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Global Geoinformatic Mapping as the Methodology and Technology of the Future

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Today, at the boundary of millennia, the Global Geoinformatic Mapping (GGM) appears as the prior direction of scientific and technical progress. Its goal is the cartographic representation of the real world and creation of the global computer model of the Earth, comprised of millions of space images and electronic maps of various subjects and scales, themes and also reference information. This fundamental problem can be solved by cartographers from countries - members of the ICA, who should meet the 21 century as partners, possessing new ideas, courage and intellectual technologies for creating and application of maps.

Due to Canadian cartographers, we have got acquainted with the amazing term «Geomatics» that reflect further integration of sciences about the Earth with mathematics and informatics on the base of modern computer-aided and telecommunication technologies.

These two approaches reflect the beginning of Geoinformation Era and evolution of ideas along with the Global Geoinformatic Revolution that now takes place in the world.

The need in collecting more complete and precise data about Earth phenomena and objects highly increases today. As a result of development of space survey, the bulk of geospatial information grows very quickly. So the new electronic technologies and standards are required to process spatial data and deliver it to the users. This means the increasing role of the intellect.

In this context, I'd like to say some words about electronic maps. I don't see anything bad in variability of their definitions. People start to think, develop notions. As a result the new scientific branch is being working out. And today we believe the most important thing is cognition of the entity of the electronic maps and their amazing property to change immediately from common spatial model of the Earth (in form of a globe) to more detailed terrain images. This seems to be the most fundamental approach to the development of concepts of global geoinformatic mapping. It may seems strange, but this entity is rendered in Russian writer M. Bulgakov's greatest novel "The Master and Margarita", where magician Woland shows his globe to Margarita [1].

"I see my globe interests you," said Woland.

"I have never seen anything so ingenious".

"Yes, it is nice. I confess I never like listening to the news on the radio. It always read out by some silly announcer who can pronounce foreign names properly. Besides, one in three of the announcers is tongue-tied, as if they were chosen especially. My globe is much more convenient, especially as I need exact information. Do you see that little speck of land, for instance, washed by the sea on one side? Look, it's just bursting into flames. War has broken out there. If you look closer, you'll see it in detail."

Margarita leaned toward the globe and saw that the little square of land was growing bigger, emerging in natural colors and turning into a kind of relief map. Then she saw a river and a village beside it. A house the size of a pea grew until it was as large as a matchbox. Suddenly and noiselessly its roof blew upward in a puff of black smoke, the walls collapsed leaving nothing of the two-story matchbox except a few smoking heaps of rubble. Looking ever closer, Margarita discerned a tiny female figure lying on the ground and beside her...

Here we can see the main advantage of the electronic map in comparison with the paper one.It can immediately, in real-time mode, in variant scale render the most actual information for any terrain. This is symbolized cartographic modelthat carries the most complete bulk of spatial data contained in existing maps, air- and space photos, and other materials describing the terrain and its phenomena and processes.

Developers of electronic maps, by means of the newest computer technologies, use the same tools as artists of all ages - from Roublev and Michelangelo to Renoir and Picasso: form, stroke, its width, length, color. Very important role also plays spatial combination of cartographic symbols, their spatial appearance, blinking etc.

But only one or several electronic maps cannot be regarded as a universal tool for all customers who want to see Earth as it is, solving multi-purpose control and navigational tasks in area of industry, agriculture, transportation, communication, meteorology, tourism etc. It is necessary to combine different electronic maps of various scale, projection, coordinate system, content and appearance in the whole system. This means to create the united computer model of the Earth, which includes thousands of electronic maps of various purposes and scales. We speak about the development of the Electronic Maps System that means the aggregate of electronic geographic, topographic and thematic maps integrated under common idea and ordered by geodetic base, content and design. It also includes orthophotomaps, city maps, air- and space photo images, reference information stored on computer media.

The Global Geoinformatic Revolution has penetrated all aspects of Cybercartography with the Canadian Geographic Explorer as its interesting example [2].

Variation of goals and tasks of cartography does not change its entity as the skill, science and technology for map production. This is also promoted by the automated cartographic systems (ACS), developed in 60-s, and some late inventions such as GIS and GPS, that are intended not only for processing information and production of electronic maps, but also for multi-aspect application of geospatial data. ACS, GIS and GPS, new intellectual technologies can only increase the effectiveness of acquisition, analysis, processing, modeling, displaying and transfer of spatial data, and using this data in queries and calculations, converting data to commodity output.

The elaboration of these tools is closely connected with the development of methodology that creates a theoretical reserve and, hence, must have a priority.

The matter of GGM is preparation and fulfilment of measures directed to develop and implement conceptual and methodological basis, normative and legislative documents and standards of metadata for geographic, geodetic, gravimetric, space, photogrammetric and cartographic information, electronic photomaps and and spatial (3-D) terrain models, formats for spatial data interchange; to develop and implement methods, hard- and software tools and technologies for acquisition, storage, analysis and processing digital cartographic data, creation of usual (paper) and electronic maps; to develop and implement Base of metadata and Balk of spatial data, digital and electronic maps, geoinformation systems of various intent. At the modern stage, GGM is closely connected to the development of geography, geodesy, remote sensing, photogrammetry and cartography.

The Electronic Maps System is based on the following principles:

- system approach as the conceptual basis for creation and implementation of cartographic models, as the methodology of research and projecting the System, and as the scientific method of development of effective computer-aided technologies;
- principle of mathematical and cartographic modeling as a way to visualize terrain features and objects;

- principle of rasterized input/output of cartographic data, and processing data in vector form;
- principle of controlability of digital cartographic data;
- principle of utmost complete acquisition, one-time exhaustive analytic/synthetic spatial data processing and its use by many customers.

In order to implement the main statements of GGM it is necessary to solve the following methodological and technological tasks [3]:

- investigation and generalization of the international experience in Earth mapping and application of geospatial data;
- development of cartographic thinking, revelation and exploration of objective regularities and features of Earth mapping, formulation of principles of GGM on this base;
- investigation and elaboration of the concepts, intellectual methods and technologies of acquisition, integration, analysis, processing, modeling, displaying of electronic maps, 3D-images, dynamic cartographic models, virtual maps;
- development of basic categories and notions, international and national standards in the area of GGM;
- creation of the International Earth Knowledge Management System, Global Base of Metadata and Banks of Geospatial Data, telecommunication networks;
- development and implementation of high-skilled expert ACS and GIS of various intent;
- increasing professional skill level of the personnel in the area of GIS and intellectual technologies at all educational levels;
- revelation of contradictions in the area of GGM, determination of directions of its evolution, elaboration of the criteria and methods for evaluation of the effectiveness of the new technologies;
- development and implementation of the international cooperation programs in the area of GGM strategies including participation of governmental and private cartographic enterprises of countries - members of the ICA.

In future works the new high-precision technology of creating electronic orthophotomaps will play very important role.

This technology provides for the use of high-resolution space photos and various maps. It includes creation of geodetic basis, digital data processing, recognition of images, producing digital orthophoto plans and maps, digital models of terrain features, digital terrain elevation models, spatial terrain models, electronic topographic and thematic maps, electronic city maps. Its important part is improvement of quality of source images and supervision of production quality.

Digital orthophoto plans serve as the main carriers of terrain information. The main function of them is to provide maximum amount of data. In contrast to maps, they are not work of art, and they have no cartographic design. Digital orthophoto can include cloudness and other defects. The main features of electronic maps is obviousness and think-through contents that can be achieved by means of symbolization system and methods for cartographic image generalization based on theory of visual perception, engineer-psychological evaluation and modeling. Electronic maps must have no defects.

The use of space technologies in mapping provide an unlimited review and acquisition of huge bulk of multi-purpose terrain information. In comparison with traditional technologies, the problem of mapping can be solved with much less financial and temporal expences, with greater quality and reliability. The process of mapping the difficult-to-access regions is now solving only by means of space technologies.

The huge bulk of multi-purpose terrain information allows to realize an effective method of mapping according to the principle «from general to individual» (like the globe of Bulgakov’s Woland). Wide-range space information gives an opportunity to represent long-area terrain features, pick out the necessary objects and phenomena on large areas.

The advantages and distinctions of space information in comparison with usual (air and land) are the result of space flight pecularities: height and speed of spacecraft movement. Space information allows to create new, more informative types of cartographic products - digital orthophoto plans and electronic orthophotomaps. Space survey allows to update existing cartographic materials with any desired periods of time. The spatial resolution of obtained information becomes the most important factor for solving most of the problems, including creation of maps.

In whole, the technology includes complex amount of operations: preparation and analysis of source data; digitizing source data; creating digital terrain elevation model; transformation and correction of single photos; building mosaic plan; obtaining digital data of the electronic orthophotomap.

The implementation of these measures, based on the new ICA cooperation principles, will provide more closely collaboration and fruitful contacts of cartographers throughout the world, and allow to realize a breakthrough and move up. The cartographer must become a God who creates the new world of cartography and new appearance of a map by means of fantasy of electronic images.

References

1. Bulgakov, M. The Master and Margarita. Meridian, New York, 1993.
2. Taylor, D.R.F. Maps and Mapping in the Information Era. Proceedings, 18th ICA International Cartographic Conference, Stockholm, 1997.
3. Martynenko, A. The Development of a Concept and Methods for Creating an International System of Geographic Maps as an Universal Basis of the Earth Knowledge. Proceedings, 17th ICA International Cartographic Conference, Barcelona, 1995.

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Important Initiatives in Geographic Information Science and Spatial Data Collection with Implications for Cartography

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Abstract

Within the United States of America there are three major initiatives that are having and will have a direct impact on the science and application of cartography. The first of these initiatives is the Digital Earth Initiative that was introduced by Vice President Albert Gore in February 1998. Mr. Gore envisioned a database of one-meter resolution data for the entire planet that would enable any desktop computer user to experience any place or location in the world. This Digital Earth system would sit on top of the Internet. The cartographic problems of the storage and management of distributed geo-referenced data repositories, the integration of multi-resolution, multi-layer data with analytical techniques, and the use of advanced visualization techniques, all figure prominently in the Digital Earth Initiative.

The second of these initiatives is the Digital Library Initiative funded primarily by the National Science Foundation. The Digital Library Initiative has completed two rounds of competitive funding (1994 and 1998) resulting in major research grants being awarded for the study of the role of digital spatial data and geo-referenced manuscripts and their information in the libraries and archives of the future. The concept of a geo-library, or a library for geo-referenced data and information, has been one of the thrusts of the research in this initiative. Cartographers have been involved in these competitions. The third Initiative is the Digital Government Initiative, again funded by the National Science Foundation. This initiative is a program begun in 1998 that has held two competitions to date and whose goal is to "fund research at the intersection of the computer and information sciences research communities and the mid- to long-term research, development, and experimental deployment needs of the Federal information service communities." (NSF 98-121, 1998) Very large-scale data and information acquisition, management, analysis, dissemination, and visualization are at the core of the Digital Government Initiative. The Initiative seeks to improve government operations and government/ citizen interactions.

Each of these programs has major implications and will drive the future of our field. National mapping programs of the past, in most nations, were federal spatial data and information gathering and storage archives for the nation. Cartographers in most instances controlled these analog data and information systems and technology. Will this continue to be the future for Cartographers? What roles should cartographers play in this future?

Introduction

As Cartography and cartographers settle into using the digital electronic technology that has rapidly replaced the analog technology they have used for the past 300 years, they quickly find that it is not simply a replacement technology but also an enabling technology. Map readers and users that formerly were the main customers of the paper map products of analog cartography are now demanding new and more exacting digital products, often ones that they produce themselves. These demands will only accelerate as the full impact of the electronic technology is embraced by the public. What does this mean for cartographers?

This paper apprises the profession of three developments that will have major impacts on the developing stage in which cartography in the 21st century will operate. Cartographic expertise is vitally needed in each of these developments to ensure success. These three developments are the Digital Earth Initiative, the Digital Libraries Initiative, and finally the Digital Government Initiative. Although the developments described below are taking place within the United States, I am certain that similar developments are occurring elsewhere in the world and eventually all three will have universal consequences. It is my hope that cartographers will be a primary directing force in each of these developments, thus assuring a continued future for our discipline.

Digital Earth Initiative

The concept of Digital Earth was addressed at the highest levels of the United States government by Vice President Al Gore on January 31, 1998. Gore stated: " I believe we need a 'Digital Earth'. A multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data. Imagine, for example, a young child going to a Digital Earth exhibit at a local museum. After donning a head-mounted display, she sees Earth as it appears from space. Using a data glove, she zooms in, using higher and higher levels of resolution, to see continents, then regions, countries, cities, and finally individual houses, trees, and other natural and man-made objects. Having found an area of the planet she is interested in exploring, she takes the equivalent of a "magic carpet ride": through a 3-D visualization of the terrain." [Gore, 1998]

This multi-resolution, three-dimensional model of the earth will accommodate vast quantities of data with a proposed resolution of one meter for the intended audience of all citizens, not just trained specialists. This requires that the interfaces and the underlying framework must be intuitive enough for young children to use, yet powerful enough to provide meaningful results for research scientists. [Crockett, 1998] Access at museums, public libraries, schools, workplaces, and homes is envisioned.

Gore recognizes that no one organization in government, industry or academia could undertake such a project, but he also recognizes that most of the technologies and capabilities that are required to build a Digital Earth already exist or are under current development.

NASA has been asked to lead the effort within the United States to formulate a Digital Earth Initiative. They have held five workshops to date and several interagency committee meetings among US Federal agencies involved in geo-referenced data. Several working committees have been established on such topics as (1) reference model/architecture, (2) compilation of a current document which inventories capabilities, and (3) an organizational and charter development for interagency activities. [Mitchell, 1998] NASA is planning on issuing a Cooperative Agreement Notice in the spring or summer of 1999 to stimulate activity and identify promising technologies.

Initially the Digital Earth Initiative will be composed of a number of cooperative agreements among universities and industry, internal agency development activities and partnerships with museums and other sites where public access can be provided. The intent is to fund hundreds of content-based regional and thematic pilot projects and public displays and to support technology research, development, and commercialization. These activities will engage the public in determining the manner in which the vision of Digital Earth is realized. All visualizations will be built around an agreed upon model which will enable many different kinds of data to be presented simultaneously. The underlying architecture will accommodate the integration of standards, new technologies and data types as they become available. [Mitchell, 1998]

Digital Earth is the Global Spatial Data Infrastructure, GSDI, discussed with increasing frequency in the cartographic literature. [from Morrison, 1994, to Fuller, 1998] With the GSDI needed to enable the realization of Digital Earth, the future that cartography must create is a seamless distributed database providing information and knowledge about all aspects of the Earth in response to specific queries from individuals. One of the first and most difficult challenges is the integration into a distributed database of existing digital data from multiple sources with varying resolutions. A second set of challenges is to move (1) from thinking in terms of "ownership" of data to thinking of "access" to data, (2) from thinking of products to thinking of services, and (3) from thinking locally (proprietary systems) to thinking globally and the use of open systems. If NASA is fully funded for the Digital Earth project, monies will be widely available for cartographers to participate in this gigantic undertaking.

Digital Libraries Initiative

In 1994 the National Science Foundation in cooperation with the Defense Advanced Research Projects Agency and the National Aeronautics and Space Administration conducted a competition entitled the Digital Library Initiative. Six large multi-year grants were awarded. One of those grants was to a team of researchers at the University of California-Santa Barbara whose proposed project deals with the handling of spatial or georeferenced data in the libraries of the future. The Santa Barbara team named their project the Alexandria Digital Library Project, ADL.

> "The goal of the Alexandria Project is to build a distributed digital library that allows users to access and manipulate information in a variety of classes of collection items in terms of geospatial reference. A central function of ADL is to provide users with access to the information in a large range of digital materials-ranging from maps and images to text to multimedia-in terms of geographical reference. An important type of query is "What information is there in the library about some phenomenon at a particular set of places?". From the Internet, both users and librarians can access various components of ADL, such as its catalog and collections, through powerful, graphical interfaces without having to know where these different components are located on the Internet". [ADL, 1998]

Since October 1994, the ADL has employed a strategic approach that involves: (1) a focus upon access to the information contained in many classes of collection items, including non-traditional items, by geographical reference; (2) the development of the user interface and catalog components of the digital library architecture; (3) accessibility to the ADL catalog and collections via the Internet for a wide variety of users; (4) close interaction and interoperability with other digital library activities by way of Internet-related technologies; (5) a process of incremental, evolutionary design and implementation of ADL that takes advantage of critical technological developments and especially Internet-related technologies; and (6) digitally-supportable extensions to traditional library functionality.[ADL, 1998] A series of prototypes led to an operational library in 1997. Since that time ADL has been loading significant collections of geospatially-referenced information including such items as the metadata and data for AVHRR, Digital Elevation Models, Digital Raster Graphics, scanned aerial photographs, Landsat TM, and seismic datasets.

A second round of competition for the continuation of research on Digital Libraries was held in 1998, and a further round of competition had a proposal due date of May 17, 1999. The goals of the phase 2 competition were to (1) selectively build on and extend research and testbed activities in promising digital libraries areas;

(2) accelerate development, management, and accessibility of digital content and collections; (3) create new capabilities and opportunities for digital libraries to serve existing and new user communities, including all levels of education; and (4) encourage the study of interactions between humans and digital libraries in various social and organizational contexts. [NSF 98-63, 1998]

The Digital Libraries Initiative lies at the interface between library science and geographic information science. This interface must make the positioning of geospatial data transparent to the end user. Conflation ambiguities must be deconflicted and datums, projections, resolution and scale differences must be capable of being transformed one to another without in-depth knowledge by the user. The necessary manipulations must be built into the system. Cartographers are well equipped to direct the creation of this capability.

Digital Government Initiative

The digital government program of the National Science Foundation began in 1998 and completed its first round of competition on September 1, 1998. Each March 1 thereafter will be the due date for a new round of proposals. The digital government initiative seeks to provide a transition strategy for migrating Federal Information Services from legacy systems, through the interoperable systems of the Internet, and toward more advanced integrated global systems. At this stage of development many of the first truly operational systems based on electronic technology are in need of replacement in most Federal Agencies. These legacy systems are generally independently built within the confines of a single agency and utilize home-grown software that does not allow the systems to be interoperable, and thus tremendous inefficiencies are being encountered. The initiative seeks to improve government operations and government/citizen interaction by creating interoperable systems that operate through the Internet and allow access to the very large databases maintained by Federal agencies.

Included in the potential research topical areas of the digital government program announcement are areas of direct concern to cartographers: for example, (1) very large scale data and information acquisition and management for geospatial and multidimensional data, (2) advanced analytics for large dataset/information collections, (3) intelligent information integration, and (4) information services of citizens/customers. [NSF 98-121, 1998]

Implications for Cartography

Taken together, the Digital Earth Initiative and the Digital Libraries Initiative encompass the entire field of cartography. Add the Digital Government Initiative and we are adding additional data, analytical processing and visualization needs. Therefore, one can state that the entire field of cartography is affected by these programs. Recently the Geography and Regional Science Program at the National Science Foundation sponsored an in-house workshop on geographic information for the various programs and directorates within NSF. Included in the report of that workshop were several visions of the practice of geospatial research in the year 2010. One vision is reproduced here with the intent of dissecting it to learn those critical needs that require solutions before the vision can be realized, and to relate those needs to the three initiatives defined above. The abbreviations DE=digital earth, DL=digital libraries, and DG=digital government are inserted by this author into the quote.

> "A sociologist is studying crime [DG-federal data] in a city in the northeastern United States, trying to understand the pattern [DE-visualization] of assaults. Sitting in front of a multimedia system [DE& DL-hardware], he requests that all assaults in the past year be shown on a map [DL-archive manu-

script] of the city. While he is looking at the map, the system computes correlations [DG & DL-analytics] with other available data, and notes several phenomena that have spatial associations with the crime data. One of these is an association between the pattern of assaults and the density of bars (drinking establishments) [DL-local data]; the researcher accepts this particular suggestion, and the system adds [DE-visualization] the bar locations to the map. Next, the researcher opens a modeling window and composes a rule:[DE-analytics] a "bar assault" is any assault within 100 meters of a bar, between the hours of 5 p.m. and 2 a.m. local time. He then asks for all bar assaults to be shown as yellow dots [DE-visualization], and to display assaults that are not bar assaults in red. Next, he has the system show area lighting [DL-local data], traffic patterns [DL-local data], and police patrol patterns [DL-local data]. The system automatically runs standard correlations and plots summary associations [DE-analytics] so that individual events can be examined. The variables with the highest correlations appear in a window, ordered from strongest to weakest correlation, and the system asks if he would like to see correlations between similar variables that have been published in similar studies of other U.S. cities [DL-archive data and DE-visualization]. The system is providing this spatially enabled scientist with tools and methods [DE-analytics] to facilitate spatial thinking and inference, spatial analysis, and spatial statistics. The system automatically finds background data [DL-archive data] he requests, based on either coordinates or place names, checks that the data are compatible in terms of scale, accuracy, and map projection [DE-analytics], and integrates [DE-analytics] data from different sources automatically, leaving the researcher to concentrate on thinking about the crime patterns themselves and their possible causes." [NSF, 1999]

From this example it is obvious that the tasks which cartographers perform are deeply embedded in this scene from 2010. Data problems involving the integration of federal and local datasets and the archiving of data are evident. The long standing problem area of data conflation and the real-time needs for data archiving and retrieval are readily apparent. The statistical processing of spatial data, the creation of summary statistics, and the visualization of the results are considered routine in this scenario. Mere solutions to these problems are only one stage of the needed research.

