SPATIAL DATABASE TRANSFER STANDARDS:

Current International Status

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Current International Status

Edited by

H.MOELLERING
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PRESIDENTIAL FOREWORD

The impact of the computer on cartography is now all pervasive. As a result, many nations hold much of their cartographic data in digital format. This has made the issue of spatial database transfer standards one of great significance for the discipline of cartography. This volume is the most definitive study on the topic yet produced, and is an excellent example of the international scientific cooperation which marks the work of the International Cartographic Association (ICA).

The ICA was established in 1959 in Bern, Switzerland, and currently has 62 member countries. The Association is the world body for cartography and much of its scientific work is carried out through its various Commissions and Working Groups. This volume is a result of the efforts of a working group of the Standing Commission on Advanced Technology. The group was chaired by Professor Harold Moellering who, with the assistance of Hedy Rossmeissl of the United States Geological Survey, edited this volume on *Spatial Database Transfer Standards*. The current situation in 16 ICA member nations is discussed together with the efforts of two international groups working on standards issues. The production of this volume is a major contribution to the fulfillment of one of ICA's central aims which is the initiation and coordination of cartographic research through cooperation among cartographers from all member nations and, as President of ICA, I welcome its appearance.

D.R.F. TAYLOR
President
International Cartographic Association

PREFACE

The growth in concern over environmental issues, at scales ranging from the local to the global, has been matched by the rapid evolution of geographical information systems in terms of power and functionality. The systems provide a tremendous capability to manipulate and analyse geographical data. As the application of these systems is taken up by an ever growing community of users, there is one common need—data! Industry estimates now suggest that 60 percent of the cost of implementing a geographical information system (GIS) involves the development of the necessary data base.

While each GIS application may require certain unique data layers, many themes will be common to a number of applications. Many applications in local government environments depend upon multiple agencies for data base development. For these efforts to be successful, data standards are essential. Such standards must address a range of issues more encompassing than exchange formats. Digital data standards are especially key to success in the various global change research projects now underway.

Thus, it is particularly timely that Dr Moellering has been able to assemble an international summary of standards work. He is to be congratulated for a thorough and wide-ranging volume addressing standards issues from an international perspective. As Chairman of the ICA Standing Commission on Advanced Technology, I offer thanks to Dr Moellering and his colleagues for a valuable contribution.

K. ERIC ANDERSON
Chairman
ICA Standing Commission on Advanced Technology

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ACKNOWLEDGEMENTS

The ICA Working Group on Digital Cartographic Database Exchange Standards was formally founded at the ICA meeting held at Budapest in August, 1989. At that meeting a goal was established for the Working Group to write a monograph concerning activities in the cartographic world to develop spatial database transfer standards. This monograph is the result. It contains 18 chapters that describe these standards activities on a world wide basis.

The editor offers his thanks to each of the authors for their efforts devoted to developing their chapters that describe the activities in their countries or organizations. As part of this writing effort the Working Group held a meeting in Switzerland in July, 1990, to review the draft chapters. The final copies of the chapters were finished in the Fall of 1990.

Thanks are due to the Executive Secretary of the Working Group, Ms Hedy Rossmeissl of the US Geological Survey in Reston, Virginia, who supervised the assembling and formatting of the chapters into the monograph. She also supervised the production of the final camera ready copy. Secretarial support for this project was provided by Adonnis Goldstein and Cathy Taylor. Without their dedication and hard work this document would not be a reality.

HAROLD MOELLERING,
Editor
Columbus, Ohio, USA

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INTRODUCTION

Since the middle of the 1960's various individuals, groups and organizations in many countries in the world have been building various kinds of cartographic databases to use with their cartographic software systems to analyze and display their data. In the early years this work was uncoordinated and somewhat haphazard, but as the years progressed it came to be realized that great efficiencies could be gained if the cartographic database built by one group could be used by another on a system that is different from the originating system. It has been further realized that more efficiencies could be gained if transfer standards could be developed that would facilitate transfers of cartographic databases.

This idea has arisen in many cartographic and spatial data processing groups and organizations in the 1980's where groups have been working on this problem for some years. Other groups and organizations have become interested in the challenge of this problem more recently. As this work was initiated in various countries, research workers began to informally compare notes and experiences concerning such developments. A number of informal discussions have been held at the last few International Cartographic Association technical meetings. During the ICA congress in Morelia, Mexico, in 1987 under the Commission on Advanced Technology under the leadership of Dr. Eric Anderson, the topic was formally examined and discussed.

