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THE DEVELOPMENT OF NATIONAL DIGITAL TOPOGRAPHIC DATA BASE

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Introduction

The increased appreciation of the advantages of map data in digital form is accelerating the application of digital mapping and automated cartography. Various disciplines which have traditionally related their data to topography through the medium of printed maps for analogue processing have now converted to or are planning to convert to electronic data processing. To meet the growing demand for digital topographic data, the Surveys and Mapping Branch of the Department of Energy, Mines and Resources is actively adopting digital mapping technologies.

The initial development of the data base is a major problem because of time and resources required for the conversion of analog data to digital. Computer-assisted interactive digital photogrammetric map compilation was introduced in 1976 on an experimental basis and the first production system was procured in 1978. These systems are producing high accuracy positional information for a base at 1:50 000 resolution. To expedite the process of acquiring digital topographic data, a system based on the use of raster scanning technology for the automatic digitizing of existing maps was installed in early 1984.

At the present time, the data collected by both systems is primarily used to support the automated cartography system. To exploit the wealth of information inherent in the generated data files, a combination of software and on-line data manipulation was required to create a national digital topographic data base.

As the needs of geoscientists for digital topographic data are identified, the requirement for a graphic data base will be secondary in comparison to the need for data manipulation, analysis and modelling. To satisfy these requirements, there is a need for the definition and recording of spatial relationships between features, and the use of data base management systems becomes eminent.

Initial Data Base Development

The input of the National Digital Topographic Data Base (NDTDB) comes basically from two sources:

1. direct digitization from aerial photography on a photogrammetric instrument,
2. automatic digitization of existing grpahics on a raster scanner, and subsequent vectorization and post processing of scanned data.

Photogrammetric Digitizing System

The present digital mapping system of the Surveys and Mapping Branch is based on man/machine digitization of air photography. Basically, this system is used for the generation of topographic position data files for 1:50 000 digital mapping and automated cartography.

The spatial data (x, y and z) are obtained by assigning a unique cartographic code for the feature and stereoscopically tracing this feature on a photogrammetric instrument. Based on the feature type the operator digitizes the center line of the linear features, the center of point features and the edge of area features.

To collect error-free digital data two basic tasks are involved: the digitizing process and the display/editing process. The photogrammetric instrument is interfaced to the computer via a microprocessor. While digitizing, the microprocessor accepts the tri-axis encoder pulses (x, y, z), computes model coordinates and subesquently transforms them to ground coordinate system (Universal Transverse Mercator (UTM)). The computed X, Y, Z coordinates are transmitted to the Graphics Data subsystem. The cartographic code identifier and the association code describing the data is also transmitted.

An interactive graphic terminal constitutes an integral part of the photogrammetric digitizing workstation. The digital mapping systems software allows for the display and editing of the digitized topographic features. In addition, the stereo plotter operator have unrestricted access to the digital data of the model he is compiling and of the adjacent stereomodels compiled by him or others. The operator may view the digitized features on the screen and perform any necessary editing. He can tie in adjacent stereo models and make any required changes to the digital data that he normally would make on a pencil manuscript in the graphic compilation mode.

Initially data acquisition is by stero-model and the compiled data forms the "position file". In this file all topographic features are recorded in their true geographic position without regard to cartographic symbolization. In addition to the photogrammetrically compiled features the position file will contain surveyed field data e.g. international boundaries and features marked on the aerial photography in the precompilation field completion phase.

Each feature of the digitally compiled data is assigned a unique "cartographic code". This code serves various aspects of system operation. A typical cartographic feature code would be as follows (Gibbons 1982).

03020 03 03 0 L <AIRPORT RUNWAYS>

where

03020 is a unique numeric code classifying the feature

03 will assign the feature to graphic viewing line 3

03 assigns the feature to logical pen no. 3 for proof plot (line weight)

0 assigns a condition for "solid" line displays

L defines the feature type as a curve which closes to 5 m, and

<..> encloses the feature name for user interface.

In addition to providing the information for classification and user interface, the above coding structure is a standard against which the acquired data can be evaluated. Procedures for quality control and inspection at various stages of the initial data base collection has been developed and are operational in the Branch on a production basis since 1978.

Automatic Digitizing of Existing Graphics

To expedite the process of converting the initial map data from analog to digital form, a system for the mass digitization of existing graphics using raster scanning technology was installed in the Surveys and Mapping Branch early in 1984. This system consists of several subsystems, namely: the scanner, vectorization/processing system: the edit/tagging system; data file management system and the automated cartography output system.