After solutions are found, they need to be implanted in the various contexts within which they will be used. It is conceivable that various contexts will require modifications to the solutions. For example, in the above scenario suppose that the location of drinking establishments is available only for 1995, while the assault crime statistics refer to 1998, and the latest police patrol patterns in the database are for 1997. How are conclusions to be drawn from these data? Even if we could rapidly call forth the datasets, how would we deal with the resulting uncertainty due to different time stamps?

What are the appropriate statistics to use to calculate a pattern? Most statistical techniques, for example the correlations referred to in the above scenario, are based on statistical theory that assumes a random distribution. Spatial data are usually not random but highly autocorrelated. Do we need a new set of spatial statistics based on an assumption of high autocorrelation in the data? What is the level of specificity that the question raised needs for a useable answer. In other words what level of generalization is acceptable in the result? How do we relate that acceptable level to the generalization of available data? What is the best way to display the results? These questions raise the issues of data compression and generalization. What are the most efficient ways to store geospatial data? What compression algorithms are most useful. For display, what generalization algorithms are most efficient?

Finally in the area of data updating and maintenance can we create intelligent data that knows when they need to be updated, or when they should not be used in conjunction with other data? With the vast quantities of data that are and will continue to be available, it is necessary that updating and maintenance be as automated as practicable. Assuming we move to storage of data by features, can we embed enough intelligence in a feature for it to automatically seek updating when it needs it? The concept of a "knowledge object" that can automatically compare its attributes with attributes derived from a new imagery source and update itself if necessary is being researched.

Can we also create intelligent symbols: symbols that carry information about themselves and can use that information to aid the researcher to more quickly understand what it represents, including the uncertainty of its representation? Can the symbol be programmed to take on different forms depending on the context of the visualization? For example could a symbol for soils change depending on the needs of the user, being one shade if the soil type or soil sub type is relevant to the needs of the user and becoming a different shade when it is not relevant. In general can a symbol be imbedded with intelligence to allow it to automatically change classes depending on context?

The implications are clear, **cartographers need to directly confront these areas of research and solve these long standing problems**. We must work with professionals in other fields in designing and perfecting the system. If cartographers do not step forward to these initiatives, other disciplines will.

Challenges to Cartography

Clearly the impacts are profound, but we need to approach these impacts with changed thought patterns. These changes in thought patterns constitute the real challenges to cartographers in 1999. As stated earlier, we need to think in terms of access to data and of providing services to users or customers. We must stop thinking in terms of products and the ownership of data. It has been suggested that because cartographers have been product oriented for years, i.e. image frames, map sheets, intelligence reports, that our entry into the digital world has led us to file-oriented storage and retrieval, i.e. image data servers, catalog search and browse, licensed products. As a result each of us probably can easily identify more than five attempts at the creation of complete files of the highway and street networks of the United States done by different agencies and firms. Each maintains that their file is more up-to-date and has more current attributes than the competition's and is more easily used. In fact, what we need is one on-going collective effort to maintain the base highway and street layer of data for the United States. Think how much cheaper one comprehensive file would be and how the money currently wasted in competition between agencies could be better used to realize more quickly the scenario described above. We should use our resources for digitizing the world wisely and not wastefully. We should plan for seamless data and information provided by many distributed providers, quickly accessible on line to any type of user. Maybe we should create a cartography utility. A utility provides a service, much like electricity. Fortunately we do not have five sets of electric lines coming into our homes with switches that allow us to use one source for heating, one source for lighting, and a third source for cooking.

To meet these changes in thinking we have to be able to work with different resolutions and qualities, different bandwidths, different time stamps and derived information interrelated to specific theme layers. We are just beginning to fuse data from different image sources and to combine data from a new image with data in existing databases in attempts to eliminate uncertainty and to build more comprehensive databases. In the area of automatic feature extraction, we are just now moving away from reliance for extraction from a single source to the reliance on a combination of sources, including existing database information to reduce uncertainty.

We also need to think globally. We can ill afford to think about proprietary systems that exist in isolation. We must plan and use open systems. Understanding the vision for 2010 requires an integrated approach for producing, cataloging, and publishing online content. The global system must accommodate imagery data, derived information, and available knowledge that is both classified and unclassified, produced publicly and privately, and available for a fee or free. It requires cooperation among corporations, governments and non-governmental organizations. Fuller [1998] proposes one strategy that includes focused data/information production by government, prolific content production by commercial providers, use of commercial content by government, use of open GIS and dynamic interoperability which will permit transparent access by all to heterogeneous geodata.

A further challenge is that we must work outside our discipline. We do not and can not control the future. In the past we did have a measure of control when we dealt with products, ownership of data, and proprietary systems. That is not the future. We must work with professionals in many other disciplines, bringing our expertise to bear and sharing it with their expertise. The task is larger than cartography, yet cartography is an integral part of the Digital Earth or Global Spatial Data Infrastructure task. I have often hypothesized over the past 30 years that 30 years ago cartography attracted an introverted person who took extreme pride in his/her work and was most happy when given a task and allowed to pursue that task through to its completion, producing a work-of-art type product. Today cartography needs to attract a person who works well with others, who is self confident, who knows the subject so well that he/she knows when to compromise and where not to compromise.

The funding for the three programs that I outlined at the outset of this paper appears to be forthcoming. If the direction and comments that I have made are even half-correct, cartographers face a great opportunity accompanied with a need for change to realize that opportunity. The impacts and the challenges to the field appear greater today than they have over the past three centuries. We need to redefine cartography and then go through the sometimes-painful process of reinventing cartography and cartographic institutions to be in line with the redefinition. This is an evolutionary process. During our history every time that ideas and opportunities have presented themselves from outside our discipline we have met them, changed, taken advantage of the opportunity, and become a more vital and vibrant discipline. I do think that what we are experiencing today will be any different. The true cartographer will persevere and the good ideas from outside will be accepted and incorporated into our content and the bad ideas will fall by the wayside. It is an exciting time to be a cartographer.

References

Alexandria: A Digital Library for Geographically-referenced Materials, (1998). Project Summary. http://www.Alexandria.ucsb.edu/pub…cuments/annual_report98/node2.html

Crockett, Thomas W, (1998). Digital Earth: A New Framework for Geo-referenced Data. Institute for Computer Applications in Science and Engineering Research Quarterly, 7(4), http://www.icase.edu/RQ/archive/v7n4/digitalEarth.html

Fuller, G.W, (1998). A Vision for a Global Geospatial Information Network. http://digitalearth.gsfc.nasa.gov/documents.html

Gore, A, (1998). The Digital Earth: Understanding our Planet in the 21st Century. http://digitalearth.gsfc.nasa.gov/VP19980131.html

Mitchell, H, (1998). The Digital Earth: The Coming Data Explosion. http://digitalearth.gsfc.nasa.gov/handouts.html

Morrison, J.L, (1994). A Global Spatial Data Infrastructure: A Proposal. GIS/LIS ’94 – Central Europe. Building Linkages. 23-27.

National Science Foundation (1998). Digital Libraries Initiative Phase 2 Program Announcement 98-63. Joint Agency Programs. http://www.dli2.nsf.gov/announce.html

National Science Foundation (1998). Digital Government Program Announcement 98-121. Directorate for Computer and Information Science and Engineering. Division of Experimental and Integrative Activities. http://www.nsf.gov/pubs/1998/nsf98121/nsf98121.html

National Science Foundation (1999). Geographic Information Science: Critical Issues in an Emerging Cross-Disciplinary Research Domain. http://www.geog.buffalo.edu/ncgia/GIScienceReport.html

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Metadata Standard Architecture Based on Digital Earth

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Abstract

Digital Earth is the trend for geoinformatics or cartographic related area. Now people are considering to establish digital earth for geospatial information sharing. As an important part of digital earth, metadata standardization is the key technology for it.

In this paper, the authors presented a metadata standard draft that can be used for digital earth at the level of National Spatial Information Infrastructure (NSII). The standard consisted of two levels, the first level is the general metadata elements that can be used for the information sharing at the national or global area; the second level is the main contents of metadata elements, it consisted with eight standard sections.

Through the analysis to the architecture of digital earth and metadata, the authors also presented a method that can be used to establish metadata software system via internet. The software that used for the NSII is an experimental product of metadata based on digital earth. The whole theory and method that used by this paper is very important for the implementation of digital earth.

INTRODUCTION

The Global Information Society is a rapidly emerging trend. An important and fundamental component of this trend is the Global Spatial Data Infrastructure (GSDI) [1], it results digital earth. Powerful technologies such as Remote Sensing(RS), Geographic Information System(GIS), and Global Positioning System(GPS) are providing voluminous amount of spatial data for digital earth. One of the resulting challenge is the effective and efficient sharing of the spatial data, and the key technology is metadata standard.

U.S. vice president Al Gore said that metadata is one of six key technologies for digital earth[2], it made various geographic organizations to respond the challenge. The U.S. Federal Geographic Data Committee (FGDC)[3], Open GIS Consortium (OGC)[4], European Committee for Standardization (CEN/TC 287)[5], and the International Organization for Standardization (ISO/TC 211)[6] are participating in the metadata standardization of digital earth, but so far a systematic theory about Metadata does not exist.

This paper presents a Metadata standard system which could be used in National Spatial Information Infrastructure (NSII) to establish digital earth through analysis of the social background, theory architecture, and application prospect of spatial Metadata. The Metadata standard will be appropriate for the needs of national digital geographic information sharing, and currently, the experimental network software system based on this Metadata standard has been established[7]. The whole theory and method that used by this paper is very important for the implementation of digital earth, and it also will be popular in the areas related to the application of digital earth (Figure 1) [2].

CONCEPT OF METADATA

Metadata is “data about data “ or “information about information”[8], it used to describe the content, quality, representation, spatial information reference, managing method and various characteristics of a geographic dataset[7]. Metadata is one of the critical standards needed for the sharing of digital geographic datasets. Metadata is structured data used to describe information resources; the information can be used to manage and organize information; it also can be used to accurately discover or locate information, and then to compare the same elements in different datasets in order to get new or necessary information from different organizations or datasets.

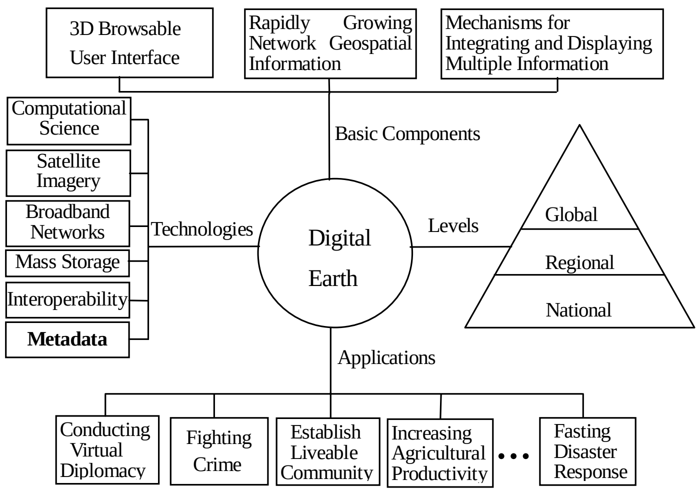

Figure 1 Basic Architecture of Digital Earth

Of course many people think that metadata is a complex architecture that can only be used in the areas of computer science or information technology. As truly, metadata has been used in the area of geoscience for many centuries, such as the legend around ancient map or chart is a simple metadata. The importance of metadata were acknowledged by people since computer was used in the area of geoscience.

With computer, people can use and exchange information via different computers or different computer operation systems. But with the establishing of different cartographic data bases or geographic information systems all over the world, they find it is difficult for them to know where they can get the needed information. Therefore, in order to use and get spatial information, people present the word metadata and began to research it. By the support of metadata, people will have the ability to share digital information all over the world. Especially with the development of digital earth, they will use metadata as an spatial engine to get information and use them for making decision.

ARCHITECTURE OF METADATA STANDARD

Frame Architecture of Metadata

Although in 1992, FGDC already began to discuss metadata, and presented a standard draft in 1994 and a revised standard in 1997[3], but there still does not exist a systematic theory for Metadata. ISO/TC 211, which established in 1994, has 20 items to research geographic information standards and metadata project belongs to item 15[8]. For the complexity of metadata, those international organizations still have divergence on metadata standards. CEN/TC 287 disassembled metadata into 10 sections to research it, FGDC divided it into 7 sections, ISO/TC 211 decomposed it into 8 sections. So how to research metadata for digital earth is very difficult to decide yet, and even if the powerful standard of metadata for geographic information-ISO/TC 211 metadata standard will be finished by the end of 1999.

In fact, digital earth is very difficult to establish. So the effective way to implement it is via the level of global, regional, and national level. Among them, National Spatial Information Infrastructure (NSII) is very important for the implementation of digital earth at the national level, because different countries will fund the research with the meaning of strategy. Therefore, we selected the metadata standard based on NSII as the experimental research.

Table 1 Contrast to Content of Metadata Standard

CEN/TC 287	FGDC	ISO/TC 211	Our Standard
Dataset Identification	Identification Information	Identification Information	Identification Information
Dataset Overview	Data Quality Information	Data Quality Information	Data Quality Information
Dataset Quality Elements	Spatial Data Organization Information	Lineage Information	Lineage Information
Spatial Reference System	Spatial Reference Information	Spatial data Representation Information	Spatial Data Organization Information
Extent	Entity and Attribute Information	Spatial Reference Information	Spatial Reference Information
Data Definition	Distribution Information	Application Feature Catalogue information	Entity and Attribute Information
Classification	Metadata Reference Information	Distribution Information	Distribution Information
Administrative Metadata		Metadata Reference Information	Metadata Reference Information
Metadata Reference			
Metadata Language			

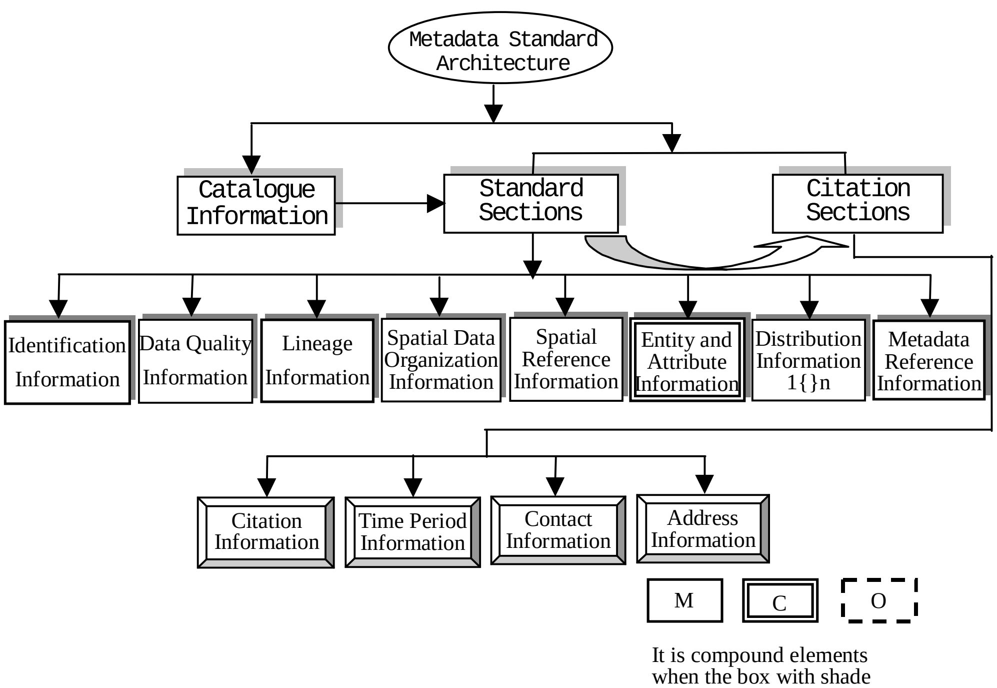

Figure 2 Organization Frame of Metadata Standard Architecture

With considering to those metadata standards presented by FGDC, CEN/TC 287, ISO/TC 211, the authors think although there are some divergence on the sections of metadata, they still have some commonness in the contents[9]. Then through analysis and research to the standards, the authors presented a metadata draft that can be used on the level of NSII. The standard consisted with two levels(Figure 2), the first level is a cataloging part, it consisted with the compound elements and data elements needed for managing and querying geographic information via national spatial data clearinghouse, and the contents of it are somewhat the macro part of dataset; the second level is the main part of the Metadata standard, it consisted with 8 normalization sections and the other 4 citation sections, and the contents include the mandatory (M), mandatory if applicable (C), and optional (O) elements for fully describing geospatial information. The whole content of the Metadata standard is organized according to the sections, compound elements, and data elements.

Brief Introduction of Metadata Standard

The elements of metadata standard on the first level depend those on the second level, and the second level is the main body of its content. The following is a brief introduction of metadata standard on the second level, the detail of it are included in the reference[7].

1 Identification Information

Identification Information is the basic information about the dataset. Through Identification Information, the producer of dataset can describe the basic information of dataset, such as the title of dataset, the author information, the language which used to describe the dataset, the environment to support it, and the thematic classification, the restriction to access the dataset, etc. The users of the dataset also can get general information of it with the help of Identification Information.

2 Data Quality Information

Data Quality Information is used to assess the general quality of the data set. Through elements included in this section, users can get the geometry accuracy and attribute accuracy which related to the dataset, they also can get the logical consistency and completeness information of it. With those information, users will have the ability to decide if the dataset is useful for their application, the producer of the dataset will also reference it to describe the method and procedure which used to assess the quality of the dataset.

3 Lineage Information

Lineage Information are those related to the events, parameters, and source data which used to construct the dataset, and also information about the responsible parties. Through those information, producers will have the ability to describe the middle procedures which used to establish the dataset, such as to produce a dataset with the procedure of aerial photograph interpretation, autovectorize, compile digital map, and revised. By the help of those description, users will clearly to the procedures of how to produce a dataset, and also made it easy to understand the role of each procedure.

4 Spatial Data Organization Information

Spatial Data Organization Information is used to represent the spatial information in the dataset. It includes spatial representation type, vector spatial representation information, raster spatial representation information, image spatial representation information, and sensor band information, etc. Those information are used for data interchanging and to decide if the data can be used to run on users' computer platform. With Spatial Data Organization Information, users can deal with or analysis those data after they get them.

5 Spatial Reference Information

Spatial Reference Information is used to describe the coordinate reference frame and the encoding method of the dataset, it is the bridge to connect the reality and the geographic digital world, such as geographic identifier reference system, horizontal and vertical coordinate system, and geodesy model, etc. Through those elements, user can get the information of how geographic entity was changed to digital world and the parameters which used for the transformation. Of course, with those elements, we also can get the information of reality through digital elements.

6 Entity and Attribute Information

Entity and Attribute Information is the information that used to describe the content of the dataset, such as the entity types, their attribute and the domain of attribute value. Through this section, the dataset producers can describe the name of different entities, the identifiers and their meanings. They also made users can get the name information of geographic attribute code, their meaning and the authority resource of those information.

7 Distribution Information

The Distribution Information is the information related to the dataset distributing and the method to get it. The contents include distribution party, the describe of data resource, the responsibility of distributor, the ordering procedure, custom order process and the technology information to correctly use the dataset. Through Distribution Information, users can get the information of dataset of where it is, how to get it, what media to storage it, and the fee to pay for it.

8 Metadata Reference Information

The contents of Metadata Reference Information are related to the present and the responsible party of metadata standard, they include the date information, contact information, standard information, restriction condition, security information, and the extension information of metadata. Through Metadata Reference Information, users will have the ability to get all information that used to describe metadata content, they also can be used to understand the contents of dataset.