From those meetings the ICA Working Group on Digital Cartographic Database Exchange Standards was founded in early 1989 by Prof. Harold Moellering of the U.S.A. The following goals were established by Prof. Moellering for the Working Group (WG):

1) The WG will be organized in the 1989 time period;

2) The initial meeting of the WG will be held at the ICA meetings in Budapest in August, 1989;

3) To exchange information and reports by the ICA member countries concerning the development of digital cartographic data exchange standards;

4) To collect and distribute in the WG copies of all standards published in ICA countries;

5) To serve as a focal point of information concerning digital cartographic data exchange developments throughout the world;

6) To identify research needs that arise from the standards process;

7) A presentation by each member of the WG will be made at the Budapest meetings concerning cartographic standards activities in his/her member country.

An effort was made to contact the ICA countries that were engaged in or interested in such work to nominate a member for the WG. International organizations that were known to be working on this problem were invited to nominate an observer to the WG. The idea was to have a member or observer to represent each active ICA nation and international organization in the world.

The founding meeting of the Working Group was held at the ICA technical meetings in Budapest, Hungary in August, 1989. Representatives from 16 ICA countries were present for this meeting. At this meeting many WG members gave presentations concerning the status of cartographic database transfer standards in their country. At this meeting in Budapest, the WG also added an eighth goal, that of producing an ICA monograph that discusses the present state of development of such standards in the various ICA countries and organizations throughout the world. That desire has resulted in this monograph coming into existence. Since the meetings in Budapest the members of the Working Group have been working diligently to produce their chapters. The WG met in Switzerland in July, 1990 to review their draft chapters and to do the final polishing on them. You see the results of their diligent efforts before you.

This monograph is organized into an introduction by the editor that provides the background for this effort. It also provides an explanation of some of the important concepts that underlie this effort, as well as a discussion of the transfer process itself. This preliminary material is important to the reader can more clearly understand the individual standards efforts. This introduction also contains a brief review of each following chapter to succinctly encapsules each effort in a larger context. It concludes with a brief summary of this introductory material. Following that are about 20 substantive chapters that

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presents the efforts going on in each country and organization represented. This presents a comprehensive picture of the cartographic database transfer standards development efforts that are active throughout the world. In one or two cases groups invited to write chapters did not complete them.

As one reads these individual descriptions of the activities of these standards developments in the ICA countries and other organizations, it is possible to get the impression that all of the theoretical details are completely understood. This is far from the case. Rather there are many theoretical concepts that are incompletely understood or in some cases, not well at all. These situations provide a number of interesting research opportunities, as described in Moellering (1991b).

BASIC CONCEPTS

In order to efficiently understand the transfer process and following discussions, it is crucial to clearly comprehend the fundamental cartographic theory that underlies this work. They are the notions of real and virtual maps, deep and surface cartographic structure, and the notion of cartographic data levels. These concepts, and many others, are emerging from the developing area of analytical cartography, which is major thrust to develop a more theoretical and mathematical basis for cartographic concepts. A brief review of analytical cartography has recently been written by Moellering (1991a).

The first major concept of interest here is that of real and virtual maps. During the early 1970's there arose many cartographic products such as CRT images and digital terrain models that went beyond the conventional definition of a map as a fixed hard copy product. These developments resulted in calls to expand the definition of what constituted a map. This dilemma was crystallized by Morrison (1974) in the lead article of the first issue of the American Cartographer where he recognized this growing problem and called for an expanded definition of what constitutes a map. Moellering was faced with the same problem and took up the challenge issued by Morrison. After a few years of research the concept of real and virtual maps was proposed (Moellering, 1980).

It turns out that there are two crucial characteristics that differentiate conventional hard copy maps from other kinds of virtual maps. The first is whether the product can be directly viewed as a cartographic image. Conventional maps and CRT images can be seen that way, but cartographic data files and things like Fourier transforms cannot. They must be transformed to a state that has direct viewability first. The second crucial characteristic is whether the product has a permanent tangible reality. Figure 1 shows a four class diagram that shows the resulting classes of real and virtual maps that are generated by yes/no answers to the two characteristics. The definitions for these classes (Moellering, 1980) are as follows:

> Real Map - is any cartographic product which has a directly viewable cartographic image and has a permanent tangible reality (hard copy). There is no differentiation as to whether that real map was produced by mechanical, electronic means.

