International Hydrographic Review, Monaco, LXXIII(1), March 1996

MAPPING THE FUTURE OF GEOMATICS

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Published in ISO BULLETIN, Vol. 26, No. 12, December 1995.

Abstract

When looking at an average world map, the amount of detailed information required to create each square centimetre is colossal. The cartographers of old did admirable work with often fragmentary information and left it to their artistic imaginations to do the rest; our new electronic possibilities allow an unprecedented accumulation of information of all kinds from a multitude of disciplines, areas of knowledge and sources (outer space and deep-sea diving are two among many that play their part) to be brought together to provide extraordinarily accurate and complete maps, to be used in fields as broad as petrol prospection and desert irrigation, city planning and environmental protection

CHARTING A PATH THROUGH HISTORY

The field of geographic information is one of the oldest areas of science, as well as one where some form of standardization has been recognized for hundreds of years. The earliest known maps were drawn by the Babylonians in 2 500 BC, and for centuries mapping and mathematics went hand in hand, with names like Ptolemy and Eratosthenes. Later, the great explorers were the driving forces behind mapping science, so that a proud tradition lies behind today's geomatics activities. It is interesting to note that the very earliest maps were already being implemented in the same application areas as many large automated GIS (geographic information system) projects today: in property management and ... the taxation of real estate!

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Long before the introduction of digital, or computer techniques, it was recognized that, to ease interpretation and understanding of a map, the visual presentation needed to be uniform and homogeneous. By the introduction of computerized methods in the 1960s, first for automating the map-making process, then later as a means of analysing the spatial aspects of information, it became even more necessary to agree upon a description of content and format of data. Data had at this point to be transferred from a computer system at the producer end to another system at the user end - and yet both had to interpret the information in the same way.

Many countries have initiated efforts over the last 10 to 15 years to produce national standards, especially as concerns the transfer of digital geographic information between users with different computer systems and environments. It was therefore only natural and a matter of time before this important field should have been taken up by ISO.

THE BUSINESS CASE FOR GEOGRAPHIC INFORMATION

Geographic information is for multi-disciplinary use, meaning that it is used as a tool in virtually every conceivable field. Research has shown, for instance, that 80% of all work undertaken in the public sector at national, regional or local level has some spatial or geographical aspect or application. The public sector is still the main consumer of geographic information and tools, but in the last few years the impact in the private sector has been growing. Analysts claim that geographic information technology is one of the fastest expanding fields of information technology as a whole, and within this, the private sector is now increasing most rapidly of all.

You will find the application of geographic information in just about every area from banking and finance to tourism and travel. There are, of course, certain domains where that use is more important than in others at present. To mention a few: transport and fleet management; utility and cable networks, natural resources and environmental control.

Marketing is emerging as one of the many important new application areas in the private sector, as addresses and postal codes are digitalized and develop spatial references with the aid of coordinates. Think of a business with a huge customer base where every customer has a known address; when you also have coordinates for these addresses, and are in a position to put your customers on a map, you can then start making an analysis. Where, you might ask, are my bad customers, those who do not pay or pay late? If a geographical tendency or spread emerges, you can start asking why. Where are my customers in relation to my regional offices? It could be that some offices should be closed down. In other areas, maybe I should rather build up the services I provide. GIS (geographic information system) is now used daily for such purposes - by really large enterprises as well as small ones that can all take full advantage of technological progress.

GEOMATICS TO HELP TAKING RISKS

Insurance companies have started to reference the risks they insure spatially. Before GIS came along, they had not been in a position to estimate their total risk geographically. Every flat in an apartment building was seen as a separate, independent risk - but when that apartment burns down, those risks become all of a sudden highly interdependent! There are companies refusing customers on this basis as they do not want to accumulate more risks within a given area!

Have you taken a taxi lately and been surprised by the short time-lapse between your call and the arrival of the taxi to collect you? This may be due to the fact that the taxi company is using the new technology available; cars equipped with GPS (the new global satellite navigation system) send their position continuously to the taxi central control station. The central control station thus has a complete overview of the situation and knows the exact position of each car; it can therefore direct the one closest to you to fetch you. Another important benefit is the highly improved security for the driver; in case of attack, he can push the alarm button, and the taxi central control station, knowing his precise position, will be able to assist him without any time wasted. If the car is hijacked, the centre can follow its exact movements on the map on the computer screen.

These are but a few examples of all the possible uses of the new technology. No one today can claim to have a total view of all its possibilities, but these potential applications share at least one thing in common: the same base technology and the same base requirements for general background map data (or, digital geographic information, as it is best referred to). It is not difficult to see that without a major effort to develop standardization, users and vendors will be left in total chaos and faced with finding far more expensive solutions. As with any new technology, there may have been a period where proprietary solutions enjoyed a commercial advantage, but that period is now long over as far as the base technology and the basic information are concerned.