The first priority for the system is the conversion of the 1:250 000 national topographic map series from graphical to digital form. The existence of colour-separated film plates for this series of 918 maps will facilitate the use of raster scanning technology. Basically the contour, drainage, vegetation (Wood Cover) and transportation overlays are scanned, and the other overlays which normally include fewer features are manually digitized.

The scanner is a stand-alone system and is capable of accommodating graphics up to 60 x 100 cm. The captured raster data is recorded on a magnetic tape, which will be processed for the generation of the initial data base map data.

The processing of the scanned data starts with the vectorization of the raster data i.e. conversion of data from raster to a vector form.

The vector data file is then displayed to inspect the results of the vectorization process and to decide on the necessary post-processing batch edit operations. This may include the use of software for the editing of short connected or unconnected spikes, correction of "nodes" resulting from the intersection of two or more lines, etc. The data file is then transformed to a ground coordinate system.

Upon completion of this batch processing phase, the data files are not error free. In addition, the topographic features are not coded with their "cartographic codes" and the contour lines are not tagged with their proper height values.

To perform these on-line editing and coding operations, the data is transferred to the edit/tagging subsystem. The amount of editing required depends on the complexity of the graphic, quality of line and type of overlay.

For the contour overlays the editing is minimal, for example detecting bridges beween close contour lines, closing long gaps due to contour labelling etc. The tagging of contours is also assisted by means of several functions, which speeds up the process of coding the contours with their height values.

Overlays where features are intersecting, e.g. hydrography or transportation pose additional problems because of the multi-nodes created at the intersections of lines with varying thickness. In addition, the nodes causes segregation of the feature, and to be able to code the entire feature with one code all segments have to be complexed together.

Upon completion of the editing and feature coding operations the data in considered part of the initial topographic data base (NDTB).

At this stage, the topographic data base will be primarily a cartographic data base, and the spatial data represent the center or center line of symbols from the 1:250 000 NTS map series overlays.

With the automatic digitizing system, collection from the 1:50 000 NTS map series is also a possibility for selected areas of Canada in accordance with major user requirements.

Data Structure

The initial data base file generated by the automatic digitizing system is managed by the graphic interactive information system (GINIS) developed by SysScan, Kongsberg, Norway.

The data structure is built up in the form of a hierarchy, which can be extended horizontally or vertically. Using this structure, the national standards system for the classification of topographic features was used to build the horizontal and vertical levels of the hierarchy, as shown schematically in Figure 1.

Data Base Parameters

Analysis of short term and long term goals need to be made so that a well developed strategy on the type of data base can be implemented from the beginning.

More generally, a decision on the broad type of data base needs to be made. A digital graphic data base is oriented towards a limited product range while a digital topographic data base is multi-purpose. A digital graphic base covers a number of map sheets, the data is structured according to the data acquisition system (in most cases a turnkey automated mapping system). In addition map elements are grouped into map overlays, and the accuracy and resolution is set by the immediate needs to the map product.

On the other hand in the digital topographic base the data is structured, the features are uniquely coded into many classes and input data meets long term accuracy requirements. In broad terms the digital topographic data base should be capable of dealing with the graphic, non-graphic and relational categories of information.

The graphic information deals with data related to location in real world space (spatial data). It also contains information on the graphic data representation or display, and, the feature data type (point, line, area, and mixed case of these data types).

The non-graphic information includes attribute data, descriptive and name information, accuracy and some non-topographic specifications (e.g. object length, area, etc.) In addition some topological relationships of network features (e.g. road network, drainage, boundaries, etc.) may be considered as part of this category.

The relational information consists mainly of data on the topological structuring between the various features in the topographic data base (vertical integration between various classes or layers of data, e.g. intersection among features, coincidence or common edges between areas, etc.).

In a topographic data base the graphic, non-graphic and relational information categories can be either separately organized and stored or may be included in the topographic data record which may be managed using a data base management system.