9 Citation Sections

Citation Sections is composed of citation information, time period information, contact information, and address information. These four sections are repeating parts in the content of metadata standard and as citations used in the other sections of it, they shall not be used alone. Among them, citation information contains information such as the title, author information, reference time, and version information of dataset; time period information contains the elements such as date and time used by all compound elements in the standard; contact information contains identity of person(s) or/and organization(s) associated with the dataset; address information contains the metadata elements required to provide the address and other means to communicate with persons and/or organizations associated with the dataset. These sections are important for the implementation of metadata software and to simplify the standard.

SOFTWARE ARCHITECTURE OF METADATA

Architecture of Metadata Level

The key role for metadata is to get and discovery information via internet or digital earth, so the implementation of software for it is very important. Of course, to design a software system is very difficult, it must to consider different computer platforms and operation systems. In order to make users exchange information via internet with different personal computers and workstations, to represent metadata with different languages and forms, and to get and evaluate the contents of metadata, programmers must to use general encoding method to design it. According to this aim, programmers will make it easy for the input, search, query, retrieval and presentation of metadata.

As truly, the complexity of geographic information is one of important feature for it to distinguish with other data, it not only refers to three dimensional reality, but also the world is variational, it made us always must to face a huge system with the fusion of human and nature information. Metadata is one of key technology to deal with those features, and the serial datasets are the sample of the complex system.

For traditional paper map, it is very easy to understand serial maps, but in the digital world, for the divergence of different concepts to dataset, it becomes difficult than those in traditional one. Of course, metadata with lineage relationship in serial datasets, it made many same elements among them, just like coordinate reference system, metadata reference information, etc. Programmers should to clearly consider those reasons, and it will make the input, renewal and the report or results to be produced more easily.

The metadata levels include dataset serial metadata, dataset metadata, feature type, and feature example metadata, attribute type and attribute example metadata. Among them, the model of dataset metadata is needed, the others are optional.

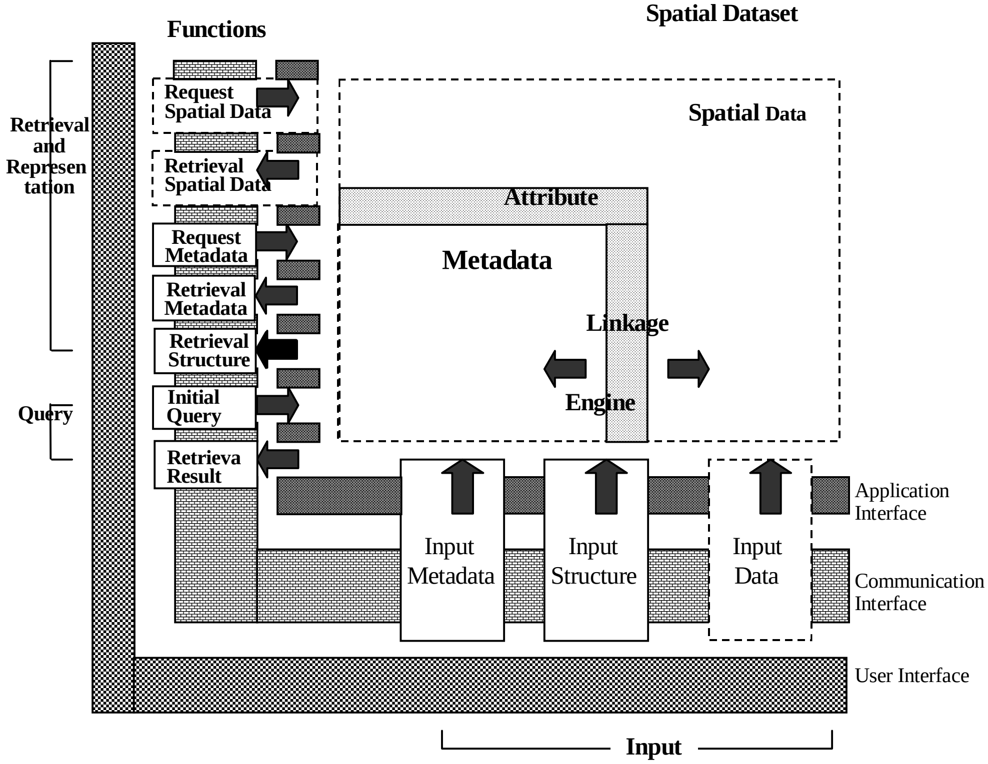

Figure 3 Logical Model of Metadata

Logical Model of Metadata Software

Metadata is known as the vanguard of Spatial Information Infrastructure or Geoscience Information Highway, it also the spatial engine of digital earth. Therefore, in order to query geoinformation easily, metadata software should with the functions of data input, query, retrieval and representation. Figure 3 is the generalized logical model of metadata[8].

In this model, the central square box is the body of metadata, it connects spatial data and attribute data with spatial data engine. With the engine, it will assure the renewal of data base and metadata at same time. The spatial dataset and the outside is connected with application interface, and users are connected with communication interface. In the procedures, clients and servers are communicated each other in the distributed environment, and most the other functions of metadata are implemented by the models included in figure 3.

The data storage, encoding, and linkage of metadata are also very important factors for the implementation of metadata software. Generally, there are two forms for the management of data storage, they are file and data base. When there are few datasets, it is easy to use file storage method, but with the development of datasets, data base management will be appropriate for large scale datasets. With data base management method, it will also be easy for the query of metadata. Encoding should to be done with the language of SGML, it will standardized the input and output of metadata, and made the data transmission and representation very easy. According to the method, the input of metadata elements will form a standard SGML document, it will help the management of metadata. The linkage of metadata and spatial data is also an important part for the design of the software, there are three methods that can be used for it, they are off line spatial method, spatial data in the server of metadata, and spatial data and metadata in different servers. The programmers should to consider the three methods sufficiently and to assure metadata be renewed periodically.

Function Models of Metadata Software

The specific functions required for interaction with metadata are input, query, retrieval and representation. The following are the introduction of them.

Input function is consisted with input structure, input metadata, and input spatial data. Among them, input structure is used to describe how metadata is organized inside data base, it is the reference to decoding information at the client computer; input metadata is the core content for metadata elements, it used to describe the content of dataset for producers; input spatial data information is used to linkage spatial data base, it is the optional part for the functions, and acted an important role when database is online. Of course these functions should to be implemented with the restriction of level architecture and should to avoid duplication.

Query function is composed of initiate query and receive result list. When users submit a query and an algorithm at the side of a client computer, the server will echo to it and supply an translate and retrieve results to the client computer. In the process to design the software system, they should to include the metadata identifier, the title, and the extend information in the result elements. The identifier of metadata is used to link elements of metadata, and it will not to be shown. The transport protocol shoult to accept TCP/IP or OSI standard, the protocol of data querying and searching should to accept ISO 10163:1995 standard, the query form at client side should to accept HTML standard.

Retrieval function is composed with request metadata, retrieval metadata, retrieval structure, request spatial data, and retrieval spatial data. When user submit a request, it will be transported to server accompanied with metadata identifier. Then the sever will response to the request and to search an appropriate information that can match the query condition. After the condition is matched, the server will encode the results of metadata with the protocol of ISO 8879:1985, and encapsulate the metadata result with the ISO 10163:1995 standard supported language and returned it to the client. When the client accepted the result information, it will translate the information into the form which his own system can understand it, such as HTML etc. So far, with the methods what we refers in the paper, the input, query and retrieval operation of geographic spatial information will be implemented via network.

EXPERIMENTAL SOFTWARE FOR METADATA

Method to Implement Metadata Software

The implementation of metadata software is the trend for the usage of metadata standard, it connected with the technology of computer science and communication, such as data base system, network, and web browser technology. With these technologies and protocol, and relationship we refers before in the paper, programmers will with the ability to describe and manage metadata architecture using object oriented technology, to design the query and retrieval page using web technology, and to implement the communication between client and server using network technology, etc.

Of course with the emergence of information society, there will have new technology to be used implementing metadata standard. Therefore, we will no longer to discuss the methods of how to implement metadata standard. In general, one technology will be useful to design metadata software if it could be used to content all functions of metadata. The experimental metadata software in the late of the paper is implemented with the object oriented technology, network technology and web technology, the system is based on the distributed network and client/server architecture.

Example of Metadata Software

Through the research and analysis to geographic metadata features and the developing trend, we have designed a metadata prototype software that can be used for digital earth at the level of NSII. The metadata standard of the software is depended on the draft which we have implemented in the reference[7].

The metadata software is divided into three major functions, they are input, query, and retrieve. With the software, dataset producer will have the ability to fully describe geographic information in the environment of network through input function, and effective and efficient to manage metadata contents with data base manage system. The metadata data base is designed with the architecture of ODBC, it made the query can be implemented by the query function of metadata, and the results can be represented with the form of HTML etc.

Therefore, according to the model architecture of metadata which described in the paper, it will be easy to implement the sharing of NSII geographic information via client to server and then to client again. It also can be extended to the implementation of digital earth.

CONCLUSION

The standardization of geographic information and the implementation for information sharing is the international trend in present[10], it also is the hot on the field of geographic information research. Now geographic information research is experiencing an thriving and prosperous, and with the development of remote sensing, geographic information system, global positioning system, network communication, computer technology, WebGIS, and Virtual Reality GIS, people are urgent for metadata system[11]. Therefore, the research to the standard of metadata and the implementation of its software is important to the establishment of NSII and the digital earth. It also will promote the prosperous of geoscience into a new period of renaissance. With metadata, it will be easy for the establishment and usage of digital earth, and the time of digital earth era is coming to us.

References

1 Zhao Yongping, Henry Tom, Cheng Jicheng. The Research and Perspective of Global Spatial Data Infrastructure. Science & Technology Review. 1998,(2)17-19

2 Al Gore. The Digital Earth: Understanding our planet in the 21st Century. http://www.opengis.org/info/pubaffairs/ALGORE.htm. Given at the California Science Center, Los Angeles, California, on January 31, 1998.

3 Federal Geographic Data Committee. Content Standards for Digital Geospatial Metadata. http://www.fgdc.gov/metadata,1994, rev 1997.

4 OpenGIS Topic 11. OpenGIS Abstract Specification - Metadata (version 3).http://www. opengis. org/techno/specs.htm, 1998.

5 CEN/TC287 Secretariat. CEN/TC 287 Geographic Information. http://www.statkart. no/sk/standard/cen, 1996.

6 ISO/TC 211N603. Geographic information - Metadata (CD version 4.0). http:// www.statkart.no/isotc211/dokreg06.html, 1998-11-04.

7 Zhao Yongping. Research of Metadata based on the National Spatial Information Infrastructure and the Implementation of Experimental sharing System. Ph.D. Dissertation of Peking University, June 1998.

8 David Danko. The ISO Metadata Standard for Geographical Data. Geo-Infomatics Conference of the International Eurasian Academy of Sciences and the Fourth International Workshop on Geographical Information System, Beijing'97, 1997, pp:98-104.

9 Cheng Jicheng, Zhao Yongping. The Geographic Information and Metadata Normalization Research. Journal of Remote Sensing. 1998,2(2):149-154

10 Henry Tom. GIS Standards—The Time Has Come. GIS Asiapacific, 1996,(2):18-19.

11 Zhao Yongping, Cheng Jicheng. The Standard Research of Geographic Information Metadata. China Standardization, 1998(1):8-11.

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Reinventing Cassandra: Building the U.S. National Spatial Data Infrastructure

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Abstract

The paper discusses some implications of a 1998 report on United States federal government civilian agency geographic information functions and the role federal geographic information in building the United States National Spatial Data Infrastructure (NSDI). The initial collaborative behaviors of four separate federal agencies- -representing three Cabinet-level Departments- -in funding the study and developing the four major questions posed in the contract with the National Academy of Public Administration (NAPA), resulted in a mutuality that offered significant prospects for advancing the NSDI. This mutuality was subsequently "trumped by turf" during the agencies' review and subsequent commentary on the draft report Additional commentary (much of which appears to be supportive of the recommendations contained in the NAPA report) from state governments, interest groups, and professional societies involved with the different disciplines of geographic information is now being considered by the Federal Geographic Data Committee. Expanding the discussion of these issues to the public at large remains an elusive goal for the geographic information community, and will require innovative efforts well beyond the NAPA's perhaps unintentional serving as a "reinvented Cassandra" for the federal geographic information community. The views expressed in this essay are solely those of the author and do not reflect the views or positions of his employer.

"The Panel found that there are many technological challenges to realizing the full potential of a robust NSDI, but the greatest challenges now appear to be on the human side. The technology makes it possible to provide remarkable new capacities for governments and the American people to many things more efficiently, but implementation requires significant changes in human relationships and behaviors as well."

Scott Fosler, President, National Academy for Public Administration, in the Foreword of "Geographic Information for the 21st Century: Building a Strategy for the Nation."

"Cry, Troyans, cry! Lend me ten thousand eyes
And I will fill them with prophetic tears."

Cassandra, Trollius and Cressida, Act II, Scene ii

While we know that the prophetess Cassandra was daughter to King Priam of Troy, we can only infer that her craft was informed to some extend at least by an understanding of both the then-current events in, and the history of, that area we sometimes call today "the Balkans." Given the ebb and flow of peoples back and forth across the Straits of the Bosporus, that narrow hour-glass between East and West, one may suggest, if mostly light-heartedly and for purposes of discussion, that Cassandra would- -as a King's daughter- -have been geographically aware of the fragmentations and contentions of those who called the Balkans home.

In a like manner, it is possible to view the January, 1998 National Academy of Public Administration report on the United States federal government civilian agency geographic information activities as serving a Cassandra-like function both those involved in geographic information activities and the public at large. While the report describes the heavily balkanized nature of geographic information functions with the federal civilian agencies, it also avers, as noted in Scott Fosler's acutely insightful observation above, that the major stumbling block to building the U.S. NSDI is not technical, but human. There can be little doubt that the report produced tears in the eyes of three of four agencies who funded the study (see the agency comments in Appendix J of the report), but those tears neither flowed from Cassandra's asked-for 10,000 eyes nor were they "prophetic." Reaching that flood-level of lachrymose activity will require a greater awareness of the problem with the national and international geographic information communities. Further, such an outpouring will be a necessary precondition for building the U.S. NSDI.

As in all great undertakings, there is abundant irony within the events leading to issuance of the report. Perhaps the greatest of these ironies is the disappearance of the collaborative and collegial relationship that emerged among the four agencies sponsoring and funding the study and the professional society that brokered it. In fact, that mutuality greatly informed the study and set the groundwork for possible joint actions on implementing certain of the report's recommendations. Given the report's numerous mentions of the geographic information "community," and its willingness to work collaboratively toward the building of the NSDI, the federal agencies' responses to the draft report can only viewed as "fashionably Balkan" in their self-interests.

Background:

The study, which was funded collaboratively by the Department of the Interior's Bureau of Land Management (BLM) and its United States Geological Survey (USGS), the Department of Agriculture's Forest Service (FS), and the Commerce Department's National Ocean Service (NOS), was brokered by the American Congress on Surveying and Mapping (ACSM). Those agencies met during mid-1995 to discuss a number of issues regarding federal surveying and mapping matters, no the least of which were static/declining budgets and calls within the legislative branch or restructuring federal surveying and mapping activities, including possible privatization of some functions.

In August of 1995, the following questions were hammered out by the agencies and ACSM as the central issues to be addressed in the study:

(1) Is Geographic Information acquisition, analysis, and distribution critical to keeping the United States competitive in a global economy? What are the most important uses of this information on a national scale?

(2) What is the appropriate role, given recent technological and sociological trends, of the federal government in civilian surveying, mapping and other geographic information? What functions are largely federal, as contrasted with those that are more appropriately administered by state and local governments, the private sector, or academe?

(3) IF some functions are deemed suitable to be commercialized, privatized, or transferred to other non-federal governments, what would be the effectiveness and economic impact of those transfers?

(4) Are there opportunities to consolidate or otherwise restructure federal surveying, mapping, and other geographic information functions to achieve greater economy and efficience and performance? If so, what functions should be brought together and how should they be structured?

The selection of a contractor to accomplish the study was viewed by the agencies and the ACSM perhaps the critical element of the effort. In choosing the National Academy of Public Administration, the agencies noted its continuing reputation for producing high-quality, disinterested reports, its status as an independent. Congressionally-chartered research entity, and its being a co-equal to the perhaps better known- -at least within the natural resources community- -National Academy of Sciences. The agencies and ACSM believed this was needful given the highly-charged nature of the questions to be addressed in the study.

After being awarded the contract in September of 1996, NAPA requested that each of the sponsoring agencies and ACSM name one headquarters office person to serve on a permanent Advisory Committee during the course of the study. The

Committee would be used to facilitate data gathering, provide contacts with agency field office personnel, and a host of other administrative tasks that would assist NAPA staff in researching the questions set forth in the contract.

One of the first tasks of the Advisory Committee involved the preparation of each agency's list of names to be contacted by NAPA during the research phase of the study. Agencies were asked to submit names of experts in geographic information for possible inclusion as members of the Study Panel which would provide executive direction to the NAPA staff. Agencies were also asked to identify individuals within their own organizations who might be interviewed by NAPA staff and the Study Panel members. There was a remarkable degree of congruity among the agencies submissions for Study Panel members, which eventually included such luminaries as Jack Dangermond of ESRI, Larry Ayers of Intergraph, and Edward E. David, former Science Advisor to the President of the United States.

It is hard to over-emphasize the contributions of the Advisory Committee in keeping the complicated management processes involved in the almost $1,000, 000 contract on target. Given the fac that three different Cabinet departments were represented among the four collaborating/funding agencies, that differing missions (science versus land management) characterized those agencies, that the constituencies/stakeholders of the agencies represented an incredibly broad range of interests, and the conflicts between each agency's headquarters and field personnel over the need for the study, the Advisory Committee can justly claim no small part in bringing the contract to fruition. Perhaps the severest test of their competencies involved the expansion of the contact to move beyond mere surveying and mapping concerns into the more inclusive realm of "geographic information." A modification of the contract had to be negotiated and the need for same explained to agency budget officers, not to mention the securing of additional monies for the expansion once the need was made clear. All told, the Advisory Committee's deliberations were a model of mutuality, perhaps reflecting the general tendency within the geographic information community at large to be well-disposed toward such collaborative models.

Issuance of Draft Report

When the agencies and the ACSM received their copies of the draft report for analysis and comment in September of 1997, they had an incredibly short amount of time to digest a lengthy and complex set of issues. Given the many levels of review, particularly within the land management agencies with their decentralized field offices, it is hardly surprising that all felt the pressure of time in preparing their comments. Nevertheless, there were discussions among members of the Advisory Committee concerning the possibility of preparing a joint response to the draft. Given the controversial nature of certain of the report's recommendations, it is perhaps remarkable that such an attempt at continued collaboration was even discussed, let along assayed. Indeed, the logistics of attempting such across the three Cabinet-level departments alone would have likely been sufficient cause to abandon any such effort, regardless of the nature of the report's recommendations.

Now, however, mutuality and collaborative behaviors too a back seat to the dominance of agency "turf" issues. The "zero sum" nature of certain of the recommendations, particularly those that involved moving organizational elements from one home to another within the larger geographic information community, doubtless predisposed the agencies to issue separate responses. Even so, the relative ease with which "turf triumphed" over the budding mutuality of the Advisory Committee, and, more importantly, the general tendency of the larger geographic information community toward such mutuality in sharing information, is remarkable.

Of the more than 50 recommendations in the report, none caused more intense reaction that (1) the recommendation to build the NSDI through legislation and the creation of a National Spatial Data Council ("Council") located in the private sector and (2) the recommendation to create, from the existing, balkanized federal agencies geographic information function, a Geographic Data Service (GDS) within the Department of the Interior to serve as a necessary “critical mass” of federal geographic information. The report envisions a synergy from these actions, which, if taken together, will speed the development of the NSDI.

Regarding the “Council,” the report noted that a truly “national” spatial data infrastructure could not be built under the present arrangements which feature the federal government in a lead role. While the report lauded the work done by the Federal Geographic Data Committee (FGDC) in initial development of the NSDI (and particularly singled out its pushing of Executive Order 12906 which sets forth the Executive Branch’s vision for the NSDI), it acknowledges that federal resources were too fragmented and scant to allow a timely building of the NSDI. Continuance of constrained federal budgets, devolution of more and more federal functions to other levels of government and the private and non-profit sectors, and rapidly expanding private sector capabilities in geographic information were combining to effect a change of the federal role in the geographic information equation.

