetry and survey management.

The survey profession as a whole is represented by the Surveyors Institute of Zambia which is affiliated to the Commonwealth Association for Surveying and Land Economy (CASLE) and is a member of the International Federation of Surveyors (FIG). Membership of the Land Survey Chapter of the Institute is drawn from the Government, private and education sectors.

A Geographical Place Names Committee and a National Remote Sensing Committee have been established under the auspices of the Survey Department, with full representation from all relevant departments and organizations.

Zambia is a member of the Regional Centre for Services in Surveying, Mapping and Remote Sensing, based in Nairobi, and has received membership benefits in the form of short courses on technical subjects, on basic survey instrument maintenance and on consultancy services. Zambia is also a member of the Southern Africa Development Co-ordination

Conference (SADCC), and initiatives are in hand to promote cooperation specifically in survey and mapping among member States of the Conference.

The Survey Department has been represented at United Nations cartographic conferences for Africa, International cartographic conferences and conferences of Commonwealth surveyors. The Department has benefited from consultancy agreements with the National Land Survey of Sweden (NLS) and map exchange agreements with the United Kingdom of Great Britain and Northern Ireland, the United States of America, and Zimbabwe.

CONTROL SURVEYS

Geodetic control, together with related photo control, forms a common base for both national and cadastral mapping in Zambia. Maintenance and extension of the existing network is a small but vital task on which integrated and comprehensive mapping depends.

The national datum for planimetric control is the Arc-1960 Datum used for adjustment by the former Directorate of Overseas Surveys of the Arc of the thirtieth meridian, which passes through Zambia. Adjustment of all orders of national triangulation and traverse are related to the Arc. National datum for height is based on a fundamental benchmark at Chirundu on the border with Zimbabwe, with a height referred to mean sea level at Beira in Mozambique.

The spheroid used in Zambia is Modified Clarke 1880 with two coordinate systems. For most cadastral surveys tied to national datum, the system is the Gauss Conformal or Transverse Mercator in two-degree belts centred on odd-numbered meridians and known as $L0^\circ$ (longitude zero). Scale factor is unity on the central meridian, and coordinates increase south and west. For national mapping, the Universal Transverse Mercator (UTM) system is used. Where there is a common central meridian between $L0^\circ$ and UTM, coordinates differ only in origin and scale factor.

There are some 7,000 permanently marked survey control stations in Zambia, ranging from Doppler fixes, and primary, secondary and tertiary stations to permanently marked reference marks in towns and international boundary beacons. Reference marks are established as the lowest order of control for town cadastral surveys, and are extended in areas of likely urban development.

Many existing and new cadastral surveys are, however, on local datums (usually plane coordinate systems oriented on magnetic North), either because the local geodetic net is too sparse or was established after cadastral surveys in the area had already been undertaken. Cadastral surveys from the 1920s and onwards along the rail corridor from Livingstone to Lusaka and Ndola pre-date the national net in many cases and have not been subsequently tied to it.

Modern survey techniques are now being employed in the provision of new control. In western Zambia, Doppler position fixing was used for some 50 control points in a joint project between the Survey Department and the National Land Survey of Sweden. Zambia participated in the African Doppler Survey (ADOS) project, with five stations observed and coordinated within the country. One Global Positioning System (GPS) survey has been carried out in eastern Zambia for geophysical research by a consultant company. In central and northern Zambia, a system of motorized levelling, similar to that developed in Sweden and other countries, was successfully introduced with assistance from the National Land Survey, and has contributed to the extension of lines of precise levels along major road routes.

The Survey Department has adopted an appropriately cautious approach to computerization. Two IBM personal computers are in regular use, one for aerial triangulation adjustment and the other for geodetic computations and access to computerized survey control and bench-mark data. (Shreeve and Malik, 1986).

To strengthen and extend the existing control network, the Survey Department is planning a GPS project in cooperation with international agencies. This will involve planning, training, equipment hire or acquisition and project evaluation. Research is being carried out into a new range of suitable office-based computation facilities.

The overall aim is to improve the service provided for national and cadastral mapping. In particular, efforts are being made to bring all cadastral surveys onto the national datum and to ensure that they are related to a complete and homogeneous national system.

NATIONAL MAPPING

Zambia's national mapping consists of small-scale topographic series of one of more sheets covering the whole of the country; large-scale contoured plans of town areas, and a range of tourist, street and national atlas maps.

The Mapping Services Branch of the Survey Department is fully equipped for photogrammetry, cartography and photoreproduction, with trained and experienced staff.

The Photogrammetric Section carries out aerial photography contract planning, aerial triangulation and stereoplotting. Record copies of photography are maintained in an Air Photo Library, and prints, enlargements and mosaics are available for sale.

The main items of photogrammetric equipment are Wild A-7 (with EK-22), A-8 (with EK-5a), two B-8s, AG-1 and PUG-4 and Santoni Microcart.

The Cartographic Section produces new and revised small-scale maps, including the derived 1:250,000 series, and a wide range of tourist, street and atlas maps. Equipment includes a Datype photo-typesetting machine and Protocol punch register.

The Photoreproduction Section undertakes enlargements and reductions using a Hohlux Universal process camera, contact printing using a vacuum frame, contact prints of aerial photography using Milligan electronic printers and colour proofing, as well as providing reprographic services to the Departments.

Zambia is well covered by aerial photography at scales ranging from 1:6,000 to 1:88,000. The Survey Department arranges an annual aerial photography contract and deals with requests for new photography from other departments, development agencies and individuals. Photography forms the basis for all topographic mapping and is widely used for agricultural planning, town planning, soil surveys and forestry.

The formation of a National Remote Sensing Committee (Musabula, 1986) in 1985 has helped to foster interest in, and use of, satellite imagery. LANDSAT imagery has been used in Zambia for soil and geological mapping, and consultancy studies have been undertaken to assess the potential of SPOT imagery for land use inventory and monitoring. The Survey Department acquired complete LANDSAT coverage of Zambia on tape, held by the Satellite Image Corporation of Sweden for processing and production of imagery as required.

Zambia is covered by 58 sheets of 1:250,000-scale mapping, of which all but four (covering the area west of 22°

east longitude) have been published. Approximately a quarter of the country is covered by 1:100,000 mapping (43 out of 71 sheets published and the rest in production) and the remainder by 1:50,000 mapping (835 sheets). In addition, there is a one-sheet general topographical map of Zambia at 1:1,500,000, as well as maps in the international 1:1,000,000 series.

Cadastral boundaries for lots and farms are shown on published maps at 1:50,000 scale. This is of benefit for planning purposes and the production of site and sketch plans.

Tourist maps include Livingstone and Victoria Falls and Kafue, South Luangwa and Lochinvar National Parks. Of a series of 40 loose-leaf thematic atlas maps, 32 have been published, covering subjects such as rainfall, minerals and medical facilities. Nine street plans have been published, for Lusaka, Ndola, Kitwe, Kabwe, Luanshya, Mufulira, Chingola, Livingstone and Chililabombwe.

Large-scale contoured township maps derived from aerial photography are plotted, with inked machine plots available for dyeline copying. Some 78 towns have been mapped at 1:2,500 scale and 47 at 1:5,000 scale (Republic of Zambia, 1986).

Revision of national mapping is a continuous process, and priority is given to areas of rapid change and development potential. All new and revised mapping is subject to field checking and annotation by Survey Department staff.

Distribution of national mapping is mostly through a map sales office in Lusaka, although some maps are also available through regional survey offices. Popular small-scale maps, street plans and tourist maps are made available for sale at hotels or through tourist agencies.

Production priorities for mapping are completion of the 1:250,000 and 1:100,000 series and ongoing revision at these scales and at 1:50,000. Particular emphasis is placed on large-scale contoured mapping for engineering projects, such as dam sites and commercial agricultural development.

A major, outstanding work project is the integration of township mapping with cadastral boundary information. This process is complicated by the different datums or coordinate systems used for cadastral surveys in some towns as well as the inherent differences between a field-observed numerical cadastre and air visible topographic detail.

CADASTRAL MAPPING

Cadastral mapping involves the process of executing, examining, approving and recording surveys for title to land. This process is a service provided to the Zambia Lands Department (also part of the Ministry of Lands and Natural Resources), which is responsible for approving site plans in advance of cadastral survey and, on receipt of approved cadastral diagrams from the Survey Department, for issuing title deeds. The Department has national responsibility for examining and approving all cadastral surveys whether completed by government or private surveyors, and for the storage and retrieval of all cadastral records and plans.

In Zambia, all land is vested in the President, and only leasehold title is available. The most common forms are a 14-year lease based on an approved but unsurveyed sketch plan; and a 99-year lease based on a full cadastral field survey.

Cadastral surveys are detailed and regulated by the Land Survey Act and Regulations of the Laws of Zambia, and a system of licensing of surveyors is controlled by a legally established Survey Control Board.

Small-scale national mapping plays an important role in cadastral activity. Topographic maps at 1:50,000 scale, for example, are widely used for site planning, for the preparation of sketch and site plans and for reconnaissance and planning of field-work. Large-scale topographic maps such as township plans at 1:2,500 or 1:5,000 scale are used for general planning by local authorities but do not show cadastral boundaries. This is because they are derived from aerial photography and show only air-visible features, whereas cadastral boundaries, especially in towns, are defined entirely by lines between coordinated beacons, the lines not necessarily being coincident with such physical features as may be air-visible.

The Survey Department surveyors, based at the Department's five regional offices, undertake surveys for title on instructions from headquarters. All surveys are returned to headquarters for checking by the Examination Section. The Plan Room holds all cadastral records, index plans and related data. The Cadastral Drawing Office undertakes the production of survey diagrams and plans, while there are also cartographic staff in the regional offices. All drawing is at present done by hand. Computerization of a property register by the Lands Department has been completed, and the Department has a terminal for access to the data.

The staff of the Survey Department includes three licensed surveyors and some 20 professional and technician surveyors engaged in cadastral work.

In the private sector, there are 9 licensed land surveyors spread between 7 private survey offices and one parastatal department. These surveyors undertake work according to the Land Survey Act and submit it to the Survey Department for examination and approval. Their total production is, very approximately, equal to the combined output of the Department's offices.

Production of cadastral surveys is divided between three types of land parcel: the stand in residential town areas; the lot in periurban areas for agricultural or residential use; and the farm in rural areas. There has been a slow but steady increase in output from Government and private sectors, and in 1987, 2,500 parcels were surveyed in total. At the same time, there is a backlog of about 10,000 parcels of which 2,000 are lots and farms, although a significant proportion of the instructions for these parcels are outdated and no longer valid. Increased demand is expected, with settlement schemes being planned in various parts of Zambia in order to expand the amount of land under effective agricultural use. With present resources, the backlog of work will therefore continue to grow.

Fees are charged for all cadastral surveys according to the Land Survey Regulations. Private surveyors may ask for a 50 per cent deposit before starting work; they have to cover all their costs from the fees, but may choose which surveys they take on. Fees for surveys by the Survey Department are the same, but do not have to be paid until the lease is issued, while the Department has to undertake all surveys regardless of cost. In practice, limited resources mean that priorities have to be set, with emphasis placed on carrying out groups of surveys of contiguous parcels rather than responding to ad hoc survey requests.

Title deeds are particularly valued as providing security for development loans. The parcel diagram based on an approved survey is an essential part of the title procedure, but survey production is clearly unable to meet demand. Despite this, neither the Government nor the private survey sector is at present expanding. Urgent consideration is therefore being given to administrative and technical changes that

would enable production to be increased. In this process, there are two major issues: the minimum requirements for a cadastral survey and the options open for change, given existing resources.

The requirements for a cadastral survey are seen, in general terms, as follows (Shreeve, 1988).

(a) The boundary of any parcel must be marked on the ground so that the owner knows where his boundaries are;

(b) The ground marked boundary must be representable graphically on a registry map, so that its scale, orientation, extent and position with respect to all neighbouring parcels and boundaries can be defined;

(c) All existing established cadastral boundaries must be respected;

(d) Survey methods must be codifiable and amenable to description and overall control, and an examination and checking procedure must exist;

(e) The possibility of re-establishment of boundaries lost through movement of beacons or man-made features must be available;

(f) Survey methods must be adaptable and flexible so as to take account of such factors as topography, access, location in Zambia, size and distribution of parcels, land use and existing survey data.

It is important that these requirements are appreciated by all concerned with cadastral survey, since if they are not met there is a very real danger of proliferation of boundary disputes, grossly inaccurate work requiring costly re-survey, and creation of a non-viable system which is not respected and does not, in effect, give security of title.

Among the options being actively considered by the Survey Department for increasing production in rural areas are the following:

Aerial photography. Photography is already used for plotting river boundaries where they form the limits of parcels. Tests of photogrammetric methods for cadastral survey have been carried out, but have generally been inconclusive because the results have been compared directly with those of conventional ground survey. However, taking into account the particular conditions in Zambia, there are three major drawbacks with the use of aerial photography:

(a) Few parcel boundaries on the ground are air-visible, and the use of air marks, the planting of hedges or other devices are expensive and time-consuming. Identification of boundaries by reference to physical features is inaccurate and error-prone. Both air marking and identification are likely to be incomplete processes, leaving problems that have to be sorted out by additional field trips;

(b) Cost-effective cadastral photography can only be flown for large blocks, and individual or isolated parcels cannot be covered economically;

(c) Flying is restricted by weather conditions to a few months each year. With the need for ground control, air marking or identification and subsequent plotting and field checks, there can only be a very slow response to the urgent need for new surveys now and in the immediate future.

Alternative field methods. Options here include the use of simple field methods such as compass and tape or tacheometry, but within a well controlled framework; acceptance of physical features such as hedges and fences, where they exist, in lieu of beacons; greater emphasis on surveying land as demarcated rather than following site plans with an unnecessary level of accuracy; and cooperating more closely with field staff from other government departments who are

responsible for planning and siting layouts and for the initial demarcation of new sites.

Although some technical and administrative changes may help production, it has to be said that no major increase will occur without improved investment in cadastral survey and a recognition of its value: there are no significant shortcuts.

The Survey Department's future plans for cadastral surveys include extending local services to all provinces of Zambia by opening new offices as and when sufficient trained and experienced manpower, equipment and other resources are available. Surveys, particularly during the dry season from May to October, will increasingly be targeted on lots and farms rather than on stands. Further efforts will be made to develop alternative field methods to improve overall production, with valuable consultancy work now being carried out through grants from Sweden and the United Kingdom.

One major question is whether surveys by the Government sector can continue to be made on an ad hoc basis, or whether block surveys, with cadastral boundaries demarcated and defined over wide areas, should predominate. The availability of resources and national planning policy affect the answer.

The provision of cadastral information, provided by the field-work of both Government and private surveyors, has a potential value beyond the issue of title deeds. Systematic property mapping at large scale, in tandem with the production and revision of national topographic mapping, provides an invaluable base for national, regional and local planning. This aspect of cadastral mapping in Zambia deserves further attention.

CONCLUSIONS

Control surveys, which form a common base for national and cadastral mapping in Zambia, consist of a network of coordinated and heightened points. Modern methods, including satellite positioning and motorized levelling, have been used to extend the net, but the sparsity of control in many areas, and the fact that some cadastral surveys pre-date

the net, mean that many such surveys are on local datums. This problem, together with the ongoing need to provide photo-control for new topographic mapping and revision, provides scope for improved control survey services.

Zambia is fortunate in having a considerable archive of aerial photography, while comprehensive national mapping nears completion. The main tasks ahead are the completion of national series and the ongoing problem of revision. Integration of large-scale topographic township mapping with cadastral data is a further priority.

Cadastral surveys for title to land are carried out by both government and private land surveyors, but the level of production is not meeting demand, which is itself increasing. There are minimum requirements for cadastral survey that have to be met, but some technical and administrative changes are possible to improve production. However, the overriding needs are for a recognition of the value of cadastral surveys and investment in the resources necessary to carry them out.

Zambia has the potential in the Government of private sectors to produce and revise national mapping and carry out cadastral survey. At the same time, existing survey, photographic and map data and records are national resources to be exploited and used as a firm base for new work. With adequate funding, this work can meet the national demand for mapping which is one of the basic tools for development.

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AGENDA ITEM 5

Review of the latest technology in cartographic data acquisition, manipulation, storage and presentation, with special emphasis on potential applications in developing countries

(a) *Conventional and satellite geodesy, including global positioning systems*

IMPACT OF THE ACTIVE CONTROL SYSTEM ON SURVEY CONTROL NETWORKS*

Paper submitted by Canada

RÉSUMÉ

Le service géodésique canadien travaille depuis 1985 à la mise au point d'un "Système de contrôle actif". Ce système comprendra des stations automatisées implantées en divers points du territoire, équipées de récepteurs du Système mondial de localisation (GPS) commandés par micro-ordinateurs qui enregistreront continuellement les observations en phase porteuse et en fausses distances de tous les satellites visibles. Elles recueilleront et enregistreront également les données météorologiques. Ces données seront transmises régulièrement à une station centrale de contrôle actif et elles auront quatre utilisations principales. Elles seront utilisées, en même temps que des données similaires recueillies dans les stations de surveillance d'autres pays, pour le calcul des éphémérides orbitaux précis à l'intention des utilisateurs canadiens du Système mondial de localisation et pour le raccordement des réseaux géodésiques des utilisateurs fondé sur des combinaisons de Points de contrôle actif et des ensembles de données des utilisateurs. Comme les coordonnées des stations du Système de contrôle actif seront déterminées très précisément (grâce à la continuité dans la collecte des données), elles permettront d'obtenir une grande précision dans les canevas sans requérir la présence des utilisateurs du Système mondial de localisation dans les stations géodésiques. Elles permettront en outre de calculer et de diffuser des corrections différentielles aux fins de navigation et de vérifier l'intégrité de l'ensemble des satellites du Système mondial de localisation.

Le Système de contrôle actif pourrait remplacer la plupart des réseaux primaires et secondaires (tant horizontaux que verticaux) au Canada. Les incidences pour les services géodésiques et géographiques ainsi que la gamme des applications possibles seront examinées.

RESUMEN

Desde 1985 se ha estado desarrollando en la División de Levantamientos Geodésicos del Canadá un "Sistema de Control Activo". Este sistema constará de varias estaciones automatizadas distribuidas por todo el país, consistentes en receptores del sistema mundial de determinación de posiciones (GPS) controlados por microcomputadoras que registrarán continuamente la fase portadora y observaciones pseudotelemétricas de todos los satélites visibles. También se reunirán y registrarán datos meteorológicos. Estos datos se transmitirán periódicamente a una "Estación Directriz de Control Activo" (MACS) y se utilizarán con cuatro finalidades principales. Los datos se utilizarán, junto con datos análogos reunidos en estaciones de vigilancia de otros países, para el cálculo de efemérides orbitales precisas, que se distribuirán entre los usuarios canadienses del GPS, y para conexiones a la red de control de los usuarios basadas en combinaciones de Puntos de Control Activo (ACP) y juegos de datos de los usuarios. Debido a que las coordenadas de las estaciones del Sistema de Control Activo (ACS) se determinarán con gran precisión (gracias a la reunión continua de observaciones en estas estaciones), permitirán un control muy preciso sin que los usuarios del GPS deban permanecer en las estaciones de control. Los datos también permitirán el cálculo y la divulgación de correcciones diferenciales con fines de navegación y para verificar la integridad de la constelación de satélites del GPS.

* The original text of this paper, prepared by D. J. McArthur and R. R. Steeves, Geodetic Survey Division, Canada Centre for Surveying, appeared as document E/CONF 81/L 18

El Sistema de Control Activo podría reemplazar a la mayoría de las redes primarias y secundarias convencionales (tanto horizontales como verticales) en el Canadá. En la monografía se analizarán los efectos sobre los encargados de la topografía y la información sobre tierras y sus usuarios y la amplia gama de posibles aplicaciones que podría brindar un sistema de dicha índole.

SUMMARY

An "Active Control System" (ACS) has been under development at the Geodetic Survey of Canada since 1985. This system will comprise a number of automated stations across the country consisting of microcomputer-controlled GPS receivers, which will continuously record carrier phase and pseudo-range observations from all visible satellites. Meteorological data will also be collected and recorded. These data will be transmitted regularly to a central "Master Active Control Station" (MACS) and used for four main purposes. The data will be used, along with similar data collected at monitor stations in other countries, for the computation of precise orbital ephemerides for distribution to Canadian GPS users and for user control network connections based on Active Control Point (ACP) and user data sets combined. Because the coordinates of the ACS stations will be very precisely determined (owing to the continuous collection of observations at these stations) they will provide precise control without the requirement for GPS to occupy control stations. The data will also provide for the computation and broadcasting of differential corrections for navigational purposes, and for verifying the integrity of the GPS satellite constellation.

The Active Control System could replace most conventional primary and secondary (both horizontal and vertical) networks in Canada. The paper will discuss the impact on the surveying and land information community and the possible wide spectrum of applications that such a system could offer.

PRESENT STATUS OF A CANADIAN ACTIVE CONTROL SYSTEM

The development of the Canadian Active Control System (ACS) is progressing well and gaining momentum. Ultimately the System will consist of a number of active control points (ACPs) spaced uniformly throughout the country and will continuously monitor the constellation of satellites established by the United States' Department of Defense's Global Positioning System (GPS). Each ACP will consist of a microcomputer-controlled GPS receiver, which will collect data from all visible GPS satellites. The data collected by these ACP stations will be used to support orbit refinement computations, for user control network connections through relative positioning computations based on ACP and user data sets combined, as a means of verifying the integrity of the GPS satellite constellation, and for broadcasting differential corrections for navigational applications. This methodology can substantially improve the integrity, accuracy and economics of both static and kinematic positioning applications using GPS. For more details, refer to Delikaraoglou, Steeves and Beck (1986).

Interest in the benefits that such a system will offer has been indicated by federal, provincial and private agencies. The development of a working prototype ACP has been completed recently by the Geodetic Survey of Canada under contract with Meridian Surveys Ltd. This ACP consists of a TI-4100 GPS receiver connected to, and controlled by, a Micro-VAX II computer. This has resulted in a capability to automatically control and monitor the GPS receiver, to capture, interpret, record and validate data, and to automatically transfer data from the ACP to a main computer facility using

DATAPAC (eventually a communications satellite channel will be utilized), and to also allow interrogation of the ACP system by a main control computer. This main computer system is part of the Master Active Control Site (MACS).

These data transmitted to the MACS will be edited, validated, compressed, archived, used for orbit computation, and made available to users in Canada operating in the "effective area" of specific ACPs. A fully mature ACS has the potential for serving the positioning needs of both static and kinematic users in both real-time and post-mission modes; this paper, however, will primarily address the subset of the ACS pertaining to the static precise relative positioning user.

The initial development of the MACS, research into the required data links between ACPs, MACS and users, and development of data messages and formats is being carried out in-house by the Systems Development Section of the Geodetic Survey. The Survey is also canvassing GPS equipment manufacturers with regard to GPS receiver requirements and development for ACS integration, and is keeping abreast of progress by other groups who are developing differential applications of GPS.

The question of data message content and format is also being addressed in our work for the design of the ACS. Several formats have been suggested to date. The 104 format of the Radio Technical Commission for Maritime Services (RTCM) Special Committee appears to meet the basic requirements for data communication from ACP to MACS as well as for the real time differential user. It is rigid in structure but is sufficiently flexible to allow content changes so that it can be adapted as the ACS evolves. The document

(Kalafus and others, 1985) should be referred to for more details.

Although the format is designed for the broadcasting of differential corrections, it was developed not only to accommodate marine users, but land based and aircraft users as well. Both static and kinematic applications are supported by the RTCM format. We will be adopting this format in principle because we feel that this format will be accepted and utilized by a great majority of GPS equipment manufacturers and government agencies world-wide. However, in order to meet the additional requirements of the ACS it will be necessary to augment the different data types of the RTCM message format (McArthur, 1987) since not all required data are included in this format.

The development of the MACS must address three main tasks: system control, orbit computation and data management. The system control will maintain and control overall operation of the ACPs; the orbit computations will provide for near real-time and post-mission ephemerides; the data management tasks will include collecting, archiving and distributing all the ACP data in real-time, on-line and off-line modes.

The MCAS development is proceeding well. In March, 1987, a VAX 8300 computer was installed at headquarters. Although not entirely dedicated to the ACS, it will allow for the development of the required MACS software and database, and testing of the prototype ACP using various communication methods.

The capability of producing precise orbits is also under investigation. GSC has installed the NASA satellite orbit determination program GEODYN, which was modified to accept GPS carrier phase data. A new program, GIPSY (GPS Inferred Positioning System), developed at the Jet Propulsion Laboratory, will be installed and tested for this application.

Other issues to be addressed concerning MACS are the system reliability, integrity, security, and computer backup provisions.

To meet the communication requirements necessary to relay the collected GPS data from each ACP unit to the central facility at the MACS, and to provide a communications link universally acceptable to all ACS user groups, is perhaps the most difficult task with current communication technology. This is due to the cost of communication services and the ACS requirements for integrity, reliability, continuous operation, country-wide application, mobile applications, and overall complexity of the communication system. The two problems, ACP-to-MACS and MACS-to-user communications are distinct and most likely will not have the same solution. At present, we are researching various existing and future (proposed) satellite communications technologies.

The data link and interface to the user GPS receiver is also being addressed. There are in fact two data links and interfaces required: one for the transmission of differential corrections to the user in real time, and a second for interfacing the user to MACS for retrieval of ACP and precise ephemeris data in a real-time or post-mission mode (either on-line or off-line).

The data link from the user to the MACS for on-line retrieval of data can be provided by conventional telephone lines and services such as DATAPAC. For off-line users, magnetic media will be distributed for which formats must be developed. The real-time data link to the user's GPS receiver can take a number of forms and can operate at a

number of frequencies and at various data rates. The data link will continuously carry the differential messages without interruption, either at a fixed or at burst rates. The user GPS receiver system must then incorporate the broadcast ACS data in real time. It is hoped that receiver system manufacturers will provide software to do this, given that they will be aware of the broadcast ACS data formats.

GPS receiver requirements for the ACP and users are being addressed. The ACP receiver(s) must have the ability to monitor all operational satellites in view, which is up to 10 for an elevation cut-off angle of +5 degrees. This receiver must track both GPS frequencies, so that ionospheric corrections could be generated for use by single frequency receivers surrounding the ACP (Georgiadou and Kleusberg, 1987). The ACP receiver architecture can be multi-channel or single channel, employing parallel and/or sequential tracking techniques. GPS code and carrier phase measurements must be made available to the ACP computer.

The user GPS set could be any GPS code-type receiver; it does not have the same restrictions as those of the ACP receiver. For real-time applications the user equipment would consist of a GPS receiver with antenna, a differential data processor, and the ACS data receiver system. The data processor would incorporate the corrections and additional carrier phase data received with the observations measured by the user's GPS receiver.

The database management system (DBMS) must be capable of receiving, verifying, and storing all data transmitted from all ACP's. In addition it must be interfaced to the orbit determination program and be capable of storing the computed precise ephemerides, keeping track of on-line and off-line storage of all data, and allowing for data dissemination to the on-line and real-time user.

Issues to be addressed also include traffic, volume, speed, organization, continuous updating and operation, integrity, maintenance and reliability.

At this time the ACS is in a developmental stage. As it matures it will evolve into an automated operational system. The ACS is being developed in stages so that major objectives and milestones are successfully completed at each phase. The figure below depicts the currently anticipated implementation schedule.

Activity	1988	1989	1990	1991	1992	
ACS-PROTOTYPE						
MACS						
COMMUNICATIONS						
N STATION ACS						
ORBITS						
USER APPLICATION						
DATA MGT						
OPERATIONAL GPS						
<div> <div></div> Initial Development </div> <div> <div></div> Operation and Ongoing Development </div>						

It is expected that the majority of the required development will be carried out under contracts to the private sector and universities. The speed of development and implementation of the Canadian ACS is mainly a function of the level of financial and operational support from the system benefactors.

Numerous American states and agencies are actively pursuing the implementation of an ACS-type system: these include Texas, Alaska, Georgia, New Mexico, Arizona, Florida, Michigan, Montana; and the agencies, National Geodetic Survey (NGS) and the Department of Transportation (Hothorn, 1987). Also, private companies are developing ACS applications.

The National Geodetic Survey is discussing the implementation of a network of 13 ACPs throughout the continental United States (estimated total \$US 1.3 million) to be used as a reference frame for surveyors, and for GPS satellite orbit determination (Kaula, 1987).

IMPACT ON CONTROL NETWORKS

The plan for a Canadian ACS calls for a network of active control points (ACPs). As mentioned earlier each ACP consists of a microcomputer-controlled GPS receiver, which collects data continuously from all visible GPS satellites. A meteorological data collector would also operate continuously under control of the microcomputer. All collected data would be automatically transmitted to the central facility, MACS. These data would then be used for three main purposes:

(a) Orbit improvement computations: orbit determined from international tracking stations would form the basis for this improvement process;

(b) User relative positioning with respect to the ACS; both static (e.g. geodetic and engineering surveying) and kinematic (real-time navigation for ships, aircraft, automobiles etc.) users would thus be automatically referenced to the national three-dimensional coordinate system (datum);

(c) Differential corrections for users would be a by-product of having very precise coordinates for the ACPs; together with the determination of an ionospheric correction model for Canadian users, determined from the ACS data, this provides the means for attaining the best possible positioning accuracy, reliability, and integrity from GPS.

Data transmission from the ACPs to the MACs, and from the ACS to users, will ultimately make use of a satellite communications facility. Initially, DATAPAC or UHF channels could be used.

The ACS is therefore "active" in the sense that it will be an "invisible" (to the user) control network. Users will not have to physically occupy the ACPs, and intelligent receivers with the capability of automatically collecting data from specified ACPs will eventually make such a control system completely user-transparent.

Conventional positional control networks may thus be called a "passive" control system (PCS), in that users must physically occupy the control stations, and the agency responsible for the PCS must re-occupy each station for purposes of physical maintenance or accuracy improvement. The ACS, on the other hand, automatically and continuously improves the positional accuracy of the ACPs, and through automatic interrogation of each ACP by the MACS computer, physical maintenance is performed only when necessary.

The ACS has the potential to replace many conventional primary and secondary (both horizontal and vertical) networks in Canada. This replacement process would take place gradually over three to seven years. Some local PCSs may be required for some time (e.g. in urban areas), but these would represent a very small proportion of positional control cost. Even large portions of urban networks can be replaced by the ACS, as indicated by recent interest expressed by Metro-

politan Toronto in establishing three ACPs for their use. In deep urban areas, where large structures cause GPS "holes", strategically located pseudolites can fill the gaps.

An ACS can satisfy positioning requirements of a much wider application spectrum than can conventional monumented control networks (which basically serve only one application area). Both static and kinematic positioning requirements would be well served by an ACS. Major user groups would be in the areas of:

Ground navigation (commercial trucks, railways, automobiles)

Air navigation (commercial and private aircraft)

Seaway navigation (commercial ships, pleasure boats)

Geographical information systems (e.g. data collection)

Survey and mapping

Search and rescue.

This may not be an exhaustive list of user groups, but it is clear that the number of users of the ACS will number in the order of several million. We will assume 2 million users in making estimates of user fees (below).

From the operational and technical points of view, the ACS will most likely consist of three major hierarchical layers or components as follows:

(a) A national component which would provide the "framework" for the country;

(b) provincial and territorial components which would provide the denser "secondary" control;

(c) Urban and special project components which would provide very local control for specific applications. Examples of special projects are dam construction, St. Lawrence seaway navigation, airport guidance etc.

These components can be referred to as "national", "provincial", and "special". Assuming an average national ACP spacing of 500 km, approximately 50 ACPs are needed for the ACS framework. An average provincial spacing of 250 km would require an average of 16 ACPs per province or territory (192 ACPs). Note that these spacings are average, and allow for more dense spacing in densely populated areas than in less densely or unpopulated areas.

The number of "special" ACPs required is more difficult to determine. Some of these will be temporary installations, and some will be permanent. The capital and operational costs will simply be an additional budget item for such projects. Most projects, however, should require only the national and/or provincial ACS components for their control.

The operation of the ACS (all three components) can be handled by Canadian industry. Satellite communications systems are being developed with the capability of broadcasting selectively to paid-up subscribers. Cost recovery could therefore be easily implemented on a subscription basis.

There are two distinct types of accuracy requirement for positioning:

(a) Accuracy relative to the national control fabric, or relative accuracy over long distances;

(b) Relative accuracy within any single project, or relative accuracy over short distances.

The ACS will provide the Canadian positional control fabric, and with ACS spacings as discussed above, every user will have an average of four (more in densely populated areas) ACPs within a radius of 125 km of his or her receiver(s). In densely populated areas, where the ACP

spacing will be in the order of, say, 100 km, each user will have at least four ACPs within a radius of 50 km of him. This will obviously result in the highest possible accuracy for type (a) requirements. Each receiver will be directly connected to at least four very precise (ACP) stations without having to occupy them. The accuracy of positioning with this method is also enhanced by differential corrections provided by the ACS. Note that reliability and integrity of this approach are as important as the high accuracy capabilities.

The relative accuracy within any single project is mainly a function of the relative observations within the project. That is, when the relative accuracy requirement between two points is high, direct measurements must be made between them. However, if we examine a hypothetical case of four project stations (with a receiver on each), making use of four nearby ACPs, we will see how the redundancy (and therefore accuracy and reliability) increases. Within the project itself, we have redundancy of 9 (3 free stations, or 9 unknowns, with 6 baselines, or 18 observations). When we add four ACPs to the overall project network, we add 12 additional coordinate unknowns (three for each ACP), but we add 12 observations between the ACPs, and 48 observations from the ACPs to the project stations. With no fixed station, we have 24 unknowns (8 stations), and 78 observations, giving a new redundancy of 54. By using the ACS, we have increased our redundancy by a factor of 6! The redundancy is increased even further if we make use of more distant ACPs. In theory, it is possible to use all of, or more practically any subset of, the 242 ACPs. This results in a capability for high degrees of integrity and reliability in that, because of the high redundancy, problems with any station (ACP or project) or satellite can be identified and removed immediately. This high integrity capability is especially important for those users whose applications are kinematic, but also significantly improves the efficiency and reliability of static applications.

The major costs of implementing an ACS are:

- (a) Capital cost of each ACP and its housing;
- (b) Operational and maintenance costs of the ACPs and the central facilities

In arriving at the estimates below, it has been assumed that most ACPs can be housed in existing facilities (as our Yelloknife monitor station has been). This should be a reasonable assumption, because the total space required for an ACP is equivalent to the space required for an office desk. The spacing requirements of ACPs are a function of population (and therefore infrastructure) density, and independent initiatives with the same or more demanding requirements for housing across the country are under way (e.g. weather stations, and data collection and digitizing operations). Also, estimates are based on the assumption that the average costs of GPS receivers and microcomputers over the period of implementation will be \$20,000 and \$10,000 respectively. The capital cost for each ACP will therefore be approximately \$45,000, including \$5,000 for meteorological equipment, modems, etc.

The total capital cost for the national ACS component would therefore be approximately \$2,250,000 (\$45,000 times 50), and the average cost for each province would be approximately \$720,000 (\$45,000 times 16). The total capital cost for all 242 ACPs would thus be approximately \$10,890,000. If we assume an average lifetime of 6 years for this equipment, the capital cost is equivalent to \$1,815,000 per year.

Operational and maintenance costs for the ACPs will be minimal. We estimate that these costs will average \$1,000 per year per ACP, giving a total of \$242,000 per year.

The total cost per year is therefore \$2,060,000. Assuming that this total cost is to be recovered by industry with a profit margin of 15 per cent (giving the amount to be recovered per year as approximately \$2,470,000), and assuming there will be 2,000,000 users, fees of \$1.25 per year would have to be charged.

Even if our assumptions are wrong by a factor of 1,000, the user fee would be only \$1,250 per year.

Even if the cost of data transmission is as high as \$500,000 per year, an additional charge of \$0.25 per user receiver would cover it.

The ACS would be, of course, implemented on the basis of regional requirements and capabilities. Major factors that will determine when the ACS will be capable of replacing conventional networks are:

- (a) Sufficient implementation of the GPS constellation of satellites (1990-1991);
- (b) Sufficient number of GPS receivers in use;
- (c) Rate of capital investments in implementing the ACS.

Exactly when the ACS becomes fully operational depends to the largest extent on the third factor. The utility of GPS receivers for the variety of its applications depend on having an ACS. Therefore, when the ACS is capable of serving those applications, the market for receivers will increase in size. When the market size increases, the price of receivers decreases, making them readily accessible to all users. It is critical, therefore, to make the required capital funds available to ACS development.

The development of the ACP hardware/software system and the required MACS software should be complete by 1989. Several ACPs should be in operation by then. Depending on the rate of capital investment, the ACS could be in full operation in the early 1990s.

In three to seven years, the ACS could be fully operational. During the interim period, conventional control networks will be required for surveys and mapping. But conventional control networks exist, and have been fulfilling surveys and mapping needs to date. The question is therefore: can present conventional networks, which will still exist for the next five to ten years, satisfy surveys and mapping requirements for the interim period before the ACS is operational? The greatest requirement, by far, for conventional control is for mapping, and existing control is more than sufficient for that purpose. Thus, right away, the control needs of less significant applications must be examined. We suggest that all other applications are local, or at most regional, in extent, and if existing control is not sufficiently accurate for their purpose, that control can be upgraded as part of the survey.

ACTIVE CONTROL SYSTEM COST-EFFECTIVENESS STUDY

Currently, an in-depth study is being performed of the cost-effectiveness of the proposed ACS. The analysis will answer several questions, and make recommendations, including rationales, as to whether such a system should be implemented in Canada. The study will answer the following:

What are the direct costs of implementing and maintaining the system?

What are the economic benefits?

Is the implementation of the system the most cost-effective means of meeting future Canadian requirements for positioning (including navigation)?

If the system is deemed to be cost-effective, what should be the respective roles of industry and Government in the development, operation, and maintenance of the system?

What implementation strategy and schedule would be most appropriate for the ACS?

What applications would a fully operational ACS serve directly (e.g. geodetic positioning, air and marine navigation) and indirectly (e.g. transportation, recreation)?

What impact would a fully implemented ACS have on existing federal and provincial government positioning services?

Is cost-recovery feasible for the ACS, and if so, to what extent and by what means?

This study, which is being performed by private consultants, will be completed by February 1989.

CONCLUDING REMARKS

It is obvious that there is a need for a Canadian ACS, and the acceptance of the ACS concept is already evident. In Canada the development of the ACS is well under way. Increased active participation and support by additional Canadian agencies will see the ACS mature in time for the full GPS constellation deployment.

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UNIFIED WORLD GEODETIC NETWORK BASED ON THE USE OF THE GLOBAL POSITIONING SYSTEM*

Paper submitted by Hungary

RÉSUMÉ

Le présent document décrit certaines propriétés des Systèmes mondiaux de localisation par satellite NAVSTAR et GLONASS. Compte tenu de l'utilisation faite de ces deux systèmes, il est proposé de créer, avec l'appui de l'ONU, un réseau géodésique mondial unifié.

RESUMEN

En el documento se describen algunas características de los Sistemas Mundiales de Determinación de Posición NAVSTAR y GLONASS y se sugiere que se establezca, con apoyo de las Naciones Unidas, una red geodésica mundial unificada basada en la utilización de esos dos sistemas.

* The original text of this paper, prepared by Sz. Mihály, FÖMI Satellite Geodetic Observatory, and A. Szentesi, National Office of Lands and Mapping, appeared as document E/CONF 81/L. 2

SUMMARY

The paper describes some characteristics of the NAVSTAR and GLONASS global positioning systems (GPS). Based on the use of the two systems it is proposed that a unified world geodetic network be established, sponsored by the United Nations.

Recently, various systems of global positioning by satellite (GPS) have been under development all around the world. These systems are used for precise fixing of coordinates and the velocity of static and moving objects as well as for precise timing. Determination of these factors is planned to be available continuously — whenever and wherever on the Earth's surface or in space it is needed, and for however short a time interval — and to be highly accurate.

The benefits of such systems are obvious for navigation, surveying, mapping, geodesy and geodynamics. Some civil applications are given below:

(a) Airborne, land and maritime navigation (approach, enrouting, helicopter operations, vehicle monitoring, use in remote areas);

(b) Space navigation, search and rescue;

(c) Static positioning (offshore resource exploration, hydrographic, geophysical and geodetic surveying, mapping, geodynamic investigations).

For the above purposes, common utilization of the NAVSTAR and GLONASS-GPS would give a much more effective and powerful tool for geodesists, surveyors and navigators of the world.

SATELLITE SYSTEMS

There are a number of satellite systems being developed for global purposes. The NAVSTAR-GPS of the United States and the GLONASS-GPS of the USSR seem to be most significant. A brief description of these systems is given below for those who are not familiar with them.

NAVSTAR-GPS

The sponsor for the NAVSTAR-GPS system is the United States Department of Defense. NAVSTAR is in the advanced development phase and entering into production and implementation. Full operational capability is promised by 1992/93. The experimental stage has already shown a widespread application all around the world.

The NAVSTAR will give global coverage at land, sea, air and space for navigation, surveying, geodesy and geodynamics. In the user segment, precise timing and three-dimensional positioning and velocity determination will be (and partly is) available. The precise version will serve only authorized users concerned in national defence; civil users can access the coarse version of NAVSTAR-GPS.

When fully operating, the system will consist of 18 satellites (and 3 spares), distributed in 6 circular orbit planes with 30° separation, 55° inclination, 12 hours period and 20,000 km height above the Earth's surface. Each satellite will be visible above the horizon of any ground station during 5 hours, and 4 or more satellites will be visible at the same time.

The satellites transmit at two frequencies ($L_1 = 1565.2 = 1585.7$ megahertz (MHz) and $L_2 = 1217.4 - 1237.8$ MHz) to account for the ionospheric correction. Transmission is performed in continuous mode, carriers, precise and

coarse acquisition code (P-code and CA-code). The P-code transmission at 10.23 MHz repeats only about once every 38 weeks (267 days). The CA-code transmission at 1.023 MHz repeats every millisecond. The radiation power is -41 dBW/Hz.

On a satellite board 2 cesium + 2 rubidium clocks work at 10^{-13} long term and 5×10^{-13} short term stability.

A control segment consisting of five tracking stations, one centre and three injection-stations operate to track and compute the satellite orbits and to inject the orbital data onto the satellite board.

In the user segment, GPS receivers operate at the stations to be determined. Production of receivers for NAVSTAR-GPS is well organized.

The P-code system accuracy at two frequencies is 15 m of 30 position, 0.1 m/sec of velocity and 100 nanoseconds (nsec) of timing. At CA-code with only L_1 frequency the available accuracy is 100 m in XY and 160 m in Z and 200 nsec in time. These are referred to as single-point positioning accuracies.

In differential GPS-technique the relative position of the receivers (ground points) can be determined. This method plays a very important role in geodynamics, geodesy and surveying. The relative position accuracy of 1-5 cm can be achieved for short distances. At medium distances some 5-10 cm and for long distances 5-25 cm of relative position accuracy can be obtained.

GLONASS-GPS

All of the technical details on GLONASS are taken from freely available and already published sources (McDonald and Greenspan, 1985; Klass, 1987).

The sponsor for the system is the Ministry of Post and Telecommunication of the USSR. GLONASS is at an advanced experimental and developmental stage. No reports on the application results are known to the author.

GLONASS will provide global coverage on land and sea, and in air and space for navigation, survey, geodesy and other purposes. In the user segment precise timing and 3-dimensional positioning and velocity determination will be possible. It will serve for defence purposes and probably for civilian users with hypothetical precise and coarse versions.

The number of satellites in full operation is not known to the author. More than 24 satellites are now in orbit and only some of them are active. The satellites will be distributed in three circular orbit planes at 60° separation, 64° inclination, 11.25 hours period and 19,100 km height above the Earth's surface. Each satellite will be visible above the horizon of any ground station during almost 5 hours, and 3 or more satellites will be visible simultaneously.

GLONASS uses dual frequencies: $L_1 = 1597-1617$ MHz and $L_2 = 1240-1260$ MHz. Unlike NAVSTAR, GLONASS satellites use different frequencies for both L_1 and L_2 bands

(this may complicate the receiver design for GLONASS). The P-code channel spacing for the L1 signal is 0.5625 MHz and, for L2, 0.4375 MHz. Like NAVSTAR, GLONASS uses a spread-spectrum digital pseudorandom-noise signal format with binary phase-shift keying to denote "ones" and "zeroes". The band-width of both being only half that of NAVSTAR'S codes, GLONASS supposedly promises only half the range measurement resolution, which results in somewhat less position-fixing accuracy. The P-code transmission is supposed to be many days long; transmission time for CA-code is not known (Klass, 1987). The radiation power is -44 dbW/Hz.

No information is available on the satellite clocks and their stability or on the control segment structure of GLONASS.

In the user segment no information on GLONASS GPS receivers has yet been published. In Klass (1987) it is supposed that GLONASS-NAVSTAR combined receivers could be designed and constructed.

There is no concrete information on the accuracy of the system. However, as a starting point from the GLONASS's signal structure, frequencies and bands, the single point positioning and the relative positioning accuracies are expected to be close to those of NAVSTAR.

STATUS COMPARISON OF NAVSTAR AND GLONASS

From the point of view of civilian practical application of the two systems (or one of them) the following conclusions on their status can be stated:

NAVSTAR-GPS

(a) The space segment (the satellite) is in experimental use. Though not yet fully operating, its development is firmly scheduled and there is no doubt of its geodetic realization. It is already being used for practical purposes;

(b) The control segment is operating and injecting orbital parameters computed from the regular tracking network observations. However, the orbital data are of limited accuracy. For more sophisticated applications and in the case of codeless receivers independent regional tracking networks are supposed to provide highly accurate orbital data for local or regional geodetic tasks;

(c) The user segment has recently been well provided with CA-code or codeless GPS-receivers operating on one or two frequencies. More sophisticated and cheaper receivers, as well as their free availability, are expected in the future.

GLONASS-GPS

(a) The space segment is in the experimental phase. The development schedule of GLONASS is not known and thus the future users may not prepare for entering the system. So far it has been available for only a very limited number of authorized users. It would be desirable to make this promising and probably expensive system available for scientific and production (i.e. practical) purposes in geodesy and navigation;

(b) Nothing is known about the control segment. In the case of GLONASS, regional tracking networks are supposed to provide highly accurate orbital data for geodetic tasks;

(c) The civilian user segment does not exist at all. There are attempts to build codeless receivers but with no success so far. In 1988 the GLONASS system was opened for world-wide use, which will probably help and quickly solve the absence of GLONASS GPS receivers.

TRACKING NETWORKS FOR OBTAINING ACCURATE ORBITS

In the case of NAVSTAR a control segment of five stations guarantees the orbital elements of the satellites. However, the accuracy of such broadcast ephemerides is not enough for some precise relative geodetic positioning. For that reason different tracking networks are under arrangement or operation. Some of them are given below:

(a) A Cooperative International GPS Network (CIGNET) is continuously tracking the NAVSTAR satellites and providing orbits for them. CIGNET is a world-wide network.

(b) In the area of Japan a "Super Precision GPS Network" project started with the purpose of high accuracy orbit determination (CSTG, 1988);

(c) With a similar goal an "Australian GPS Orbit Determination Pilot Project" is being carried out (CSTG, 1988);

(d) In Canada a regional network of active control points is planned to start (CSTG, 1988);

(e) In Europe, and in different regions of the continent, tracking networks have started or are planned to provide accurate orbits for geodetic and geodynamic purposes (CSTG, 1988; Mihaly, 1987).

UNIFIED WORLD GEODETIC NETWORK BASED ON GPS

The most important aspect may be to construct a world-wide civilian satellite tracking network for precise ephemerides with common geodetic utilization of the NAVSTAR and GLONASS GPS systems. Cooperation with the United States and the USSR, as well as with other countries, may be indispensable for this purpose. In arranging such cooperation the United Nations is requested to play a very important role.

Concerning the potential possibilities of the GPS it can be stated that in practice there are no irreconcilable distances. Connecting continental networks and upgrading them to a unified world geodetic network can be a rational scientific, technical and economic aim.

Herein a unified world geodetic network is proposed to be realized with the support and sponsorship of the United Nations and in the framework of the IUGG/IAG (International Union of Geodesy and Geophysics/International Association of Geodesy), which will be required to provide

(a) A common geocentric Earth-fixed coordinate system with unique scale;

(b) A world-wide unified datum and projection system;

(c) A basis for positioning techniques and geodynamics;

(d) Overall and equal-density coverage of the Earth's surface;

(e) Joint precise orbit determination of NAVSTAR and GLONASS.

The sites of the proposed UWGN could be situated on the continents and islands with an average distance of approximately 3,000 km between them. In this case some 70-80 sites would give the UWGN-frame providing one point per 7M km² density. Some of the sites could be situated at the already active space-geodetic (or complex geodynamic) stations, while others should be newly established. The whole set of UWGN could be divided into 7 subsets of sites, each grouped by a continental plate boundary (supposing the Earth surface as consisting of 7 plates or plate-combinations).

The proposed UWGN would have numerous advantages in geodesy, geodynamics, positioning, navigation and, generally, in Earth sciences. Some of them are briefly discussed below.

The space segments of NAVSTAR and GLONASS could be commonly utilized through the UWGN by means of suitably designed multipurpose GPS receivers. The demand for such useful multipurpose GPS receivers probably would decrease the price of the receivers. As a result, the GPS technique would spread more widely and rapidly, accelerating the realization of global scientific programmes and regional/local production.

A UWGN-coordinated international global positioning system could be born with an optimized space segment, diminishing the expenses of GPS maintenance.

A UWGN would provide, simultaneously, a world satellite tracking network, optimal in configuration, and uniform in instrumentation; and, as a result, a much more accurate ephemerid survey (orbital prediction).

The UWGN and its sites could be used for a wide range of solutions to the problems of Earth sciences. As an example, regular GPS observations at the sites of UWGN would provide world-wide monitoring of plate tectonics. Such regional geodynamic projects, such as the MEDLAS-WEGENER and the IDEAL, could be supported by UWGN. In local areas the San Andreas fault problems or the rifting of continents at the Red Sea (Bonatti, 1987) could be monitored.

The individual groups or subsets of UWGN could serve for high precision and beneficial relative positioning with GPS in regional and local areas in a unified datum or coordi-

nate system (establishment of a modern control network in developing countries and upgrading the existing networks in developed countries).

The realization of unified world geodetic network will be possible only on a cooperative basis and after revising defence considerations in the interested countries. Such a step would serve the peaceful use of GPS and the peace of the world.

Of course the design, arrangement, possible establishment and operation of UWGN would need a special board within the IUGG/IAG framework, cooperating with the United Nations.

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(b) Remote sensing for cartography

USE OF LANDSAT™ IMAGERY IN 1:100,000 TOPOGRAPHIC MAP COMPILATION*

Paper submitted by Hungary

RÉSUMÉ

Le présent document commence par une brève introduction concernant la publication de cartes établies à l'aide d'images transmises par satellite, puis examine les différents procédés de cartographie, y compris les problèmes de transformation d'images et de séparation de couleurs, ainsi que la compilation des cartes, et l'impression de la nouvelle carte au 1/100 000 de la Hongrie établie à partir d'images transmises par satellite. Il se termine par une comparaison de deux cartes obtenues à l'aide de ces données.

RESUMEN

El documento contiene una breve introducción sobre la publicación de mapas basados en imágenes transmitidas por satélite. A continuación se analiza el proceso para el levantamiento de mapas, incluido el problema de la transformación de las imágenes y la separación de colores, así como la confección de mapas y la impresión del nuevo mapa de Hungría a una escala de 1:1.000.000, basado en imágenes transmitidas por satélite. Finalmente, se comparan los mapas basados en dichas imágenes y preparados de dos maneras diferentes.

* The original text of this paper, prepared by Ms. Eva Csató, FÖMI Remote Sensing Center, and Edgár Sasváry, Cartographia, appeared as document E/CONF 81/L.3. The work described was supported by National Research Funds of the Hungarian Academy of Sciences.

SUMMARY

The paper gives a short introduction to the publication of satellite image maps. It discusses the process of map-making, including the problem of image transformation and colour separation as well as map compilation and printing of the new Hungarian satellite map on scale 1:100,000. Finally, the satellite image maps prepared in two variants are compared.

Before the LANDSAT satellites were launched, Apollo space photographs were used (in 1969) to prepare satellite image maps (Colvocoresses, 1986). The publication of new types of satellite image maps, prepared by combining the content of images and maps, has undoubtedly been done longest in the United States where the United States Geological Survey has already published more than 100 such maps of various types and scales. The majority are based on multi-spectral scanner (MSS) images (Batson, 1984).

After the launching of LANDSAT-4, since 1984, thematic mapper (TM) images were used for preparing image maps. TM images, owing to their high spatial resolution, are much more suitable for this purpose than the MSS images that were in use before.

COMPILATION AND PRINTING OF THE IMAGE MAP SHEET No. 78 (MEZŐCSÁT) OF THE UNIFORM NATIONAL MAP SYSTEM

Image transformation

The multispectral images made by LANDSAT-5 thematic mapper were purchased by FÖMI in their digital form (computer compatible tape), which was already radiometrically and geometrically corrected at the receiving station (Fucino).

The image base for the sheet No. 78 (Mezőcsát) was a cut section from the quarter scene LANDSAT-5 TM 187-27/2. The spectral bands applied were TM 2, TM 3 and TM 4 with the colours yellow, magenta and cyan respectively.

For the image display of the digital data the following operations were carried out in the computer laboratory of FÖMI: conversion for film-writing (image display); statistical calculations; and preparation of blue-green-red negatives on an Optronics Colormation 4500 film-writer machine.

The negative film obtained this way was optically transformed on the corresponding 1:100,000-scale sheet made in the uniform national map system. The transformed scene was a conventional infra-coloured positive picture and it showed excellent dynamics of colours; this product served as a basis in the forthcoming stages of processing.

Colour separation

The reprotechnique processing of the positive paper photograph was carried out on an electronic colour separation instrument, Hell Cromograph C-100, which operated with argon laser scanning.

The uniqueness of the machine is that a silver-sensitive screen can be placed between the light-sensitive film and the lighting laser rays. The product is a colour separated screen-positive film that—in addition to electronic corrections—can be easily rectified, even manually.

Adjustment of the original extension of tones of the satellite image needed major corrections in the reproduction pro-

cess. To achieve the legible representation of linear elements in orange, blue and black in the proposed image map, the tonal extension of the reproduction was somewhat reduced if compared with its original extension. The work was carried out in two variants:

Variant 1. The colours of the original photocopy were only slightly modified. The intensity of colours was only reduced a little, while the neutral colour balance was kept.

The following screen values were applied for the representation of lightest and darkest parts in the picture:

	Minimum (%)	Maximum (%)
Cyan	9	90
Yellow	9	85
Magenta	7	78
Black	0	45

(Normally, maximum percentages: C = 95%, Y = 90%, M = 85%)

Variant 2. The colours of the original photocopy were basically changed: the screen values and the tonal extension of the darkest places in the picture were largely reduced.

The following values were applied:

	Minimum (%)	Maximum (%)
Cyan	7	75
Yellow	7	70
Magenta	5	61
Black	0	32

Cartographic processing

Four pieces of screened and colour separation film positives of the images were available for cartographic processing in each of the two variants. The fair draft of the 1:100,000 scale derived topographic map covering the specific area was also available.

Examination of the map

In the first phase of processing, the size of the printing plates of the topographic map and the size of the original and the colour separation film positives were precisely measured for comparison. The observations made it clear that some 100 km² area in the north-west corner of the colour original was distorted. The maximum value of distortion sometimes reached 0.5 mm.

Fitting

This operation was carried out with plotting the sheet-corner values of the fair draft of linear elements of the topographic map on scale 1:100,000. Then, the colour separation films made from the satellite images were superimposed on the fair draft of linear elements; after the precise adjustment of planimetric outlines, the correct sheet-corner values were also drawn onto the films.

Assembly

The register marks and the clearly visible control points in the map were drawn onto the coordinate system of the assembling plate. In order to eliminate distortions, the colour separation films were bisected in North-South direction. The cut lines were chosen so that they ran along planimetric features (railways or roads). This way it was achieved that the linear elements and their corresponding outlines in the colour separation films were also reasonably adjusted in the distorted section of the image.

Map compilation

The compilation was made on a diazo-print of the original fair draft. The purpose of compilation was to transform the information content of the 1:100,000 sheet derived from the topographic map series and to make it suitable for unification with the content of the digitally and optically transformed image.

Two basic problems had to be solved:

(a) Forming a quantitative and qualitative balance between the information content of the map and the satellite image;

(b) Creating a contrast between the relatively dark-tone colour background of the satellite image filling the whole sheet and the fine symbols of the derived topographic map, that would give a basis for equal evaluation of their information content.

Furthermore, in studying the satellite image, it was observed that the image, owing to the limits of its geometric resolution, was unable to provide for pictures that could satisfy the representation requirements for quality of certain elements in the topographic map on scale 1:100,000. This statement was true for settlements, houses, various categories of railways and roads, embankments, vegetation, certain hydrological features as well as for smaller objects on the terrain, and relief. This is why these elements had to be represented with the symbols of the derived topographic map;

In order to create the proper contrast effect,

(a) The tones of the satellite image were deleted from the surface of roads; in this way the white surface of the road network became clearly visible;

(b) Minor canals and other water currents represented with two contour lines were filled with blue; thus hydrology became somewhat enhanced;

(c) The colour tones of the image over the area of wetlands were preserved, making it possible to reflect water transparency and its pollution.

The dotted representation of vegetation boundaries and the symbols of vegetation therein used in the derived map were adopted.

For the representation of forests and in order to increase the contrast effect, tree-characters were applied with their halves being black and white, while the colour tones under these signs were preserved.

Lettering of geographic names was thoroughly selected in order to have less image section covered. The compilation plan was supplemented with the legend of bands.

Fair drafting

Fair drafts were made on astralon with colour separation. The reversal copy was made on astralon sensitized with chromegum.

The printers received the following manuscripts:

1. Unified planimetry and lettering (black I)
2. Hydrology (blue)
3. Relief (brown)
4. Screened satellite image colour separation (yellow)
5. Screened satellite image colour separation (cyan)
6. Screened satellite image colour separation (magenta)
7. Screened satellite image colour separation (black II)

Preparation of the printing plate

The printing forms were prepared on Microprint plate in a Kalle frame.

Printing

The print was made on 120 g/cm² baryta papers on a Druckma-proof press. The number of printing colours was 7.

Colours for line elements: blue, brown and black

Colours for tones: cyan, yellow, magenta and black

The print was made in two variants

In the first variant, the colours of the printed image were very much closer to the original tones in the satellite image. It was printed with normal colour density values: $C = 1.45 D$, $Y = 1.00 D$, $M = 1.20 D$

As for the second variant, the density values of colours were reduced in order to create a sharper contrast between linear and tonal elements. Density values: $C = 1.20 D$, $Y = 0.90 D$, $M = 1.10 D$

In order to achieve clear colours, some of the sheets were not overprinted with a black screened plate.

Examination of the proof-prints

Observations on the first variant:

(a) Colours approximate the colours of the original composite;

(b) Background tones in the satellite image are strong and have high density values. For this reason, the satellite image has greater influence on the outlook of the satellite image map than has the linear topographic map; therefore the content of the latter is sometimes overwhelmed;

(c) Contrast of settlements is acceptable;

(d) The road-network, with its white surface, is well visible on colour and dark-tone background;

(e) Lines of hydrographic features sometimes shade into the tones of the image; only the redrawn lines are easily recognizable;

(f) Dotted lines for vegetation boundaries are faint;

(g) Geographic names, especially those written with very thin letters, are sometimes hardly legible.

Observations on the second variant:

(a) Colours are fainter and weaker than those of the original colour composite;

(b) Background tone of the satellite image is faint, which makes the satellite image map well-balanced, and the fine symbols of the topographic map also show up well against the fainter background;

(c) Satellite image map has much more of the characters of maps;

(d) Settlements are clearly expressed against the colour background;

(e) White lines of roads show up the road-network;

(f) Lines of hydrographic features are well expressed in the colour tone surface;

- (g) Vegetation boundaries are recognizable;
- (h) Geographic names, even on dark-tone areas, are legible.

EVALUATION OF THE SATELLITE IMAGE MAP

The accuracy of the linear elements in the satellite image map corresponds to that of the 1:100,000 scale derived topographic map sheet. When the content of the satellite image is compared to the linear topographic elements, positional errors of ± 0.3 mm can be observed at certain places. This is partly produced by local distortions through the transformation of the satellite image, and partly by the colour adjustment errors and paper distortions caused by the sevenfold printing on the proof-press. These errors can be reduced by using digital transformation and another kind of machine.

The differences sometimes noticeable between the vegetation boundaries in the map and their relevant tones in the satellite image are explained by the fact that the topographic map was made in 1983, while the satellite image reflects the state of the land in 1987.

The settlements, houses, types of railways and roads, embankments, as well as certain hydrographic features, smaller objects and the relief cannot be unambiguously interpreted from the satellite image without the help of the data in the derived topographic map.

The above-described technology—in our opinion—is suitable for the rectification of the topographic map content as well as compilation and issuance of new types of photomaps.

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LINE MAPPING FROM SATELLITES IN THE ORDNANCE SURVEY*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Ce document décrit une activité réelle de production de cartes à partir des images transmises par le satellite SPOT. On y examine également les perspectives d'avenir de la cartographie au moyen de détecteurs situés dans l'espace et on conclut que ceux-ci devront jouer un rôle dans le domaine du développement et de l'aide.

RESUMEN

Esta es una reseña de un trabajo de producción real en el que se utilizan imágenes del SPOT. También se examina el futuro de la cartografía a partir de sensores en el espacio y se concluye que tienen un papel que desempeñar en el desarrollo y la asistencia en el futuro.

The current emphasis in the geographic and land information community on Geographic Information Systems (GIS) tends to take for granted the existence and accuracy of the topographic maps on which they are invariably based. In the United Kingdom we are fortunate in having some of the best medium-scale mapping in the world at 1:50,000. In developing countries this may not be the case. While maps, at some scale, exist in most of the developing world, much of the coverage is so out of date that it cannot be relied upon as a basis for identifying potential for new development. Some areas were mapped, in the early years, by techniques that gave accuracy standards that are no longer acceptable for any purpose except basic navigation. As countries develop or areas of potential are identified, maps at scales larger than the existing 1:200,000 or 1:250,000 become necessary.

The basic techniques for topographic mapping have remained much the same for forty years. Stereo air-

photography is used as the basic source document, contours and topographic details being plotted photogrammetrically. Surveyed ground control is needed to orient and scale the stereomodels, and field completion teams are needed to provide the essential information that is rarely apparent on any imagery: boundaries, road classifications, place names and so on.

Over the years the costs of acquiring data and land information of all kinds, and height of the sensors used to capture these data, have risen progressively. One of the recent innovations in data capture has been the French SPOT-1 satellite, which has been in a "near Polar" circular orbit since February 1986. With its 10-m pixel size, panchromatic image, off-nadir viewing capacity, stereo capability and ability to accept commissions for imagery of specific areas, SPOT has characteristics that should be a boon to the cartographic community. The development of SPOT has generated a great deal of interest in the remote sensing and scientific community, but despite many encouraging claims as to its utility and accuracy, so far very few cost-effective products or processes have been developed.

* The original text of this paper, prepared by W. S. Hartley, Directorate of Marketing, Planning and Development, Ordnance Survey, appeared as document E/CONF 81/L 11.

Within the framework of a topographic mapping programme funded by the Overseas Development Administration in Yemen, the Overseas Surveys Directorate has experimented with the use of SPOT as a primary data source and has now started a production mapping programme. An area of 25,000 sq km in the north-eastern part of the country is being mapped at 1:100,000 scale with contours, and 28 SPOT scenes have been commissioned. A field survey team spent some months in this arid and unfriendly environment establishing the ground control necessary for mapping. It is a very good test-bed for assessing satellite imagery; there is little vegetation to hide detail and there is virtually no cloud to prevent data capture. SPOT, like all visible band sensors, cannot see through cloud, a vital but often underestimated limitation to most earth-pointing remote sensors.

Mapping from SPOT is not simply a matter of tracing of detail from the imagery onto the map; the geometry of the image is both complex and dynamic. The SPOT-HRV sensor has an array of 6,000 charged couple device sensors, which sample reflected radiation every few microseconds to create a digital image of a swath 10 m long and 60 km wide. Every swath has a perspective but off-nadir view. A whole image is built up swath by swath while the satellite rotates around its Y axis to keep the sensor pointing at the earth. During the seven seconds it takes to record a 60x60-km ground image, the earth has revolved by up to 3.2 km (at the equator), which means that an apparently square image represents a perspective view across a skewed area on the earth's surface. The complex geometry is compounded when using stereo-imagery as the X axes of the two images taken of the same ground area from different orbits are converging (as the orbits of the satellites converge at the Poles). Discussion of the subject is further complicated as, if the Z axis of the satellite is projected from the earth's centre through the satellite and a satellite's X axis is in the plane of the orbit, the satellite's Y axis is nearly parallel to the X axis of the stereo-image in the photogrammetric convention.

To make matters even more complex, the satellite has perturbations as it rocks about its axis and varies in its attitude, height and velocity. The end effect is such that a line which is straight on the ground appears as a wavy, skewed, far from straight line on the image. Ground control points of known geodetic position, which are positively identifiable on the image, allow polynomial modelling of the image data to achieve photogrammetric restitution; in other words, a scaled, oriented and usable model of the terrain.

University College, London, has developed the necessary algorithms and written these as software for use on an analytic photogrammetric plotter. Ordnance Survey quickly saw the benefit of such software and installed it on their own plotters.

The digital data, downloaded from SPOT, is not much use unless it can be seen, measured and interpreted. This is done by loading it into a digital image processing machine where the contrast can be manipulated to achieve a well-toned and enhanced image. This is then plotted onto film using a laser plotting device where each original pixel, or data cell, is plotted at 30-micron size. The hard-copy image can then be loaded into the analytic plotter, surveyed control points and the satellite ephemerides data are entered into the system software and the processor calculates the photogrammetric solution. In effect, for any position selected in the model the computer first calculates the image coordinates, then moves the left or right images to create a viewable model, then computes the ground coordinates and finally moves the plotting head to the appropriate point on the new map plot. This complex calculation takes place 50 times a second, which

means that an operator can move his viewpoint around the image model in real time without any noticeable time lag.

Provided that sufficient ground control is available, that attitude variations in the satellite during the seven or so seconds required to expose the image are linear, and that the operator can distinguish ground features, the output map is effectively no different from any other small-scale map.

There has, however, been a tendency for satellite data to be oversold in the past. A variety of tests undertaken in universities throughout the world have all indicated better than expected geometric accuracy and fidelity. Few workers like to advertise shortcomings but SPOT does have significant limitations. The 10-m resolution makes positive identifications of features difficult or sometimes impossible. Data when you want and where you want them are difficult to obtain; cloud, mist, dust or operational pressures on the satellite preclude early data acquisition, and digital data are not necessarily any cheaper than air photography. The ambiguities in identification require more ground effort to confirm detail and to show the necessary classifications which help to make the topographic map usable. The greatest savings appear to be in plotting and computing times and, of course, the obtaining of data where local political pressure would preclude normal air-photo sorties. Data acquired from space will not revolutionize mapping but will help it to evolve. The Directorate regards this new data source as just that, another data form, with associated techniques and tools to help in producing an often underrated but vital value-added product—a map.

