THE APPROACH TO AUTOMATED CARTOGRAPHY: TOPOGRAPHIC DATA BANKS IN CANADA

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The planning, management and control of man's exploits on the earth require accurate and up-to-date terrain information. Traditionally, terrain information has been provided in the form of a wide range of maps and charts, which are mainly derived from or are overlaid upon a topographic map, or a skeleton of it, to depict an almost infinite variety of themes.

With the advent of computer technology, and the recent advances in computer graphics, the concept of collecting and communicating terrain information has changed. The increasing power of the computers, accompanied by a general decrease in their cost, is making a positive impact on the terrain information managers, commonly known as map makers and cartographers. It is now possible for civilian organizations, operating within a modest budget, to produce digital terrain data and to store these data in digital data banks, which permit simple access, update and retrieval of information. The method of portraying terrain information in the form of a topographic map will stay with us for a long time although the format and the graphics will in the future vary considerably from the traditional cartographic nomenclature.

These developments, in addition to the offer of better drafting accuracy, and flexibility in the choice of the type of output, led to the decision to develop the Canadian Automated Cartographic data system. In order to understand the approach taken by the Surveys and Mapping Branch to data banks and automation in cartography, one must realize that the major thrust of the Topographical Survey is directed towards the completion of 1:50,000 topographic maps of Canada and the revision of existing maps. To date approximately one half of the total of 13,150 sheets at 1:50,000 scale has been compiled. The task of completing the remaining ± 6,600 sheets and of keeping up-to-date the increasing number of map sheets is large by any standard.

New mapping is more directly related to specific development projects such as pipelines, roads, transmission lines, etc., and consequently requires a rapid response, and offers the depiction of specialized information.

The digitized terrain data were initially looked upon as a by-product of the map. However, within the present concept of terrain information being stored in digital form, as the basic source for all sorts of graphical and numerical presentation, the digitized data are of prime importance. This digital terrain information is stored in digital data banks, which permit simple access, update and retrieval of information. The concept of a digital data base provides a more flexible data storage for the user.

A digital data bank comprises collections of data stored in files; in such a way they can be accessed and retrieved in an orderly manner. Just as books might be withdrawn from or replaced in a library by using the catalogue shelf number and book number, so can an item or file be accessed or retrieved in a digital data bank.

A digital data base, on the other hand, is not restricted to only elementary operations on files and on sequential data in files arranged in a specified order. The data themselves become the primitive elements. They are stored as entities without reference of any application and without any need for the user to know their physical location in storage, either as a file or as an item in a file. By means of appropriate software the data base system accesses the data and brings them into association to fulfill the user's requirement or to provide the answer to the user query. The operation is similar to putting a question to a researcher in a library. The researcher would access the data in the books and bring them together for study to enable the question to be answered.

At the present time, the file system structure of the automatic cartography system is capable of supporting an extensive data bank facility. The data organization has been chosen for further evolution to a full data base system; developments are now underway for the subsequent use of a data base in conjunction with certain thematic application areas.

The cartographic feature was the fundamental element in the cartographic digital data file in the system, when first produced. Around this feature was formed the basic record, which consisted of the cartographic feature code, the qualifier code, and the coordinates defining and locating the feature.

The subsequent level of production software provides more comprehensive services and scope for greater modeling of the data. The first system led to a glut of cartographic feature codes. The next level permits a generalization of the code structure so that variations or divisions within a cartographic type or class of feature are described as attributes.

The association between features is encoded so that it can be used in processing when required. (See Figure 1). For example, the embankment of a railroad would be stored in terms of the coordinate definition of the railroad. Thus, there is not redundant data definition and the association can be used in the preparation of the map graphic, especially where conflicts are likely to occur between map features.

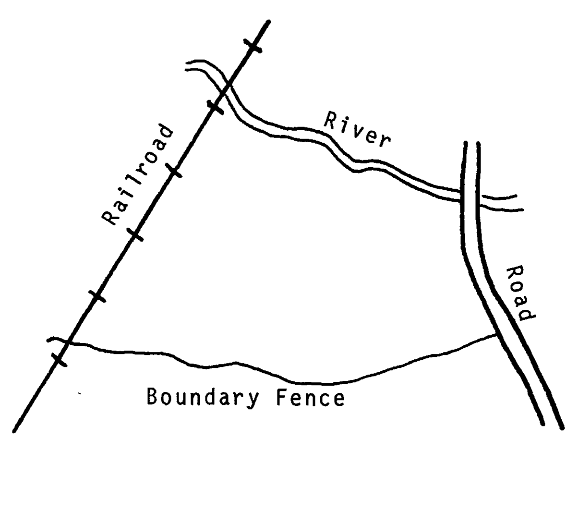

Figure 1

The present system is shown diagramatically in Figure 2. The system is designed to be expanded if need be, to handle up to 60 digitizers and 6 automatic drafting