Regarding the proposed Geographic Data Service, the reported noted that a truly national NSDI could not be built without having one central locus for all federal civilian geographic information--a “critical mass” to use the report’s compelling image. It pointed out that the FGDC has no enforcement authority over its members and that this lack served to constrain the effectiveness of the FGDC in accomplishing its goals and objectives. The report also noted that there appeared to no cross-cutting budget reviews of federal civilian agency geographic information activities, and that such information would likely make a strong case for the need for the GDS.

Even the most cursory look at the agency responses to the draft report shows the haste with which the agencies donned the sacred mantle of “mission” in repudiating the report. Noting that the creation of the GDS “would remove a core mission from land management agencies,” the BLM raised the specter of “more bureaucracy” when it averred that “the GDS would create an additional step by requiring land managers to petition another bureau for information needed on a day-to-day basis.” (NAPA, 338) Even within a category of response it labels “recommendations it might support if provided with further justifications for their validity,” the BLM fudges its facts; its statement that “we will continue as a leader in the strengthening of the ICCC [Interagency Cadastral Coordination Council] to satisfy multi-agency requirements” overlooks the fact that it had been more than four years since the ICCC last met.

The FS was equally adept in donning the Mission Mantle. While stating its support for building the NSDI, it heavily qualifies such support by insisting that “the newly proposed legislation should not in any way detract from land management agencies (sic) abilities to achieve their program requirements.” (NAPA, 345) Lest even such a plain statement be misconstrued, the FS concludes that particular paragraph by noting that “ [H]owever, additional funding from Congress will be needed in order to successfully accomplish the tasks specified in the report.”

The NOS, while opposing the creation of the Council and the GDS (NAPA, 355), in part for the same turf reasons cited by BLM and FS, took a more balanced tone throughout its comments and declared “the study provides a thoughtful analysis of the significance of GI [geographic information] to the nation’s present and future economic and environmental well-being.” (NAPA, 352)

The most proactive of the agency comments came from the USGS. In characterizing the report as “complete and thoughtful” (NAPA, 348), the USGS seemed to understand both the reasons underlying the need for the study and the intent of the four questions asked of NAPA. It urged the “creating of a national coordinating council to allow for equal representation of all components of the NSDI” (NAPA, 348) and “endorses the goals and objectives that would be achieved by the establishment of a Geographic Data Service” while suggesting “additional efforts be put toward a comprehensive cost/benefit analysis and designing a strategy that could realize the GDS goals and objectives before resorting to physical consolidation.” (NAPA, 349)

Even at this writing, some 15 months after these agency responses, the ACSM- -broker of the study and ensuing report- -seems resigned to the report’s fate as yet one more ornament on the bookshelves of the seemingly impervious federal agencies. At its Spring, 1999 Conference in Portland, Oregon, there was no forum convened to discuss the status of the report. This was surprising given the well-attended forums at both its Spring (Baltimore) and Fall (Ft. Worth) Conferences in 1998 and its Fall 1997 Conference in Cincinnati.

Future prospects:

If the NAPA report is to avoid the ignominious fate of becoming yet another ornament on federal agency bookshelves, it will need substantial and persistent prodding of the federal civilian geographic information agencies by state and local governments, their related public interest groups (such as the National States Geographic Information Council) and the professional societies in the geographic information. Prospects for the avoidance of such a fate are promising, if those groups follow the lead of the state of North Carolina, the National States Geographic Information Council, and the American Society for Photogrammetry and Remote Sensing.

An August 2, 1998 letter to NAPA signed by Jane Smith Patterson,, Senior Advisor to the Governor for Science and Technology, notes the State's Geographic Information Coordinating Council members

> ". . .are pleased to endorse the NAPA study report and believe it will enhance and focus efforts to make the National Spatial Data Infrastructure (NSDI) an important national priority within the United States. We are particularly pleased that the report places such strong emphasis on the benefits, opportunities, and collaboration goals of the NSDI and recognizes the need for a National Spatial Data Council."

Of more interest, perhaps, to the members of the International Cartographic Association is the "position statement" attached to the letter. Choosing "to review. . .the suite of recommendations in the report as an integrated proposal," the Coordinating Council avers its "understand[ing] that examining any one recommendation or issue in isolation is precarious and likely to compromise the integrity and intend of the complete proposal." Its endorsement of the proposed National Spatial Data Council is similarly strong and direct: "we wish especially to stress our avid, favorable reaction to the creation of the National Spatial Data Council as a forum for the bringing together of views of all the stakeholders of the NSDI." Apparently, North Carolina understands well the benefits of the multi-lateral partnering that the NAPA report believes is crucial for rapidly growing the NSDI, for the position statement concludes with a ringing affirmation of the fact that the NSDI cannot be built by the federal government alone.

"Lastly, the GICC wishes to express appreciation and support of the NAPA panel's persistent attention to the collaborative nature of the NSDI; the value of participation and empowerment of state and local government, *federal agencies in the field*, academia, and the private and non-profit sectors; and the importance of US involvement in international efforts related to geographic information. This multi-lateral collaboration is of vital importance to North Carolina and the nation." (Emphasis not in original)

A similar expression of support is offered by the National States Geographic Information Council (NSGIC) which terms the report "important and timely." NSGIC offers a small tweak to the proposal to create a National Spatial Data Council.

"The Council heartily supports the concept of an NSDC and feels strongly that NSGIC should be part of the charter of such an organization. However, attention should be paid to the structure and function of such a group. A permanent, full-time entity is needed and thought should be given to changing the proposed name to reflect this, such as a "center," "association," or "institute."" It also states that "it is reasonable to designate an Office of Management and Budget (OMB) program associate director for natural resources, energy, and science to be a full member of the FGDC." This tracks well with the NAPA report's observation regarding the inability to track geographic information spending on a cross-cutting basis among agencies with functions and programs in geographic information.

NSGIC also "concurs" with the report's recommendation to consolidate base geographic information functions into a new Geographic Data Service, and echoes the USGS' perspective that alternatives to a physical consolidation should be examined before such an action is taken.

"Federal reorganization efforts to incorporate GI functions currently housed in the Departments of Commerce, Interior, and Transportation into a Geographic Data Service (GDS) is a recommendation we expected to see included in this study. We concur with the panel that the objectives behind this recommendation are sound and must be achieved in order to better align federal GI programs and activities toward effective realization of an NSDI. However, NSGIC proposes that alternative strategies toward achieving the same set of objectives be pursued before a reorganization is considered to be the best solution."

The February 22, 1999 policy statement of the ASPRS on the NAPA study begins with a stark declaration on the collaborative nature of any NSDI.

"The American Society For Photogrammetry and Remote Sensing (ASPRS) supports, without reservation, increased attention to the collaborative nature of the National Spatial Data Infrastructure (NSDI) as essential to providing full access to quality geographic information and technology for all citizens."

Like the state of North Carolina, ASPRS chose to "consider the suite of recommendations in the report as an integrated proposal." Particularly telling is the following excerpt from the policy statement:

"ASPRS has refrained from selective endorsement or rejection of individual study recommendations in favor of supporting the overall philosophy conveyed by the report. Nevertheless, we stress our favorable reaction to a forum, such as a National Spatial Data Council, for bringing together all stakeholders of the NSDI in an environment where no single sector is perceived as having control."

It will be interesting to see how the Federal Geographic Data Committee deals with these, and subsequent, statements from state governments, public interest groups, and professional societies. What is remarkable about the North Carolina, NSGIC and ASPRS statements is their positive, forward looking, and collaborative aspects- -particularly as contrasted with the narrowly focused, mission-driven statements of the BLM, the FS, and the NOS.

Conclusion:

Whether the federal geographic information "community" can make the necessary "leap of faith" to a collaborative, multi-lateral partnering environment remains to be seen. To do so, it will have to shake off its historic legacy of being primarily "do-ers" and learn how to be "enablers." Those are two very much different roles, and large organizations, whether public or private, are notoriously slow to either adapt to, or reward new, behaviors. Certainly the shifting away of more and more functions from the federal arena to states and local governments and the private sector has set the stage for the reluctant feds to make such a leap. Declining budgets have had a similarly salubrious effect in pushing the feds nearer the proscenium from which the leap is to be made.

It may, therefore, be not too unrealistic to hope that the NAPA report will serve as a Cassandra to the federal geographic information community and, with its cathartic effect of producing the 10,000eyes filled with prophetic tears, enable the United States to begin building a truly national spatial data infrastructure.

References

Donahue, A.E., Sperry, R. L., and others. 1998, Geographic Information for the 21st Century: Building a Strategy for the Nation, National Academy of Public Administration, Washington, DC., ISBN 1-57744-062-5

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GeoGratis: A Canadian Geospatial Data Infrastructure Component that Visualises and Delivers Free Geospatial Data Sets

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Abstract

Many countries are in the process of setting up geospatial data infrastructures. The United States Federal Geographic Data Committee (FGDC) has assumed leadership in the evolution of the National Spatial Data Infrastructure (NSDI). Similarly, the National Geospatial Data Framework (NGDF) of the United Kingdom facilitates collaboration, standards and access to geospatial data. The Canadian Geospatial Data Initiative (CGDI) has five objectives to facilitate access, partnerships, framework data sets, supportive polices, and standards. GeoConnections is the program to build the CGDI. GeoGratis is an operational and fundamental component of Geo-Connections. The GeoGratis objective is to provide a wide range of free vector and raster geospatial data sets of the Canadian land and water mass to the public. During the early stages of GeoGratis, previously archived geospatial data sets were distributed using an Internet based File Transfer Protocol (ftp). Data sets include the Canada Land Inventory and a sample of panchromatic, multi-spectral and hyperspectral imagery. Recently implemented delivery methods are based upon the HyperText Transfer Protocol (HTTP) that permits the development of a friendlier user interface and a screen to capture a client's profile. The client is prompted to download the file in the original format and projection or the user can change these parameters according to individual preference. GeoGratis supports the distribution of framework data sets that meet national and international standards. Free and open distribution ensures that these frameworks will be widely accepted. The National Atlas of Canada base maps are the essential framework data sets in GeoGratis. In Canada, GeoGratis reflects the philosophy that the widespread distribution of free or low cost geospatial data stimulates research and development, and promotes a more diversified user base. GeoGratis develops partnerships across government departments. Many departments are protected from the vagaries of the Internet by strong firewalls. The GeoGratis project provides a simple operational tool for these departments. Recognising the needs of a diverse and new user base, GeoGratis plans to use a variety of technologies that offer a range of interfaces to view and access the data sets. Levels of complexity range from simple bitmaps to a more complex on-line GIS with file conversion facilities. The GeoGratis project is developing database design, visualisation software and access methodologies, which may be applied to any country's geospatial data infrastructure.

Introduction

The Canadian Geospatial Data Infrastructure (CGDI) compliments NRCan's vision within other federal departments and provincial governments. The CGDI vision is *"to enable timely access to geo-info data holdings and services in support of policy, decision making and economic development through a co-operative interconnected infrastructure of government, private sector and academia participants"*, (Labonte, 1998). CGDI' five objectives are to facilitate data access, develop partnerships, derive framework data sets, provide a supportive policy environment, and publish standards. GeoGratis, which is found at http://geogratis.cgdi.gc.ca, is primarily an access component of CGDI. However, GeoGratis does affect the other objectives through the distribution of some framework data and the development of supportive policies; a free-data license and embracing the cost-avoidance business model. GeoGratis is a web and FTP site that distributes geospatial data of Canada. Vector, raster and tabular data are available for download, without charge. Geospatial data sets include legacy data, framework data or data that can be used for research purposes. The GeoGratis business model is based on cost-avoidance by decreasing costs associated with traditional client support while increasing the breadth and depth of public access. This paper outlines the GeoGratis objectives, audience, business model, development phases, technology, candidate data set categories and metadata requirements.

GeoGratis objectives

GeoGratis provides a mechanism for data suppliers, typically government organisations, to distribute data sets in a cost-effective manner. Established, technologies are applied in order to minimise distribution cost while maximising current market penetration and exposing geospatial information to new markets in a user-friendly environment. GeoGratis objectives are to:

1. provide free, easily accessible, vector, raster, multispectral, hyperspectral and tabular data,
2. distribute framework data sets,
3. increase awareness and accessibility of data sets,
4. extract and distribute legacy data, and,
5. support an open geomatics environment, balanced by the needs of a set of proprietary solutions.

Canadian values and social priorities are a hybrid of European and United States practises. By executive order, The United States offers unclassified government data without charge, while some European countries charge clients based on full cost recovery. Over the last ten years Canadian governments, at all levels (federal, provincial, municipal) have adjusted their business practises around a philosophy of user pay. Hence, Canadian practice is a continuum that ranges between free data access and cost recovery. However, the concurrent emergence and widespread acceptance of the Internet over the last ten years has forced national organisations to accept that data transfer does not respect political borders. GeoGratis provides, as a first objective, a free, easily accessible, source of Canadian data for Canadians and the World. GeoGratis will offer a variety of vector, raster, multispectral, hyperspectral and tabular data from many sources.

Many countries realising the value of geospatial data as an integral component of institutional management information systems and are in the process of developing geospatial data infrastructures. Examples of geospatial infrastructures include:

- Canadian Geospatial Data Infrastructure (CGDI) co-ordinated by the CGDI Secretariat,
- National Spatial Data Infrastructure (NSDI) instituted by the United States Federal Geographic Data Committee (FGDC),
- National Geospatial Data Framework (NGDF) of the United Kingdom,
- Australia - New Zealand Land Information Council (ANZLIC), and,
- European Umbrella Organisation for Geographic Information (EUROGI).

Coleman, 1998, argues that geospatial infrastructures are defined from several perspectives. GeoGratis contributes to two of these perspectives; data and technology. Telecommunications technology, the Internet, is a transforming technology that is contributing to a focus on an infrastructure conduit, rather than content. GeoGratis is an operational conduit between data suppliers and data consumers. Another consistent requirement for geospatial infrastructures is the provision of framework data. Framework data is defined as a foundation of reliable geospatial data to enabling value-adding applications, and more specific detailed data collection (CGDI, 1998). Thus, as a second objective GeoGratis distributes framework data sets *between* data suppliers and data consumers. Note that "between" implies an ever-expanding circular flow of data. The vision is to facilitate bi-directional data flow to accommodate data quality control by several authorities.

Government organisations and their programs can be large and complex. Developing awareness of data sets, searching and retrieving data within, among and outside government organisations is problematic. A third objective is to increase awareness of these data sets within the public and private sectors and to provide easy access using Internet and geomatics technologies.

Legacy data, archived data or data used for independent research is very valuable: valuable in terms of absolute cost of collection but more importantly, as a resource for others to build upon. Typically data of this type is difficult to access. It may be housed in a climate-controlled vault or squirreled away under a scientist's desk. Nevertheless, a GeoGratis objective is to extract these data sets and make them publicly available on the Internet.

The geomatics community has long struggled with open standards *vs*. proprietary solutions. The GeoGratis project recognises the importance of an open geomatics environment, while noting that a truly open software environment will remain elusive in a capitalist economy. Therefore an objective is to support a set of proprietary and non-proprietary file formats and, within reason, not favour one solution at the expense of another. File formats that are compatible in various work environments will increase the breadth and depth of public access by diversifying the use of geospatial data from the traditional geomatics market to other, non-geomatics, professions.

Target audience

The initial audience for GeoGratis is the Geomatics community in academia, private and public sectors. Response from this community has been overwhelming and very positive. GeoGratis download logs between January 1, 1999 and March 31, 1999 indicate that 47,699 *data files* were downloaded. Every university and federal government department has made use of the service as well as provinces, municipalities and most major corporations. Of interest, 27% (12819 files) were downloaded by other federal government departments. This suggests the GeoGratis business model is meeting a need for those departments that was not being meet before.

Notwithstanding this success further work is required as the data is in a highly specialised and proprietary format. GeoGratis intends to appeal to a broad spectrum of users from those who simply want to insert a bitmap graphic into a document or presentation, to the graphic arts and business communities, and finally to the traditional geomaticians. This mission will be achieved by the objective of supporting an open geomatics environment through a wide variety of file formats that suit each group's requirements.

Business model

GeoGratis operates on the principle of cost-avoidance that takes into account those costs associated with selling data. These costs include client support, license monitoring, assessing fair market value, person years, and "haggling" with other government departments on joint projects. In many cases these costs are comparable to the revenue garnered from sales. In the case of the National Atlas of Canada, 2.0 person years were allocated to sales related functions. By placing the National Atlas data on GeoGratis it has been possible to re-allocate approximately 1.5 person years to improving the geospatial data and associated metadata. The new license developed for GeoGratis users simply encourages, and expects, the private sector to add value to the data before being redistributed by the private corporation. By relaxing licensing requirements new symbiotic opportunities have come to pass. Partnerships with the private sector to actively market GeoGratis data sets in conjunction with their software products is a triple win scenario between the data supplier, through increased awareness and access, the private sector for increased application value, and, most importantly, the consumer (and taxpayer). For example, ESRI and Autodesk are modifying GeoGratis data sets and using their extensive marketing network to distribute a new product to compliment their respective software applications.

Large scale geographic data is more expensive to maintain than small scale data for the same area. Producers of large scale geographic data sets argue that cost-recovery is required to finance those operations. Natural Resources Canada continues to charge for large scale data sets, including the National Topographic Data Base at 1:50K and 1:250K. Small scale data, equal to and less than 1:1M, and legacy data, at all scales, is distributed by GeoGratis without charge.

Development phases

GeoGratis had a humble beginning. It started on November 17, 1997 with one hyperspectral file distributed on the CCRS ftp site, accessed from an internal web page, buried under prototypes. During the summer of 1998, the addition of the Canada Land Inventory files and several earth observation images brought some diversity to the site. The National Archives of Canada, Agriculture and Agri-Food Canada and Statistics Canada co-operated to extract, un-archive, the Canada Land Inventory. The principal tasks in the development of GeoGratis are presented in Table 1.

Table 1. GeoGratis Development Phases

Phase	Date	Technology	Data sets
Phase Ia	November, 1997	- FTP	- Hyperspectral
Phase Ib	August 1998	- Descriptions of data sets using web pages	- LandSat MSS of the Great Lakes area - SPOT panchromatic - ERS-1 mosaic and DEM - Canada Land Inventory, stage 1
Phase II	January 1999	- Web visualisation and access	1. National Atlas of Canada 2. Canada Land Inventory, stage 2
Phase III	May 1999	1. Distributed search 2. File format translation 3. Selected re-projection	- VMap Level 0 Release 4 tiled by province and mapsheet - Small Hydro (Energy Sector) - Geological Survey of Canada, National Geoscience Mapping Program (NATMAP) Shield Margin Project - Canada Land Inventory, stage 3 - Canada land cover mosaic - Pipeline navigator
Phase IV	Undetermined	- CEONet API - Data warehouse - Distributed visualisation - Metadata driven visualisation	- gtopo 30 - Earth observation mosaics - Compressed Arc Digitised Raster Graphics - SeaSat

Table 1 indicates that several distinct technologies are and will be used to access an ever growing catalogue of data sets. Each phase of GeoGratis development builds on the previous. For example, the ftp service initiated in Phase I will remain available in Phases II, III and IV.

Technology

A primary requirement during development of the technology used in GeoGratis is that it must be Commercial Off The Shelf (COTS) software that is mature and widely supported. Given that the fundamental objective is to deliver data via the Internet elaborate or highly customised solutions are not necessary.

Phase Ia used a very simple web page to access files on a file transfer protocol (ftp) server, ftp://ftp.ccrs.nrcan.gc.ca. This technique was simple to implement and was successful in delivering files to a technical audience using well established technology. Phase Ib added more data to the site, some preview images and more detailed explanations of the data sets.

Phase II incorporated Phase I but due to the large number of files from the National Atlas of Canada and the Canada Land Inventory, Microsoft Active Server Page (ASP) technology was introduced. The user can select a file of interest, scale, and file type, using pull down menus. At this stage only files used for working purposes within an organisation are distributed. The National Atlas of Canada uses ESRI software to produce digital and hardcopy maps. Therefore the ESRI coverages and E00 files are the original, native, file format. For production and client service functions, the National Atlas of Canada maintained two projections (geographic and Lambert Conformal Conic), five scales (1:2M, 1:7.5M, 1:12M, 1:20M, 1:30M) and three file formats (ESRI E00 and AutoCAD DWG and DXF). The ASP technology simply provided an intuitive interface to select a specific file from several choices. Users consistently requested file formats or projections that were not available. Since GeoGratis is an exercise in cost avoidance, requests of this nature would have been charged at full cost recover of $400 CDN per day during this Phase. Conversely, maintenance of many files is expensive for the National Atlas of Canada, which is reviewing which formats and projections to maintain. The numerous scales may be derived from one 1:1M base using automated generalisation tools (Brooks, 1999). Generalisation and file format translation tools will reduce the National Atlas of Canada maintenance cycles. GeoGratis is implementing translation tools in Phase III.