The future for mapping from space seems to be assured. France is planning a continuous SPOT programme into the twenty-first century. The United States has recently announced plans for a 5-m resolution scanner aboard the LANDSAT-6 satellite. Meanwhile the Soviet Union has recently made available, from their KFA-1000 camera, 5-m resolution photographic data. The competition to supply high resolution data from satellites in low orbits appears to be increasing.

The British large-scale map archive is not likely to be updated and revised by satellite data for a long time, if at all; a resolution of at least one metre will be required for that, but it is likely that, even with a complex urbanized landscape, maps at 1:25,000 scale and smaller may be revised from such data sources within the next decade.

The main market for such systems remains in the developing countries where basic topographic archives are so often out of date. It seems ironic that the technology transfer involved in equipping local survey departments in the British Commonwealth over the last two decades can now be seen to leave us essentially as we were when we started. The developed world still has better data, techniques and expertise, the developing countries have the need.

Future developments in mapping systems are likely to revolve around a totally digital approach. Producing film from digital data (and vice versa) tends to degrade the image quality and interpretability, so it makes good sense to keep the data in digital form. Image processing hardware and software is likely to be used more and more in traditional photogrammetry and map compilation. Already it is possible to produce digital terrain models from digital data fully automatically; it can be but a few years before expert systems, artificial intelligence and computer vision systems, at present the subject of research, allow automatic feature recognition, extraction and labelling—in short, totally automated mapping.

This is a time of increasing commercial competitiveness in the mapping field and, indeed, in all types of aid input. With extreme economic pressures, and immediate human need for food, shelter and disaster aid affecting many countries, it is difficult to maintain a proper balance between the supply of such immediate necessities and the maintenance of the accurate geographic information which will underlie

efficient and cost-effective development in the future. Mapping, be it digital or conventional, old-style paper sheets or new-sounding geographical information, must take advantage of all opportunities to supply data more cheaply and more quickly. The use of satellite imagery needs further research and, more important, development before its true place in the cartographers' armoury is determined.

EVALUATION OF DIGITAL LAND-COVER MAPPING OF VIEDMA, ARGENTINA, USING MERGED LANDSAT-TM AND SPOT PANCHROMATIC DATA*

Paper submitted by the United States of America

RÉSUMÉ

En avril 1986, la Commission de cartographie de l'Institut panafricain de géographie et d'histoire a approuvé un projet pilote visant à évaluer les applications cartographiques des données de télédétection. Ce projet, proposé par le Groupe de travail des applications cartographiques de la télédétection, a été exécuté en collaboration avec le Service géologique des Etats-Unis (United States Geological Survey) et l'Instituto Geográfico Militar de Argentina. La zone retenue pour l'étude, Viedma, se trouve à l'intérieur du nouveau district métropolitain proposé par l'Argentine, en bordure du Rio Negro près de la côte atlantique, à 806 kilomètres au sud-ouest de Buenos Aires.

Le projet pilote comporte deux parties : a) une photocopie au 1/50 000 combinant les données de l'instrument de cartographie thématique (TM) de LANDSAT (résolution de 30 mètres) et les données panchromatiques de SPOT (Système probatoire d'observation de la terre) [résolution de 10 mètres]; b) la cartographie numérique de l'occupation des sols combinant les données LANDSAT-TM et SPOT. Le but du document est de présenter les résultats de l'évaluation de la deuxième partie du projet. Les résultats de la première partie ont été décrits en novembre 1987.

Plusieurs méthodes de traitement et de classification des données ont été utilisées dans cette entreprise aux fins de comparaison. L'exactitude des résultats a été évaluée en comparant le produit de la classification numérique de l'occupation des sols avec les cartes existantes, les photographies aériennes et les échantillons prélevés sur le terrain.

On n'a pas tout à fait réussi à classer les catégories d'occupation des sols de niveau II et de niveau III par les techniques numériques, ce qui donne à penser que la photo-analyse des données LANDSAT-TM et des données SPOT panchromatiques pourrait être plus utile pour la cartographie de l'occupation des sols ou d'autres applications thématiques, où les détails sont essentiels.

RESUMEN

En abril de 1986, la Comisión de Cartografía del Instituto Panamericano de Geografía e Historia aprobó un proyecto experimental cuyo objeto era evaluar y demostrar las aplicaciones para la cartografía de los datos obtenidos mediante teleobservación. Este proyecto, que fue propuesto por el Grupo de trabajo sobre la aplicación de la teleobservación a la cartografía, se ejecutó con la cooperación de la Dirección de Levantamientos Geológicos de los Estados Unidos de América y el Instituto Geográfico Militar de la Argentina. La zona seleccionada para el estudio, Viedma, se encuentra en el distrito de la nueva capital propuesta para la Argentina, y está situada junto al Río Negro y cerca de la costa atlántica, a 806 kilómetros al sudoeste de Buenos Aires.

El proyecto experimental constó de dos partes: a) Trazado de mapas mediante imágenes a una escala de 1:50.000 utilizando una combinación de datos pancromáticos de 30 metros de cartógrafo temático (TM) del LANDSAT y datos pancromáticos de 10 metros del sistema SPOT (Sistema Experimental de Observación de la Tierra), y b) Trazado digital de mapas de la cubierta de la tierra utilizando una combinación de datos del TM del LANDSAT y datos del SPOT. En noviembre de 1987 se informó de los resultados de la primera parte, a saber, el trazado de mapas mediante imágenes.

* The original text of this paper, prepared by Richard D. Sanchez, United States Geological Survey, appeared as document E/CONF.81/L.26. The use of trade names and trade marks is for descriptive purposes only and does not constitute endorsement by the United States Geological Survey.

Para fines de comparación, en el trazado de mapas de la cubierta de la tierra se utilizaron varios métodos de procesamiento y clasificación de datos. Los resultados se evaluaron para determinar la exactitud de la interpretación comparando la clasificación digital de la cubierta de la Tierra con los mapas existentes, fotografías aéreas y muestras tomadas sobre el terreno.

Los intentos de clasificar tipos de utilización de la tierra y de la cubierta de la tierra de nivel II y nivel III mediante técnicas digitales no fueron totalmente exitosos, lo que indica que tal vez sea más útil utilizar el análisis mediante interpretación visual de las imágenes obtenidas con una combinación de datos pancromáticos del TM del LANDSAT y datos pancromáticos del SPOT en el caso del trazado de mapas de la cubierta de la tierra u otros mapas temáticos que imprescindiblemente deben presentar detalles.

SUMMARY

In April 1986, the Commission on Cartography of the Pan American Institute of Geography and History, approved a pilot project to evaluate and demonstrate the cartographic applications of remote sensor data. This project, which was proposed by the Working Group on Carto-Application of Remote Sensing, was implemented with the cooperation of the United States Geological Survey and the Instituto Geográfico Militar de Argentina. The selected study area, Viedma, falls within the proposed new capital district of Argentina and is located along the Río Negro near the Atlantic coast, 805 kilometres south-west of Buenos Aires.

The pilot project consisted of two parts: (a) image mapping at 1:50,000 scale using merged LANDSAT Thematic Mapper (TM) 30-metre, and SPOT (Système probatoire d'observation de la terre) 10-metre, panchromatic data; and (b) digital land cover mapping using merged LANDSAT-TM and SPOT data. The purpose of this paper is to present the evaluation results of the second part of the project. The results of the first part, image mapping, were reported in November 1987.

Several data processing and classification methods were applied in the land cover mapping effort for comparative purposes. The classification results were evaluated for interpretation accuracy by using existing maps, aerial photographs, and field sampling.

Attempts to classify Level II and Level III land use/land cover categories by digital techniques were not completely successful, which suggested that visual image interpretation analysis of merged LANDSAT-TM and SPOT panchromatic data may prove more useful for land cover mapping or other thematic applications where detail is essential.

In April 1986, the Working Group on Carto-Application of Remote Sensing, under the auspices of the Pan American Institute of Geography and History, and in cooperation with the United States Geological Survey and the Instituto Geográfico Militar of Argentina, began a two-part project to evaluate the use of remote sensing technology for mapping in Latin America. Results of the first part of the project, mapping of the Viedma area in Argentina at 1:50,000 scale, using merged LANDSAT-TM 30-metre and SPOT 10-metre panchromatic data, were presented in November 1987 at the SPOT International Colloquium in Bogotá, Colombia (Sánchez, 1988). The second part of the project, digital land cover mapping, using merged LANDSAT-TM and SPOT panchromatic data, is now complete and the results are presented in this paper.

The objective of this part of the project was to evaluate the suitability of merged LANDSAT-TM and SPOT panchromatic data for digital land cover mapping. To meet this objective, a digital classification analysis was conducted with TM and SPOT panchromatic data acquired over the study site in June and July 1986 (figure 1).

For this study, 20 Level II and Level III land use/land cover classes (table 1) were identified for analysis of an 11×12-km area centred within the new proposed federal district.

Several data processing and classification techniques were applied for comparative purposes. Training samples of the field were selected using polygon selection from the image display and unsupervised clustering of groups of pixels in the image. The polygon-collected samples were classified with two different algorithms: minimum distance and maximum likelihood. The clustering training samples were input only to the minimum distance classifier.

The two land cover classification algorithms were applied to a TM and SPOT panchromatic data set. Prior to classification, the data set was registered using photo-identified ground control points to a 10-metre Universal Transverse Mercator (UTM) grid and resampled by a cubic convolution algorithm before being merged, using intensity-hue-saturation (IHS) conversion. The computer processing and classification of the data set were performed using the ERDAS Primos and stand-alone systems.

The results were evaluated for interpretation accuracy by comparing the digital land cover classification output with existing maps, aerial photographs and field samplings. In the field, spectral measurements taken with a MK-I hand-held radiometer with spectral filters that correspond to LANDSAT bands 1, 2, 3, 4, 5 and 7 were used to verify tonal/spectral anomalies and to identify sources of

Figure I. Satellite image map coverage and location diagram

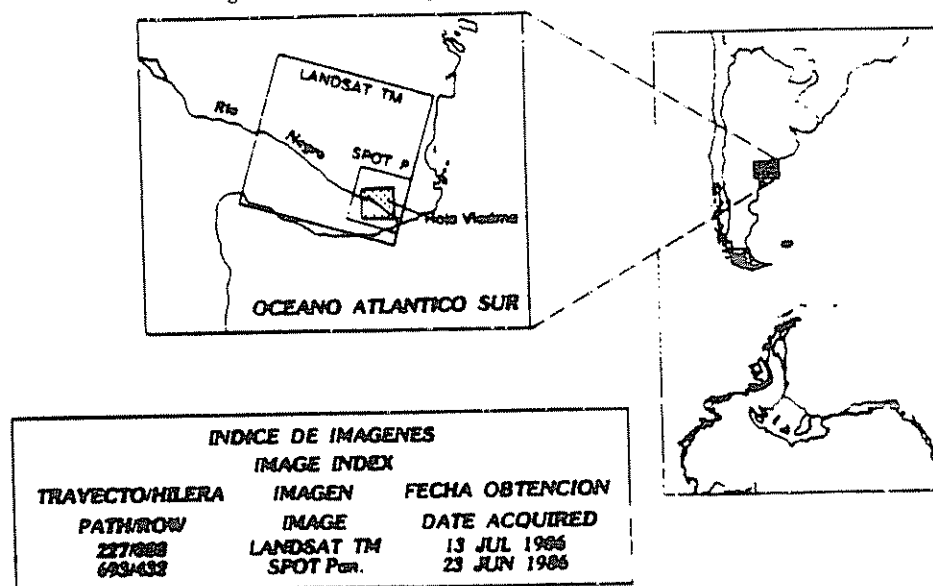


TABLE 1. LAND COVER CLASSES IDENTIFIED FOR STUDY

<i>Urban or built-up land (1)</i>	
11	Residential
12	Commercial and services
121	Commercial
122	Institutional
13	Industrial
14	Transportation, communications, and utilities
141	Road, highway, railroad
142	Utilities
17	Other urban or built-up land
171	Improved open space; includes soccer fields, cemeteries, parks
172	Unimproved open space; includes brush land
<i>Agricultural land (2)</i>	
21	Cropland and pasture
22	Orchards, groves, and garden areas
23	Confined feeding operations
<i>Rangeland (3)</i>	
31	Herbaceous rangeland
32	Shrub and brush rangeland
33	Mixed rangeland
<i>Forest land (4)</i>	
41	Deciduous forest land
42	Evergreen forest land
43	Mixed forest land
<i>Water</i>	
51	Rivers, streams, and canals
<i>Barren land (7)</i>	
75	Quarries and gravel pits
76	Transitional areas

Source. Anderson and others, 1976

error. Spectral measurements were taken of 15 major land cover types.

DESCRIPTION OF STUDY AREA

The land cover classification study area encompasses approximately 132 square kilometres and is situated along the Río Negro near the east central coast of Argentina. It lies within the portions of a 216-sq.-km area which is proposed as the new national capital site of Argentina (figure II). The towns of Viedma and Carmen de Patagones are within the

planned federal district and have a combined population of 50,000. The terrain in the area is gently rolling with the exception of the river valley, which is a flat flood plain bounded by steep escarpments. The dominant land use is ranching and farming. Much of this transitional Pampa-Patagonia region is native grassland characterized by short to medium grasses and low shrubs and brush. Vegetation growth in the area begins relatively early in the austral spring (September). The grasses have adapted to summer drought by early dormancy, and by the end of January most of the vegetation may be dry. The amount of forage on the rangelands may vary significantly, depending on the productivity of the site and seasonal precipitation. Orchards, groves, and gardens flourish along the Río Negro flood plain, where irrigation aqueducts provide water, and rows of poplar trees provide protection from strong winds.

METHODOLOGY

Source data

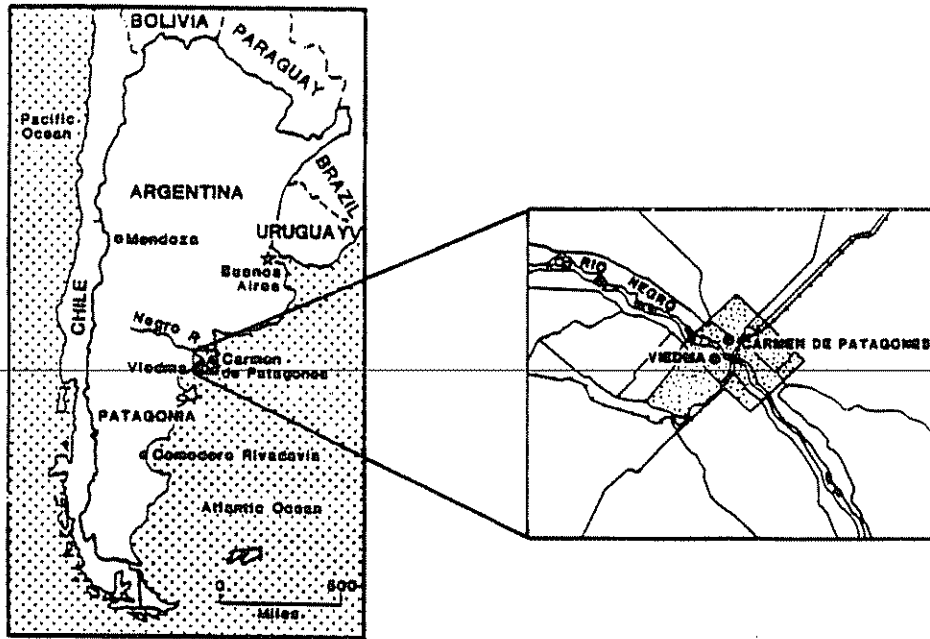
The TM imaging system onboard LANDSAT-5 collected the area data on 13 July 1986. The SPOT panchromatic data was collected over the same area on 23 June 1986. Parameters for these data acquisitions are shown in figure I and table 2. The finer resolution element of the SPOT 10-metre panchromatic data was selected for integration with the TM data to improve the interpretability of the imagery. The system-corrected LANDSAT-TM and SPOT panchromatic digital data (1B processed) were acquired without registration and resampling to the map reference. Prior to using the SPOT panchromatic data, enhancement was required because of an excessive amount of vertical striping.

TABLE 2. LANDSAT-5 THEMATIC MAPPER AND SPOT-PANCHROMATIC PARAMETERS

	LANDSAT-TM	SPOT-Pan
Date collected	13 July 1986	23 June 1986
Altitude	705 km	832 km
Swath	185 km	60 km
Resolution	30 m	10 m

Control point selection, geometric registration, IHS transformation, and enhancement of the merged LANDSAT-TM and SPOT-panchromatic data set for the production of the

Figure II. Location of study area and proposed new federal district (shaded area).



1:50,000-scale image map of the Viedma area were performed by the United States Geological Survey at its Sioux Falls, South Dakota, facility. For comparison, a second merged output data set was produced using ERDAS software at the Geological Survey's offices in Reston, Virginia. In this second data set, registration of the TM and SPOT-panchromatic to the 1:50,000-scale map reference involved selecting 12 well-distributed photo-identified control points in the images and correlating their X,Y coordinates to UTM coordinates (eastings, northings). These points were used in a least-square analysis to derive a first-order polynomial transformation of both images (SPOT-panchromatic and TM band 4) to 10-metre resolution, with root-mean-square residual errors of 1.0 pixels. After the fit between the two images was verified, the full three-band TM files (TM band combinations 2, 3, and 4, and 3, 4, and 5) were resampled to 10-metre resolution by using a cubic convolution algorithm to produce the final registered TM file. The merging of the data set was accomplished by converting the red, green, blue (RGB) channels of the TM file to IHS, substituting the SPOT panchromatic channel for the intensity channel, and then converting the resulting IHS back to RGB (Haydn and others, 1982). The following ERDAS expression sets were used for the conversions:

RGB TO IHS	IHS TO RGB
1 intens (x3, x2, x1)	ihs2red (x4, x2, x3)
2 hue (x3, x2, x1)	ihs2grn (x4, x2, x3)
3 satur (x3, x2, x1)	ihs2blu (x4, x2, x3)

where TM bands become variable x1, x2, x3 on the RGB to IHS pass and SPOT panchromatic become variable x4 on the IHS to RGB final run.

The inability of ERDAS software to stretch or match the histograms of the single SPOT image and the intensity channel of the IHS image resulted in an output image with poorer colour resolution than the data set produced in part I of the project. (This should be resolved with the release of the HSTMATCH program by ERDAS)

The ground control data supplied by the Instituto Geográfico Militar of Argentina were based on the Gauss-Kruger

projection and the Campo Inchauspe 1969 datum. Before use in the geometric registration of the images to the study area, several computation steps were required to transform the control to the UTM plane coordinate system (Zone 20) and the South American datum of 1969.

Training sample selection

Training samples for use in classifying the spectral data were selected by two methods:

(a) Supervised polygon selection (FIELD), where training samples are outlined on the image display in polygon form using the joystick or cursor keys;

(b) Unsupervised clustering (CLUSTER), where the computer automatically builds clusters (groups of points in spectral space) that become the signature used to assign classes.

Supervised polygon selection. Utilizing the FIELD program, training samples were outlined on the image display in polygon form using the joystick. The spectral statistics within each polygon were made as homogeneous as possible. To verify the homogeneity of each polygon outline and outlying matching areas, signature statistics, histograms, and "quick alarms" were used. In the selection of areas falling within the desired land cover or land use classes (except the urban area), relatively small values in the standard deviations and co-variance matrices were obtained. Most samples were located in areas of known land cover types. The value of the resultant training set of signatures was examined prior to performing the actual classification by using scattergram or ellipse plots and contingency matrices.

Unsupervised clustering. In contrast with the supervised polygon selection, the unsupervised clustering required only the minimal amount of input of specifying several statistical parameters. The first of the two pass modes of the CLUSTER program through the entire data set sequentially built 27 clusters, or groups of points in spectral space. These clusters became the signatures used to assign classes in the output file.

Pattern recognition

The spectral signatures developed for each data set were used to perform a pixel-by-pixel classification of the multi-spectral data with two spectral pattern recognition algorithms: minimum distance and maximum likelihood.

During the application of the above techniques, probability files of the distance values of pixels associated with each class identified by the classifiers were saved. These files were used for refining the classifications by screening out pixels that did not meet a confidence level or threshold value of 20 per cent. The final supervised classification results provided six major land cover classes (table 3).

TABLE 3. DIGITAL LAND COVER CLASSES OF VIEDMA AREA

Class names/Code	Land cover type
Urban or built-up land (1)	Consists of business district, paved areas, parks, residential areas, churches, warehouses, hospitals, junk yards, unimproved open space and other structures typical of small towns
Agricultural land (2)	Consists of ploughed stubble, harvested or fallow land, bare ground
Rangeland (3)	
31 Herbaceous rangeland	Dominant land cover consists of short and medium native or prairie grasses
33 Mixed rangeland	Dominant land cover consists of mixed sparse native or prairie grass, shrubs and brush
Forest land (4)	
43 Mixed forest land	Dominant land cover consists of mixed deciduous and coniferous trees
Water	
(5)51 Rivers, streams and canals	Río Negro is the dominant feature, with minor streams and aqueducts

Source: Modified from Anderson and others, 1976

In the second pass mode of the CLUSTER program, each pixel in the data set was classified according to the minimum distance classifier. The algorithm calculated the spectral distance between the candidate pixel and the mean value for every cluster by using the mean values that were computed in the first pass. The pixel was then assigned to the class (cluster) with the minimum or shortest spectral distance. The resultant 27 output clusters were aggregated into the major land cover classes shown in table 3.

Accuracy evaluation

The land cover classification results were reviewed for interpretation accuracy by comparing with the 20 Level II and III categories correctly identified from ground-verification sample points, existing maps and aerial photographs. This interpretation accuracy is defined as the proportion correctly interpreted on the map when compared to the ground truths established from the above sources (Sturdevant, 1981). To obtain the ground-verification sample points, a set of 104 grid-line intersections (sample points) was randomly selected, plotted on the 1:50,000-scale colour image map of the area, and then visited in the field. The field visits consisted of locating each point and noting the land cover for that area. Using the overlay capability of the image processing system, the land cover classes were overlaid on the unclassified image and compared with all the available ground truth information. Compared to ground truth the resultant map accuracy was about 50 per cent (sampling error of ± 5 per cent). With the land cover class data aggregated to provide the six major categories in table 3, the overall interpretation accuracy rose to 90 per cent.

RESULTS AND DISCUSSION

The evaluation of the 20 Level II and Level III classes revealed that the digital classification results were heavily biased by the inability to identify many of the Level II and all of the Level III classes in the merged data set. Consequently, only six major land cover classes were generated.

Results of the supervised and unsupervised classification methods showed significant differences. The only class where there was general agreement was water. The classifications showed large discrepancies for urban and open space. The unsupervised classifier was unable to distinguish separate classes for agricultural lands and rangelands, and misclassified many pixels representing rangeland as forest. For both classifiers, barren land (in transition to unimproved open space) within the flood plain south of Viedma was misclassified as agricultural land because of spectrally similar signatures. This misclassification is attributed to seasonal changes during the southern hemisphere winter (July) when most agricultural land is either ploughed stubble or bare ground.

A comparison of the classified land cover maps produced by the supervised classifier showed there were no major differences in the accuracy of classification between minimum distance and maximum likelihood. The computer processing of minimum distance classification, however, proved to be more time efficient. Prior to classification, locating photo-identified control points on the image for registration and resampling to the map reference were much easier on the 10-metre SPOT panchromatic data than on the 30-metre LANDSAT-TM data.

The methodology employed in this investigation yielded digital land cover classes with insufficient detail to be of use in most thematic studies. A preliminary visual analysis of the merged TM and SPOT-panchromatic image yielded a higher number of land cover classes, especially in urban areas. Consequently, it would appear that a more efficient method for land cover mapping using the merged data set may be by means of visual image interpretation.

RECOMMENDATIONS

Several factors may have contributed to the low number of classes and accuracies in this study. In particular, the date of coverage of the LANDSAT and SPOT image data (selected primarily because they were the only cloud-free-system-corrected data available at the time) was not optimum. The low sun illumination and austral winter season, as well as the date of the ground truth collection, may have affected the level of class identification and accuracy.

If the evaluation of digital land cover mapping were to be repeated, improvement could be realized by acquiring source data with more temporal commonality. Additional improvement may be realized by maximizing the amount of information contained in a LANDSAT-TM three-band combination and minimizing the information lost by absence of the other three TM bands by using selective principal component analysis (Chávez and Howell, 1984). These improvements would facilitate comparative evaluation of the potential and the advantages of the spectral resolution of LANDSAT-TM bands combined with 10-m spatial resolution of SPOT panchromatic data for thematic mapping.

Follow-up studies are recommended to determine the potential of merged LANDSAT-TM and SPOT panchromatic data or compilation of thematic maps depicting Level II and Level III land cover categories using visual image interpretation techniques. Consideration should also be given to

the investigation of merged image and map data sets for change detection and map revision at 1:50,000 scale.

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(d) Hydrographic surveying and nautical charting

ACTIVITIES OF THE INTERNATIONAL HYDROGRAPHIC ORGANIZATION*

Paper submitted by the International Hydrographic Organization

RÉSUMÉ

Depuis la troisième Conférence cartographique régionale des Nations Unies pour l'Amérique, l'OHI a fait paraître plusieurs publications nouvelles ou mises à jour. On en trouvera la liste dans le "Catalogue des publications de l'OHI" (PPO4), publié tous les ans et que l'on peut se procurer gratuitement, en anglais et en français, en s'adressant à I. H. Bureau, B P 445, MC 98011 Monaco Cedex, Principauté de Monaco. Les documents dont l'intitulé suit présentent un intérêt particulier pour les cartographes :

- MP 004 Critères pour l'établissement des cartes de l'OHI; publication à feuillets mobiles en anglais, espagnol et français contenant les spécifications, les symboles convenus et les abréviations à utiliser par tous les Etats membres de l'OHI qui produisent des cartes.
- MP 005 Standards of Competence for Hydrographic Surveyors [Normes de compétence des spécialistes des levés hydrographiques], cinquième édition (1987)
- MP 009 Catalogue of Agents for Sale of Charts worldwide [Catalogue des points de vente de cartes dans le monde] (janvier 1989)
- SP 52 Draft specifications for Electronic Chart Display and Information Systems (ECDIS) and appendix — Updating the Electronic Chart [Projet de spécifications des systèmes d'affichage de cartes électroniques et d'information (ECDIS) et appendice — mise à jour de la carte électronique].

On peut maintenant se procurer des cartes de tous les océans du monde en deux séries internationales (INT), au 1/3 500 000 et au 1/10 000 000, produites par les services hydrographiques de 17 Etats membres et reproduites par tout Etat membre souhaitant les incorporer à sa série nationale. De nombreux Etats membres ont maintenant commencé à travailler à la production d'une série de cartes INT à moyenne et à grande échelles pour le monde entier. Une fois cette entreprise terminée, tous les navires, quelle que soit leur nationalité, pourront utiliser des cartes produites par une nation — selon les limites et échelles convenues, les données normalisées et les symboles et légendes internationalement admis — reproduites par tout autre nation. A la fin de 1988, plus de 170 cartes avaient ainsi été publiées.

Noms géographiques. La publication de l'OHI, *Index des noms géographiques de détails sous-marins* (BP008, novembre 1988), contient la liste complète des noms figurant sur les cartes INT à petite échelle de l'OHI ainsi que des directives, termes et définitions à respecter dans les nouveaux noms proposés pour des détails découverts dans des zones océaniques. La mise à jour de *Limits of oceans and seas* (SP23), qui est épuisée, ne progresse que lentement.

Enseignement, formation. Un conseil consultatif mixte OHI/FIG se réunit régulièrement pour examiner les normes minimales de compétence des spécialistes des levés hydrographiques et pour examiner les programmes d'étude de divers établissements.

* The original text of this paper appeared as document E/CONF 81/L 7.

d'enseignement et de formation dans le monde entier, des certificats internationaux étant décernés pour les cours jugés conformes aux normes minimales.

RESUMEN

Desde la Tercera Conferencia Cartográfica Regional de las Naciones Unidas para América, en 1985, la Organización Hidrográfica Internacional (OHI) ha publicado varios trabajos, nuevos o actualizados, que figuran en el catálogo anual de publicaciones PPO4 de la OHI, que se puede obtener en forma gratuita en francés e inglés en el I. H. Bureau, BP 445, MC 98011 Mónaco Cedex, Principado de Mónaco. Las siguientes publicaciones revisten especial interés para los cartógrafos:

- MP 004 *Especificaciones de la OHI* para los mapas hidrográficos, en español, francés e inglés, en carpetas de hojas sueltas, donde figuran especificaciones, abreviaturas y símbolos aceptados para que lo utilicen todos los Estados miembros de la OHI que elaboren mapas hidrográficos.
- MP 005 *Normas de competencia para los cartógrafos*, quinta edición, 1987.
- MP 009 *Catálogo mundial de representantes de venta de mapas hidrográficos*, enero de 1989.
- SP 52 *Proyecto de especificaciones para la representación visual de los mapas electrónicos y sistemas de información (ECDIS)* y apéndice—Actualización de las mapas electrónicos.

Actualmente, todos los océanos del mundo figuran en dos conjuntos de mapas internacionales a escala de 1:3.500.000 y 1:10.000.000, confeccionados por las oficinas hidrográficas de 17 Estados miembros y reproducidos por cualquier otro Estado miembro que desee incluirlos en sus series nacionales. Se ha iniciado ahora la confección, por muchos Estados miembros, de un conjunto mundial de mapas internacionales a escala media y grande que, cuando estén completos, permitirán a todos los barcos de cualquier nacionalidad utilizar mapas confeccionados por una nación—de acuerdo con límites y escalas convenidos, con un contenido estándar y con símbolos y descripciones internacionalmente comprendidos— y reproducidos por cualquier otra nación. A finales de 1988 se habían publicado más de 170 mapas de ese tipo.

Nombres geográficos. *Gazetteer of Geographical Names of Underseas Features*, publicación de la OHI (BP008, noviembre de 1988). Contiene una lista completa de todos los nombres que figuran en los mapas internacionales de pequeña escala de la OHI, junto con las directrices, términos y definiciones que han de seguirse al proponer nombres para los nuevos accidentes topográficos descubiertos en los océanos. Sólo lentamente ha sido posible avanzar con la actualización del SP23, "Límites de los océanos y los mares" (SP23), que está agotado.

Educación, formación. Una junta consultiva mixta OHI/FIG se reúne regularmente para examinar las normas mínimas de competencia para los cartógrafos y revisar los programas de estudios presentados por diversas instituciones mundiales de formación y educación. La Junta otorga certificados internacionales a los cursos que, a su juicio, cumplen las normas mínimas.

SUMMARY

Since the Third United Nations Regional Cartographic Conference for the Americas was held in 1985, IHO has issued several new or updated publications. These are listed in the annual "Catalogue of IHO publications" (PP04), which is available, gratis, in English and French, from the International Hydrographic Bureau, BP 445, MC 98011 Monaco Cedex, Principality of Monaco. Of particular interest to cartographers are the following:

- MP004 *Chart Specifications of the IHO*, in English, French and Spanish, in loose-leaf binders. Gives specifications, agreed symbols and abbreviations to be used by all chart-producing IHO member States.
- MP005 *Standards of Competence for Hydrographic Surveyors*, 5th Edition (1987).
- MP009 *Catalogue of Agents for Sale of Charts World-wide*. January 1989.
- SP52 *Draft Specifications for Electronic Chart Display and Information Systems (ECDIS)*, with appendix. Updates the electronic chart.

Complete coverage of the world's oceans is now available in two sets of international (INT) charts, at 1:3,500,000 and 1:10,000,000 scales, produced by the hydrographic offices

of 17 member States and reproduced by any other member wishing to include them in its national series. Work has now started on the production, by many member States, of a world-wide set of medium- and large-scale INT Charts which, when completed, will allow all ships of whatever nationality, to use charts produced by one nation — to agreed limits and scales, with standard contents and internationally understood symbols and legends — and reproduced by any other nation. By the end of 1988, over 170 such charts had been published.

Geographical Names. IHO publication *Gazetteer of Geographical Names of Under-seas Features* (BP008, November 1988) contains a complete list of all names appearing in the IHO small-scale INT Charts together with guidelines, terms and definitions to be followed in proposing new names for features discovered in ocean areas. Slow progress only has been possible with updating "Limits of oceans and seas" (SP23), which is out of stock.

Education, training. A Joint IHO/FIG Advisory Board meets regularly to consider the minimum standards of competency for Hydrographic Surveyors and to review the syllabi submitted by various world-wide training/educational institutes, awarding international certificates to those courses which are judged to meet the minimum standards.

Since the Third United Nations Regional Cartographic Conference for the Americas was held in 1985, the International Hydrographic Organization (IHO) has issued the following new or updated publications. They are available from the International Hydrographic Bureau, B.P. 445, MC 98011 Monaco Cedex, Principality of Monaco.

MP004 *Chart Specifications of the IHO* Regulations of the IHO for international (INT) charts, INT Charts 1, 2 and 3.

These give the specifications for compiling nautical charts together with agreed symbols and abbreviations, which have been adopted for general use by member States, and the regulations that control agreements for the production and printing of INT Charts. Issued in six sections, i.e. Section 100, General; Section 200, Format, Positions, Compasses; Section 300, Topography; Section 400, Hydrography and Navigational Aids; Section 500, Geographic Names, Lettering, Numerals; Section 600, Latticed Charts. All sections of the "Specifications and Regulations" are in the process of being reissued in loose-leaf format, in English, French and Spanish.

INT Charts 1, 2 and 3 demonstrate how the "Specifications" can be put into effect by providing examples of the various cartographic features.

MP005 *Standards of Competence for Hydrographic Surveyors*, 5th edition (August 1987). See under agenda item 6(e).

MP006 Reference texts for training of hydrographic surveyors (Bibliography). See under agenda item 6 (e).

MP008 *Chart symbols and abbreviations* List of sheets published by various maritime countries, 6th edition (November 1987) English/French.

This list aims to keep member States and users informed of the most recent sheets published by the various chart-producing maritime States.

MP009 *Catalogue of Agents for the Sale of Charts*, 4th edition (December 1988) English/French.

Contains details of the cartographic production of each IHO member State as well as the addresses etc. of their chart agents where their charts and nautical publications can be obtained.

MP010 *Catalogue of International Charts at Small Scales*, 7th edition (November 1988) English/French.

Describes, by index, chartlets and texts, the 79 INT Charts at 1:3,500,000 and 1:10,000,000 scales with names of producer and printer nations.

SP44 *IHO Standards for Hydrographic Surveys*. Classification criteria for deep sea soundings; procedures for elimination of doubtful data. 3rd edition (November 1987) English/French.

Chapter 1 provides guidance to hydrographic surveyors relative to the minimum acceptable standards for surveys. Chapter 2 offers a

uniform set of criteria for classifying bathymetric soundings after they have been taken, for record purposes and for the guidance of cartographers, scientists and other users. Chapter 3 provides a basis whereby features charted as "Doubtful" (ED, PD, SD, PA) may be considered as proved to exist or disproved in order that decisive chart action may be taken.

SP50 *Tidal Constituent Bank* Station catalogue, 1st edition,

A catalogue of stations for which tidal constituents are held in the IHO Tidal Constituent Bank by the Canadian Hydrographic Service.

SP51 *Manual on Technical Aspects of the Law of the Sea*, 1st edition (November 1988).

To date, only the first part of this two-part manual has been published: this provides a glossary of technical terms. The second part, to be published at a later date, will provide a discussion of technical applications, including computer programs.

SP52 *ECDIS draft specification* 3rd draft (October 1988).

Following its development of standard specifications for the traditional paper chart and the INT Chart series, the IHO has been involved in evolving draft specifications for a new form of chart medium, namely the video display of electronic chart display and information systems (ECDIS) for the consideration of the hydrographic community, manufacturers and users. This third draft is intended as a guide to manufacturers in the development of equipment and will be supplemented by other guidance in the form of provisional-operation-performance-standards-and-updating-procedures, as experience is gained of this new development. Much of this work is undertaken in concert with IMO.

INT Charts

The small-scale (1:3,500,000 and 1:10,000,000) INT Chart series has been completed by the hydrographic offices of 17 member States. Following their successful completion, work has now started on the production of a complete set of medium- and large-scale charts which will, when completed, allow all ships of whatever nationality to use charts produced by one nation, to agreed limits and scales and with standard contents, and reproduced by any other nation. Regional charting commissions have been asked to produce schemes for their regions and, by the end of 1988, it is anticipated that over 170 such charts will have been published.

IHO CENTER FOR DIGITAL BATHYMETRY

The proposal to establish a world-wide digital data bank of oceanic bathymetry on behalf of the member States of IHO is fully discussed under agenda item 5 (g) below, in the article entitled "Proposal for creating an IHO Centre for Digital Bathymetry" (E/CONF.81/L.9).

GEOGRAPHICAL NAMES (Agenda item 6 (d))

The International Hydrographic Bureau, as the secretariat for the IHO/IOC GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features, has continued to process proposed names for undersea features received from national institutions, hydrographic Offices and individuals for approval by the Sub-Committee. There has been encouraging reaction by scientists and others to a widely published article by Dr. Robert L. Fisher, Chairman of the Sub-Committee, entitled "A proposal for modesty—naming undersea features".

BP0008 *"Gazetteer of Geographical Names of Undersea Features shown (or which might be added) on the General Bathymetric Chart of the Oceans and on the IHO small-scale INT Chart series"*

The *Gazetteer* was published in November 1988 after approval by the GEBCO officers. The list includes all named underwater features, together with the numbers of the GEBCO and small-scale INT Charts on which they appear (or might appear), as well as an explanation of the terms and definitions used and a list of addresses of the national authorities to which completed proposal forms should be sent. The proposal forms are available, at present, in Arabic, English, French, Greek, Portuguese and Spanish. The publication is bilingual English/French with a cross-reference of a French alphabetical index to the English terms and definitions. A specimen page is attached in the annex.

SP23 *Limits of Oceans and Seas*

The Bureau has re-started work on this publication, which describes the limits of oceans, seas, and main gulfs and straits and which is intended solely for hydrographic purposes. For the time being, SP23 exists only in the form of a "Draft fourth edition" which must be amended as a result of comments received from the IHO member States in reply to the Bureau's circular letter 6/1986. A new circular letter, containing new proposals for the areas under discussion, has been sent to the IHO member States in order to try to resolve some outstanding differences of views. The Bureau hopes to have reached agreement and to have a new fourth edition published in late 1989.

EDUCATION, TRAINING AND RESEARCH (Agenda item 6 (e))

MP005 *Standards of Competence for Hydrographic Surveyors* 5th edition (August 1987).

In 1974, at the XIVth Congress of the International Federation of Surveyors (FIG) in Washington, D.C., it was resolved that the FIG and IHO Working Groups, set up in 1971 and 1972 respectively, should combine to produce joint standard syllabi for the training of hydrographic surveyors. A joint Board was formed with eight members, four nominated by FIG and four by IHO, "being persons of known competence world-wide, in the government, civil and educational sectors of hydrographic surveying". The Board meets at intervals of not more than two years, to review and update the minimum standards of competence for Hydrographic Surveyors, taking into account comments and recommendations received from National Focal Points and other authorities; to review the syllabi submitted by hydrographic offices, institutions and learned bodies, to provide advice and comments on such syllabi by comparison with the recommended minimum standards, and to award certificates of recognition to those institutions whose programmes meet at least the recommended standards.

MP006 Reference texts for training of hydrographic surveyors.

A bibliography in various languages of suitable texts to be used in the training of hydrographic surveyors and to assist them in meeting the course requirements established in MP005.

SP47 *Training Courses in Hydrography and Nautical Cartography*. 3rd edition (September 1988). English/French; Spanish edition in hand.

This new edition provides information on the courses available at educational institutions in member States. It also gives details of technical assistance relating to scholarships/training awards. The importance of nautical cartography is stressed by its inclusion in the title of this third edition and of details provided. A fourth edition will be produced when a sufficient amount of new information becomes available.

SP47 lists the IHO member States offering training in hydrography and nautical cartography, together with the addresses of the Hydrographic Offices to which enquiries should be made for details as to the dates of the next courses. Copies of SP47 are available from the IHB.

Nautical cartography

In order to provide standards for the training of nautical cartographers, a Working Group is about to be formed to lay down minimum standard syllabi for various levels of courses. As cartography is carried out primarily by government organizations, the Working Group will not act jointly with FIG. The Group hopes eventually to produce a publication on the lines of MP005.

TECHNICAL ASSISTANCE (AGENDA ITEM 7)

IHO Information Paper No. 6, "Technical Assistance", November 1987, gives details of arrangements within the IHO for technical assistance in connection with hydrographic surveying and nautical charting. In order to improve the coordination of such technical assistance, a joint FIG/IHO technical assistance coordination committee will be established, with the following terms of reference:

(1) To establish and maintain a full, complete and up-to-date inventory of all hydrographic surveying and nautical charting projects involving technical assistance to developing countries; this includes assistance in the way of academic and on-the-job training of surveyors, cartographers and maintenance staff, provision of expert advice, provision or loan of equipment and projects under consideration, in hand or recently completed; and to distribute such data in a timely fashion to all known interested parties, including international and national organizations and funding agencies, as well as those in the private sector;

(2) To establish procedures for the coordination of all expert advice and other technical assistance involving hydrography and nautical charting to any developing coastal State and subsequently to follow-up all such projects so as to ensure the maximum benefit from them and to avoid nugatory expense and effort by donor countries and/or funding agencies;

(3) To review the status of hydrographic surveying and nautical charting in developing coastal States, on an annual basis; to review the standards of accuracy and validity of data available; to consider the interaction of such standards and validity between coastal, offshore and harbour areas and between differing requirements of safety of navigation, dredging, port and coastal development, offshore exploration

tion and exploitation and environmental protection; and to use this information to advise donor organizations where assistance could be of most benefit and best utilized;

(4) To establish close relationships with international

organizations, such as IMO, IOC, and the United Nations, and with international and national funding agencies, and to promote the provision of financial assistance to hydrographic projects at every opportunity.

ANNEX
Specimen page: *Gazetteer of geographical names
of undersea features (BP0008)*

GEOGRAPHICAL NAMES AND GENERIC TERMS	GEOGRAPHICAL POSITION	REFERENCE		REMARKS (*) Shown in the ACUF/BGN Gazetteer of Und Features
		GEBCO 5th Ed	Small Sc INT Chart	
COLOMBIAN Trench	3°15'N - 78°45'W	5.07		*
COLON Ridge	2°00'N - 96°00'W	5.07		*
COLORADO Seamount	33°15'N - 37°20'N		11-12-14	*
COLUMBIA Seamount	20°45'S - 32°00'W	5.12		*
COLVILLE Ridge	30°00'S - 180°00'	5.10	600-602	*
COMORO Basin	14°00'S - 44°00'E		701-702	*
COMSTOCK Seamount	48°15'N - 156°50'W	5.03	50	*
CONCEPTION Bank	29°55'N - 12°45'W		11-12 14 104	* INT 11-14 = Seamount
CONFANCE Shoal	18°30'S - 152°30'W		606-607	INT 606 = Seamount
CONGO Canyon	5°50'S - 9°20'E	5.12		*
CONGO Cone	6°00'S - 8°30'E	5.12		* = Fan GEBCO = should be Fan.
CONGRESS Seamount	33°07'N - 54°49'W		11-12-13	*
CONRAD Fracture Zone	55°45'S - 3°30'W	5.16		* (June 1987)
CONRAD Rise	53°00'S - 41°00'E	5.13		
(CONSTANTINE Bank)	20°25'S - 171°15'E	5.10		This feature has been canceled by AUS Notice to Mariners 793/1984
COOK Canyon	51°20'N - 128°40'W	5.03		* (June 1984) GEBCO-SCGN/6 (Replaces COOK Trough)
COOK Fracture Zone	26°30'S - 169°00'E to 28°30'S - 179°00'E	5.10		GEBCO-SCGN/7
COOPER Ridge	7°00'N - 149°00'W	5.07		*
CORA DIVH	13°45'N - 72°10'E		71-72-73 705	Bank.
CORAL Basin	13°40'S - 151°20'E	5.10	604	* and INT 604 = CORAL SEA Basin
CORAL PATCH Bank	34°56'N - 11°57'W		103-104	* = Seamount
CORNER Seamounts	35°30'N - 51°30'W	5.08	11-12-13	*

USE OF MULTISPECTRAL IMAGERY IN HYDROGRAPHIC CHART PRODUCTION AND VERIFICATION OF NAVIGATIONAL HAZARDS*

Paper submitted by the United States of America

RÉSUMÉ

On a découvert que les images multibandes étaient très utiles à la Defense Mapping Agency (DMA) dans son programme de compilation de cartes hydrographiques. Le Département des cartes terrestres et marines du Centre d'hydrographie et de topographie de la DMA utilise un système optique de dessins avec rétroprojecteurs et un système récemment acquis de traitement des images, qui lui permettent d'appliquer les toutes dernières techniques pour exploiter les images LANDSAT et d'autres formes d'images multibandes. Les produits venant de ces systèmes servent à l'établissement de cartes des côtes et de graphiques de planification avant les opérations de levés, ainsi qu'à la vérification des dangers à la navigation. Le système aéroporté de levés bathymétriques (ABS), mis au point par l'Agence navale de recherche-développement océanographique, qui doit être exploité par le Bureau naval d'océanographie (NAVOCEANO) en 1989, rassemblera les données multibandes et les sondages par laser et fournira l'élément numérique du système de traitement des images au Centre d'hydrographie et de topographie.

RESUMEN

Las imágenes multiespectrales han resultado de utilidad en apoyo del programa de levantamiento de cartas hidrográficas del Organismo Cartográfico de la Defensa. El Departamento de Levantamiento de Mapas y Cartas del Centro Hidrográfico-Topográfico del Organismo Cartográfico de la Defensa utiliza un sistema de trazado óptico de proyección por transparencias y un sistema de procesamiento de imágenes recientemente adquirido para contar con las técnicas más avanzadas de explotación de las imágenes del LANDSAT y otras formas de imágenes multiespectrales. Los productos de estos sistemas se utilizan en apoyo del levantamiento de mapas de las zonas costeras, para gráficos de planificación previa a los levantamientos y para la verificación de los peligros para la navegación. El sistema de levantamientos batimétricos aerotransportados, elaborado por la Dirección Naval de Actividades de Investigación y Desarrollo Oceánicos y que pondrá en explotación la Oficina Oceanográfica Naval (NAVOCEANO) para 1989, reunirá datos multiespectrales y sondeos mediante láser y producirá entradas digitales al sistema de procesamiento de imágenes del Centro Hidrográfico-Topográfico.

SUMMARY

Multispectral imagery has been found to be useful in support of the hydrographic chart compilation programme at the Defense Mapping Agency (DMA). The Mapping and Charting Department of the Hydrographic/Topographic Center of DMA utilizes a rear-projecting optical drafting system and a recently procured image processing system to provide state-of-the-art exploitation of LANDSAT and other forms of multispectral imagery. Output from these systems is used to support production of coastal charts, combat charts, and pre-survey planning graphics and for verification of navigational hazards. The Airborne Bathymetric Survey (ABS) system, developed by the Naval Ocean Research and Development Activity, which is to be put into operation by the Naval Oceanographic Office (NAVOCEANO) by 1989, will collect multispectral data and laser soundings and provide digital input to the image processing system at the Center.

* The original text of this paper, prepared by Leslie A. Manfull and Stephen D. Zupko, Defense Mapping Agency, appeared as document E/CONF.81/L.21

The Hydrographic/Topographic Center of the Defense Mapping Agency is responsible for providing information for the navigational safety of ships of the United States Navy and of mariners in general on a world-wide basis. This responsibility is carried out by disseminating information to navigators via nautical charts, navigation publications, and daily radio navigation warnings. Failure to make use of available data when compiling these products and services may adversely affect the safety of lives and property at sea. Consequently, new information sources are constantly being reviewed to aid the Center in fulfilling its mission. Multispectral imagery, if recorded in specific spectral bands, is one such data source. It has proven to be a useful addition to other source material in the compilation of nautical charts and also in the detection and verification of navigational hazards.

MULTISPECTRAL IMAGERY BACKGROUND

Multispectral imagery is imagery of any area that is obtained simultaneously in a number of discrete bands of the electromagnetic spectrum. Two important characteristics of multispectral imagery make it useful for hydrographic applications. First, multispectral imagery has the unique ability to penetrate the water's surface and show bottom features. This becomes especially useful to the chart compiler in shallow ocean areas. Second, multi-temporal coverage—imagery taken of the same area at different times—makes it possible to detect dynamic changes and increases the possibility of obtaining cloud-free and turbid-free coverage. Under ideal conditions (i.e. clear water with no surface effects), depths of 40 metres have been determined.

With the development of the airborne bathymetric survey (ABS) system, multispectral imagery (calibrated with laser soundings) will soon be used for surveying coastal regions, providing full coverage of the area if necessary. The laser sounder will be the primary sensor, measuring depths up to 30 metres (depending upon water clarity) with approximately 10 metres between the soundings. Owing to data-processing limitations, however, the multispectral data will be processed only as needed to locate coastlines, identify surface features, verify unusual laser soundings, analyse submerged features etc. Positioning will be derived from Global Positioning System (GPS) data.

At present, the Center primarily uses LANDSAT imagery. Recent LANDSAT satellites have carried a thematic mapper sensor that measures reflected radiation in seven spectral bands with a spatial resolution of 30 m. Thematic mapper imagery is preferred over multispectral scanner imagery in the chart-making process because of its improved spatial resolution—also because it provides imagery in two deep-water sensing bands (up to 40 m) instead of one as in the multispectral scanning, yielding greater spectral resolution. The multispectral scanner in the ABS system is based upon the thematic mapper design, providing a resolution of 1 m when flown at an altitude of 500 m. Soon, the Center will begin to process European SPOT data, too, providing a resolution of about 10 m.

THE KRONES LZK REMOTE SENSING SYSTEM

The KRONES LZK is a rear-projecting optical system which is used to enlarge analog data for compilation of coastlines and navigational hazards, at 1:200,000 and smaller scales, and to assess imagery for use on the second image processing system at larger scales.

The system consists of the structural frame, projector system, calibration device, a large mirror and projection

screen. Analog data is placed on the projector surface and a map or manuscript containing a minimum of four near-nadir control points at the desired scale is secured on the projection screen. The projector is then scaled and focused so that the image fits the control points. Data can then be compiled on a clear overlay placed on the projection screen. The product is a compilation manuscript showing shoreline and coastal features, such as reefs and shoals.

The maximum enlargement of LANDSAT data on the KRONES LZK varies with data type and its resolution and is limited to a spatial oblique projection. Generally it is not advisable to compile with the KRONES LZK at scales larger than 1:200,000, although it may be used to inexpensively and quickly assess imagery for possible digital analysis and processing.

SECOND IMAGE PROCESSING SYSTEM

To fully exploit the use of multispectral imagery for the chart-making process, the Mapping and Charting Department of the Center has recently procured its Second Image Processing System (SIPS). It provides the Center with the capability to utilize LANDSAT, SPOT, or other types of digital multispectral imagery to detect, position, and delineate heretofore unknown navigational hazards and to update information relative to known but poorly described or positioned hazards. It has also reduced processing time by about one third owing to its specially designed software.

There were four requirements in the procurement of the SIPS. It had to be able (a) to input LANDSAT multispectral scanner and thematic imagery as well as other remote sensor data; (b) to perform geometric corrections on the input data, and output to any of four map projections; (c) to provide shallow water depth extraction capabilities from LANDSAT imagery; and (d) to perform state-of-the-art image enhancement techniques.

Input capabilities of the SIPS are such that both digital and analog imagery may be accepted. The tape input routine permits the reading of any form of digital raster data as long as the tape format is known. At times it is not possible to attain a computer compatible tape. In this case, the Eikonix photo-digitizing camera is used to scan analog film imagery and transform it into a digital image for further image manipulations. The Eikonix camera also allows for the photo-digitizing of maps and charts, which then can be merged with the multispectral imagery for use in change detection along the shoreline or in the shallow-water area.

With the aid of a digitizing table for the integration of at least four control points, the input imagery can be geometrically corrected and output to a Mercator, Transverse Mercator, Lambert Conformal Conic, or Polyconic projection at scales of 1:50,000 and smaller. An image may also be warped to another image or to a photo-digitized map or chart image. The SIPS employs a polynomial transformation for geometric correction and its accuracy is usually within five metres.

SIPS is capable of many typical image enhancement techniques, including destriping routines, image smoothing, and contrast stretching. These are applied before data processing is undertaken.

A unique characteristic of the SIPS is the software designed specifically to be used with multispectral imagery for hydrographic applications. Utilizing two or more multispectral bands along with the input of a few known depth points, multiple regression techniques can be employed to yield a shallow water depth graphic for a larger area. A less precise technique uses a density slice to predict approximate

depths when there are no known depth points available. A synthetic blue enhancement technique intensifies the value of highly reflective light features which are generally found in shallow areas. This technique is most effective using the MSS bands 4 and 5 or the green and red bands. By combining them and then subtracting the darker band, 5, the lighter features are more apparent and can more easily be interpreted and compiled. Navigational hazards can be detected and verified in this way. The shallow water depth graphic and synthetic blue enhanced image can then be output on paper via an ink-jet plotting system, on film via a laser plotter, or on digital tape.

AIRBORNE BATHYMETRIC SURVEY (ABS) SYSTEM

By 1989, the Naval Oceanographic Office (NAVOCEANO) will be collecting multispectral data along with laser soundings during coastal surveys employing the ABS system.

The ABS system is designed to be flown at 220 knots in a Navy RP-3D aircraft at an operational altitude of 500 m, using GPS navigation. The laser sounder will collect data in a 280-m swath beneath the aircraft over an 8-10 m grid. The multispectral scanner, based upon thematic mapper technology, will collect data over a swath width of up to 570 m, providing full coverage at 1-m resolution (pixel size).

The ABS system will permit rapid survey of a large coastal area, producing a tremendous amount of data that will be stored on high density tape or optical disk. Limited real time processing will allow the operators to monitor data quality in the aircraft, but full processing will be done at NAVOCEANO.

The multispectral hardware will consist of a 9-channel (.45 to 12.5 microns) sensor, signal processor, recorder, video monitor, and power supply. During post processing, depths will be determined from a reflectance model and compared with depths derived from the laser data. A multi-band algorithm will be used to minimize the difficulties encountered due to changes in bottom reflectance and water attenuation. A planned upgrade of the system includes replacing the multispectral sensor with a pushbroom-type scanner.

Development of the multispectral data-processing software is currently focused on providing a rapid qualitative analysis as required, yielding reasonably accurate depth measurements. Eventually, the effort will shift to improving the quantitative capability without incurring the excessive increase in processing time.

APPLICATIONS AT THE DEFENSE MAPPING AGENCY

The aforementioned hardware and software were procured in this configuration for the purpose of supporting four programmes in the Mapping and Charting Department. These four programmes are: Coastal Charts; Combat Charts; support to NAVOCEANO; and Navigational Hazard Verification.

Coastal charts

Every coastal chart produced at the Center, 1:50,000 scale and smaller, has a LANDSAT feasibility performed prior to its compilation. Available LANDSAT imagery is assessed as to its image quality, cloud coverage, and water clarity. If suitable imagery exists, a shallow water depth graphic is produced on the SIPS, depicting shoreline and 2-, 5-, 10- and 20-m depth curves. This becomes a part of the source package, which is forwarded to the compiler.

Combat charts

On combat charts, which have limited use and distribution and are not for navigation, the coastal area is often enhanced with information derived from multispectral imagery. The SIPS will be utilized to exploit LANDSAT imagery to produce four coastal colour bands to be overlaid or printed on combat charts. These four bands correspond to depths of 0-2, 2-4, 4-8, and 8-16. The standard deviation is approximately 10 per cent of depth for multispectral scanner and 5 per cent of depth for thematic mapper imagery. The LANDSAT-enhanced combat chart is intended for planning purposes, not for navigation. It provides depth estimates, identifies hazards, displays overall bottom structure, and identifies areas to focus pre-landing reconnaissance.

Pre-survey planning graphics

It has been determined that approximately 500 ship-years are needed to completely survey the shallow ocean areas of the world required by the DMA. In support of the Center, NAVOCEANO operates two ocean survey vessels. Multispectral imagery is useful in aiding NAVOCEANO in reducing the amount of survey time in certain areas. Pre-survey planning graphics depicting shoreline, shoals, and underwater features are prepared from LANDSAT imagery for areas NAVOCEANO knows they will be surveying. If the planning graphic closely resembles the bottom characteristics of the existing chart of the area, then NAVOCEANO can perform a less extensive survey. If the opposite is true, survey tracks will be positioned so that an extensive survey of the area can be accomplished yet still keep the survey ship out of danger.

Navigational Hazards Verification

In the Navigational Hazards Verification programme at the Center, efforts have been concentrated on developing a quick response to ship reports and radio messages citing a navigational hazard. Analog LANDSAT imagery is inspected, and if the existence of the hazard can be verified, then immediate action is taken to notify all mariners via "Notice to Mariners," and the chart is corrected (James, 1983).

LIMITATIONS

It is important to understand the limitations of multispectral imagery in the chart-making process. Due to the 30-m spatial resolution of the thematic mapper imagery, chart scales which can be supported are 1:50,000 and smaller (Colvocoresses, 1986). ABS data will support large-scale charts in the future.

Major obstacles in shallow water depth determination are the amount of turbidity, or clarity of the water, vegetation and variations in bottom surface reflectance. These dictate the depth that can be ascertained. Multi-date imagery should be obtained to aid the interpreter in overcoming these factors.

CONCLUSION

Multispectral imagery provides a unique capability for the collection of useful data covering shallow sea areas worldwide. Since the Defense Mapping Agency is liable for the information appearing on its published charts, it is imperative that this type of imagery be utilized as a viable piece of source by the chart compiler.

The KRONES second image processing system and the airborne bathymetric survey system compose a state-of-the-

art configuration for the use of multispectral imagery in chart compilation, and verification of nautical hazards at DMA.

DMA hydrographic product currency, accuracy, production costs and efficiency have improved with the use of multispectral imagery and the development of new data collection and processing techniques.

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RECONCILING THE NAVIGATIONAL GRID WITH THE INERTIAL NAVIGATION SYSTEM*

Paper submitted by the United States of America

RÉSUMÉ

Le canevas de navigation, qui est surimprimé sur certaines cartes de navigation et cartes générales à petite échelle publiées par la Defense Mapping Agency, était conçu au départ à l'intention des navigateurs des régions polaires qui utilisent notamment les techniques de navigation astronomique ou de LORAN-C. Le nord du quadrillage leur permettait d'utiliser une direction de référence uniforme et non les méridiens, qui sont convergents. Ce "nord qui ne change pas" ressemble fort à celui que donne un système de navigation par inertie lorsque la plate-forme de niveau local n'est pas couplée (dérive alpha). Mais, très rapidement, les angles directionnels donnés par le système de navigation par inertie divergent nettement de ceux qui sont mesurés sur les cartes.

Le canevas de navigation, très utilisé avant la navigation par inertie, conserve peut-être son utilité. Il pourrait cependant être nécessaire d'utiliser la projection gnomonique pour les cartes marines des pôles et de renoncer à la conformité des projections actuellement utilisées. Comme la navigation par pilotage a perdu de l'importance, il se peut que cela soit moins difficile qu'il n'y paraît. Les navigateurs utilisant les systèmes inertiels préfèrent calculer alpha à l'aide de la formule décrite dans le document. Avec l'introduction des systèmes liés, qui sont équipés d'ordinateurs de navigation très perfectionnés, cela semble chose facile.

RESUMEN

El cuadrículado de navegación superpuesto de ciertas cartas náuticas y de planificación en pequeña escala publicadas por el Organismo Cartográfico de Defensa estaba destinado inicialmente a navegantes de regiones polares que utilizan técnicas como la navegación astronómica y el sistema LORAN-C. El norte del cuadrículado daba al navegante una dirección de referencia uniforme que la permitía prescindir de los meridianos altamente convergentes. El concepto de un "norte invariable" es muy similar al que se aplica en el sistema de navegación por inercia con la plataforma de nivel local no sujeta a rotación (*alpha-wander mode*). Sin embargo, los ángulos direccionales calculados mediante el sistema de navegación por inercia difieren rápidamente de los medidos por medio de las cartas.

El cuadrículado de navegación, sumamente valioso para los navegantes antes de que se utilizara el sistema de navegación por inercia, aún puede ser de gran utilidad. Sin embargo, tal vez haya que elaborar cartas polares en proyección gnomónica y sacrificar la conformidad que caracteriza a las proyecciones actualmente en uso. Como el pilotaje ha pasado a ser una consideración de menor importancia, el hecho de que haya que sacrificar la conformidad tal vez no sea tan negativo como podría parecer en un principio. A nivel de quienes aplican el sistema de navegación por inercia parece aconsejable calcular alfa a partir de la fórmula descrita en la monografía. Gracias a los sistemas móviles (*strapdown*) con computadoras de navegación muy avanzadas, ello parece constituir una tarea mínima.

* The original text of this paper, prepared by Lori D. Wanner and John Hopkins, Defense Mapping Agency Aerospace Center, appeared as document E/CONF 81/L. 23

SUMMARY

The navigation grid overprinted on certain small-scale navigation and planning charts published by the Defense Mapping Agency was originally intended for use in polar regions by navigators utilizing such techniques as celestial navigation and LORAN-C. The use of grid North gave the navigator a uniform reference direction to use rather than the highly convergent meridians. The concept of a "non-changing North" is remarkably like that encountered in an inertial navigation system with the local-level platform untorqued (alpha-wander mode). However, the directional angles computed by the inertial navigation system rapidly diverge from those measured from the charts.

The navigation grid, which was of great use to pre-inertial navigators, can still be of great use. It may be necessary, however, to produce polar charts on a gnomonic projection and sacrifice the conformality inherent in the currently used projections. Since pilotage navigation has become less important a consideration, the sacrifice of conformality may not be as unpalatable as it may seem. In the inertial navigation community it seems desirable to compute alpha from the formula described in the paper. With the advent of strapdown systems with very sophisticated navigation computers, this seems to be a nominal task.

The navigational grid is a rectangular network of straight lines overprinted on navigation and planning charts so that grid North coincides with the northward direction on the Greenwich meridian. It provides a uniform pseudo-North as an azimuth reference, rather than highly convergent meridians. The navigation grid is overprinted on several series of small-scale (1:2,000,000 and smaller) charts, especially those to be used in the polar regions. However, one series, the Global Navigation Chart (GNC, scale 1:5,000,000) series has the overprint on all charts in the series, even those near the equator. The Jet Navigation Charts (1:2,000,000 and 1:3,000,000) have the overprint on those charts covering the continental United States for training purposes. The navigational grid was originally used for celestial navigation and radio aids such as LORAN-C and OMEGA.

Chart-making presents the problem of representing the surface of a spheroid upon a plane surface. The surface of a sphere or spheroid is said to be undeveloped because no part of it can be flattened without distortion.

The desirable properties are:

- (a) True shape of physical features;
- (b) Correct angular relationship: a projection with this characteristic is said to be conformal or orthomorphic;
- (c) Equal area, or the representation of areas in their correct relative proportions;
- (d) Constant scale values for measuring distances;
- (e) Great circles represented as straight lines;
- (f) Rhumb lines represented as straight lines.

It is possible to preserve any one and sometimes more than one property in any one projection, but it is impossible to preserve all of them. For instance, a projection cannot be both conformal and equal area, nor can both great circles and rhumb lines be represented as straight lines.

THE PROBLEM

Subpolar charts use the Lambert Conformal Conic Projection. In this projection, the cone intersects the earth at two standard parallels. The area between the two standard parallels is compressed, and that beyond is expanded. If, in such a projection, the spacing of the parallels is altered so that the distortion is the same along the meridians, the projection

becomes conformal and is known as the Lambert Conformal Conic Projection. It is the most widely used conic projection for navigation, though its use is more common among aviators than mariners. The modified Lambert Conformal Projection is virtually conformal over its entire extent, and the amount of its scale distortion is comparatively little if it is carried only to about 25" or 30" from the pole. Beyond this, the distortion increases rapidly. A great circle is very nearly a straight line anywhere on the chart. The Lambert Conformal Conic Projection portrays longitude in an angle less than true longitude. When a flight crosses the 180° meridian the Inertial Navigation System (INS) doesn't know it is supposed to "flip over", so that alpha angle, or the angle between grid North and true North, just keeps increasing in magnitude instead of changing sign and decreasing.

Polar charts use the Transverse Mercator Projection. A Transverse Mercator Projection is a conformal projection upon a plane. The cylinder is tangent along a meridian. Since the area of minimum distortion is near a meridian, this projection is useful for charts covering a large band of latitude and extending a relatively short distance on each side of the tangent meridian. This projection portrays meridians as slightly curved lines. Therefore, a great circle is actually a curved line on the charts. Alpha angle, measured on the chart, does not agree with the INS, nor does the yaw angle, the angle between grid North and the path frame measured clockwise, as measured on the chart.

These problems should be brought to the attention of the inertial navigation community so that the systems and programmes which emulate systems can be modified.

OBSERVATIONS

Investigation was made of 11 flight tracks, selected to cover several conditions: hemisphere considerations, crossing of the 0° and 180° meridians, and polar and subpolar regions. Two projections were investigated, the subpolar Lambert Conformal Conic, with the standard parallels chosen to give the least deviation from true scale over the chart, and the Polar Transverse Mercator with the true scale on 90°E and 90°W.

The following formulas show how the Navigation Frame Heading Angle, alpha, is computed. Alpha is measured counterclockwise from true North.