GEOGRAPHIC INFORMATION AND THE INFORMATION INFRASTRUCTURE

The multi- and interdisciplinary aspects of geomatics prove that we are dealing with an area that forms part of the infrastructure of society. With all attention focused at this moment on Information Highways, it is only natural that many nations should start work on the concept of a spatial information infrastructure. Because geographic information underpins so many activities, it is fully justified to talk of geographic information as an *infrastructure element* (Fig. 1). It is of course not "physical" in the same way as roads, telecommunications and harbours are, but already - and even more in the future - information is about to overtake many such physical elements in importance. In the United States, the National Spatial Data

Infrastructure (NSDI) approach was taken, while the European Union is working on a European Geographic Information Infrastructure (EGII).

An information infrastructure is built up layer upon layer from the physical connections with cable and satellite connections at the bottom level, up via logical networks based on standardized protocols to reach the application and service layers. Many of these layers are common to all applications and services and therefore have to be based on the same general information technology standards, while the applications differ. Our task in ISO/TC211 is to define the geomatics standards needed to support the general infrastructure on the one hand and the user requirements on the other. Our long-term vision is to realize an electronic market-place for geographic information and services.

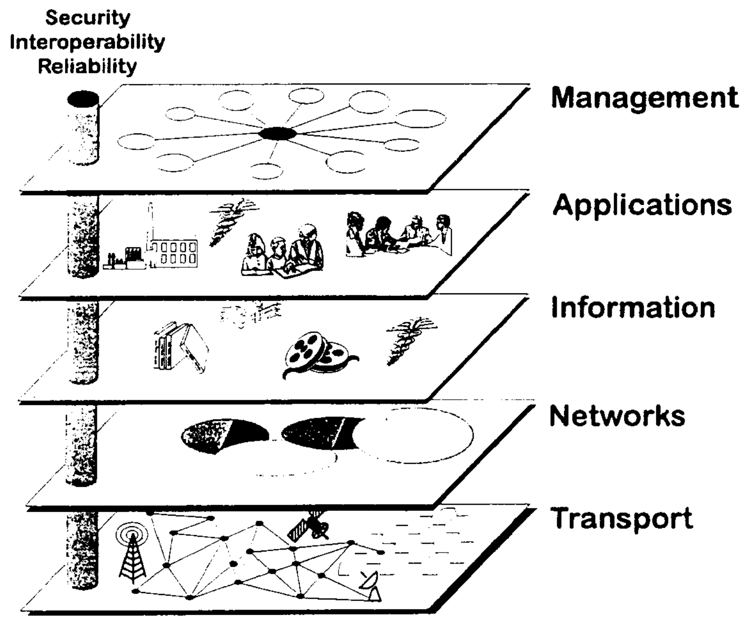

FIG. 1.- An information infrastructure is built up layer upon layer from the physical connections with cable and satellite connections at the bottom level to the applications and service layer, with management capping the whole.

STATUS OF THE COMMITTEE

The Technical Committee set up to serve the international community of users of geographic information standards is ISO/TC211, *Geographic information: Geomatics*, established in April 1994. It held its inaugural meeting in Oslo, Norway, in November 1994. There are at present 23 active, or participating (P-), members and 13 observer (0-) members. In addition, formal liaisons have been created with different organizations involved in relevant fields of work.

Canada took the initiative in establishing a new committee on Geomatics in 1993 [1]. This initiative was based upon - among other things - the national Canadian work and their work within the defence cooperation of NATO. The proposal covered a fairly wide field, and included standardization of analogue maps, e.g. symbolization.

The ISO proposal gave rise to many interesting questions, as, for instance, coordination with CEN, the Standards Committee for Europe. Nine external organizations have been accepted for Class A liaison status with ISO/TC 211 [2] These external liaisons represent a broad range of interests in the field of geographic information.

ICA, FIG, IAG and ISPRS are large international professional organizations holding conferences periodically around the world. They all emphasize different aspects of the profession, but all have subcommittees doing scientific and/or professional work and studies - often with a standardization aspect. ICA, the International Cartographic Association, for instance, has a commission that has studied all existing national, regional, international and *de facto* standards and published the results in books and monographs.

The UN ECE, United Nations Economic Commission for Europe, represents the statistical use of geographic information that is becoming a larger and larger area of application; statisticians are now a group challenging both the technology with their requirements, but maybe more importantly, the availability of data compliant with the standards. They are thus *users* of the technology. Open GIS Consortium is a king of industry group with a large representation of information technology companies, data-base system vendors, GIS vendors, and others, emphasizing the interoperability of systems and information. They are closely relating to the infrastructure thinking in the business, and will - I suspect - be a major contributor to the content of many of the standards produced by ISO/TC 211.