Phase II also completed the metadata to populate the CEONet (Canadian Earth Observation NETwork at http://ceonet.cgdi.gc.ca) database. Metadata maintenance is an important stage to facilitate distributed searches from CEONet and to provide a basis for Phases III and IV.

Technically phase III is a substantial change from the previous phases. The CCRS ftp server used in Phase I an II was no longer large enough for the number of datasets on GeoGratis. In order to resolve space, technical access issues, translation and visualisation requirements new equipment and software was purchased using CGDI funding. The new GeoGratis server hardware is a quad 400 MHz Intel platform with six 18 Gig hard drives on a Windows NT operating system. NT was chosen over UNIX as many on-line mapping tools only support NT, while most UNIX programs have been ported to NT.

The new GeoGratis server is configured for both http and ftp requests. During Phase I and II operations several users had problems accessing files on the CCRS ftp server. Two sources of difficulties were encountered. Many users are not comfortable outside a browser (Netscape or Internet Explorer) environment. Browsers are not efficient tools for ftp access, therefore users needed to meticulously follow the extensive GeoGratis ftp help file in order to use the ftp protocol from a DOS-UNIX command line or from an ftp specific application. A second issue was firewall or proxy server configurations that can impede access to an ftp site. Therefore an http site was designed using a familiar electronic commerce shopping model.

Using a web http interface the user is prompted for several parameters; vector or raster, scale, spatial extent and keywords. A search is then carried out on a CIDAS database (http://www.cidas.com/) that has metadata and shopping cart functionality. GeoGratis generates a list based on the user's parameters. The user then adds files of interest to a virtual shopping cart. However, GeoGratis is a dream store where the shopping carts bypass the cash register! If vector files have been selected the user may select a file format preference. Vector files are translated to a variety of user specified formats using the Feature Manipulation Engine (http://www.safe.com). Similarly raster and multispectral files are translated using GeoGateway (http://www.pcigeomatics.com). If client response warrants, a user specified re-projection service may be offered a future Phase. Once the files are translated, they are compressed and the user is notified by e-mail where to retrieve the file(s).

Unresolved, at this time, are what tools will be used for visualising the data. Two prominent technologies are being considered; MapGuide by Autodesk (http://www.mapguide.com) and MapObjects from ESRI (http://www.esri.ca). While MapGuide is adept at rendering and querying maps from data located on several servers (distributed data visualisation / query), MapObjects can be automatically populated based on metadata. Alternatively visualisation may be deferred until Phase IV, Data Warehousing.

Phase IV requirements are yet to be well defined however some general observations are in order.

- Maintenance: the GeoAccess Division of the Canada Centre for Remote Sensing is also responsible for CEONet and the National Atlas of Canada, therefore tools from the CEONet / Atlas / GeoGratis trilogy need to be complimentary. In particular metadata will be used extensively to maintain the trilogy from a central database.
- Develop a general, cost effective, methodologies that can be applied to other agencies. A working example for distributed metadata query is the CEONet application programming interface, CEONet API.
- Seamless maps: the ability to view and extract information between several adjoining mapsheets.
- Delivery: quality data delivered from a small number of framework data sets in a variety of formats and projections.

Data warehouse technology, CubeSTOR (http://www.cubewerx.com) and ESRI Spatial Database Engine (http://www.esri.ca/products/sde/) are being evaluated in conjunction with the visualisation software noted in Phase III.

Description of Data Sets

GeoGratis distributes data that fit one of the following categories:

- Data that fits the cost-avoidance business model
- Framework data as defined by CGDI
- Archived data sets
- Data for research purposes
- Sample or low resolution data.

As previously mentioned the National Atlas of Canada fits the cost-avoidance business model. National Atlas data was used to generate the paper map illustrated in Figure 1. The National Atlas data is also classified as a framework data set. VMap Level 0, Revision 4, (formerly the Digital Chart of the World) is a global 1:1 000 000 scale data set. VMap is being extracted and compiled to become a new base map for the National Atlas of Canada within a global framework (Brooks, 1999). In Figure 2, the populated places and transportation layers of VMap have been overlaid on the 1:250 000 scale Canada Land Inventory map sheets.

The Canada Land Inventory (CLI) is an excellent example of a data set that was held by the National Archives of Canada and is now distributed on GeoGratis. The Federal Government approved the Canada Land Inventory program under the Agricultural and Rural Development Act (ARDA) in 1963. Subsequently, the national classification systems were drawn up through the co-operative efforts of the provincial and federal government departments responsible for resource development. As noted on Figure 2 five CLI themes are available: historic landuse, and the capacity for recreation, ungulates, waterfowl and forestry. With the exception of historic landuse, the themes refer to the capability of land to support a particular activity. Similar to geology maps, the CLI is timeless. To facilitate use of the data in federal, provincial, and regional planning the Canadian Geographic Information System (CGIS)- the first fully operational GIS in the world- was implemented. The system excelled in the building of continent wide seamless databases, with capability to overlay all CLI layers for nation wide or regional analysis. CLI is an excellent data set for development of GeoGratis technology due to consistency of methodology and the National Topographic System naming convention. The CLI was an ambitious federal - provincial program that mapped the southern portion of Canada in terms of land capabilities. The 2.6 million square kilometres mapped include the Atlantic provinces and substantial portions of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec, see Figure 3. The original cost of the program was in the order of 100 of millions of dollars in the 1970's. Recovery and distribution on GeoGratis cost in the order of $100,000. Needless to say recovery of legacy data is of great value to the taxpayer and geomatics community.

Figure 1. National Atlas of Canada, paper map MCR0100.

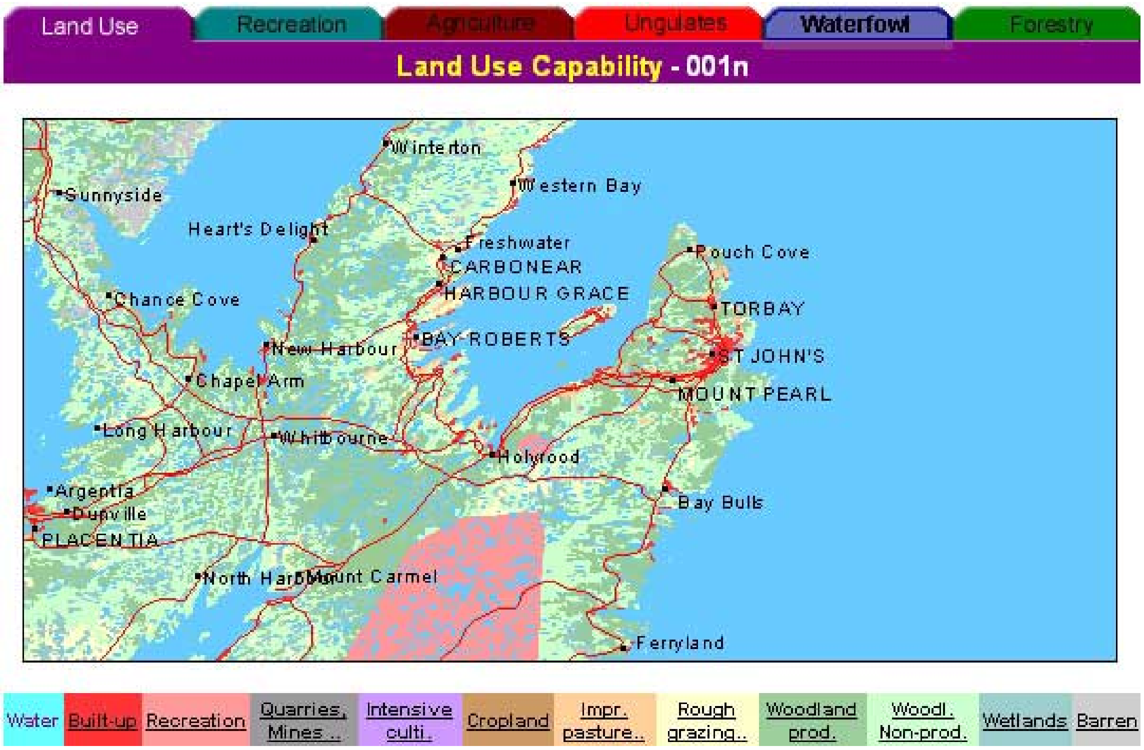

Figure 2: VMap overlaid on Canada Land Inventory, St. John's, Newfoundland, Canada NTS# 001n

The primary area of interest for researchers and educators is the study of techniques and methodologies. Therefore the spatial extent and temporality of a particular data set may not be of concern to this community. Several earth observation data sets are available on GeoGratis. Panchromatic, multispectral and hyperspectral data that is typically expensive and difficult to obtain when ordered, are available for free on GeoGratis.

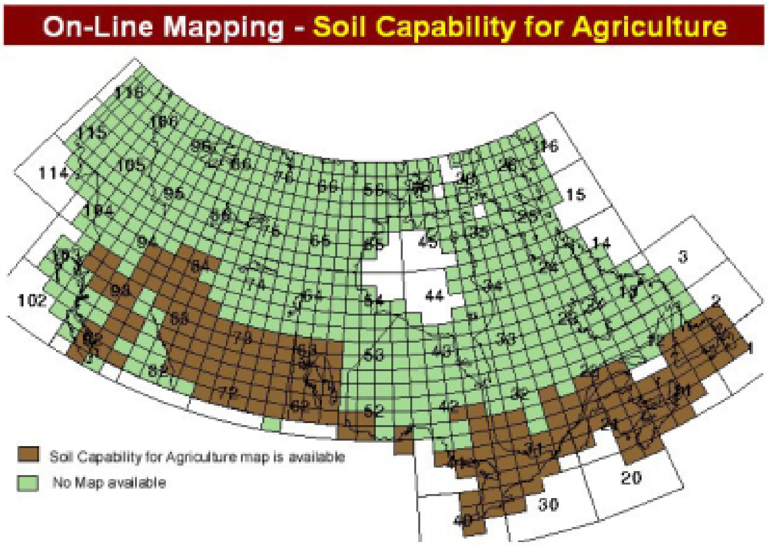

Figure 3. Canada Land Inventory, geographic extent of agricultural capability.

Figure 4. A slice from the AVRIS hyperspectral cube of Canal Flats, British Columbia, Canada

A slice from the AVRIS hyperspectral radiance cube of Canal Flats, British Columbia, Figure 4, is an example of an image with low commercial or operational utility, but which is, nonetheless very valuable for students and researchers studying image analysis techniques. Between November 17, 1997 and March 31, 1999, the Canal Flats Hyperspectral file has been downloaded 140 times. Quite the volume considering the esoteric nature of the file that is described as: “The file canal_flats.rs.bsq is an AVIRIS hyperspectral radiance cube. It is a flat raster, band sequential file, with 200 columns, 200 rows, and 224 bands. The data itself is 16 bit, unsigned integer.” (Wilson, 1998).

Sample or lower resolution data on GeoGratis will provide users an opportunity to further understand higher resolution or detailed data that may require a payment, while minimising the risk of purchasing an inappropriate data set. Retailers refer to this practise as loss leading. While government agencies typically do not market in this manner, disseminating knowledge to increase the potential use of data in order to efficiently use natural resources is well within NRCan’s mandate. For example an image mosaic of Canada resampled to a lower resolution could be distributed.

Metadata requirements

Metadata is required to search for data in a distributed server environment. CEONet facilitates public requests from multiple sources of metadata. Within the GeoAccess Division of CCRS, CEONet can search the National Atlas database managed by GeoScope or GeoGratis that uses CIDAS Metamanager.

GeoGratis Phase III requires metadata for the database to query and select data sets that meet user specified parameters. The metadata may originate from products that are specific to GeoGratis, *i.e*. the CLI, or the metadata is maintained by a separate initiative. The National Atlas of Canada maintains a metadata database of thousands of files. Therefore, GeoGratis architecture must be able to query GeoScope (National Atlas) and respond to queries from CEONet and GeoScope. Similarly the name and location of files and data sets need to visible to the National Atlas and CEONet, respectively. The bi-directional flow of information between the CEONet / National Atlas / GeoGratis is illustrated conceptually in Figure 5.

Conclusions

The GeoGratis project is managed by the GeoAccess Division, Canada Centre for Remote Sensing, Natural Resources Canada. GeoGratis delivers data as a compliment to CEONet's role as the access component of the Canadian Geospatial Data Infrastructure as managed by the CGDI Secretariat. Raster, vector and tabular data are offered for free from the GeoGratis web site at http://geogratis.cgdi.gc.ca. Objectives are to provide free data, distribute framework data sets, increase awareness and accessibility of selected data sets, extract legacy data, and promote an open environment in order to expand geomatics to other sectors. Between January 1, 1999 and March 31, 1999 47,699 data files were downloaded to a diverse audience within academia, private and public sectors. A direct mail campaign during April 1999 (when this paper was written) in conjunction with the release of Phase III should increase demand. GeoGratis uses a business model based on cost-avoidance and public good rather than the cost-recovery. The GeoGratis project is a work in progress that is entering Phase III. Each phase of the project contributes new data and the technology to search and retrieve that data in an accessible manner and format that can be used by the client's application. Metadata is the cornerstone of accessibility via CEONet, the access tool for the Canadian Geospatial Data Infrastructure.

Continued success for GeoGratis is a function of sustainability. Only through active participation and goodwill from other organisations will the GeoGratis philosophy and services expand to serve the geomatics community and the yet to be tapped non-geomatics communities. Ask not what GeoGratis can provide to you, but what can you contribute to GeoGratis.

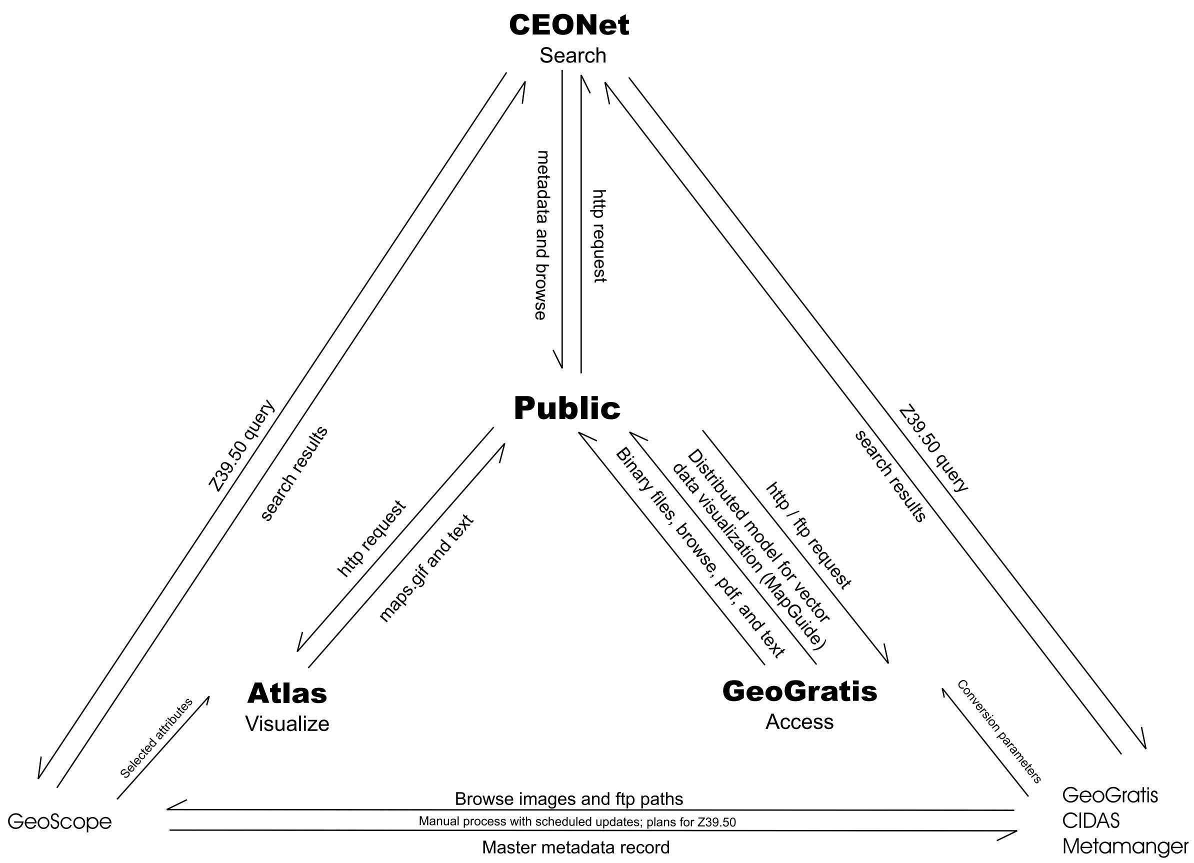

Figure 5: CEONet / National Atlas / GeoGratis Metadata Trilogy

References

Brooks, R. 1999. The New and Improved Base Framework for National Atlas Base Data. In Proceedings, 11th General Assembly of the International Cartographic Association and the 19th International Cartographic Conference in Ottawa, August 14 to 21, 1999.

Coleman, D., and McLaughlin, J. 1998. Defining Global Geospatial Data Infrastructure (GGDI): Components, Stakeholders and Interfaces. Geomatica, V. 52, No. 2, pp. 129-141.

Labonte, J., Corey, M., and Evangelatos, T. (1998). Canadian Geospatial Data Infrastructure (CGDI) - Geospatial Information for the Knowledge Economy. Geomatica, V. 52, No. 2, pp. 194-200.

Wilson, C. 1998. GeoGratis : Canal Flats - British Columbia. Introductory notes on http://geogratis.cgdi.gc.ca/geogratis/eodata/e_canal.htm

Session / Séance C1-D

The Canadian Geographical Names Data Base (CGNDB): its past, present and future

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Abstract

The Canadian Geographical Names Data Base (CGNDB) is the authoritative data bank of Canada's geographical names and contains approximately 500 000 records. Over 30 attributes may at present be stored for any name. The CGNDB is maintained by the Geographical Names Section, part of the Centre for Topographic Information (CTI), Geomatics Canada, Natural Resources Canada (NRCan). The purpose of the CGNDB is to: (1) provide a national repository for geographical names that have been recognized by the Canadian Permanent Committee on Geographical Names (CPCGN); and (2) make these names available for both government and public use. Currently, the CGNDB provides official names for such applications as national and international mapping and charting applications and gazetteer production. It is also used to maintain a geographical names reporting data base that may be accessed via the World Wide Web.

By 1924, a card-index registry had been created to serve as Canada's national repository for officially approved geographical names. As names were approved, index cards were created and added to the repository. Naming information on these cards included the officially approved name, locational information for the named geographical feature and the origin of the name. In 1978, a digital database, referred to as the National Toponymic Data Base, was developed to replace the card-index registry. This digital database was remodeled in 1987 into its current relational database form and was later renamed the CGNDB. Currently, the CGNDB is managed using Oracle and resides on a UNIX based computer system.

A recent study of the CGNDB identified that - in order for the CGNDB to continue to fulfill its mandate and to take advantage of new information technologies - a re-engineering of the database was required. A project is now underway at NRCan to re-engineer the CGNDB, which includes: (1) analysing and revising the existing data model; (2) upgrading the version of Oracle server used to manage the CGNDB to Version 8.x; and (3) redeveloping the User Interface (i.e. data entry, query and reporting facilities) for the database.

This paper describes the evolution of the CGNDB from a card-index registry to a RDBMS client/server, including a brief description of the issues that led to the development of different forms of the CGNDB. This is followed by a presentation of both: (1) the methodology and technology used in the re-engineering project; and (2) the 're-engineered' CGNDB. Finally, the impact of both the application software used to re-engineer the CGNDB and new DBMS technology on the Geographical Names Section and its stakeholders is identified.