Lambert Conformal Conic Projection:

$$\sin \phi_0 = \frac{\ln N_1 \cos \phi_1 - \ln N_2 \cos \phi_2}{\ln \tan(45^\circ - \frac{1}{2} \phi_1) \left(\frac{1 + \epsilon \sin \phi_1}{1 - \epsilon \sin \phi_1} \right)^{\frac{1}{2} \epsilon} - \ln \tan(45^\circ - \frac{1}{2} \phi_2) \left(\frac{1 + \epsilon \sin \phi_2}{1 - \epsilon \sin \phi_2} \right)^{\frac{1}{2} \epsilon}} \quad (1)$$

where ϕ_1 = upper standard parallel
 ϕ_2 = lower standard parallel
 $\epsilon = e$ = eccentricity of reference ellipsoid
 $N_i = a/(1 - e^2 \sin^2 \phi_i)^{1/2}$
 a = semimajor axis of reference ellipsoid

Then $\alpha = -\lambda \sin \phi_0$ in the Northern Hemisphere (2)

$\alpha = \lambda \sin \phi_0$ in the Southern Hemisphere (3)

Transverse Mercator Projection:

$$x = \frac{a}{2} \ln [(1 + \cos \phi \sin \Delta \lambda) / (1 - \cos \phi \sin \Delta \lambda)] \quad (4)$$

$$y = a \tan^{-1} [\tan \phi \sec \Delta \lambda] \quad (5)$$

where $\Delta \lambda = \lambda - \lambda_0$

λ_0 = longitude of central meridian of projection

$$\text{Then } \frac{\partial x}{\partial \phi} = \frac{1}{2} a \left[\frac{2 \sin \phi \sin \Delta \lambda}{1 - \cos^2 \phi \sin^2 \Delta \lambda} \right] \quad (6)$$

$$\frac{\partial y}{\partial \phi} = a \left[\frac{\sec^2 \phi \cos \Delta \lambda}{\cos^2 \Delta \lambda + \tan^2 \phi} \right] \quad (7)$$

$$\alpha = \tan^{-1} \left[\frac{\frac{\partial y}{\partial \phi}}{\frac{\partial x}{\partial \phi}} \right] \quad (8)$$

If $\lambda > 0$ in the northern hemisphere, or if $\lambda < 0$ in the southern hemisphere, then α equals the supplement of the angle computed in equation 8.

On both the polar and subpolar charts, the yaw angle (η_z) is computed by:

$$\eta_z = \alpha + \phi \quad (9)$$

where ϕ = angle between true north and path angle measured clockwise.

On the polar charts, computed angles and measured angles agree reasonably well. The alpha angle is very nearly equal in magnitude to the longitude of a point. The closer a flight track parallels grid North, the greater the agreement. The more a flight track is perpendicular to the grid North, and the farther it is away from the meridian of true scale, the less the agreement and the further a great circle deviates from a straight line.

On the subpolar charts, the problem is a bit more difficult. A difference in longitude is represented by an angle somewhat less than the difference. The ratio is known as the convergence factor and is given as a $\sin \phi_0$, where ϕ_0 is the latitude of a central parallel, which in turn is related to the two standard parallels of the projection. Equation (1) above is the quite awesome formula for computing $\sin \phi_0$, but conveniently it is given in the margin of the chart as the convergence factor. The product of this convergence factor and the longitudes is given in a table on the margin of the chart (figure 1).

SOLUTIONS TRIED

One solution tried on the polar charts was to compute a new grid using the Transverse Mercator Projection. The 0°, 180°, 90° W lines were drawn at true scale. The great circles originating at these lines were plotted at an angle of 90°. Lines running North and South parallel to the meridian are straight lines, but the lines running East and West are curved lines. The only straight lines running East and West are the 90°E and the 90°W. As one gets more and more away from the line of true scale, the lines deviate more and more.

If points on the surface of the earth are projected geometrically onto a tangent plane, from a point on the surface of the earth opposite the point of a tangency, a stereographic projection results. The scale of the stereographic projection increases with distance from the point of tangency. An entire hemisphere can be shown on the stereographic projection without excessive distortion. Great circles through the point of tangency appear as straight lines. All other circles, including meridians and parallels, appear as circles or arcs of circles. Plotting the new grid was also tried, with the 0°,

Figure 1. Convergence table from subpolar chart

CONVERGENCE TABLE—STANDARD PARALLELS 37° & 65°											
LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV	LONG CONV
0° - 0°00'	16° - 12°34'	32° - 25°00'	48° - 37°42'	64° - 50°16'	80° - 62°50'	96° - 75°24'	112° - 87°58'	128° - 100°31'	144° - 113°05'	160° - 125°39'	176° - 138°13'
1° - 0°47'	17° - 13°21'	33° - 25°55'	49° - 38°29'	65° - 51°03'	81° - 63°37'	97° - 76°11'	113° - 88°45'	129° - 101°19'	145° - 113°53'	161° - 126°26'	177° - 139°00'
2° - 1°34'	18° - 14°08'	34° - 26°42'	50° - 39°16'	66° - 51°50'	82° - 64°24'	98° - 76°58'	114° - 89°32'	130° - 102°06'	146° - 114°40'	162° - 127°14'	178° - 139°48'
3° - 2°21'	19° - 14°55'	35° - 27°29'	51° - 40°03'	67° - 52°37'	83° - 65°11'	99° - 77°45'	115° - 90°19'	131° - 102°53'	147° - 115°27'	163° - 128°01'	179° - 140°35'
4° - 3°08'	20° - 15°42'	36° - 28°16'	52° - 40°50'	68° - 53°24'	84° - 65°58'	100° - 78°32'	116° - 91°06'	132° - 103°40'	148° - 116°14'	164° - 128°48'	180° - 141°22'
5° - 3°56'	21° - 16°30'	37° - 29°03'	53° - 41°37'	69° - 54°11'	85° - 66°45'	101° - 79°19'	117° - 91°53'	133° - 104°27'	149° - 117°01'	165° - 129°35'	
6° - 4°43'	22° - 17°17'	38° - 29°51'	54° - 42°25'	70° - 54°58'	86° - 67°32'	102° - 80°06'	118° - 92°40'	134° - 105°14'	150° - 117°48'	166° - 130°22'	
7° - 5°30'	23° - 18°04'	39° - 30°38'	55° - 43°12'	71° - 55°46'	87° - 68°20'	103° - 80°53'	119° - 93°27'	135° - 106°01'	151° - 118°35'	167° - 131°09'	
8° - 6°17'	24° - 18°51'	40° - 31°25'	56° - 43°59'	72° - 56°33'	88° - 69°07'	104° - 81°41'	120° - 94°15'	136° - 106°48'	152° - 119°22'	168° - 131°56'	
9° - 7°04'	25° - 19°38'	41° - 32°12'	57° - 44°46'	73° - 57°20'	89° - 69°54'	105° - 82°28'	121° - 95°02'	137° - 107°36'	153° - 120°10'	169° - 132°43'	
10° - 7°51'	26° - 20°25'	42° - 32°59'	58° - 45°33'	74° - 58°07'	90° - 70°41'	106° - 83°15'	122° - 95°48'	138° - 108°23'	154° - 120°57'	170° - 133°31'	
11° - 8°38'	27° - 21°12'	43° - 33°46'	59° - 46°20'	75° - 58°54'	91° - 71°28'	107° - 84°02'	123° - 96°36'	139° - 109°10'	155° - 121°44'	171° - 134°18'	
12° - 9°25'	28° - 21°59'	44° - 34°33'	60° - 47°07'	76° - 59°41'	92° - 72°15'	108° - 84°49'	124° - 97°23'	140° - 109°57'	156° - 122°31'	172° - 135°05'	
13° - 10°12'	29° - 22°47'	45° - 35°20'	61° - 47°54'	77° - 60°28'	93° - 73°02'	109° - 85°36'	125° - 98°10'	141° - 110°44'	157° - 123°18'	173° - 135°52'	
14° - 11°00'	30° - 23°34'	46° - 36°08'	62° - 48°42'	78° - 61°15'	94° - 73°49'	110° - 86°23'	126° - 98°57'	142° - 111°31'	158° - 124°05'	174° - 136°39'	
15° - 11°47'	31° - 24°21'	47° - 36°55'	63° - 49°29'	79° - 62°03'	95° - 74°36'	111° - 87°10'	127° - 99°44'	143° - 112°18'	159° - 124°52'	175° - 137°26'	

Lambert Conformal Conic Projection
Standard Parallels 37° and 65°
Scale 1:5,000,000
Convergence Factor 78535

180°, 90°E, and 90°W lines drawn at true scale, on the stereographic projection. All lines except the 0°, 180°, 90°E and 90°W lines are curved lines.

PROPOSED SOLUTIONS

If a plane is tangent to the earth, the points are projected geometrically from the centre of the earth and the result is a gnomonic projection. Distortion is so great that shapes, as well as distances and areas, are very poorly represented, except near the point of tangency. The usefulness of the projection rests upon the one feature that any great circle appears on the map as a straight line. This is apparent when it is realized that a great circle is the line of intersection of a sphere and a plane through the centre of the sphere, this centre being the origin of the projecting rays for the map. This plane intersects any other non-parallel plane, including the tangent plane, in a straight line. It is this one useful feature that gives charts made on this projection the common name great-circle charts.

When the new grid on a gnomonic projection was plotted, centred at the pole, it was discovered that the measured angles were correct. To compute the alpha angle for the gnomonic projection in the polar region the following formulas are used.

$$\text{Northern Hemisphere} \quad \alpha = -(\lambda - \lambda_0) \quad (10)$$

$$\text{Southern Hemisphere} \quad \alpha = -(\lambda - \lambda_0) \quad (11)$$

A solution for charts in the subpolar region was not found. The alpha angle can be computed by using the convergence factor given on the margin of the chart and the following formulas.

$$\alpha_c = \lambda \sin \phi_0 \text{ (with adjustment for the hemisphere)} \quad (12)$$

$$\eta_{ct} = \eta_{ct} (\alpha_c - \alpha_t) \quad (13)$$

where c = computed
 t = time

Figures (2) through (7) are charts covering the polar areas using the gnomonic projection.

CONCLUSIONS

The navigation grid, which was of great use to pre-inertial navigators, can still be of great use. It may be necessary, however, to produce polar charts on a gnomonic projection and sacrifice the conformality inherent in the currently used projections. Since pilotage navigation has become less important a consideration, the sacrifice of conformality may not be as unpalatable as it may seem. In the inertial navigation community it seems desirable to compute alpha from the formulas given above. With the advent of strapdown systems with very sophisticated navigation computers, this seems to be a nominal task.

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(f) *Small-scale and thematic mapping, national and regional atlases and the like*

DIGITAL LARGE-BLOCK MOSAIC OF LANDSAT-MSS IMAGERY OF ANTARCTICA*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

Dans la pratique courante, on utilise le canevas géodésique pour le redressement et l'orientation absolue des données images des satellites enregistrées numériquement. En Antarctique, par exemple, ce canevas peut être représenté d'ordinaire par les sommets isolés des montagnes (*nunataks*) ou d'autres détails topographiques stationnaires.

Toutefois, un canevas planimétrique suffisant fait en général défaut. Les points fixes sont souvent déterminés selon plusieurs systèmes de coordonnées indépendants. De vastes zones sans aucun canevas doivent être intrapolées par cheminement. Les points sont souvent mobiles ou changeants.

Le document décrit une méthode qui permet en général de résoudre les problèmes susmentionnés et qui est fondée exclusivement sur le traitement numérique. Il donne des détails sur un projet au cours duquel 74 images obtenues par le SMB de LANDSAT-5 et quatre images obtenues par le SMB de LANDSAT-1, couvrant essentiellement la région de Filchner-Ronne-Schelfeis et la terre Coats (Antarctique), ont été traitées au moyen d'une compensation générale des blocs. Dans cette région, dont les dimensions sont d'environ 1 500 km sur 2 000 km, le canevas géodésique ne comprenait qu'une trentaine de points fixes.

* The original text of this paper, prepared by Jörn Sievers/Andreas Grindel, Institut für Angewandte Geodäsie, and Willi Meier, Institut für Angewandte Geowissenschaften, appeared as document E/CONF 81/L 13

RESUMEN

Es práctica corriente utilizar el control geodésico para la rectificación y orientación absoluta de datos de imágenes obtenidas mediante satélites registrados digitalmente. En la Antártida, por ejemplo, este control puede representarse ordinariamente por cumbres montañosas aisladas (*nunataks*) u otros rasgos topográficos estacionarios.

Sin embargo, normalmente se carece de una cantidad suficiente de testigos terrestres. A menudo se determinan puntos fijos en diversos sistemas de coordenadas independientes. Deben llenarse las lagunas que ocurren en vastas regiones en las que no hay testigos. Los puntos a menudo se mueven o varían.

En el documento se bosqueja un método con el que en general será posible resolver los problemas mencionados *supra* basado sólo en la elaboración digital. Informamos sobre un proyecto en que 74 escenas del explorador multispectral del LANDSAT-5 y cuatro del LANDSAT-1, que abarcan principalmente la región de Filchner-Ronne-Schelfeis y la tierra de Coats (Antártida), se tratan en un ajuste de bloques global. En esa zona, que se extiende alrededor de 1.500 km por 2.000 km, sólo se disponía de control geodésico para alrededor de 30 puntos fijos.

SUMMARY

It is current practice to use geodetic control for the rectification and absolute orientation of digitally recorded satellite image data. In Antarctica, for example, this control regularly can be represented by isolated mountain peaks (*nunataks*) or other stationary topographic features.

However, normally sufficient ground control is lacking. Fixed points are often determined in various independent coordinate systems. Vast areas containing no control at all have to be bridged, and points are often moving or changing.

A method is outlined with which, in general, it will be possible to overcome the above-mentioned problems, based only on digital processing. A project is reported in which 74 LANDSAT-5 and 4 LANDSAT-1 MSS scenes, mainly covering the region of Filchner-Ronne-Schelfeis and Coats Land (Antarctica) were treated in an overall block adjustment. In that area, extending over about 1,500 by 2,000 km, geodetic control was only available for some 30 fixed points.

Satellite images have become an essential tool in various tasks of scientific research world-wide, as well as for planning and thematic applications. Because of the outstanding potentialities of satellite imagery to demonstrate and unveil extended glaciological correlations of difficult or inaccessible areas, this technique is all the more valid for work in Antarctica (Williams and others, 1982; Swinbank and Lucchitta, 1986; Lucchitta and others, 1987).

However, though an increasing number of nations and scientists are involved in Antarctic research, and though the operational imaging satellite system LANDSAT has been in orbit since 1972, satellite image maps are still lacking for very large parts of Antarctica. While topographic line mapping has been done systematically for nearly all mountainous regions at 1:250,000 scale, either by conventional terrestrial methods or by aerial photogrammetry, this makes up only the smallest part of Antarctica.

The reasons are obvious. The making of maps requires the availability of sufficient geodetic ground control (fixed points), which generally will be provided by nunataks or other stationary topographical features. These fixed points are an absolute prerequisite for providing a definite and unique scale and for constructing a definite graticule for the map.

In Antarctica researchers confront the following problems:

- (a) Sufficient ground control is lacking;
- (b) Fixed points are often determined in isolated ranges which are not or could not be tied together by geodetic observations;
- (c) Vast snow- and ice-covered areas of many hundreds of square kilometres containing no fixed point must be bridged;
- (d) Surface features are often moving or changing.

In this paper a method is outlined by which, in general, it will be possible to overcome the problems mentioned above. It is based only on digital processing.

DIGITAL SATELLITE DATA ACQUISITION

The geometric and spectral resolution of LANDSAT thematic mapper (TM) and of the French satellite SPOT (Système probatoire d'observation de la terre) open up unexpected possibilities to produce satellite image maps even at 1:25,000 scale. The data quality of these sensors, however, has to be paid for by the high purchase cost of the original data and by the handling of enormous quantities of data.

In the Antarctic there is a demand for maps at small scales. On the one hand, we are a long way from a continuous map series at 1:1,000,000 scale, and on the other hand Antarctica maps have other requirements than is the case in industrialized countries. In Antarctica at present, the most impor-

tant aim is to produce maps giving synoptic representations of extended areas. For that purpose satellite image maps at 1:1,000,000 scale are ideally suited.

Some 20 scenes covering an area of 185 x 185 sq. km are required to produce one map sheet at 1:1,000,000 scale. If only one spectral band is being used (single-colour reproduction), about 160 megabyte data of multispectral scanning (MSS) must be managed (see table 1). One must cope with a quantity of 760 Mbyte when dealing with TM and 1.7 giga-byte or 7 Gbyte, respectively, in the case of operating with SPOT data. A coloured reproduction (three spectral bands) trebles the quantities quoted.

At present, therefore, digital recordings of LANDSAT-MSS may be the only meaningful tool for producing satellite image maps at 1:1,000,000 scale. This is valid all the more because in Antarctica objects of a size of about 100 m (equal to 0.1 mm on the map) are being imaged identifiably. Imagery of Antarctica digitally recorded by SPOT and TM, therefore, will be applied by the Institut für Angewandte Geodäsie (IFAG) mainly to some detailed large-scale investigations.

TABLE 1: COMPARISON OF DIGITAL LANDSAT/SPOT DATA QUANTITIES TO BE PROCESSED

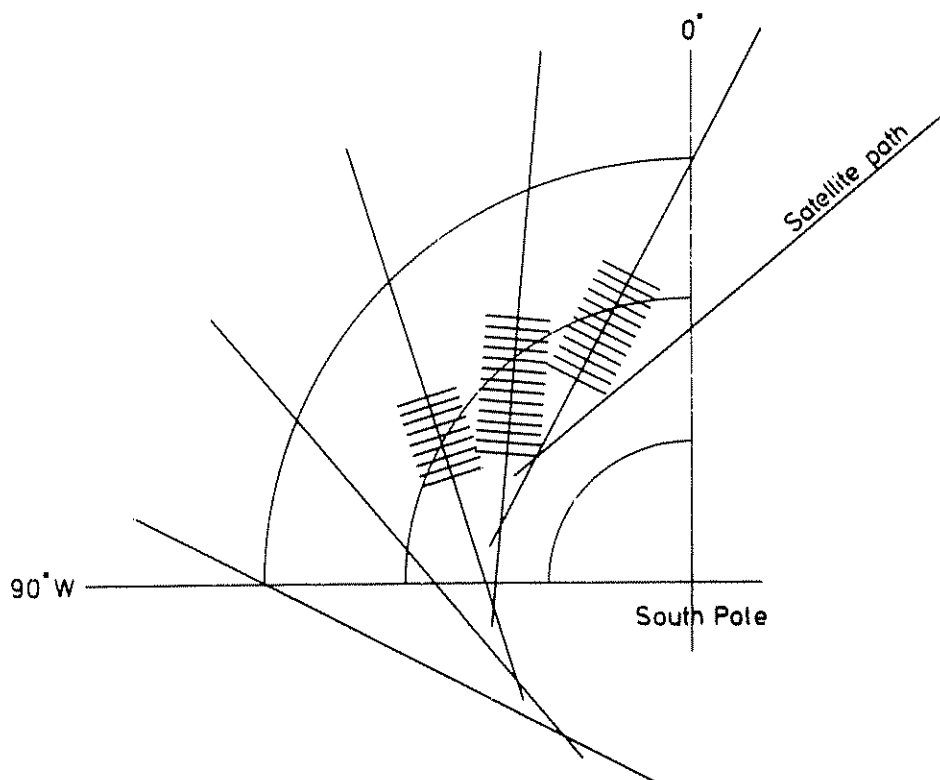
	LANDSAT MSS	LANDSAT TM	SPOT Multi- spectral	SPOT pan
Area covered (sq. km)	185 x 185	185 x 185	60 x 60	60 x 60
Pixel size (sq. m)	60 x 80	30 x 30	20 x 20	10 x 10
Spectral bands	4	7	3	1
Pixels (Mbyte) per band	8	38	85 ^a	342 ^a
Pixels (Mbyte) for a map sheet at 1:1,000,000 scale (1 band)	160	760	1 700	7 000

^a Extrapolated to a covered area of 185 x 185 sq. km without considering any necessary side overlap of the mosaicked scenes

Satellite scanning system

LANDSAT-4 and 5 orbit the earth on a near-polar, sun-synchronous path with an inclination of 98°. Both satellites scan about 100 km further south than the earlier LANDSAT-1, 2 and 3. The southernmost area covered is at approximately 82°45'S.

Figure I. Varying LANDSAT-MSS scanning coordinate systems



Paths of different orbits of LANDSAT are shown schematically in figure I. The continuous scanning and recording process is perpendicular to the path of the satellite. Therefore, scan lines of adjacent LANDSAT scenes do not run parallel, but intersect each other. That is, all the different path/scanning coordinate systems have to be transformed to a single system (see figure II). Owing to the extent of the area dealt with, some problems are created regarding data processing, data management, and archiving.

To conduct the above-mentioned programme, production of satellite image maps at scales of 1:1,000,000 and

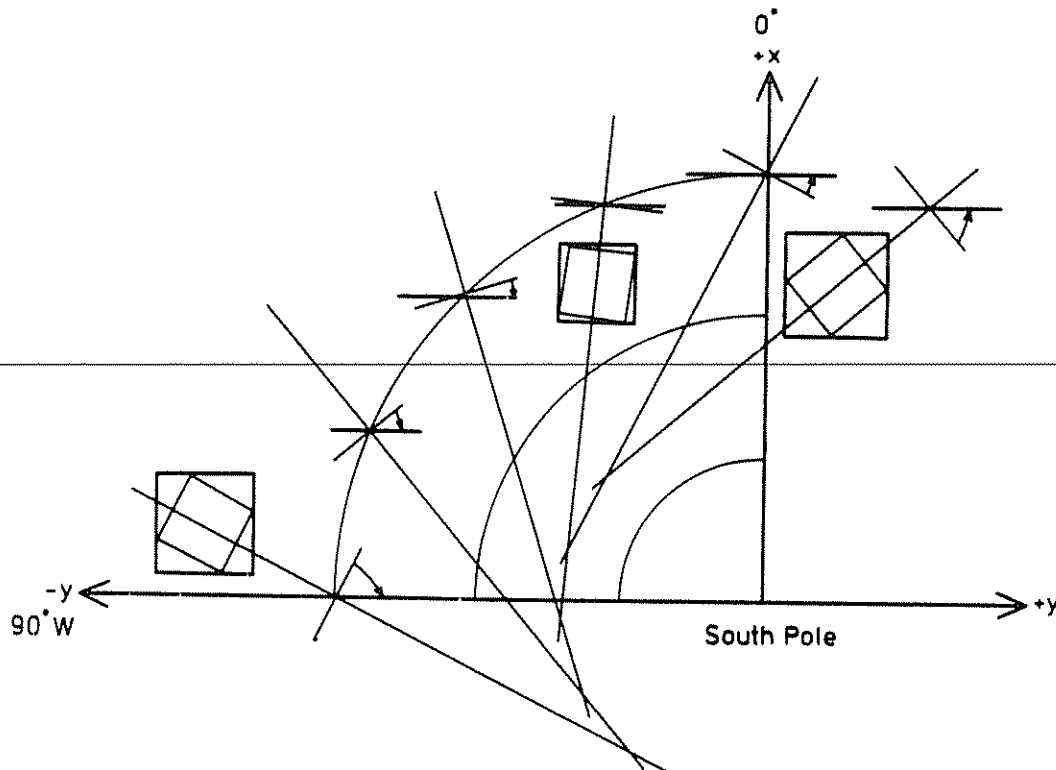
1:250,000 the following specifications have been agreed upon:

- The 0° meridian corresponds with the positive X-axis of all Lambert systems;
- The pixel size of the resampling is 60 x 60 sq. m.

CONCEPT OF MOSAICKING

The satellite image maps are being produced from digital data of LANDSAT-MSS available in computer compatible

Figure II. Uniform resampling x,y-coordinate system



tape (CCT) format. At present only a black-and-white map version has been published for which spectral band 3 or 4 (or band 6/7 of LANDSAT 1, 2, and 3) are being used. Each scene has been digitally processed to maximize geometric fidelity and radiometric information while minimizing inevitable contrast differences between adjacent scenes.

The process of mosaicking can generally be conducted by two methods (Zobrist and others, 1983; Göpfert, 1984; Albertz and others, 1987).

Method A (see table 2) is based on the processing and rectification of single scenes. Geometric discrepancies in the seams between adjacent scenes are neglected. An overall adjustment of all image coordinates measured in all single scenes is not carried out. The method is easily and expediently applicable if sufficient ground control is available (generally four to nine points for each single scene) drawn from maps or positioned on the ground.

In Antarctica about 20 LANDSAT-MSS scenes are necessary to produce a satellite image map at 1:1,000,000 scale. The procedure of tying together single scenes rectified independently of each other cannot be used for that task. Mostly we lack sufficient ground control or we are failing in the positioning of control points.

Method B (see table 2) is based mainly on the measurement of image coordinates of features appearing in the overlap between adjacent LANDSAT scenes. Ground coordinates for these common points, also called "tie points" or "seam points", are not known. To adjust the mosaic to a coordinate system, only sparse geodetic ground control is required.

An overall block adjustment is applied to all image coordinates measured in all scenes of the mosaic. The results are sets of transformation parameters for each scene. The adjust-

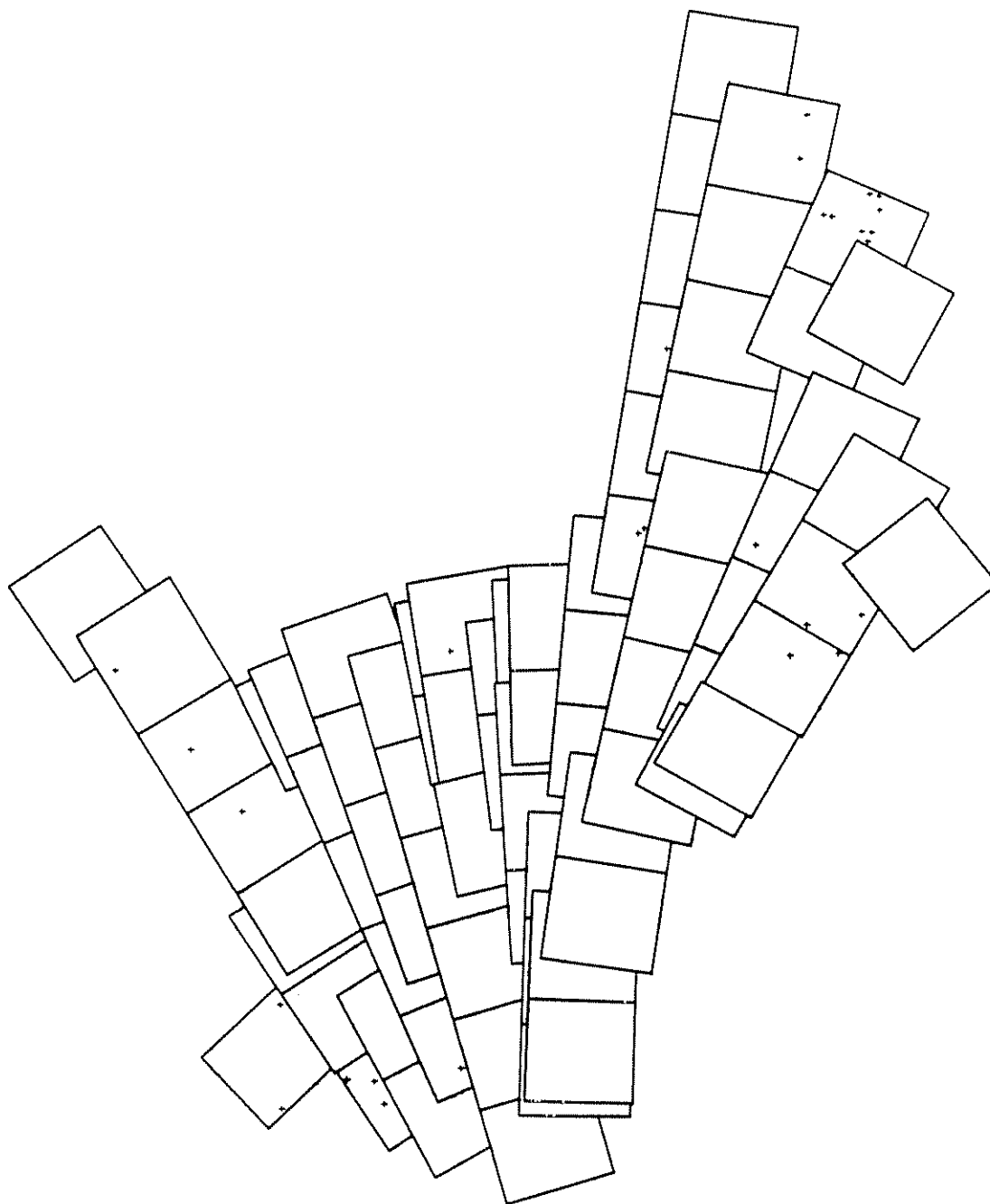
ment can be conducted with reference to the specified map projection. In the case discussed here the block adjustment is carried out relative to a spheroid, which is the more general solution.

TABLE 2. CONCEPTS OF DIGITAL SATELLITE IMAGE MOSAICKING

A. Single-scene processing	B. Block adjustment using tie points
Original digital raw data	Original digital raw data
Preprocessing	Preprocessing
	Selection of tie points
Digital measurement of image coordinates of—	Digital measurement of image coordinates of—
—ground control	—ground control
	—tie points
Single-scene adjustment of all ground control referred to a specified map projection	Block adjustment of all ground control and tie points referred to an ellipsoid
Result: 1 set of transformation parameters for 1 single scene	Result: Sets of transformation parameters simultaneously adjusted for each scene
Resampling of 1 single scene to the specified map projection = geocoding	Resampling of each scene to any optional reference system or map projection = geocoding
Interactive-digital geometric and radiometric mosaicking	Interactive-digital geometric and radiometric mosaicking

It is common to all methods described that various effects of the dynamic scanner/spacecraft geometry have to be compensated for. In some cases it is necessary to apply the corrections to the original unprocessed image geometry, notably the elimination of regular striping patterns (six band noise) and the correction of variable scanline length.

Figure III. Imagery coverage diagram of LANDSAT-MSS mosaic, Filchner-Ronne-Schelfeis, Coats Land



+ geodetic control by GPS or Doppler satellite positioning
Map sheet line system based on International Map of the World, 1:1,000,000

Other effects can be treated simultaneously in the block adjustment as it is performed in method B. The effects are mainly spacecraft motion and earth rotation during the scanning process, earth curvature, panorama distortion, variable mirror velocity, and instability of satellite attitude. A mosaic has been compiled after applying the method of block adjustment using tie points, for which results are reported below.

Digital satellite image mosaic: Filchner-Ronne-Schelfeis, Coats Land

In collaboration between IFAG at Frankfurt am Main, and the Institut für Angewandte Geowissenschaften (IFAG) at Offenbach, a mosaic comprising 78 LANDSAT-MSS scenes was produced and digitally tied together in May 1988 (in 1987 an analog mosaic of that area was assembled and served as a basis for a glaciological satellite image interpretation. This work is published as a line map (Swithinbank, Brunk and others, 1987).

The block contains four scenes of LANDSAT-1 (acquired in October/November 1973), two scenes of LANDSAT-5 (January 1985), and 72 LANDSAT-5 scenes (recorded from January to March 1986). The imagery covers large parts of Coats Land and nearly the entire Filchner-Ronne-Schelfeis area. Only small parts of the ice shelf beyond the orbital limit of LANDSAT-5 ($82^{\circ} 45'S$) are not imaged. The whole area extends from 10° to $90^{\circ}W$ and from 71° to $82^{\circ}45'S$. The maximum extent of the mosaic is 2,000 km by 1,500 km.

Figure III shows the satellite imagery coverage diagram of the mosaic. Only 28 ground control points are available, bunched together in some 15 irregularly distributed groups. The entire Filchner-Ronne-Schelfeis, about 900×500 sq. km in area, contains just one geodetic control locality (at $50^{\circ}W$ and $77^{\circ}S$). The southern boundary of the mosaic is without any reference points. Most of the control has been positioned by survey campaigns of the United States Geological Survey and the British Antarctica Survey from 1975 to 1978. Values of positioning accuracy have been reported by Renner (1982). Standard deviations are estimated to be 10-20 m.

No particular intricacy arose from selecting the tie points, apart from an organizational problem encountered as a result of the large number of tie points. Seasonal changes of the appearance of objects did not occur within the short period of data acquisition. Similarly movement of the snow and ice features was negligible in most cases. Insufficient overlapping occurred at only two places.

The mosaic presents specific characteristics. In some cases sequences of consecutive images have been recorded continuously and consist of as many as six scenes. Such sequences can be tied together with absolute certainty. This is of particular significance in the block adjustment.

Altogether 1,460 image coordinate readings of ground control and tie points have been made. Of that number less than 20 readings (about 1 per cent) had to be eliminated because of obvious misinterpretation or wrong numbering.

The block adjustment is based on a mathematical model of higher-degree polynomials for which the interior geometry of each scene is considered individually. The model comprises all parameters of the dynamic scanning geometry of the satellite: spacecraft motion, earth rotation and curvature, panorama distortion, variable mirror velocity, and instability

of satellite attitude. The adjustment was performed with two-dimensional ellipsoidal coordinates and is referred to the reference spheroid WGS 72. An adjustment referred to a planimetric coordinate system of a map projection is not considered because:

(a) The mosaic covers several 4° -zones of the Lambert projection;

(b) Ellipsoidal coordinates are much easier to transform to other reference systems and map projections rather than planimetric coordinates.

Standard deviations s_x , s_y of all 78 scenes are calculated from the residuals for each scene. The s_x , s_y vary from ≈ 40 m to ≈ 200 m, from which an average standard deviation of point position of ± 125 m is calculated.

CONCLUSION

The lack of geodetic ground control in Antarctica demands particular procedures for the digital preparation of satellite image maps at 1:1,000,000 scale. Digital mosaicking based on the method of block adjustment with tie points is demonstrated on two examples of mosaics assembled from 15 to 78 LANDSAT-MSS scenes respectively, with maximum extents of 2,000 and 1,500 km. The major advantage of the method applied is that even extremely large areas (900×500 sq. km) containing no ground control can be bridged geometrically.

Compared with simpler procedures applied to single scenes, additional expenditure is incurred for the preparation and organization of the digital image coordinate measurement. Furthermore considerable computer capacity is required. However, without employing block adjustment the production of satellite image maps of the Antarctic at 1:1,000,000 scale cannot at present be performed to cartographic quality standards.

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REPORT OF THE MEETING OF THE UNITED NATIONS AD HOC GROUP OF EXPERTS ON THE INTERNATIONAL MAP OF THE WORLD ON THE MILLIONTH SCALE, 9-11 DECEMBER 1986*

Paper submitted by the United Nations Secretariat

The annual reports issued by the Cartography Unit of the Department of Technical Co-operation for Development of the United Nations Secretariat, which is responsible for monitoring the progress of the International Map of the World on the Millionth Scale (IMW), have shown a substantial decrease in the activities of member States related to this map series **

In implementing resolution 9, adopted at the Third United Nations Regional Cartographic Conference for the Americas in February 1985, an Ad Hoc Group of Experts met at United Nations Headquarters from 9 to 11 December 1986 to study the situation and to make appropriate recommendations. The Group consisted of representatives of Canada, France, the Federal Republic of Germany, the United Kingdom of Great Britain and Northern Ireland, the United States of America (Convenor), the International Civil Aviation Organization (ICAO) and the United Nations Secretariat

Regrets were received from representatives of Australia, the German Democratic Republic and India, who were invited but could not attend.

The Group examined the background and status of the IMW and the information available to the Group and to United Nations Headquarters.

The Group noted that many countries had stopped work in IMW maps altogether and others had delayed IMW production or revision for often lengthy periods, owing to priority determination or non-availability of funds. The number of sheets reported to the United Nations by Member States had dwindled so that the intended annual report had been possible only once every few years. The last published report was produced in 1977, followed by briefer supplements in 1982, 1984 and 1986. The Group also found that while production and interest in the IMW had been falling off in many countries, other countries had continued to produce maps and distribute them widely for a variety of uses.

The relationship between the IMW and the World Aeronautical Chart (WAC) was clarified and thoroughly discussed.

After taking note of the out-dated state of this map series, the Group of Experts looked into known technical possibilities likely to serve the original objectives of the IMW to meet the needs of users.

Having reviewed some relevant aspects of the state of the art of cartography, its current problems and some fresh approaches for the future offered by new technology, the Group concluded that it was not possible, under present conditions, to offer an alternative practical solution to the IMW problem. The Group agreed to a number of findings and recommendations as follows:

(1) The Group finds that the request framed in resolution 9 of the Third United Nations Regional Cartographic Conference for the Americas, February 1985, was fully justified, and they have used the recommendations as the basis for its deliberations.

(2) The Group finds that the concept of the International Map of the World on the Millionth Scale appears to be no longer appropriate or feasible.

(3) The Group considers the present prospect of achieving successful production of any international map series to be remote.

(4) The Group recommends that there is no longer a need for the United Nations to continue monitoring the IMW programme by which Member States are urged to produce and report on IMW maps.

(5) The Group recommends that those countries that elect to produce or continue to produce millionth scale maps as part of their national map series should be encouraged to use the Bonn 1962 IMW specifications for this purpose.

(6) The Group recognizes the obligation of Member States of ICAO to produce world aeronautical charts—ICAO (1:1,000,000). The Group recommends that those Member States fulfilling this obligation by providing an aeronautical overprint on existing IMW maps should continue to maintain the IMW maps.

(7) The Group agrees that existing IMW maps have value and recommends that States Members of the United Nations retain and make available IMW map stocks. Further, the Group recommends the immediate requirement for Member States to retain IMW reproduction material in operational condition.

(8) Given the acceptance of paragraph 4 above, the Group recommends that the United Nations IMW map collections be maintained in the Dag Hammarskjöld Library at United Nations Headquarters in New York.

(9) The Group requests the Department to submit the report and recommendations of the meeting to the next round of United Nations regional cartographic conferences for consideration by Member States.

* The original text of this paper appeared as document E/CONF 81/L.10

** International map series are defined as those series drawn to internationally agreed specifications and produced multinationally rather than by a single country. All maps in the series must be universally available.

SEASONAL VEGETATION MONITORING WITH AVHRR DATA FOR GRASSHOPPER AND LOCUST CONTROL IN WEST AFRICA*

Paper submitted by the United States of America

RÉSUMÉ

Ces quatre dernières années (1985-1988), des pluies saisonnières sont venues couper la sécheresse du milieu de la décennie en Afrique de l'Ouest. Cette amélioration de l'habitat a également eu pour conséquence une multiplication des sauterelles et des criquets pèlerins. Les infestations acridiennes qui en résultent menacent la capacité de production vivrière de la région. Il est essentiel, pour l'efficacité des programmes de lutte anti-acridienne, de détecter les conditions environnementales favorables à ces insectes. Depuis quelques années, l'utilisation des données satellite pour la surveillance de la végétation a ajouté une dimension nouvelle au dénombrement des sauterelles et des criquets pèlerins et à la lutte anti-acridienne.

Le Centre de données EROS du Service géologique des Etats-Unis a mené à bien une étude visant à mettre au point, tester et évaluer une procédure d'observation en temps quasi réel des rythmes saisonniers de croissance de la végétation en Afrique de l'Ouest. Les données concernant la région, obtenues par le radiomètre perfectionné à très haute résolution de la NOAA, ont été utilisées dans les programmes de lutte anti-acridienne pour cartographier l'état de la végétation. On a établi des cartes de verdure en combinant les données relatives à l'index normalisé de la végétation fournies par le radiomètre avec les données cartographiques d'un système d'information géographique. On a produit, pendant la saison des pluies de 1987 et 1988, pour plusieurs pays du Sahel, des cartes combinant les valeurs maximales de l'index normalisé de végétation pour des périodes de 15 jours. Les équipes de lutte anti-acridienne utilisent ces cartes pour planifier et effectuer des dénombrements sur le terrain et aériens et pour situer avec plus de précision les zones d'infestation.

RESUMEN

Las lluvias estacionales de los últimos cuatro años (1985-1988) han puesto fin a la sequía de mediados del decenio de 1980 en el Africa occidental. El mejoramiento de las condiciones en el hábitat ha traído también aparejado un aumento en el número de langostas y saltamontes. La infestación de insectos resultante pone en peligro la capacidad de la región para producir alimentos, y la vigilancia de las condiciones ambientales favorables para los saltamontes y las langostas resulta esencial para la aplicación de programas de control eficaces. En los últimos años, el uso de datos de satélites para vigilar las variaciones en la vegetación estacional ha añadido una nueva dimensión a la vigilancia y la lucha contra el saltamontes y la langosta.

El Centro de Datos EROS de la Dirección de Levantamientos Geológicos de los Estados Unidos completó un estudio para desarrollar, poner a prueba y evaluar un procedimiento en tiempo casi real encaminado a vigilar las modalidades de crecimiento de la vegetación estacional en el Africa occidental. Se utilizaron datos de satélite sobre la zona obtenidos mediante el radiómetro avanzado de muy alta resolución (AVHRR) de la Administración Oceánica y Atmosférica Nacional (NOAA) para preparar mapas de las variaciones de la vegetación en apoyo de los programas de lucha contra la langosta y el saltamontes. Se prepararon mapas del verdor de la vegetación mediante el registro y la fusión de índices normalizados de variaciones de la vegetación obtenidos del AVHRR con datos cartográficos en un sistema de información geográfica. Los mapas, que representan compuestos de los valores máximos del índice normalizado de variaciones de la vegetación para períodos de 14 días, se produjeron en 1987 y 1988 durante la estación lluviosa para varios países del Sahel. Los equipos de lucha contra el saltamontes y la langosta están utilizando los mapas para planificar y realizar estudios sobre el terreno y aéreos y para ubicar más eficazmente las zonas de infestación.

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SUMMARY

The seasonal rains of the last four years (1985-1988) have broken the drought of the mid-1980s in West Africa. Improved habitat conditions have also brought an increase in the breeding of grasshoppers and locusts. The resulting insect infestations threaten the region's ability to produce food. Monitoring environmental conditions favourable to grasshoppers and locusts is essential for effective control programmes. In recent years, the use of satellite data for monitoring seasonal vegetation patterns has added a new dimension to grasshopper and locust survey and control.

A study was completed by the EROS Data Center of the United States Geological Survey to develop, test, and evaluate a near-real-time procedure to monitor seasonal vegetation growth patterns in West Africa. Local area coverage satellite data from the advanced very high resolution radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) were used to map vegetation conditions in support of grasshopper and locust control programmes. Maps of vegetation greenness were produced by registering and merging AVHRR-derived normalized difference vegetation index (NDVI) data with cartographic data in a geographic information system. The maps, each representing maximum NDVI value composites for 14-day periods, were produced during the 1987 and 1988 rainy seasons for a number of Sahelian countries. Grasshopper and locust control teams are using the maps for planning and conducting field and aerial surveys and for locating infestation areas more efficiently.

With the return to near normal rainfall during the past several years, environmental conditions favourable for locusts and grasshoppers have resulted in large populations of these insects. In 1985 and 1986, the Senegalese grasshopper (*Oedaleus senegalensis*) threatened cropland in a number of Sahelian countries. A major upsurge in the population of the desert locust (*Schistocerca gregaria*) occurred in mid-1987, resulting in the present serious threat to agriculture in vast areas of northern Africa.

International donors have mounted emergency assistance programmes for grasshopper and locust control in Africa. In early 1987, the United States Agency for International Development (USAID) prepared for another major campaign to control grasshoppers in West Africa. One goal of the programme was to improve grasshopper prediction and survey techniques. To meet this goal, an improved capability to monitor the distribution and seasonal changes of natural and agricultural vegetation in the zones of the Sahel and the Sudan, where the grasshoppers and locusts hatch and develop, was required. For this reason, the Bureau for Africa of USAID requested that the Data Center of the Earth Resources Observation System (EROS) of the United States Geological Survey conduct a pilot project to develop, test and evaluate a near-real-time monitoring procedure using satellite data. These data, along with geographic information system (GIS) technologies, were used to support the grasshopper and locust control programmes. Previous studies have shown that the use of satellites for monitoring locust habitat is very promising (Hielkema, 1980; Bryceson and Wright, 1986).

Inherent in the pilot project was the need to format and present information for acceptance and use by decision makers and grasshopper control technicians. The information was presented in the form of vegetation index or "greenness" maps derived from two-week composites of local area coverage satellite data from the advanced very high resolution radiometer (AVHRR). The maps are based on the normalized difference vegetation index (NDVI), which has been shown to be directly related to the photosynthetic

capacity of vegetation canopies (Sellers, 1985), and herbaceous biomass production (Tucker and others, 1985; Prevost, 1988), and is useful for monitoring seasonal fluctuations in vegetation (Goward and others, 1985; Justice and others, 1985; Schneider and others, 1985). The maps represent maximum NDVI value composites for 14-day periods through the Sahelian and Sudanian zone summer growing season, and were used and evaluated in the 1987 campaigns in Senegal, the Gambia, Mauritania, Niger and Chad. The programme continued in an operational mode in 1988 in support of efforts to control locusts in Mauritania, Mali, Niger, Chad, the Sudan, Morocco, Algeria and Tunisia.

BACKGROUND

Grasshoppers and locusts have caused problems for man since the beginning of recorded history. The insects destroy the crops and grasses upon which man and his animals feed, at times resulting in widespread starvation and disease. In 1958, locusts destroyed 167,000 tons of grain in Ethiopia, sufficient to feed one million people for a year. Following the end of the Sahelian drought in the mid-1980s, dramatic increases in grasshopper and locust populations were observed. Of particular concern to those monitoring the situation was the return of the Senegalese grasshopper and the desert locust.

The Senegalese grasshopper

The Senegalese grasshopper is one of the most economically important species of acridids in the Sahel. This insect can attain high densities and migrate on the wind, inflicting heavy damage on food crops. The range of grasshopper distribution is a band across Africa corresponding roughly to the Sahelian and Sudanian zones, but also reaching south into the United Republic of Tanzania. The grasshoppers migrate during the wet season from an area of initial breeding in the Sudanian zone, northwards through a transitional breeding area, to a northern breeding area in the Sahelian zone. At the end of the rainy season, the grasshoppers

migrate back into the transitional and initial breeding areas, laying egg pods as they go (Launois, 1979). The eggs go into diapause dormancy throughout the dry season until a rain, generally 25 mm or more, triggers a hatch. Grasshopper development rates and migration patterns are determined by environmental conditions, including moisture, temperature, vegetation conditions, photoperiod, wind patterns, and grasshopper population levels (Launois, 1979).

In 1986, damage to food crops by the Senegalese grasshopper was reported in parts of Senegal, Mauritania, the Gambia, Mali, Burkina Faso, Niger and Chad (Famine Early Warning System, 1987), and major grasshopper control campaigns were mounted involving large-scale aerial spraying operations. As a result of the campaign and biological factors, populations of the Senegalese grasshopper were more limited in 1987 and 1988. Serious outbreaks occurred only in localized areas.

The desert locust

The desert locust is the most feared of all the locusts in the world. This insect has great mobility (up to 1,000 km a week), a vast invasion area, a potential to reach high population densities, and the ability to consume its own weight in food every day (Pedgley, 1981). The range and biology of this locust is markedly different from that of the Senegalese grasshopper. During locust recession years, when the population is low, locusts are found in the semiarid or arid regions of 30 countries in northern Africa, the Middle East, and Asia. During plague years, large swarms of locusts move out of the recession areas into a large invasion area covering portions of 57 countries (Pedgley, 1981).

The desert locust, like other true locusts, differs from grasshoppers by its ability to transform its physiology, form, and behaviour in response to changes in population density. When populations are low, locusts are smaller, behave independently, tend to avoid each other, and are in the "solitary" phase. By contrast, locusts in the "gregarious" phase are larger and swarm together. Favourable breeding conditions that lead to crowding for more than one generation are required to produce the fully gregarious characteristics associated with locust plagues.

During favourable breeding periods, a population of locusts may increase 100 times or more per generation, and as many as 6 generations may be produced per year. Therefore, population suppression measures must strive for at least a 98 per cent mortality rate to be effective.

Locust breeding is seasonal, and occurs in two major east-west belts that have suitable rainfall: a summer breeding season extending across the Sahel, southern Sahara, Ethiopia and the south-western Arabian peninsula; and a spring breeding season in northern and north-western Africa, the Arabian peninsula, the Islamic Republic of Iran and Pakistan. Between these two belts lies a third area of winter breeding, primarily in the Somali Peninsula and the Red Sea coast.

Locusts require certain ecological conditions for breeding. The main variables are rainfall, topography, soil type, vegetation, and temperature (Pedgley, 1981). Rainfall is the most important requirement for producing a favourable breeding environment because it provides the soil moisture necessary for egg development, and triggers germination and growth of vegetation upon which the hoppers (nymphs) and adults feed. Topography can influence where and when breeding occurs by modifying rainfall patterns and the resulting run-off. Locusts show a preference for sandy or silty soils for egg laying. The presence of vegetation influ-

ences where swarms will settle to lay eggs, the distribution and density of egg pods, and the behaviour of newly hatched hopper bands. Healthy vegetation, especially annual herbaceous vegetation that germinates in response to seasonal rains, assures the survival of the hoppers by providing both food and shelter. Temperature is the main factor in determining the rate of egg and hopper development (Pedgley 1981).

A major upsurge in the desert locust population has occurred since 1986 as a result of prolonged and widespread favourable breeding conditions in Africa. Seasonal rains in 1986 produced considerable increases of nonswarming populations in parts of the northern Sahel (FAO, 1987).

In Mali and Niger, small gregarious swarms were reported, leading to gregarious breeding by October 1986. The breeding became fairly extensive, spilling into Mauritania in November. In July 1987, desert locust populations were reported in north-eastern Chad following heavy rains and vegetation green-up. Breeding continued from August through November in Chad and Niger, producing several successive generations. Large-scale migrations were tracked into northern Mali and Mauritania where further breeding occurred. Swarms also moved north-west across Algeria. Some of these swarms moved into southern Morocco and across north-central Algeria, Tunisia, and the north-western part of the Libyan Arab Republic. Spring breeding occurred in the North African belt, producing two generations of locusts, which then migrated back into the Sahelian zone prior to the onset of the seasonal summer rains. The favourable 1988 Sahelian rains produced ample moisture and abundant vegetation growth, providing ideal conditions for widespread locust breeding and aggravating the present plague situation.

METHODS

Since the early 1980s, considerable attention and research has focused on the use of high-temporal-frequency, coarse resolution satellite data for earth resource monitoring. The primary source of these data has been the AVHRR of the National Oceanic and Atmospheric Administration's (NOAA) series of meteorological satellites. These polar-orbiting satellites provide image data for the earth's surface on a daily basis at low cost (\$US 0.02 per 1,000 sq. km). NOAA-9 satellite data (launched 1984) were used for the present project.

The study area

In 1987, greenness maps were produced every two weeks from May until November for the north African countries of Senegal, the Gambia and southern Mauritania, and from August until November for the countries of Niger and Chad. In 1988, maps were produced every two weeks during time periods most appropriate for locust habitat monitoring for the countries of Mauritania, Mali, Niger, Chad, the Sudan, Morocco, Algeria and Tunisia.

Data flow and processing

The satellite data are recorded by NOAA-9 and transmitted to the National Climatic Data Center in Washington, D.C. Approximately three scenes per week were acquired for most of northern Africa. The satellite data were converted from wide-band video to computer-compatible tapes and sent via air express to the United States Geological Survey's EROS Data Center in Sioux Falls, South Dakota. At the Eros Data Center, each scene was entered into the AVHRR data reception and processing system (ADAPS) and previewed for cloud cover and to determine whether a

country of interest fell into the near nadir (central) portion of the scene. Scenes that passed this initial screening were processed further by ADAPS. The visible (channel 1) and near-infrared (channel 2) data were calibrated, registered to a base map and used to compute the NDVI. The thermal (temperature) data (channel 4) were also retained for subsequent processing.

Calibration converted the raw data counts into albedo using pre-launch calibration coefficients. The images were registered using an approach that aligns image features, such as rivers or coastlines, with computer maps of the same features. Transformations were applied to register the rest of the image (Boyd, 1987). Figure 1 is an example of a registered AVHRR image of West Africa.

The NDVI is a data transformation that combines visible (channel 1) and near-infrared (channel 2) spectral data into a single variable, which is strongly correlated to amounts of green vegetation cover and green biomass (Deering and Haas, 1980). The NDVI was computed from the calibrated channels 1 and 2 using the formula:

$$NDVI = \left(\frac{\text{Channel 2} - \text{Channel 1}}{\text{Channel 2} + \text{Channel 1}} + 1.005 \right) \times 100$$

The NDVI and thermal data were then entered into the Land Analysis System for image processing. An important processing step is cloud screening. Portions of AVHRR scenes that are obscured by clouds must be replaced with data from another date on which the area is free of clouds. This process was accomplished by combining numerous scenes within a two-week period. The process also involved determining a threshold temperature level in channel 4, which distinguishes between cool clouds and the warmer land surface. A 0-1 digital image mask was generated from the thermal channel in which zeros represented clouds. The mask was multiplied with the NDVI image, which replaced all the cloud-contaminated pixels with zeros. This process was repeated for each scene within the two-week composite period.

All cloud-masked NDVI images produced for the two-week period were merged to generate a single composite scene. The scenes were overlaid and the maximum NDVI value at any pixel location over the two-week period was retained. Cloud-contaminated areas were replaced with cloud-free data; however, typically, a few areas obscured by clouds remained. This procedure not only "removes" clouds, but during green-up also favours the retention of near-nadir, clear-sky NDVI values close to the end of the two-week composite period. After the peak of green, however, NDVI values near the beginning of the composite period are favoured.

The final product: vegetation index maps

Vegetation index or greenness maps depicting the current distribution and relative amounts of green vegetation were the primary products of this project. The maps contain locational information, including international and provincial boundaries, major roads, cities and towns, and geographic coordinates. These cartographic features were taken primarily from operational navigation charts. Map scales varied from 1:1,000,000 for the smaller countries to 1:2,500,000 for the larger ones. All of the locational map information was processed using ARC/INFO geographic analysis and plotting software. Map information and text were processed and arranged into a map "collar" including all locational data, legend and text. The final maps were created by combining these data with the satellite-derived greenness information

and output on colour ink-jet or electrostatic plotters (figure 2). Since the intent of the greenness maps was to show the distribution and relative amounts of photosynthetically active green vegetation, a colour legend was developed to depict this information in a way that would be intuitive to the map user. The NDVI range was divided into 19 classes of unequal intervals, with the highest sensitivity (narrower class intervals) in the ranges representing low amounts of green vegetation. Areas with little or no green vegetation were displayed in shades of orange and yellow. Areas with increasing amounts of green vegetation were shown in shades of green, from light to dark. The highest levels of greenness were shown in shades of dark blue. Areas obscured by clouds were symbolized with white. The satellite-derived greenness data were thus colour-coded and combined with the map collar information into a single file for plotting on the colour ink-jet plotter. The maps were laminated to provide protection for field use.

Multiple copies of each map product were sent to each participating country, using an express courier. The maps were available within the individual countries for use in the grasshopper campaigns four to six days after the end of a map production cycle. In addition, greenness information was communicated to each country via telex, using a geographic reference grid. This provided users with the latest greenness information immediately following a map production cycle, generally three to four days following the latest satellite pass over Africa.

RESULTS

The greenness maps were used by numerous organizations involved in grasshopper and locust control in the Sahelian countries. The primary users were the crop protection service (CPS) agencies responsible for planning and carrying out control activities, and USAID and personnel of the Food and Agriculture Organization of the United Nations (FAO) involved directly in supporting the campaigns in each country. The maps provided new, detailed, and more timely input for the task of monitoring a continuously changing environment (figure III). The maps assisted grasshopper and locust control teams to:

- (a) Monitor locations of favourable grasshopper and locust habitats;
- (b) Predict potential upsurges of pest populations in favourable habitats;
- (c) Survey areas likely to harbour significant populations of grasshoppers or locusts;
- (d) Plan the subsequent implementation of control operations.

The greenness maps provide a means of monitoring two key environmental factors that strongly influence the population dynamics of grasshoppers and locusts: vegetation condition (through direct monitoring of vegetation reflectance characteristics), and moisture conditions (indirectly through vegetation response to rainfall). Vegetation condition refers primarily to herbaceous stratum of the Sudanian, Sahelian, and, potentially, Saharan vegetation formations upon which grasshoppers depend for food and shelter. The herbaceous stratum responds quickly to a rainfall of at least 25 mm through germination and rapid growth. This amount corresponds to the approximate threshold of rainfall needed to trigger at least partial hatching of Senegalese grasshopper eggs (FAO, 1987), and approximately the amount needed for successful breeding of the desert locust.

Figure 1. NOAA-9 AVHRR image acquired on 8 November 1987, covering a major portion of West Africa. Digital data from images such as this one were used to compute the NDVI to produce the greenness maps.



Figure 2. A vegetation index map of Mauritania showing the maximum NDVI (greenness) values during the period of 11 to 24 September 1987.

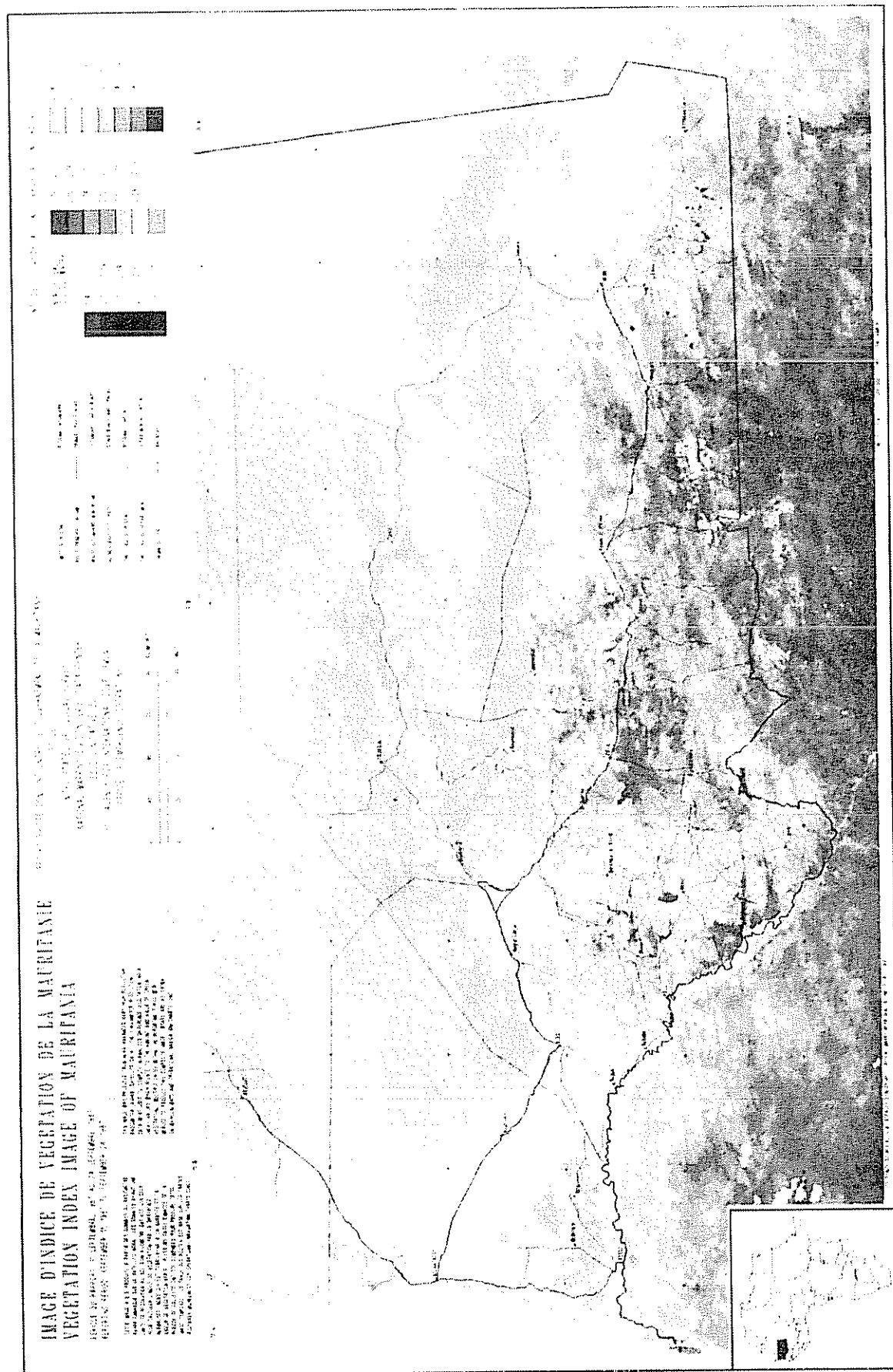


Figure III. Vegetation index maps of Mali showing vegetation growth between 1 and 15 August 1988, and the development of greenness in the wadis (linear drainage features) of north-eastern Mali. Greenness in the wadis indicates very favourable locust breeding conditions.

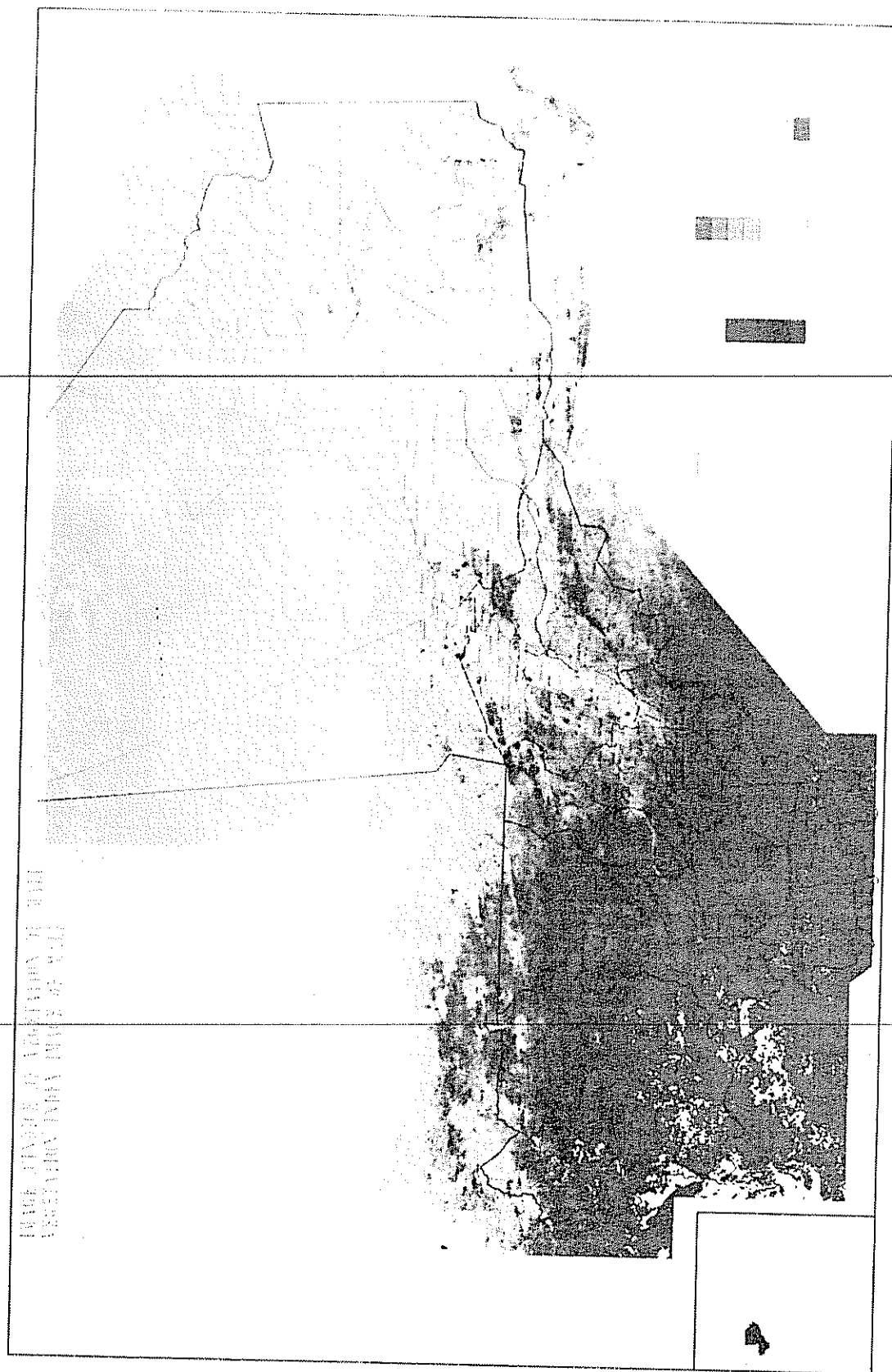


Figure IV. This greenness map serves as a background for isohyets based on the indicated accumulated rainfall at each station. The dashed line indicates the estimated location of the northernmost extent of green vegetation based on the station data. The map also indicates this boundary more precisely and shows isolated areas of green vegetation.