DIRECTLY VIEWABLE AS A CARTOGRAPHIC IMAGE

PERMANENT TANGIBLE REALITY	YES	NO
YES	**REAL MAP** Conventional Sheet Map Globe Orthophoto Map Machine Drawn Map Computer Output Microfilm Block Diagram Plastic Relief Model	**VIRTUAL MAP-TYPE 2** Traditional Field Data Gazeteer Anaglyph Film Animation Hologram(stored) Fourier Transform(stored) Laser Disk Data
NO	**VIRTUAL MAP-TYPE 1** CRT Map Image a) refresh b) storage tube c) plasma panel Cognitive Map (two-dimensional image)	**VIRTUAL MAP-TYPE 3** Digital Memory(data) Magnetic Disk or Tape(data) Video Animation Digital Terrain Model Cognitive Map (relational geographic information)

Figure 1. The Four Classes of Real and Virtual Maps

Virtual Map - Type I - has a directly viewable cartographic image but only a transient reality as has a CRT map image. This is what Riffe called a temporary map. Given the direction of current scientific work, electro-cognitive displays may be possible.

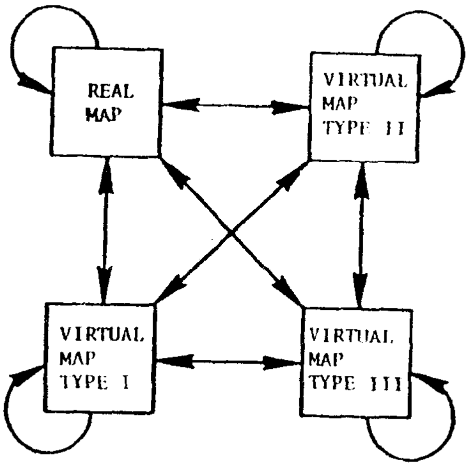
Virtual Map - Type II - has a permanent tangible reality, but cannot be directly viewed as a cartographic image. There are all hard copy media, but in all cases these products must be processed further to be made viewable. It is interesting to note that the film animation adds a temporal dimension to the cartographic information.

Virtual Map - Type III - has neither of the characteristics of the earlier classes, but can be converted into a real map as readily as the other two classes of virtual maps. Computer-based information in this form is usually very easily manipulated.

Here it can be seen that conventional cartographic products such as sheet maps, atlases, and globes that have a fixed tangible reality, and are directly viewable as a cartographic image are called Real Maps. The other three classes lack one or both of the two characteristics and are called Virtual Maps. These three classes provide for the expanded definition of maps that reflects many of the developments in modern cartography. It turns out that Virtual Maps can contain the same information as a Real Map, and in the case of a cartographic database, perhaps more. Moellering recognized that even cartographic databases should be considered maps because they can contain the information of a Real Map and can be transformed into one if necessary. This solution solves the dilemma recognized by Morrison.

Expanding on a notion pioneered by Tobler (1979), transformations between the four classes of Real and Virtual Maps can be used to define all of the important data processes in cartography. As shown in Moellering (1984) these 16 transformations define operations such as digitizing (R --> V3), CRT display (V3 --> V1), making a CRT hard copy (V1 --> R), direct plotting (V3 --> R), or data base transfer (V3 --> V3). These transformations can also be used to design cartographic systems (Moellering, 1983) and can also be used to define the field of cartography itself (Moellering, 1987).

It turns out that the information in these various classes of Real and Virtual Maps can be transformed from one to another as shown in Figure 2.



Real and Virtual Map Transformations

Figure 2. The 16 Real/Virtual Map Transformations

The second major concept is that of deep/surface cartographic structure developed by Nyerges in his dissertation (1980). Surface structure is defined as the graphic realization of cartographic information and when realized in a fixed hard copy form is called a Real Map. Following the precepts of Noam Chomsky in structural linguistics, Nyerges realized that there was a direct spatial analog to the linguistic deep structure. Cartographic deep structure is the set of spatial entities, attributes and relationships between them that may or may not be graphically realizable. This information is always in a virtual state and is usually found in Virtual Map Type 3 databases. Figure 3 shows this relationship graphically where the lower part of the figure, the surface structure made up of Real Maps and