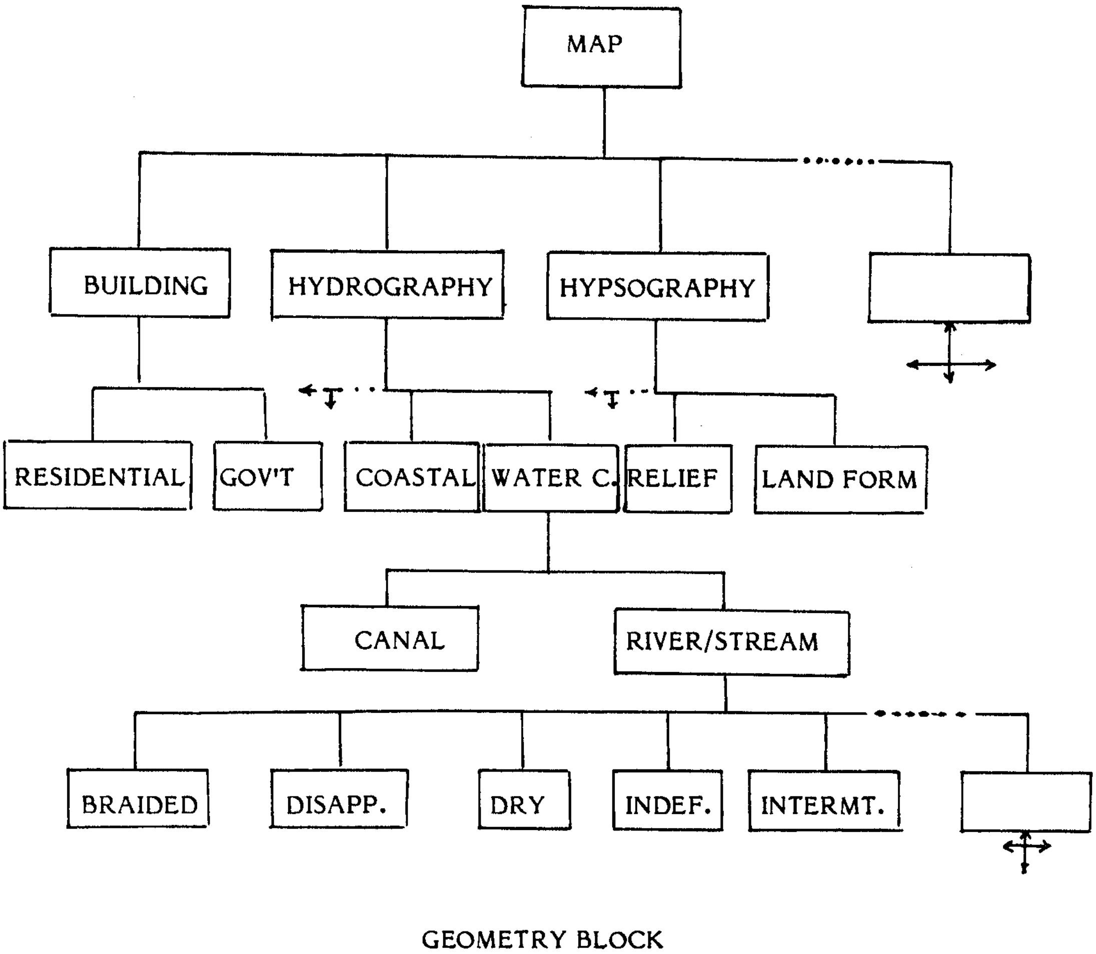

Fig. 1: Data Structure

Assignment of Non-Graphic Information

The assignment of non-graphic information to spatial data is an essential task in the development of digital topogrpahic data base.

The process of assigning non-graphic (e.g. attribute) information can be achieved during the man/machine digitization process or after the initial data collection, if automatic digitizing systems are used.

In the Surveys and Mapping Branch, the current graphic interactive information system available with the automatic digitizing system provide facility for allowing files of alphanumeric non-graphic information to be linked locally to spatial data in the graphic data file.

Relational Information

The geometric and logical structure of topographic map features can be described by relations. Relationships are imposed on the features by stating a relation between them through a composition rule. Therefore, relations may be thought of as the primitive linkages by which associations among features are described. For example, the feature "road" may cross another feature such as "railroad". In this example the relationship cross is the composition rule.

Some relationships between topographic features are quite simple, such as the concateration of two "linear" features of the same class (e.g. two streams in the hydrography class). Other relationships are more complex, such as the overlapping of real features belonging to two different classes, e.g. the overlapping "forest" area boundary with the boundary of a "county" area. In this example the relationship overlap is between classes "land cover" and "delimiter".

A potential set of relations useful in describing the features includes:

a) "inside" such as a point, a line, or an area inside an area feature, e.g. a tower inside an airport, a cut line inside a forest or an island inside a lake.
b) overlap of aerial features;
c) proximity of points to points, lines or area, lines to lines of areas, and area to area;
d) concatenate linear features at end;
e) parallel of linear features on to another.