Isohyet Map: Cumulative Rainfall (mm) from May 1 to July 10 1987

**SOURCE:
AGRHYMET**

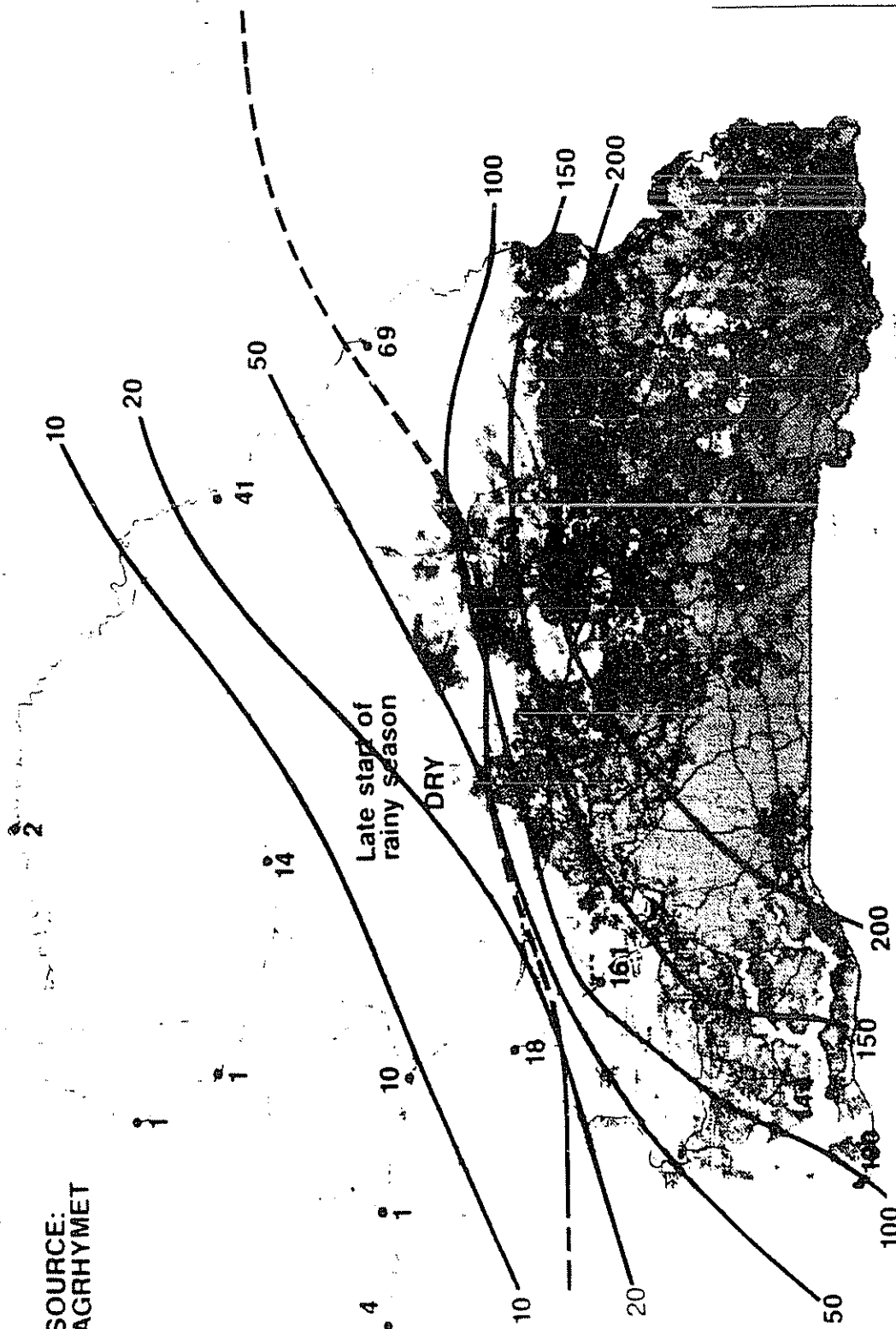
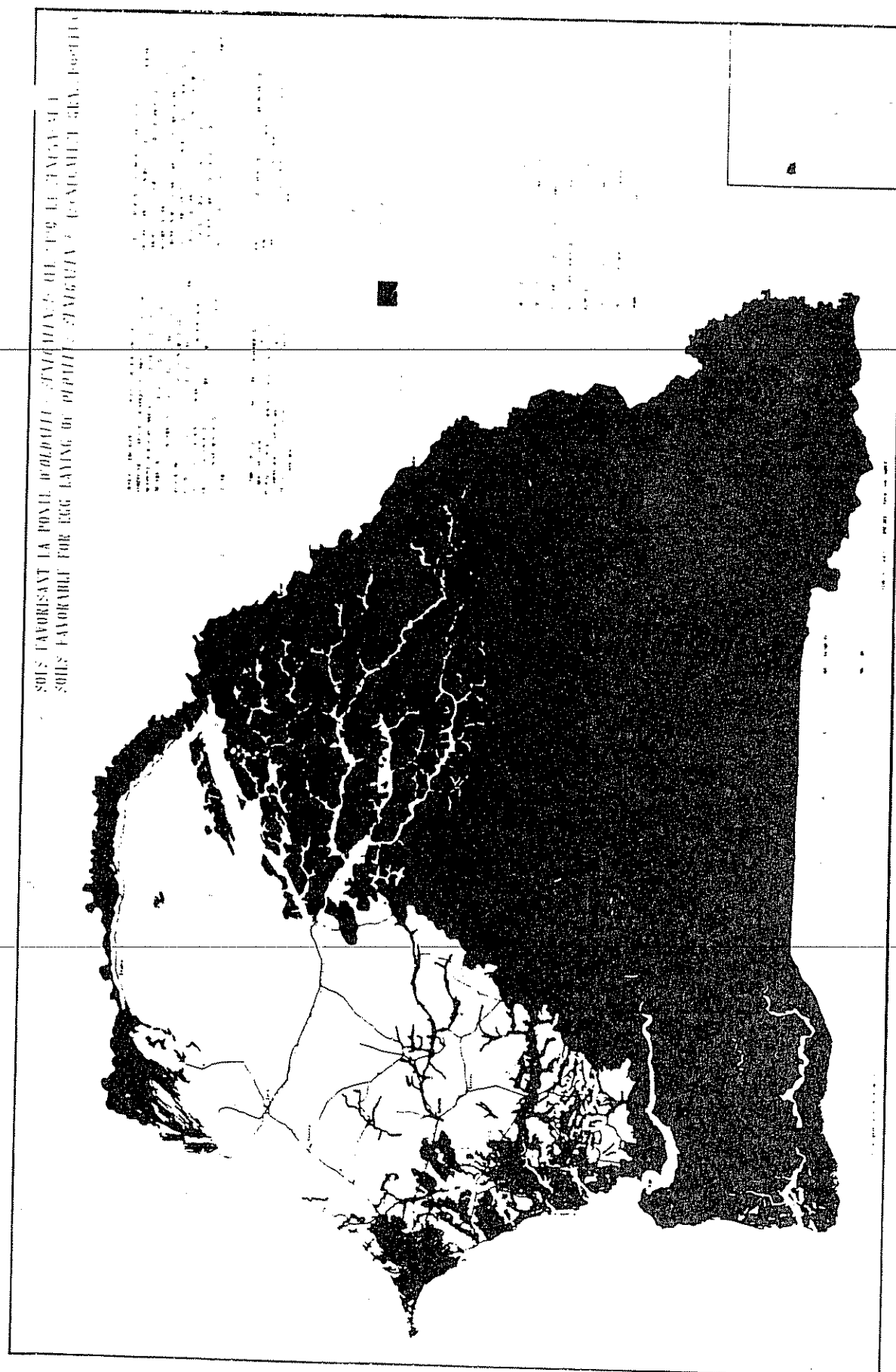


Figure V. A GIS product using a soils database of Senegal and the Gambia. The map indicates soils that are favourable for egg laying of the Senegalese grasshopper (white areas). This map can be used with the greenness maps to guide survey teams to potential breeding areas.



Map use for grasshopper control, particularly the Senegalese grasshopper, was based on the principle that seasonal rainfall triggers both the growth of herbaceous vegetation and the development and hatching of grasshopper eggs present in the topsoil. For example, in comparing data from field surveys in Senegal from May to August 1987 (Philips, 1987; Cavin, 1987) to the biweekly greenness maps, positive correlations were found among the initial emergence of herbaceous vegetation, the presence of hoppers of various species, and NDVI values of 0.08 to 0.13. Map use in support of desert locust control differs from that of the Senegalese grasshopper because of the biological and behavioural differences of the locust. The approach, presently being tested by the participating countries, is for the maps to serve as indicators of favourable sites likely to be invaded and colonized by migrating swarms, as well as favourable breeding areas. During migration, locusts do not directly seek out and fly towards green vegetation. Instead, the insects are carried downwind to areas of low level wind convergence where rainfall has often occurred and green vegetation is therefore present. For successful breeding and survival of the species, the desert locust must find favourable moisture conditions. Rainfall must have occurred in an area prior to egg-laying to provide the necessary soil moisture for egg development. The equivalent of 15-20 mm of rain 24 to 48 hours before laying provides the most suitable conditions (Pedgley, 1981). Again, the same rains promote the growth of seasonal herbaceous vegetation that provides food and shelter for the hatching nymphs.

Field observations in Senegal in 1987 indicated that herbaceous vegetation began to emerge 4 to 6 days after a useful rainfall of at least 20 mm (depending on soil type, slope and other factors). Preliminary indications are that emerging cover can be first detected using NDVI about 10 days following useful rainfall, and that NDVI values of 0.07 to 0.08 correspond to initial detectable emergence. Under ideal conditions of moisture and temperature, locust hatching occurs 10 days after laying (Pedgley, 1981) or 10 to 12 days after sufficient rainfall. Thus, the nymphs appear at about the same time emerging vegetation can be detected from satellite data. The period of hopper development under ideal conditions is about 36 days, at which time fledging occurs and the locusts gain flight capability. Allowing for the four to six days it takes to produce and deliver a greenness map, and depending upon the timing between vegetation emergence and a given map-compositing period, map users have 17 to 30 days to field check areas of emerging vegetation to determine whether they contain developing hoppers. If control measures are warranted, they should be taken before the hoppers reach the mobile adult stage.

Operational use of the maps in 1987 varied from country to country. In Senegal, prior to the regular use of the greenness maps, the grasshopper control team relied upon agricultural-hydrological-meteorological (AGHYMET) rainfall data and CPS field reports to estimate the general position of the advancing green-up line. The maps provided additional information on the intricate patterns of vegetation green-up. The CPS used the map information to send field teams to green areas and avoided wasting time in dry areas (figure IV). The survey teams noted positive correlation between the maps and ground observations. In Niger and Chad, USAID staff used the greenness maps as major sources of information for planning and conducting aerial surveys. In Niger, some green areas identified on the maps were visited and found to contain large populations of gregarious locusts. The CPS staff frequently used the maps for making decisions on whether to conduct field surveys. In

Mauritania, the greenness data were used by both USAID and the CPS to monitor the green-up patterns as a supplement to rainfall data and to confirm field reports on vegetation conditions.

A number of users suggested providing thematic resource information in conjunction with the greenness maps (for example, land use). Using a GIS approach, resource information can be integrated into the greenness maps, or provided on overlays. Analysts would then be provided with improved information on greenness, and its relationship to such phenomena as vegetation types, crop condition and drought. For demonstration purposes, existing soils data for Senegal were entered into a geographic database. In order to show how this resource information can be used within the context of a grasshopper control programme, certain attributes of the soils data, including soil texture, were identified and plotted to produce a thematic map indicating soils favourable for egg laying by the Senegalese Grasshopper (figure V). When used with greenness information, this map can serve as a tool to further narrow areas being considered for grasshopper surveys.

CONCLUSION

The prediction and survey of grasshopper and locust populations depend on analyses and syntheses of several major data sources. Traditionally, these analyses have included historic records on pest occurrence, weather patterns, historic and current rainfall, egg pod distributions, field reports, and various biological models. While every effort must be made to continue to integrate these sources, the data are often inadequate or unavailable for large areas in the vast Sahelian and Saharan environments. The recent use of satellite-derived greenness data for monitoring seasonal vegetation development has added another dimension to improving grasshopper and locust surveys.

Over the past two years, the greenness maps have been very useful to each country involved in pest control efforts. The maps have been used to locate actual locust infestations in a timely and efficient manner, saving survey time and expense. However, further work is needed to evaluate the use of the greenness maps specifically for control of the desert locust during plague years, a situation that has only recently arisen. Additional research into the incorporation of GIS technologies related to the overlay of soils, egg pod survey results, and historical information is also required.

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(g) *Development and application of digital cartographic databases, including digital terrain modelling*

DEVELOPMENT OF A GEODETIC INFORMATION SYSTEM USING A STRUCTURED DATA MODELLING APPROACH*

Paper submitted by Canada

RÉSUMÉ

Ce document décrit les travaux effectués par la Division des levés géodésiques du Centre canadien des levés pour mettre au point un système national d'information géodésique. L'accent est mis sur les méthodes informatiques utilisées dans la modélisation des données géodésiques. Les progrès réalisés (planification du projet, mobilisation des données et construction du prototype) sont examinés. Le document se termine par un examen des plans futurs.

RESUMEN

En esta monografía se describe la elaboración del Sistema Nacional de Información Geodésica (NGIS) en la División de Levantamientos Geodésicos del Centro de Topografía del Canadá. Se presta atención a la metodología de la ingeniería de información en lo que atañe a la confección de modelos de datos geodésicos. Se analizan los avances hasta la fecha, inclusive la planificación de proyectos, la confección de modelos de datos y la construcción del prototipo del NGIS. La monografía concluye con un examen de los planes futuros.

SUMMARY

This paper describes the development of the National Geodetic Information System (NGIS) by the Geodetic Survey Division of the Canada Centre for Surveying. The emphasis is on the information engineering methodology as related to the modelling of geodetic data. The developments to date, including project planning, data modelling and building of the NGIS prototype, are discussed. The paper concludes with a discussion of future plans.

* The original text of this paper, presented by C. A. Chamberlain and K. Lockhead, Geodetic Survey Division, Canada Centre for Surveying, appeared as document E/CONF 81/L. 19

MANDATE OF THE GEODETIC SURVEY DIVISION

The Geodetic Survey Division is one of three divisions within the Canada Centre for Surveying of the Surveys, Mapping and Remote Sensing Sector of the Department of Energy, Mines and Resources. The objective of the Division is to "ensure the availability of geodetic information concerning the Canadian landmass based on international standards and national criteria for geodetic reference systems" (E.M.R., 1988). This divides into the following main functions:

- (a) To establish and maintain the primary geodetic control networks of Canada;
- (b) To establish supplementary control networks as required for the National Topographic Series Mapping Program;
- (c) To establish supplementary control networks in the Yukon and Northwest Territories only, as required, for land administration, resource development, engineering works etc.;
- (d) To carry out special geodetic surveys in support of earth science activities, mainly to monitor deformations of the earth's crust and to support gravity surveys;
- (e) To carry out research and development in geodesy.

Data management at the Geodetic Survey Division

Within the Division, the main data management tool has been the National Geodetic Data Base (NGDB). The system was designed in the early 1970s, and has proved very useful in the intervening years. Similarly, databases exist for other geodetic data such as astronomic observations and Doppler observations and elevations. Over the years these "stand alone" databases have been developed independently with little thought as to how they interact. In fact, they use different database management (DBM) systems or in some cases, no DBM system at all, which has made it virtually impossible to share data between them.

Recent projects, such as the redefinition of the North American Datum (NAD-83) (Boal and Henderson, 1988) and the development of an Active Control System (ACS) based on the Global Positioning System (GPS) [Delikaraoglou, Steeves, Beck, 1986] are producing new sources of data that cannot be efficiently managed by these existing systems. The NAD-83 project will result in redefined coordinates for the survey control points plus the variance-covariance matrix of the coordinates. The NGDB can effectively manage the coordinates; however, the covariance matrix would require a completely new design and implementation. The ACS will produce more data in one month than presently exists in the NGDB. The NGDB was simply not designed to deal with such vast quantities of data. In addition, the ACS will require near real time access for both distribution and computation. Again, the existing system is simply inadequate.

The existing databases have been developed on a variety of DBM systems, usually using a hierarchical data model or sequential data files. In some instances these models have proved successful; however, if "information", as well as "data", is required, then the relational model is much more efficient. In this context "data" are facts, such as the coordinates of a point, whereas "information" is obtained by applying some intelligence to the facts to draw inferences. Owing to recent advances in computer technology, relational DBM systems to fit this application have only recently become available in the marketplace.

As stated above, the existing systems have been developed in a non-integrated environment. Very little thought has been given to the efficient sharing of data between the systems. The databases are "project" oriented rather than "data" oriented. In this context, "data" implies all the underlying data upon which the organization operates. Several authors, most notably James Martin in his book, *Strategic Data Planning Methodologies* (Martin, 1982) points out that an organization's data are relatively stable, whereas the processes around that data vary greatly. As an example, the instrumentation for collecting survey observations and the adjustment methodologies have changed dramatically over the years; however, we still basically use distance, direction and azimuth observations to compute coordinates. Only recently have systems such as Doppler, ISS and GPS added a new observable, coordinates and coordinate differences.

Based on these facts it was decided that a new approach to data management was required at the Geodetic Survey. It was recognized that only with a proper "data model" could data management developments be successful.

DATA MODELLING APPROACH

Bringing about a successful integration of information depends largely on the functions and the size and complexity of the organization. To integrate information requires rigorous analytical techniques, backed by powerful tools and a methodology that oversees the total life cycle of an entire development project.

The methodology chosen for this project was the Nijssen Information Analysis Methodology (NIAM) (Nijssen and others, 1979; Verheijen and Van Bekkum, 1982; Isloor, 1987). The six-phased approach of the NIAM Information Analysis Methodology results in a comprehensive, easy to understand, rigorous, stable and verifiable requirement specification. User participation, project planning, data modelling and prototype construction are critical to this approach. The following discussion on the data modelling and application summarizes the details found in references (Isloor and Chamberlain, 1988; Systemhouse, 1988).

The NIAM Information Analysis Methodology is divided into six phases as follows:

- Developing the project model
- Developing the functional model
- Developing the information flow model
- Developing the semantic information model
- Generating the data model and a relational schema
- Validating the requirements model

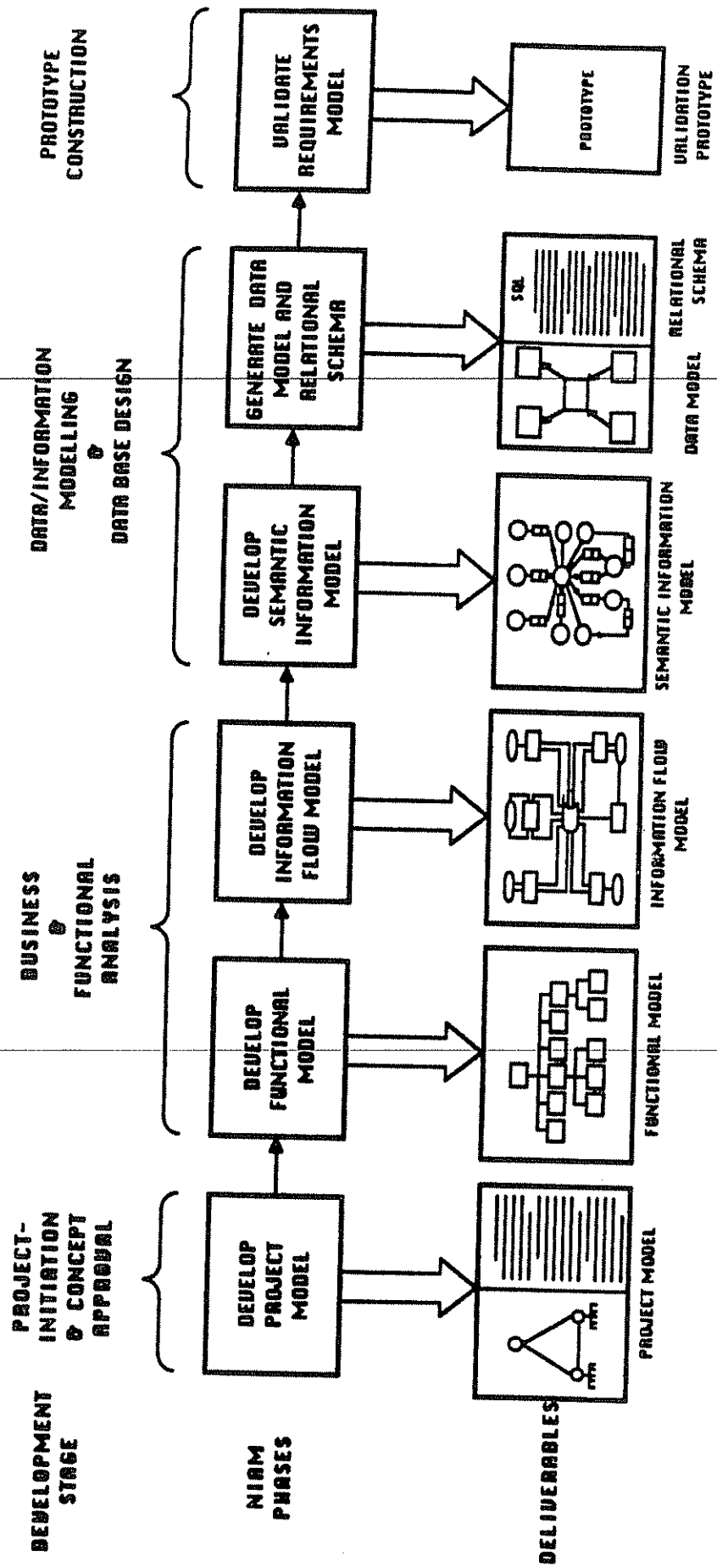
Figure I graphically shows the development stages, NIAM phases and associated deliverables.

Developing the project model

This phase is designed to facilitate understanding and commitment. The project model created during this analysis will provide a clear idea of the roles, responsibilities, activities and milestones associated with each stage of the project. The project model identifies two crucial aspects: project organization and project activities.

Vital to the project organization phase is the identification of three critical resources from within the project organization: executive responsible, acceptor and project manager. The end result of the analysis of this phase is a formal document called the "project model". This plan identifies the problem scope and objectives and defines the roles, phases and deliverables. In addition, the project model presents the initial schedule for the project.

Figure 1. Phases of the Nijssen Information Analysis Methodology (NIAM)



Developing the functional model

The intent of the functional model is to gain a clear and stable picture of the hierarchy of basic tasks that will serve as a foundation upon which to build the information system.

The functional model is a hierarchy of basic tasks in a business or operation. This phase takes an unbiased, objective look at the various tasks. In a series of brainstorming sessions, the project team isolates and analyses the system functions, breaking them down into subfunctions until a hierarchy evolves that describes the total operation. This method of analysis, termed "top-down decomposition", provides checkpoints for completeness and relevancy at each level.

Although basic functions remain stable, how one handles these functions is subject to change. For instance, an analysis of the current functions in light of today's changing technologies could cause the automation of one or more previously manual functions or could lead to reorganization. For this reason, the functional model looks beyond the current methods, structures, technologies and organization. Its intent is to give a clear and stable picture of the functions that will serve as the foundation for an information system that can adapt to change. Figure II shows the functional model formed during this project.

Developing the information flow model

The information flow model represents the logical sequence of the functions by means of the information that must flow between the functions. The model serves as the basis for the derivation of the scope of the information system models and it also depicts the interfaces to environments external to the functions in the functional model.

In this phase, the project team develops and establishes relationships between functions identified in the functional model. Like the functional model, the information flow model is not tied to the current organizational structure, methods and processes.

Information flow is divided into two areas: input used by the function and output produced by the function. Figure III is an example of an information flow model.

Developing the semantic information model

The semantic information model (Nijssen and others, 1979; Verheijen and Van Bakkum, 1982) addresses what information is used and graphically identifies relationships, behavioural constraints and validation requirements. This model is a rich semantic network that concentrates on the meaning of information rather than on its structure. The information flows that were identified in the information flow model are decomposed into objects and their references. These individual objects are then related to one another to show how they work within the function.

Figure IV shows the semantic information model for the "validated data" (Terrestrial Observed Set) information flow of the information flow model of figure III.

Generating the data model and relational schema

Using rigorous rules, the binary facts and constraints of the semantic information model are grouped to form a data model. This model provides an overview of the data structure.

Figure II. Functional model for the National Geodetic Information System

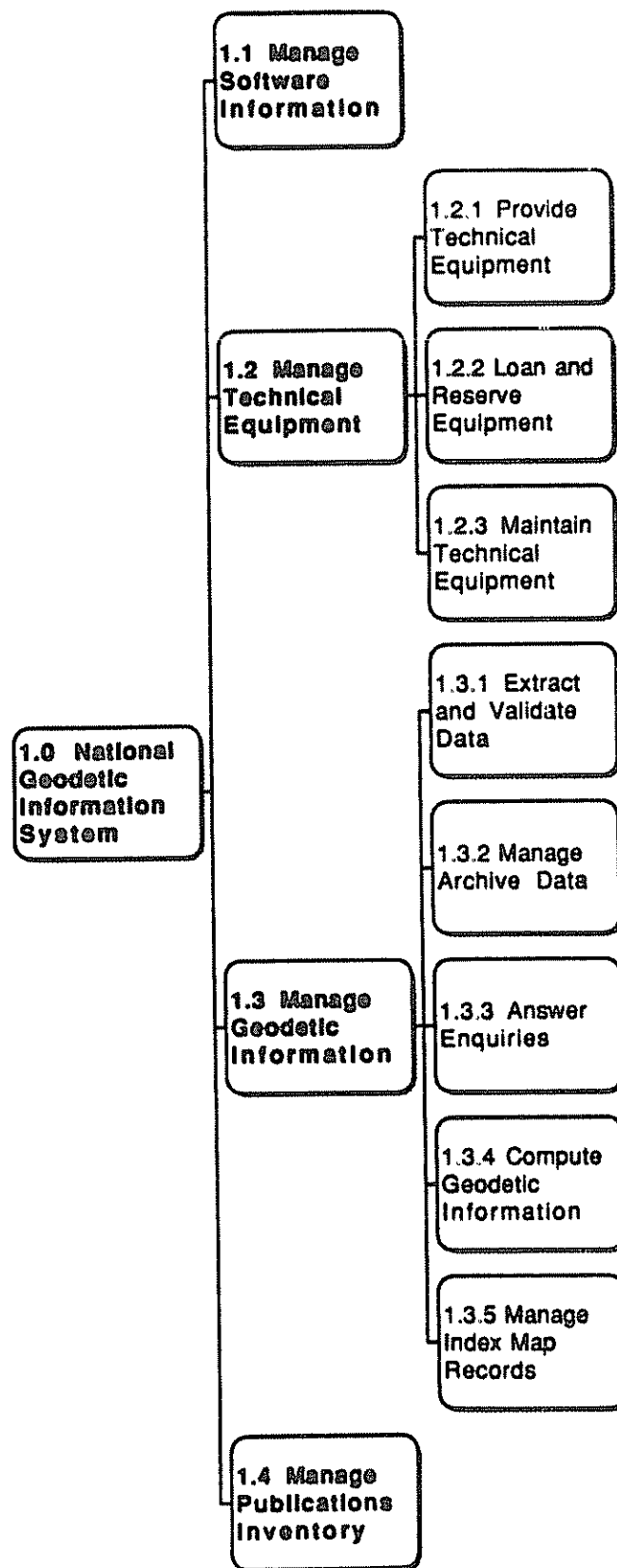


Figure III. Information flow model of function 1.3.1 (Extract and validate data) of figure II

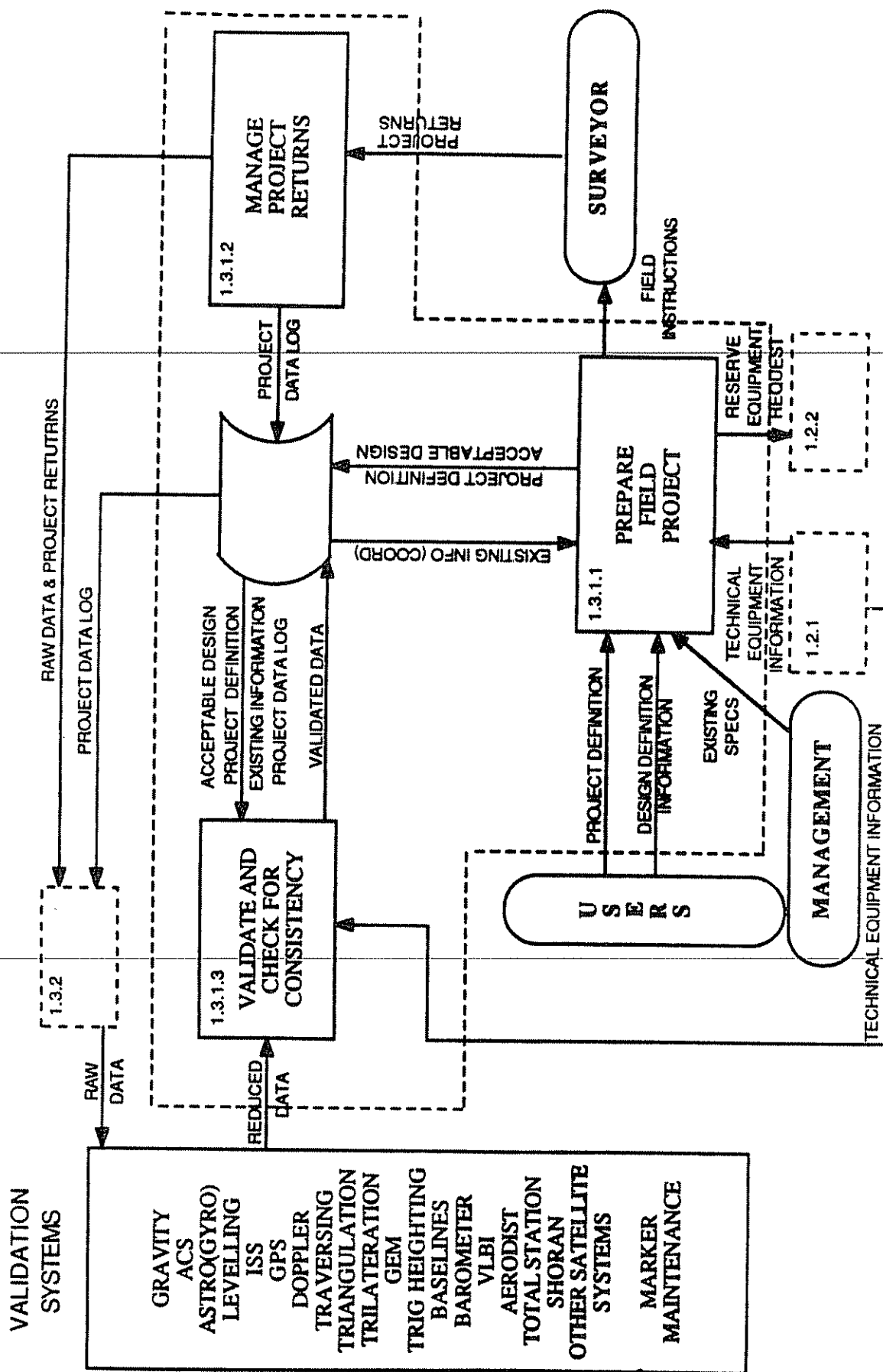
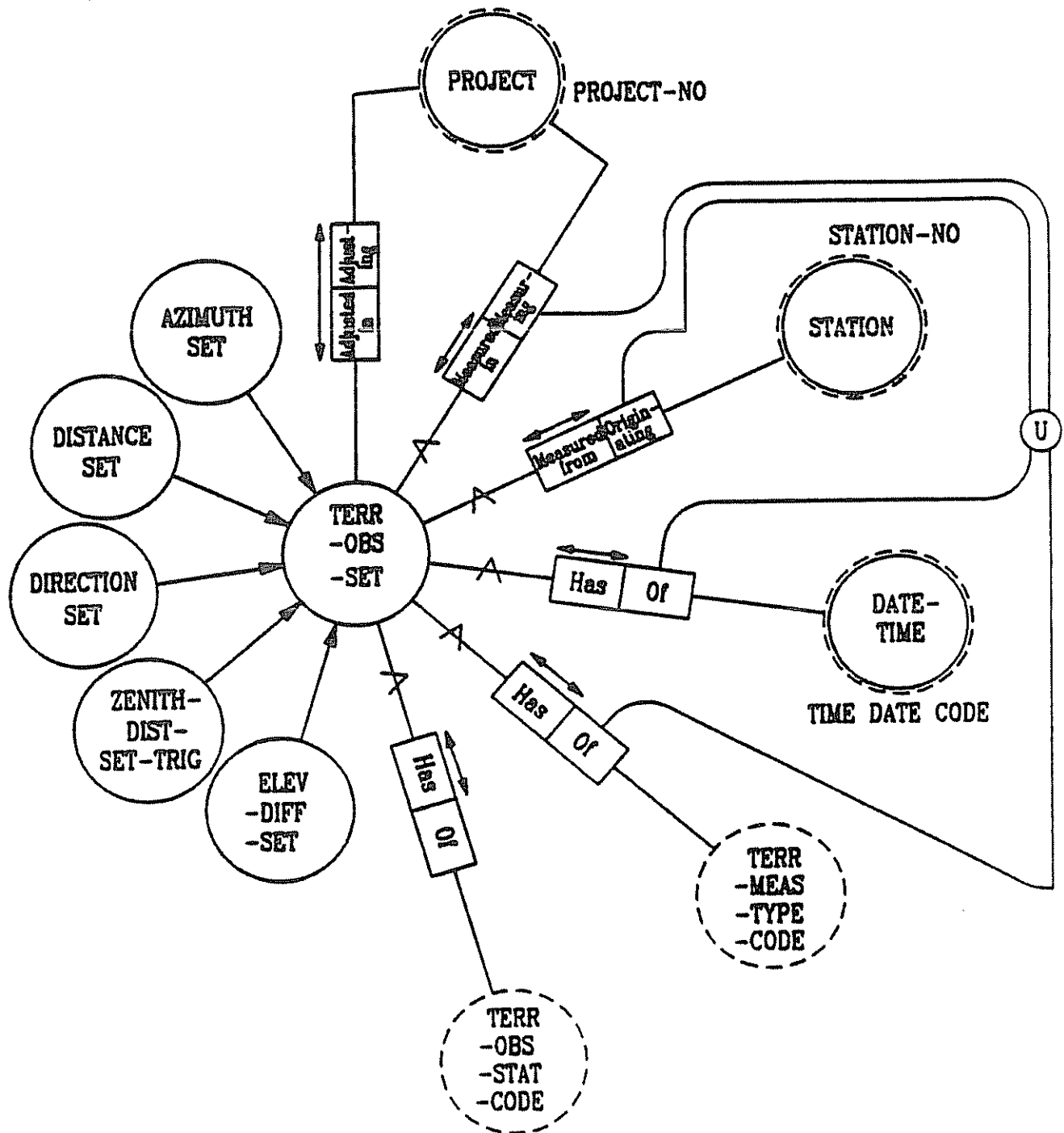


Figure IV. Semantic information model for the validated data (Terrestrial observed set) information flow of figure III.



The data model is a normal form record model generated from the semantic information model. By providing an overview of the entire data structure, the data model assists in the selection of a database management system that fits the needs, model data/information architectures and identifies key interfaces for integrated applications. The next step is to use specific target DBM system pipes to generate relational schemas for the chosen target DBM system.

Validating the requirement model

The models developed thus far have provided a rigorous and computable set of requirement specifications. To further enhance the value of these models, a validation prototype is created for verification. The validation prototype generates the prototype database, collects and loads real data and simulates logical processes.

APPLICATION OF THE METHODOLOGY AT THE GEODETIC SURVEY DIVISION

The application of the NIAM methodology for the modelling of survey-related data in NGIS proceeded as three major phases, namely, project planning, data planning, and data validation prototype

Project planning phase

At the beginning of this phase, a project team of 12 personnel (9 survey engineers and 3 computer scientists) was trained in NIAM methodology. The project team participated in the specific definition of the project and constructed a functional description of NGIS. The team also created a high-level information flow model of NGIS functions and their external interfaces. The purpose of this phase was to gain a complete understanding of the project. The elapsed time for this phase was approximately two months.

Data planning phase

The initiation of the data planning started with the review of the results of the project planning phase. IBM's Joint Application Development (JAD) technique, with an external consultant acting as a facilitator, was used in this phase to develop the data model. The results of the analysis were:

(a) The functional model was developed. The highest levels of the model are shown in figure II. Each box or function on this figure was broken into sub-functions and defined in detail to gain a clear picture of the basic tasks to be performed;

(b) The information flow model was developed to specify the data flows between the functions developed in the functional model (see figure III);

(c) The semantic information model was developed for each piece of information. The relationships, constraints and validation requirements of the data model were developed and graphically defined (see figure IV).

Details of the semantic information model were:

Number of objects modelled: 200

Number of attributes of objects modelled: 500

Number of subtypes in the model: 40

Number of constraints modelled: 90.

In developing the data model, the entire team worked together to resolve all outstanding questions before a concept was finalized. Often, the initial attempt at defining a concept was done by a subset of the team as appropriate to the area under consideration. Members of the team consulted other Divisional staff on an individual basis when such discussion was deemed essential to the analysis. A series of integration work sessions was held by the project team in order to ensure that an overlap or duplication would be identified and resolved. The elapsed time for this phase was approximately four months, and the effort involved was 3 person-years.

Data validation prototype phase

The computer program PC-LAST (Control Data Corporation) was used to capture the semantic information model pictorially. This tool is a typical product from the emerging field of computer-aided software engineering (CASE). Using rigorous, automated rules, the binary facts and constraints of the semantic information model were grouped by PC-LAST to generate the data model.

In the case of NGIS, this grouping produced approximately 500 records. Analysis of these records showed that, based on sound design principles, several records needed to

be combined into larger records. Suppression of several reference classes and allowing null values in the semantic information model allowed PC-LAST to regenerate a data model resulting in approximately 230 records. PC-LAST's SQL schema generator created an SQL schema for the NGIS prototype.

The technical environment chosen to develop the NGIS prototype was the DEC/VAX 8300, using RDB as the data manager with POWERHOUSE (Cognos Corporation) as a prototype generator. The prototyping environment is shown in figure V. The 200 screen NGIS prototype consists of: three subsystems: geodetic, publications and software. The model was divided into three subsystems to test the prototyping environment with two smaller models. In each subsystem the first screen established user identity and enforced user authorization. Subsequent menu screens provided access to various logically organized subsystems within the three major subsystems. A prototype evaluation subsystem was developed which was automatically invoked at the end of using every logical subsystem to capture user comments (when fresh). This system gathered all comments and suggestions in an RDB database, which provided an excellent repository of suggestions for the design phase.

The success of this prototype development is best illustrated by the following points:

(a) Expertise in developing information systems and using automated CASE tools for development such as POWERHOUSE and PC-LAST, was developed within the Geodetic Survey Division;

(b) An accurate data model was developed that will be used in the final implementation of NGIS;

(c) The prototype helped to identify many management issues and technical complexities that must be addressed before a successful implementation of NGIS is possible.

FUTURE PLANS

A roadmap for the development of a full implementation of NGIS is shown in figure VI. A project must be initiated to perform each of the functions shown in the boxes. The modelling of the processes, as identified in the prototype development, is to be carried out in parallel with the standardization of codes (such as province codes, station numbers etc.). Once the codes have been standardized, the data conversion requirements to fit the data model can be determined. These activities are labelled as phase 1. The next step, phase 2, is a feasibility study that must be carried out to develop a cost/benefit analysis and to address hardware, software and data communication issues. Phase 3 is the acquisition of any hardware and software needed for the system. In parallel with the acquisition, work will be performed on the design of NGIS in the chosen hardware/software environment. Phase 4 will be the development and full implementation of the NGIS. Present plans call for the system to be fully developed and implemented by 31 March 1991.

SUMMARY

The NGIS will form a solid foundation for data management at the Geodetic Survey Division. The following critical success factors will ensure that the project remains on schedule and budget:

(a) Commitment by management to the project;

(b) Commitment of a dedicated, enthusiastic project team and project leader;

(c) Use of a structured data modelling approach;

Figure V. Prototyping software environment

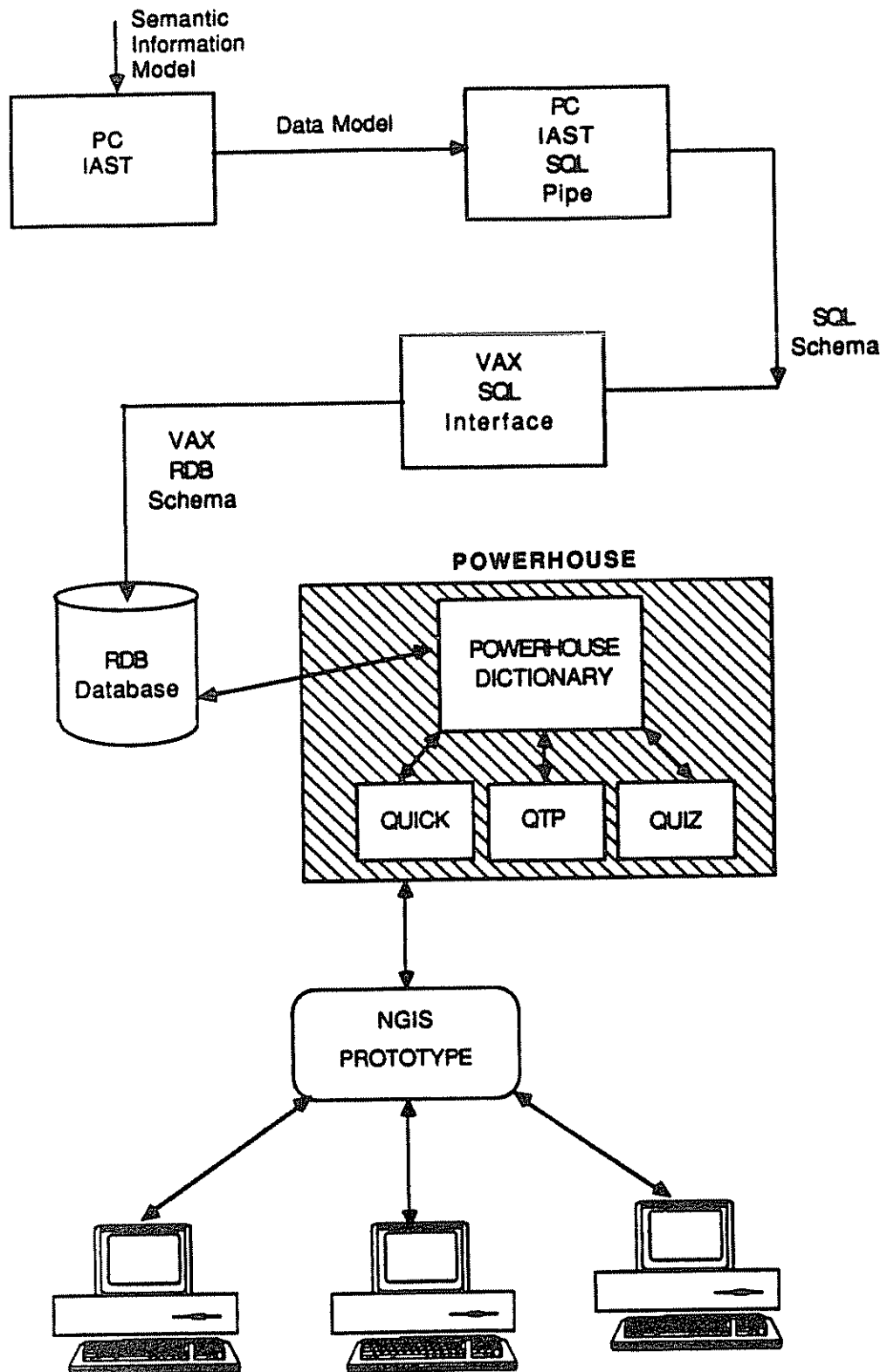
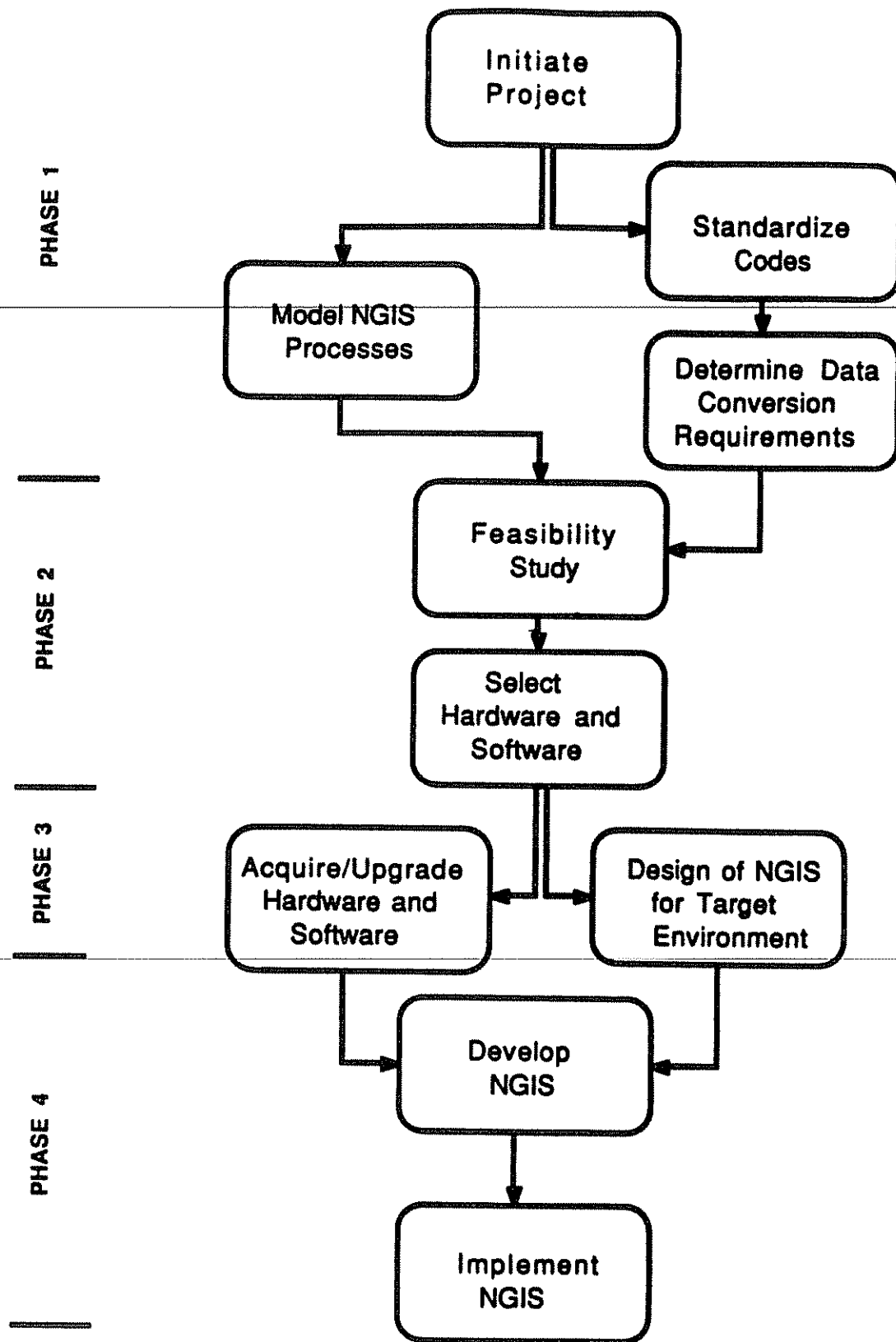


Figure VI. NGIS: Plans for the future



- (d) Use of automated and rigorous CASE tools for all phases of the development life cycle;
 - (e) Use of the Joint Application Methodology.
- When completed, the NGIS will provide:
- (a) Better data for users and information for managers;
 - (b) Enhanced planning and control capabilities for the Division;
 - (c) Enhanced technology transfer;
 - (d) An integrated environment for data processing and management;
 - (e) A qualitative improvement in the products and services of the Division.

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PREPARATION AND PRODUCTION OF DIGITAL MAPS FOR POWER SUPPLY COMPANIES*

Paper submitted by the Federal Republic of Germany

RÉSUMÉ

L'une des tâches les plus urgentes que doivent exécuter les administrations responsables des levés et du cadastre est la mise au point d'une base de données numériques géométriquement parfaite, établie à partir des plans cadastraux analogiques. Étant donné que, pour l'établissement d'une telle base de données, il faudrait s'efforcer de parvenir à l'applicabilité universelle, et compte tenu des inexactitudes existant dans les plans cadastraux analogiques, il ne suffira pas simplement d'adopter un système analogique/numérique. La compilation et la préservation des données devraient permettre leur évaluation universelle. En outre, il faut assurer l'homogénéité géométrique des données numériques grâce à des calculs numériques de vaste portée. Dans le cadre de l'accord de coopération conclu avec les compagnies d'électricité, l'administration des levés et du cadastre de la Rhénanie-Palatinat (Rheinland-Pfalz) fournira des données pour certaines zones préférentielles de sorte qu'un système d'information polyvalent puisse être établi.

RESUMEN

Una de las tareas más urgentes que enfrentan las direcciones geodésicas y catastrales es el suministro de una base de datos digitales geométricamente correctos basados en mapas de catastro analógicos. En vista del hecho de que debe tratar de lograrse la aplicabilidad universal de esa base de datos y teniendo en cuenta las inexactitudes que entrañan los mapas de catastro analógicos, no será suficiente meramente utilizar un sistema analógico/digital. La reunión y preservación de los datos debe permitir la evaluación universal. Además debe asegurarse la homogeneidad geométrica de los datos mediante un cálculo numérico cabal. En virtud del acuerdo de cooperación con las empresas de suministro energético, la dirección geodésica y catastral de Renania-Palatinado (Rheinland-Pfalz) suministrará datos para algunas regiones de preferencia a fin de que pueda establecerse un sistema de información múltiple

* The original text of this paper, prepared by Karl-Heinz Bastian, Ministerium des Innern und für Sport, Rheinland-Pfalz, appeared as document E/CONF 81/L. 14

SUMMARY

One of the most pressing tasks facing survey and cadastral survey administrations is to provide a geometrically flawless digital database based on analog cadastre maps. In view of the fact that for such a database universal applicability should be aimed at and taking into consideration the inaccuracies involved in analog cadastre maps, it will not be sufficient merely to switch over to an analog/digital system. Compilation and preservation of data should allow for universal evaluation. In addition, the geometric homogeneity of the digital data must be assured via extensive numerical calculations. Under the cooperation agreement with the power supply companies, the survey and cadastral administration of Rhineland Palatinate (Rheinland-Pfalz) will provide data for certain areas preferentially in order that a manifold information system may be set up.

Following the increasing availability of graphic data processing systems, the provision of exact geometric digital cadastre documents has become more and more important.

This is one of the most urgent tasks facing the survey and cadastral survey administration. Owing to the nature of its work and the data already available, the property cadastre is in a unique position to provide the necessary spatial data, i.e. data that are up-to-date, complete and providing area coverage.

Ideally there should be certain calculable coordinates and particular linear connections in the Gauss Krüger system for all important information contained in the official maps of the national surveying and mapping agencies. Calculable coordinates are only available for some of the points and cannot be made available within a reasonable amount of time. Thus the only realistic basis for the compilation of a digital database that will meet the manifold administrative and economic demands is an analog cadastre map.

A switchover of the existing property maps to an analog/digital system, however, is not sufficient for the compilation of such a database. Owing to variations in accuracy of the individual property maps and within the property maps (for historical reasons), extensive data manipulation is necessary to provide a geometrically flawless digital cadastre register.

When using existing cadastre maps as a basis for digital cadastre maps we should not forget the origin and aims of these information carriers. The roots of the cadastre maps go back over 150 years to the beginning of the nineteenth century. The maps were compiled to lay down correct distribution of taxes, and their main aim was to calculate the exact measurements of the property. The standards of plotting, scale and depiction varied greatly in the individual historical areas of Rhineland Palatinate (Rheinland-Pfalz). This resulted in enormous differences in the property maps. Hence, the old property maps differ greatly in scale, accuracy and depiction. The aim of the survey and land registry office in Rhineland-Palatinate in recent years therefore consisted in compiling a uniform analog property map series which was sufficiently accurate for the entire area. A general cadastral map series has been compiled for 62 per cent of the area. The remaining 32 per cent is depicted in fractional maps.

In the course of the development of the property cadastre, new goals were set with regard to proprietary rights and the varied demands of an industrial society. Even the newly compiled general property map series can no longer meet the demands of a society which is becoming more and more orientated towards telecommunications. Increasing amounts of data must be easily available and where possible universally transferable, for which reason the maps must meet the

ever-increasing demands of innovative graphic processing. Digital cadastre maps are now necessary to cope with the integration of this technology into the areas where previously analog maps were used to carry out particular tasks. A cooperation system has been built up over the last 10 years within 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)) with regard to the automated property register (ALB), the automated property map (ALK) and the instruments for graphic data processing. This provides the survey and cadastral survey administration with the necessary foundation for the provision of these data. In spite of the tight scheduling demands of the user this cannot be carried out for all areas within a short space of time. Even when the user is already applying a digital system this only helps to a certain extent, because:

(a) It is usually only an analog/digital switchover and does not take the accuracy potential contained in the cadastre maps fully into account;

(b) Further development of the digital database would certainly be problematic and outdated within a short period.

In contrast to this, the digital cadastre map register of the survey administration of Rhineland-Palatinate, which is unspecialized, allows the user to interlink his technical data with the geometrical data of the property cadastre. The necessary spatial reference data are provided for all ground-related data, thus ensuring universal availability. With the fixed point fields and cadastral maps in the Gauss Krüger coordinate system, the survey and cadastral survey administration provides a foundation covering a wide area which, together with the survey data from the cadastre map, makes up the basis for establishing a digital data system.

It is of particular importance that the user and the survey administration work closely together. Financial participation in the work of the survey and mapping agencies allows for the setting up of a concept which is satisfactory to both parties and which in the long run can be seen as a largely cooperative project.

THE CADASTRE MAP AS A BASIS FOR SPATIAL INFORMATION SYSTEMS

The survey and cadastral survey administration's concept of a neutral register of geometrical data of the property cadastre allows the power supply companies not only automatic processing of a detailed plan of work via the relevant distribution networks to be managed by interlinking the geometric database from the property cadastre with the master file and other specific files, but for the purposes of the

energy supply companies a further system is created which also can be utilized universally.

A number of the specific demands of the power supply companies are also valid for other areas. A digital cadastre map must meet these demands if it is to be of universal use. In particular, the digital cadastre map must meet the following requirements. It must:

- (a) Be based on a uniform reference system (Gauss Krüger coordinate system);
- (b) Provide area coverage free of sheet lines, homogeneous, topical and independent of scale for a large area in so far as this is available, and must ensure data transfer via an interface which is compatible with all types of manufacture;
- (c) Offer selection and modification options;
- (d) Provide adequate geometric accuracy;
- (e) Be clearly defined and easily interpretable.

If all these conditions are fulfilled, the system becomes more than a mere digital depiction of an analog map. The universal compatibility thus achieved of the digital map provides the user with the means of manipulating the data stock according to his individual needs and aims. From the outset these varying goals do not allow for a transference of the analog map, e.g. via simple scanning in a digital grid data stock. On the contrary, extensive groundwork is necessary for the preparation of the analog map, and division of the map into different acquisition levels is inevitable.

The digital cadastre map in Rhineland-Palatinate

Digitizing the analog cadastre map series is seen in Rhineland-Palatinate as a preliminary step towards the Automated Property Map (Automatisierte Liegenschaftskarte (ALK)). Extensive measures are necessary, particularly with regard to depiction, scale and accuracy of heterogeneous cadastre maps before digitization can take place. With regard to the necessary geometric homogeneity the cadastral offices must take a multitude of geometric requirements and correlations between the map elements into consideration. The most important of these are:

- (a) Surveying-in of the missing building points;
- (b) Marking and adjustment of the control points available;
- (c) Insertion of the geometric requirements (rectilinearity, parallelism, right angles, distances etc.).

This information is provided by the sketches and the numerical data stock of the property cadastre.

The digitizing proper is being carried out at the moment exclusively by the Survey Department (Landesvermessungsamt) of the province Rhineland-Palatinate by means of a graphic interactive system from Siemens. The system is based on SICAD elements to begin with, in order to comply with the aforementioned requirements. The SICAD elements are assigned to different levels. These levels are also given different elements, which provide the basis for future selection and modification. Structure and parameterization of the SICAD elements have been derived recursively from the feature map catalog of the ALK and have been defined in a SICAD interface. Object definition will take place following implementation of the ALK data bank.

Programming system for digitization, editing and improvement of unhomogeneous cadastral map data DAVID

Particular problems have arisen regarding the homogeneity of the cadastre maps. This is particularly true in the

case of the integration of fractional maps to a digital data stock free of sheet lines. The reason for this is a distortion of the cadastral maps due to map distortion (regular systematic error proportion), as well as to inaccuracies incurred in the course of measuring or plotting etc. (irregular systematic error proportion).

The programme system DAVID, which was developed at the University of Bonn by order of the survey and cadastral administration, has rendered it possible to minimize the number of discrepancies at the theoretical points, which inevitably occur during transformation matching and which can be removed by distribution within neighbouring areas.

Distortions that occur throughout the entire map sheet, in particular map distortion, can be corrected by transformation. The remaining irregular systematic errors can be registered through correlations, which then describe these values of distortion in terms of distance.

Combination of fractional maps

Every time fractional maps are combined, one further problem arises: the residual discrepancies at the points of the map margins have to be eliminated. These discrepancies at the boundary points of adjacent maps appear again in the adjacent marginal fields, which fact gives rise to the need to eliminate the discrepancies by taking these marginal fields into account. This correlation would not be treated adequately by calculating only the simple mean value of the transformed coordinates of the reference points.

Block adjustment

The present problem can be compared with the procedure of connecting independent models, which is also known in photogrammetry. Each fractional map or parts of these maps are treated as independent basic systems which, by means of a transformation, have to be shifted, turned and altered in scale in such a way that the residual discrepancies at the control points or the tie points tend to a minimum.

The functional approach of the transformation adjustment takes the directional correlation of the map distortion into account. Six transformation unknowns for each map sheet are introduced into the functional model of the adjustment: (a) the two coordinate displacements X , Y of the independent basic systems, as well as (b) the angles of rotation and the scale factors of the coordinate directions.

The adjustment then yields the six unknown transformation parameters. The result of the adjustment can be extended by the coordinates of the tie points if the coordinate differences between the adjusted and transformed coordinates are introduced with zero into the adjustment as imaginary observations.

The digitized mass points do not contribute to the adjustment result and will preferably be introduced into the common coordinate system by means of the transformation parameters only after the block adjustment.

Distribution of the residual discrepancies

The residual discrepancies remaining at the control and tie points after the adjustment, as well as the existing residual discrepancies between transformed points, to which Gauss-Krüger coordinates can be assigned as theoretical values (reference points), constitute the information background for the distribution of the residual discrepancies onto the mass points according to the principle of adjacent points. The interpolation methods required here have to take into account the systematic parts — differing in each region — of the residual discrepancies. The purpose is here:

(a) Regarding points with Gauss-Krüger coordinates, to retain the coordinates;

(b) Regarding the tie points, to introduce the coordinates gained from the block adjustment;

(c) to achieve an adjustment of the mass points according to the principle of adjacent points. This permits the relations between adjacent points originally existing in the cadastral maps to be retained.

The adjustment, avoiding residual discrepancies, requires the following steps:

(a) Transformation of the digital coordinates at the control points into reference coordinates;

(b) Distribution of the residual discrepancies considering adjacent points and accuracy of form with the utmost independence from number and distribution of the reference points.

Moreover, the procedure should apply universally and be suitable for automation.

Considering the aims in view, correlation and prediction procedures promise the best results for the distribution of the residual discrepancies, adjacent points and accuracy of form taken into account. In the correlation procedure the shift value of a mass point can be found when taking the weighted mean value of the residual discrepancies of the surrounding control points, the weight being a function of the distance between control point and interpolation point. Within the prediction procedures the influence of the control point network is expressed in a stochastic model.

Restoration of the geometric conditions

All the preceding transformations and interpolations affect in a negative way the map geometry. The algorithms which work point by point require different coordinate corrections for each point, thus the geometric conditions between the points do not remain exactly the same. This is due, in principle, to inaccurate basic maps; inexact digitizing; corrections needed to combine the fractional maps; and numerical calculations in order to homogenize the data file.

Therefore it is necessary to reproduce the original geometric relations. After having homogenized the digitized map data, the known geometric conditions have to be restored as a last step. Only the coordinates having no reference position—here, the mass points—can in principle be taken to meet this requirement. These activities are handled in a hierarchical way by proceeding from large to small. The procedure has the following sequential steps:

(a) The system of parcel limits is realized in a geometric way;

(b) The buildings are fitted into the system of parcel limits with regard to form and relationship;

(c) Design elements are fitted into the building system or the parcel system with regard to form and relationship.

Post-processing

After digitization and complex numerical and interactive post-processing of the results the land registry concerned gets a plot of the digitized maps for a final examination with regard to content and geometry. After correction of possible objections, there exists now a map file which is geometrically accurate—depending on the precision of digitization—in a digital form, technically neutral, and with a versatile field of application. The data thus collected are stored on a long-term basis in the system of the Automated Cadastral Map, including the uniform database interface. The data

can be used individually by every interested person provided that he has the right to use them. A prerequisite for a data exchange is still the communication by means of the SICAD database interface. On a medium-term basis, data exchange will be realized using the uniform database interface (EDBS).

COOPERATION WITH ENERGY SUPPLY COMPANIES

The Survey and Cadastral Administration of Rhineland-Palatinate is gradually organizing a geometrically correct digital map series by digitizing the official cadastral plans of the property cadastre, according to the procedure of the Automated Cadastral Map developed on a federal level. Thus the final product is not a digital map that has only been produced individually for the energy supply companies but a basic map for universal applications such as law, administration, planning and economy, with special attention to the needs of energy supply companies.

Based on cooperation, an operation plan is set up in common, and the technical specifications as well as those related to data processing and the interface description for a digital data exchange are fixed. The operating plan determines, in particular, for each regional area the limits and surface of the area considered; the sequence of processing; and the supposed date of delivery for the digital data.

The cooperation contracts concluded so far determine the inclusion in the operation plans from the first the locations and the location borders. If there is interest, it is also possible to capture digitally the cadastral content outside settlements. As preservation of data covering an area is intended, this is in any case imperative.

The operation plan assigns the following activities to the survey and cadastral administrations:

(a) To survey the missing buildings;

(b) To prepare and present the documents to be digitized;

(c) To digitize and process the digital data in a mathematical and geodetic way;

(d) To verify formally and technically the digital basic data;

(e) To deliver the digital maps on machine readable data carriers (within an interface description);

(f) To revise the digital map.

The extent of the data to be digitized is limited to those contents and planimetric elements represented on the official cadastral map and described in the interface defined by the survey and cadastral administration of Rhineland Palatinate. The digital maps are made available in the first phase in the format of SICAD-GDB-interface on machine-readable data carriers of the survey and cadastral administration. When the ALK database software has been implemented, the survey and cadastral administration will change the data transfer format into the format of the uniform database interface EDBS of ALK. This ensures that the data are presented in a system-neutral form.

The survey and cadastral administration leaves the digital data to EVU due to the cooperation contract. These data are earmarked for special purposes within the framework of the usufructuary right. With the transfer of the data the survey and cadastral administration guarantees that the planimetric information, transferred as digital maps, corresponds with the information of the property cadastre. The survey and cadastral administration gives thus in principle the same guarantee for the digital data as for analog extracts from the cadastral map services.

PROSPECTS

The consecutive establishment of a geometrically correct digital map series, for the time being as a preliminary stage of the Automated Cadastral Map, is the proof that the survey and cadastral administration meets the requirements of its

mission as far as new information and technologies are concerned, a mission which has to serve law, administration and planning. We have thus a basis of universal use when we establish parcel-related information systems. It is then up to the users to utilize these basic data as a foundation for their special information system.

PROPOSAL FOR CREATING AN IHO CENTRE FOR DIGITAL BATHYMETRY*

Paper submitted by the International Hydrographic Organization

RÉSUMÉ

Le premier système international d'établissement de données bathymétriques à l'échelle mondiale a été créé en 1903 par le prince Albert I de Monaco. A sa mort, survenue en 1922, le Bureau hydrographique international (BHI) s'est chargé d'entretenir, par des procédés manuels, une série mondiale de minutes de rédaction au 1/1 000 000 constituées à partir de données relativement rares. Au milieu des années 50, toutefois, les données à l'entrée étaient devenues trop nombreuses pour les ressources du BHI; 18 bureaux hydrographiques privés (BHP) ont alors accepté de se charger de la mise à jour de ces minutes de rédaction. On a demandé à tous les services hydrographiques de communiquer les nouvelles données recueillies auprès des organismes nationaux au BHP compétent. A compter de 1956, le BHI remplit les fonctions de Centre mondial de données bathymétriques.

Dans le cadre de l'établissement, à la fin des années 70, de la 5^e édition de la carte bathymétrique générale des océans, il était apparu que les coordonnateurs scientifiques du projet disposaient de données beaucoup plus nombreuses que n'en faisaient apparaître les minutes de rédaction actualisées des BHP. Cela semble dû au fait que les spécialistes des sciences de la terre rassemblaient et géraient à l'aide d'ordinateurs des données bathymétriques beaucoup plus importantes que les services hydrographiques. Les sondes caractéristiques des grands fonds sont de plus en plus souvent stockées et gérées sous forme numérique, et non sur des feuilles de sondage; or, les données numériques présentent une plus grande souplesse d'utilisation. Le Comité directeur mixte OHI/COI a fait savoir que la création d'un centre OHI des données bathymétriques numériques faciliterait grandement le stockage, dans un fichier international, des données provenant des spécialistes des sciences de la terre surtout s'il devait en retour offrir un service efficace de communication de données sur demande.

On a demandé aux BHI d'étudier la possibilité d'accepter la proposition des Etats-Unis de mettre à leur disposition les services du Centre national des données géophysiques (NGDC) de Boulder (Colorado), qui centralise les données bathymétriques, magnétiques et gravimétriques réunies dans le cadre de 2 600 expéditions et a acquis une expérience considérable dans le domaine de la gestion de ces données. Agissant en tant que Centre mondial des données bathymétriques, le BHI propose de déléguer ses responsabilités au NGDC, qui se mettrait à la disposition des Etats membres de l'OHI. Le "Centre des données bathymétriques numériques de l'OHI", dont la création est proposée, échangerait des données avec les services hydrographiques des Etats membres de l'Organisation et d'autres organisations contributantes et fournirait sur demande des catalogues des données nouvellement recueillies aux BHP, qui continueraient à mettre à jour les minutes de rédaction au 1/1 000 000. Les modalités de fonctionnement et de financement de cette proposition sont encore au stade de la négociation.

RESUMEN

El primer sistema internacional para reunir información batimétrica a nivel mundial fue establecido en 1903 por el Príncipe Alberto I de Mónaco. Desde la muerte del Príncipe, acaecida en 1922, la Oficina Hidrográfica Internacional asumió la responsabilidad de confeccionar, a mano, una colección mundial de cartas de trazado a escala de 1:1.000.000 con los datos no muy abundantes de que disponía. A mediados del decenio de 1950, los datos que se recibían sobrepasaron las posibilidades de la Oficina Hidrográfica Internacional, y la responsabilidad de actualizar las cartas fue asumida por 18 oficinas hidrográficas voluntarias. Se pidió a todas las oficinas hidrográficas que proporcionaran nueva informa-

* The original text of this paper, prepared by the United States National Geophysical Data Center, appeared as document E/CONF 81/L 9.

ción reunida por sus organismos nacionales a la oficina hidrográfica voluntaria correspondiente. Desde 1956 se reconoce a la Oficina Hidrográfica Internacional como centro mundial de información batimétrica.

Durante la elaboración de la Carta Batimétrica General de los Océanos (5a. edición), a fines del decenio de 1970, se puso de manifiesto que los coordinadores científicos de la Carta disponían de muchos más datos que los que figuraban en las cartas de trazado actualizadas de las oficinas hidrográficas voluntarias. Eso se debía, aparentemente, a que la comunidad geocientífica podía reunir y manejar, con la ayuda de computadoras, un número mayor de datos batimétricos que las oficinas hidrográficas. Los sondeos abisales se almacenan y manejan cada vez más en forma digital y no en trazados de sondeo, y los datos digitales pueden utilizarse en forma más flexible. El Comité Asesor Conjunto OHI Comisión Oceanográfica Intergubernamental (COI) indicó que un archivo internacional centralizado de batimetría digital serviría para aumentar considerablemente la corriente de información batimétrica proveniente de la comunidad geocientífica, en especial si ese centro ofreciera, a cambio, un servicio eficiente de suministro de información.

Se pidió a la Oficina Hidrográfica Internacional que investigara la posibilidad de aceptar la oferta de los servicios del Centro Nacional de Información Geofísica de los Estados Unidos (NGDC), de Boulder (Colorado), que ya dispone de datos batimétricos, magnéticos y gravimétricos obtenidos en 2.600 estudios y ha adquirido considerable experiencia en la gestión de esos datos. La Oficina Hidrográfica Internacional, en su carácter de centro mundial de información batimétrica, propone delegar su responsabilidad en el NGDC, que estaría orientado por los Estados miembros de la OHI. El Centro de Batimetría Digital propuesto intercambiaría información con las oficinas hidrográficas de los Estados miembros de la OHI y otras organizaciones contribuyentes y proporcionaría catálogos de datos actualizados a las oficinas hidrográficas voluntarias que continuaran actualizando las cartas a escala de 1:1.000.000 cuando éstas se los solicitaran. Aún se están negociando los últimos detalles de la propuesta, relativos a la ejecución y los costos.