The Canadian Geographical Names Data Base (CGNDB)

Overview

The Canadian Geographical Names Data Base (CGNDB) is the authoritative national data bank of Canada's geographical names. Over 30 attributes may at present be stored for any name. The CGNDB is maintained by the Geographical Names Section, part of the Centre for Topographic Information, Geomatics Canada, Natural Resources Canada. The purpose of the CGNDB is twofold, namely:

- to provide a national repository for geographical names that have been recognized by the Canadian Permanent Committee on Geographical Names (CPCGN)
- to make these names available for both government and public use

Approximately 67% of CGNDB names records are officially approved geographical names to be used in government publications (e.g., maps, reports, etc.). The other names in the CGNDB are considered 'unofficial' geographical names, these include formerly approved names, variants of the current names, and names that have been rescinded. Currently, the CGNDB provides official names for various applications including: mapping and charting applications (e.g., production of Canada's 1:50 000 and 1:250 000 national topographic maps; maintenance of the toponymy layer of Canada's digital National Topographic Data Base or NTDB); gazetteer production; and World Wide Web reference (i.e., maintenance of a Canadian geographical names Web site).

The naming of geographical features in Canada is, today, the responsibility of each province and territory, except for features located on federal lands, such as Indian reserves, national parks, and military establishments, where there is joint jurisdiction between the federal department and the appropriate provincial/territorial names authority. Members representing the provincial/territorial names authorities and federal departments concerned with toponymy form the CPCGN. The CPCGN is served by a Secretariat supplied by Natural Resources Canada. Therefore, names decisions approved by the provincial/territorial names authorities are sent to the CPCGN Secretariat to maintain the national registry: records are entered into the CGNDB; and files containing manuscript copies of the National Topographic System (NTS) maps are kept up to date to show the extent of features and to hold all correspondence material related to the approval of the names.

The CGNDB now contains over 500 000 geographical names records. Approximately 14% represent populated places/administrative areas, etc., 63% water features, and 23% terrain features (e.g., mountains and peninsulas). Each name record includes: a unique identifier; various codes to indicate the name status; the feature type; the region or territory in which the place/feature lies; and several location fields. In some cases, historical information about the origin/history of the toponym is also included.

Inputs into the CGNDB

The CGNDB is not a self-contained system. Geographical names updates come from the provincial/territorial names authorities and, depending on the existence of a provincial/territorial toponymic database, the data could either be a paper copy or a digital file. Typically, the size of a digital file ranges from 2 kilobytes (1 name) to 30 megabytes (1000 names). PL/SQL and UNIX shell scripts are generally used to import digital data into the CGNDB.

Business functions supported by the CGNDB

The CGNDB is used by both the CPCGN Secretariat and the Geographical Names Section to perform their business functions. These functions include:

- maintaining geographical names – that is, maintain accurate up-to-date toponymic information for Canada.
- maintaining geographical names classification system – each name is assigned several codes, some exam-

ples of these codes are: (1) generic code - indicates the generic of the named geographical feature (e.g., river, lake, city, etc.); (2) region code indicates the 'region' in which the named geographical feature occurs, (e.g., Ontario, New Brunswick, etc.); and (3) status code - indicates the status of the name (e.g., officially approved, formerly approved but now rescinded, local usage but not officially approved, etc.)

- generating NTS Nameslists – that is, nameslists that are used for both the production of Canada's 1:50 000 and 1:250 000 national topographic maps and the maintenance of the toponymy layer of Canada's National Topographic Data Base
- updating the Internet version of the CGNDB – the Geographical Names Section maintains a reporting data base (i.e., an Internet version of the CGNDB that may be accessed via Canada's official geographical names Web site - URL http://geonames.nrcan.ca) that may be used to obtain information about official and formerly official geographical names in Canada
- linking geographical names with World War II casualties – a registry of Canada's World War II casualties is contained within the CGNDB; the Geographical Names Section uses this registry to search for features that have been named after World War II casualties and to see if a particular casualty has been commemorated
- producing the *Gazetteer of Canada* series – the series contains volumes for individual provinces and territories and, in 1997, the first *Concise Gazetteer of Canada* was produced
- creating standard/customized digital names products – clients may purchase standard or customized digital files.

Links to other databases

A project was completed to match CGNDB names records to Statistics Canada 1991 place name census records. The result is a digital file that provides a link between official CPCGN place names and Statistics Canada population data. The CGNDB is also used by federal departments as the authoritative source for geographical names, for example, in the filing of environmental impact reports, now required by law. Plans have been developed for the regular import of records into the CGNDB from the Undersea Features Data Base, managed by the Canadian Hydrographic Service, a CPCGN member.

Evolution of the CGNDB: card-index registry to RDBMS client/server

This section describes the evolution of the CGNDB from a card-index registry to a relational database management system (RDBMS). Included in this section is the description of both: (1) the systems; and (2) the business and technical issues that led to the development of the systems.

CGNDB: a card-index registry

In the late 19th century, the need for a single toponymic authority - that is an authority to which questions of geographical nomenclature and orthography could be referred - was apparent. Such an authority was required for two reasons, namely:

- errors and inconsistencies existed in both the spelling and application of Canada's geographical names; and
- resource mapping beyond settled areas, together with heavy immigration that was occurring at that time made it imperative to deal with Canada's toponymy and geographic naming procedures.

As a result of the urgent need for a toponymic authority, the Geographic Board of Canada (GBC) was established in 1897. Its mandate was:

- to undertake the standardization of geographical names in Canada; and
- to provide expert advice to federal departments and agencies on the origin, spelling and use of geographical names.

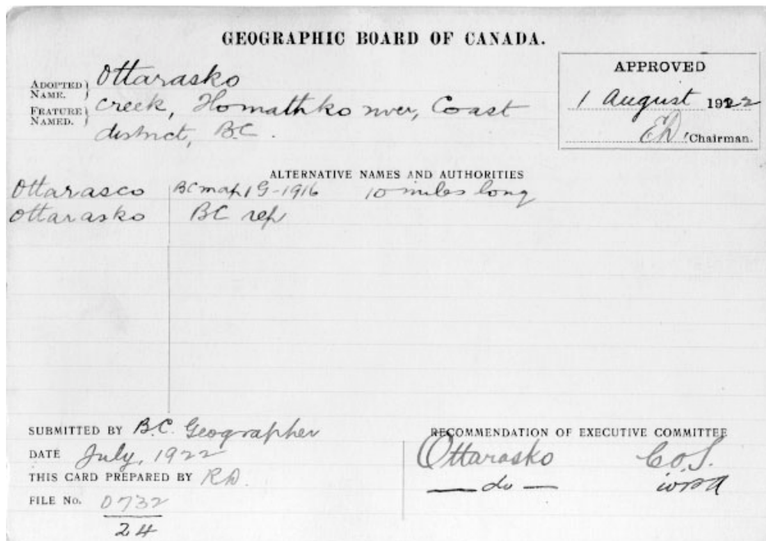
The GBC created a card-index registry in order to help fulfill its mandate. This registry was created to act as Canada's national repository for officially approved geographical names. As names were approved, index cards were created and added to the repository. Name information on these cards included such items as: the officially approved name; locational information (e.g., the province or territory in which the named feature occurs); the decision date (the date that the name was officially approved); and any other names that are (or had been) used to refer to the place or feature. Information on these cards was organized according to data categories, or information blocks. The index cards were originally filed in alphabetical order. At a later date, the card records were separated according to province or territory and filed in alphabetical order. Figure 1 shows an example of a name's index card for Ottarasko Creek.

CGNDB: A single file DBMS

During the 1970s, it was recognized that the present system – that is, the analogue card-index registry - could no longer satisfy the business requirements for both the Geographical Names Section (known as the Toponymy Unit at that time) and the CPCGN Secretariat for several reasons including:

- the amount of toponymic data required for manual input into the card-index registry was increasing at 20% per year – this meant that, the task of maintaining the data was time consuming and labour intensive; and therefore,
- the Toponymy Unit was having difficulty in satisfying requests for names information on time.

As a result of the problems associated with the analogue system, a decision to automate the names data base was made.


GEOGRAPHIC BOARD OF CANADA.

ADOPTED NAME. Ottarasko
FEATURE NAMED. Creek, Homathko river, Coast district, B.C.

APPROVED 1 August 1922
E.N. Chairman.

ALTERNATIVE NAMES AND AUTHORITIES
Ottarasco BC map 19-1916 10 miles long
Ottarasko BC ref

SUBMITTED BY B.C. Geographer
DATE July, 1922
THIS CARD PREPARED BY R.A.
FILE No. 0732 24

RECOMMENDATION OF EXECUTIVE COMMITTEE
Ottarasko C.O.S.
— do —

Figure 1. Geographical name's index card for Ottarasko Creek

A DBMS was purchased (i.e., DATABOSS/2) and the card records were encoded into the DBMS. Two of the characteristics of the DATABOSS/II, as it existed in the late 1970s/early 1980s, were: (1) it was a single file construction system with maximum record length of 512 characters; and (2) it allowed for system user customization. This system was installed on a DEC PDP/11 computer; the architecture for the system was client/server.

CGNDB: a structured query language (SQL) RDBMS

In the late 1980s, it was once again identified that a major overhaul of the CGNDB was required. This overhaul was considered necessary because of the following problems associated with the existing system (i.e., the managing the CGNDB using the Databoss/II):

- it was not user friendly and not fully interactive
- its functionality did not completely satisfy business needs – for example, it did not provide sufficient flexibility in both customizing names reports (e.g., controlling output formats and fields displayed) and cross-referencing information in the data base
- it was unilingual – that is, the applications used to interact with the information in the data base were not available in both of Canada's official languages
- it was installed on out of date hardware and, therefore, was slow.

In 1989, the system was converted into an Oracle-based system. Oracle was selected for several reasons including: it is based on both relational DBMS technology and SQL (and therefore provides significant flexibility); it allows for menu driven user interface applications to be developed; and it can provide fast and easy access to the data. Figure 2 shows an example of a form that may be used to interact with the CGNDB. Figure 2 also illustrates some of the names information for the City of Ottawa, Ontario, Canada.

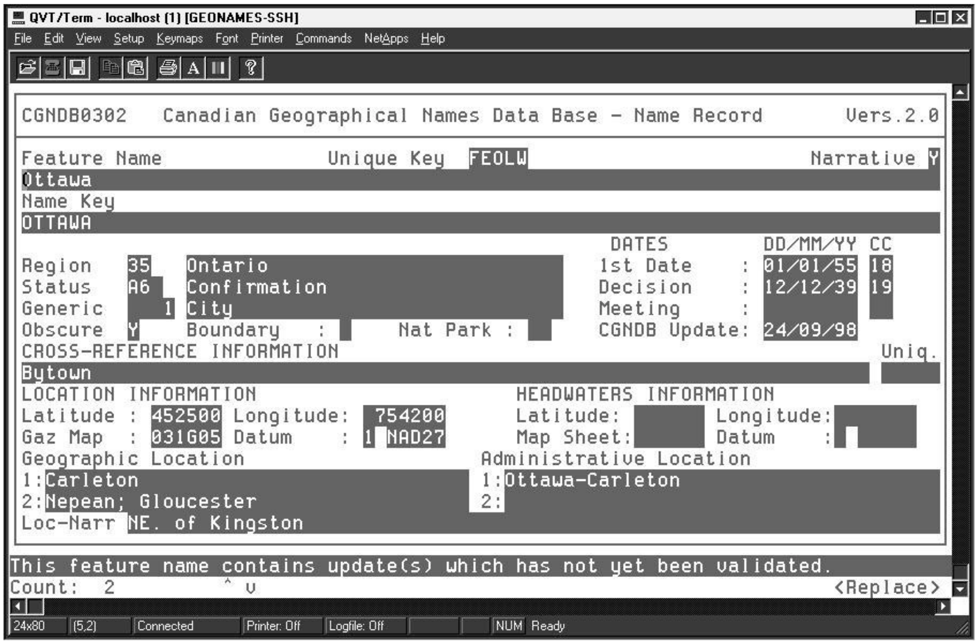

QVT/Term - localhost (1) [GEONAMES-SSH]
File Edit View Setup Keymaps Font Printer Commands NetApps Help
CGNDB0302 Canadian Geographical Names Data Base - Name Record Vers.2.0
Feature Name Unique Key FEOLW Narrative Y
Ottawa
Name Key
OTTAWA
DATES DD/MM/YY CC
Region 35 Ontario 1st Date : 01/01/55 18
Status A6 Confirmation Decision : 12/12/39 19
Generic 1 City Meeting :
Obscure Y Boundary : Nat Park : CGNDB Update: 24/09/98
CROSS-REFERENCE INFORMATION Uniq.
Bytown
LOCATION INFORMATION HEADWATERS INFORMATION
Latitude : 452500 Longitude: 754200 Latitude: Longitude:
Gaz Map : 031G05 Datum : 1 NAD27 Map Sheet: Datum :
Geographic Location Administrative Location
1:Carleton 1:Ottawa-Carleton
2:Nepean; Gloucester 2:
Loc-Narr NE. of Kingston
This feature name contains update(s) which has not yet been validated.
Count: 2 ^ v <Replace>
24x80 (5,2) Connected Printer: Off Logfile: Off NUM Ready

Figure 2. Oracle form used for interacting with the CGNDB

CGNDB: the need for re-engineering the existing system

In 1997, an evaluation of both the business and technological issues facing the Geographical Names Section – as they related to the CGNDB – was performed. The two major results of the evaluation were:

1. The CGNDB is, in its current state, effective and functionally useful – that is, it satisfies the business requirements of the CGNDB; and
2. The CGNDB is in danger of falling somewhat behind the technological mainstream – that is, (a) the version of Oracle Server used to manage CGNDB (i.e., 7.1.4) is several versions behind most recent releases of Oracle Server (i.e., 8.x); and (b) the Oracle application software used to develop CGNDB Data Entry/ Data Query facilities (i.e. SQL Forms 3.0) is not supported by recent versions of Oracle Server (i.e., Oracle 7.3.x and Oracle 8.x).

As a result of this evaluation, the Geographical Names Section decided to issue a contract to re-engineer the CGNDB. The major requirements for this contract were: (1) upgrade the version of Oracle Server used to manage the CGNDB; (2) redevelop the CGNDB User Interface; and (3) analyse and revise the CGNDB data model.

A contractor was selected for the re-engineering the CGNDB project using a competitive bidding process – that is, a request for proposal (RFP) was posted, bids were received and evaluated according to a set of pre-defined criteria, and a winning bid was selected. The re-engineering project was performed between November 1998 – July 1999, with a post-production support period from August – October 1999.

The RFP specified the technology required for use in this project (i.e. Oracle Designer) but did not specify that a particular methodology be followed. The contractor that was awarded the project recommended that Oracle's CDM be used as the development methodology for this project. This methodology was adopted and was used together with Oracle Designer to re-engineer the CGNDB. The following sections three sections discuss the re-engineering project. More specifically, these sections address: (1) the methodology and technology used in this re-engineering project (i.e. Oracle Designer and Oracle CDM); (2) benefits to the client offered by the use of Oracle Designer together with Oracle CDM; and (3) the results (e.g. database metrics and sample illustrations of the applications used to access the data) of the re-engineering project.

Re-engineering the CGNDB: method and technology used in the development

Computer-aided software engineering (CASE) tools are typically used together with a method in the development of information systems for two reasons, namely:

1. To produce the information system in a timely manner; and
2. To ensure that the resulting system satisfies the client's stated business goals and objectives.

This section describes the method and technology that were used to re-engineer the CGNDB. Before this is discussed, the term method is defined and the reasons why a system development method was deemed necessary for the re-engineering of the CGNDB are identified.

Method: what is it and why was it considered necessary to re-engineer the CGNDB

A method is a structured organization of tasks, estimates and guidelines that provide a systematic approach or discipline [Oracle, 1996]. A method may also be viewed as a guide that assists you (or the project team) in performing some activity such as developing database systems. In general, methods are essential for the development of any system for several reasons, including [McFadden and Hoffer, 1994; Oracle, 1996]: (1) they provide a framework for systems development; and (2) they ensure that an organizations business needs are clearly defined and visible throughout the entire development process. A systems development method was deemed necessary for this project for several reasons, four of which are: (1) to ensure that the resulting systems support the stated business goals and objectives; (2) to help ensure that critical tasks are not left out of the project plan; (3) to make project planning easier; and (4) to ensure that a consistent set of standards and procedures are used in the development.

Method: Oracle CDM Fast Track Approach

The method that was selected for this project was Oracle CDM; the developmental approach – defined within Oracle CDM – that was selected for this project was Oracle CDM Fast Track Approach. This section briefly describes Oracle CDM and then explains the relationship between Oracle CDM and Oracle CDM Fast Track Approach. The reasons why Oracle CDM and Oracle CDM Fast Track Approach were selected for this project are also identified in this section.

Oracle Custom Development Method

Oracle's Custom Development Method is a set of well defined processes which can be managed in several ways to guide you through a database development project [Oracle, 1996]. CDM includes 11 processes which are: Business Requirements Definition; Existing Systems Examination; Technical Architecture; Database Design and Build; Module Design and Build; Data Conversion; Documentation; Testing; Training; Transition; and Post-System Support.

Each of the above processes consists of a set of related tasks that both meet a specific project objective and results in one or more key deliverables. Some of the tasks, key deliverables (associated with the task), and a brief description of these deliverables for the Business Requirements Definition process are listed in Table 1.

Table 1. Business Requirements Definition - Some of its Tasks and Key Deliverables [Oracle, 1996]

Task	Key Deliverable	Description of Deliverable
Create a business process model	Business Process Model	Model of both the events and business processes needed to meet the organizations business objectives
Obtain high-level business descriptions	High-level Business Descriptions	Descriptions of the events, processes and functions needed to meet the organizations business objectives
Create high-level business function model	High-level Business Function Model	Model of business functions needed to meet the organizations business objectives
Create initial business data model	Initial Business Data Model	Model of information requirements needed to meet the organizations business objectives

CDM also incorporates Oracle's project management method (PJM), the goal of which is to provide a framework for planning, estimating, and controlling projects in a consistent manner [Oracle, 1996]. This means that the project team may be able to use Oracle CDM to identify both: (1) the project management tasks that are required to manage and support the project, such as resource management (e.g. identifying both the level of staffing and skills, and the working environment necessary to support the project) and quality management (e.g. implementing the necessary quality measures to ensure that the project satisfies the client's expectations); and (2) the time frame within the project life cycle that the individual project management tasks need to be performed.

The Oracle's CDM method was selected to guide the re-engineering of the CGNDB for the following reasons:

1. It starts and ends with the business;
2. It is a deliverable based method – all CDM tasks have clearly defined deliverables;
3. It provides a framework for project management;
4. It has close ties with Oracles CASE tools - Oracle Designer and Oracle Developer – in which the CTI-O has a significant investment; and
5. It has been successfully used in other database development projects

CDM Development Approaches

CDM offers three development approaches, or phasing models, which the may be used to guide the database development project. These approaches are: (1) Classic (preferred approach for medium to large database development projects); (2) Fast Track (preferred approach for small to medium database development projects); and (3) Lite: (preferred approach for small custom development projects).

The above CDM developmental approaches consist of two or more phases. For example, the Fast Track approach consists of three phases, namely: requirements modeling; system design and generation; and transition to production. Each phase, in the developmental approach, consists of a number of tasks - this means that each phase supplies one or more key deliverables.

The criteria used to select the development approach that is most suitable for a project include: scale, complexity, duration and application criticality. The developmental approach that is selected will determine the tasks that are performed for the project – some tasks necessary for complex projects may not be necessary for small database projects. Selecting the right development approach is important because the approach that is selected will impact: (1) the *time* taken to complete the project; and (2) the *success* of the project – that is, how well the developed system satisfies the clients needs; and (3) the *cost* of the project.

CDM Fast Track Approach

In general, the CDM Fast Track approach is designed for database development projects that satisfy these two characteristics: (1) a single business model may be used to define both the business's information needs and the application's implementation; and (2) the database is not enterprise wide critical – that is, the database effects the entire enterprise. The fast track approach was selected for this project because:

1. Project requirements for re-engineering the CGDNB are stable.
2. CGNDB has a low complexity system architecture.
3. CGNDB has a small (less than 15 users), concentrated (users are located in close geographic proximity) user base.
4. CGNDB is not enterprise wide critical – that is, CGNDB is critical to some (e.g. NTS mapping) but not all of CTI business operations.
5. Project Duration was anticipated to be 8 months.

Technology: Oracle Designer

Oracle Designer is a repository-based toolset that supports modeling, designing and generating client/server databases and database applications. Oracle Designer was selected for this project for the following reasons:

- it is repository-based
- it supports the whole development process
- it provides reverse engineering functionality
- it allows for multi-user access to information in the repository
- it provides graphic modeling capability
- it can generate applications that can be deployed in both client/server and Web environments.