TC 211 also maintains internal liaisons with many other ISO committees[3]: these liaisons ensure contact and cooperation with general information technology

[1] The scope is defined as: *Standardization in the field of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify: for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. This work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.*

[2] These are: IHB/IHO, International Hydrographic Bureau, res. Organization; DGIWG, Digital Geographic Information Working Group; ICA, International Cartographic Association; UN ECE Statistical Division; FIG, International Federation of Surveyors; EPSG, European Petroleum Survey Group; ISPRS, International Society for Photogrammetry and Remote Sensing; IAG, International Association of Geodesy; OGC, Open GIS Consortium Inc.

[3] ISO/IEC/JTC 1/SC 21/WG 3. *Database* (including SQL); ISO/IEC/JTC 1/SC 30, *Open Electronic Data Interchange*; ISO/TC 82, *Mining*; ISO/TC 46/WG 2, *Codeing of country names and related entities*; ISO/TC 204, *Transport Informatics Control Systems (TICS)*; ISO/TC 184/SC 4. *Industrial data and global manufacturing languages (STEP).*

as well as closely related technology - which is extremely important - and include some major user fields of GIS technology.

Even more liaison organizations are expected to apply in the future. This goes to demonstrate that the work of ISO/TC 211 is now being followed by an impressive set of organizations, representing most aspects of geographic information technologies.

HOW ISO/TC 211 FUNCTIONS

WG 1, Framework and reference model (Convener: United States), will cover the more general aspects of the committee's work. The Reference Model is of the utmost importance since it maps out (!) and identifies all components involved and how they fit together: it is the glue that somehow holds the many aspects of work within the committee together and provides a common basis. The value of terminology work cannot be underestimated either. Nearly all professional disagreements are caused by people using the same term but meaning different things. Geomatics is not a mature science like mathematics: it is still young, and its terminology is not yet stabilized.

WG 2, Geospatial models and operators (Convenor: Australia), will work on that aspect that is special to geography: the underlying geometry of the globe, and how geographic or spatial objects are to be modelled (points, curves, surfaces and volumes), and where there are important spatial characteristics, how these relate to each other - that both here and in mathematics is called *topology*.

WG 3, Geospatial data administration (Convenor: United Kingdom), will cover other important aspects of geographic information, the description of quality and the quality evaluation that will decide on whether a particular dataset is suitable for a particular task or not, and provide the description of the data itself - metadata - which can be included in catalogue services or reference systems. This group will also cover the spatial referencing of geographical objects - either directly pinned to the Earth by coordinates, or more indirectly by the use of, for instance, area codes like postal or zip codes, addresses, etc.

WG 4, Geospatial services (convener: Norway), is responsible for defining the encoding of information in transfer formats, and the description of the methodology of how geographic information is to be presented - which links back to cartography and the old traditions of standardized visualizations. This group also covers the exciting field of satellite positioning; the formats and interfaces necessary to utilize modern navigational satellite systems. Many solutions exist in this field, lying, however, entirely outside the official standardization bodies: it will be a challenge to include these environments in the work. Satellite positioning combined with geographic data is rapidly becoming a very important tool in GIS applications.

Finally, **WG 5, Profiles and functional standards** (Convener: Canada), is considering the technique of profiling, meaning in this context putting together "packages" of the total set of standards to fit special application areas or users. This is very important for rapid implementation and penetration in the user environments, as the total set of standards will obviously be very comprehensive and difficult to relate to as a whole. Falling to this group is also the equally important task of "absorbing" existing *de facto* standards from the marine and military environments and harmonizing them with the profiles of the emerging ISO standards.

The committee has decided on an allocation of work items [1] ISO/TC 211 is aiming at producing a broad series of standards under the number ISO 15046, in 20 separate parts. The committee is following the new directives of ISO, meaning that the whole work programme should reach DIS (the final Draft International Standard) stage by 1998. The secretariat has set up a World Wide Web-server on Internet for the committee. Anyone interested can find it at the following URL address: **http://www.statkart.no/isotc211/**. This will keep all informed on the committee's progress by providing updated information on work programme, organization, calendar, documents, etc.