The first international system for compiling bathymetric data on a global basis was established in 1903 by Prince Albert of Monaco. Following his death in 1922, the Government of Monaco invited the International Hydrographic Bureau (now the International Hydrographic Organization (IHO)) to take over the scheme. In 1929 the Bureau was entrusted with this task by the International Hydrographic Conference, and a world series of plotting sheets was established, at scale 1:1,000,000, on Mercator projection, on which to record and publish deep ocean soundings. Up until the Second World War the data were comparatively sparse and could be handled by the small staff at the disposal of the Bureau.

However, by the mid-1950s a great wealth of modern data became available and it was clearly beyond the resources of the Bureau to maintain the soundings data bank. In order to ensure that the 1:1,000,000 sounding sheets could be kept up to date, a network was established involving the services of volunteering hydrographic offices in 18 IHO member States. Each of the volunteering hydrographic offices (VHO) accepted responsibility for compiling bathymetric data in specific geographic areas and for periodically updating the 1:1,000,000 sounding sheets in their area of responsibility. Individual hydrographic offices were charged with ensuring the regular supply of bathymetric data to the appropriate VHO, while the IHB maintained a coordinating role in this scheme, issuing information on the status of the various sheets from time to time. Copies of the sounding sheets were available to the user community on direct application to the appropriate VHO; a nominal charge was usually made to cover the cost of copying. When the World Data Center system of the International Council of Scientific Unions (ICSU) was established following the IGY in 1956 the Bureau became recognized as the world data centre for bathymetry.

Following compilation of the fifth edition of the General Bathymetric Chart of the Oceans (GEBCO) in the late 1970s, it became apparent that a number of GEBCO scientific coordinators had at their disposal considerably more data than appeared on the 1:1,000,000 sheets of collected soundings maintained by the various VHOs. The shortfall in data submission to the VHOs appears closely related to the introduction of computer techniques for the management of bathymetric data, particularly in the geoscience community. Since the late 1960s, deep-sea soundings have to an increasing extent been stored in computer-compatible form, initially on punched cards and later on magnetic media. Bathymetric data are now more conveniently stored and managed in digital form than on hard copy sounding sheets. Furthermore, the digital nature of the data provides greater flexibility in the way the data may be used. It is anticipated that the establishment of a centralized international archive of digital bathymetry would greatly improve the flow of bathymetric data from the geoscience community, particularly if the centre were to offer an efficient service for data requests in return.

The experience of the National Geophysical Data Center (NGDC) in Boulder, Colorado, has clearly demonstrated that an international bank of digital bathymetric data is a practical proposition. The NGDC already holds some 2,600 cruises of bathymetric, magnetic and gravity data in digital form and, over a number of years, has built up considerable experience in the management of these data (see annex). Systems have been developed at Boulder for assimilation of digital bathymetry as well as magnetic and gravity data into a single archive and for disseminating selected data on request. Although the bulk of the data was collected by United States laboratories, significant contributions are also included from Canada, China, France, Japan, New Zealand, South Africa, the USSR, the United Kingdom and other countries. Indeed it is estimated that the Boulder archives

comprise a major part of the bathymetric data that are missing from the VHO-collected sounding sheets.

If IHO were to establish an international centre for digital bathymetry itself, it would virtually have to duplicate the services, facilities, and expertise already available at NGDC—this could not be done without considerable expense. It is proposed that in discharging its responsibilities as the world data centre for bathymetry, the IHB should work in close collaboration with the NGDC and delegate responsibility for maintaining the international archive for digital bathymetry to NGDC. There are obvious benefits to be gained from this arrangement—not the least of which is the ability to keep the international collection of bathymetric data in the same files as the magnetic and gravity data. A proposal as to how the NGDC might operate such an arrangement is offered below.

PROPOSAL FOR A DIGITAL BATHYMETRIC DATA CENTRE

The National Geophysical Data Center at Boulder, which is a component of the National Oceanic and Atmospheric Administration (NOAA) within the United States Department of Commerce, proposes to operate the world-wide digital data bank of oceanic bathymetry on behalf of the member States of the IHO.

It is further proposed that the portion of the NGDC activities related to digital bathymetric data services be designated "The IHO Data Centre for Digital Bathymetry". The specific activities of this international centre would be guided in their operation by the wishes of the IHO member States as conveyed by the IHO Directing Committee; they would closely follow the general principles of operation for world data centres of ICSU, as outlined in the ICSU "Guide to the World Data Center System" (November 1987), and would closely parallel the operation of the ICSU World Data Center A for Marine Geology and Geophysics.

Funds for the operation of the data centre would come from three sources: principally, from United States national funds; from the sales of data to commercial and other interests; and from any international funds provided to support data-intensive projects of interest to international organizations and project offices.

Services to be provided by NGDC on behalf of IHO would include but not be limited to:

(a) Operation of the data centre, with a focus of activity on oceanic regions with depths greater than 100 metres;

(b) Maintenance of a data exchange service whereby contributing organizations can acquire, free of charge, reasonable amounts of data, equivalent in type and amount to that which they contribute to the data centre. It is expected that IHO member State representatives will submit requests for data through the International Hydrographic Bureau;

(c) Establishment of an equitable pricing structure following United States national pricing policies, whereby contributing organizations, when not desirous of exercising their exchange privileges, or commercial and individual interests can acquire data from the data centre. Searches for available data in a specific area of interest would be provided to requesters free of charge;

(d) Maintenance of a modest quality-control facility whereby data provided to the data bank are subjected to simple checks for violation of physical principles (instantaneous changes in position, impossibly high ship speeds etc.), referring detected obvious errors back to suppliers of data for possible corrections. While every attempt would be

made to ensure reasonable standards of data quality and documentation, the ultimate responsibility for data reliability and usefulness would lie with the data contributor, not the data centre;

(e) Maintenance of inventories in digital form of all digital bathymetric data including digital contour data and the production of an annually updated catalog in digital form for recently received bathymetric data;

(f) Maintenance of trackline catalogs of newly collected data to be provided upon the request of a VHO for its area of GEBCO responsibility;

(g) Collaboration with various international organizations in the development of exchange formats and standards to expedite bathymetric data exchange, including digital bathymetric contours.

ANNEX

Organizational framework of the United States National Geophysical Data Center: relationship to world data centres

The United States National Geophysical Data Center (NGDC) is one of several major environmental data centres operated by the National Oceanic and Atmospheric Administration's National Environmental Satellite Data and Information Service. Other centres handle oceanographic, solid-earth geophysical, glaciological, climatological and solar-terrestrial physics data.

Each of the United States national data centres also operates for its respective disciplines a world data centre. The activities of these world data centres are coordinated by the United States National Academy of Science under guidance provided by the International Council of Scientific Unions (ICSU). The data holdings of an individual national and world data centre are not necessarily co-mingled nor are they necessarily held separately. Rules for cost recovery, free data and data exchange in world data centres differ from host country to host country and usually follow the rules of the respective host country or national centre acting as host and providing facilities for the particular centre.

Within the NGDC, major data files held by the Marine Geology and Geophysics Division (MGGD) include the following:

Under-way Marine Geophysical Data Base: Digital and analog bathymetry, gravity and magnetics data; single- and multi-channel seismic reflection, seismic refraction and side-scan sonar data, totalling over 26 million digital records and extensive files of profiles on microfilm. It is a global marine file organized by cruise and indexed by an on-line random access inventory. There are over 2,600 cruises of geophysical data, collected by 30 universities, research centres, government agencies and foreign organizations. The digital data include 9 million nautical miles of bathymetry, 6.1 million miles of magnetics and 4.1 million miles of gravity represented by 26 million MGD-77 records for a digital database of 3.1 gigabytes. Analog data include 4.5 million miles of seismic reflection data as well as 0.5 million miles of side-scan sonar and refraction data;

GEODAS: Index and database management system for the under-way Marine Geophysical Database, providing for assimilation, management, and dissemination of the data;

National Ocean Survey Hydrographic Data Base: Digital hydrographic survey data from the coastal waters of the United States; over 34 million digital records;

ETOPO-5: World-wide 5-minute grid of bathymetric/topographic data; 9.3 million values;

GEOLIN: Index to a variety of world-wide marine geological data sets referred to point locations, including site summaries from the Deep Sea Drilling Project and descriptions and analyses of grabs, dredges, cores and well-holes, totalling over 5 million digital data entries, and extensive files of well-logs and documents on microfilm;

Marine Boundary Data: Digital representations of the United States Exclusive Economic Zone boundary and the United States Outer Continental Shelf lease areas, over 400,000 points.

The under-way Marine Geophysical Database has been growing at a rate of about 10 per cent each year. But over the last 12 months, 450 cruises of data have been assimilated totalling 1.5 million nautical miles of analog and digital data including 5.2 million digital MGD-77 records.

MGGD receives 1,200 requests for information and data per year. The user profile:

Industry	44%
Academia	22%
Government	20%
Non-United States	13%
Other	1%
Requests for information and data from the GEODAS system average 415	

per year. The user profile closely parallels that of MGGD as a whole.

Customers can obtain both analog and digital geophysical data directly from the NGDC. Analog data include copies of seismic sections and charts on microfilm or full-size media. Digital data are supplied on magnetic tape at the desired density and code. The database may be searched for data by parameter, date of cruise, institution, platform, cruise identifier, date added to system, and geographical area. Area searches can be done by rectangle, polygon, 10-degree-area index, and special area group (e.g., GEBCO chart number).

THE AERONAUTICAL CHART AUTOMATION PROJECT DATABASE CONCEPT*

Paper submitted by the United States of America

RÉSUMÉ

La Division de cartographie aéronautique (ACD), l'une des principales unités du Service océanographique national (NOS) de l'Agence nationale d'étude de l'atmosphère et des océans (NOAA) a commencé d'appliquer son système de production automatisée de cartes aéronautiques (ACP). Lorsque ce système sera pleinement opérationnel, il permettra non seulement de diminuer le temps de production actuellement nécessaire pour tenir les cartes à jour, mais aussi de répondre rapidement aux nouvelles demandes, de valider et de tenir à jour les données aéronautiques et d'automatiser un grand nombre de fonctions de révision cruciales. En fin de compte, le système fournira des négatifs ou des positifs prêts à aller sous presse, ce qui réduira considérablement les coûts de gravure manuelle des négatifs et de traitement photomécanique.

RESUMEN

La División de Cartas Aeronáuticas, elemento importante del Servicio Oceanográfico Nacional de la Administración Oceánica y Atmosférica Nacional, ha iniciado la aplicación del sistema de producción automática de cartas aeronáuticas. La plena aplicación del sistema dará como resultado no sólo una disminución en el tiempo de producción necesario para mantener las cartas actuales, sino que proporcionará también una respuesta rápida a las nuevas necesidades, a la validación y al mantenimiento de los datos aeronáuticos, y la automatización de muchas funciones de revisión críticas. El sistema proporcionará en última instancia imágenes positivas o negativas listas para las placas de impresión, reduciendo así drásticamente los costos de la elaboración manual para la reproducción de negativos y de los procedimientos fotomecánicos.

SUMMARY

The Aeronautical Charting Division (ACD), a major element of the National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA), has begun implementation of the Aeronautical Chart Automated Production (ACAP) system. Full implementation of this system not only will yield a decrease in production time to maintain current chart products, but will provide for rapid response to new requirements, validation and maintenance of aeronautical data, and automation of many critical review functions. The system will ultimately provide press-plate ready positives or negatives, thus drastically reducing manual negative engraving and photo-mechanical processing costs.

* The original text of this paper, prepared by Ronald M. Bolton, F. Robert Niedermair and Russel A. Hoover. National Ocean Service, appeared as document E/CONF 81/L. 25

The Aeronautical Charting Division (ACD) of the National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA) publishes approximately 8,180 aeronautical charts and 26 publications in support of recreational, military and commercial aviation. The area of charting responsibility of the Division encompasses primarily the United States and its possessions. The Division maintains active digital files containing over 222,000 records on airports, obstructions, aids to navigation, fixes, Air Route Traffic Control Center Boundary points, and other miscellaneous information critical to air navigation. In the performance of its mission, close coordination is required with the Federal Aviation Administration (FAA), the Department of Defense and the Canadian Government, and with the United Nations International Civil Aviation Organization (ICAO). The Division also receives changes in the Caribbean/Gulf of Mexico area from the Defense Mapping Agency (DMA) and subscribes to the Bernal publications for Mexican data. A file of flight information products for all areas outside the limits of the United States is kept current.

Each year there are thousands of changes to information affecting the navigable airspace. Not only is this number of changes significant, but it requires many times that number of changes to accurately reflect the structure of the airspace on the various aeronautical chart products. Recent analysis of a sample group of 204 changes to the airspace system revealed over 602 changes to visual chart products alone. By applying these changes to the other chart series affected, it is easy to see that the manual evaluation, drafting and review of aeronautical chart products on a cyclic basis is a monumental, time-consuming task. Increased use of the nation's airspace by more complex aircraft, new technologies in airborne and ground aids to navigation, and more complex air traffic control regulations and procedures made it essential for the Division to turn to automation in order to perform its mission cost-effectively. For these reasons, the Aeronautical Chart Automation Project was undertaken, and the result of this project's effort, the Aeronautical Chart Automated Production (ACAP) system, is at present serving the Division in all product areas. Future modularly implemented expansion and upgrade will provide for the needs of the ACD and the aviation community well into the future.

SYSTEM ATTRIBUTES

The ACAP system is an overall and coherent aeronautical chart automated production system, predicated on general functional requirements rather than being customized for the specific content and format of current output products. The system supports the following activities:

- (a) Processing database updates, transaction edits, and extractions;
- (b) Providing processing support for a variety of workstation components, such as graphics display terminals, data entry terminals, and digitizing/plotting equipment;
- (c) Supporting communication requirements to the FAA database, NOAA computers, system workstations, and on-line remote terminals;
- (d) Meeting required response times by providing sufficient processing speed, internal storage I/O ports, and auxiliary storage;
- (e) Processing on-line transactions, data management requests, and management reports;
- (f) Monitoring jobs on a real-time basis and providing for interface with operations personnel;

(g) Processing system overhead requirements, such as file backup/restore operations, software development, operating system/database management overhead, and job accounting overhead;

(h) Supporting a large calculation workload to process cartographic compilation and review requirements;

(i) Maintaining, through very high system availability (reliability) features, the capability of "fail soft" operations to meet time-critical schedules for support to the production of chart products in the event of component or multiple component failure;

(j) Providing a modular expansion capability through the availability of upward compatible components without the need to change existing software;

(k) Allowing "fail soft" operations or "graceful degradation" without risk to the integrity of the database;

(l) Providing the capability to process present cartographic workloads while providing sufficient reserve processing power to cope with the projected increase in that workload;

(m) Allowing all frequently used files to remain on-line with interactive update of any allowed only by authorized persons.

Although the hardware procurement specifications for the system hardware described a "turnkey" system, nearly all of the machine-independent software necessary to perform these activities was developed in-house and is currently operational. The machine-independency of the software was thoroughly tested on the vendor's equipment during the hardware acceptance tests and it performed all functions as anticipated.

SYSTEM CONCEPT AND DATABASE INTERACTION

Since the ACAP system is predicated on general functional requirements for presenting aeronautical data in the form of charts and related products, rather than being customized for the specific content and format of current output products, the database is composed of two basic parts: chart-independent data and chart-dependent data. Since nearly all aeronautical data apply to more than one individual chart, the chart-independent portion of the database contains all physical data and other basic elements that are to be found on any of the various charts or publications to be produced. The chart-dependent portion of the database contains parameters unique to each chart or chart product. The development of both the chart-independent and the chart-dependent portions of the database was critical to the system concept, but since the chart-independent portion involved the software to support the validation storage and maintenance of the aeronautical data, it was the first database portion to be implemented. The chart-dependent database was built step by step based upon charting priorities, and is continually being expanded.

The ACAP system accepts chart-independent input data on a real-time, on-line basis through communication links with the FAA and DMA, and off-line through manual entry or magnetic tape. After machine editing, pre-programmed quality-control procedures will check for such things as format, dual entries, and other specified data. The cartographers and aeronautical information specialists access and review these raw data for cartographic validity through the use of alphanumeric terminals for textual data, and will eventually use advanced graphic edit workstations for graphic data. After validation, the data are stored in an update file which reflects additions, deletions and changes only. Rejected data are stored in a separate file for review and correction or deletion.

Quality control at this stage is performed both by automated techniques where criteria can be explicitly defined, and by analog procedures (visual review and cross-check by senior cartographers and aeronautical information specialists) where technical judgement is necessary. To prevent new data from flowing into the centralized database before they have passed validity verification, the data are controlled and closely monitored by a senior person assigned as the database manager. The database manager's primary task is to coordinate with the data verification units and, based upon predetermined scheduling, either order or withhold the update of the centralized database.

The cartographers involved in the update, review and compilation of the various products access these verified data through the graphic edit workstations. Data access is based upon the particular chart production parameters stored in the chart-dependent database. These chart parameters describe all of the attributes of the particular chart, such as projection, scale, chart boundaries, identifiers etc. Since these parameters represent the foundation, or "blueprint", of the chart, the chart-dependent database remains stable, requiring update only when new chart products are added, or when major changes are made to existing products. When satisfied with the graphic presentation of the data, the cartographer can generate final output as digital data (tapes), graphics from a precision proof plotter or, ultimately, press-ready positives from a high-resolution laser raster plotter.

For this system concept to work operationally, it was necessary to divide the chart-independent database into three functional elements or components, each interactive, thus creating a totally relational database. The three components are dictionaries, tables/specifications and data files.

Through interactive manipulation of these three components, data for a specific chart product are extracted and stored on either disk or tape to create the chart-dependent database for the specific product.

The first component, the ACAP full-time Unabridged Data Dictionary (UDD), defines each data element stored in the chart-independent files, and determines which data elements are candidates for specific products.

The UDD defines data elements by 15 distinct types of records. These records are:

- 01 Name
- 02 Mnemonic
- 03 Number
- 04 Source file
- 05 Source format size
- 06 Source units
- 07 Storage file
- 08 Storage format size
- 09 Storage units
- 10 Default value
- 11 Definition
- 12 Range/Allowable values
- 13 Related data
- 14 Related users or products
- 15 Availability

Record number 12, which defines the range or allowable values for the data, contains a MAP of the data element and its edit criteria. This enhances the documentation versatility by permitting separation of the data element's edit criteria from the editing software; thus only one set of subroutines

needs to be developed to analyse any data element in any ACAP database file.

The UDD is the basis for several other dictionaries: a product data dictionary, a real-time data dictionary, and an abridged data dictionary. The product data dictionary defines which data elements are necessary for specific products and it can be used by the cartographer as reference during compilation.

The real-time data dictionary is used in the data retrieval system incorporating the mnemonics as data element identifiers. Through support programming, a product-related real-time data dictionary can be created to obtain the available information necessary for a specific product from the data files.

The abridged data dictionary computes starting positions for data elements within each data record in preparation for the edit procedure. The abridged dictionary also contains the edit criteria for each data field. Tables and tests are incorporated into the edit system which uses the abridged data dictionary. The tables contain information used to check for correctness of changes to a field of data.

Several types of tables and tests are used in the edit system. Some testing information is contained internally in the dictionary. In a range string test (RST) the value is tested to see if it falls between a stated high and a low value. In a literal byte table (LBT) the value of each byte is acceptable. Another type of check is a literal string test (LST) where a string is compared to a table of literal values.

External tables are used when the number of acceptable values is too large to be included in the dictionary or when the table can be used by several other elements or files, for example, a table of state codes. These tables are used in the same manner as the internal tables, as string comparison, range checks, and byte comparisons.

Using the edit capabilities of the database system and other automated procedures, more than 15 chart-independent data files are maintained with current, valid aeronautical data. All files are updated on a regular cycle ranging from weekly for files maintained by NOS to 56 days for data from outside sources.

Changes and deletions in the data are maintained in a history file accessed through the data retrieval system. The cartographer not only has access to the most current data but can also check the past values to resolve any anomalies.

Through the relational data retrieval system the cartographer can obtain information from one or many files. A cross-reference method makes data acquisition more efficient and can relate similar data fields in two or more files. The real-time data dictionary allows the cartographer to choose an output format containing graphic specifications for the particular type of data retrieved.

A separate file of product specifications for graphic presentation of the chart is used in combination with the output information from the data files. Internal specifications in the output assure that a particular type of data will be depicted correctly. The external specifications can be used when showing many types of data on multiple graphic plots. Internal specifications are data-dependent, external specifications are chart-dependent. The specifications are flexible; if changes are necessary, both the real-time data dictionary and the product specifications file are easily modified outside of the system software.

To operate the system, the user signs onto the system under the designated ID and enters the generic product program, which queries the user for the generic name of the

product that is to be produced (e.g., sectional, enroute, IAP, etc.). The program takes the product name and interrogates the UDD and produces a report and a generic data-element file, which contains every data element used in the production of the product. This data-element "map" is then passed to the next program which queries the user for the name of the specific chart (Atlanta, Washington, L-2, etc.).

The program then interrogates the chart-dependent portion of the database and retrieves the specifications for the chart. The independent database file is open, and a search is performed using the chart specifications to provide all of the data elements for the chart. The symbol specification table is also examined to determine the proper symbol codes. The generic data elements and their symbol codes are then passed to the next program, which compares the newly created output file with the output file created at the last production cycle. Any unequal records will be written to a product change file and a product change report will be produced. At this point, the user determines if the changes should be applied to the chart.

All data to be applied to the chart are processed under the particular cartographic compilation and quality-control guidelines established for each particular product. Compilation aids (computer-generated proof plots) may be generated or textual material may be printed.

After passing final review by senior cartographic personnel, the changes will become valid and manually applied to the new edition of the chart. Future application of changes

will be made through interfacing with automated final copy output devices such as laser plotters or photo scribes.

HARDWARE CONFIGURATION AND STATUS

The ACAP system is currently operational via time-sharing on the NOAA UNIVAC 1100 system, assisted by a fully dedicated in-house Perkin Elmer 8-32 minicomputer. The system is accessed through over 40 alphanumeric terminals located within the individual chart compilation sections, and provides graphic output through two Calcomp precision belt plotters, and one high-precision Gerber plotter equipped with photo-scribing capability.

The final system configuration includes a Digital Equipment Corporation (DEC) VAX 750 and VAX 780. The VAX mainframe CPUs will support over 40 alphanumeric terminals, plus over 20 interactive graphic workstations. Included in the hardware will be five precision proof plotters, and ultimately a high-quality chart output device.

CONCLUSION

The ACAP dual data-base concept has been thoroughly tested and has proven itself thoroughly over five years of parallel and interactive operations with the normal ACD production process, and it is anticipated that full implementation of the hardware system will provide for the needs of the ACD into the future.

DIGITAL CARTOGRAPHIC DATA STANDARDS: THE UNITED STATES EXPERIENCE*

Paper submitted by the United States of America

RÉSUMÉ

Depuis 1982, un comité national aux Etats-Unis composé de membres venant de l'industrie privée, des services publics et des milieux universitaires travaillait à mettre systématiquement au point une norme pour les données cartographiques numériques. Parallèlement, un effort auquel ne participait que le Gouvernement fédéral des Etats-Unis était en cours depuis 1985. En 1987, une équipe spéciale a uni les deux efforts et publié une proposition de norme. Cette norme consiste en : a) une section sur la définition des termes; b) des spécifications pour le transfert de données spatiales; c) une déclaration de qualité; et d) la liste des éléments (caractéristiques) et attributs cartographiques. Un test en deux phases est en cours et se poursuivra jusqu'à la fin février 1989. La norme sera présentée pour approbation à l'Institut national des normes et de la technologie (NIST) des Etats-Unis (anciennement Bureau national des normes).

RESUMEN

A partir de 1982, un comité nacional de los Estados Unidos compuesto de miembros procedentes de la industria privada, el Gobierno y los medios universitarios ha venido elaborando sistemáticamente un conjunto de normas para los datos cartográficos digitales. Desde 1985 se ha venido desplegando un esfuerzo paralelo en el propio Gobierno Federal de los Estados Unidos. En 1987, un grupo de tareas aunó los dos esfuerzos y publicó una propuesta de conjunto de normas. El conjunto de normas consiste en: a) Una sección de definición de términos; b) Una especificación sobre la transferencia de datos espaciales; c) Una indicación de calidad, y d) Una lista de entidades (accidentes) y atributos cartográficos. Se está llevando a cabo un ensayo en dos etapas, que se prevé terminará a fines de febrero de 1989. El conjunto de normas se someterá, para su aceptación, al Instituto

* The original text of this paper, prepared by Joel L. Morrison, United States Geological Survey, appeared as document E/CONF 81/L 28. It is a synopsis of *The American Cartographer*, volume 15, No. 1 (January 1988). Copies of that issue are available from the American Congress on Surveying and Mapping, 210 Little Falls Street, Falls Church, Virginia 22046.

SUMMARY

Since 1982, in the United States, a national committee composed of members from private industry, government and academia has been systematically developing a standard for digital cartographic data. A parallel effort solely within the Federal Government has been under way since 1985. During 1987 a task force brought the two efforts together and published a proposed standard. The standard consists of (a) a section on definitions of terms; (b) a spatial data transfer specification; (c) a statement of quality; and (d) a list of cartographic entities (features) and attributes. A two-phase test is under way, which will continue through February 1989. The standard will be submitted for acceptance by the United States National Institute of Standards and Technology (NIST) (formerly the National Bureau of Standards).

In February 1980 the United States National Institute of Standards and Technology (formerly the National Bureau of Standards) and the United States Geological Survey signed a memorandum of understanding that resulted in the Geological Survey's assuming the leadership in developing, defining and maintaining earth-science data elements and their representation standards for use in the agencies of the Federal Government. Exercising this leadership, the Geological Survey contracted with the American Congress on Surveying and Mapping to establish the National Committee for Digital Cartographic Data Standards in January 1982.

The Committee consisted of a steering committee of 13 members representing government, private industry, and the academic community. Four working groups were formed initially: (a) data organization, (b) data quality, (c) cartographic features, and (d) terms and definitions. During the working life of the Committee, the fourth working group was disbanded and its members reassigned to the other three groups as experts on definitions for those groups.

The work of the Committee resulted in nine reports. Report 8, "A draft proposed standard for digital cartographic data", published in January 1987, represents the results of the five years of Committee activity. The Office of Management and Budget of the Federal Government issued a memorandum in 1983 directing the Geological Survey to eliminate duplication and waste in the development of Federal digital cartographic databases and to serve as a focal point for coordination of digital cartographic activities. In response to this memorandum, on 4 April 1983, the Geological Survey established the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC). A Standard Working Group (SWG) was formed under the FICCDC to develop and adopt, for use by all Federal agencies, common standards of content, format, and accuracy for digital cartographic base data to increase their interchangeability and enhance their potential for multiple use. The FICCDC-SWG selected as its priority task the development of a data exchange format.

The priority task resulted in the issuance by the FICCDC-SWG of its final report in December 1986, entitled "Federal geographic exchange format: a standard format for the exchange of spatial data among Federal agencies". Nine Federal agencies had representatives on the FICCDC-SWG. The National Committee report and the FICCDC-SWG report were distributed together to over 1,200 addresses in January 1987.

Because the responsibility for the production of this stand-

ard rested with the Geological Survey both by directive from the Office of Management and Budget and by request from the National Institute of Standards and Technology, the Geological Survey established the Digital Cartographic Data Standards Task Force in March 1987, charging it to meld the draft standards developed by the National Committee and the FICCDC-SWG into a single digital cartographic data standard that could be submitted to the National Institute. The Task Force was composed of 15 members (8 voting and 7 advisory). It presented its results in a report entitled "The proposed standard for digital cartographic data", which appeared as the January 1988 issue of *The American Cartographer*. It is the contents of that proposed standard that form the body of this presentation.

THE PROPOSED STANDARD

The standard consists of four parts:

1. Definitions and references
2. Spatial data transfer specification (SDTS)
3. Digital cartographic data quality
4. Cartographic features.

To outline the details of the standard, it is most useful to discuss first the definitions, followed by the features and quality, and last, a discussion of the SDTS.

Definitions

It is very important in the specification of any standard that the potential users of the standard agree on the definition of terms used to specify it. The United States experience includes close attention to the specification of what can be termed cartographic "objects". Cartographic objects are defined as digital representations of cartographic "features". The standard makes use of a systematic and comprehensive set of such objects to support the various cartographic operations carried out by modern cartographic data systems. Objects are specified for zero, one and two dimensions. The objects can be defined for "geometry only", "geometry and topology", or "topology only". The standard defines explicitly "geometry only" and "geometry and topology". The "topology only" class is defined implicitly.

Fundamental to the entire standard is the idea of a feature. To define "feature" it is necessary to define two other terms. The first term, "entity", is a real-world phenomenon that is not subdivided into phenomena of the same kind. The second term, "object", is a digital representation of all or part of an entity. The term "feature" is used to refer to a defined entity and its object representation.

Table 1 lists the primitive and simple objects recognized as necessary for the digital processing of cartographic data. The figure is divided into zero-dimensional, one-dimensional, and two-dimensional cartographic objects. Compound and complex objects can be constructed from these primitive and simple objects.

TABLE 1. PRIMITIVE AND SIMPLE OBJECTS

point	A zero-dimensional object that specifies geometric location. A set of coordinates specifies the location.
node	A zero-dimensional object that is topological junction or end point and which may specify geometric location. An optional set of coordinates specifies the location.
line	A one-dimensional object.
line segment	A direct line between two points.
string	A sequence of line segments. A "string" does not have nodes, node identifiers, or left and right identifiers and may intersect itself or other strings.
arc	A locus of points forming a curve that is defined by a mathematical function.
link	A one-dimensional object that is a connection between two nodes; <i>alias</i> : edge.
chain	A directed sequence of non-intersecting line segments and/or arc with nodes at each end. References to left and right area identifiers are optional.
ring	A sequence of non-intersecting chains, strings, links, or arcs with closure. (A "ring" represents a closed boundary, but not the interior area inside the closed boundary.)
area	A bounded continuous two-dimensional object which may or may not include its boundary.
polygon	An area consisting of an interior area, one outer ring, and zero or more non-intersecting, non-nested inner rings.
pixel	A two-dimensional picture element that is the smallest non-divisible element of an image.
grid cell	A two-dimensional object that represents an element of a regular or nearly regular tessellation of a surface.

Data quality

Often when one hears the term "standard" it is thought of as being synonymous with accuracy standard. Such is not entirely the case with the proposed United States standard. Early in the deliberations, the committees recognized that the needed statement of the data quality was not only essential but also rather complex. What is data quality? The committees agreed that a truth-in-labelling style of stating data quality would be more useful than specifying an arbitrary numerical value for quality. Information, in addition to the numerical accuracy of position, is as necessary in the digital world as it was in the predigital world. To date, however, measures of positional accuracy for digital data are generally not provided.

Data quality is composed of five components as defined in the proposed United States standard: lineage, positional accuracy, attribute accuracy, logical consistency, and completeness.

Lineage includes a description of the source material from which the data were derived and the methods of derivation, including coordinate transformations.

Positional accuracy reports the degree of compliance to the spatial address and coordinate coding standard specified in the standard itself. Positional accuracy must be described. Variations in positional accuracy are reported either as additional attributes of each feature, or through a reliability diagram. Measures of positional accuracy can be deductive

estimates, interval evidence, comparison to source, or comparison to an independent source of higher accuracy.

Attribute accuracy refers to a report of the assessment of accuracy for measures on a continuous or categorical scale. The report lists the results of the use of procedures similar to those used for positional accuracy determination.

Logical consistency describes the fidelity of relationships encoded in the data structure of the digital data. The quality report in the standard must detail the tests performed and the date and results of the test. Both graphic and topological tests are permitted.

Completeness refers to quality information about the selection criteria, definitions used, and other relevant mapping rules. The concepts of minimum areas or widths used to encode the data must be reported. The procedures used for testing and the results are described in the quality report.

A sample quality report could look something like the following.

"Certain node-area-line relationships are collected or generated to satisfy topological requirements. Some of these requirements include: lines must begin and end at nodes, lines must connect to each other at nodes, lines do not extend through nodes, left and right areas are defined for each line element and are consistent throughout the file, and the lines representing the limits of the file (neatline) are free from gaps. Test of logical consistency performed by UGLGES (USGS) program. Test on neatline closure was performed by comparison check (UGLGES) between theoretical length and actual length. Check plots were made to test for polygon 'flooding'. Logical test performed in 1981. Automated procedure (UGLGES) used to check logical consistency, although some UGLGES-produced files have been found not to be 'topologically clean'."

The importance of including data quality information in the standard cannot be overemphasized. In the computer-assisted world of cartography, even more than in the manual world, inexact data can be masked when displayed.

Cartographic features

As defined earlier, cartographic features are entities, real-world phenomena that are not subdivided into phenomena of the same kind, and their associated objects are digital representations of entities. A defined entity may be represented by one or more objects. Entities have attributes and attributes have values. An attribute is a defined characteristic of an entity. An attribute value is a specific quality or quantity assigned to an attribute. Table 2 gives an example of an entity and its associated attributes and attribute values that might be of use to a cartographer.

The standard also makes use of the concepts of standard term and included term. A standard term is recognized as a primary label for an entity or an attribute. An included term is a non-standard label of an entity or attribute that is cross-referenced to a standard term (table 3).

TABLE 2. SAMPLE ENTITY WITH ATTRIBUTES AND ATTRIBUTE VALUES

Entity:	Bridge
Attribute:	Composition
Attribute value:	Wood
Attribute:	Covered/Uncovered
Attribute value:	Covered

TABLE 3 INCLUDED TERMS MAPPED TO STANDARD
TERM WITH ATTRIBUTES

Included term	Standard term, attributes
Covered bridge	Bridge: Composition: wood Covered/Uncovered: covered
Draw bridge	Bridge: Span movement: draw
Bascule bridge	Bridge: Span movement: bascule

Clearly, not all entities and attributes are defined at this time. The standard provides for a maintenance authority that will have as one of its primary functions the addition and revision of the feature and attribute lists and definitions contained in the proposed United States standard.

Several other concepts about the features included in the proposed United States standard are worth mentioning. First, the list of features is non-hierarchical. Entities are not embedded within other entities. Provision has been made, however, to allow both attributes and attribute values to have attributes. A second concept is that of scale independence. By using the above definition of entity, it is possible to make the list of features independent of scale. The members of the Committee and working groups drafting this standard feel that this is an important concept.

Spatial data transfer specification

The fourth and most involved part of the proposed United States standard is the spatial data transfer specification (SDTS). The purpose of the SDTS is to allow the easy transfer of spatial data from one data handling system to another. Consider the often-encountered case where one institution has data in a specified data structure and format and software and hardware of a given manufacture that process those data. At another location, another institution has data in a different data structure and format, processed by the software and hardware of a different vendor.

One institution wishes to use its data along with the other institution's data in its own processing environment. SDTS is designed to facilitate this exchange of data.

Specifically, SDTS is to provide a mechanism for the transfer of digital spatial information between non-communicating parties using dissimilar computer systems by preserving the meaning of the information and by reducing to a minimum the need for information external to the standard. The SDTS is written so that the contents are clearly separated from its implementation.

SDTS is based on the conceptual model of features composed of entities and attributes. Relationships exist between entities, between attributes, and between entities and attributes. Correspondingly, the conceptual model in the digital world is composed of spatial objects. Spatial objects can be used to represent entities and can be defined in terms of spatial attributes (that is, geometry) and spatial relationships (that is, topology).

The proposed United States standard consists hierarchically of transfer forms, transfer modules, fields and subfields. A transfer form is a construct that is composed of a group of related modules. The proposed United States standard has three transfer forms and requires the use of at least one transfer form in any given utilization. In addition, there are two general forms: "global" and "quality". The three transfer forms are labelled "vector", "relational", and "raster". For any given utilization it is necessary to utilize the global, the quality, and one of the three transfer forms,

depending on the data one wishes to transfer. The vector transfer form consists of transfer modules that carry all information or links to information about one cartographic object representing a feature. The relational transfer form allows vector data to be expressed in the form of a set of relational tables. Here each module represents a relationship between objects, or between objects and attributes, or between attributes. The raster transfer form organizes spatial data by location and is used for the exchange of raster-or-grid-cell structured data.

Modules within the global form specify global parameters necessary for interpreting the data being transferred. In any given utilization, it is not necessary to utilize all of the modules in the global transfer form. The five modules included in the quality general form were discussed previously under "Data quality". There is one module for each component listed.

The vector transfer form has six modules, four of which have multiple object representation. The relational transfer form has 15 modules and the raster transfer form has only three modules.

Each module consists of fields and subfields. Table 4 gives an example of a sequence of SDTS modules resulting from the encoding of a Geological Survey Digital Line Graph-O (DLG-O) data set. The mnemonics used in the right-hand column of table 4 are detailed in the January 1988 issue of *The American Cartographer*. Table 5 gives an example of the coded transfer module along with fields and subfield identifiers that specify the DLG-O data. Tables 4 and 5 present some insight into the encoding and decoding processes that are necessary to utilize the SDTS.

Once the data are conceptually mapped to the SDTS modules, these modules are reformatted and it is only necessary to implement the specifications using ISO/8211 as the transfer vehicle. ISO/8211 was selected because it is already an accepted international standard for the physical coding of specified logical file structures onto various digital media.

Although the reading and the discussion of the proposed standard are complex, once the software has been written, this complexity will in large part be transparent to a user. With software in place, the transfer of common data files from one user to another should take place merely by identifying the existing data structure and format and by specifying the structure and format to which one wishes the data to be transferred. It is further hoped that manufacturers will adopt the proposed standard and will provide software that will decode data existing in the SDTS exchange format into their system formats. It would only be necessary, therefore, for users to learn to encode their data into SDTS.

1988 ACTION AND THE FUTURE

The proposed United States standard is undergoing several sets of testing. These tests, along with the comments received from those who read the proposed standard, will allow a final edit to the document to be completed in early 1989. Submission to the National Institute of Standards and Technology is scheduled for early 1989.

The testing of the standard consists of the processes of encoding, decoding and verification. The encoding process consists of (a) a conceptual mapping of existing data into cartographic objects and features and the selection of a transfer form; (b) the reformatting of the existing data fields into SDTS modules/fields/subfields and the design of the SDTS logical file structure; and (c) the creation of an ISO/8211 exchange data set with data descriptive records and data records. The decoding process, as its name implies, involves

TABLE 4. OPTIONAL DLG DISTRIBUTION FORMAT TO
SDTS TRANSFER MODULES

DLG record	SDTS		
	Module		Field/Subfield
1	Identification	IDEN	Comment
2	Catalog/Spatial domain	CAIS	Map
	Identification	IDEN	Map date 1 Map date 2 Scale 1 Comment
3	Identification	IDEN	Comment
4	Identification	IDEN	Data structure
	External spatial reference	XREF	Reference system name Zone number
	Internal spatial reference	IREF	X component of horizontal resolution Y component of horizontal resolution
	Identification	IDEN	Comment
5-9	Not used (SDTS requires standard coordinates)		
10	Internal spatial reference	IREF	Scale factor X Scale factor Y X origin Y origin
Control points	Spatial domain	SPDM	Domain spatial address Comment
Category/Overlay	Identification	IDEN	Theme description
	Catalog/Spatial domain	CAIS	Theme
	Transfer statistics	STAT	Module record count
Node records	Point-node	PNTS	Object ID
		SADR	Spatial address
		AVAL	Attribute value
Area records	Point-node	PNTS	Object ID
		SADR	Spatial address
		AVAL	Attribute value
	Polygon-ring	POLY	Object ID
		LFID	Line foreign ID
Line records	Line	LINE	Object ID
		SNID	Start node ID
		ENID	End node ID
		SADR	Spatial address
		AVAL	Attribute value

TABLE 5. SDTS TRANSFER MODULES FROM OPTIONAL DLG DISTRIBUTION FORMAT

SDTS module	Source of input
Catalog/Spatial domain	Programmed constants and DLG record 2
Catalog/Cross-reference	Programmed constants
Identification	Interactive input, programmed constants, and DLG records 2, 3, and 4
Internal spatial reference	Programmed constants and DLG records 4 and 10
External spatial reference	Programmed constants and DLG record 4
Spatial domain	Programmed constants and DLG control point records
Data dictionary/Definition	Programmed constants
Data dictionary/Domain	Programmed constants
Transfer statistics	Programmed constants and DLG category/overlay record
Data quality	Interactive input and programmed constants
Lineage	
Positional accuracy	
Attribute accuracy	
Logical consistency	
Completeness	
Point-node #1	Programmed constants and DLG node records
Point-node #2	Programmed constants and DLG area records
Polygon-ring	Programmed constants and DLG area records
Line	Programmed constants and DLG line records

receipt of the SDTS file in ISO/8211 format and transformation into the target structure used by the decoder. The verification process confirms that the data in the transfer meet the criteria specified in the standard. This process is useful as the final step in encoding and the first step in decoding.

The initial tests were performed by representatives of agencies participating in the Committee, FICCDC-SWG, and the Task Force. Beginning in January 1988, the Bureau of the Census encoded a TIGER file; the Geological Survey, a DLG-O file; and the Defense Mapping Agency, a world vector shoreline file. All of these files utilized the vector form of SDTS. Naval Ocean Research and Development Activity encoded data in a raster form, and the EROS Data Center of the Geological Survey encoded data in the relational and raster forms. Thus, all three forms of SDTS have been tested.

These tests indicated errors or improvements needed in the standard and resulted in data sets that were known to

have been successfully transferred via the standard. A more general round of testing, to begin in September, will make use of these data sets. The verification will be done by Geological Survey personnel, and these same individuals will be available to assist others who wish to test their own data.

To enable changes to the proposed standard to be handled in an efficient manner, the document appearing in *The American Cartographer* was placed under configuration management. A board of people who have been involved with both the testing and writing of the proposed standard and who represent Federal agencies, private firms, and universities was named to serve as the configuration management board. All suggested changes to the proposed standard are carefully considered by the configuration management board. The work of this board will enable the final rewriting of the draft for submission to NIST to be done quickly and efficiently.

(h) *Land/geographic information systems*

PREPARING YOUR ORGANIZATION FOR GIS/LIS: AVOIDING SURPRISES WHEN HARDWARE/SOFTWARE ARRIVES*

Paper submitted by Canada

RÉSUMÉ

Afin d'assurer le succès de l'application des techniques des systèmes d'information géographique ou foncière dans toute organisation, celle-ci doit exécuter plusieurs tâches essentielles avant la livraison du matériel et du logiciel. Le document contient un examen des méthodes et des procédures permettant de déterminer les besoins des utilisateurs des systèmes d'information géographique ou foncière et d'entreprendre des projets pilotes (projets de référence et prototypes) afin de démontrer l'application de ces techniques.

On examine également le cadre institutionnel nécessaire pour répondre efficacement aux besoins des utilisateurs et pour mettre en place une structure organisationnelle appropriée afin d'appuyer l'application des systèmes d'information géographique ou foncière.

Le document aborde également d'autres questions telles que : la nécessité d'un programme de formation à court et à long termes pour les employés déjà en fonctions et le personnel nouvellement recruté; le rôle du personnel de direction dans l'application des systèmes d'information géographique ou foncière; les problèmes posés par la commercialisation des données; la responsabilité et les droits d'auteur; et la nécessité d'élaborer des normes pour les systèmes d'information géographique ou foncière.

RESUMEN

Para asegurar el éxito de la aplicación de la tecnología de los sistemas de información geográfica/sistemas de información sobre las tierras (GIS/LIS) en cualquier organización, ésta debe realizar varias tareas esenciales antes de la entrega del equipo y de los programas. En el documento se examinan los métodos y procedimientos para determinar las necesidades de los usuarios de la información de GIS/LIS y para realizar proyectos experimentales (de referencia y prototipos) para demostrar la tecnología.

Se examinan los requisitos en el marco institucional para responder eficazmente a las necesidades de los usuarios y crear una estructura organizacional adecuada para apoyar la aplicación de GIS/LIS.

En el documento también se tratan cuestiones tales como la necesidad de un plan de educación a corto y a largo plazo para los empleados existentes y el nuevo personal, la función de los administradores de categoría superior en la aplicación de GIS/LIS, los

* The original text of this paper, prepared by Zul Jiwani and M. Mosaad Allam, Department of Energy, Mines and Resources, appeared as document E/CONF 81/L 17.

problemas de la distribución de los datos, la responsabilidad legal y los derechos de autor, la necesidad de formar sociedades o consorcios entre la organización y otros para compartir el costo inicial del desarrollo del sistema y los requisitos para elaborar normas relativas a GIS/LIS.

SUMMARY

To ensure successful implementation of GIS/LIS technology, several key tasks must be undertaken by the organization prior to the delivery of the hardware/software. The paper discusses the methods and procedures for determining GIS/LIS information users' requirements and for the need to undertake pilot (benchmark and prototype) projects to demonstrate the technology.

Institutional framework requirements to effectively respond to users' needs, and for creating a proper organizational structure to support GIS/LIS implementation, are also discussed.

The paper also addresses other issues, such as the need for a short- and long-term education plan for existing employees and/or new staff; the role of top management in GIS/LIS implementation; the problems of data marketing; liability and copyrights; and the requirements for developing GIS/LIS standards.

The acquisition, implementation and maintenance of a geographic information system (GIS) are a major undertaking and, in many cases, may change the way organizations are doing business. Creating and maintaining a database take time. In addition, problems of data collection or initial database creation, format for storage, sources of data, interchange of data and integration of data which are held in different formats all have to be addressed and resolved. These problems are technical and may also give rise to several political/institutional issues.

Institutional issues are the least publicized aspects of GIS implementation. As a first step there is a need for the fullest cooperation among people who are drawn from very different areas of education and experience, as well as different segments of the organization. This should be followed by addressing important issues, such as the impact of adopting geographic and land information systems (GIS/LIS) technology on the organization (institutional and staff); the use and value of geographic information (economic); the liability of using and disseminating geographic data (legal); freedom of information and access to public geographic and land-related information (constitutional); and questions related to privacy and confidentiality of the data (human rights).

In addition, marketing opportunities for GIS should also be explored. These include undertaking pilot studies or experimentation by specialists, technologists and potential users, and the development of applications which potential users understand and are willing to buy.

Further, the paper discusses procedures for preparing a project plan for GIS/LIS implementation and suggests procedures for determining the requirements of potential GIS/LIS users.

Lastly, the paper discusses several technical and institutional issues such as the need for the development of human resources for the GIS/LIS project team, the role of management in GIS/LIS implementation, data exchange, marketing, liability and the need for developing GIS/LIS standards.

THE FIRST STEP

Normally, a first step is taken when an organization decides to convert its analog, geographically referenced information base to that of a digital GIS or LIS.

At that time, intensive planning should begin, to ensure minimal interruption of daily work procedures while maximum speed of implementation takes place. Steps in planning should include a thorough evaluation of systems available, their suitability for the task and, most important, the costs involved.

The tasks of evaluation, design and procurement of a GIS/LIS should be carried out by selected employees of good technical background, well briefed in the aims and objects of the project and, preferably, with a demonstrated interest in the tasks assigned. Special care should be taken in the selection of the management of the project in order that planned progress may be maintained. The management must ensure that personnel assigned to specific areas of responsibility do not emphasize the procurement aspects of the tasks assigned over the institutional considerations of implementation, as sometimes happens.

DEVELOPMENT OF THE GIS/LIS PROJECT PLAN

The design and implementation of GIS/LIS require that many institutional, as well as technical, issues be addressed. The success of the technology implementation will depend on how the project plan is prepared and executed.

In general, a typical GIS/LIS project plan will include the following technical tasks:

(a) Determining users' requirements for land-related information (including the examination of how information flows from one producer/user to another and constraints in the flow process). In general, this is a users' requirements study and it may be achieved by:

- (i) Organizing a methodology workshop to discuss the project objectives, the current GIS/LIS technology available in the market, and what is expected from the GIS/LIS technology implementation in the organization;
- (ii) Survey of resources and conducting interviews and collecting pertinent information using questionnaires;
- (iii) Conducting an initial review and analysis of the data;
- (iv) Reviewing the project with all participants;

(b) Developing policy-level responses to these requirements (e.g., establishing priorities, assigning responsibilities and resources, and setting standards and monitoring activities);

(c) Developing the necessary GIS/LIS standards;

(d) Developing system-level responses (improving existing systems or introducing new systems);

(e) Developing technology-level responses (assessing and designing tools and techniques for acquiring, positioning, analysing, storing and disseminating the information), which can be achieved by conducting a pilot study, or by benchmarking GIS/LIS technology;

(f) Addressing institutional issues that will have an impact on the project plan. This includes:

(i) Formalizing the GIS/LIS organization/group structure;

(ii) Conducting manpower development studies to identify staff education/training requirements, estimate the manpower required at different levels, and schedule training of staff and the number of different levels;

(iii) Identifying and studying institutional issues related to data dissemination, security/privacy of data and liability and copyright considerations;

(g) Determining the cost of GIS/LIS implementation and conducting a cost/benefit study;

(h) Preparing a detailed work-plan for the system.

STUDY OF GEOGRAPHIC INFORMATION REQUIREMENTS

Determining the requirements for geographically referenced information in the organization may be achieved by conducting interviews, and organizing workshops or written surveys among major users.

Workshops for different groups of professionals in the organization (planners, forecasters, resource managers etc.) will serve to identify potential users and cooperators. Also, these workshops may be used as a forum for familiarizing users with commercially available GIS/LIS technology, and with experience of GIS/LIS implementation in the other agencies.

Workshops should be followed by interviews with key producers/users of geographic information and by conducting a written survey by means of questionnaires.

The object of conducting these interviews and/or surveys is to find out what GIS is worth to the organization, determine the current level of service and decide what GIS can do in the future. In addition, the collected information should assist in preparing a comprehensive planning, acquisition and implementation document and in developing and recommending a practical and cost-effective approach to the organization.

Information collected from the workshops, interviews or surveys should form the basis for the preparation of a comprehensive report to management identifying the following major elements:

Current and potential GIS/LIS users

Geographic data management needs in the organization

Database creation efforts, size and development strategy

Applications, products, characteristics, expectation and cost of these products

Major applications that will drive the GIS and will affect the database design and creation, and software, hardware and output

Current practices in the organization, with the objective of maximizing the existing automated, non-automated and personnel resources

Current and future work flow in the organization

Current cost of maps and geographic database creation and application

Priority list of the GIS applications and identification of those that yield maximum benefit to the organization as well as those that will produce results in a short period

Configuration of GIS/LIS that will meet the required data volumes, production rates and data management requirements

Cost of GIS implementation and expected cost/benefit ratios of using the new technology

Institutional framework in order to respond to users' needs most effectively

This report should also provide management with a description of the data sets and database management capabilities in the organization, and future needs, as well as modelling and analytical needs, and product generation requirements.

Based on this study, recommendations should be made on the appropriateness of applying GIS/LIS technology to the organization and other direct or indirect benefits that may result from using the technology. Some of these benefits may include:

(a) Improving accuracy of products;

(b) Allowing for composite maps and graphic displays;

(c) Providing centralized access to dispersed resources;

(d) Detecting errors in locational data;

(e) Maintaining historical records;

(f) Comparisons of dissimilar layers;

(g) Providing reference to other data sources.

These factors will assist management in measuring the value of the additional benefits before reaching a decision on GIS/LIS implementation.

DEVELOPMENT OF GIS/LIS STANDARDS

GIS/LIS reflect the expanding role of computer technology within earth science disciplines for the replacement of specific repetitive or manual activity. This has evolved to include sophisticated complex and analytical digital spatial applications for producing information. This ability, in large part, is dependent upon standards.

Standards are needed to control the various activities in GIS/LIS from observation and collection of data to their analysis and use in the decision-making process.

The process of data acquisition will require the development of standards for the conversion of analog records (graphic and non-graphic data) to a digital form. This will necessitate the development of digitizing specifications, data classification and coding standards as well as standards for the evaluation of data quality, completeness and up-to-dateness.

Standards for the definition of the various forms of data are also required. This will include standards for the cartographic objects (points, lines or areas) and non-map data which may consist of values for the attributes.

Since data storage involves data formats and storage structure, a standard data format should be developed.

Standards for the generation of GIS/LIS products are also needed. This may be in the form of cartographic data output standards, a standardized format for digital output or a for-

mat for report output. Standards for GIS/LIS data interchange (data communication) with other systems are also crucial in order to facilitate the process of accessing data from a variety of sources.

BENCHMARKING GIS/LIS TECHNOLOGY

Benchmarking of GIS/LIS technology is necessary to test the functionality and performance of the various components of the system (data entry, data storage, retrieval and analysis, database management and data output).

Benchmarking must be done on products and capabilities identified in the geographic information requirements study and should take into account the various GIS/LIS applications, products, characteristics, estimated future data volumes, and the compliance of the system with the functional and performance specifications.

A set of mandatory and desirable system functions should be identified and a series of tests should be designed. Also, these tests should take into consideration the functional components of hardware and software.

Although benchmarking tests will vary from one agency to another, depending on the applications and specific GIS/LIS requirements, the following set of basic tests will serve as a guideline:

- (a) Data entry tests, which include tabular data entry, update, on-line query and editing;
- (b) Geographic data entry, which includes digitization, display, editing, map join/edge match;
- (c) Geometric data manipulation, which includes building topology, polygon overlays, vector/cell conversion, projection change and transformations, coordinate filtering, calculations (length, area, volume and slope), three-dimensional viewing;
- (d) Network analysis and modelling, which may include optimal path selection, flow simulation;
- (e) Capabilities for reformatting data from other systems;
- (f) Database management system (spatial and attribute query);
- (g) Production generation.

During these tests, computer execution time and operator utilization time for each step should be recorded.

COST OF GIS IMPLEMENTATION

An important element of the managerial aspects to be addressed before the acquisition of the technology is the cost of GIS implementation. This will include identifying the cost associated with the following:

- (a) Hardware requirements;
- (b) Software requirements;
- (c) Cost of initial database;
- (d) Training of personnel;
- (e) New staff requirements;
- (f) New budget items and expenses, e.g., system maintenance, peripheral equipment, training, etc.);
- (g) Overhead and costs associated with system set-up (space and facility, technical and environmental requirements);
- (h) Operating costs (personnel, system depreciation, supplies, etc.);
- (i) Quality control;
- (j) Cost of applications development and administrative costs.

Until the cost of these items is defined and is supported by management, it is safe to say that you do not have a system.

TRAINING ISSUES

The shortage of staff trained in GIS/LIS operations, data management and analysis is a matter of considerable concern. Also, there is a limited supply of trained people to fill positions at all levels of government, the private sector and academia. The lack of qualified personnel could be a limiting factor for the organization in developing the system.

For existing staff, retraining is the most logical route for the development of the necessary GIS/LIS professionals. This may be achieved by means of:

- Vendor training programmes
- Vendor customized courses
- In-house training programmes
- Workshops and seminars
- Short courses offered by universities and colleges

In addition, selected staff may attend undergraduate or graduate programmes offered by universities.

Training is an important factor in the success of GIS/LIS implementation in the organization. Vendor training programmes are generally given as part of the system acquisition package. These courses normally address the "how to do it" and not the "why". For this reason, it is important that retraining needs of staff should be identified before the acquisition of the system and that these needs be made a requirement in the Request for Proposal (RFP). Application-oriented courses and those dedicated to addressing interaction with the GIS/LIS software and system management should also be identified and included in the RFP.

In-house training programmes should be designed to upgrade the qualifications of personnel already employed in GIS/LIS-related positions in the organization. This type of programme normally includes basic courses in computer, GIS/LIS-concepts/fundamentals, technical issues and functions of GIS, and hands-on operational training.

INSTITUTIONAL ISSUES

GIS/LIS is an assembly of human resources and technical resources which captures, analyses, represents and delivers data and information. This adoption of technology in the organization will give rise to several issues that should be addressed before the arrival of hardware and software. These include organizational structure, issues related to liability, copyright and privacy of GIS/LIS data.

Organizational structure

Questions such as "Where will the system be implemented?", "Who will fund it?" and "Who will manage and operate the system?" are frequently heard in organizations adopting GIS/LIS technology.

In most cases, GIS/LIS design, acquisition and implementation will be carried out by an ad hoc team collected from the various divisions or interest groups in the organization. If this type of implementation team is selected, then the organization is risking the success of the venture.

To avoid this risk, it is important that a proper organizational structure be developed, that technically qualified personnel and competent management be assembled, and that the status of this GIS/LIS group be formalized. This is needed to ensure the commitment of the staff to the project.

In addition, the formalized group will serve as the focal point for potential cooperators in the organization and should help in developing a GIS/LIS-oriented perspective among participants.

Liability issues

Input data to GIS/LIS are normally based on graphic sources (maps/charts) and alphanumeric information (attributes); they may contain some errors. If the data had been acquired by another agency, where they were processed further and possibly enhanced by some added-value information, and then resold, then who would be liable if the original data were in error? Such situations can result in conflict and, ultimately, in litigation.

The question of liability should be addressed if the organization is disseminating GIS/LIS information or if the products are used by the public.

Copyright issue

Because of freedom of information acts, the requirements for disclosure of publicly held data and the need for recovering a fair, equitable price for them, it is difficult to establish a data distribution policy. The problem is more complicated if the data are repackaged with added-value information and resold.

The copyright issue and freedom of information acts should be assessed, particularly as they relate to GIS/LIS data and to the uniqueness of the information.

Privacy issue

The privacy of GIS information and the need for its protection in public files are a litigious issue. Questions relating to dealing with confidential information in GIS/LIS data records and how to protect the data from unauthorized access should be addressed before the design and acquisition of the system.

ROLE OF MANAGEMENT IN GIS/LIS IMPLEMENTATION

GIS/LIS should be supported by management. Specifically, it should support the need for change from a "manual" to an "automated" system. Management should understand the future benefits well enough so that it can promote the technology at the corporate level of the organization. This will ensure that the momentum for GIS/LIS is not lost in the first few months, and will encourage interaction with other managers in the organization.

The role of management is also crucial in securing the necessary resources and expenditures for the project and in promoting professional development of existing staff.

In addition, management plays an important role in formulating the policy of GIS/LIS, and approving decisions for staffing of the organization. Management should recognize the need for change, support the long-term development of the system and provide vision and direction. Its support is needed to institutionalize the necessary organizational structure of the system and to facilitate securing human and financial resources for the GIS/LIS activity. Management decision-making is crucial in explicitly defining the lines of responsibility among staff and in streamlining the necessary procedures for system management.

CONCLUSION

This paper has described an approach for planning a GIS/LIS development project and for specifying the various technical tasks and institutional issues that should be addressed before acquisition of the hardware and software. There is a challenge for organizations to commit themselves to a sound strategic planning process in the development of geographic information systems. Not only does this orderly approach to GIS/LIS project planning benefit the organization in developing the system, but it also allows vendors of hardware and software to offer quality products in a cost-effective manner.

A "GEOCADASTRE" FOR NEW ORLEANS AND SOUTHERN LOUISIANA*

Paper submitted by the United States of America

RÉSUMÉ

La mise au point de systèmes d'information foncière continue à susciter un intérêt croissant, surtout dans les zones urbaines et suburbaines des Etats-Unis. Comme les autres communautés dynamiques et en pleine expansion, La Nouvelle-Orléans s'y intéresse également. L'affaissement progressif des terres observé à La Nouvelle-Orléans et dans d'autres régions du sud de la Louisiane pose des problèmes particuliers dans la tenue du système national de référence géodésique et complique considérablement la mise au point d'un système d'information foncière. Pour marquer cette différence avec les systèmes habituels d'information foncière dans les zones stables et rendre compte de la diversité des éléments qui doivent être fournis par d'autres services, nous avons appelé ce système le "Géocadastre".

Le Géocadastre doit combiner les techniques existantes et les techniques nouvelles, par exemple le Système mondial de localisation, pour assurer la fiabilité du système d'information foncière. Il comporte tous les éléments d'un cadastre polyvalent avec l'addition d'autres données, géologiques, hydrologiques et relatives aux marées, par exemple. Si l'on veut modéliser l'affaissement, il faudra analyser ces autres données et les rapprocher des données géodésiques concernant la région pour obtenir de bonnes estimations des mouvements futurs.

Les principales tâches qu'implique le Géocadastre sont décrites dans ce document.

* The original text of this paper, prepared by Gilbert J. Mitchell and David B. Zilkoski, National Ocean Service, appeared as document E/CONF 81/L. 24

RESUMEN

El interés en la elaboración de sistemas de datos sobre las tierras continúa aumentando rápidamente, especialmente en las zonas urbanas y suburbanas de los Estados Unidos. Nueva Orleans, al igual que otras regiones dinámicas y en crecimiento del país, comparte este interés por los sistemas de datos sobre las tierras. El hundimiento progresivo de las tierras que se observa en Nueva Orleans y en otras regiones de Luisiana meridional plantea problemas muy especiales en lo que hace a mantener el sistema de referencia geodésica nacional e introduce problemas muy complejos para la elaboración de sistemas de datos sobre las tierras. Para poner de relieve esta diferencia con los sistemas de datos sobre las tierras corrientes en zonas estables y en reconocimiento de la variedad de insumos que se necesitan de otros organismos, hemos denominado a este sistema "Geocatastro".

El concepto de Geocatastro se propone para vincular las tecnologías existentes y en surgimiento, es decir, el Sistema Mundial de Determinación de Posiciones, a fin de lograr un sistema fiable de datos sobre las tierras. Este concepto incluye todos los aspectos de los catastros de fines múltiples, con la adición de otros elementos, tales como datos geológicos, hidrológicos y de mareas. A fin de preparar modelos del hundimiento, esos datos deben analizarse y correlacionarse con datos geodésicos de la región a fin de permitir estimaciones confiables de los novimientos futuros.

En este documento se analizan las principales tareas que deberán realizarse para el Geocatastro.

SUMMARY

Interest in the development of land data systems continues to increase at a rapid pace, especially in urban and suburban areas of the United States. New Orleans, like other dynamic and growing regions of the country, shares this interest in land data systems. The pervasive land subsidence experienced by New Orleans and other regions of southern Louisiana presents unique problems for maintaining the national geodetic reference system and introduces a very complicated problem for land data system development. To emphasize this difference from the usual land data system in stable areas, and in recognition of the variety of inputs needed from other agencies, we have denoted this system as the "Geocadastre".

The Geocadastre concept is proposed to link existing and emerging technology, i.e., the Global Positioning System (GPS), to assure a reliable land data system. This concept includes all aspects of a multi-purpose cadastre plus the addition of other data elements such as geological, hydrological, and tidal data. In order to model subsidence, these other data elements must be analysed and correlated with geodetic data in the region to allow reliable estimates of future movement.

The major tasks that need to be accomplished for the Geocadastre are discussed in this paper.

"There is a critical need for a better land-information system in the United States to improve land-conveyance procedures, furnish a basis for equitable taxation, and provide much-needed information for resource management and environmental planning." This opening statement appears in a National Academy of Sciences (NAS) report, entitled "Need for a multipurpose cadastre", and succinctly defines a problem that is increasingly attracting the attention of Federal, state and local governments, universities, private companies and individuals. The report identifies the concept of the multi-purpose cadastre as "a framework that supports continuous, readily available, and comprehensive land-related information at the parcel level". The components of a multi-purpose cadastre are the following:

- (a) A reference frame consisting of a geodetic network;
- (b) A series of current, accurate large-scale maps;
- (c) A cadastral overlay delineating all cadastral parcels;

- (d) A unique identifying number assigned to each parcel that is used as a common index of all land records in information systems;

- (e) A series of land data files, each including a parcel identifier for purposes of information retrieval and linking with information in other data files.

Interest in the development and implementation of multi-purpose cadastres or land data systems has been strongly in evidence at the county level of government, with increasing interest at the state level. The concept of the multi-purpose cadastre has been more widely supported in the densely populated countries of Europe, and some of those countries have made considerable progress in implementing multi-purpose cadastres. The United States should use the knowledge gained by the Europeans in developing land data systems. An accurate land data system is essential in solving the multifaceted, interdependent problems of modern societies.

The seemingly simple task of inventorying and assessing land value becomes a Herculean task without an accurate land data system.

Some areas of the United States, e.g., New Orleans and vicinity, have a compounded problem due to continuing subsidence of the land. Further complications are introduced by the potential for flooding by the Mississippi River, and the threat of tropical storms and attendant storm surges.

In addition to the obvious concerns of state governments and local jurisdictions, a number of Federal agencies have a vital interest in the prediction and effects of subsidence. The National Oceanic and Atmospheric Administration (NOAA) is concerned about the accuracy and reliability of the National Geodetic Reference System (NGRS) and the National Tidal Network, and the user need related to these systems. The Federal Emergency Management Agency (FEMA) has the responsibility of administering the National Flood Insurance Program and requires local jurisdictions to connect to the National Geodetic Vertical Datum of 1929 for verification of elevations to determine flood insurance rates. The United States Army Corps of Engineers' (COE) mission is to plan, design, construct, operate and maintain civil works. This includes the construction of levees and other facilities that assist in the safeguarding of life and property. COE uses NGRS and the National Tidal Network in the development of their plans and facilities. The Department of Energy is concerned about safeguarding energy sources and is especially interested in the effects of subsidence on salt dome oil storage areas and geothermal energy projects in southern Louisiana.

These agencies and local parishes have cooperated in relevelling portions of NGRS in Louisiana during the past 20 years. Some of these relevelling efforts have covered large areas of the region and, as analysed by Holdahl (1973), and Brown and others (1982), generally show a continuing subsidence of the land areas. (While subsidence appears continuous, rates of subsidence vary over the entire area.) There is always a question of how much relevelling is necessary to assure the reliability of NGRS. Geodetic levelling to detect subsidence is expensive and time-consuming, and a comprehensive relevelling of the greater New Orleans vicinity could amount to several hundred thousand dollars. There is a need for a systematic approach to measuring and monitoring subsidence as opposed to the present fragmented approach, as well as a need to provide for the development of an accurate and reliable land data system. NGRS is an essential component of improving the monitoring of subsidence and meeting the needs of accurate land data systems.

The development and deployment of satellites comprising the Defense Mapping Agency's Global Positioning System (GPS), described by Hothem and others (1984) and Strange and Wessells (1985), offer a unique opportunity for a cooperative effort between all concerned parties. The potential of GPS for monitoring subsidence at key locations throughout the area could dramatically reduce the amount of levelling needed to assure an accurate and reliable NGRS for all users. GPS also offers a more timely response to problems of immediate urgency. This is impossible using past techniques. In addition to geodetic data, there are a number of other data elements that must be integrated to develop this systematic approach to monitoring and modelling subsidence in the region. To distinguish this approach from the usual land data systems in stable areas, and in recognition of the variety of inputs needed from other agencies, we have designated this concept the "geocadastre". This paper describes the geocadastre concept and its elements.