Table 2. Relationship between Oracle Designer tool, CDM Fast Track Approach deliverable, phase, and process

Deliverable	Tool	Phase	Process
Business Process Model	Process Modeller	Requirements Modelling	Business Requirements Definition
Business Descriptions	Process Modeller/ Function Hierarchy Diagrammer	Requirements Modelling	Business Requirements Definition
Business Function Model	Function Hierarchy Diagrammer	Requirements Modelling	Business Requirements Definition
System Data Model	Entity Relationship Diagrammer Repository Object Navigator	Requirements Modelling	Database Design and Build
Logical Database Design	Database Design Transformer/ Design Editor/	System Design and Generation	Database Design and Build
Physical Database Design	Repository Object Navigator	System Design and Generation	Database Design and Build
Production Database DDL	Repository Object Navigator	System Design and Generation	Database Design and Build
Conversion Modules	Design Editor	System Design and Generation	Data Conversion
Application Code	Design Editor	System Design and Generation	Module Design and Build

Relationship: How are Oracle Designer and the CDM Fast Track Approach deliverables related?

Oracle's CDM is designed for use with Oracle Designer. This means that the Oracle Designer toolset is well suited for creating the CDM Fast Track Approach project deliverables. Table 2 provides several examples of which Oracle Designer tool was used to create some of the CDM Fast Track Approach project deliverables. Table 2 also includes the associated process, task (each process consists of a set of related tasks that results in one or more key deliverables) and phase (each phase consists of a number of tasks) for each deliverable.

Using Oracle Designer and the CDM Fast Track Approach: Benefits for the Client

As mentioned earlier, the RFP issued by the client (i.e., Geographical Names Section) specified the technology required for use in this project (i.e., Oracle Designer) but did not specify that a particular methodology be followed. The contractor that was awarded the project recommended that Oracle CDM be used. This methodology was adopted and was used together with Oracle Designer to re-engineer the CGNDB. It became evident during the early stages of this project that using both Oracle Designer and Oracle CDM Fast Track Approach offered several significant benefits to the client, including:

- Oracle CDM Fast Track Approach clearly defines both the tasks and deliverables for a database development project and the order in which the tasks are to be performed – this meant that the client knew both the work was going to be performed for this project and the order in which the work would be performed.
- Oracle CDM Fast Track Approach identifies the quality assurance (QA) measures for a database development project – this meant that the client knew both the QA tasks would be performed and the phases in which these QA tasks would be take place in.
- Oracle Designer can be used to perform database development tasks as specified in Oracle's CDM methodology – this provided the client with an understanding of what tool would be used to perform which task.
- Oracle Designer supports the whole database development process – this means that only one CASE software product would be required to develop the new application (i.e., Oracle Designer can be used to define business functions, develop data models (e.g., logical, physical), create application code, etc.).
- Oracle Designer is repository based – this means that both: (1) all details of the re-engineered CGNDB application, from business requirements to application code, would be captured in a repository; and (2) once the project is completed, Geographical Names Section staff could extend the functionality of the new CGNDB system by modifying the information stored in a central location (i.e. the repository).

The contractor also mapped the deliverables specified in the RFP to the CDM deliverables. This provided a further benefit to the client because it allowed the client to relate its perception of the work that had to be performed to that specified by Oracle CDM Fast Track Approach. Table 3 includes a subset of the RFP Deliverables and the equivalent CDM deliverables and, if applicable, the Designer tool that was used to create the deliverable.

Table 3. Relationship between RFP Deliverable, CDM Fast Track Approach deliverable and Oracle Designer tool

RFP Deliverable	CDM Deliverable	Oracle Designer Tool
ER Diagram of CGNDB Data Model	System Data Model	Entity Relationship Diagrammer
Table Instance Charts for the CGNDB	Logical Database Design	Design Editor
Design Specifications for the User Interface	Design Standards Build Standards Application Standards Menu Standards	Repository Object Navigator Form Builder
Design Specifications for the CGNDB Environment	Technical Architecture	N/A
Design Specifications for CGNDB Backup Strategy	Recovery and Fallback Strategy	N/A
User Interface	Application Code	Design Editor/ Form Builder

Results of the re-engineering project: The new CGNDB system

The work performed for the re-engineering project included:

1. a complete redevelopment of the user interface;
2. a substantive revision of both the system data model and the physical database design;
3. an upgrade of the version of Oracle Server from 7.1.4 to Oracle 8.x; and
4. a conversion of data from the existing system into the new system

Some of the metrics for the new system are: number of business tables = 38; number of tables spaces = 9; initial database size (i.e. size of database after conversion) = 1.18 Gb; estimated database size after five years = 1.54 Gb; and number of modules (forms and reports) = 20. Figure 3 shows the module (form) that is used to maintain and query generic codes.

The CGNDB: its past, present and future

The CGNDB has changed considerably from both a technical and a business perspective. Three of the changes that have occurred include:

- architecture of the CGNDB: Since its initial conception, the architecture of the CGNDB has evolved from a completely analog system (card-index registry) to a completely digital system (SQL-based RDBMS client/server).
- production of nameslists: Before the automation of the CGNDB, nameslists production was a manual, labour intensive process. The use of an SQL RDBMS has dramatically decreased both the time required to respond to a nameslist request and the resources required to create nameslists.
- mechanisms for obtaining information about Canada's geographical names: The Geographical Names Section maintains an Internet version of the CGNDB data base, which can be accessed via Canada's official geographical names Web site (URL http://geonames/NRCan.gc.ca). This reporting data base allows for the querying of geographical names and currently receives over 3000 hits per day.

Table 4. Operations supported by the technology and its impact on the Geographical Names Section

Operations supported by the Technology	*Effect on the Geographical Names Section*
Deploying CGNDB applications in a Web browser	Allow for universal access to CGNDB , or more specifically, allow CGNDB stakeholders to access the CGNDB over the Internet
Supporting the whole database development process including post-implementation support	Allow Section to respond quickly to meet changing needs of its clients by adding to (or modifying) its business model and automatically generating applications to meet the 'changing' need.
Allowing for end-users to access repository	Allow CGNDB stakeholders to access information about CGNDB functions, data models, and modules, etc.
Adding a spatial component to the CGNDB	Expand its business functionality to include spatial analysis operations (e.g., neighborhood and connectivity operations).

It should be further emphasized that both automating the CGNDB and providing access to the CGNDB over the Internet has had three major impacts on the Geographical Names Section, namely: (1) it has dramatically decreased the time required by the section's staff to perform technical/clerical operations (e.g., responding to names queries, maintaining accurate up-to-date toponymic information, producing digital nameslists, etc.); (2)

it has allowed staff to focus on the qualitative improvement of the names information in the CGNDB; and (3) it has allowed the Section to better respond to the information needs of its clients.

As in the past, changes in both technology and business will impact the future of the CGNDB. Even though it is difficult to predict its long-term future, both the application development software used to re-engineer the CGNDB (e.g. Oracle Designer) and the new DBMS technology now available (e.g. Oracle Spatial – allows for storage, retrieval of spatial data in an Oracle Database) will have the following impact on the Geographical Names Section and its stakeholders. Table 4 lists the operations supported by either the re-engineered form of the CGNDB or Oracle Spatial and its anticipated effects on the Geographical Names Section.

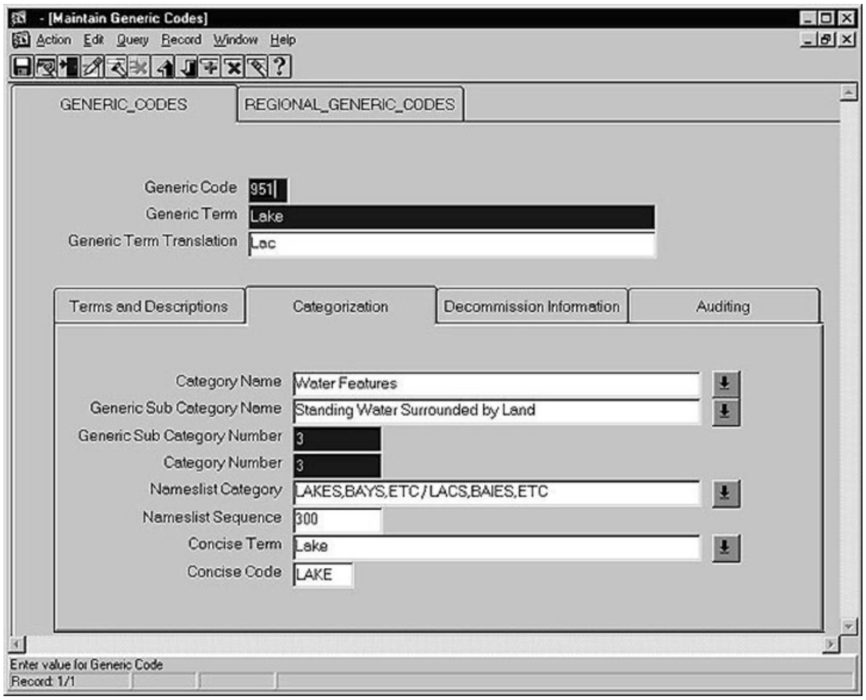


Figure 3. Generic code maintenance and query form

Acknowledgements

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References

Oracle Corporation (1996). Oracle Method: Custom Development Method Handbook, Release 2.0.1. Oracle Corporation, Redwood City, California, USA.

McFadden, F.R. and Hoffer, J.A. (1994). Modern Database Management, 4th ed. The Benjamin/Cummings Publishing Company, Inc., Don Mills, Ontario, Canada.

Session / Séance C7-A

Actualisation du réseau routier canadien

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Résumé

En 1998, le Centre d'information topographique de Sherbrooke (CitS) complétait la numérisation de tout le réseau routier apparaissant sur les cartes topographiques fédérales. Alors que ces données étaient insérées dans la Base nationale de données topographiques (BNDT), le réseau routier des 300 plus grandes villes était mis à jour. Cependant, à l'extérieure de ces zones urbaines, les cartes numérisées datent parfois de plus de 30 ans.

Afin de répondre aux usagers de la BNDT, une stratégie d'actualisation et d'amélioration de la précision de l'ensemble du réseau routier canadien a été mise sur pied. L'approche consiste à s'entendre rapidement avec les provinces pour distribuer les données provinciales existantes si elles sont à jour, ou pour partager les coûts de leur actualisation. Si une entente n'est pas réalisable dans les délais requis, un contrat d'actualisation du réseau routier est émis pour le territoire concerné.

C'est ainsi qu'en Colombie-Britanique, le réseau routier sera mis à jour par la province alors que l'entreprise privée aura le mandat d'actualiser les territoires du Nord-Ouest et du Yukon. L'objectif est d'avoir complété une première mise à jour du réseau d'ici cinq ans et de maintenir ce cycle de révision par la suite.

Historique

Produit cartographique

Depuis près de 100 ans, nous travaillons à cartographier le territoire canadien. Pour représenter l'ensemble de la masse continentale canadienne, c'est près de 13000 cartes topographiques qui doivent être réalisées et maintenues à jour. Actuellement, 90 % de la couverture nationale a été complétée.

Ce travail colossal a été réalisé par photogrammétrie et supporté par une vérification détaillée sur le terrain. Ces vérifications détaillées sont nécessaires en raison de la richesse du contenu cartographique proposé. De plus, ces opérations doivent être effectuées tant lors du captage initial que lors des opérations subséquentes de mise à jour. Les ressources investies pour la réalisation ou la mise à jour d'un feuillet cartographique sont donc importantes. En conséquence, un nombre limité de feuillets est actualisé annuellement, ce qui entraîne une diminution du cycle moyen de révision et un vieillissement du produit.

Base nationale de données topographiques (BNDT)

À la fin des années 80, le Centre d'information topographique de Sherbrooke a reçu comme mandat de réaliser et de maintenir une Base nationale de données topographiques. L'objectif était de fournir la représentation numérique du territoire canadien nécessaire aux utilisateurs d'information géographique pour soutenir le développement, l'utilisation et la protection du pays et de ses ressources. Les données distribuées devaient donc satisfaires aux exigences des usagers d'application SIG en terme de contenu et de structure, tout en permettant la réalisation du produit cartographique conventionnel.

Pour se faire, nous avons procédé à la numérisation par balayage des cartes topographiques au 1:50,000 et 1:250,000. Lorsqu'elles étaient existantes, nous avons utilisé des données stéréonumérisées provinciales et fédérales à différentes échelles. Ces fichiers composent actuellement 10 % de la BNDT.

À ce jour, les 980 fichiers de la couverture au 1:250,000 sont complétés. Pour la couverture au 1:50,000, plus de 6,000 fichiers sont maintenant offerts, incluant les 3479 feuillets sur lesquels nous retrouvons des sections du réseau routier.

Actualisation des données

L'âge moyen des cartes couvrant le territoire habité du Canada est de 15 ans. De ces cartes, 20 % ont plus de 20 ans et certaines en ont plus de 50. Depuis le début des années 1990, beaucoup d'énergie a donc été investie à l'élaboration d'un processus d'actualisation de ces informations. Différentes approches ont été utilisées, tant administratives que technologiques.

Au niveau administratif, beaucoup d'efforts ont été déployés à réaliser des ententes de partenariat avec les provinces. Les résultats obtenus sont cependant mitigés. Le peu d'intérêt soulevé chez les partenaires potentiels et les différences normatives ne permettent pas d'actualiser l'ensemble du produit cartographique actuel.

Au niveau technologique, l'utilisation jumelée d'images satellites et de vérifications terrain s'est avérée l'approche la plus efficiente. Si cette approche permet une vue instantanée du territoire (uniformité temporelle entre les données), ses coûts sont cependant encore trop élevés pour permettre une amélioration significative du cycle moyen de révision.

Nouveaux paradigmes

Diminution des ressources

Une diminution significative des budgets au cours des dernières années a éliminé toute possibilité d'ajustement des processus sans un ajustement au produit BNDT. L'ajustement du produit, et la réorganisation des processus de production pour le maintenir, ne pouvaient être faits sans une participation des usagers à sa définition.

Répondre aux besoins des usagers

Des études externes et internes donnaient déjà des pistes quant aux priorités des besoins de nos usagers. Nous nous sommes donc appuyés sur ces études afin de revoir la définition du contenu, de la précision et des cycles de révision des données. À partir de ces informations, nous avons initialement proposé d'actualiser le réseau routier en 2 ans en milieu urbain, 5 ans en milieu rural, et d'ajuster les données de la BNDT à la géométrie des nouvelles routes. En raison des ressources disponibles, l'actualisation des autres thèmes était reportée.

Avant de procéder, nous avons fait valider notre approche auprès de groupes cibles d'usagers (Focus Group). Ceux-ci nous ont alors donné deux informations importantes qui nous ont permis d'ajuster notre stratégie. Premièrement, l'actualisation exclusive du réseau routier sans une révision à moyen terme des autres thèmes de la BNDT était questionnée. Les usagers considéraient préférable un cycle de révision plus long en milieu urbain, dans la mesure où les ressources libérées permettaient la révision des autres thèmes. En second lieu, l'ajustement des données de la BNDT à la géométrie des nouvelles routes était inacceptable. Pour eux, cet ajustement de données de dates différentes revenait à maquiller les informations contenues dans la base de donnée. Il ne devait donc pas y avoir d'intégration géométrique entre données de dates différentes. Ces informations nous ont emmenés à gérer l'actualisation de la BNDT avec une approche nouvelle.

Gestion de l'actualisation

Un des coûts importants de l'actualisation est l'obtention des sources de données à partir desquelles le travail peut s'effectuer. Nous avons donc décidé d'aborder l'actualisation en fonction des sources utilisées plutôt qu'en fonction du découpage Snrc.

Les sources de données, et les thèmes qui en sont extraits, seront généralement de dates différentes. Conformément à la demande des usagers, ils ne seront pas intégrés géométriquement si les dates diffèrent de façon significative. L'utilisation optimale de chaque source de données et l'accroissement du volume d'actualisation pour chacune de ces sources devraient entraîner une diminution importante des coûts de production par unités de surface. Dans le cas des partenariats, l'actualisation par thème accroît les possibilités d'entente en limitant considérablement les contraintes techniques.

L'été dernier, le Centre d'information topographique de Sherbrooke (CitS) a décidé d'exploiter à fond l'approche thématique. Dans le cas du réseau routier, l'approche consiste à s'entendre rapidement avec les provinces pour intégrer les données provinciales existantes si elles sont à jour ou pour partager les coûts de leur actualisation. Si une entente n'est pas réalisable à court terme, le CitS émettra un contrat d'actualisation du réseau routier pour le territoire concerné. Ces données seront rendues disponibles aux usagers mais les routes ne seront pas intégrées géométriquement aux autres entités de la BNDT.

Actualisation du réseau routier canadien

Définition du réseau routier canadien

Le réseau routier canadien se définit comme étant l'ensemble de l'infrastructure routière carrossable du Canada. Actuellement, le réseau que nous possédons compte 875,000 kilomètres de routes. Ce n'est cependant pas une image précise de la réalité sur le terrain puisque l'âge moyen des routes que nous possédons est de 12 ans. Notre approche thématique nous a néanmoins permis d'actualiser plus de la moitié de ces routes au cours des trois dernières années. En terme de couverture Snrc, les routes de 750 des 3479 fichiers concernés ont été modifiées. Le défi est maintenant d'actualiser la moitié restante du réseau et d'en maintenir sur un cycle de 5 ans par la suite.

En terme de géométrie et de contenu, le réseau routier est composé d'entités linéaires et ponctuelles qui décrivent l'infrastructure routière (autoroutes et bretelles d'autoroute, routes principales, secondaires et rues.) et les infrastructures associées (ponts, tunnels, paraneiges et barrières). En terme de précision, l'accroissement constant des applications utilisant des systèmes de positionnement global (GPS) nécessite une précision accrue des données. Actuellement, la précision géométrique du réseau est très variable. Avec une moyenne à 50 mètres (90 %), la précision varie de 10 à 100 mètres selon les régions. Notre intention est de ramener l'ensemble à une précision supérieure à 10 mètres dans tous les cas.

Acquisition des données provinciales

L'actualisation de la moitié du réseau routier au cours de trois dernières années est le résultat d'une approche thématique. Les récentes délibérations des partenaires de Geoconnexion (Infrastructure canadienne de données géospatiales) ont d'ailleurs confirmé la priorité à accorder au réseau routier.En plus de permettre l'actualisation du réseau routier des 300 plus grandes villes canadiennes, l'approche a également permis l'actualisation des routes du Nouveau-Brunswick, et la Sasketchewan via des ententes de partenariat. Une part importante des ressources utilisées était cependant dédiée à l'intégration géométrique des données aux autres entités de la BNDT. Notre nouvelle approche élimine cette étape, ce qui répond mieux aux besoins des usagers, simplifie le travail à effectuer et accroît le potentiel d'entente.

Une première entente de partenariat, conforme à notre nouvelle approche, a été signée l'été dernier avec la Colombie-Britanique. L'entente associe un consortium de partenaires provinciaux et le CitS. Elle porte sur le partage des coûts d'acquisition du réseau routier de la province. L'entrepreneur qui réalise le contrat recueille l'ensemble des informations exigées en une seule fois. Par la suite, les informations obtenues sont rendues disponibles selon les normes techniques de chacun. Chaque partenaire obtient donc les informations qui lui sont nécessaires dans son propre modèle de données. Cette entente est certainement un modèle que nous essaierons de réaliser avec d'autres provinces en raison de la baisse substantielle des coûts d'acquisition de la donnée.

Contrat d'actualisation

Lorsqu'une entente de partenariat ne sera pas possible dans des délais raisonnables, nous passerons alors à des demandes de proposition auprès de l'industrie géomatique canadienne pour réaliser l'actualisation de la province. Les propositions devront couvrir l'ensemble de la province ou du territoire concerné. L'objectif étant de diminuer nos coûts de gestion et de favoriser des coûts de production plus bas pour les entrepreneurs via une production de masse. Les contrats devront être réalisés dans des échéanciers d'un à trois ans. Ces échéanciers permettront de rencontrer le cycle de révision escompté, répartir la charge de travail sur plusieurs provinces en parallèle et permettre un contrôle de qualité adéquat.

De nombreuses entreprises possèdent déjà des portions du réseau routier canadien. Celles-ci sont souvent propriétaire des données, maintiennent l'information qu'elles possèdent et la distribuent à leurs clients. Afin de bénéficier des données existantes et baisser les coûts d'acquisition, nous avons modifié entièrement les contrats d'acquisition de données. Il ne s'agit plus d'achat de données mais plutôt d'obtention de licences exclusives d'utilisation, de modification et de distribution des données obtenues. Cette approche simplifie la gestion des contrats en nous permettant d'obtenir le produit désiré à partir de données existantes, sans empêcher la distribution des données d'origine par leur propriétaire. Elle accroît également la qualité potentielle des données dans la mesure ou celles-ci sont déjà appréciées par leurs clients.