The above relationships were cited as an example and they may expand depending on the required complexity between the various features, and the various classes of features considered. The definition of a complete set of relationships between features is only feasible when all features are enumerated and each feature is examined to find out its possible relationships to all other features.

Digital Topographic Data Exchange Standards

By the mid-1970's, the Canadian surveying and mapping community had become concerned at the lack of standardization in the handling, storing, retrieving, transmitting and merging of digital spatial data. Established in April 1979 and operating under the auspices of the Canadian Council on Surveying and Mapping three technical Committees were formed to develop standards for (i) classification and coding of topographic features, (ii) quality evaluation and (iii) EDP (electronic data processing) file format.

The first draft of the national standard was published in April 1982. Taking into consideration comments received on the first draft a revised version of these standards was published by the Surveys and Mapping Branch in July 1984.

Since the developed file format did not allow for the exchange of spatial relationships between features, in October 1984 a sub-committee was formed to develop a digital topographic information model. This model includes topography, attribute, text and topology. This model will be used as a basis for digital development of a modified file structure for the exchange of digital topographic data. The data model has been developed and the development of the file structure is scheduled for January 1986.

Data Base Management System

Commercial data base management systems (DBMS) ban be used for digital topographic data files management. In this case, the digital topographic data base (DTDB) should consist of a unified set of data files.

This set of digital topographic data files will be generated as a result of converting the data files created in the initial data base development to the national standard file format. It is important to note that only the files are managed and not the coordinate and attribute or relational data within the files.

Each file must have a standard set of parameters and the format should include a description of these parameters and the characteristic of the data file. This set of file parameters may consist of: data file name, geographic coverage, level and categories of information contained (graphic, non-graphic, relational), coordinate system, projection, data resolution and accuracy, source and data capture techniques, classes of data contained, scale, etc.

The purpose of the digital topographic data base management system will be to accept, catalog, archive and retrieve topographic data files. In addition, the DBMS can be used for the assessment and reporting statistical data about the files upon request.

Spatial Data Base Management (SDBMS)

The use of a DBMS for the management of spatial data, attribute and other non-graphic information and relational information is a massive undertaking. SDBMS may be used for the management of limited data sets with a predefined set of queries that are going to be placed upon the data base.

Conclusion

In recent years digital spatial topographic data have expanded in size and complexity, as a result of the need for a national digital topographic data base. Some of the challenges in digital cartography have changed from a decade ago, but many sill exist. We must continue to refine the data collection/data base creation process, promulgate uniform standards, and demonstrate the application of spatial data in the solution of the many earth science problems that face us. Perhaps the largest immediate challenge to the mapping community is to develop a spatial data base management system to provide user oriented geographic information systems that are capable of integrating and analyzing the large mass of spatial data now available to the earth science community.

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Abstract

The Surveys and Mapping Branch of the Department of Energy, Mines and Resources is actively adopting computer technologies to meet the increasing demand for a national digital topographic data base (NDTDB). For the initial data base development the input to the NDTDB comes basically from two sources: a digital mapping system based on direct digitization from aerial photogrpahy, and a system for the automatic digitization of existing graphics using raster scanning technology. In addition, the paper discusses the basic parameters for the digital topographic data base, the procedure established by the Branch for the development of national standards for the exchange of digital topographic data, and the role of data base management systems for the management of the digital data base.

ENTWICKLUNG EINER NATIONALEN TOPOGRAPHISCHEN DATENBANK

Zusammenfassung

Die Abteilung Surveys and Mapping des Department of Energy, Miens and Resources benützt zunehmend Computertechniken, um der steigenden Nachfrage nach einer nationalen digitalen topographischen Datenbank (NDTDB) gerecht zu werden. Der Aufbau der NDTDB wird im wesentlichen von zwei Informationsquellen gespeist: Einem digitalen Kartiersystem auf der Basis direkter Digitalisierung aus Luftbildern und der automatischen Digitalisierung vorhandener Karten mit Raster-Abtast-Technik. Der Aufsatz diskutiert weiterhin die grundlegenden Parameter der digitalen topographischen Datenbank, das Verfahren für die Entwicklung nationaler Standards zur Speicherung und zum Austausch digitaler topographischer Daten und die Rolle von Datenbank-Management-Systemen zur Handhabung der digitalen Datenbank.

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