GEOCADASTRE CONCEPT

The geocadastre concept includes all aspects of a multi-purpose cadastre, plus the addition of other data elements, including geological, hydrological, and tidal data. In order to model subsidence, these other data elements must be analysed and correlated with geodetic data to estimate vertical movements accurately. Inputs to the geocadastre are:

- Basic geodetic vertical surveys
- Basic geodetic horizontal surveys
- Basic gravity surveys
- Local survey densification
- Geologic formations
- Hydrologic factors
- GPS surveys

Real-time subsidence measurements (extensometers)

Many data already exist that could contribute to the geocadastre, such as data obtained from previous primary geodetic surveys, core drillings, oil well development, river gauges and tide gauges and densification surveys undertaken by Federal, state, and local agencies. The major tasks to be accomplished for the geocadastre are:

- Establish Technical Committee
- Identify data sources and availability
- Collect new data
- Design integrated database
- Develop numerical model of subsidence
- Devise methodology for dissemination

Establish Technical Committee

The Geocadastre Technical Committee should have representatives with the requisite skills from Federal, state and local agencies, the private sector, and academia. The number of active members should be 12 to 15 at any one time. Additions or deletions should be made as the nature of the tasks before the Committee changes. Members with backgrounds in the following fields should be included:

Computer science	Hydrology
Engineering	Land data systems
Geodesy	Property assessment
Geology	Soil mechanics
Geophysics	

Financial support for the members of the Technical Committee should be provided by their own organizations, since it is assumed they will have a vital interest in the Committee's activities. The Regional Planning Commission, headed by the Executive Director, has provided excellent cooperation in arranging meetings and preliminary support to organizing the geocadastre effort. It is recommended that this type of support for the Committee be continued.

Identify data sources and availability

Many of the data that could be included in the development of the database are already in existence or are being collected. A major sub-task for the Committee is identification of sources of data and accessibility. Thereafter the necessary impetus must be developed to convert the data into standardized formats for analysis. There is a need to format all potentially useful geodetic data in the manner described in *Input Formats and Specifications of the National Geodetic Survey Data Base* of the Federal Geodetic Control Committee (FGCC) (FGCC, 1980a, 1980b, 1985). For instance, COE has indicated a willingness to consider more carefully which of their surveys may be put into the FGCC format.

One problem that needs to be addressed is the lack of user-friendly, automated techniques for inputting geodetic data. The New Orleans area parishes have cooperated with NOAA in a releveling programme in the past year that will be contributive to the geocadastre.

The Louisiana Department of Transportation has completed a releveling that will be relevant to this effort and will be incorporated in the FGCC format. Orleans and Jefferson Parishes have recently completed releveling densification projects that will be submitted in the FGCC format.

Also needed is the input of geologic and hydrologic data from those Federal and state agencies, such as COE, the United States Geological Survey, and the Louisiana Department of Natural Resources, that routinely collect such data in their activities. In addition, colleges and universities in the area may have relevant data to include. COE also maintains data on the Mississippi River and adjacent waterways which could be contributive. NOAA and the Louisiana Department of Natural Resources have a cooperative tidal observation programme that can provide data inputs.

A number of other Federal, state, local and private organizations, including oil companies, may have holdings of gravity and other data that could be beneficial to the geocadastre. There are three inactive extensometers in the Baton Rouge, Louisiana, area that could possibly be used in conjunction with geocadastre development.

Collect new data

Techniques likely to be used for additional data collection include, but are not limited to, the following:

- Releveling
- GPS surveys
- Siting and operation of extensometers
- Inputting geological data
- Inputting COE and local densification data
- Local survey densification
- Assimilating river/tide data
- Inputting hydrologic data

The extent of additional primary vertical network releveling that will be required should be determined after the Technical Committee has been formed and data available from all sources inventoried. The same is true of the requirement for basic gravity surveys. Some releveling and gravity surveys will be required to provide appropriate connections between some of the new GPS stations and to assist in understanding the relationship between geological structure and subsidence (Holdahl, 1973; Strange and Wessells, 1985; Strange and Carroll, 1974).

The Harris-Galveston Subsidence District in Texas and other agencies have installed extensometers to aid in the measurement of subsidence on a real-time basis (Gabrysch, 1982; Zilkoski, 1984). As indicated earlier, there are three extensometers in the Baton Rouge area that possibly could be used in the development of the geocadastre. Extensometers would provide an extra dimension to the overall geocadastre, but they are very expensive to establish, ranging in cost from \$US 200,000 to \$300,000.

GPS offers a new tool that shows promise in improving the speed and reducing the expense of monitoring subsidence. GPS surveys would be established initially to show the relationship between the NOAA/state tide gauges, COE river gauges, National Geodetic Vertical Datum of 1929, areas of known subsidence, and areas of known stability. It is anticipated that the initial GPS observations would pro-

vide baseline coverage from the tide gauges along the Gulf of Mexico through the subsidence areas of New Orleans and into stable areas north of the city. In addition, other GPS stations would be established to provide the basic horizontal and vertical control to meet multi-purpose cadastre needs. Further densification, both horizontal and vertical, could then be undertaken by other Federal, state and local agencies. About 150 to 200 GPS stations would be required to meet the needs as currently known.

The vertical accuracies that can be expected from GPS observations are still being investigated; however, preliminary studies by NOAA (Strange and Wessells, 1985) indicate possible repeatability at the centimetre level. Other analyses performed by NOAA (Hothem and others, 1985), in estimating sloped and orthometric heights from GPS surveys, indicate that, with appropriate planning of GPS surveys for connection to benchmarks, proper field observation procedures, and correct strategy for estimating geoid undulation differences and orthometric height values, it is possible to use GPS survey methods to estimate orthometric heights to meet a wide range of engineering requirements. NOAA will continue to investigate GPS-derived orthometric heights and will develop standards and specifications for GPS surveys.

The GPS observations should be done as much as possible within the same time-frame as the releveling surveys. The GPS network will also provide an improved framework for the development of the Survey Information Network (SIN), an extension of NGRS essential to an accurate and reliable land data system.

Design integrated database

The design of the integrated database will be a major task for the Technical Committee. Important questions of design, data input, output, updating cycles, and relationships to other Federal, state and local databases must be answered. It is essential to the success of the geocadastre that an innovative database be developed, since it is central to the purpose of the geocadastre, i.e., the providing of accurate and reliable data on which to make decisions. Specialized knowledge of database development will be required, and it may be necessary to develop specifications internally and use contract sources for this development. It is important that the design address all possible user requirements of the New Orleans area.

The integrated database will provide data for the development of the subsidence model and eventually be the mechanism for the distribution of data to users. While the physical location of the database is relatively unimportant, easy access must be available to New Orleans area users for both inputting and obtaining data. A major aspect of the consolidated database will be that all users/interested parties will be operating with the same data set. The database must be flexible enough to allow new data entry while at the same time provide a consistent approach to data dissemination that minimizes the day-to-day disruption of activities.

Develop numerical model of subsidence

Another major task of the Technical Committee will be the development of the numerical model (or models) of subsidence. This task can be started before all data formatting and collection are completed. The Committee members should draw on their knowledge of similar models, and research other models to minimize the effort. The assembly

in the integrated database of the recommended data sets should allow the development of meaningful models. Considerable interaction is anticipated in this effort between Committee members experienced in computer techniques and other members of the group.

In addition to the development of the subsidence models, the following outputs are expected from the geocadastre effort:

- Integrated database
- Subsidence maps
- Variations in sea level
- Consistent set of parameters (heights, subsidence rates)
- Basic data for accurate land data system

Devise methodology for dissemination

The Technical Committee should provide guidelines for the distribution or dissemination of the outputs described above. One approach could be to develop an integrated database for all elements contributing to determination of the rates of subsidence that would serve all of the metropolitan New Orleans area. The organizations that desired these data and wanted additional information for their own database could be linked to the database. They would then add the additional data needed for their particular purpose, e.g., the proposed Survey Information Network (SIN), a subset of NGRS, recommended to support land data systems.

As stated previously, the physical location of the database can be almost anywhere, but easy electronic access for input and output is essential. The following benefits would result from the outputs derived from the development of the geocadastre:

- Dynamic reference framework
- Future physical changes modelled
- COE/local projects included in NGRS database
- Structural design improvement
- Improved flood prediction
- Consistent set of parameters

CONCLUSION

The overall cost of the geocadastre in the New Orleans area will range from \$2.1 million to \$3.5 million. More detailed cost estimates can be developed after initial analysis by the Technical Committee. It is anticipated that any Federal, state or local agency with input to or need for geocadastre products will be interested in participating in the development and funding of the programme. The Regional

Planning Commission could be requested to develop local input and supporting activities while overall coordination could be under the auspices of NOAA and/or the Federal Geodetic Control Committee.

The New Orleans area, like other rapidly growing regions of the nation, has a vital need for accurate and reliable land information. The geocadastre, as described herein, provides an effective approach to solving the unique problems experienced in this area due to pervasive land subsidence.

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A PROCESS FOR EVALUATING GEOGRAPHIC INFORMATION SYSTEMS*

Paper submitted by the United States of America

RÉSUMÉ

Les services fédéraux doivent de nos jours traiter rapidement des problèmes complexes qui mettent en jeu des ensembles très divers de données ayant un dénominateur géographique (données épidémiologiques, socio-économiques ou relatives aux ressources naturelles). Etant donné les responsabilités de ces services en matière d'administration et de réglementation, les systèmes d'information existants sont mis à rude épreuve. Face à ces besoins croissants, les méthodes traditionnelles d'acquisition, de stockage et d'analyse de données localisées dans l'espace se révèlent trop onéreuses et rigides.

Aussi les systèmes automatisés d'information géographique (GIS) sont-ils appelés à devenir l'outil de choix pour le traitement de données spatiales dans la solution de problèmes géographiques complexes. Or, peu de principes directeurs existent pour aider les services fédéraux à identifier les activités possibles et les instruments appropriés faisant intervenir un système adéquat d'information géographique. Afin de combler cette lacune pour les administrateurs fédéraux et les scientifiques, le Groupe de travail des échanges technologiques du Comité fédéral de coordination interinstitutions sur la cartographie numérique a préparé un rapport sur les méthodes d'évaluation des systèmes d'information géographique à l'intention de ceux qui envisagent d'adopter un tel système. Ce rapport donne un aperçu des techniques utilisées dans les systèmes d'information géographique (GIS) et dresse un tableau d'ensemble de toute la procédure à suivre dans l'évaluation des systèmes d'information géographique. Il couvre aussi des normes et directives pertinentes, des fonctions logicielles, des composants et des bancs d'essai.

RESUMEN

En la actualidad, los organismos federales deben responder con rapidez a diversos problemas complejos que abarcan toda una gama de conjuntos de datos con referencias geográficas (tales como datos sobre recursos naturales o datos socioeconómicos o epidemiológicos). Las responsabilidades administrativas y de regulación asignadas a los organismos oficiales han impuesto enormes exigencias a los sistemas de información existentes. Los métodos tradicionales para adquirir, almacenar y analizar datos con referencias espaciales han demostrado ser demasiado caros y rígidos para satisfacer esas necesidades, cada vez mayores.

Los sistemas de información geográfica (GIS) computadorizada se vienen perfilando como los instrumentos preferidos para manejar datos espaciales a los fines de resolver los problemas geográficos complejos antes mencionados. Sin embargo, son pocas las normas existentes para ayudar a los organismos a individualizar las actividades posibles y los instrumentos apropiados que pueden constituir una solución adecuada en la esfera de los sistemas de información geográfica. Para llenar la laguna a que deben hacer frente a este respecto los administradores y científicos federales, el Grupo de Trabajo de Intercambio de Tecnología del Comité Federal de Coordinación entre Organismos sobre Cartografía Digital ha preparado un informe titulado "Un proceso para evaluar sistemas de información geográfica" destinado a los interesados en utilizar sistemas de ese tipo. En el informe se presenta un cuadro general de la tecnología de los sistemas de información geográfica y un panorama global de la totalidad del proceso que debe seguirse para evaluar los méritos de esa tecnología. En él se analizan también las normas y directrices pertinentes, las funciones de los programas, los componentes físicos y los elementos referenciales de evaluación.

SUMMARY

Today, Federal agencies must quickly respond to complicated problems involving a wide variety of geographically referenced data sets (such as natural resource, socio-

* The original text of this paper, prepared by Stephen C. Guptill, United States Geological Survey, appeared as document E/CONF 81/L. 29. The paper summarizes the report of the Technology Exchange Working Group of the Federal Interagency Coordinating Committee on Digital Cartography, entitled "A process for evaluating geographic information systems". Copies of the report are available at no cost by application to the United States Geological Survey, 516 National Center, Reston, Virginia 22092.

economic, or epidemiologic data). Administrative and regulatory responsibilities assigned to government agencies have placed tremendous pressure on existing information delivery systems. The traditional methods of acquiring, storing, and analysing spatially referenced data are proving to be too costly and inflexible in meeting these growing needs.

Computerized geographic information systems (GIS) are emerging as the spatial data handling tools of choice for solving complex geographical problems. However, few guidelines exist for assisting agencies in identifying potential activities and appropriate tools that comprise an appropriate GIS solution. To fill this void for Federal managers and scientists, the Technology Exchange Working Group of the Federal Interagency Coordinating Committee on Digital Cartography has prepared a report entitled "A process for evaluating geographic information systems", for those considering implementing a GIS. The report provides an overview of GIS technology and a general picture of the entire process to be followed in evaluating the merits of GIS technology. It also discusses related standards and guidelines; software functions; hardware components; and benchmarking.

A geographic information system (GIS) is a computer system designed to allow users to collect, manage, and analyse large volumes of spatially referenced and associated attribute data. Because GIS technology allows analysts to process and interrelate many more kinds of data than were previously feasible, agencies have the potential to greatly improve traditional missions such as data collection, research, assessment, and information delivery.

In order to assist Federal managers and technical specialists in evaluating, designing, and procuring GISs and acquainting them with the issues surrounding GIS usage, the members of the Technology Exchange Working Group of the Federal Interagency Coordinating Committee on Digital Cartography have prepared a 142-page report entitled "A process for evaluating geographic information systems". The objective of this document is twofold. First, it provides an overview of GIS technology and a general picture of the entire process of evaluating a GIS. This overview is given in part I of the document, which consists of five chapters. It is written for an audience of both managerial and technical personnel who may not be familiar with GIS technology. Secondly, in part II, the report provides advice and guidelines to those who are directly involved with the technical issues of implementing or procuring GISs. The four chapters of part II discuss related standards and guidelines, software functions, hardware components, and benchmark testing. Appendices provide details on standards, definitions of terms used in the report, and Working Group membership.

The Working Group actively promotes the exchange of information and ideas on technology and methods for collecting and using digital cartographic data. It also monitors developments in GIS technology and documents guidance for utilizing that technology.

WHY GISs ARE USEFUL IN THE FEDERAL ENVIRONMENT

Federal agencies must acquire, analyse, manage, and disseminate tremendous volumes of spatial and attribute data to accomplish their missions. Spatial data analysis is a multidisciplinary concern. Geographical, medical, sociological, military and earth science activities, among others, require spatial data analysis. Spatial data sets are frequently heterogeneous, having data elements such as soils, land use, and population statistics, and are often from data sources having differing scales, coordinate systems, accuracies and areal coverage. The data originate from source material in multiple formats, such as text, maps, charts or remotely sensed imagery. In some instances, agency functions require that basic data sets be reduced for incorporation into multidimensional numeric models. The management and analysis of

these data in a non-automated hardcopy environment to support such modelling and other analytical procedures is often tedious and cumbersome, inhibiting the efficient achievement of agency goals.

Spatial data sets are unique in providing the geographical positions of features related to known coordinate systems; in specifying attributes of features that may be independent of position, such as colour, cost and size; and in describing the spatial and topological relations among features in the data set. GISs are specifically designed to manage and analyse spatial data sets having such characteristics.

At present, a number of GIS packages have been developed within the public and private sectors. Some applications are specific and some are generic. Development within the GIS field is continuing and more GIS packages can be expected to become available. Agencies can often apply existing systems directly to their applications, eliminating the need for costly system development work. This trend is changing the question of GIS implementation from one of being able to develop a system to meet agency requirements, to one of selecting the best existing system.

EFFECTIVE USE OF A GIS

As GISs become widely implemented, their procurement and operation are being more closely monitored for adherence to agency information resource management guidelines and procedures. Such scrutiny may be a new experience for GIS programme managers who may have first acquired their GIS capability as part of a low-visibility research effort. Therefore the reader should be aware that a great deal has been written on effective information resources management practices.

For example, the General Accounting Office (GAO) has identified the following five basic objectives for the acquisition and operation of information systems (see GAO, 1986).

(a) *Ensure system effectiveness.* System effectiveness is measured by determining whether the system performs the intended functions and whether users get the information they need, in the right form, in a timely fashion.

(b) *Promote system economy and efficiency.* An economical and efficient system uses the minimum number of information resources to achieve the output level the system's users require.

(c) *Protect data integrity.* Data integrity requires that systems have adequate controls over how data are entered, communicated, processed, stored and reported.

(d) *Safeguard information resources.* Information resources, which include hardware, software, data and peo-

ple, need to be protected against waste, loss, unauthorized use and/or fraud.

(e) *Comply with laws and regulations.* Compliance with laws, regulations, policies, and procedures that govern the acquisition, development, operation, and maintenance of information systems must be ensured.

The guidance and recommendations, such as those contained within the GAO document, should be observed so that GIS requirement documents meet these objectives. This will help to ensure that a given GIS implementation will comply with the various guidelines and procedures should a review or audit occur.

IS A GIS FOR YOU?

A GIS is successful when it comprehensively and consistently meets the needs of users. Development of a successful GIS depends on well-defined user requirements. A user requirements analysis is a detailed study of the needs of potential system users. The analysis should result in a clear statement of end product characteristics, required production rates, estimated data volumes, and cost/benefit rationale. Steps in performing the analysis include:

- Identification of users
- Definition of required products
- Evaluation of work flow
- Sizing database development efforts
- Inventorying user applications
- Refinement of GIS product characteristics
- Calculating production rates
- Estimating data volumes
- Measuring cost/benefit ratios

The personnel conducting the analysis should prepare a report for the organization management. This report should clearly, and in detail, identify the:

- Operation, users, and data requirements of the existing system
- Potential users of a GIS
- Products required by users, both digital and hardcopy
- Data volumes and production rates the GIS will be required to meet
- Database required to support GIS implementation
- Cost/benefit ratios in using GIS technology

The user requirements analysis provides managers with a comprehensive description of the data sets, database management capabilities, modelling and analytical needs, and product generation requirements for successful GIS implementation. On the basis of this information, the manager must weigh the merits of GIS usage relative to the organization's applications.

The cost/benefit analysis is one indicator of the need for applying GIS technology within the organization. The degree to which intangible benefits have been adequately measured and quantified must be considered in a subjective manner when the cost/benefit ratio is evaluated. When the cost/benefit ratio is marginal, that is, close to 1.0, further research may be required, particularly into the intangible benefits, before a decision on GIS implementation can be made based on the cost/benefit ratio.

The manager must also consider the appropriateness of applying GIS technology to the organization's applications regardless of the recommendations of the user requirements analysis. The analysis documents how an existing organization functions and supports its users, and then quantifies and

defines an alternative operation based on GIS technology. It does not address related issues, such as the organization's objectives, goals or staff capabilities, that are not quantifiable technical issues.

WHICH GIS?

If upon completing a user requirements analysis and assessing the appropriateness of GIS applications for the organization's missions the managers determine that GIS technology should be incorporated into the operation, evaluation criteria must be devised to serve as the basis for selecting a GIS. Evaluation criteria should be clearly specified so that both the organization and the vendors have a clear understanding of what is requested and what is required. The evaluation criteria should be incorporated into the standards used in benchmark testing.

Hands-on experience with GIS capabilities will often be of value in developing reasonable evaluation criteria. A useful method to acquire such experience is to perform a small-scale pilot project. The pilot project should be designed to test the ability of GIS systems to meet an organization's operating needs. Pilot tests can be a source of realistic data on production rates, memory and storage requirements, human interface functionality, and user response to GIS products.

All or only portions of the GIS design for the organization may be tested, depending upon the organization's familiarity with GIS systems. It may be desirable to test only the portions of the GIS that are most critical to organizational needs or represent the elements with which the organization is least familiar. Pilot test results can be used to refine evaluation criteria that were based solely on a user requirements analysis.

THE ROLE OF STANDARDS AND GUIDELINES

Standards enable the integration of GIS. Internally, standards enhance the inherent integrative capabilities within a GIS by coordinating data, software and hardware to optimize application efficiency, effectiveness and economy. Externally, standards facilitate integration with other GISs or information systems through compatibility in data administration, database management, graphics, hardware and software. Such standardization augments the functionality, flexibility, and productivity of a GIS while extending its availability to a greater audience. Interface standards enable communication among information systems; they include data interchange, database conversion, graphics, software and hardware standards.

Standards and guidelines for GISs apply to both general computer systems and specific GIS activities. A set of GIS-related standards, guidelines, de facto and developing standards, and references is given in appendix A of the Working Group's report. Most of the standards listed are Federal Information Processing Standards (FIPS) which are directly applicable to civilian and military agencies of the Federal Government. Standards of the American National Standards Institute (ANSI), the International Organization for Standardization (ISO), and those of industry are cross-referenced to FIPS standards where appropriate.

In addition, special mention should be made to the proposed standard for digital cartographic data, which was published as a special edition of *The American Cartographer* (vol. 15, No. 1, January 1988). See also, in this volume, E/CONF.81/L.28.

The proposed standard consists of four major components: (a) definitions and references; (b) spatial data trans-

fer; (c) digital cartographic data quality; and (d) cartographic features.

The standard is an attempt to meet the recognized requirement for easy transfer of spatial data from one spatial data handling system to another, with both systems possibly residing on computer hardware and operating system software of different makes.

TECHNICAL ISSUES

Defining a set of processing functions to meet specific application needs is an important step in the design or evaluation of a GIS, and is a direct outgrowth of the user requirements analysis phase. Identifying required functions often begins with a detailed listing of required GIS products and their specifications. Further product analysis subsequently leads to identifying the type of processing functions required for each product.

The functional components of a GIS can be grouped into five broad categories: a user interface; system/database management capabilities; database creation/data entry capacity; spatial data manipulation and analysis packages; and display/product/generation functions. Individual processing functions within these categories are often prioritized as either mandatory or desirable capabilities. Mandatory software capabilities, when merged with parameters that quantify specific application needs, such as required response time, accuracy, precision, product generation frequency, and data volumes, lead directly to mandatory hardware capabilities.

Existing GISs are extremely diverse both in functionality and database structure. Systems use various methods for digitizing, assigning and storing attribute, coordinate and topological information. The capability to manipulate, analyse, and display these data varies widely across systems. Capabilities of a given system are often oriented towards providing a specific capability or supporting a specific application area, such as computer-aided design

(CAD), computer-aided mapping (CAM), surveying, natural resource management, terrain analysis and image processing.

The technical issues facing the potential user of a GIS include the following:

Does the system have the software functions required to perform the application?

What hardware components will allow these functions to be performed in an efficient manner and provide a path for growth with respect to data quantities and analysis work?

How can a series of benchmark tests be set up to provide information to allow the above questions to be answered?

The Working Group's report addresses these topics in chapters 7, 8, and 9 respectively. Chapter 7 contains an extensive list of GIS functional capabilities, organized in a check-list fashion so that the user can indicate the functions his application requires. Chapter 8 enumerates various GIS hardware components, to be matched with the necessary software functions. Chapter 9 provides some sample benchmark tests for GIS software and hardware.

CONCLUSION

The traditional method of acquiring, storing, and analysing spatially referenced data are proving to be too costly and inflexible in meeting the information needs of Federal agencies. GISs are emerging as the spatial data handling tools of choice for solving complex geographical problems.

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AGENDA ITEM 6

Review of the latest developments related to policies and management of national mapping and charting programmes

(a) *Managerial and technical aspects of national programmes*

MODERNIZATION OF THE UNITED STATES GEOLOGICAL SURVEY MAPPING SYSTEM*

Paper submitted by the United States of America

RÉSUMÉ

Le Service géologique des Etats-Unis est en train de moderniser son équipement et ses installations pour améliorer la productivité et tirer parti des tendances actuelles et futures des systèmes numériques de cartographie. Le programme de modernisation se fonde sur le principe d'un système global, c'est-à-dire que, en l'élaborant, on considère tous les éléments du processus cartographique préalables à la lithographie. Le programme se divise en quatre sections fonctionnelles pour la gestion du projet : production de données; production de produits; bases de données; et gestion du programme. Le présent document décrit la méthode utilisée pour développer le programme, l'état actuel des travaux et le rôle de la photogrammétrie classique et numérique dans le programme.

RESUMEN

El Estudio Geológico de los Estados Unidos (U.S. Geological Survey) está modernizando su equipo e instalaciones para aumentar su productividad y aprovechar las tendencias actuales y futuras en materia de sistemas de levantamiento digital de mapas. El programa de modernización se basa en un concepto de sistema total, es decir, abarca todos los componentes del proceso de levantamiento de mapas previos a la litografía. El programa se divide en cuatro esferas funcionales para la gestión de los proyectos: producción de datos; generación del producto; bases de datos, y gestión del programa. En la monografía se describe la metodología utilizada para elaborar el programa, el estado en que se encuentra actualmente y la función que cumple en el programa la fotogrametría convencional y digital.

SUMMARY

The United States Geological Survey is modernizing its equipment and facilities to improve productivity and to take advantage of current and future trends in digital mapping systems. The modernization programme is based on a total system concept, that is, the development considers all components of the mapping process prior to lithography. The programme is divided into four functional areas for project management: data production; product generation; databases; and programme management. This paper describes the methodology used to develop the programme, its current status, and the role of conventional and digital photogrammetry in the programme.

* The original text of this paper prepared by Ernest B. Brunson, United States Geological Survey, appeared as document E/CONF 81/L.27. Use of trade names and trade marks is for identification purposes only and does not constitute endorsement by the United States Geological Survey

In 1973 the Office of Management and Budget (OMB) sponsored a study of civilian agency mapping that called for revision of the National Mapping Program to better meet the country's mapping needs. Based on OMB's recommendations, the United States Department of the Interior established a new National Mapping Program and designated the United States Geological Survey as the lead agency for its administration. The Geological Survey established the following objectives for the year 2000:

(a) To complete the population of the National Digital Cartographic Data Base (NDCDB) with all feature categories;

(b) To accomplish all map revision in a digital mode using the NDCDB;

(c) To perform all graphic production from the digital data in the NDCDB.

Within the National Mapping Program, the Mark II Program was established to assist in ensuring achievement of these objectives. The Mark II Program is a modernization programme that will provide enhanced capabilities to populate and utilize the NDCDB for graphic and digital production. In particular, the Mark II Program will increase productivity and support the National Mapping Program through achievement of the following goals:

(a) Improve the production technology by adding and enhancing existing digital production to support the population of the NDCDB;

(b) Improve the management of data resources to increase production rates and to improve response to customer requests;

(c) Improve management of all production resources;

(d) Use as many of the capabilities of the other Federal mapping agencies' development programmes as are applicable to the Program's requirements.

The last goal is derived from the long-standing working relationship and technology transfer that exist among the Geological Survey and other mapping agencies. In the same time-frame as the Geological Survey's Mark II Program, several agencies have initiated modernization programmes that will result in improved hardware and software for mapping.

MARK II SYSTEM DESCRIPTION

The Mark II Program is a modernization procurement effort that will provide enhanced capabilities to populate the NDCDB and permit its use for graphic and digital production in an all-digital environment. The Mark II system is the collection of all equipment and software that will support production in the 1992-to-2000 time-frame. It necessarily includes a number of elements from different sources. Specifically, it includes:

(a) Existing systems resident at the production centres;

(b) New acquisitions planned between now and 1992;

(c) Hardware and software obtained from other governmental agencies.

The Mark II system documents cover the full range of activities to be accomplished in the 1992-to-2000 time-frame. The following discussion is a brief summary of each Mark II component together with a more detailed description of the data production component, which is a major user of photographic source materials and photogrammetric procedures. The Mark II system consists of the following five components:

Database component (DB/C)

Data production component (DP/C)

Data services component (DS/C)

Product generation component (PG/C)

Production management component (PM/C)

The database component provides database management support for system access, database access, database processing, database control, integrity protection, interactive query processing, batch processing, command language processing, spatial data file processing, and output and reporting. The DB/C also provides local and wide-area communications support for network interface, network management, and digital data transfer for the Mark II system for both the operational database (ODB) and the archival database (ADB). The ADB contains the NDCDB. An ODB will be resident at each National Mapping Division (NMD) production site.

The data production component produces digital data by digitizing hardcopy graphic material, converting digital data provided by non-NMD sources, extracting feature data from softcopy and hardcopy imagery, and integrating these data into the digital line graph enhanced (DLG-E) data model. After validation, these data are transferred to the ODB and archived in the ADB.

The data services component accepts source imagery and associated support data, accesses softcopy imagery and non-image source materials for use in generating and updating NMD products, and provides for the storage, manipulation, and management of these data prior to transmittal to the data production component.

The product generation component generates master reproducibles of NMD digital and graphic products. PG/C also generates error detection reports for the production management component so that the data production component can be authorized to make the appropriate revisions to the ODB and the ADB.

The production management component provides for integrated management of planning and scheduling of production assignments. PM/C performs technical planning, which includes non-imagery source assessment and data preparation. PM/C is also responsible for resource management, standards compliance and maintenance, and systems performance tracking activities for the Mark II system.

MARK II SYSTEM INTERFACES

The Mark II system has been defined to be the hardware, software, and operational procedures used from 1992 into the twenty-first century. This section covers the Mark II internal and external interfaces.

MARK II SYSTEM INTERNAL INTERFACES

The Mark II system is composed of both new components procured under the Mark II Program and existing hardware and software. The internal data interfaces fall into two broad categories: hardcopy and digital.

Hardcopy data: Include map separates, printed maps, compilation manuscripts, and ancillary data sources (books etc.).

Digital data: Include features data, elevation data, meta-data, and management data as discussed below. All physical transfers are accomplished through the communications capability provided by the DB/C.

TABLE 1. MARK II MAPPING MODERNIZATION SYSTEM LOGICAL INTERNAL INTERFACES

From./To:	Data production	Product generation	Database	Production management	Data services	Existing systems	Sales	New acquisitions	Print shop
Data production	n/a	Raster data Manuscripts DLG-E/IB DLG-E/SDTS metadata	Raster data OMO data DLG-E/IB metadata DLG-E/IA DLG-E DLG-E/SDTS	Status metadata	None	DLG-E/SDTS Plots DLG-E/IB	None	DLG-E/SDTS metadata	None
Product generation	DEMs metadata	n/a	Raster data DLG-E/IB DLG-E/IA DLG-E/SDTS DLG-E metadata DEM	Status metadata	None	Exposed film	Digital products	None	Separates
Database	All digital	All digital	n/a	Status metadata	None	DLG-E/SDTS DLG-E/IB	Digital products	DLG-E/SDTS metadata	None
Production management	TIPs SIUPs Maps Separates	TIPs SIUPs	TIPs	n/a	TIPs	TIPs(H/C)	None	TIPs SIUP	TIPs(H/C)
Data services	Imagery metadata Instrument data file	None	Metadata	Status metadata	n/a	None	None	None	None
Existing system	Transactions DLG-E/IB	None	Transactions DLG-E/IB	Status metadata	None	n/a	None	None	Separates
New acquisitions	None	None	DLG-E/SDTS	Status metadata	None	None	None	n/a	None

Table 1 contains all the logical interfaces existing in Mark II. The data groups and formats identified in the table are discussed below.

Digital data groups

There are five groups of digital data managed and transmitted by the archival and operational databases: metadata, management data, NDCDB digital data, NDCDB product-specific data and supplemental data.

Metadata Group. Metadata are descriptions of the data content of the NDCDB. These descriptions apply to sets of records such as quadrangle series and include such information as data source, processing history and accuracy. The metadata will also contain feature keys to quadrangle coverage.

Management data group. The management data group consists of the data required for the management of production within the Mark II environment. The data group also includes inventory and directory data, production reporting data, production scheduling data, task implementation plans (TIPs), source identification and use packages (SIUPs), production history data, and status reports.

NDCDB digital data group. The NDCDB digital group is spatial data that are partitioned by series, quadrangles and categories. These partitions are defined as:

Series—a partition by data content (imagery, elevation matrices, cartographic data) and scale (1:24,000, 1:100,000, 1:2,000,000);

Quadrangles—partitions along rectangular latitude, longitude boundaries;

Digital quadrangle—a quadrangle area that contains feature data as defined in the DLG-E data model. DLG-E

contains all the feature data required to produce a standard Geological Survey graphic or digital product covering that area;

Categories—a logical subdivision of a series into classes of related data (transportation, hydrography etc.). Intercategory topological consistency is required.

NDCDB product-specific data group. The NDCDB product specific data group consists of data in digital format used and generated during the production processes. This group includes feature data, other (thematic) data, symbolized graphic data, digital elevation data, and NDCDB support data. The NDCDB support data consists of archival data (ADB only), error reports, digitized data, and digital ancillary data.

Supplemental data group. This data group includes temporary files, backup files, and non-NMD data.

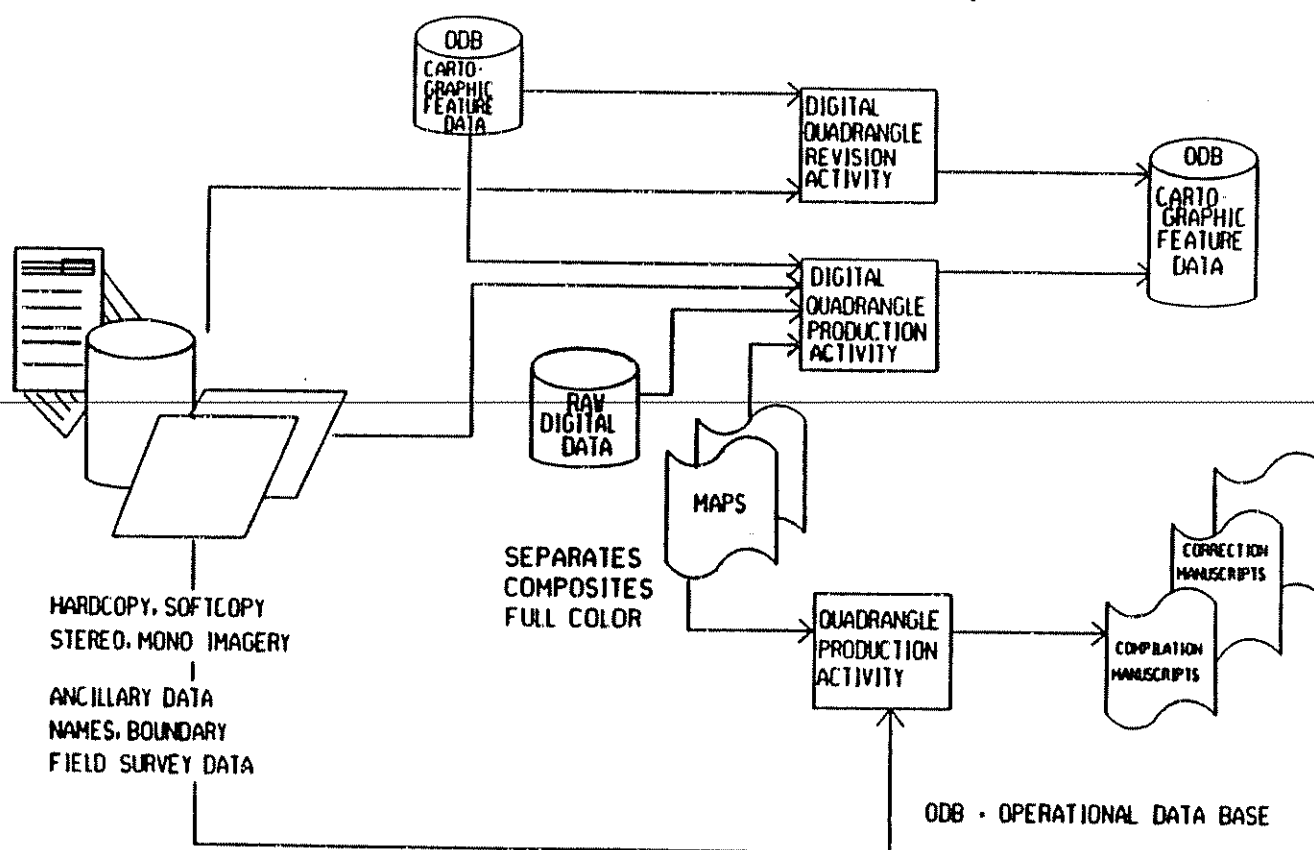
Feature data formats

Within the above-mentioned data groups, specific exchange formats have been defined that provide greater depth of information and understanding to the interface descriptions. These formats and their use are illustrated in table 2.

Mark II system external interfaces

The Geological Survey headquarters and map production centres have interfaces with the Federal agencies, other mapping organizations, state agencies, vendors, and clients. Table 3 contains a summary of these major external interfaces.

Figure 1. United States Geological Survey cartographic data production component overview



DATA PRODUCTION COMPONENT

Conceptually speaking, a component can be described in terms of three elements: hardware, software and operations. The following discussion presents an overview of the data

TABLE 2 DATA FORMAT USE WITHIN THE MARK II MAPPING MODERNIZATION SYSTEM

	Mark II acquisitions	Existing equipment	New acquisition equipment	Sales equipment	Archive database
DLG generic ^a	X	X			(TBR) ^b
DLG-E	X				
Transactions ^c	X	X	(TBR)		
DEM ^d	X	X	(TBR)	X	X
DLG-E/SDTS ^e				X	

^aDLG generic: Used to refer to existing NMD digital line graph (DLG) holdings in DLG-S, and DLG-O formats.

^bTo be resolved

^cTransaction file: An internal NMD digital data format used in current production operations. Transaction files contain unstructured digital data with operations codes, attribute codes, feature identification, and raw geometry. The format is user-definable. Contents include in any order:

File header
Corner points
Action identifiers
Element identifiers
Attributes
Coordinates

^dDigital elevation model (DEM): A raster or grid-formatted file of elevation data with equal X, Y, post spacing

^eDLG-E/SDTS: An ASCII product or distribution format for the DLG-E data model; a device-independent graph which uses the ISO 8211 standard for the physical implementation; output from the Archival database for distribution to customers

production component (DP/C) with respect to these three elements, beginning with operations or, more specifically, "major operational activities", since activities provide the framework within which the hardware and software must operate.

TABLE 3 UNITED STATES GEOLOGICAL SURVEY MARK II MAPPING MODERNIZATION SYSTEM EXTERNAL INTERFACES

External element	Received from	Sent to
Federal/State agencies	Mapping requirements	Requirements Solicitation Billing
Other mapping organizations	Source materials Information	Inquiries Orders
Vendors	Goods Services Billing	Contracts Funds
Clients	Inquiries Orders Funds (payments)	Information Products Billing
Treasury	n/a	Deposits
United States Geological Survey bureau management	Other division mapping requirements Budget Reports Administrative policies Personnel policies	Progress reports Journal vouchers Administrative Personnel reports Budget and accounting

Major operational activities

Based on functional requirements of the data production component (DP/C), it is possible to identify a hierarchy of activities necessary to meet those requirements. Using a top-down approach, this methodology results in the identification of three levels of work to be performed. The highest-level groupings of requirements are translated into major operational activities. Thus, major operational activities can be described as the highest level activities to be performed by the DP/C. Major operational activities are composed of tasks, which are in turn made up of subtasks. This hierarchical structure forms the basis for the data production component operations concept described below.

Four major operational activities have been identified for the data production component. They are:

- Digital quadrangle (quad) revision
- Digital quadrangle (quad) production
- Quadrangle (quad) production
- Intracomponent services

Figure 1 provides an overview of the data production component and the functions of these activities within it.

The following sections describe the four major operational activities.

Digital quadrangle (quad) revision

The digital (quad) revision major operational activity contains high-level activities associated with revision of DLG-E feature data from imagery source. This includes preparing the data for feature extraction activities, performing extraction, and revising or updating operational database holdings for use in product generation activities.

There are three tasks associated with the Digital Quad Revision activity:

- Extract from advanced monoscopic (mono) source
- Extract from advanced stereoscopic (stereo) source
- Extract from conventional monoscopic (mono) source

Extract from advanced mono source task: Provides the functionality to support revision of operational database feature data holdings using advanced softcopy image source and the Mark II monoscopic extraction workstation (MEWS).

Extract from advanced stereo source task: Provides the functionality to support interactive stereo digitization of feature data (including hypsography) from advanced hardcopy image source to support the revision of operational database feature data holdings. This task utilizes existing NMD workstations.

Extract from conventional mono source task: Provides functionality to support interactive digitization of feature data for the revision of operational database feature data holdings using hardcopy orthophoto or rectified image sources. This task utilized the Mark II precision digitizing workstation (PDWS).

Digital quadrangle (quad) production

The Digital Quad Production major operational activity contains tasks associated with the generation of DLG-E feature data from imagery, cartographic and digital data sources. This includes the update of existing DLG-S, DLG-O, and DLG-O* holdings to DLG-E standards, the generation of DLG-E feature data from imagery and cartographic sources, and the processing of non-NMD-produced data for entry in the ADB. Included in these tasks are subtasks that provide the functionality for preparing data for feature

extraction activities, performing extraction, and revising or updating operational database holdings for use in product generation activities.

There are five tasks associated with the digital quad production activity:

- Extract from advanced stereoscopic (stereo) source
- Process digitized data
- Digitize graphic source
- Extract from conventional monoscopic (mono) source
- Process other mapping organization data

Extract from advanced stereo source task: Provides the functionality to support interactive stereo digitization of feature data (including hypsography) from hardcopy image source for addition to operational database feature data holdings. This task utilizes existing NMD workstations.

Process digitized data task: Provides the functionality to input and process minimally attributed feature data, topologically integrate and structure it (if required), edit, and attribute it for addition to the operational database. This task processes output from the scan hardcopy task, and transaction files input to Mark II.

Digitize graphic source task: Provides the functionality to interactively digitize and edit feature data collected from cartographic sources, utilizing the Mark II precision digitizing workstation.

Extract from conventional mono source task: Provides the functionality to support interactive digitization of feature data for the revision of operational database feature data holdings using hardcopy orthophoto or rectified image sources. This task utilizes the Mark II precision digitizing workstations.

Process other mapping organization data task: Provides the functionality to support the input of digital features from a variety of other mapping organizations and contractor sources and process the data for subsequent use in other data production component activities or for direct entry into the operational database.

Quadrangle (quad) production

The quad production major operational activity contains high-level activities associated with the analog or manual collection of feature data and the generation of new or revised feature manuscripts. The three tasks associated with the quad production activity include:

- Collect analog data (mono)
- Collect analog data (stereo)
- Analog manuscript quality assurance.

Collect analog data (mono) task: Includes the manual extraction/revision of feature data from orthophoto source. This task is accomplished utilizing existing light tables and manual extraction techniques.

Collect analog data (stereo) task: Includes the manual extraction/revision of feature data from conventional stereo source. This task utilizes existing optomechanical stereo-plotters and analog extraction techniques.

Analog manuscript quality assurance task: Includes the functionality to inspect compiled manuscripts manually in order to certify that the manuscripts comply with the extraction and product specifications used to produce the product.

Intracomponent services

The intracomponent services major operational activity contains high-level functions that are performed as as inter-

nal service to the other activities within the component. Three tasks are associated with this activity:

- Scan hardcopy data
- Plot generation
- Quality assurance.

Scan hardcopy data task: Provides the functionality to scan symbolized hardcopy map separates or products and generate minimally attributed DLG-E data.

Plot generation task: Provides the functionality to create device-independent metafiles and generate check plots of unsymbolized feature data.

Quality assurance task: Contains the functionality to certify the feature data being output from the component.

Hardware

Based upon the requirements currently defined in the data production component specification, the following Mark II hardware configuration items (CIs) will be required:

- Cartographic workstations (CWS)
- Mono-extraction workstation (MEWS)
- Precision digitizing workstation (PDWS)
- Automated digitization and compression (ADAC)
- Object file processor (OFP)
- Clustered shared resource (CSR)
- Check plotter (CP).

Existing NMD equipment will be utilized within the data production component as well. These include:

- SCITEX raster scanning system
- Kern PG-2 stereoplotter
- Wild B-8 stereoplotter
- Intergraph standalone editing system
- Laser-scan digitizing system
- ALTEK digitizing system.

This list does not include all NMD assets to be utilized but includes those considered critical in development of the operations concept.

CONCLUSION

The modernization of the United States Geological Survey mapping system represents a major commitment of human and financial resources over the next six years. This commitment of resources will significantly accelerate the transition of the Geological Survey cartographic production operation from a graphic to an all digital production system. The Mark II development is also occurring at a time when significant advances are being made in the area of digital photogrammetry and cartography. These advances will enable the Geological Survey to meet the long-term Mark II goal of completing the population of NDCDB with all feature categories. Successful completion of this goal will permit the Geological Survey to meet national requirements for current digital cartographic data and map products more efficiently.

ORGANIZATIONAL ISSUES IN THE TRANSITION OF THE UNITED STATES GEOLOGICAL SURVEY'S NATIONAL MAPPING PROGRAM INTO THE NEXT DECADE*

Paper submitted by the United States of America

RÉSUMÉ

Depuis plus de 40 ans, la Division de cartographie nationale du Service géologique des Etats-Unis fournit aux utilisateurs des Etats-Unis des coupures de base au 1/63 360 pour l'Alaska et au 1/24 000 pour les 49 autres Etats. Fin 1988, il existait des coupures de base et des produits connexes pour 95% environ du pays. L'ensemble du pays devrait être couvert d'ici à 1990.

La Division a récemment entrepris de mettre au point un nouveau système qui permettra d'utiliser des techniques et des procédures de production perfectionnées, compte tenu des besoins du Programme de cartographie nationale d'ici à l'an 2000. A ce moment-là, la base de données cartographiques numériques nationales devrait contenir des données numériques correspondant à la série de cartes de base et d'autres séries à petite échelle. Elle sera utilisée principalement pour l'archivage et la distribution aux utilisateurs des données numériques aux fins d'analyse des systèmes informatiques et pour la production des produits graphiques courants du Service géologique.

Avec la publication des cartes au 1/24 000 pour l'ensemble du pays et la demande croissante de cartes révisées et de données cartographiques numériques, le Programme traditionnel de cartographie nationale est véritablement un programme de transition. Il s'ensuit qu'il devra appliquer des techniques nouvelles et créer le matériel et le logiciel que nécessite l'accomplissement de ses tâches : formuler et instituer des normes en vue de faciliter le transfert et l'utilisation des produits; satisfaire des demandes en évolution constante; renforcer et élargir des services de diffusion de l'information; améliorer les

* The original text of this paper, prepared by Lowell E. Starr, United States Geological Survey, appeared as document E/CONF 81/L 32

communications et la coordination avec les autres services ainsi que l'assistance fournie; offrir des possibilités de formation en vue de constituer un réservoir approprié de spécialistes et de techniciens.

RESUMEN

Durante más de 40 años, la División Nacional de Mapas de la Dirección de Levantamientos Geológicos de los Estados Unidos ha proporcionado a los usuarios de los Estados Unidos mapas primarios a una escala de 1:24.000 para 49 Estados y de 1:63.360 para Alaska. A fines de 1988 se disponía de mapas primarios y productos conexos para el 95% del país aproximadamente. Se prevé que los mapas iniciales de todo el país estén disponibles en 1990.

Recientemente, la División comenzó a elaborar un nuevo e importante sistema, mediante el cual se aplicarán tecnologías y procedimientos de producción avanzados para satisfacer las necesidades del Programa Nacional de Mapas hasta el año 2000. En el año 2000, la Base Nacional de Datos Cartográficos Digitales contendrá información digital que abarcará el contenido de la serie de mapas primarios y de otras series en pequeña escala. Esa base de datos cumplirá dos funciones importantes: servirá de archivo central para difundir datos digitales a la comunidad de usuarios con miras al análisis de los sistemas de información, y de base de datos para la elaboración de productos gráficos normalizados de la Dirección de Levantamientos Geológicos.

En momentos en que empieza a disponerse de los mapas iniciales completos de la nación a una escala 1:24.000 y aumenta la necesidad de revisar los mapas y de obtener datos cartográficos digitales, el Programa Nacional de Mapas utilizado hasta ahora verdaderamente adquiere un carácter transitorio. Ello da lugar a los problemas concomitantes de aplicar nuevas tecnologías y producir el equipo, los programas y la documentación de computadoras para cumplir las tareas programáticas de elaborar e instituir normas encaminadas a facilitar la transferencia y la utilización de los productos; satisfacer las necesidades de productos, que cambian constantemente; fortalecer y ampliar los servicios de difusión de la información; mejorar la comunicación y la coordinación con otros organismos, así como el apoyo que a ellos se presta, y brindar oportunidades de capacitación para establecer un plantel adecuado de personal profesional y técnico.

SUMMARY

For more than 40 years the National Mapping Division of the United States Geological Survey has provided map users in the United States with primary quadrangle map coverage at 1:24,000 scale in the lower 49 States and at 1:63,360 scale in Alaska. By the end of 1988, primary quadrangle maps and related map products were available for about 95 per cent of the country. Initial national coverage is scheduled to be available by 1990.

Recently, the Division has begun a major new system development effort that will implement advanced technologies and production procedures to satisfy National Mapping Program requirements through the year 2000. By 2000, the National Digital Cartographic Data Base should contain digital data representing the content of the primary map series and other smaller-scale series. This database will serve two major functions—as a central archive for the dissemination of digital data to the user community for information systems analysis, and as a working database for production of standard Geological Survey graphic products.

As initial coverage of the nation at 1:24,000 scale becomes available, and the need for map revision and digital cartographic data increases, the traditional National Mapping Program is truly a programme in transition. With this transition come the attendant issues of implementing new technologies and developing appropriate hardware and software to accomplish programmatic tasks; of developing and instituting standards to facilitate the transfer and utility of products; of accommodating constantly changing requirements for products; of strengthening and expanding information dissemination services; of improving communication and coordination with and support to other agencies; and of providing opportunities for training to develop an appropriate mix of professional and technical personnel.

The United States Geological Survey, through the National Mapping Division's National Mapping Program, provides a diversity of cartographic, geographic, and remotely sensed data, products, and information services for the United States and its territories and possessions. The products include several series of topographic maps in both graphic and digital forms, photo-image maps, land-use and land-cover maps and associated data, geographic names information, geodetic control data, and remotely sensed data.

By the end of 1988, primary quadrangle maps (1:24,000 scale in the lower 49 states and 1:63,360 scale in Alaska) and related map products were available for approximately 95 per cent of the country. Initial national coverage is scheduled to be available by the end of 1990. As we approach this milestone of attaining coverage of the nation at 1:24,000 scale, there is a dramatic increase in the need for map revision and digital cartographic data. Thus, the traditional National Mapping Program is truly in programmatic and technological transition. With this transition come the attendant organizational issues of:

(a) Implementing new technologies and developing appropriate hardware and software to accomplish programmatic tasks;

(b) Developing and instituting standards to facilitate the transfer and utility of products;

(c) Accommodating constantly changing requirements for products;

(d) Strengthening and expanding information dissemination services;

(e) Improving communication and coordination with and support to other agencies;

(f) Providing opportunities for training to develop an appropriate mix of professional and technical personnel.

IMPLEMENTING NEW TECHNOLOGIES

For about 100 years the Geological Survey has provided map users in the United States with topographic maps and related cartographic information in graphic form. In the mid-1970s the transition to digital production began as the Geological Survey began collecting digital data from the graphic source materials produced by the National Mapping Division. The Division has been involved continually in the development and implementation of new and improved systems and procedures to expand and enhance digital data production capabilities. In 1980, a comprehensive review was conducted of existing production systems and their capabilities for digital cartographical and geographic data production, and a series of production improvements were implemented. Major system modifications were not made, as the existing system was considered to be stable and maintainable over the short term, although it was judged to be inadequate to meet the projected long-term requirements for digital data. The opportunity to gain several years of experience, while allowing technology to advance and become more cost-effective, was judged to be the appropriate next step towards the ultimate goal of modernization necessary to build and maintain a national digital cartographic database.

In 1985, two studies were conducted to address long-range requirements and to continue the development of the Division's digital systems. One study addressed the programmatic issues of transforming an ongoing production programme from a traditional graphic operation to a digital environment, while coping with an increasing requirement for revision of the basic cartographic series of the country. The second

study addressed the technical aspects of this transition. Upon completion of the two studies, an integrated development/production plan was adopted to guide the Division through the remainder of the century.

Recently, the Division began a major new system development effort, termed Mark II, that will implement advanced technologies and production procedures to satisfy National Mapping Program requirements through the year 2000. Specific tasks are being implemented to (a) expand and improve mass digitization capabilities; (b) modify data structures to support increased content and access requirements; (c) develop digital revision capability; (d) develop product generation capability for standard, derivative, and digital products; (e) improve quality control; and (f) support advanced analysis applications. By the year 2000, the National Digital Cartographic Data Base (NDCDB) should contain digital data representing the content and accuracy of the primary map series and other smaller-scale series. This database will serve two major functions—as a central archive for the dissemination of digital data to the user community for use in information systems analysis, and as a working database for the production of standard Geological Survey graphic products.

The implementation of a comprehensive management strategy is critical to the overall success of Mark II. The management of Mark II includes the organization of the development effort and the establishment of a development cycle.

Management and development of the Mark II effort are being accomplished by making some changes in the current organizational structure of the Division. The research staff has been realigned to effect the overall coordination and management of the development effort. The Mark II effort is divided into components and modules, and component management is assigned to existing staff offices. Module responsibilities are assigned throughout the Division.

The activity has been divided into two phases: design and development. The design phase begins with the assignment of component and module tasks, and ends with the approval of the component and associated module designs. The development phase begins with the approval of the component design and ends with the implementation of the developed capacities into the production centres.

The primary review and approval authority for the designs is assigned to a National Mapping Division Configuration Control Board. This senior-level management board was established to review and certify the initial design of the system and to control the subsequent configuration of the hardware and software systems developed.

The development and implementation of new technologies into the Geological Survey mapping system represent a major commitment of both human and financial resources over the next six years. This commitment of resources will significantly accelerate the transition of the Survey's cartographic production operation from a graphic to an all-digital production system.

DEVELOPING AND INSTITUTING STANDARDS

The transition of the National Mapping Division into a digital database-centred programme of operation requires extensive development of both graphic and digital standards. Specific issues being addressed during this development include database design, digitizing procedures, data accuracy and content, symbology and product generation rules, graphic and digital revision, and data applications and transfer.

Basic design decisions must be made if a database, and the data stored therein, will meet the needs of the producing agency and the prospective user community. Data sources, level of content, accuracy, associated history of lineage information, and the resulting database issues of size, structure and indexing are being addressed within various elements of the Division. The basic source for digital data in the near term will continue to be the series of standard graphic products produced by the Division. Various types of photography and remotely sensed imagery will become more widely used as source materials for programme development.

Digitizing procedures are closely related to the desired data accuracy and the available or foreseen hardware and software systems. The intent of the Division is to be able to use digital cartographic data to support the production of the standard graphics product currently in the programme. A minimum data accuracy level is required to produce acceptable products. The Division is proceeding to define this accuracy, and related verification procedures, as well as initiate the procurement of production systems capable of achieving these standards.

The graphic products supported through the digital cartographic database will be prepared using highly automated techniques. The existing graphic symbol specifications are being modified to improve their utility in an automated environment. In addition, a major effort is being applied towards developing product generation rules that will define, for each series of products, feature inclusion and representation specifications. These rules will be used to develop the software needed to symbolize and plot the data in final form.

As the initial graphic coverage of the United States is completed and the digital cartographic database increases in size, becoming the primary source for future graphic production, the procedures and specifications for accomplishing graphic and digital revision are being modified. For the near term, graphics will be revised using traditional manual methods and then digitized. The existing files can then be revised on the basis of the new graphics. In the future, new sources of revision information, such as data from other sources like local governments, and the use of advanced digital cartographic systems will permit direct revision of a digital file prior to production of a revised graphic. These advanced methods will require procedures and specifications for data gathering and interpretation in addition to modified field classification and verification techniques. The categories of map revision may require clarification or redefinition based on the characteristics and capabilities of the evolving digital programme.

The issue of data application and transfer is being addressed through the Division's development of an enhanced data structure and format that will replace the current DLG-3 format. In addition, the Division is leading the development of a digital cartographic data standard, including a spatial data transfer specification, which is being proposed as a national standard.

ACCOMMODATING CHANGING REQUIREMENTS FOR PRODUCTS

Federal and state agencies annually report their cartographic requirements for maps in graphic form as well as for map-related data in digital form to the Geological Survey through the Office of Management and Budget, Circular A-16, process. This formal solicitation process allows agen-

cies to identify their requirements by type of product, geographical area of interest, and year of need.

The primary purpose of the A-16 process is to minimize duplication of effort and costly single-purpose mapping activities among Federal agencies. However, not every requirement of every agency can be met through this process. The A-16 solicitation in fiscal year 1988 yielded requests from 11 Federal agencies and 34 states for primary map revision, intermediate-scale mapping, and digital data production. Primary map revision and digital data production accounted for requests covering about 7,000 quadrangles and 5,000 quadrangles respectively. With the overlap of these graphic and digital requirements, about 9,000 quadrangles will need to be put into work. The highest priority requirements exceed present production capacities by about four to one.

Several major trends for Division products and services emerged from the analysis of the most recent A-16 solicitations. The need for digital data appears to be the most urgent specific requirement, particularly hypsography digital line graphs (DLG), more accurate digital elevation models (DEM), and land-use/land-cover data to support geographic information systems (GIS) applications. Other requested requirements include accelerating the primary map revision programme, production of high-resolution orthophotoquads in conventional and digital form, image maps, digital state bases, county maps, and revision of the existing 1:250,000 scale land-use/land-cover map series based on the now available 1:100,000-scale maps.

With the impending realization of initial primary map coverage of the nation, many state agencies are seeking cooperative agreements with the Division to acquire digital data. The impact of a large number of cooperative projects on other programme goals and objectives must be assessed. Major reimbursable programmes of national importance will also play an increasing role in the Division's planning and execution of the National Mapping Program. The challenge is to strike a balance among existing programmes and new cooperators and reimbursable programmes, making it possible to conduct major projects requiring large amounts of data in a relatively short time-frame, such as the production of digital terrain elevation data for the Defense Mapping Agency and the production of 1:100,000-scale DLGs for the Department of Energy. Mark II is being designed to accommodate the growing and increasingly complex user requirements. At the same time, new contract proposals and work-share and data-share arrangements will also need to be explored as a means of effecting this balance.

STRENGTHENING AND EXPANDING INFORMATION DISSEMINATION SERVICES

The Geological Survey disseminates much of the nation's earth science information through its Public Inquiries Offices (PIO) and National Cartographic Information Centers (NCIC). The information exists in many forms, from maps and books to computer-readable magnetic tapes. The PIOs serve as contact points for obtaining information regarding the results of geoscientific investigations, for providing research facilities for technical reference collections of both formal and informal reports, and for selling Survey publications. The NCICs serve as the public's primary source for information concerning the availability of cartographic, geographic, and remotely sensed data. These products consist of maps and charts, aerial photographs and space images, geodetic control data and cartographic data in digital form.

To address the ever-increasing number and diversity of inquiries from users as well as advances in information dissemination technology, the Geological Survey is in the process of combining the broader earth science capabilities of the PIOs with the cartographic and geographic expertise resident in the NCICs. These newly combined operations, called Earth Science Information Centers (ESIC), will provide the Survey with a more efficient, effective, and responsive method of supplying earth science data and information to the user community. This merger of operations will require some changes in operational management, administrative support, staffing and funding. When complete, the ESICs will be a unified network for disseminating a wider spectrum of earth science information and products.

In addition to restructuring information dissemination service operations, the Survey is exploring ways to offer its products using different media. Geoscience information is now being created on, or converted to, videodisks, magnetic tapes, and floppy disks. Databases containing hundreds of thousands of records of aerial photography project information, descriptions of maps and charts, and other cartographically related items are being made available in CD-ROM (compact disk-read only memory) form. In the future, various publications of the Survey may also be published in the CD-ROM format.

Digital maps, coupled with data from global positioning systems, are being developed for the dashboards of automobiles. The world of microcomputers is affecting all aspects of geoscience information handling. These technological advances are changing our thinking of how data will be collected, stored, analysed, marketed and distributed in the future. Major issues concerning costs, copyrights, and data reproduction for this electronic information will have to be addressed in the years ahead.

IMPROVING COMMUNICATION AND COORDINATION WITH OTHER AGENCIES

By a directive of the President's Office of Management and Budget, the Geological Survey has responsibility for coordinating certain Federal mapping activities. This coordination is effected through an annual solicitation letter to Federal and state agencies and is only one of several coordination mechanisms used by the National Mapping Division. Other mechanisms include coordinating committees, liaison activities, and cooperative agreements. Federal agency coordination is usually facilitated through inter-agency programme coordination committees, whereas coordination with state agencies is aided through state mapping advisory committees. The primary goal of Division coordination efforts is to identify mutually beneficial solutions to common problems and to improve organizational effectiveness through the application of information about the nature of the users and their requirements.

The Division has been successful in its coordination efforts. A number of agencies have entered into reimbursable or cooperative agreements with the Division and the shared costs and/or work have expedited mutually beneficial cartographic production. In fiscal year 1988, the Division entered into 78 reimbursable agreements with 37 Federal agencies and joint funding agreements in 33 states with 43 state agencies.

Many states are becoming more sophisticated users of geographic information system technology and are requesting more digital cartographic data. Concurrently, the tremendous growth in the use of geographic information systems in Federal agencies has dramatically increased the

need for digital data. This interest in digital products and the variety of National Mapping Program spatial data activities has resulted in increased user inquiries regarding Division data, services and cooperative activities. These increasing interests heighten the need for communicating with users of cartographic and geographical data about the use of existing products, the evaluation of new products, the identification of future needs, and the development of plans for specialized technical assistance. The Division has traditionally focused its coordination efforts at the Federal and state level, but as Survey products and services are being used more by local agencies, it is now important to broaden coordination efforts and initiate improved communication with county-level agencies.

A reorganization is under way to ensure that coordination receives a greater focus and higher level of support. To ensure that the transition to a new coordination and requirements process is built on a recognition and understanding of past successes and failures, a task team has been formed to gather information and prepare a report of its findings. The task team's report will be available in early February.

PROVIDING OPPORTUNITIES FOR TRAINING

Rapid growth of GIS technology and digital cartography has had a direct impact on the organizations that implement them. The use of advanced technology requires that personnel have new skills and advanced training. Accordingly, the Division has begun to assess its future needs by forming two working groups to address requirements for training and staffing. The staffing working group is identifying the types and quantities of people required. The training working group is identifying the kinds of training needed, and will be developing an overall training plan to provide an effective transition for employees from their current primarily graphic production environment to a primarily digital data production environment.

The capabilities, operation and physical requirements of the new advanced cartographic systems and associated programme requirements will have a significant impact on the number and kind of persons necessary to perform assigned duties. Issues being addressed include shift-work demands, daily workloads, automation of equipment to perform duties independent of human intervention, and skill and knowledge necessary to manage, operate and maintain the equipment.

Training will be required for all personnel involved in the operation of advanced cartographic systems equipment, including system operators, management staff and support personnel. The overall training plan currently proposes five categories of required training: preparatory, prerequisite, component specific, system level and full production. Each of these categories represents a different level of complexity and will require different approaches for acquiring this training.

The major impact of training will occur on those employees directly responsible for digital data production. The need still remains, however, to provide training for those employees targeted to assume increased responsibilities in technical research activities and/or in the management of Division operations and programmes. For the foreseeable future, this type of training will continue to be pursued through long-term graduate school opportunities and participation in the Manager Development Training Program of the Department of the Interior.

CONCLUSIONS

The National Mapping Program is undergoing a major technological and programmatic transition that is both exciting and challenging. Central to this transition is the development of the National Digital Cartographic Data Base, which will become the focus of most mapping activities, including maintenance and revision of the primary map series. The

transition involves dealing with organizational issues that will tax the Division's resources to the maximum, yet, at the same time, should provide a most rewarding professional experience. Successful resolution to these issues will enable the United States Geological Survey to accomplish its mission to support Federal, state, and local government and private user requirements for both graphic and digital cartographic data products through the next decade.

(d) *Management and standardization of geographical names*

JOINT PROGRAMME OF THE DEFENSE MAPPING AGENCY INTER-AMERICAN GEODETIC SURVEY AND THE PAN AMERICAN INSTITUTE FOR GEOGRAPHY AND HISTORY ON GAZETTEERS AND GEOGRAPHICAL NAMES*

Paper submitted by the United States of America

RÉSUMÉ

Les pays d'Amérique latine ont de riches patrimoines culturels qui ont fourni une abondance de noms à leur géographie. Les noms de lieux utilisés dans les langues écrites et parlées de ces pays représentent un système primaire de référence géographique. A mesure que ces pays se sont développés et que leurs sociétés sont devenues plus techniquement complexes, l'importance qu'il y avait à normaliser les formes écrites de ces noms est devenue évidente.

Le Service géodésique interaméricain de la Defense Mapping Agency et l'Institut panaméricain de géographie et d'histoire sont conscients du fait que la normalisation des noms géographiques est particulièrement importante pour la production de cartes terrestres et marines, pour les levés terrestres, aériens, hydrologiques et minéraux, pour les besoins des services de transports postaux et maritimes, pour la sécurité des transports par voie de terre et par voie d'eau et pour les études démographiques et autres.

Bien que le Groupe d'experts des Nations Unies sur les noms géographiques ait établi des principes utiles concernant la normalisation des noms, le Service géodésique interaméricain et l'Institut panaméricain ont pris une autre mesure importante pour aider les pays d'Amérique latine à établir des programmes nationaux sur les noms géographiques. En octobre 1987, des représentants de plusieurs pays membres de l'Institut ont assisté au premier stage sur les noms géographiques offert par le service géodésique dans son Ecole de cartographie à Panama. Ce stage, qui durait deux semaines, couvrait toute une gamme de sujets, y compris des exercices pratiques de collecte de noms sur le terrain et des procédures en bureau.

RESUMEN

Los países de América Latina poseen un rico acervo cultural que ha contribuido con una abundancia de nombres a su geografía. Los nombres geográficos utilizados en los idiomas hablados y escritos de estos países constituyen un sistema primordial de referencia geográfica. A medida que nuestros países adquieren un mayor desarrollo y sus sociedades se tornan tecnológicamente más complejas, queda en evidencia la importancia de uniformar las formas escritas de estos nombres.

El Servicio Geodésico Interamericano del Organismo Cartográfico de la Defensa y el Instituto Panamericano de Geografía e Historia se percatan de que la normalización de los nombres geográficos reviste especial importancia para la confección de mapas y cartas; para las prospecciones terrestres, aéreas, hídricas y minerales; para las necesidades del correo y la navegación; para la seguridad del transporte terrestre y acuático y para los estudios demográficos y de otra índole.