ELECTRONIC CHART DISPLAY

The maritime environment was quick to recognize the potential for digital geographic information, and the importance of standardized solutions. No trade is more international than shipping, and for decades sea charts have been highly standardized to convey both the same content and provide the same visualization to seafarers the world over, and wherever they be. When the idea of combining sea maps in electronic form with the ship's position and even a display of the radar screen started to crystallize, it was obvious that there had to be a global standard for the system

This task was undertaken by the International Hydrographic Organization IHO. IHO is the international umbrella organization for the national hydrographic offices, and works in collaboration with the International Maritime Organization (IMO) to increase safety and efficiency at sea. Key elements in this development are the definition of the Electronic Navigational Chart (ENC) and the Electronic Chart Display and Information System (ECDIS). To support these efforts, standardization is needed to define the contents and transfer of digital hydrographic information. IHO has therefore published such specifications in their *Special Publication 57 (S-57)*, and have also defined a transfer format called DX-90. S-57 serves among other things as an object catalogue for geographic objects related to hydrography.

The development of ECDIS led to the concept of electronic seaways, or ship routes supported by electronic navigational charts and precision satellite navigation signals. These electronic seaways improve safety at sea as well as the competitivity of shipping, by allowing greater speed in narrow waters, for instance.

[1] Work items: **WG 1**: 1 *Reference model*; 2 *Overview*; 3 *Conceptual schema language*, 4 *Terminology*, 5 *Conformance and testing*; **WG 2**: 7 *Spatial subschema*, 8 *Temporal subschema*, 9 *Rules for application schema*, 20 *Spatial operators*; **WG 3** 10 *Cataloguing*, 11 *Geodetic reference systems*, 12 *Indirect reference systems*, 13 *Quality*, 14 *Quality evaluation procedures*, 15 *Metadata*; **WG 4**: 16 *Positioning services*, 17 *Portrayal of geographic information*, 18 *Encoding*, 19 *Services*; **WG 5**: 6 *Profiles*.

One of the world's largest ship-classifying companies has calculated that 40% of shipwrecks or ships running aground can actually be avoided.

Accidents causing enormous environmental damage, as with the famous EXXON VALDEZ incident off the coast of Alaska, may then be averted. IHO is working closely with ISO/TC 211 to ensure that future versions of their global standards can be defined as profiles of the generic standards developed by ISO.

THE MILITARY SCENE

No military operations or battles for centuries past have been waged without maps. For long, military needs represented the main reason for mapping territories, and most national mapping agencies have a background in military history.

Today, modern weapons rely totally on computing power, and data such as geographic information has become more and more important. To launch a missile to hit its target hundreds or thousands of kilometres away with surgical precision requires sophisticated and detailed terrain - or topographic - information.

The arms trade is international, and so, too, are more and more paramilitary operations like peace-keeping operations under UN command. It is thus no wonder that the military has addressed the GIS standardization issues for the last two decades. The most mature results are with Digital Geographic Information Working Group (DGIWG), a NATO-based group, who has defined the DIGEST family of geomatics standards.

While there is normally a longish gap between the definition of standards and their real and practical implementation, the DGIWG countries have also worked hard at producing data conforming to the standard. Thus, already a couple of years ago, we had a global dataset of geographic information, *Digital chart of the World*, delivered on four CD-ROMs conforming to DIGEST. Although the resolution of the data is somewhat coarse, corresponding to maps in scale 1:1 000 000, this is the first example of a general geographic dataset covering the whole world. The dataset is furthermore available at close on distribution cost, and several system vendors have tailored it to their own systems. At present, the same group is at work on a global dataset representing mapping to the scale of 1:250 000 to be available by the end of the century. This dataset will fill 234 CD-ROMs, that is to say about 150 GB (billion bytes) of information!

ISO/TC 211's liaisons include DGIWG, that is also aiming to harmonize its present *de facto* standards with the future ISO standards as profiles. If we manage to bring about this harmonization, we will have an International Standard that is already accepted by the user community and with a vast amount of information in compliance with the standard. This would really herald a flying start for ISO/TC 211 standards!

GLOBETROTTER STANDARDS

The demand for International Standards in the field of geographic information and geomatics is manifest and rapidly on the increase. Important *de facto* contributions from, for example, the military and maritime environments already exist. Official standardization work within ISO/TC 211 is now organized, and the committee will be able to produce mature results within a fairly short timeframe. These efforts will eventually ensure interoperability, a flow of information and re-use of information, enabling competition on an equal basis, thereby reducing costs to users entering the growing field of GIS utilization.

Geographic information technology is moving from being a vertical market segment to representing a horizontal one - proof of this is that some of the major general relational database vendors incorporate spatial models into their base technology, enabling any business to use the geographic tools in its application. Another proof we might well experience: if we use the latest versions of two spreadsheets showing the largest market-share, we will be able to visualize our data partially, that is on a map, and this ability is built into the systems. Both vendors - representing the world's two largest software companies - have acquired GIS technology in the desktop mapping market and integrated it into their spreadsheet products. In the long run this may prove to be the real start of new mapping era; suddenly all of us have become "cartographers"!