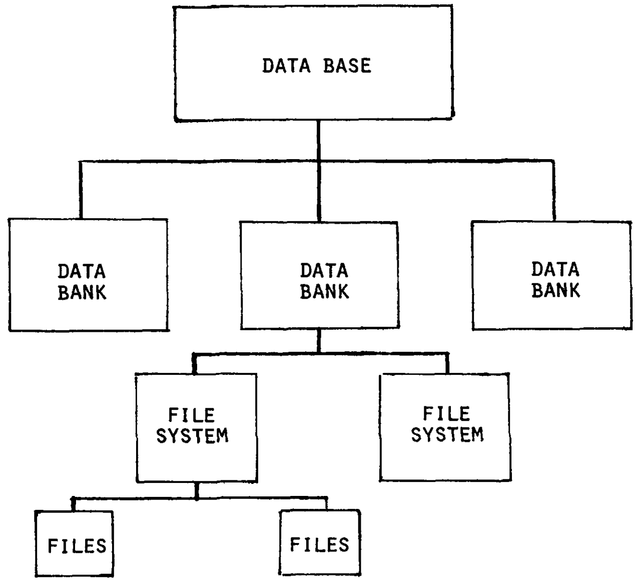

Figure 2. Organization of Data for a Data Base

machines in the map production area. The system has a "distributed" structure and can support, in addition to the map production equipment mentioned above, many mini-computer based sub-systems, each of which may be physically remote from, but on-line to, the central site, as in the case of the sub-system of the Geological Survey of Canada. Each sub-system can typically contain one automatic drafting machine, six digitizers and seven terminals. The links between the sub-systems and the central facility are digital data communication links. Further, for data query operation, the system is capable of accepting a large number of enquiry terminals.

The drafting machine draws the graphic from a computer controlled cartographic digital data file. The feature to be drafted can be automatically selected as can the symbolization, the scale, the projection etc. Moreover, since the 1:50,000 map acts as the foundation for many thematic maps, the extension of the system is evolving as a general purpose cartographic facility. Thus, the version of the software now being completed accommodates the needs of other areas, e.g., those of the Geological Survey maps.

The input to the present auto-carto system for the production of the National Topographic Series maps is provided by digitizing existing scribed map sheets or edited map manuscripts, compiled by photogrammetric methods. Since approximately one half of the 1:50,000 NTS sheets still remain to be compiled and some of the existing sheets in the populated areas must be recompiled during the revision process as they do not meet the accuracy standards, we have embarked on a development program of a system which would permit to input into data base of the terrain information digitized directly on the photogrammetric plotting instruments. This approach has two basic advantages:

- It eliminates the necessity of digitization of compilation graphics.
- Utilization of the stereo model for the production of x, y, z coordinates directly from the stereoplotter offers a higher resolution than the compilation graphics.

The second advantage is particularly important when the ultimate objective is to create a terrain information data base and data bank.

The major research and development effort of the Topographical Survey is directed towards devising such a system and evaluating it from the point of view of the overall economy and operational performance.

Other developments include the progressive introduction of improved peripheral hardware which the modularity of the system design allows -- say, the introduction of laser digitizers and laser drafting machines, and the continuing development of application software to satisfy the requirement of each application area and discipline connected to the system, both on-line and off-line. Here a distinction is made between the "system" software and the "application" software. In the work of the Surveys and Mapping Branch, the system software would include such matters as the extraction of data on grid sheet lines from data organized on graticule sheet lines, and the drafting of graphic primitive elements. The application software would be concerned with the assembly of the primitive drafting elements to form symbols or with the creation of symbols in some other manner for topographical maps, aeronautical charts and atlases.

An automated cartography system directed exclusively to the task of replacing human draftsman limits its cost effectiveness. By introducing the terrain information data base and data bank concepts into the system and utilizing these data to provide a variety of specialized information to a multitude of users, the full power of the automated cartography system is realized, thereby, greatly improving its cost effectiveness and economical working.

When embarking on the road of automated cartography one must realize that the computer alone will not solve all the problems. One must let the computer do what it can do best and leave to the human those functions which he can best perform. An interaction between the computer and the human will most likely provide satisfactory and economical solution.

One must also guard against the temptation of creating something new just for the sake of employing new technology and also against employing new technology to copy the manual methods slavishly.

Our objective is to devise a flexible terrain information system which will meet the needs and requirements of the present and of the future.