Aunque el Grupo de Expertos de las Naciones Unidas en Nombres Geográficos ha promulgado útiles principios relativos a la normalización de nombres, el Servicio Geodésico y el Instituto Panamericano han dado un importante paso en lo que se refiere a ayudar a los países latinoamericanos a instaurar programas sobre nombres geográficos. En

* The original text of this paper, prepared by Richard R. Randall, Defense Mapping Agency, appeared as document E/CONF 81/L 22

octubre de 1987, representantes de varios países miembros del Instituto asistieron al primer curso sobre nombres geográficos impartido por el Servicio Geodésico en su Escuela Cartográfica en Panamá. El curso, de dos semanas, abarcó una amplia variedad de temas, entre ellos ejercicios prácticos sobre la reunión de nombres sobre el terreno y procedimientos de oficina.

SUMMARY

Latin American countries have rich cultural heritages that have contributed a wealth of names to their geography. The geographical names used in the spoken and written languages of these countries represent a primary system of geographic reference. As countries become more developed, and their societies grow more technologically complex, the importance of standardizing the written forms of these names becomes evident.

The Inter-American Geodetic Survey of the Defense Mapping Agency and the Pan American Institute for Geography and History (PAIGH) are aware that the standardization of geographical names is particularly important for map and chart production; for land, air, water, and mineral surveys; for postal and shipping requirements; for land and water transportation safety; and for demographic and other studies.

Although useful principles concerning names standardization have been promulgated by the United Nations Group of Experts on Geographical Names, the Inter-American Geodetic Survey and PAIGH have taken an important step towards helping the Latin American countries establish national programmes on geographical names. In October 1987, representatives from several PAIGH member countries attended the first course on geographic names offered by the Inter-American Geodetic Survey at its Cartographic School in Panama. The two-week course covered a full range of subjects, including practical exercises in field collection of names and in-office procedures.

Geographical names play an important role in programmes related to the geography—and to the well-being—of the Americas. Although nations in the Americas have long understood the importance of their rich cultural heritage, in too many cases little attention has been paid to how geographical names provide evidence of that heritage. Now this aspect is being documented. Furthermore, in the past two decades nations have recognized that the study and dissemination of information on geographical names meet other important functions. As societies grow technologically more complex, it is accepted that names are essential to a broad variety of national needs. Mapping and charting, mineral exploration and extraction, rail and road construction, postal services, communication, and tourism depend heavily on accurate names information. The role of geographical names—sometimes called toponymy—is now well appreciated and it is beneficial to understand how this important field has been promoted.

THE UNITED NATIONS AND GEOGRAPHICAL NAMES

Since 1967, the United Nations has held five conferences on the standardization of geographical names and 13 sessions of a Group of Experts on that subject. In addition, representatives of regional divisions of the Group of Experts have met to discuss local problems. These activities have led to the creation of a large library of documents on principles, policies and procedures on the standardization of names. By applying these guidelines, a number of countries have formed national names authorities, and exchanges of experiences and publications between countries are now common.

Despite these successes, not all countries have benefited as fully as desired. One reason is that the costs of attending the conferences and sessions have prevented full participation. In addition, some countries have special requirements

for dealing with names that may not have been adequately addressed. There is also a view that other organizations should be asked to contribute to the goals of national and international standardization. For example, United Nations programmes on standardizing undersea feature names are now largely entrusted to the International Hydrographic Organization. The International Astronomical Union, similarly, has assumed responsibility for standardizing names of planetary features.

PAIGH WORKING GROUP ON GAZETTEERS AND GEOGRAPHIC NAMES

For many years the Pan American Institute of Geography and History (PAIGH) was involved with names only to a limited extent, as it had been agreed that United Nations programmes should address basic hemispheric names in this field. The development, in 1980, of a PAIGH programme for a series of national topographic maps at 1:250,000 based on common specifications, however, prompted the thought of preparing national gazetteers of names found on the maps. Members of the former PAIGH Committee on Geographical Terminology met to create a programme and the 12th General Assembly of PAIGH, meeting in Chile in 1980, created the Working Group on Gazetteers and Geographic Names. In 1986, the 13th General Assembly of PAIGH formally recognized this expanded role and in this way PAIGH became another organization that could properly implement United Nations programmes. This role was furthermore endorsed by a resolution of the Fifth United Nations Conference on the Standardization of Geographical Names in 1987.

INTER-AMERICAN GEODETIC SURVEY

Founded in 1946 as a vehicle to permit countries of the Americas to share their experiences and capabilities in geo-

detic surveying and cartographic production, the Inter-American Geodetic Survey (IAGS) has made many impressive contributions to hemispheric progress. When the goals of the new PAIGH Working Group were defined, IAGS recognized the value of the programme and assigned an individual to assist. He and the president of the Working Group travelled to Latin American countries to discuss the expanded programme with personnel in national mapping institutes. The assistant followed up by additional travel and by communication with interested parties and often providing answers to their questions. Much national interest was generated by these activities and, in 1986, PAIGH allocated money to support the work of the Working Group for the next four years. To assure coordination with the Latin American Division of the United Nations Group of Experts, the Working Group was requested to name a liaison for the purpose, and the director of the Instituto Cartográfico Nacional of Venezuela accepted that post.

IAGS-PAIGH COURSE ON GEOGRAPHICAL NAMES

Members of the Working Group decided that the first order of business was to hold a course on basic techniques of standardizing geographical names. The course would be open to PAIGH member States that desired to increase their knowledge and skills in toponymy. The experience of IAGS in cartographic education was seen as an advantage, and officials of that agency agreed to support the course. In this way, IAGS became a collaborating partner with PAIGH. With a syllabus designed by the president of the Working Group, and with funds for travel and daily expenses provided by PAIGH for students and by IAGS for instruction, the course was held at the IAGS Cartographic School in Panama from 5 to 16 October 1987. Attending the course were 18 students from Bolivia, Costa Rica, El Salvador, Ecuador, Honduras, Guatemala, Mexico, Panama and Venezuela. Instructors came from Canada, Guatemala, Mexico and the United States.

The course began with basic principles and progressively covered more complex topics. Students learned the special vocabulary of toponymy. Procedures for producing gazetteers according to PAIGH specifications were covered

and the different kinds of gazetteers published by some PAIGH countries were discussed. Problems of dealing with features having two or more names were addressed; functions of a national names authority and its technical support staff were covered; and exercises were held in making decisions on various kinds of names.

An outstanding feature of the course was sessions held on the collection of names in the field. These were organized and conducted by a participant who has had extensive experience in geographical names as the long-time president of the Commission de Toponymie du Québec. Using maps provided by the Instituto Cartográfico Nacional "Tommy Guardia" of Panama, the class travelled to a rural region north of Panama City to carry out its work. Students interviewed local residents about names and endeavoured to obtain spoken evidence about names. Discussions with residents about names of mountains, valleys, rivers, and villages and towns in their own neighbourhoods illustrated many interesting factors. These and other observations were reviewed in the classroom and students learned practical procedures for dealing with such problems.

CONCLUSIONS

All agreed that the course was a significant success, and the students requested that the course be repeated annually. A post-class exercise was for students to write to the Working Group president to say how they had applied their new knowledge in their own agencies. Another assignment was to develop a list of generic terms with appropriate abbreviations and definitions as a PAIGH standard. Those responsible for developing the course take great satisfaction in knowing that the primary goal, that of offering instruction of the most practical kind, was well achieved. Plans are now under way to offer a similar course during 1989.

While geographical names meet a wide variety of requirements, the field of cartography perhaps is the major user. The location of the Working Group in the PAIGH Cartography Commission further illustrates this relationship. The connection between maps and names is further demonstrated by the fact that most persons interested in the Working Group represented national cartographic agencies.

GEOGRAPHIC NAMES INFORMATION SYSTEM: A TOPONYMIC RESEARCH TOOL*

Paper submitted by the United States of America

RÉSUMÉ

Le Système d'information sur les noms géographiques est un système automatisé et polyvalent mis au point par le Service géologique des Etats-Unis et approuvé par le Conseil des noms géographiques des Etats-Unis. Il vise à répondre aux besoins nationaux en fournissant des services à toute une gamme d'utilisateurs à tous les niveaux des secteurs public et privé. Ce système sert de dépositaire national pour les noms géographiques aux Etats-Unis et représente un outil pour les recherches et les applications toponymiques. Il sert également à produire toute une variété de produits, y compris des index géographiques, des microfiches, des supports magnétiques et des listes spécialisées pour certaines applications.

* The original text of this paper, prepared by Roger L. Payne, United States Geological Survey, appeared as document E/CONF 81/L.30.

RESUMEN

El sistema de información de nombres geográficos es un sistema automático y polivalente elaborado por la Dirección de Levantamientos Geológicos y aprobado por la Comisión de Nombres Geográficos de los Estados Unidos. Su objeto es satisfacer las necesidades en el plano nacional proporcionando servicios a una amplia variedad de usuarios en todos los niveles del Gobierno y del sector privado. El sistema sirve de archivo nacional de nombres geográficos de los Estados Unidos y constituye un instrumento para la investigación toponímica y su aplicación. El sistema también se usa para generar una amplia variedad de productos, entre ellos diccionarios geográficos, microfichas, modelos magnéticos y listas especializadas destinadas a fines concretos.

SUMMARY

The Geographic Names Information System is a multi-purpose, automated names system developed by the United States Geological Survey and approved by the Board on Geographic Names. It is designed to meet national needs by providing services to a wide range of users at all levels of government and the private sector. The system serves as the national geographical names depository of the United States and is a tool for toponymic research and application. The system also is used to generate a wide variety of products, including gazetteers, microfiche, magnetic media, and specialized listings for specific applications.

The Geographic Names Information System (GNIS) is an automated names system aimed at the collection and publication of geographical names. It is a multi-purpose system developed by the United States Geological Survey and approved by the United States Board on Geographic Names, and it provides services at all levels of government and the private sector. The system has been designed to serve as the national names depository of the United States of America, to assist the National Mapping Program of the United States Geological Survey and to provide a basis for toponymic research.

The computer-based system meets a broad spectrum of information and program needs, including cartographic support, standard reference, geographical base for specialized files, special publications, digital products and application, toponymic and other research and national standardization.

The use of electronic data processing for capture and storage of large quantities of names data and sophisticated data retrieval and processing is a powerful tool. The primary thrust of this paper is to describe the data and some of their uses rather than the various software packages that drive the database.

The first task in developing a geographical names depository was to determine the most efficient means of gathering and digitally encoding the estimated 4 million to 5 million geographical names in the United States. The scale of the task required long-range planning. Encoding names from the large-scale topographic maps of the Geological Survey was determined to be the most efficient means of establishing a National Geographic Names Data Base, because these maps provide a clear and concise means of identifying features and their associated information. From 1976 through 1981, most of the names found on the approximately 55,000 topographic maps of the United States were identified, encoded and added to the database. Some categories of names were excluded because more complete sources were available in digital form from other Federal agencies. Completed in 1981, this initial compilation effort is referred to as Phase I and includes most of the names on the large-scale topographic map published by the Geological Survey.

The second phase of compilation, termed Phase II, was begun in late 1981. Only about 50 per cent of the known names are shown on Geological Survey topographic maps; therefore, additional sources were to be checked during this second phase of data gathering. The original purpose of Phase II was to identify names that were not shown on Geological Survey topographic maps, but were published on other Federal maps and were used in documents. Even after an examination of these materials, it was known that the database was still incomplete with respect to other known published names. In order to meet the demands of the user community and to satisfy the requirements of public law 242-80 (U.S. Congress, 1947), the Phase II requirements were changed to include additional research materials. These additional materials included maps and documents of other Federal agencies and of the various states of the United States as well as non-governmental sources and maps and texts that described names. Additionally, because of requests from the user community, historical documents were also included as source material. When the second phase of compilation is complete, most published categories of named features will be included in the database except roads and highways.

NATURE OF THE DATA

The nature and collection procedures of the database have evolved and expanded during the past five years to accommodate the growing applications and needs of GNIS users. Originally, categories of information associated with names were mainly locative in nature and were coded in some cases for eventual interchange among the digital-data user community. To this end, the first phase of compilation included the following categories of data:

- (a) *Entity name*: the single name reference of a particular feature;
- (b) *Type of feature*: general categorization of features with similar attributes primarily for purposes of database search and retrieval;

(c) *First-order civil subdivision*: the countries or country equivalents in which the feature is located, represented as a five-digit code for digital data interchange;

(d) *Geographical coordinates*: the location of the feature by degrees, minutes, and seconds of latitude and longitude;

(e) *Topographic map*: the topographic maps on which the feature is shown, represented as a four-digit code for inventory and digital data exchange;

(f) *Elevation*: elevations published on the maps for named features

Evolution of the database over the past five years centred on enhancing existing categories of data for publication purposes and on the addition of certain categories of information based on specific user requests and application requirements. Categories enhanced for publication and increased user-friendliness include:

(a) *First-order civil division*: the name of each civil division to supplement the five-digit code;

(b) *Topographic map*: the names of the topographic maps on which each feature is located to supplement the map code.

The categories added because of user application requirements include:

(a) *Variant names*: any name other than the officially accepted name (spelling or form) by which a feature was known in the past or may be currently known, recorded and cross-referenced to the primary or official name;

(b) *Public land survey system reference*: the rectangular grid reference of the public land survey system in the United States, where applicable;

(c) *Federal status*: names considered official by the Board on Geographic Names, official by an administrative organization or unofficial because they are not within the purview of the Board;

(d) *Size*: the size of the feature (length, breadth, area);

(e) *Name origin and etymology*: the history of the feature and its name origin (if time permits during data compilation);

(f) *Administrative responsibility*: when applicable, the organization that has administrative responsibility for the feature and its name;

(g) *Population*: population data for incorporated places;

(h) *Zip code*: the Zoning Improvement Plan (ZIP) postal code associated with populated places to facilitate data interchange and for integrating names data with other databases;

(i) *Bibliographic code*: a code that identifies the published source in which the name was found.

Undoubtedly, user application requirements will demand additional data categories in the future. The software that manages the database easily accommodates natural evolution and expansion of data requirements, and any software enhancements or replacement will retain this vital characteristic.

MAINTENANCE

The system is maintained by the National Mapping Division of the Geological Survey. As part of the maintenance programme, each regional mapping centre compiles and formats new names data, which are electronically submitted to the GNIS staff for a final check for any problems before entry into the system. A series of checks and balances assures the integrity of the database so that all users can

retrieve and use the information with confidence. Security of the system is paramount; therefore, a series of codes and passwords is necessary to change, add or delete information. While all users are able to retrieve information, only GNIS staff may alter information in the system.

The maintenance schedule is on a continual basis, and is being expanded to include other Federal agencies so that names from a variety of sources will become part of the database. The same checks and balances will be applied to ensure data integrity. The expanded maintenance programme will ensure that most controversial names will be researched and resolved accordingly.

USE IN TOPONYMIC RESEARCH

The automated names system may be applied to toponymic research in two general ways. The information may be used in digital form to enhance other databases requiring names as a reference point. The system's software also provides a convenient means of retrieving, arranging and analysing information for specialized needs

Standard products

The primary standard reference product is the *National Gazetteer of the United States of America*, which is being published with each state, territory, and outlying area as separate volumes. The official gazetteer is published after the second phase of compilation, and includes variant or secondary names cross-referenced to the official names, as well as names from most known sources. Since all state files have not yet been completed through the second phase of compilation, preliminary gazetteers are available for these states as a reference source. These preliminary gazetteers are not as complete because they contain only those names found on topographic maps and do not indicate variants or secondary-name cross-references. The same information found in the official and preliminary gazetteers may also be obtained in the form of microfiche and on magnetic tape.

Special applications and analysis

Part of the overall power of GNIS is its flexibility. One can retrieve, manipulate, arrange and analyse information according to specific requests and needs. Because the system's software is based upon categories of information about a name, the associated possibilities for comparison and analysis purposes are virtually limitless.

The interactive version of the retrieval software allows the toponymist a friendly environment in which to pose questions about geographical names, to retrieve the desired results, to arrange the retrieved information, and to direct the information to any conventional (bound listings) or magnetic media, including standard tapes and soft diskettes for use with personal computers. The information may also be displayed as a thematic map.

Examples of specific applications

The system is designed for a diverse user community and, as such, is truly application-oriented. GNIS information has been utilized by a broad cross-section of society in all levels of government, business, education and the private sector. For example, the information in this database is used for local transportation planning, regional planning, product marketing, site selection and analysis, emergency preparedness, genealogical research, and problem solving requiring the use and analysis of geographical names. Other areas of specific application include the use of graphic names overlays in fieldwork for the National Mapping Program of the United States.

Regional planners utilize the specific locative information to supplement graphical displays, while genealogists generally utilize the historical and descriptive categories of names information. Emergency preparedness experts utilize names information for graphically displaying categories such as hospitals, schools and churches that may be used in a community during an emergency, and these may be displayed within incremental distances of some defined point. Emergency vehicle-dispatching services incorporate locative information for critical nodes in local transportation networks.

An increasingly important use of names information is in geographic information systems, where spatial data may be graphically displayed by the digital layering technique and interactively altered to fit a specific application. For example, it may be useful to display all of the schools and shopping centres in an area of a contaminated water supply.

GNIS as a research tool is as useful in scholarly research as it is in practical application. Scholars and other names researchers now have the ability to process and analyse large quantities of names information and to obtain results never before possible. The possibilities are tremendous and are limited only by availability of data and the researchers' imagination.

One area of special interest has been classification of the generic part of the name or type of feature. GNIS contains catalogued information for more than 1,600 types of features

including the location and nature of use for uncommon features. Early settlement patterns and cultural development of the United States may be seen in thematic maps of generics. The system is also being used extensively for research towards developing a standard method of classifying the specific part of the name as well. This information, once put into the system, will allow research to retrieve and map the occurrences of Indian names in New England. The particular possibilities are virtually limitless if the information can be properly identified and encoded.

CONCLUSIONS

The Geographic Names Information System was developed as a single, unbiased source of geographical names in the United States. It was designed to provide a standard gazetteer-type reference as well as specific information for specialized applications.

The automated names system is designed for ease of use, yet it is powerful enough to house and manipulate millions of names. Its limitations are only in available source materials, time and funds for data entry, and the imagination of the researcher. There are broad ranges of both practical and scholarly areas of known and defined research, but since the unbiased system is application-oriented, the uses are defined only by the existing problems.

(e) *Education, training and research*

TRAINING COURSE IN TOPONYMY*

Paper submitted by Canada

RESUMEN

Del 7 al 19 de agosto de 1988 tuvo lugar en Quebec (Canadá) un curso de capacitación en toponimia para los representantes de 12 países de África y el Caribe donde el francés se utiliza en la administración pública y un país de América del Sur: Benín, Bolivia, Côte d'Ivoire, Gabón, Haití, Madagascar, Malí, Marruecos, Níger, Senegal, Togo, Túnez y Zaire. También participó un representante de Arabia Saudita.

El curso fue patrocinado por las Naciones Unidas y organizado por la Comisión de Toponimia de Quebec, con la participación del Comité Permanente Canadiense de Nombres Geográficos (CPCGN), que en esa ocasión actuó de anfitrión.

SUMMARY

A training course in toponymy was held in Quebec, Canada, from 7 to 19 August 1988, for representatives of 13 African, Caribbean and South American countries where French is used in government administration: Benin, Côte d'Ivoire, Gabon, Haiti, Madagascar, Mali, Morocco, Niger, Senegal, Togo, Tunisia, Zaire and Bolivia. A participant from Saudi Arabia also took part in this course.

Sponsored by the United Nations, the training course was organized by the Commission de toponymie du Québec, with the participation of the Canadian Permanent Committee on Geographical Names (CPCGN) which, on this occasion, represented the host country.

* The original text of this paper, prepared by the Commission de toponymie du Québec, appeared as document E/CONF.81/L.15. The French text appears on p. 107.

The need to organize training courses in toponymy has often been expressed at the United Nations regional cartographic conferences, at the United Nations conferences on the standardization of geographical names and at various meetings of the United Nations Group of Experts on Geographical Names.

The government of Indonesia hosted the first pilot training course, which was held at Cisarua, from 7 to 18 June 1982. That course was followed by another in November 1985 in Rabat, Morocco, which brought together some 30 representatives of Arabic-speaking nations.

OBJECTIVES OF THE TRAINING COURSE

The immediate objective of the course held in Québec was to ensure that senior officers and highly qualified technicians from national cartography and toponymy establishments received the most up-to-date information on methods and techniques used for on-site collection of place-names, the processing and conservation of data, the solutions to various problems encountered in toponymy and the terminology used in this field.

In the longer term, the course was to provide an opportunity for the participating countries to obtain the technical aid they required in order to establish or strengthen permanent national organizations responsible for place-names.

COURSE PROGRAMME

To meet the objectives of the course, an intensive programme of theoretical courses and practical activities was established. Centred on the preparation, completion and processing of surveys of geographical names in the field, the programme was also to deal with various aspects of toponymic standardization as a whole, and of the structures required to accomplish this task.

The participants were given the opportunity to carry out a field survey of the Charlevoix region, accompanied by staff members of the Commission de toponymie, who contributed to both the practical and technical aspects of the training course, and who brought their experience to bear on certain more theoretical aspects of standardization.

Several guest speakers from outside the Commission de toponymie (faculty from Laval and Ottawa universities, research, legal experts, representatives of the CPCGN secretariat and of Federal, provincial and municipal agencies) presented papers at the session and thus provided participants with a wide range of toponymy-based subject matter.

The core of the course, which dealt essentially with the cataloguing of geographical names within the context of standardization, was supplemented by the following thematic papers:

- Standardization as practised by international, national and local authorities
- Toponymic and terminology activities at the Federal level in Canada
- Examination of standards for selecting and writing place-names, and for geographical terminology
- The language of toponymy
- Problems of linguistics
- Relationships between geography, cartography, history and toponymy
- Stages in managing toponymic information, from data collection to dissemination
- Designation of places without names
- "Alternate" geographical names

Regional names

Problems involved in naming streets and roads

Advantages of having a competent authoritative body responsible for geographical names in each country

Structure and operation of an authoritative body responsible for geographical names

Jurisdiction as regards geographical names

INVOLVEMENT OF PARTICIPANTS

Throughout the training course, the participants were invited to describe their own experience in managing projects in toponymy. This gave rise to numerous discussions, even to the presentation of papers by the representatives of Benin, Madagascar, Niger, Tunisia and Zaïre.

Additional activities

As a supplement to the courses, several activities were added to the programme. The first objective was to make the participants aware of the diversity of place-names in Quebec, and the second to establish contacts likely to lead to cooperative projects between Canada, Quebec and interested countries.

The participants were invited by the Canadian Parks Service to the unveiling of a place-name interpretation plaque set up on Dufferin Terrace, in Vieux-Québec. This plaque had resulted from close cooperation between the Canadian Parks Service and the Commission de toponymie. The Canadian Parks Service took this opportunity to organize a visit to Artillery Park, a national historic park.

During a toponymic excursion between Quebec and Montreal, the students became familiar with place names along the St. Lawrence River and the Richelieu River. This excursion proved to be an interesting follow-up to the survey they had previously carried out in the Charlevoix region.

Through a visit to the Commission de toponymie and a meeting with its staff, the participants also had the opportunity to go deeper into certain themes introduced by earlier speakers, namely, computerized data processing.

It should be pointed out that the training programme also included technical demonstrations of computerized data processing on the National Toponymic Data Base (NTDB), the Quebec provincial database (TOPOS) and the Banque de terminologies du Québec.

During the same visit, Commission staff members gave the participants a full and detailed picture of basic operations in managing toponymic data.

TEACHING MATERIALS USED AND DOCUMENTATION DISTRIBUTED

Students were shown the video "Méthodologie des inventaires toponymiques" as a tool for learning the techniques for preparing, completing and processing of on-site surveys. This teaching aid was especially appreciated by the participants, and all asked for a copy. A printed version with the same title was also distributed to them.

The field trip in the Charlevoix region was preceded by a short film entitled "Je me souviens de Charlevoix". Its content, primarily toponymic, situates the region clearly in this context.

The Commission gave each participant about 15 of its official publications. Other published materials were distributed by the CPCGN secretariat on behalf of Federal, provincial and territorial Committee members. As the session

progressed, numerous support documents likely to be of use in standardizing place-names were also handed out.

EVALUATION

A period was reserved at the end of the programme to allow participants to evaluate the training course they had just attended. The analysis of the evaluation questionnaire showed the great satisfaction of the students in regard to the objectives pursued and reached by the course, the relevance of the subjects dealt with, and the technical and material organization.

Two activities of the programme were especially appreciated. These were the place-name survey in the field, and the demonstrations of the use of computers in processing place-names. The great satisfaction of the students from the various countries invited was confirmed by service units with which several of the participants were in contact after the session.

At the end of the course, the Commission de toponymie presented each participant with a certificate of participation attesting to the completion of the training course held under the auspices of the United Nations and the sponsorship of the Government of Canada.

RÉSUMÉ

Du 7 au 19 août 1988 se déroulait à Québec (Canada) un stage de formation en gestion toponymique pour des représentants de 13 pays d'Afrique, des Antilles et d'Amérique du Sud où la langue française demeure d'usage dans l'administration gouvernementale : Bénin, Côte d'Ivoire, Gabon, Haïti, Madagascar, Mali, Maroc, Niger, Sénégal, Togo, Tunisie, Zaïre et Bolivie. Un représentant de l'Arabie saoudite a également participé à ce stage.

Placé sous le patronage des Nations Unies, ce stage a été organisé par la Commission de toponymie du Québec avec la participation du Comité permanent canadien des noms géographiques (CPCNG) qui, en l'occurrence, représentait le pays hôte.

Le besoin d'organiser des stages de formation en matière de toponymie a été exprimé à plusieurs reprises à l'occasion des conférences cartographiques régionales des Nations Unies, des conférences des Nations Unies sur la normalisation des noms géographiques et lors des diverses réunions du Groupe d'experts des Nations Unies pour les noms géographiques.

Le Gouvernement de l'Indonésie fut l'hôte du premier stage pilote tenu à Cisaure, du 7 au 18 juin 1982. Ce stage a été suivi par celui de Rabat (Maroc) en novembre 1985, où se retrouvèrent environ 30 représentants de pays de langue arabe.

OBJECTIFS DU STAGE DE FORMATION À QUÉBEC

L'objectif immédiat du stage tenu à Québec était d'assurer auprès des cadres supérieurs et des techniciens hautement qualifiés venant des établissements nationaux de cartographie ou de toponymie la diffusion de l'information la plus à jour sur les méthodes et les techniques utilisées dans la collecte des noms de lieux sur le terrain, le traitement et la conservation des données, la solution des différents problèmes rencontrés en gestion toponymique et la terminologie employée dans ce domaine.

A plus long terme, le stage devait fournir aux pays participants l'occasion d'obtenir l'assistance technique leur permettant d'établir ou de renforcer une organisation nationale permanente responsable des noms de lieux.

PROGRAMME DU STAGE

Afin d'atteindre les objectifs du stage, un programme intensif de cours théoriques et d'activités pratiques a été établi. Centré sur la préparation, la réalisation et le traitement d'inventaires toponymiques sur le terrain, le programme devait aussi aborder les différents aspects rattachés à l'ensemble du domaine de la normalisation des noms de

lieux et des structures nécessaires à l'accomplissement d'une telle tâche.

Les stagiaires ont ainsi pu effectuer une enquête de terrain dans la région québécoise de Charlevoix, accompagnés par des membres du personnel de la Commission de toponymie qui ont apporté leur expérience aux aspects pratiques et techniques de la formation et à certains éléments plus théoriques du domaine de la normalisation.

Plusieurs conférenciers extérieurs de la Commission (professeurs des Universités Laval et d'Ottawa, chercheurs, juristes, représentants du secrétariat du CPCNG et d'autres organismes fédéraux, municipaux et provinciaux) ont présenté des communications lors du stage et ont ainsi offert aux stagiaires un large éventail de sujets ayant trait à la toponymie.

Au corps central du stage qui portait donc sur l'inventaire toponymique dans le contexte de la normalisation sont venus se greffer les exposés thématiques suivants :

- La normalisation pratiquée par les autorités internationales, nationales et locales;
- Les activités toponymiques et terminologiques du niveau fédéral canadien;
- L'examen des normes relatives au choix et à l'écriture des toponymes, de même qu'à la terminologie géographique;
- Le langage de la toponymie;
- La problématique linguistique;
- Les relations entre la géographie, la cartographie, l'histoire et la toponymie;
- Les étapes de la gestion toponymique allant de la collecte des noms à leur diffusion;
- La dénomination des lieux dépourvus de noms;
- La question des toponymes parallèles;

- Les avantages de l'existence dans chaque Etat d'une autorité toponymique compétente;
- La structure et le fonctionnement d'une autorité toponymique;
- La question des juridictions en matière de noms géographiques

INTERVENTIONS DES STAGIAIRES

Les participants ont été invités tout au long du stage à faire part de leur propre expérience en matière de gestion toponymique. Cela a donné lieu à de nombreuses discussions, voire à la présentation d'exposés par les représentants du Bénin, de Madagascar, du Niger, de la Tunisie et du Zaïre.

Activités d'appoint

En plus des sessions, plusieurs activités se sont greffées au programme de stage. Elles avaient comme premier objectif la sensibilisation des stagiaires à la diversité de la toponymie québécoise et comme second objectif l'établissement de contacts susceptibles de déboucher sur d'éventuels projets de coopération entre le Canada, le Québec et les pays intéressés.

Les stagiaires ont ainsi été invités par le Service canadien des parcs au dévoilement d'un panneau d'interprétation toponymique sur la terrasse Dufferin, dans le Vieux-Québec. Ce panneau est d'ailleurs le résultat d'une étroite collaboration entre l'organisme fédéral concerné et la Commission de toponymie. Le Service canadien des parcs a profité de l'événement pour faire visiter le parc de l'Artillerie, parc historique national, aux stagiaires.

Lors d'une excursion toponymique entre Québec et Montréal, les stagiaires ont pu se familiariser avec les toponymes riverains du Saint-Laurent et du Richelieu. Cette excursion s'est avérée un complément intéressant à l'enquête toponymique effectuée antérieurement dans la région de Charlevoix.

Une visite à la Commission de toponymie et une rencontre avec son personnel ont d'autre part fourni aux stagiaires l'occasion d'approfondir certains thèmes abordés lors des exposés, notamment le traitement automatique des données.

Il faut préciser que des démonstrations techniques du traitement automatique des données des systèmes des gouvernements fédéral (Base nationale de données toponymiques — BNDT) et provincial du Québec (TOPOS) ainsi qu'une interrogation du fichier de la Banque de terminologie du Québec étaient inscrites au programme du stage.

Lors de la même visite, des membres du personnel de la Commission ont brossé pour les participants un tableau complet et détaillé des opérations de base en matière de gestion des toponymes.

MATÉRIEL DIDACTIQUE UTILISÉ ET DOCUMENTATION DISTRIBUÉE

Le document vidéo sur la *Méthodologie des inventaires toponymiques* a été présenté aux stagiaires comme outil d'apprentissage des techniques de préparation, de réalisation et de traitement des relevés de terrain. Cet ouvrage didactique a particulièrement été apprécié par les participants qui ont tous souhaité en obtenir une copie. L'ouvrage imprimé du même titre a aussi été distribué aux stagiaires.

La journée d'enquête sur le terrain dans la région de Charlevoix avait été précédée par la présentation du court métrage intitulé "Je me souviens de Charlevoix" dont le contenu, avant tout toponymique, situe particulièrement bien la région dans ce contexte.

La Commission a, par ailleurs, remis à chacun des stagiaires une quinzaine de ses publications officielles. Des publications supplémentaires ont été distribuées par le Secrétariat du CPCNG au nom de ses membres fédéraux, provinciaux et territoriaux. Tout au long de la session, de nombreux documents d'appoint sont venus s'ajouter, susceptibles de soutenir toute démarche liée au processus de normalisation de noms géographiques.

ÉVALUATION

Une période avait été réservée en fin de session pour permettre aux participants de procéder à une évaluation du stage auquel ils venaient d'assister. L'analyse du questionnaire d'évaluation démontre la grande satisfaction des stagiaires face à l'atteinte des objectifs poursuivis par la session, à la pertinence des sujets traités et à l'organisation technique et matérielle.

Deux activités du stage ont particulièrement été appréciées. Il s'agit de l'enquête toponymique sur le terrain et de différentes démonstrations qui ont été faites sur l'utilisation de l'ordinateur dans le traitement des noms géographiques.

La très grande satisfaction des représentants des divers pays invités à l'égard du stage nous a été confirmée par différentes unités de services avec lesquelles plusieurs des stagiaires ont été en contact après le stage.

Au terme du stage, la Commission de toponymie a remis à chacun des stagiaires un certificat de participation annonçant la réalisation du stage sous les auspices des Nations Unies et sous le patronage du Gouvernement du Canada.

COMPLETION OF THE ESCUELA DE TOPOGRAFÍA, CATASTRO Y GEODESIA*

Paper submitted by the Federal Republic of Germany

At the Second United Nations Regional Cartographic Conference for the Americas, held at Mexico City in 1979, a paper was presented on the possibilities offered by the Federal Republic of Germany for education and training in the fields of surveying, mapping and the cadastre. The same subject was pursued at the Third Conference held in New York in 1985 to which an account was submitted on activities

of the Federal Republic of Germany in the fields of surveying and mapping in South and Central America and in the Caribbean.¹

This paper will further enlarge on the Escuela de Topografía, Catastro y Geodesia (ETCG), which was founded with the help of the Federal Republic of Germany within the National University of Costa Rica at Heredia. It is part of an extensive development project establishing cadastral works in the countries of Central America and Panama, assisted by the Agency for Technical Co-operation of the Federal

* The original text of this paper, prepared by Prof. Johannes Nittinger, appeared as document E/CONF.81/L.12.

Republic of Germany (Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)) in Eschborn.

In the papers cited above it was pointed out that education and training offered to technical staff of the national geographical institutes in Central America and Panama were not up to the level of modern establishments offering qualifications in cadastral work, and land informations systems, with photogrammetric and remote sensing methods. It was therefore planned from the first that the ETCG should give training not only to technicians but to middle management, since effective and extensive work in surveying, mapping and the cadastre is not possible without trained middle-management personnel.

The National University of Costa Rica at Heredia has from the outset wished to add courses for technicians and for licentiates, and these were started in 1982 with the aid of GTZ. Lately, a partnership has been formed between the ETCG and the Geodetic Section of the University of Hannover. The Academic Interchange Service of the Federal Republic of Germany (Deutscher Akademischer Austauschdienst) sponsors and finances the partnership on the German side, with the professional assistance of the Geodetic Section.

GTZ will grant modern equipment, since the available equipment, kept since 1974, is out of date.

ETCG has thus received renewed impetus for long-range development. Such cooperation between two institutions is important for both sides. Interchange of experience and mutual transfer of new knowledge brings about results that are equally valuable to ETCG and the Geodetic Section.

Establishment of the first steps of education for middle management met with some criticism because a prejudice exists that educational progress from top to bottom is not regular. This criticism is unjustified. Without middle management, it is not possible to realize the vast production of data necessary in surveying, mapping and land information systems. Experience has shown in the course of establishing the cadastre in countries of Central America and Panama that the education of middle management is just as important as that of the top management.

ETCG presents a model for two-tiered education: for practical purposes, two tiers suffice. How far the two tiers can be set up in other developing countries would depend on the demand and financial circumstances. It seems sensible, however, to accommodate both tiers in a single school, because this approaches the character of a joint academy.

The rise from the lower to the upper tier can thus be well controlled. Furthermore, such a comprehensive institution is less costly than if each tier were situated in a separate school. Certainly, for the Central America and Panama region, this model has proven convenient.

From the point of view of the Federal Republic's cooperation activities with countries of the third world, the ETCG is a good example of "on site" assistance. It is not indispensable that staff under training must travel abroad to obtain it.

A very effective aspect of the ETCG is its regional scope, which has been maintained between 1974 and 1982 by virtue of numerous scholarship grants to the countries of the region by the Federal Republic of Germany. It would be important at this time for those countries and other Latin American countries to grant many more such scholarships than they do:

(a) To support the regional scope of ETCG;

(b) To assist in the education of technicians and licentiates as an essential contribution to the development of the region;

(c) To promote cooperation between the Federal Republic of Germany and the countries of the Americas and to stabilize the ETCG

The organizational scheme of ETCG is shown in the following table.

Education	
Technicians	Licentiates
Middle-level, to improve the personnel structure in the public and private sector	Higher level; the university wished this academic education, which has assisted the Federal Republic of Germany
Duration of course: 5 terms	Duration of course: 5 terms
Technicians may rise to the licentiates in certain conditions	
1974-1982 scholarships, granted by the Federal Republic of Germany	Partnership between ETCG and the Federal Republic of Germany
During term recess, training courses are planned for advanced training	
ETCG has the character of a comprehensive (joint) school for surveying, mapping and the cadastre (Gesamthochschule)	

NOTE

¹ Third United Nations Regional Cartographic Conference for the Americas, vol. II. *Technical Papers* (United Nations publication, Sales No. E/F/S.88.I.89).

UNITED NATIONS INTERREGIONAL TRAINING COURSE IN LARGE-SCALE MAPPING OPERATIONS*

Paper submitted by the German Democratic Republic

RÉSUMÉ

L'objectif à long terme du stage était d'aider les pays en développement à mettre en place des institutions nationales chargées d'organiser d'une façon suivie les opérations de cartographie à grande échelle, qui comprennent les levés cadastraux et l'établissement de cartes urbaines et de cartes des services publics, ou de renforcer les institutions existantes.

Le stage avait pour objectif immédiat de fournir au personnel d'encadrement technique ou autre des services nationaux de cartographie les renseignements les plus récents sur les méthodes et techniques de levés à grande échelle en vue de la réalisation de

* The original text of this paper appeared as document E/CONF 81/L. 33

programmes de levés cadastraux et de cartographie urbaine ainsi que de cartographie à l'intention des services publics, et de démontrer à son intention l'application de ces méthodes et techniques. En outre, on y a étudié les diverses modalités devant permettre aux pays en développement de se prévaloir à un coût raisonnable de programmes d'établissement de cartes à grande échelle utilisables et exactes couvrant les zones urbaines comme les zones rurales. On a accordé une attention particulière aux débats et au rapport du Groupe spécial d'experts des Nations Unies sur les levés et plans cadastraux et les systèmes d'information foncière (1983).

RESUMEN

El objetivo a largo plazo del curso fue asistir a los países en desarrollo en la creación o el fortalecimiento de las instituciones nacionales encargadas de la elaboración a gran escala y el archivo de mapas, actividades que comprenden estudios catastrales y planos urbanos y de instalaciones.

El objetivo inmediato del curso fue suministrar a los técnicos experimentados y al personal especializado de las instituciones nacionales encargadas del trazado de mapas la información más actualizada sobre los métodos y técnicas de trazado a gran escala de planos catastrales, y urbanos y de instalaciones. Además, se investigaron las diversas formas en que los países en desarrollo pueden ejecutar programas de trazado a gran escala de planos útiles y precisos que abarquen las zonas urbanas y rurales a un costo razonable. Se prestó especial atención a las deliberaciones y al informe del Grupo Especial de Expertos sobre Levantamiento y Planos Catastrales y Sistemas de Información Geográfica (1983).

SUMMARY

The long-range objective of the course was to assist developing countries in creating or strengthening national institutions for the development and maintenance of large-scale mapping operations, which include cadastral surveys, urban mapping and utility mapping.

The immediate objective of this course was to inform and demonstrate to senior-level technicians and personnel from national mapping establishments the latest available information on methods and techniques in conducting large-scale surveys for cadastral and urban mapping programmes and utility mapping activities. In addition, the various ways in which developing countries can assure themselves of usable and accurate large-scale mapping programmes covering both urban and rural areas, at reasonable costs, were investigated. Special attention was given to the deliberations and report of the United Nations Ad Hoc Group of Experts on Cadastral Surveying and Land Information Systems (1983).

The Interregional Training Course in Large-scale Mapping Operations for Planning and Cadastral Purposes was held at the Engineering School for Geodesy and Cartography in Dresden, German Democratic Republic, from 30 July to 14 August 1986.

Twenty-three delegates from 19 States, including 13 African States (Angola, Benin, Cameroon, Congo, Egypt, Ethiopia, Ghana, Morocco, Mozambique, Niger, Nigeria, Tunisia, Zaire) took part in the course. Further participating States were the former People's Democratic Republic of Yemen, India, Jordan, the Lao People's Democratic Republic, Pakistan and Viet Nam.

The following lecturers participated in the course:

Sune Anderson, Director General, Central Board for Real Estate Data, Gävle, Sweden

Prof. John McLaughlin, Chairman, Department of Surveying Engineering, University of New Brunswick, Fredericton N.B., Canada

Dr. Borivoj Delong, Director, Department of Special Geodetic Works, Czech Office for Geodesy and Cartography, Praha, Czechoslovakia

On behalf of the German Democratic Republic, 13 lecturers, dealing with very different subjects, made their contributions. Dr. Habil Haack (German Democratic Republic) was Director of the course. The function of Co-director was held by Dr. Maximilian de Henseler from United Nations Headquarters in New York. Rapporteur of this course was Dmitry Votrin, also of the United Nations Secretariat. Official representatives of the Government of the German Democratic Republic took part in the opening and closing ceremonies.

The training course was prepared and carried out on the basis of contractual arrangements between the Government of the German Democratic Republic and officials of the Department of Technical Co-operation for Development of the United Nations Secretariat. The long-range objective of the course consisted in assisting developing countries in the creation and consolidation of national institutions for the production, updating and maintenance of large-scale maps, including cadastral surveys, urban mapping and utility mapping.

The immediate objective consisted in informing senior-level technicians and personnel from national mapping insti-

tutions about modern methods and techniques in conducting large-scale surveys (up to scale 1:10,000) for cadastral and urban mapping programmes and utility mapping activities, and in demonstrating these methods. In addition to that, different methods were scrutinized whereby developing countries could, at reasonable cost, take over usable and accurate programmes for the production of large-scale maps covering both urban and rural areas.

The following lectures were part of the course programme.

Large-scale map, scale 1:10,000 and larger: tools for management and planning in administration and economy

Consideration of the preparation of programmes for the production, updating and management of large-scale maps for planning and cadastral purposes

Development and management of land registration and land survey systems

Development and use of land information systems

Considerations in the production, updating and management of large-scale maps for urban areas with special emphasis on cadastral documentation

Requirements placed on the value-in-use properties of large-scale maps

Geodetic control networks for the production and updating of large-scale maps

Production of large-scale maps on the basis of numerical survey techniques with electronic tacheometer and automated plotting

Production of large-scale maps on the basis of field-table tacheometry with optical tacheometer and manual plotting

Cartographic processing of large-scale maps by scribing technique

Photogrammetric mapping at large scales

Development trends in photogrammetric mapping technologies

Production and use of large-scale orthophoto maps

Training of geodetic and cartographic experts in the GDR

United Nations possibilities of rendering technical assistance in large-scale mapping to developing countries

The lectures were supplemented by:

(a) Three field and laboratory demonstrations of techniques and technologies of topographic photographs, and digital and graphical plotting;

(b) Technical excursions to the enterprises of Carl Zeiss, Jena and Robotron, Dresden, where geodetic and photogrammetric surveying and processing equipment, as well as computer techniques, were demonstrated;

(c) A technical excursion to a cartographic institution in Leipzig, where photogrammetric mapping techniques and technologies were demonstrated.

The programme was further supplemented by a lecture of Dr. de Henseler on mapping operations and hydrographic and bathymetric charting in developing countries; and by information from the Academy for Agricultural Sciences of the GDR on the subject of agricultural maps. In addition to the lectures, demonstration exercises and technical excursions, a lively and active exchange of views on technical problems took place. Moreover, the delegates' reports on national conditions and experience in the field of large-scale mapping operations in their respective countries attracted special interest and generated a comprehensive exchange of experience.

Visits to places of cultural interest and sights in Dresden and the surrounding area, as well as in Leipzig, were also on the agenda.

The participants appreciated the content and organization of this United Nations interregional training course and assessed that its objectives were achieved. The course contributed at the same time to the direct implementation of several resolutions adopted at various United Nations regional cartographic conferences for Asia and the Pacific, for the Americas and for Africa.

The Training Course dealt profoundly with ways, techniques and technologies of mapping operations in order to meet ever better the increasing demand for large-scale maps in developing countries. The importance of large-scale mapping activities for developing the infrastructure of any country and its influence on the entire economic and social development could be directly demonstrated by taking a socialist State as a model. The treatment of such focal points as organization and techniques of producing and updating large-scale maps, and the creation of land information systems in connection with the development of infrastructure, were among the outstanding merits of this training course.

On behalf of the German Democratic Republic, the course participants received, among other things, an album containing the lectures of the course (in English and French) as well as information material on training opportunities (university, technical college and skilled workers training) in the field of geodesy and cartography in the German Democratic Republic.

CARTOGRAPHIC ACTIVITIES IN THE AMERICAS*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Le document expose la contribution apportée par les services gouvernementaux britanniques aux travaux de levés et de cartographie menés dans les pays et les mers d'Amérique depuis la troisième Conférence. Le Directorate of the Overseas Surveys et le Service géographique de l'armée britannique ont entrepris des opérations de triangulation, nivellement et cartographie dans 14 pays de la région, dans le cadre du programme d'assistance du Royaume-Uni. Le Département d'hydrographie a poursuivi son travail de mise à jour des cartes de l'Amirauté pour les secteurs dont il est chargé, et la Marine

* The original text of this paper appeared as document E/CONF 81/L 5

britannique a mené à bien divers travaux de levés dans les Caraïbes et les Antilles. Le document contient une description des activités menées dans chaque pays ainsi qu'une liste des cartes établies.

RESUMEN

En esta monografía se describe la contribución hecha desde la celebración de la Tercera Conferencia por los organismos oficiales del Reino Unido en materia de levantamientos y confección de mapas de países del continente americano y cartas náuticas de los mares de la región. Como parte del programa de ayuda del Reino Unido, la Dirección de Levantamientos de Ultramar del Servicio de Levantamientos del Ejército emprendió actividades de cartografiado y levantamientos en 14 países de la región. El Departamento de Hidrografía continuó su actualización de las cartas del Almirantazgo en las partes de la región que están a su cargo, y la Armada terminó de realizar varios levantamientos en la zona del Caribe y las Indias Occidentales. Se describen las actividades llevadas a cabo en cada país y se enumeran los mapas y cartas confeccionados por esos organismos.

SUMMARY

This is an account of the contribution to the surveying, mapping and charting of the countries and seas of the Americas made by government agencies of the United Kingdom since the Third Conference. The Overseas Surveys Directorate of the Ordnance Survey undertook mapping and surveying in 14 countries in the region as part of the United Kingdom's aid programme. The Hydrographic Department continued their work of updating the Admiralty charts in those parts of the region for which it is responsible and the Royal Navy completed a number of surveys in the Caribbean and West Indies. Activities in each country are described and the maps and charts produced by the agencies are listed.

TOPOGRAPHIC SURVEYING AND MAPPING

Topographic surveying and mapping projects were undertaken by the Overseas Surveys Directorate (OSD) in collaboration with local survey departments in the following countries of the region:

Anguilla	Dominica	Saint Kitts and Nevis
Antigua	Falkland Islands	Saint Lucia
Barbados	Grenada	Saint Vincent and the
Bermuda	Guyana	Grenadines
Bolivia	Jamaica	Turks and Caicos
British Virgin Islands	Montserrat	Islands

In Guyana a joint project was established in which production of the reconstructed 1:50,000 series was shared between OSD and the Lands and Survey Department, both working to an agreed specification.

The majority of the projects were to:

- (a) Revise and extend large-scale mapping for the development of specific areas and town planning;
- (b) Revise and reconstruct smaller-scale mapping in support of specific projects, general administration and tourism.

Activities of the Overseas Surveys Directorate

The main OSD activities in relation to these projects and in general in this field were as follows.

Air photography. A contract was arranged with a commercial firm for air photography of Dominica. Because of bad weather only a portion of the required cover was achieved.

Computing. The secondary and tertiary trig network of Jamaica was adjusted as a single block. The 42 primaries

were held fixed and 2,200 secondary and tertiary stations were adjusted. First, 10 separate height adjustments were done.

In the Falkland Islands, around Stanley, 15 stations were adjusted in plan and height.

The 50 new Doppler stations in Guyana were computed, using Magnet software in the translocation mode.

Field survey. OSD survey parties worked in Guyana and the Falkland Islands. The Guyana party worked with seconded members of the local department, fixing plan points for photogrammetric control by Doppler in the coastal areas to the north-west of the country and near the Suriname border. The Falkland Islands party produced control for large-scale mapping around Stanley and Fox Bay.

Map production. New or revised topographic series maps were produced for 14 countries in the region at scales ranging from 1:500 to 1:125,000. Geological mapping of north-eastern Bolivia was produced at scales 1:100,000 and 1:250,000. Normally, when larger-scale mapping was undertaken, monochrome reproduction material was sent to the country concerned for local printing on demand. An exception was the Falkland Islands 1:2,500, where print runs of 1,000 were requested for the two sheets covering Stanley.

Activities of the Directorate General of Military Survey (DGMS)

Air photography. The Royal Air Force flew 1:40,000 cover of 87 per cent of Belize during 1988. This is to be used for the revision of the 1:50,000-scale mapping of the country.

Field survey. Doppler observations were made in Belize to support hydrographic activities and in the eastern Caribbean to support negotiations to define exclusive economic zones. This latter task was sponsored by the British Commonwealth secretariat.

Details by country

Details of the topographic surveying and mapping undertaken in each country are given in annexes I and II.

CADASTRAL SURVEYING AND MAPPING

Small pilot land registration projects are in progress in Dominica, Saint Vincent and Saint Kitts with assistance from OSD.

HYDROGRAPHIC CHARTING AND SURVEYING

Navigational charts

The Admiralty world chart service consists of approximately 3,400 sheets. These are distributed through a worldwide agency system and are maintained by information promulgated in Admiralty "Notices to Mariners".

In home waters and certain areas where the United Kingdom has a historic charting responsibility, such as some commonwealth countries and certain parts of the Caribbean and Middle East, Admiralty charts provide, wherever possible, detailed cover of all significant ports and their approaches, together with general cover of all coastal waters. These charts constitute about a third of the whole series; the remainder are derived mainly from published foreign government charts and are designed to provide, for international shipping, coverage of ocean and coastal passages, approaches and entry to 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 ranging 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 and anchorages	1:50,000 or larger
Terminal facility	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, Trinidad and Tobago and areas adjoining some other countries with little or no charting capabilities of their own.

Since the last report, 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 from October 1984 to October 1988, in addition to regular Notices to Mariners, publications have included 136 new editions and 51 new charts in the Americas. Details of these are given in annex III.

Hydrographic surveying

Hydrographic survey effort in British areas of interest in the Caribbean and West Indies has concentrated on important harbours and anchorages, passages between the islands and offshore banks.

Surveys were conducted in the Leeward and Windward Islands and in Jamaica. The survey of an extensive area within Belizean waters in the Gulf of Honduras was begun in late 1988. Details of surveys completed and in hand are given in annex IV.

OTHER MAPPING

Thematic Mapping

Work on the Bolivian multicoloured geological map series was completed during the period. These maps at 1:100,000 and 1:250,000 scales illustrate the work of the joint United Kingdom/Bolivia survey (British Geological Survey GEOBOL) of the pre-Cambrian Shield area of north-eastern Bolivia.

Tactical pilotage charts

Two sheets at 1:500,000 scale were produced by DGMS: one being of Belize and part of the Yucatan peninsula, and the other of part of Guyana and Venezuela.

Miscellaneous

Revised films for moving map displays for Harrier, Tornado and Jaguar aircraft have been produced for the Goose Bay and Cold Lake training areas in Canada. Belize and the western Caribbean are now covered by moving map displays. A film to give general coverage of all United States and Canadian training areas was also produced.

TRAINING

Training in the United Kingdom is reported on elsewhere in this volume in a paper entitled "Training in survey and mapping for overseas students in the United Kingdom" (E/CONF 81/L.6).

SECONDMENTS

Senior OSD staff were seconded to Saint Lucia, Montserrat, Dominica and Bermuda for varying periods of time. A technical cooperation photogrammetrist served in Guyana.

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 the surveying and mapping in the Americas.

Remote sensing in hydrographic survey

Since the Third Conference, satellite imagery has established itself as a valuable new source of data within the Hydrographic Department where it can improve the detailed content and/or the positional accuracy of information included on charts. It can augment the data that already exist in an area, and where no further hydrographic surveys are likely to be available, imagery can put new life into old surveys by:

- Improving internal relative positions;
- Detecting features missed by early surveyors; imagery provides area cover rather than transverse cover;
- Improving the delineation of features sketched by early surveyors.

Most of the work done so far with satellite imagery has been in equatorial regions where clear water allows detection of some features under shallow water. The spatial resolution, even of SPOT with a pixel size of 10 x 10 metres, however, is such that small pinnacle features that could be lethal may not be detected by satellite sensors

LANDSAT-MSS, TM and SPOT imagery are all used to support nautical charting. Most of the imagery is used in the form of hard-copy positives. LANDSAT data are geometrically corrected and SPOT processed to level 1B. Use is made of the discrimination properties provided by the separate wavebands; the near-infrared band provides a very clear definition of the land/water boundary, while the green band provides water penetration and depiction of features under shallow water. The film positives are interpreted optically and either photographic enlargements are used, or the imagery is used in conjunction with traditional photogrammetric equipment.

Satellite imagery has been used in the Gulf of Honduras to assist in the fitting of old surveys, covering offshore keys, to the Belize coastline, taken from modern mapping/air photography, and also to locate previously unknown shoals

ANNEX I

Topographic surveying and mapping by country

Anguilla

The last of the 53 sheets of revised and contoured 1:2,500 series was completed by March 1985. Revised 1:25,000 and 1:80,000 sheets were printed.

Barbados

Three sheets at 1:2,500 of Bridgetown were produced as base maps for the Physical Planning Project of the United Nations Development Programme (UNDP). Twelve sheets at 1:10,000 were reconstructed and printed. Two sheets at 1:25,000 and one at 1:50,000 were revised.

Barbuda

Nine sheets at 1:10,000 were produced as monochromes for dyeline reproduction.

Belize

A team from DGMS made Doppler observations both within and outside the triangulation framework to support hydrographic work in the Gulf of Honduras.

Bolivia

Two geological sheets at 1:100,000 and eight at 1:250,000 were published.

British Virgin Islands

Eighty contoured sheets at 1:2,500 were published covering Tortola, Beef Island, Virgin Gorda and Jost van Dyke.

Dominica

Publication of the large-scale mapping of the country continued; 59 new or revised editions of contoured sheets at 1:2,500 of the most developed areas, 34 contoured sheets at 1:5,000 of the less developed areas and 10 sheets at 1:10,000 of the remaining interior area were published. This leaves 13 sheets at 1:5,000 and 1 at 1:10,000 to be completed.

Falkland Islands (Malvinas)

Contoured mapping of Stanley, 11 sheets at 1:2,500 scale, was completed. The centre of Stanley was also mapped at 1:500 for future development work. A contoured orthophotomap at 1:2,500 of an area of special interest was also produced.

Grenada

The small-scale maps were revised to incorporate the new airport.

Guyana

A field party worked for 18 months in the country putting in control for the reconstruction of the 1:50,000 and the 1:10,000 mosaic projects. The work was done using Doppler satellite translocation techniques. The remaining 51 sheets of the 1:10,000 mosaics were completed. The 48 sheets of the joint 1:50,000 project were split, 33 to be done by OSD and 15 by GLSD. Currently, 16 sheets are complete, and 15 more should be complete by the end of 1988; 7 of the GLSD sheets have been field-completed.

Jamaica

The 1:50,000 reconstruction was a joint project: 10 sheets by OSD have been completed, and 10 by the Jamaica Survey Department, of which 4 have been printed and 5 are at field completion, or fair drawing.

Montserrat

There are 27 contoured sheets of the 1:2,500 series and 7 of the 1:5,000 series at field completion. Field completion has been finished on 11 sheets of the 1:2,500.

Saint Kitts and Nevis

Eighty-three contoured sheets at 1:2,500 and one sheet at 1:25,000 were published.

Saint Lucia

A considerable amount of raw material for mapping, airphoto films, control diagrams, coordinate lists, photogrammetric adjustment results etc were supplied to the Land Registration and Titling Project; 6 sheets at 1:1,250 on Saint Vincent and 2 sheets of the Grenadines at 1:50,000 were published.

Turks and Caicos Islands

The 15 sheets of the 1:25,000 photomapping series and the last two sheets of the 1:10,000 reconstruction were published.

ANNEX II
Topographic maps of the Americas published by the Overseas Surveys Directorate,
Ordnance Survey, January 1984–December 1988

<i>Country</i>	<i>Scale</i>	<i>Series Number</i>	<i>Date</i>	<i>Remarks</i>
Anguilla	1:2,500	DOS 043	1986	Ed 2 and 3. contoured
	1:25,000	DOS 343	1986	Ed 5 BWI grid, Ed 6 UTM grid
	1:80,000	DOS 943	1986	
Barbados	1:10,000	DOS 218	1986-1988	Ed 2, 12 sheets
	1:25,000	OSD 2954	1987	Ed 1, 2 sheets enlarged from 1:50,000
	1:50,000	DOS 418	1987	Ed 4
Bermuda	1:10,560	OSD 5054	1988	Mosaics 1940 phy
	1:10,560	OSD 5055	1988	1981 colour phy
Bolivia	1:100,000	DOS 1225	1986, 1988	2 geological sheets
	1:250,000	DOS 1224	1985-1988	9 geological sheets
British Virgin Islands	1:2,500	DOS 046	1985	Ed 1 x 34 sheets, Ed 2 x 17 sheets
Dominica	1:2,500	DOS 051	1985-1986	Ed 1 x 6, Ed 2 x 53
	1:5,000	DOS 151	1986-1988	Ed 1, 34 sheets
	1:10,000	DOS 251	1987	Ed 1, 10 sheets
	1:25,000	DOS 351	1988	Ed 4, 3 sheets
	1:50,000	DOS 451	1988	Ed 3, 1 sheet
Falkland Islands (Malvinas)	1:500	OSD 00053	1988	Ed 1, 27 sheets
	1:2,500	OSD 5053	1987	Orthophotomap
	1:2,500	OSD 053	1988	Ed 1, 11 sheets
Grenada	1:50,000	DOS 442	1986	Ed 4 tourist map
	1:150,000	DOS 995	1988	Ed 4 revised
Guyana	1:10,000	DOS 240M	1987	Ed 1, 51 controlled photo mosaics
	1:50,000	DOS 440	1987-1988	Ed 3-8, 16 sheets
	1:50,000	Series 1	1985-1988	Ed 1, joint project
Saint Kitts and Nevis	1:2,500	DOS 043	1985-1986	Ed 1, 65 sheets; Ed 2, 4 sheets
	1:25,000	DOS 343	1985	Ed 5, BWI grid; Ed 6, UTM grid
Saint Vincent and the Grenadines	1:2,500	DOS 017	1988	Ed 1. 9 sheets
	1:10,000	DOS 217	1988	Ed 2, 1 sheet
	1:50,000	DOS 417	1985	Ed 1, 2 sheets BWI; Ed 2, 2 sheets UTM
Turks and Caicos Islands	1:10,000	DOS 209	1985	Ed 3, 2 sheets
	1:25,000	DOS 309P	1985-1986	Ed 2, all 15 sheets
Tactical pilotage charts of the Americas published by				
the Directorate General of Military Survey, January 1984–December 1988				
Belize	1:500,000	J-25C	1986	Also covers part of Honduras
Guyana	1:500,000	L-27B	1988	Also covers part of Venezuela

ANNEX III
New Admiralty charts and new editions
North and Central America

New charts

<i>Chart no.</i>	<i>Title</i>	<i>Scale</i>	<i>Published</i>
315	Saint Lawrence River, Sault-au-Cochon to Quebec	1:60,000	July 1988
319	Port de Québec	1:17,500	September 1988
352	Approaches to Bay of Fundy	1:300,000	September 1987
899	San Diego Bay to Point Arguello	1:363,750	October 1988
922	Vancouver Harbour	1:12,500	June 1987
1135	Baie des Sept-Îles	1:30,000	January 1985
1218	Cuba to Miskito Bank	1:1,000,000	November 1987
1551	Saint John Harbour and approaches	Various	September 1987
1573	Gulf of Honduras	1:125,000	August 1988
2428	Ridley Island	1:10,000	May 1987
2433	Prince Rupert Harbour	1:20,000	November 1987
2730	Narragansett Bay, Brenton Reef to Hog Is shoal	1:20,000	March 1988
2731	Narragansett Bay, Hog Is shoal to Providence	1:20,000	March 1988
2732	New London and Fall River Harbours and approaches	Various	March 1988
2755	Approaches to New York Harbour	1:150,000	November 1984
2813	Hampton roads and Newport News	1:20,000	January 1985
2814	Norfolk Harbour and Elizabeth River	1:20,000	January 1985
2919	Chesapeake Bay entrance	1:80,000	April 1986
2920	Chesapeake Bay, New Point Comfort to Point No Point	1:80,000	April 1986
2921	Chesapeake Bay, Point No Point to Love Point	1:80,000	April 1986
2922	Chesapeake and Delaware Canal and the northern approaches to Baltimore	Various	April 1985
2923	Potomac River, Deep Pt. to Lower Cedar Pt	1:40,000	August 1985
2924	Potomac River, Lower Cedar Pt to Washington	Various	August 1985
3184	Ports of Corpus Christi and Brazos Santiago	Various	April 1988
3185	Calcasieu, Port Arthur, Galveston, Matagorda and their approaches	Various	April 1988
3186	Houston Ship Channel, Pelican Is. to Barbours Cut	1:25,000	April 1986
3187	Houston Ship Channel, Barbours Cut to Carpenter Bayou	1:10,000	April 1986
3188	Houston Ship Channel, Carpenter Bayou to Houston	1:10,000	April 1986
3847	Approaches to Tampa Bay	1:40,000	March 1987
3848	Tampa Bay	Various	March 1987

New editions

290	Newfoundland, Placentia to Burin Harbour	1:175,000	August 1985
307	Points des Monts to Pointe au Père	Various	July 1985
311	Halifax Harbour	1:12,000	August 1987
312	Father Point to Green Island	1:101,700	July 1985
313	Saguanay River to Kamouraska Islands	1:81,000	July 1985
314	Kamouraska Islands to Goose Island	1:81,000	July 1985
320	Bedford Basin	1:18,000	August 1987
337	Yarmouth Harbour	Various	May 1985
352	Bay of Fundy—outer portion	1:258,000	July 1985
353	Bay of Fundy, Digby Gut to the head of navigation	1:253,000	August 1985
373	Plans in the Gulf of Campeche	Various	March 1987
579	Burrard Inlet to Cape Mudge	Various	October 1986
591	San Francisco Harbour	1:50,000	January 1987
592	San Francisco Bay, southern part	1:50,000	November 1986
659	Ports on the west coast of Central America	Various	September 1988
730	Cape Sable to Sambro Island	1:260,000	July 1988
1053	Mexico, Morro de Papanao to Cabo Corrientes	1:720,000	July 1987
1081	San Pedro Bay including Los Angeles and Long Beach harbours	1:12,000	December 1985 and April 1988
1082	Approaches to San Pedro Bay	1:20,000	July 1986
1132	Chenal de Mingan	Various	April 1986
1134	Cabot Strait and Îles de la Madeleine	1:250,000	August 1987
1163	Harbours and anchorages in the Gulf of Saint Lawrence	Various	April 1988
1370	Saguanay River	Various	January 1986
1499	Cross Sound to Kodiak Island	1:1,393,000	October 1988
1516	Boston Harbour	1:25,000	February 1985
1551	Saint John Harbour and approaches	Various	November 1984
1621	Saint Paul Island to Pointe de Cloriciorme	1:350,000	November 1984
1623	Anticosti Island to Pointe des Monts	Various	April 1988
1651	Nova Scotia, Prince Edward and part of New Brunswick	1:725,000	December 1987
1715	Baie des Chaleurs	1:150,000	January 1987
1717	Port Angeles	1:10,045	March 1987
1931	Costa Rica, Golfo de Nicoya	Various	February 1988

ANNEX III (continued)

<i>Chart no.</i>	<i>Title</i>	<i>Scale</i>	<i>Published</i>
1960	Plans on the west coast of Central America	Various	April 1987 and June 1988
2342	Chedabucto Bay	Various	March 1988
2410	Approaches to Halifax	1:50,000	May 1988
2456	Nantucket Sound, Buzzards Bay and approaches	1:100,000	March 1985
2488	Portland Harbour	1:24,000	May 1986
2490	Monhegan Island to Cape Porpoise	1:100,000	June 1988
2516	Gulf of Saint Lawrence	1:1,000,000	June 1987
2603	Delaware River, Delaware Pt. to Little Tinicum Is.	Various	July 1988
2604	Delaware River, Philadelphia and Camden	1:15,000	April 1988
2605	Delaware River, Philadelphia to Trenton	1:20,000	June 1988
2666	Grand Banks of Newfoundland	1:1,500,000	August 1986
2670	Cape Breton to Delaware Bay	1:1,500,000	November 1986
2692	Flint Island to Guyon Island	Various	September 1988
2754	Fire Island Inlet to Block Island	1:150,000	November 1984
2804	Winyah Bay and Georgetown Harbour	1:50,000	August 1987
2807	Plans on the coasts of South Carolina and Georgia	1:50,000	October 1984
2808	Plans on the east coast of Florida	Various	August 1986
2828	Port aux Basques	1:7,500	April 1986
2839	Columbia River from the entrance to Lord Is.	1:50,000	August 1987
2849	Columbia River—Lord Is. to Vancouver and Portland	Various	December 1987
2850	Approaches to Baltimore and Baltimore Harbour	Various	November 1985 and July 1988
2860	Outer approaches to New York	1:500,000	March 1985
2988	Ports in the Gulf of Honduras	Various	May 1987
3061	Plans in the Golfo de California	Various	October 1987
3125	Grays Harbour	1:40,000	November 1987
3204	New York, Lower Bay and approaches	1:50,000	August 1988
3187	Houston Ship Channel, Barbours Cut to Carpenter Bayou	1:10,000	August 1988
3188	Houston Ship Channel, Carpenter Bayou to Houston	1:10,000	August 1988
3849	Brazos Santiago to Galveston Bay	Various	April 1986
3850	Galveston Bay to Ship Shoal	1:500,000	November 1985
3851	Ship Shoal to Pensacola Bay	1:500,000	July 1988
CARIBBEAN AND WEST INDIES			
<i>New charts</i>			
254	Montserrat and Barbuda	Various	June 1986
457	Jamaica, Portland Bight	1:40,000	August 1988
459	Harbours on the north coast of Jamaica	Various	July 1987
481	Serpents Mouth	1:75,000	October 1984
502	Plans in Barbados	Various	October 1984
702	Aruba and Curaçao	Various	August 1987
1412	Ports in Aruba and Curaçao	Various	August 1987
2047	Approaches to Anguilla	1:50,000	April 1985
2079	Plans in Anguilla, S. Martin and S. Barthélemy	Various	April 1985
2485	Approaches to Barbados	1:100,000	January 1987
<i>New editions</i>			
257	Harbours on the south coast of Jamaica	Various	March 1988
398	Freeport roads and harbour	Various	August 1988
410	Ports and anchorages on north coast of Cuba	Various	July 1987
411	Maríel and Matanzas	Various	September 1988
443	Santiago Harbour, Cuba	1:10,130	April 1988
444	Bahía de Cienfuegos	Various	June 1987
454	Kingston Harbour	1:20,000	June 1987
463	Plans on the north coast of the Dominican Republic	Various	August 1985
467	Bayajibe to Haina, Dominican Republic	Various	November 1986
479	Boca de Monos and approaches to Port of Spain	1:25,000	September 1986
482	Harbours and anchorages in the Gulf of Paria	Various	June 1986
484	Bocas del Dragón to Port of Spain	1:50,000	October 1986
804	Approaches to Pointe à Pitre	1:25,300	September 1987
1452	Nassau Harbour	1:6,000	February 1988
2008	Virgin Is., Anegada to Virgin Gorda	1:75,000	March 1985
2016	Gorda Sound and approaches	Various	March 1985
2019	Tortola to Virgin Gorda	1:75,000	March 1985
2020	Road Harbour and approaches	1:15,000	September 1987
3197	Cuba, Bahía Nuevitas	Various	April 1988
3865	Cuba—eastern sheet	1:500,000	December 1985
3866	Cuba—middle sheet	1:500,000	December 1985

ANNEX III (continued)

<i>Chart no.</i>	<i>Title</i>	<i>Scale</i>	<i>Published</i>
SOUTH AMERICA			
<i>New charts</i>			
431	Porto de Sepatiba	1:20,000	December 1984
432	Terminal de Ilha Guaíba	Various	October 1986
433	Approaches to Porto de Angra dos Reis and Tebig Oil Terminal	Various	October 1986
521	Porto de Vitória and Porto do Tubarão	Various	May 1988
526	Ports on the north coast of Brazil	Various	January 1988
528	São Luís to Recife	1:1,500,000	November 1984
529	Recife to Cabo de São Tomé	1:1,750,000	November 1984
540	Baía de Todos os Santos	1:75,000	May 1987
545	Ports in Baía de Todos os Santos	1:20,000	January 1987
551	Ports and approaches on the east coast of Brazil	Various	May 1988
1332	Isla de Los Estados and Estrecho de le Maire	1:125,000	March 1986
<i>New editions</i>			
231	Approaches to Porto de Paranaguá	Various	May 1988
397	Porto de Belém and approaches	Various	February 1986
504	Porto de Natal and approaches	Various	August 1986
517	Trinidad to Cayenne	1:1,500,000	December 1986
529	Recife to Cabo de São Tomé	1:1,750,000	September 1988
530	Cabo de São Tomé to Rio Grande	1:1,750,000	January 1987
531	Plans on the coast of Argentina	Various	September 1987
534	Entrances to rivers in Guyane Française and Suriname	1:75,000	February 1986
535	Baía de São Marcos	Various	May 1987
539	Puerto Santa Cruz to Cabo Pilar	1:1,750,000	February 1987
541	Baía de Guanabara	Various	June 1987
546	Plans on the coast of Brazil	Various	February 1987
554	Estrecho de Magallanes	1:550,000	February 1988
556	Tramandai to Mar del Plata	1:1,750,000	February 1988
557	Mar del Plata to Comodoro Rivadavia	1:1,750,000	June 1987
558	Isla Leones to Estrecho de Magallanes including the Falkland Islands (Malvinas)	1:1,750,000	February 1988
561	Cabo Pilar to Golfo Coronados	1:1,750,000	August 1987
569	Plans on the coast of Chile	Various	January 1986
570	Plans on the coast of Chile	Various	February 1986
631	Estrecho de Magallanes, Paso del Mar and Canal Smyth	1:100,000	March 1985
1292	Plans of the coast of Chile	Various	December 1987
1306	Plans in Tierra del Fuego	Various	November 1987
1314	Ports and anchorages on the coast of Chile	Various	March 1987
1319	Bahía Concepción and Bahía San Vicente	Various	September 1988
1331	Approaches and entrance to Bahía Blanca	Various	October 1985
1375	Archipiélago de Colón	Various	February 1987
1396	Ports on the east coast of Brazil	Various	June 1985
1498	Bahía Pozuelos and approaches	Various	December 1984
1523	Plans on the coast of Venezuela	Various	September 1987
1692	Cabo Virgenes to Primera Angostura	1:100,000	January 1986
1749	Río de la Plata—Montevideo to Buenos Aires	1:250,000	October 1988
1751	Puerto de Buenos Aires	Various	September 1985
1814	Punta Avangui to Punta Verde	Various	July 1988
1853	Approaches to Bahía del Callao	Various	May 1988
1893	Bahía Darwin to Seno Aysen	1:150,000	March 1988
1963	Plans of anchorages on the coast of Venezuela	Various	July 1986
2001	Bahía de Montevideo	1:20,000	October 1985
2002	Porto de Rio Grande	1:36,000	March 1987
2004	Plans on the coast of Uruguay	Various	August 1987
2189	Rio Amazonas—approaches to Macapá and Macapá to Porto de Santana	Various	May 1985 and May 1986
2257	Punta Verde to Buenaventura	1:585,100	July 1988
3066	Quequén to Río Negro	1:500,000	December 1987
3076	Ports on the coast of Chile	Various	March 1985
3080	Plans on the coast of Chile	Various	July 1988
3083	Ports on the coast of Perú	Various	January 1987
3089	Ports on the coast of Perú	Various	June 1988
3755	Bahía Blanca	Various	July 1985
3962	Northern approaches to Río Amazonas	1:500,000	September 1988

ANNEX IV
Hydrographic surveys completed by H.M. survey ships
in American waters, 1984-1988

<i>Area</i>	<i>Scale</i>	<i>Ship</i>	<i>Year</i>
LEEWARD ISLANDS			
Antigua to Montserrat	1:50,000	<i>Fox and Fawn</i>	1984/85
Plymouth Harbour, Montserrat	1:10,000	<i>Fawn</i>	1985
Falmouth Harbour, Antigua	1:5,000	<i>Fox</i>	1985
English Harbour, Antigua	1:2,500	<i>Fox</i>	1985
Mamora Bay, Antigua	1:2,500	<i>Fox</i>	1985
WINDWARD ISLANDS			
Saint Lucia to Saint Vincent	1:50,000	<i>Fawn</i>	1985
Vieux Fort Bay, Saint Lucia	1:10,000	<i>Fawn</i>	1985
Soufriere Bay, Saint Lucia	1:25,000	<i>Fox</i>	1985
Port Castries, Saint Lucia	1:5,000	<i>Fox</i>	1985
JAMAICA			
Kingston Harbour, Jamaica ^a	1:10,000	<i>Beagle and Fawn</i>	1988
BELIZE			
Stewart Cay to Orange Point	1:50,000	<i>Beagle and Fawn</i>	1988

^a Surveys still in progress

TRAINING IN SURVEY AND MAPPING FOR OVERSEAS STUDENTS IN THE UNITED KINGDOM*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Les possibilités de formation offertes par les établissements universitaires du Royaume-Uni représentent une contribution importante au développement des techniques, des connaissances et des compétences dans le domaine du cadastre et des levés et permettent aux étudiants étrangers d'acquérir les qualifications nécessaires et d'obtenir des diplômes, maîtrises et doctorats sanctionnant leurs progrès.