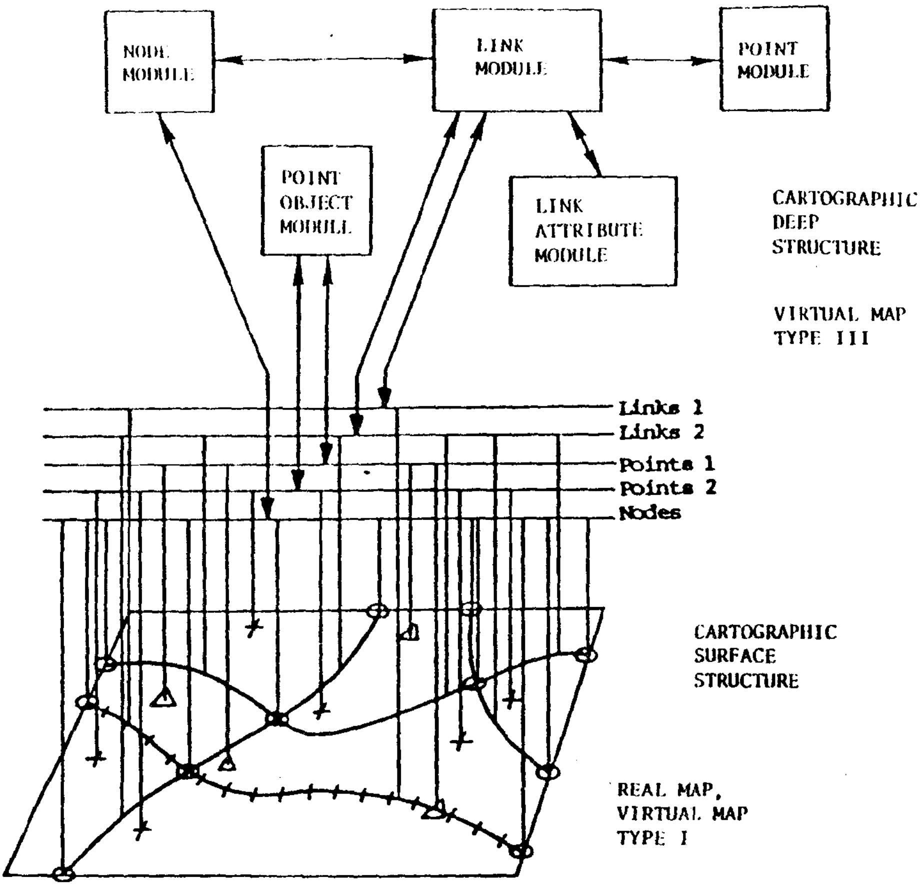


Figure 3. Deep and Surface Cartographic Structure

Virtual MapsType 1, is the area where traditional cartography has been focused for the many centuries of its long and glorious history. However, in the last decade, a new area has been identified, deep structure made up of Virtual Maps Type 3, that is now the focus of an expanding area of analytical work. Deep structure contains work on spatial data structures, analytical operators, fractals just to name a few. For a fuller discussion of analytical map use, see Nyerges (1991). This concept is introduced here because cartographic database transfers are really Virtual Map Type 3 deep structure transfers. More explanation and discussion will follow in a later section.

This concept greatly expands our understanding of cartography and directly reinforces the concept of virtual maps. It can also be seen that analytical cartography largely operates in the area of deep structure and displays its results in a surface representation of some kind, many times in the form of Virtual Map Type 1 CRT images.

The third major concept of importance here is that of Nyerges data levels (1980) which define the levels of spatial data from the most general level of Data Reality to the most specific level of Machine Storage as the bits and bytes are contained in computer hardware systems. The following table lists these levels and provides a short description of them.

Table 1. Nyerges Data Levels

1) Data Reality - The real world and data pertaining to it concerning cartographic entities and relationships between them.

2) Information Structure - A formal model that specifies the organization of information pertaining to a specific phenomenon. It includes data classes and relationships between them and acts as a skeleton for the canonical structure.

3) Canonical Structure - A data model representing the inherent structure of a data set which is independent of specific applications and systems which manage such data.

4) Data Structure - A logical data organization designed for a particular system in which specific relationships and links are implemented.

5) Storage Structure - A specification of how a particular data structure is stored in data records in a particular system.

6) Machine Encoding - The physical representation of how the structure is held in the physical devices of computer system hardware.

It turns out that early developments in cartographic data structures many researchers tried to define the Data Structure, Nyerges Level 4, directly without having defined the more general levels of the Information Structure and the Canonical Structure first. The Information Structure is a formal model of the information to be housed and managed in the spatial database, while the Canonical Structure is a model of the data to be coded, structured and housed in the database. The Data Structure is dependent on those two more

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