Toutefois, la formation dans le domaine des opérations de levé et de la cartographie ne progresse pas de façon continue et, dans les cas où il n'existe pas de services sur place, nombre de départements ont du mal à fournir une formation de technicien appropriée qui comblerait l'écart entre le quasi-débutant et l'ingénieur diplômé. Au Royaume-Uni, cette formation peut être acquise au Service géographique de l'armée, qui a assumé la responsabilité de la formation qui incombait au Directorate of Overseas Surveys jusqu'en 1984. Cette formation porte principalement sur la cartographie et la photogrammétrie, mais d'autres disciplines peuvent également être choisies.

L'écart entre un opérateur qualifié et un bon administrateur de service topographique peut être comblé par les cours d'administration de niveau intermédiaire au North-East London Polytechnic.

Ces deux types de formation occupent une place importante dans la formation que les étudiants étrangers peuvent acquérir au Royaume-Uni dans le domaine des opérations de levé et de la cartographie, et ils peuvent être offerts soit dans le cadre du programme d'aide du Royaume-Uni aux pays en développement soit moyennant remboursement.

RESUMEN

La capacitación suministrada por las instituciones de enseñanza del Reino Unido aporta una importante contribución al desarrollo de las técnicas y los conocimientos en la esfera de los estudios de tierras y levantamientos, y permite a los estudiantes extranjeros obtener las calificaciones necesarias apropiadas para la medición de su progreso, con inclusión de diversos diplomas, grados y doctorados.

En el espectro de la capacitación en levantamiento y elaboración de mapas hay, sin embargo, lagunas que estos cursos no pueden colmar, y en ausencia de instituciones locales es difícil para muchos departamentos suministrar la capacitación adecuada al nivel de

* The original text of this paper appeared as document E/CONF 81/L 6.

técnico que permita al personal superar la distancia existente entre el nivel de un principiante y un curso conducente a la obtención de un diploma. Esa capacitación se halla disponible en el Reino Unido en el Ordnance Survey, que asumió las funciones de capacitación suministradas hasta 1984 por el Directorate of Overseas Surveys. La capacitación se ofrece principalmente en cartografía y fotogrametría, aunque se ofrecen también otras disciplinas.

Análogamente, la laguna existente entre el técnico debidamente calificado y el administrador eficiente de un departamento de estudios de tierras y levantamientos cartográficos puede colmarse mediante la capacitación ofrecida por la North-East London Polytechnic in Middle Management Techniques.

Ambos tipos de capacitación integran sectores importantes de la capacitación en levantamientos y elaboración de mapas ofrecida a los estudiantes extranjeros en el Reino Unido y pueden proporcionarse como parte del programa de asistencia del Reino Unido a los países en desarrollo, o sobre la base de los pagos apropiados.

SUMMARY

The training offered by academic establishments in the United Kingdom is an important contribution to the development of techniques, knowledge and skills in the field of lands and surveys, enabling overseas students to gain the necessary qualifications by which their progress can be measured, including various diplomas and degrees.

There are, however, gaps in the continuum of training in survey and mapping that these courses cannot fill, and unless facilities exist locally, many departments find it difficult to provide adequate training at the technician level that would enable staff to bridge the gap between the level of an almost complete beginner and a diploma course. Such training is available in the United Kingdom at the Ordnance Survey, which took over responsibility for the training provided until 1984 by the Directorate of Overseas Surveys (DOS). This training is principally in cartography and photogrammetry, although other disciplines can be covered.

Likewise, the gap between the well-qualified technical member of staff and the effective manager of a lands and surveys department can be filled by training at North-East London Polytechnic in middle-management techniques.

Both types of training form important sectors of training in survey and mapping available to overseas students in the United Kingdom, and can be provided either as part of the United Kingdom's aid programme to developing countries, or on a repayment basis.

It is essential to provide adequate training to staff to enable them to improve their skills and knowledge and to allow employers to develop staff to the benefit of the organization. This is as much true of a survey and mapping organization as of any other. Unfortunately, the specialist nature of that training, which has a significant requirement for expensive equipment, and the desirability for high teacher/student ratios, are often obstacles to the provision of training establishments in developing countries.

The United Kingdom has for a long time provided a wide range of opportunities for training of staff from survey departments throughout the Americas in all aspects of survey and mapping, from basic surveying and cartography, through photogrammetry, map reproduction and cadastre, to hydrographic surveying, land resource and management studies and remote sensing. Much of this training, sponsored by the United Kingdom as part of its overseas aid programme, is arranged by the British Council on behalf of the United Kingdom Overseas Development Administration (ODA).

A guide to this training was produced by the Overseas Survey Directorate (OSD) in July 1987 under the title *Full-Time Training Facilities in Great Britain for Overseas Students in Surveying, Photogrammetry, Cartography, Map Reproduction, Land Use and Other Related Subjects*. A revised edition

should be available from OSD early in 1989 covering courses to be offered from September 1989.

ACADEMIC ESTABLISHMENTS

Most training at establishments in the United Kingdom is principally academic, has quite stringent minimum entrance qualification levels, and will lead to an academic qualification. Such courses include the TEC (Technical Education Council) diploma and higher diploma courses in Surveying and Cartography at establishments such as Kingston College of Further Education, de Havilland College, Luton College of Higher Education and North-East London Polytechnic. At a more advanced level, under- and post-graduate courses in cartography and/or surveying are available to Glasgow and Newcastle Universities, and North-East London Polytechnic, among others, leading to a B.Sc./M.Sc. degree or a diploma.

Likewise TEC diploma courses in other specializations are available to overseas students in printing at the London College of Printing, and Watford College; in Hydrographic Surveying at Plymouth Polytechnic; and an offer at an increasing number of establishments, including Aston University and University College, London.

These examples are by no means a comprehensive account of all the teaching given in survey and mapping-related subjects in the United Kingdom and, in particular, make no mention of the many university geography and civil engineering departments which offer limited instruction in those subjects during a first-degree course.

In general, all universities and polytechnic courses are open to students from any country provided that the student has the necessary entry qualifications. Pressure on university places is, however, great and a student may need more than the basic qualifications in order to stand a chance of being accepted. Furthermore, all instruction is in English.

TECHNICIAN-LEVEL TRAINING AT THE ORDNANCE SURVEY

While these establishments provide a full range of courses leading to academic qualifications, they do not cater for the basic technician-level training which may not be available in overseas countries and which needs no particular academic entry qualification level. Up to 1984, such training was provided in the United Kingdom by the Directorate of Overseas Surveys (DOS) in Tolworth, Surrey; since 1984, the Ordnance Survey has assumed this responsibility. The Overseas Surveys Directorate (OSD) of the Ordnance Survey continues to advise upon and arrange training in survey and mapping, and the Overseas Training Section of the Ordnance Survey's Training Division continues to provide basic technician-level training for overseas students in cartography and photogrammetry.

The training offered by the Ordnance Survey is essentially practical; no academic qualification is obtained although a Certificate of Practical Competence is awarded, identifying those subjects in which students have achieved practical proficiency during their course.

Courses are individually designed to suit the particular needs of the student in question by combining relevant units from those described in annex I. The time periods indicated against each unit are for guidance only and relate to the time it would take for the average student to complete that unit. As each student's course is individual, students can study at their own pace without affecting, or being affected by, the progress being made by other students, and need only cover topics of relevance to their particular requirements.

The duration of the student's course is dependent upon the number of units that are combined to make up the full programme, which can last for anything between 3 and 18 months.

If the student also requires training in subjects not covered by the units listed in annex I, such as reproduction and printing, it is often possible to arrange for training within production areas of the Ordnance Survey for limited periods as part of the overall course.

Training in automated cartography and the uses of satellite imagery and remote sensing can also be incorporated into the course programmes, as necessary.

The training is generally arranged on a Government to Government basis, and most students are funded by United Kingdom technical cooperation awards through the British Council. Applications for such awards must be made by the prospective student's Government to the local British Council representative, or where there is none, to the British Embassy or High Commission. United Kingdom awards will not normally be made if suitable training facilities are available locally or regionally.

Otherwise training for overseas students can be arranged for any organization on a repayment basis, for which the fee

at present is 350 pounds sterling per student per week, exclusive of travel, accommodation and living costs. Training cannot be arranged for individuals applying personally without an official nomination by an established organization.

Annex II shows the courses provided to trainees from the Americas between January 1985 and December 1988. Most courses were in cartography, with one in photogrammetry. Technician-level training in surveying is only very rarely provided; with the great emphasis on practical training in basic surveying, it is best done locally or regionally in topographical conditions similar to those of the student's locality, rather than in the developed environment of the United Kingdom.

MIDDLE-MANAGEMENT TRAINING

At the other end of the scale, it is often forgotten that good academic qualifications do not necessarily prepare staff for the management of lands and survey departments. To fill this important gap, the North-East London Polytechnic has for several years (on a biannual basis) held a three-month course in middle management for staff in lands and survey departments. The aim of this course is to provide training in management techniques as related to lands and survey departments. The last two courses were held in 1986 and 1988, and it is anticipated that another will be held in 1990.

A copy of the course specification for the 1988 course just completed is attached in annex III, and a list of the departments from the Americas which sent trainees on the courses in 1986 and 1988 is in annex II.

Inquiries for the 1990 course should be directed through the British Council (if technical cooperation funding is being requested) or through OSD of the Ordnance Survey.

CONCLUSION

The ability and progress of staff in the modern world are often measured only by the qualifications they have gained, but paper qualifications do not necessarily qualify them to perform their jobs to the best of both their and their employer's advantage.

A general exposure to practical skills without the pressure of examinations can often develop the abilities of a staff member who might otherwise stagnate and be ineffective in his department. DOS and now the Ordnance Survey have for many years provided the opportunity for such training, the benefits of which have been acknowledged by many overseas survey departments.

It would also be wrong to assume that a paper qualification on its own will fit someone to manage the resources and production of a survey department, particularly the management of staff, which is a department's most crucial resource. The middle management course at North-East London Polytechnic provides an opportunity for senior staff from overseas departments to be given an important exposure to modern management skills and practices.

While neither of these types of training results in an academic qualification, they can be of as much benefit to a department's needs as the longer-duration diploma and degree courses. The value of the investment made by the use of funds or a technical cooperation award in sending a member of staff for such training should not be underestimated. The technician-level training provided by the Ordnance Survey and the middle management course of the Polytechnic together help to complete the picture of a comprehensive training programme in survey and mapping which is available to overseas students in the United Kingdom.

ANNEX I

Training courses in the Overseas Training Section

Course members Mainly cartographers with varying experience, grades ranging from carto-assistants to senior grade cartographers. Other disciplines may be accommodated, such as photogrammetry.

Entrance requirements No particular academic qualifications are needed. Students must have some very basic practical experience and aptitude in cartography and/or photogrammetry.

Duration Anything from three months to more than a year. Shorter courses can be arranged in very specialist subjects, but British Council funding is not given for courses of less than three months.

Timing By arrangement (depending on student's departmental release date). After an English course (if necessary). When a place is available.

Fees All courses are for the same basic fee, with the exception of units 33, 34 and 38 for which a separate fee is payable.

Aim To expand theoretical knowledge and improve practical skills by providing acceptable techniques in the various aspects of cartography and/or photogrammetry.

Subjects covered All courses are compiled using as many of the training units as is necessary to fulfil the requirements of the student's Government or department in the time allocated. The training units are listed below. Virtually all the training is conducted within the Overseas Training Section of the Ordnance Survey's Training Division. Any advanced techniques are satisfied by attachment to production sections or external organizations.

TRAINING UNITS

All units contain talks, demonstrations and practical exercises.

The first three units, which are included in virtually every student's programme, are used as a basis for assessment of the student's technical and practical abilities. If the student's standard is low, extra time is given to these basic skills and the course content is amended.

Unit 1 Drawing to specification (2 weeks)

Assessing the student's capabilities in the use of technical, graphos and ruling pens on modern draughting media, using drawing aids and guides to simple specifications.

Unit 2 Scribing to specification (2 weeks)

Assessing the student's capabilities in the use of tripod and pen type scribing point holders with round, chisel and double cutting points on modern scribing media to simple specifications.

Unit 3 Plotting and construction (2 weeks)

Assessing the student's capabilities in: simple line division and diagonal scale construction; calculation of scales and R/F and scale bar construction; construction of metric grid and graticule; plotting and reading rectangular coordinates; coordinatograph grid construction and plotting coordinates.

The rest of a student's programme is compiled from any suitable combination of units 4-40.

Unit 4 Combined positive scribing (2 weeks)

Preparation of a two-colour topographical map. Scribing black and blue detail on white astrafoil, production of a combined positive, colour separation onto two negatives, and production of a two-colour plastic proof.

Unit 5 Introduction of topographical mapping (2 weeks)

Production of a four-colour, gridded topographical map at a scale of 1:50,000 from supplied compilation material, specifications and a prepared grid, using stabilene scribing material and out-n-strip masking negatives. Preparation of a production flow-line for the procedure.

Unit 6 Monochrome thematic mapping (3 weeks)

Preparation of a monochrome land-use map from a supplied land-use compilation using stripping film positives of dots, rulings, patterns and textures.

Unit 7 Introduction to three-coloured method—multicolour thematic mapping (3 weeks)

Preparation of a geological map, using line screens, from colour breakdown lists, through colour guides and all cartographic processes to negative proof stage. For this exercise, the black base positive and peelcoat negative masks are prepared by the instructor.

Unit 8 Multicoloured thematic mapping (5 weeks)

Preparation of a thematic map using a wide range of colour selections. An advanced three-colour exercise in which the student produces every stage up to the final negative proof.

Unit 9 Scribing for dyeline reproduction (1 week)

Initial scribing (positive reading) on a polyvinyl-based scribecoat, such as DEP Astrascribe. After completion, application of Astrascribe positive black dye to all image areas. Removal of surplus with white spirit. Removal of scribecoat with methylated spirit. Type patching of resultant positive, ready for final diazo (dyeline) copies.

Unit 10 Instrumental plot finalization (1 week)

Completion of a large-scale instrumental plot for two colours (or monochrome) reproduction. Registration of detail and contour overlays with instrumental plot. Pencil draughting of the detail to a given specification. Patching type and footnote variables. Production of a combined positive by a diazo process.

Unit 11 Layer tints (1 week)

Preparation of a topographic map incorporating layer tints. Selection of layer tint colours and production of colour guides for negative masks. Negative retouching of black, blue, red and brown detail negatives. Preparation of layer tint masks and ordering of appropriate percentage dot screens. Use of Protocol stud register for the negative proof.

Unit 12 Introduction to hill shading (2 weeks)

Shading three-dimensional figures, and hill shading a section of a map. More advanced base maps are available if student requires an extended course in hill shading.

Unit 13 Text maps (2 weeks)

Understanding the use of text maps, diagrams and figures as a means of illustrating reports. Preparation of a two-colour thematic text map (A4 size) based on map base and theme material supplied by specialists. Use of negative masks, percentage dot screens, rulings and symbols.

Unit 14 Negative scribing five-colour topographic mapping (5 weeks)

Production of a five-colour topographical map up to negative proof stage from a field-revised photogrammetric plot. Stages include negative scribing, positive type patching, final line negatives and negative masks.

Unit 15 Map compilation (3 weeks)

Calculation and construction of an accurate graticule and grid plot, and on this plot, compilation of detail derived from maps drawn on similar or other projections, to a final compilation which would be acceptable for use as a scribing key. Preliminary talks on size and shape of the earth, spheroids, projections and rectangular referencing systems. Conversion of geographical coordinates using UTM grid tables and calculation of grid convergence and magnetic declination for any sheet. Production of a derived map compilation, including the evaluation, extraction and generalization of data, using pantograph, plan variograph, and coordinatograph.

Unit 16 Map revision (4 weeks)

Demonstration of the various methods of revising maps from new air photography. Graphical and mechanical methods of plane and radial line revision are discussed and four practical exercises are undertaken:

(a) *Plane revision (graphical)*. Use of the perspective grid to transfer detail from air photographs to existing monochrome map using proportional dividers;

(b) *Plane revision (mechanical)*. Use of the Stereosketch to add detail to an existing map;

(c) *Radial line revision (graphic)*. Resection of the positions of principal points to locate accurate positions of the principal points of new photography, and the subsequent addition of revision detail;

(d) *Photodrawing*. Revision or correction to detail on negative or positive reproduction material.

Unit 17 Atlas mapping (5 weeks)

Principally designed for students whose departments are actually engaged in atlas mapping; completion of units 1, 2, 3, 7, 8, 11, 12, 13, 15, 16, 18, 19, 31 and 34 is necessary before this unit is attempted. Initial talks are given on page and printing layout, binding, borders, margins, index and gazetteer. Practical exercises include transferring from maps at various scales and from statistical sources, onto a unified atlas mapping series, and the necessary decisions on the cartographic depiction of the data. The number of atlas maps dealt with depends on the speed of the individual student. A shortened course of two weeks' duration is available for students whose needs are not so detailed.

Unit 18 Statistical mapping (2 weeks)

Talks and demonstrations of statistical graphs, charts, diagrams and maps. Practical exercises include:

- (a) Statistical line and bar graphs;
- (b) Divided circle (pie chart) or divided semicircles;
- (c) Choropleth map (population density).

Unit 19 Map design and specifications (5 weeks)

This unit is undertaken near the end of a student's course since it effectively brings together many of the skills developed in earlier units. Initial talks cover the purpose of the map, constraints affecting design and the design elements which must be studied before the design components of colour, symbols, type, etc. are selected. The practical exercise is a map produced to negative proof stage, from an existing map series, using the student's own map design specifications. The student is able to take the negative proof back to his department at the end of his course as the culmination of his training.

Unit 20 Tourist mapping (5 weeks)

Production of a multicoloured map with particular reference to items of special interest to the tourist. A basic topographical mapping procedure with the addition of tourist information.

Unit 21 Print laydowns and mosaics (1 week)

Production, after tuition, of a print laydown and an uncontrolled mosaic.

Unit 22 Photomapping (7 weeks)

Production of a 1:50,000 photomap using current production stages and techniques as practised by OSD.

A shorter introductory course (1 week) is available. This outlines current OSD photomapping techniques, but practical content is limited to examination of photomapping components, basic retouching of photomosaics and preparation of a production flow chart.

Unit 23 Field revision (1 week)

Revision of existing maps using basic survey equipment and an appreciation of the basic differences between field revision and field completion. The basic survey equipment includes surveyor's chain, steel and linen tapes, optical square and Abney level. The practical exercise consists of booking detail, taking offsets and plotting the field completion to assess its position.

Unit 24 Introduction to flight planning (1 week)

The design and production of a flight map and a flight planning data sheet. Stages are: calculation of average ground height, flying height, distance between flight lines, and distance between exposures; and selection of direction of flight. Practical use of flight planning monograms and flight planning calculator.

Unit 25 Introduction to ground control planning (1 week)

Preparation and drawing of a control planning diagram, after theoretical talks covering the following aspects:

- (a) Purpose for which ground control is required;
- (b) Types of ground control and methods of survey;
- (c) Relationship between control distribution and accuracy of aerotriangulation;
- (d) Distribution of control in relation to air cover;
- (e) Use of tie strips.

Unit 26 Photographic interpretation (2 weeks)

Purpose, requirements and techniques of photointerpretation of differing terrain at various scales, to include man-made and natural topographical features. This is performed on a mirror stereoscope.

Unit 27 Assessment of aerial photography contracts (1 week)

The student receives instructions on the procedures for visual examination of aerial photography flown under contract and then demonstrates the ability to assess such photography.

Unit 28 Graphical adjustment and plotting for single strip of photography (3 weeks)

Construction of a minor control plot from a strip of eight vertical air photographs and adjustment of this plot to a known scale. Photo-interpretation and transferring this interpretation from photos to the scale plot by graphical radial line plotting.

Unit 29 Slotted template assembly (3 weeks)

Preparation of slotted templates using overlapping strips of photography and construction of these templates into a slotted template assembly onto a scaled grid base. Photo-interpretation and transferring this interpretation from photos to the scaled plot by the mechanical radial line plotting.

Unit 30 Parallax bar (1 week)

Study of the practical applications of a parallax bar in conjunction with a mirror-type stereoscope. Practical exercises include measurement of object heights on large-scale photography, study of the effects of phi and omega tilts on a stereoscopic overlap, and the computation of the heights of a series of unknown points given two known height points on a stereoscopic pair of photographs. A profile of ground shape is then plotted.

Unit 31 Area measurement (1 week)

Practical exercises to specified accuracies showing basic methods of area measurement from maps of various scales, with appreciation of the relative accuracy of each method. After using a rapid and approximate method involving geometrical shapes, three more accurate methods are used: transparent dot overlays, hatchet planimeters and zero setting polar planimeter ("pole in" and "pole out" methods).

Unit 32 Introduction to photogrammetric instruments (3 weeks)

After introductory talks on the geometric model, "x" and "y" parallax, and methods of performing inner relative and absolute orientation, numerous practical exercises are performed. These include simple movements on a multiplex instrument to demonstrate the basic geometry of a stereoscopic model and the principles of a stereoscopic plotter, followed by the setting up of a PG2 instrument and the plotting of detail and contours to a specified scale.

Unit 33 Advanced course on photogrammetric instruments (3 weeks)

This unit is undertaken in a production area (Photogrammetric Services) and is subject to a separate training fee. More advanced exercises on a stereo-plotter are followed by aerotriangulation for height on a PG2 and a graphical height adjustment on the subsequent result. Next, aerotriangulation is undertaken on a WILD B8 and finally a test/check performed on a stereoplotting instrument.

Unit 34 Introduction to photographic processes (1 week)

This external course is provided at Southampton Institute of Higher Education and is usually held in July. It is subject to a separate training fee. Theoretical and practical work on process camera, contact printing and negative proofing, to enable the student to appreciate the vital cooperation required between cartographer and photographer.

Unit 35 Photodrawing (now incorporated in unit 16)

Unit 36 Form lining (1 week)

Theoretical talks given on general principles of form lining, its applications and advantages and disadvantages. As a practical exercise a stereo model containing heighted control points derived from parallax bar readings is form-lined, and the result is compared with a contoured map of the same area.

Unit 37 Instrumental plot preparation using a coordinatograph (1/2 week)

Selection of data to be plotted from aerial triangulation computer printout, control lists or preparation control diagram. Plotting of grid and all points from coordinate lists and sheet registration by hand drill.

Unit 38 Introduction to photogrammetric preparation (3 weeks)

This unit is undertaken in a production area (Photogrammetric Services), is usually combined with unit 33, and is subject to a separate training fee.

Production of a preparation control diagram (PCD) containing principal points, strip limits, sheet corners and geographicals. Transfer of ground control points to working prints. Marking their positions on the PCD.

Selection of principal points on a photograph, marking and annotating on PCD. Selection of aerotriangulation points on photography and transfer of film positives using a point transference instrument (WILD PUG4).

Preparation of control point, height point and base length lists.

Unit 39 Introduction to training methods (1 week)

This is undertaken in the Management Training Section of the Ordnance Survey Training Division. Design, preparation and presentation of a correctly structured training session using modern instruction techniques, including preparation of visual aids.

Unit 40 Management (introduction to basic elements) (1 week)

This unit is undertaken in the Management Training Section of the Ordnance Survey Training Division. Participation as an individual and as a member of a group in a variety of problem-solving and role-playing situations, after initial talks. Unit is concluded with an evaluation session.

VISITS

All students visit DEP (Tadworth) Ltd to see the range of cartographic tools and materials produced by this company.

Geological students and students interested in small-scale automated thematic cartography visit the British Geological Survey at Keyworth, Nottingham, while students with interests in cadastral mapping visit the offices

of H M. Land Registry, Weymouth. Students from census departments visit the United Kingdom Office of Population Census and Statistics, Titchfield, Hampshire.

All students undergoing training in October/November of each year visit the Graphics Exhibition, Olympia, London, on a one-day study trip.

ANNEX II

Trainees from the Americas

At Ordnance Survey, January 1985–December 1988

	<i>Started</i>	<i>Finished</i>	<i>Months in periods</i>	<i>Type of training</i>
Bolivia	(Before January 1985)	April 1985	4	Cartography (Geology)
Bolivia	July 1986	June 1987	12	Cartography (Geology)
Dominica	March 1985	December 1985	10	Cartography (Topography)
Dominica	September 1988	(After December 1988)	4	Cartography (Topography)
Saint Lucia	January 1988	July 1988	6	Cartography (Topography)
Saint Lucia	January 1988	July 1988	6	Photogrammetry
Turks and Caicos Islands	September 1988	(After December 1988)	4	Cartography (Topography)

Lands and surveys staff from the Americas sent to North-East London Polytechnic for middle-management training, 1986 and 1988 (one staff member each).

Anguilla	Lands and Surveys Department	1986
Belize	Lands and Surveys Department	1986
British Virgin Islands	Land Registry	1986
Jamaica	Survey Department	1988
Saint Vincent and the Grenadines	Lands and Surveys Department	1986
Turks and Caicos Islands	Land Survey Department	1988
Turks and Caicos Islands	Land Registry	1988

ANNEX III

Middle management for staff in lands and survey departments, 1988: North-East London Polytechnic

COURSE SPECIFICATION

Aim of course

To provide a training in management techniques related to the individual's role in a lands and/or survey organization. This implies a high level of personnel and resource management, the preparation of briefs for policy-making authorities, and decision making within existing policy constraints.

Course objectives

On completion of the course the successful student will, within the context of his or her organization:

- (i) Have an extended knowledge of modern techniques of personnel management in terms of the psychology of management and labour relationships, and the legal framework governing employment;
- (ii) Have improved his or her abilities to work as part of a management team in making and implementing decisions collectively made;
- (iii) Have an extended knowledge of techniques of resource control and operational methods within a department;
- (iv) Have developed improved skills in utilizing, in management terms, modern equipment;
- (v) Have improved his or her techniques in communication at both the written and verbal levels; in particular, have developed techniques of communication relevant to policy-making decisions;
- (vi) Have improved his or her skills at effective decision-making within policy constraints.

DETAILS

- (i) *Duration and form* 1 introductory week and 11 further weeks
- (ii) *Dates for the course* 25 April–15 July 1988
- (iii) *Cost* During the course there is a project which may involve additional travel and other costs of the order of 350 pounds sterling (£). Tuition costs £2,000, plus £500 for the probable residential period and project. The total fee is therefore £2,800.

(iv) *Numbers* Between 8 and 20 students

(v) *Structure* All participants will follow all aspects of the course, although there will be a flexibility of programme to allow for specialist interest and requirements to be followed in depth.

CONTENT OF COURSE

Orientation

Assembly: "Living in the Polytechnic, in London, in the United Kingdom". Meet staff. The United Kingdom surveying industry and profession. Student integration.

Introduction in management

This is an introductory module which lays the foundation for further management components that will appear later in the course. Course members will examine the nature of basic concepts and the main functions of management. Included will be the financial aspects of management and the management of human resources. The group will explore their management problems so that they may be studied in depth in later modules.

Land management and survey technology

This course will first provide an understanding of basic surveying and mapping, including production of site plans, building sketches, interpretation of existing maps and aerial photographs. The second component of this module will relate land law and registration (Deeds and Title) to land and land ownership. The basic principles of English law will be studied with a limited study of other systems, e.g., Roman Sharia, Customary. Thirdly, those aspects of practice and law relating to acquisition of land for public purposes, leasing of public land and elementary property management existing in the United Kingdom and in the students' countries will be examined.

A fourth aspect of this course will be designed to provide an updating of modern surveying technology. It will concentrate on principles and a broad understanding of methods rather than detail. The application of a knowledge of errors to the planning and organization of survey operations will enable a number of modern instruments to be studied. Particular attention will be paid to the calibration of various electronic distance measuring instruments.

The various approaches to revision will be explored, viz cyclic continuous and periodic revision.

Control and mapping activities will be placed in the context of management decisions and in particular the effective deployment of staff and equipment. In this respect modern photogrammetric and cartographic methods will be examined. Modern methods of calculation and the effective use of the small calculator will be studied. Also a limited study will be made of satellite Doppler, inertial surveying systems and other modern position-fixing devices.

Administration

Within the context of the organizations which employ the course members, various administrative activities will be examined:

(i) Organization of an office and maintenance of records—including modern methods of record-keeping, supervision and reports from subordinates, progress of work, flow-lining and critical path analysis;

(ii) Microfilming of records, modern systems of map storage and computerized records. Methods of control of finance, resources and staff will be examined in terms of various organizations.

Applications of administration, technology and land management to lands and surveys

There will be an introductory study of simple economics and the relationships of land use, land value and planning in the United Kingdom and in students' countries, to be followed by:

(i) *Valuation*. Principles and methods; meaning of value; limitation of valuation of various interests in land; valuations for specific purposes, e.g., rating, taxation and/or the assessment of duties; compulsory valuation of urban land, rural land and crops; principles of acquisition and assessment of compensation. Basic consideration of town planning.

(ii) *Costing and control of surveys*. Standards quality control, economics of mapping and revision; labour and equipment control and overheading; marketing and commercial aspects of surveying; financial control; costing, commissioning and monitoring of commercial mapping and survey contracts.

Project

The course will be divided into mixed groups of four or five persons, to undertake a series of small projects that bring together the essential features of the previous modules and which have particular relevance and interest to the participants, their employment position and wider interests.

In addition, each student will present his own project for discussion and evaluation. Individual projects will be the result of a prolonged study during the last eight weeks of the course. To enable the individual projects to be helpful to parent departments and countries, all candidates should provide, before the course, details of the organizational structure of their department, and all other "local" information and documentation required for the development of their project. The project content will be the choice of the individual, but will be supervised and directed by staff. Typical projects may be:

Stores management and distribution

Surveys for engineering purposes, and how the existing systems may be improved

The system of land administration in . . .

Land tenure in uncontrolled settlements

The cadastre as a basic information system for land reform

Improving boundary marking in rural areas

Land use control

Farmer squatter settlements

The potential use of desktop computers in . . .

Capital investment in lands and surveys departments

The need and cost of local and overseas training

The operation and maintenance of modern expensive equipment

The direct use of photographs and remotely sensed data in developing countries

Acquisition, cataloguing and maintenance of technical libraries

The need for publicity of land and surveys work: liaison with other government departments, developers, press and public

Critical evaluation of the first seven years of land registration in . . .

Establishment of a computerized land data bank in . . .

The use of aerial photography in land use mapping and resource management

Design and implementation of a multipurpose cadastre in . . .

Upgrading of urban squatter settlements

AGENDA ITEM 7

Technical assistance and transfer of appropriate and affordable technology

TECHNICAL ASSISTANCE*

Paper submitted by the International Hydrographic Organization (IHO)

RÉSUMÉ

En vertu de son statut, le Bureau hydrographique international (BHI), implanté à Monaco, fournit sur demande des directives et des conseils sur toutes les questions ayant trait à l'hydrographie, en particulier aux pays qui s'emploient à créer ou à élargir des services hydrographiques nationaux, que ce soit pour accroître la sécurité de l'ensemble des activités de transport maritime dans les eaux de leur ressort ou pour faciliter la mise en valeur de leurs ressources marines. L'OHI finance le déplacement d'hydrographes dans tout pays, membre de l'OHI ou non, qui fait une demande en ce sens.

La procédure à suivre est décrite dans le document d'information de l'OHI n° 6, Assistance technique, disponible en espagnol et en français en s'adressant à IHB, BP445, Monaco MC 98011.

Lorsque leur présence est sollicitée, les hydrographes du BHI organisent leur déplacement dans le pays demandeur — qui n'aura à prendre à sa charge que les déplacements intérieurs de l'hydrographe sur son sol — afin :

- a) D'expliquer à tous les responsables des activités maritimes la nécessité de créer ou de renforcer des capacités hydrographiques nationales.
- b) De se rendre auprès de toutes les organisations nationales ayant des responsabilités dans le domaine maritime
- c) De recommander les modalités d'organisation les plus appropriées en faisant fond sur les services existants.
- d) De procéder à une première évaluation des installations existantes et des besoins minimaux en personnel, équipement, formation, etc.
- e) De prendre des dispositions en vue d'organiser un séjour complémentaire dans les deux années qui suivent.

Dans le cas où les autorités d'un pays décident de donner suite aux conseils de l'hydrographe, le BHI lui fournira une assistance en vue d'établir un descriptif de projet à intégrer dans le plan national du pays en question, et de solliciter l'assistance de bailleurs de fonds internationaux ou bilatéraux. En ce qui concerne les demandes d'assistance technique dans le domaine de l'hydrographie, il importe de les coordonner tant sur le plan intérieur, en créant un comité hydrographique national, qu'extérieur, en assurant une liaison avec les différentes organisations internationales et nationales d'aide.

Le BHI s'emploie à constituer un catalogue mis à jour des programmes de formation et d'assistance technique dans le domaine de l'hydrographie proposés par les Etats membres de l'OHI et, en liaison avec la Fédération internationale des géomètres, à améliorer la coordination de l'assistance technique dans ce domaine.

RESUMEN

La Oficina Hidrográfica Internacional (OHI), con sede en Mónaco, en cumplimiento del mandato encomendado por la Convención que la creó, proporciona orientación y asesoramiento en todos los temas de hidrografía a solicitud de los interesados, en especial de los países que se ocupan de establecer o ampliar los servicios hidrográficos nacionales, tanto para reforzar la seguridad de la navegación en sus aguas jurisdiccionales como para facilitar el desarrollo de sus recursos marinos. La OHI ha financiado diversas visitas de expertos en hidrografía a los países que lo solicitan, sean o no Estados miembros.

Los procedimientos que han de seguirse figuran en el Boletín Informativo No. 6 de la OHI, titulado "Asistencia técnica," que se puede obtener en español y en francés en IHB, BP445, Monaco MC 98011

* The original text of this paper appeared as document E/CONF 81/L 8.

Al recibir la solicitud de una visita, un experto de la OHI llevará a cabo todos los trámites necesarios, sin costo alguno para el país, salvo el correspondiente a los viajes internos. Las visitas cumplen los siguientes propósitos:

- a) Explicar a todas las personas que se dedican a las actividades marinas la necesidad de establecer o fortalecer la capacidad del país en materia de hidrografía;
- b) Visitar a todas las organizaciones nacionales que se ocupan de las actividades marinas;
- c) Recomendar la organización más adecuada de los servicios existentes;
- d) Realizar una evaluación inicial de los servicios existentes y de las necesidades mínimas de personal, equipo, capacitación, etc.;
- e) Organizar una visita complementaria dentro de los dos años siguientes.

Si el país decide seguir el consejo del experto, la OHI lo asistirá en la elaboración de un proyecto de documento que formará parte del plan nacional del país, así como en los trámites necesarios para solicitar asistencia de fuentes internacionales o bilaterales de financiación. ~~Es importante que las solicitudes de asistencia en materia de hidrografía se coordinen, tanto en el plano interno, mediante la creación de un comité hidrográfico nacional, como en el plano externo, con diversas organizaciones internacionales y nacionales de ayuda.~~

La OHI está haciendo acopio de información actual sobre los programas de asistencia técnica y capacitación en hidrografía emprendidos por sus Estados miembros y se ha vinculado con la Federación Internacional de Agrimensores con el objeto de fortalecer aún más la coordinación de la asistencia técnica en la materia.

SUMMARY

The International Hydrographic Bureau (IHB), based in Monaco, is required by its Convention to provide guidance and advice on all hydrographic matters, upon request, in particular to countries engaged in setting up, or expanding, national hydrographic services—both to enhance the safety of all shipping in their waters and to facilitate the development of their marine resources. The IHO has provided funds to enable visits to be made by hydrographic experts to any country, whether an IHO member State or not, requesting such visits.

The procedures to be adopted are described in IHO information paper 6, "Technical assistance", which is available in French and Spanish, from the International Hydrographic Bureau, BP445, Monaco, Monte Carlo 98011.

On receiving a request for a visit, an IHB expert will arrange to visit the country—at no cost to the country other than for internal travel—with a view to:

- (a) Explaining to all those with responsibility for marine activities the need for establishing or strengthening the country's hydrographic capabilities;
- (b) Visiting all the various national organizations with marine responsibilities;
- ~~(c) Recommending the most suitable organization, building on existing services;~~
- (d) Making a first assessment of existing facilities and the minimal level of personnel, equipment and training required;
- (e) Arranging a follow-up visit within two years.

If a country decides to follow up the expert's advice, the IHB will assist in processing a project document, as part of the country's national plan, and in applying for assistance for international or bilateral funding. It is important that requests for hydrographic technical assistance should be coordinated both internally by the formation of a national hydrographic committee and externally to various international and national aid-giving agencies.

The IHB is building up a repository of current information on hydrographic training and technical assistance programmes initiated by IHO member States and, in liaison with the International Federation of Surveyors, is further improving the coordination of hydrographic technical assistance.

The Convention of the International Hydrographic Organization (IHO) gives the International Hydrographic Bureau (IHB) responsibility for providing guidance and advice on all hydrographic matters, upon request, in particular to

countries engaged in setting up or expanding their hydrographic service, in order to enhance the safety of national and international shipping in their waters, thus reducing the risks of pollution of their marine environment.

At their International Hydrographic Conferences, which take place every five years, IHO member States have approved various IHO technical resolutions (TR) concerning technical assistance (including training) in the field of hydrography, including resolutions TR 4.1 (Technical assistance in the field of hydrography); TR 4.2 (Hydrography in developing countries); and TR 4.3 (Training and technical assistance in developing countries). These resolutions are shown in the annex to this report.

In order to provide this important service, the IHO has allocated funds in each of the years 1988 and 1992 to enable visits to be made by experts in the fields of hydrographic surveying and nautical charting to any country — whether an IHO member State or not — requesting such visits.

Following adoption of technical resolution TR 4.1 in 1982, the Directing Committee of the IHB formulated procedures for the effective implementation of these resolutions and was able to report to the 1987 Conference that in the five years 1982-1987 a total of 16 maritime States had been visited by representatives of the IHB; reports had been written and, in many cases, draft technical assistance project documents had been prepared for further action by the State concerned.

The Directing Committee is at present studying how best to improve its activities in this important area, bearing in mind that it would probably be ineffective to visit a country uninvited, or unless a comprehensive programme had been agreed in advance so that all of the many organizations with an interest in the total marine environment could be visited.

The procedures to be adopted will entail the following stages:

(a) The IHB will contact all of its 57 member States, reminding them of the assistance available to developing hydrographic offices under TR 4.1 and TR 4.2 and of the part which member States can play in accordance with TR 4.3;

(b) The IHB will contact all those non-member States listed in the IHO *Yearbook* and those not yet included in the *Yearbook*, informing them of the availability of the services of the IHO and the IHB in providing technical assistance (including professional and technical training);

(c) The IHB will continue to work in close cooperation with the International Maritime Organization (IMO) to ensure that IMO's technical representatives raise the question of the development of hydrography during their assignments and, where necessary, include the subject in their reports and inform the IHB so that early information would be available as to where assistance is needed;

(d) On receiving a positive request from a country wishing to develop its hydrographic surveying or nautical charting capability, one of the IHB staff will arrange to visit the country — at no cost to the country other than for travel within the country — with a view to:

(i) Explaining to all those with responsibility for marine activities the need for establishing or

strengthening the hydrographic capability of the country;

(ii) Visiting the various national organizations with marine responsibilities;

(iii) Recommending the most suitable organization for the various hydrographic and nautical charting tasks, taking into account the unique services available in the country;

(iv) Making a preliminary assessment of the facilities already available and the minimal level of equipment, personnel, training etc. required in the country to meet its hydrographic and nautical cartographic needs;

(v) Arranging a date for a subsequent visit within a maximum of two years;

(e) Should the developing country decide to follow up the preliminary assessment, the IHB will, on request, assist in the preparation and finalization of a project document for further processing by Governments as part of their national development plans. The IHB will also assist, where possible, in the procedures involved with the subjects of hydrographic surveying and nautical charting in the technical cooperation agreements it has with developed countries (such as TR 4.3); or in the "country plan" for the current, or next, UNDP cycle; or in agreements with other aid-giving agencies, such as the World Bank, the Colombo Plan, the Commonwealth Fund for Technical Co-operation, Norwegian Aid (NORAD) or the Canadian International Centre for Ocean Development (ICOD) etc.;

(f) Once a project document has been finalized, the IHB will notify its member States so that any developed country may take any action possible to assist in the project, which should then be progressed through normal diplomatic channels, keeping the IHB informed;

(g) The IHB will request a further visit to the country about 12 months after the original visit to monitor progress and offer any further advice needed.

The IHB is taking steps to build up a repository of current specific information on hydrographic training and technical assistance programmes available from member States in accordance with paragraph 4 of TR 4.3, and further information papers will be published.

The IHB is also taking steps to liaise with Commission IV (Hydrography) of the International Federation of Surveyors (FIG) with a view to coordinating with FIG and the national hydrographic offices any technical assistance and training that may be undertaken by the non-governmental organizations, agencies, industry, and training establishments in various parts of the world.

While the above procedures envisage initial action by the IHB, it is hoped that developing countries will feel free to approach the IHB at any time. If an individual member State is approached by a developing country, the IHB should be kept informed so that the IHB repository may be kept up to date.

ANNEX
Extracts from technical assistance resolutions of
the International Hydrographic Organization

4 1 Technical assistance in the field of hydrography

1. It is resolved that, in accordance with articles II and VII (e) of the Convention on the International Hydrographic Organization, the IHB should take every opportunity to remain in the forefront of organizations acting as the source of technical advice and as a coordinating body for the promotion of measures aimed at establishing and/or strengthening the hydrographic capabilities of developing countries through cooperative programmes and other appropriate means, upon request by the recipient countries

2. It is further resolved that the IHB shall actively assist developing countries in establishing or strengthening their hydrographic capabilities in a suitable manner, including the following:

(a) By notifying countries and appropriate international organizations that it serves as a primary source of technical advice in hydrography;

(b) By arranging for experts from the Bureau or member States to visit developing countries, upon request, in order to:

(i) Assess the existing facilities and needs;

(ii) Advise on measures that can be taken to establish or strengthen hydrographic capabilities including the identification of the most appropriate national structure;

(c) By maintaining an inventory of all training courses on hydrography by updating SP 47 periodically;

(d) By providing guidance on the method of establishing a hydrographic service, including cartographic facilities;

(e) By investigating the availability of funding from international organizations and providing advice to developing countries on the formulation of projects;

(f) By encouraging and subsequently following the development of bilateral arrangements between countries having well established hydrographic offices and those desiring to establish hydrographic capabilities

3. The Directing Committee is invited to report annually to member States on measures taken regarding the above-mentioned actions

4 2 Hydrography in developing countries

The XIth Conference.

Recognizing that many member States do not yet have adequate hydrographic facilities,

Further recognizing the urgent necessity of establishing full national capabilities to meet the growing need for modern hydrographic survey and charting programmes.

1. Strongly urges that developing member States give urgent consideration to establishing or expanding their hydrographic capabilities, if necessary by applying — through their respective Governments — for assistance which is available from UNDP, or by entering into bilateral arrangements with developed member States

4 3 Training and technical assistance to developing countries

The XIth Conference.

Realizing the need for cooperation of all maritime countries to meet the expanding requirements for hydrographic surveying and nautical charts and publications.

Realizing further the urgent need for training of hydrographic personnel of developing member States and other developing nations.

Noting that training and technical assistance, both extended on a bilateral basis and sponsored through programmes of international organizations, are expeditious and effective means of accomplishing these aims.

1. Urges the member States with developed hydrographic facilities to give favourable consideration to requests for training and technical assistance from new and developing member States;

2. Urges all member States to seek opportunities to advise officials of new or developing nations of the work of the IHO;

3. Recommends that developed member States offering scholarships, technical assistance and training programmes should forward the details of such scholarships and programmes to the IHB;

4. Resolves that the IHB shall maintain a repository of current specific information on hydrographic training and technical assistance programmes available from member States for dissemination to all members and other inquiring nations, in accordance with article VIII of the Convention

**UNITED NATIONS INTERREGIONAL SEMINAR ON INTRODUCTION
OF MODERN MAPPING TECHNIQUES***

(Hønefoss, Norway, 14-20 September 1988)

Paper submitted by Norway

RÉSUMÉ

Un séminaire interrégional de l'ONU sur les techniques cartographiques modernes s'est tenu du 14 au 20 septembre 1988 dans les locaux du Service cartographique norvégien à Hønefoss.

S'adressant au personnel technique d'encadrement des services de levés et d'établissement de cartes nationales dans les pays en développement, il a eu pour principal objectif de contribuer à faire comprendre de façon réaliste les possibilités offertes par les techniques de cartographie numérique. Le programme combinait de façon équilibrée les exposés, les démonstrations et les exercices d'application. Il a été suivi par 14 participants venus de 13 pays en développement d'Asie, d'Afrique et d'Amérique latine.

L'analyse d'un formulaire d'évaluation rempli par les participants a fait apparaître un taux de satisfaction de 80 %.

Un volume reproduisant les débats du séminaire et les documents techniques a été distribué aux participants et à d'autres parties intéressées.

* The original text of this paper, prepared by Erik O. Dahle, Director, Ministry of Environment, appeared as document E/CONF 81/L. 4

RESUMEN

Del 14 al 20 de septiembre de 1988 se llevó a cabo un Seminario Interregional de las Naciones Unidas sobre técnicas cartográficas modernas en la sede de la Dirección de Cartografía de Noruega, en Honefoss.

Participaron en el Seminario funcionarios de alto nivel técnico en representación de instituciones nacionales de topografía y cartografía de algunos países en desarrollo. El principal objeto del Seminario fue el de contribuir a un conocimiento real de las posibilidades que ofrecen las técnicas de cartografía digital. El programa del curso comprendió una combinación equilibrada de clases teóricas, demostraciones y ejercicios. Asistieron 14 participantes de 13 países en desarrollo de Asia, Africa y América Latina.

El resultado que arrojó el análisis de un formulario de evaluación que llenaron los participantes fue de un grado de satisfacción del 80%.

Se distribuyó a los participantes y a otros interesados un volumen con las deliberaciones del Seminario y las monografías técnicas.

SUMMARY

The United Nations Interregional Seminar on Introduction of Modern Mapping Techniques was held on the premises of the Norwegian Mapping Authority at Honefoss, Norway, from 14 to 20 September 1988.

The Seminar was aimed at participants at senior technical level, each representing a national surveying and mapping establishment in a developing country. Its main purpose was to contribute to a realistic understanding of the possibilities offered by digital mapping techniques. The course programme was composed of a balanced combination of lectures, demonstrations and exercises. It was attended by 14 participants from 13 developing countries in Asia, Africa and Latin America.

An analysis of an evaluation form completed by the participants resulted in a rating of 80 per cent satisfaction.

A volume containing the proceedings of the Seminar and the technical papers was distributed to the participants and other interested parties.

At several United Nations regional cartographic conferences a number of resolutions concerning transfer to developing countries of appropriate technologies in surveying and mapping were adopted. In pursuance of the recommendations of those resolutions, Norway, in 1988, served as host country for the United Nations Interregional Seminar on Introduction of Modern Mapping Techniques.

Responsibility for the planning and execution of the project was entrusted on behalf of the United Nations to the Cartography Unit of the Department of Technical Cooperation for Development, and to the Ministry of Environment, on behalf of the Government of Norway.

The Seminar was aimed at participants at senior technical level representing national surveying and mapping establishments or specialists directly involved in national programmes aimed at the creation of such establishments. The final selection of participants was made by taking into account the qualifications and experience of the nominated candidates.

During the last decade mapping technology has been computerized to a large extent, and interacting graphic and geographic management systems have opened up new possibilities for increased effectiveness in map production. The tool that above all has opened new avenues within

the mapping profession — as within nearly any other sector of organized society — is the electronic computer. From being a mysterious black box of often insurmountable cost, in recent years research and development efforts have brought computer technology down to a level of reasonable cost and complexity. The real obstacle now seems to be the transition from well-established analog methods and routines to those of digital techniques. The main purpose of the Seminar was to contribute to a realistic understanding of the possibilities offered by this new technology.

For practical implementation of the project, the Ministry of Environment enlisted the Norwegian Computing Centre to arrange for the lecture programme and its direction; the Norwegian Mapping Authority provided all conference facilities and practical demonstrations, while the Norwegian Association for Cartography, Geodesy, Hydrography and Photogrammetry took care of all logistic needs.

The course programme was composed as a balanced combination of lectures and practical demonstrations and exercises, and included such topics as:

Introduction to modern cartography

Vector and raster representation of cartographic data

Digital data capture
 Database management
 Geographic information systems
 Map generalization, presentation and reproduction
 Introduction to remote sensing
 Introduction to modern geodesy
 Modern cartographic methods and organizational changes

The Seminar was attended by 14 representatives from 13 developing countries in Asia, Africa and Latin America, which included:

Bhutan	Sri Lanka
Colombia	Sudan
Egypt	United Republic of
Ethiopia	Tanzania
India	Viet Nam
Indonesia	Zaire
Malaysia	Zambia

Practical demonstrations were given of Kartoscan, Sysscan, SCITEX and Terragon equipment.

A weekend field excursion to a mountain resort included a comprehensive presentation of Norwegian mapping companies and equipment manufacturers, and also sessions for presentation of status reports by the participants from developing countries.

The sessions were conducted in the English language, but summaries in French were presented at the end of every working day.

An analysis of an evaluation form completed by the participants showed that the arrangements received a rating of 80 per cent satisfaction.

A volume containing the proceedings of the Seminar and the technical papers has been completed for the convenience of the participants and other interested parties and will be made available shortly.

The total cost of the Seminar amounted to \$US 85,000, of which one third was covered by the United Nations and two thirds by Norway.

UNITED NATIONS TECHNICAL COOPERATION ACTIVITIES IN SURVEYING, MAPPING AND CHARTING, WITH SPECIAL EMPHASIS ON THE AMERICAS*

Paper submitted by the United Nations Secretariat

RÉSUMÉ

Le présent document contient une description des principales tendances et activités entreprises par le Département de la coopération technique pour le développement du Secrétariat de l'ONU. Les projets de coopération technique, qui portent sur les levés géodésiques, la cartographie, l'hydrographie, la photogrammétrie et l'établissement de cartes, offrent une assistance dans les domaines suivants : création d'institutions, transfert de compétences techniques aux services cartographiques et hydrographiques nationaux et fourniture de moyens de formation et d'équipement.

RESUMEN

La monografía describe las principales orientaciones y actividades del Departamento de Cooperación Técnica de las Naciones Unidas para el Desarrollo. Los proyectos de cooperación técnica sobre levantamientos geodésicos, cartografía, hidrografía, fotogrametría y elaboración de mapas comprenden el fortalecimiento institucional, la transferencia de conocimientos técnicos a instituciones nacionales de cartografía e hidrografía y el suministro de capacitación y equipos.

SUMMARY

This paper describes the main trends and activities undertaken by the United Nations Department of Technical Cooperation for Development. Technical cooperation projects covering geodetic surveying, mapping, hydrography, photogrammetry and map production include institution building, transfer of technical expertise to national cartographic and hydrographic institutions and provision of training and equipment.

* The original text of this paper appeared as document E/CONF 81/L 20.

Technical cooperation activities reported in this paper are limited to those executed by the Department of Technical Cooperation for Development of the United Nations Secretariat. Surveying and mapping activities by other executing agencies of the United Nations system (International Labour Organisation, Food and Agriculture Organization of the United Nations, World Health Organization etc.) are not reported here, since generally they are application-oriented support activities for other aspects of technical cooperation (e.g., irrigation schemes). In the majority of cases, those activities lack the dominant element of "institution-strengthening" and their impact is therefore of a more immediate, but ephemeral, nature. This report includes activities financed from the regular budget of the United Nations, as well as those funded from extrabudgetary sources (United Nations Development Programme (UNDP), cost sharing by recipient Governments and third parties, and trust funds).

As of 31 December 1988, 19 technical cooperation projects in the surveying and mapping sector were under execution in Bhutan (two projects), Burundi, Ethiopia, India, Iraq, Jordan (two projects), Madagascar (two projects), Nepal (two projects), the Philippines, Qatar, Saudi Arabia, Sri Lanka, Trinidad and Tobago and Viet Nam (two projects).

All the components traditionally associated with technical cooperation (technical advisory services, training, equipment and subcontracts) are still necessary, but their relative importance may vary. Transfer of technology, by the long-term assignment of experts to projects, is losing some of its earlier importance, mainly because the reservoir of trained national professionals is increasing steadily. On the other hand, short-term consultants in highly specialized fields are increasingly in demand, whereby the consultancy frequently includes "hands-on" cooperation by the consultant in order to overcome initial inhibitions to employ new technologies and methodologies. Such consultancies often require a follow-up visit after some months to ensure that the newly acquired skills continue to be utilized properly. Long-term training abroad of national professionals remains a high priority need, but is occasionally at variance with the development strategy of some donors, as far as training at the Master's and doctorate levels is concerned. Study tours to comparable institutions in developed and developing countries are becoming an important tool for the transfer of managerial and technical skills.

In the context of United Nations technical cooperation activities, the rapidly increasing costs of equipment, particularly of computer-assisted cartographic systems, have become a major concern. In this aspect, the trend reported in the status report for the Third United Nations Regional Cartographic Conference for the Americas (held from 19 February to 1 March 1985) has intensified. It continues to affect the realization of valuable projects, not only because it inflates the total costs of projects beyond affordable limits of the individual country programmes of UNDP, but also, even if this hurdle could be overcome, because it elevates the percentage of the equipment component of the total budget of a project to a level unacceptable to UNDP. Co-funding of projects with investment-oriented and bilateral donors has not developed to the extent hoped.

Ongoing cooperation projects of the sector are generally well on schedule, with a total project budget of some \$25 million. Difficulties in the timely nomination of national candidates for training abroad have largely subsided. On the other hand, the recruitment of short-term consultants has proved more difficult than before, especially in the growing

field of computer-supported cartographic production systems.

The widespread use of computerized systems in cartographic production has focused the attention of donor organizations in general once again on the question of sustainability of the positive results generally achieved by development cooperation projects after the withdrawal of the sponsor, because computerized systems require more and regular maintenance. In many countries such services are only available against convertible currency, which is difficult to obtain for many national mapping organizations in sufficient quantity. This aspect must be considered in the design stage of any project and may lead to a very prolonged involvement of donor organizations (over a decade or longer), which in itself is contradictory to the development philosophy, at least, of United Nations technical cooperation.

The backstopping activities for technical cooperation mapping/surveying projects are handled within the operational set-up of the Infrastructure Branch of the Natural Resources and Energy Division of the Department of Technical Cooperation for Development. The Cartography Unit of the same Branch is handling activities which are essentially falling under the regular programme of the United Nations.

The following two conferences were organized since 1985:

(a) The Eleventh United Nations Regional Cartographic Conference for Asia and the Pacific was held at the Headquarters of the United Nations Economic and Social Commission for Asia and the Pacific at Bangkok, Thailand, from 5 to 16 January 1987.

(b) In cooperation with the Government of Canada, the Fifth United Nations Conference on the Standardization of Geographical Names took place at Montreal from 18 to 31 August 1987.²

The following six seminars and training courses, organized in cooperation with national counterpart institutions, were also held during the period 1985-1988:

(a) The United Nations Interregional Seminar on the Role of Surveying, Mapping and Charting in Country Development Planning was held in Aylmer, Quebec, Canada, 4-8 November 1985;

(b) A United Nations training course in toponymy for Arabic-speaking countries was held in Rabat, Morocco, 2-7 December 1985;

(c) A United Nations interregional training course in large-scale mapping operations for planning and cadastral purposes was held in Dresden, German Democratic Republic, 30 July-14 August 1986;

(d) The United Nations Interregional Seminar on Hydrographic Surveying and Bathymetric Charting was held in Hamburg, Federal Republic of Germany, 1-6 September 1986;

(e) A United Nations interregional training course in toponymy for French-speaking countries was held in Quebec, Canada, 7-19 August 1988;

(f) The United Nations Interregional Seminar on Introduction of Modern Mapping Techniques was held in Hønefoss, Norway, 14-20 September 1988.

In addition, the following ad hoc meetings and sessions of the United Nations Group of Experts on Geographical Names were held:

(a) Meeting of an ad hoc group of experts on the present status and value of the *International Map of the World on the Millionth Scale*, New York, 9-11 December 1986;

(b) United Nations Group of Experts on Geographical Names: twelfth session, Geneva, Switzerland, 29 September-7 October 1986;

(c) United Nations Group of Experts on Geographical Names: thirteenth session, Montreal, Canada, 17 and 31 August 1987.

The fourteenth session of the United Nations Group of Experts on Geographical Names is planned to take place at Geneva from 17 to 26 May 1989.

The publication of the United Nations series *World Cartography* (in English and in French) was continued. Volume XVIII, issued in 1986, was devoted to the standardization of geographical names; volume XIX, issued in 1987, was devoted to an overview of the state of the art in cartographic data acquisition, manipulation and depiction; and volume XX, which is currently being finalized, contains, *inter alia*, an updated study on the status of world topographic mapping. In 1988 a biannual *Newsletter* of the United Nations Group of Experts on Geographical Names was also issued. In addition the reports and proceedings of all the conferences, seminars, training course and experts' groups mentioned above were published. The annual report on the status of the *International Map of the World on the Millionth Scale* has been discontinued following the recommendation of the ad hoc group of experts concerned on this subject.

The level of involvement of the United Nations system in technical cooperation in the surveying and mapping sector in the Americas has regrettably declined further in absolute terms, as well as in comparison with work done in Africa and Asia. In 1986, 1987 and 1988, respectively, only 7.7, 6.2 and 1.3 per cent of total expenditure in cooperation activities in the field of surveying and mapping was spent for projects in the Americas.

Some hopeful signs of more countries of the region being interested in cooperation activities in this field with the United Nations were reported at the Third United Nations Regional Cartographic Conference for the Americas in 1985. Unfortunately, such signs did not lead to tangible results. The reasons for this evident disinterest have not been defined, and are not clearly understood. It is regretted that the positive trend in number and scope of projects in Africa and Asia is not matched by a similar development in the Americas region.

The only large-scale project during the reporting period concerns Trinidad and Tobago (TRI/79/008: "Hydrographic

Surveying"). The project is, operationally, largely completed, with a budget of \$1,738,000. Its main feature was the construction and commissioning of a fully equipped 25-metre survey vessel, which is extensively used for surveys in the territorial waters of Trinidad and Tobago. The project included 69 man-months of expatriate professional expertise and 14 man-months of training and study tours. Negotiations for a follow-up project, possibly with co-funding by a bilateral donor, are still under way.

The small-scale projects reported earlier in Jamaica and the Cayman Islands have been completed successfully. No indications have been received that follow-up actions are required.

An advisory mission to Guyana has unfortunately not resulted in the formation of a project for the rehabilitation of the hydrographic services.

An advisory mission to Haiti has led to the formulation of a major project for the comprehensive strengthening of the sector. Its implementation has been affected by the current political unrest in the country.

On a more positive note, mention must be made of the important role that the learning institutions of the Americas, particularly those of the United States and Canada, have always played in the formal training of national counterparts from all over the world. National counterparts have also been attending several seminars held in North America. The United States and Canada remained important sources for high-technology equipment utilized in almost all projects, and a number of experts and consultants have been recruited in the region and have been or are currently serving in several key projects.

It is hoped that still more surveying and mapping specialists of the Latin Americas and Caribbean subregion will participate in conferences, seminars and symposia organized under the auspices of the United Nations. The United Nations Secretariat will gladly assist interested parties in this respect in any possible way.

NOTES

¹ *Eleventh United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 5-16 January 1987*, vol. 1, *Report of the Conference* (United Nations publication, Sales No. E.87.I.13).

² *Fifth United Nations Conference on the Standardization of Geographical Names, Montreal, 18-31 August 1987*, vol. 1, *Report of the Conference* (United Nations publication, Sales No. E.88.I.7).

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