Une première demande de proposition a été publiée au mois de mars de cette année pour l'actualisation du réseau routier du Yukon et des Territoires du Nord-ouest. Les échéanciers de livraison s'étendent sur un peu plus d'un an. Les routes des communautés isolées ne sont pas incluses dans la demande. Une seconde demande de proposition, concernant cette fois la province de Québec, devrait être rendue publique au courant de l'été 1999.

Processus de validation

Compte tenu du niveau attributif et de la précision requise, nous nous attendons que les entrepreneurs livrent des données obtenues à partir de systèmes GPS embarqués. Les données livrées devront être structurées et respecter les normes de la Base nationale de données topographiques.

Au cours de la dernière année, nous avons élaboré un processus de validation automatique des données reçues des contractants. Ce processus valide la structure, et assure un minimum d'intégrité en ce qui concerne le contenu et la précision des données reçues. Ce processus n'est cependant pas suffisant pour assurer la qualité du travail effectué sur le terrain. La validation de la précision et du contenu des données reçues sera effectuée par un contrôle terrain indépendant.

Le contrôle de la structure, de la précision et du contenu sera réalisé tant pour les données obtenues des partenariats que pour celles obtenues par contrat. Les fournisseurs de données sont donc tenus de corriger toute erreur détectée dans des délais prescrits. L'objectif est que les propriétaires de données, particulièrement provinciaux, corrigent les erreurs à la source, assurant ainsi la qualité des informations lors d'échanges subséquents.

Conclusion

Le Centre d’information topographique - Sherbrooke (CitS) a décidé d’exploiter à fond une approche thématique à l’actualisation des données.

Dans le cas du réseau routier, l’approche consiste à privilégier le partenariat des provinces mais, lorsqu’une entente achoppe, le besoin des client nous oblige à émettre rapidement un contrat d’actualisation pour le territoire concerné. En terme de contenu, le réseau routier est composé d’entités linéaires et ponctuelles qui décrivent l’infrastructure routière et les infrastructures associées. En terme de précision géométrique, l’accroissement constant des applications utilisant des systèmes de positionnement global (GPS) nécessite une précision accrue des données. Notre objectif est de ramener l’ensemble du réseau routier à une précision supérieure à 10 mètres (90 %). Comme ces données seront beaucoup plus récentes que les autres entités de la BNDT, elles ne seront pas intégrées géométriquement aux autres entités. En plus d’être conforme aux demandes de nos usagers, ce choix diminue substantiellement les coûts de mise à jour.

L’approche thématique, le potentiel accru de partenariat qui en découle, des contrats à moyen terme impliquant un volume important de données, l’absence temporaire de relation géométrique avec les autres entités de la BNDT, sont autant de facteurs qui devraient provoquer une baisse significative des coûts d’actualisation.

Pour se faire, nous devrons renouveler les normes de la base nationale de données topographiques pour qu’elles soient compatibles à une vision plus mouvante de l’environnement. Les ressources qui seront libérées dans l’exercice pourront enfin être mises à contribution dans l’actualisation des autres thèmes de la BNDT.

Session / Séance C7-B

Nunavut Territory
Property Mapping: Past, Present and Future

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On April 1st, 1999, Nunavut will become the first territory to enter the federation of Canada since Newfoundland joined in 1949. This event will change the face of Canada's map at both the macro and micro level. On the macro level, mapping the division of the Northwest Territories will be a significant task. However, on the micro level there will be challenges in both the gathering and the maintenance of property mapping.

Nunavut is a vast isolated land, making up approximately 1/5th of Canada's land mass, with a population of only 25,000 people. The Territory is further divided into lands titled to the Inuit and those administered by the Crown. The titled lands are scattered throughout the Territory making for unique challenges to the new Government with respect to land management.

The first mapping of the North was done by the early explorers in search of the Northwest Passage. Although not always geographically correct, this information provided the skeletal knowledge of the northern islands in relation to each other and the mainland. Mapping in the north has changed significantly from the days of the explorers. Currently extensive data is being collected through the use of GPS combined with traditional techniques as part of the implementation of the Nunavut Land Claim Agreement. This information in turn is being used to build a property mapping base for the new Territory of Nunavut .

The future poses many challenges to the mapping community. Gathering, storing, portraying, and customizing dynamic information in this isolated region are just some of the issues.
Stan Hutchinson is an employees of Natural Resources Canada in Yellowknife. He is a Canada Lands Surveyor with many years of surveying experience in Canada's north and will be opening the Legal Surveys Division office in the Nunavut Territory for April 1, 1999.

Session / Séance 18-D

Remapping Zambia for Census, Elections and Other Needs

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Abstract

Remapping Zambia for census, elections and other needs is a paper conceived with a view to try and address the wastage of resources and duplication of effort currently going on in the country in preparing maps for various purposes by various government institutions. In particular attention is paid to the Central Statistical Office and the Electoral Commission mapping exercises with regard to the Zambia Survey Department, the national mapping authority.

A view of an integrated system of mapping that would not only cater for census and elections needs, but also for various other needs such as health, education, agriculture and infrastructure planning is presented. Such an integrated system is what has been referred to as the New Census Mapping Frame (NCMF) that would culminate into a National Mapping Frame (NMF).

The form the NCMF should take has thus been presented taking into account the already existing structures in the various government institutions that would play a major role in the realisation of this new mapping frame. Therefore, ways in which this frame could be realised have also been discussed taking cognisance of the existing constraints (in funding especially), the available resources and expertise in the country.

Finally, the expected impact of such a frame has been discussed too. In conclusion, the paper notes that a good base of geographical information is important for a government to come up with equally good policies. It is thus imperative that a good national mapping frame that caters for all stakeholders be realised. This is feasible even in the prevailing circumstances in Zambia today.

Introduction

Zambia, a land mass of about 750 620 km^2 with an estimated population of about ten (10) million inhabitants, is divided into various categories by different government institutions with a direct dealing with the population at large. These divisions, by different government institutions, are not co-ordinated hence the existence of a lot of different mapping and data collection units within one area. For example, the Electoral Commission uses the wards which do not correspond to the Standard Enumeration Area (SEA) or Census Supervisory Area (CSA) used by the Central Statistical Office (see Figure 1). This kind of scenario has resulted in difficulties in integration and disaggregation of data collected by these government institutions. There is also a considerable wastage of resources in repeated processes in these institutions.

It is however self-evident that geography is of vital interest to map makers, statisticians and decision-makers (politicians in most cases). A good government thus requires a lot of good geographically referenced and differentiated information to come up with good and informed policies, be they economic, environmental, defence or political.

It is therefore imperative that Zambia must be remapped in such a way that unnecessary duplication of effort and wastage of scarce resources, among other things, were eliminated; and to ensure that data, geographical or otherwise, were collected at all levels necessary in the remapped set-up. This process will thus require the involvement of all stakeholders particular those in the public sector such as local authorities and other government departments.

Key to this new set-up is the Central Statistical Office (CSO) which conducts national population census every ten (10) years. This office collects benchmark data for estimating demographic and socio-economic characteristics of the country. These data are provided to various sections of society such as NGOs, government ministries and the Electoral Commission for their work and development planning. These data need to be provided at the lowest disaggregatable unit common to most users such as chief's areas down to village level. At present this is not possible at all.

In looking at this proposed remapping of Zambia, this paper endeavours to discuss what should be done, with regard to stakeholders, to realise the New Census Mapping Frame (NCMF) for Zambia, given the present scenario where each organisation/department does its own thing. CSO will thus be taken as the focal point with reference to other institutions where necessary.

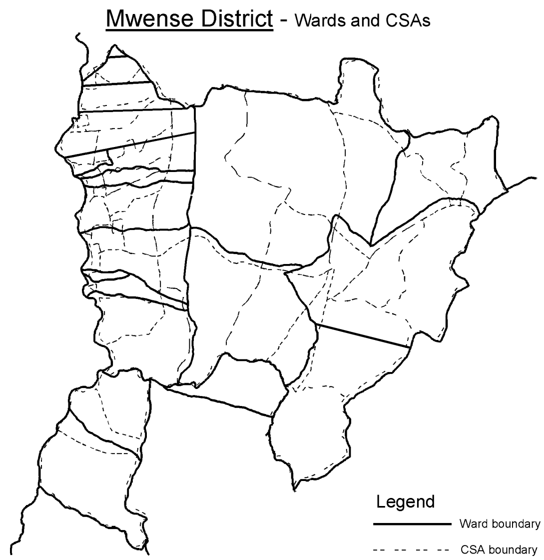

Figure 1. Ward and CSA boundaries overlayed

Central Statistical Office (CSO) Mapping

The CSO is a government arm in the Ministry of Finance and Economic Development charged with statistics in various areas of human endeavour. Cardinal in this regard is the carrying out of a population census every ten (10) years. In order to facilitate this task, maps are necessary for use during enumeration in the field. It is therefore vital that these maps are compatible with societal requirements as regards data collected based on such maps.

Census Maps to Date

Prior to the 1980 census Polling Districts (PDs) were used as enumeration areas. But PDs were found to be unsuitable for they varied greatly in size and population which made the work of enumerators and their supervisors difficult. This problem led CSO to devising a somewhat suitable enumeration unit. Thus the first mapping exercise for purposes of census was undertaken between 1978 and 1980 in preparation for the 1980 population and housing census.

A cartographic unit was set up at CSO in 1978 with a qualified cartographer seconded from the Zambia Survey Department (ZSD) to oversee the mapping operations. Base information for this exercise was obtained from various ZSD maps. Permanent natural and man made features which were useful for georeferencing and orientation in the field made up the base information.

Field mapping was then undertaken throughout the country using magnetic compasses and bicycles that were mounted with milometers to acquire up-to-date information about human settlements and other permanent features. A quick population and amenities count was also done at the same time. The information so collected provided the basis for demarcating what became known as Standard Enumeration Areas (SEAs) based on nearly equal population sizes and clearly ground identifiable boundaries. Population estimates for rural SEAs were 300 – 500 people and 600 – 800 people for urban SEAs. SEAs were then grouped into Census Supervisory Areas (CSAs) of 2 – 3 in rural areas and 1 – 6 in urban areas. Maps from this process became standard census maps which were only updated between 1987 and 1990 for the 1990 population census.

Although this was a success story for CSO, data collected based on these maps could only make sense to other users at district, provincial and national levels. Disaggregation to lower administrative levels failed since the data abstraction unit, the SEA, and its subsequent aggregation into CSA was only known to CSO. Akende (1997) therefore recommended that in order to meet the current demands on census data at our everyday administrative and political levels, the present census enumeration units be redesigned to fit sub-district administrative and political divisions of Zambia [Sikanyiti, 1997].

The 2000 Census Mapping and Beyond

The resigned census maps should still have the SEA as the smallest data collection unit. But the approach now should be to disagggregate from the district to the SEA following the present political and administrative boundaries. It is proposed that the following structure (in ascending order) be used: SEA, CSA, PD, WARD, (Chief's Area), constituency, District, Province and Nation (see Figure 2). It is however true that most political and administrative boundaries are 'imaginary' such that they are difficult to locate in the field.

The redesigning process should therefore take into account the need for terrain traceable boundaries without necessarily compromising the essence for which they were originally designed. Thus upholding the need for participation of the various stakeholders in the redesigning and redefining of these boundaries [Silanda, 1997]. This will also ensure that resources were properly used by not repeating activities which had already been accomplished by others [Mwanza, 1997].

National, Provincial and District Boundaries

Since there seem to be no problems with these boundaries the major task at hand is designing workable subdivisions from District to SEA. This paper will thus dwell so much on the subdivisions within the district. At present, uncorrupted census data is only available at CSA and SEA levels which are unknown to other users other than CSO. Between the CSA and the District data is just extrapolated from SEA statistics.

Constituency Boundaries

A constituency is an area that is represented by an elected Member of Parliament (MP). There are 150 constituencies in Zambia. Any increase or reduction in the number of the constituencies is done by a delimitation commission appointed by the president in preparation for a general election. Therefore to alter the boundaries of any constituency to conform to the concept of identifiable boundaries on the ground will need such a commission. This is feasible now that we are preparing for the 2001 elections.

It is thus necessary to adjust these boundaries to fit within the district boundaries based on ground identifiable features. A district may comprise of one or more constituencies that are further divided into wards.

Ward Boundaries

A ward is an area represented by a councillor in a City, Municipal or District Council. There may be more than one ward in a constituency. Ward boundaries are often imaginary and definitely need to be based on identifiable ground features for ease of identification in the field. They also need to be properly fitted into constituencies in which they belong. For election purposes the ward is further divided into Polling Districts (PDs) which may be as many as 19 in a single ward.

Polling District Boundaries

A Polling District (PD) is an election polling area with a population of not more than 3500 people. It falls within a ward. Registration of voters is done at this level. Its boundaries are largely imaginary as well. They also need to be based on identifiable ground features to make them easily located on the ground. The polling district will then comprise of the SEAs grouped into CSAs. Thus the CSA boundaries must be fitted within particular PDs.

Census Supervisory Area (CSA)

A CSA is a grouping of SEAs that can be supervised by one supervisor. In the new setup it will thus be a subdivision of a PD. It will comprise a suitable number of SEAs as may be determined depending on some other factors.

Standard Enumeration Area (SEA)

A SEA is an enumeration area that shall be properly delineated with ground identifiable boundaries with a prescribed population size. It shall be the smallest statistical unit capable of being covered by a single enumerator under the supervision of a CSA supervisor. At present the population of a SEA ranges from 300 – 500 people in rural areas and 600 – 800 people in urban areas.

Chief's Area

A Chief's Area is a traditional administrative subdivision of a district but also of a Senior Chief's Area and/or of a Paramount Chief's Area. Sometimes statistics about the Chief's Area are required for specific operations like relief operations, agricultural purposes and other developmental projects. At present such statistics are just crude estimates derived from SEAs approximately falling within such a Chief's Area whose boundaries may not be identifiable on the ground and might not correspond with those of the SEAs used.

In order to circumvent this problem it would be better to include the Chief's Areas' boundaries in the Census Mapping Frame (CMF). But such an inclusion could entail a lot of adjustments and resolution of boundary conflicts as regards PDs and wards. It is therefore prudent to leave them out but have an inbuilt mechanism in the data collection procedures that would ensure that data about Chief's Areas could easily be deduced from the collected data. Asking the inhabitants and noting down on the enumeration forms in which Chief's Area or village their premises fall could achieve this. This should be differentiated from '*to which Chief's Area they themselves belong*'. With the envisaged use of a GIS [Sikanyiti, 1997], population figures for a particular Chief's Area or village should be easily obtained on querying the database for the same.

The New Census Mapping Frame (NCMF)

The suggested hierarchy in the mapping of census maps, as defined in Figure 2, will result in the New Census mapping Frame (NCMF). In the NCMF:

- a SEA will only belong to one CSA
- a CSA will only have a maximum of six (6) SEAs and shall only belong to one PD
- a PD shall in turn equally belong to only one Ward
- a Ward shall only belong to one Constituency
- a Constituency shall only belong to one District
- a District shall only belong to one Province and
- a Province shall only belong to one Nation

The NCMF will thus have the advantage that data collected based on it will not need to be extrapolated for the day to day needs at various common subdistrict levels as such levels will have already been catered for during data collection in the field. Therefore the NCMF will make raw census data readily available to the users.

The NCMF will also make such census or any other data based on it easily integrated with that of others with data based on various subdistrict levels without introduction of errors that come with data extrapolation processes. In other words the NCMF can easily be adopted as a National Mapping Frame (NMF) upon which all spatial related data could be based. The NMF could thus provide the frame for the digital mapping and GIS for Zambia.

Realisation of the NCMF/NMF

Indeed suggesting such a frame is another thing and realising it is yet another. So how could such a mapping frame be realised then?

Such a mapping frame already exists but in a disjointed form since each department has its own maps to suit its operations and tastes. Base information for all such maps is obtained from ZSD maps. In fact in most cases ZSD draws the maps for these departments/institutions. The major task therefore, in realising the envisaged mapping frame, lies in properly integrating the existing maps/information from the various institutions.

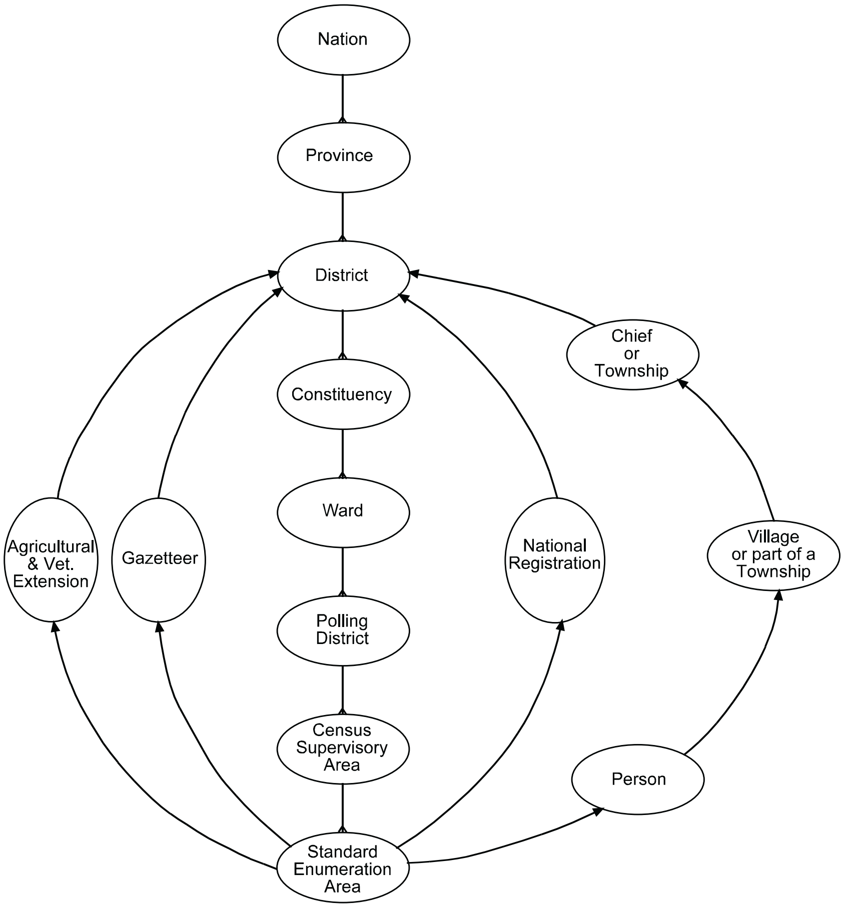

Figure 2. Proposed Structure of the New Census Mapping

CSO has already initiated this process by calling up a workshop on the NCMF for the year 2000 census. Therefore regular meetings and discussions between various concerned departments/institutions as well as good high level representation of such institutions on bodies like the Zambia Association of Geographic Information Systems (ZAGIS) is one way that could facilitate the envisaged integration of the now disjointed data sets under consideration. Such meetings could culminate into an Interdepartmental Group for Geographical Information (IGGI), grouping all stakeholders, to iron out any impediments that might affect integration and raise awareness about the advantages of working together [Meakings & Rhind, 1998].

In this regard a leaf could be taken from the collaboration of the Ordnance Survey and the Office of National Statistics of the UK. In this collaboration creation and dissemination of boundaries for the 1991 census areas and creation and provision of metadata in the UK was done in conjunction with the private sector [Meakings & Rhind, 1998]. They are also in the process of including ward codes to a map product called the Boundary-Line in order to streamline census planning as well as to provide a direct link to their metadata.

In Zambia's case the Electoral Commission and the CSO receive a lot of funding to carry out mapping for their activities. This same funding could be channelled to ZSD to create and update the NCMF in the same way the two did but more enhanced this time. Hand held GPS receivers and computers [Jones, 1997] and general field visits could help tremendously in collecting data for this new frame. In fact this exercise could only be so involving in marking out the ground identifiable boundaries, after which other details could be filled in easily using the wide network of the civil service which the two institutions have always taken advantage of in the past. It is thus my considered view that realisation of the NCMF/NMF is feasible within the available resources.

But where funds permit there is no harm in taking advantage of the high-resolution satellite imagery now emerging on the world market [Fritz 1996, Bujakiewicz & Mwanza 1998]. With their wide coverage, good repetitivity and multiple usage, satellite imagery would definitely be a good data source for this exercise as well. Atilola (1992) reports that SPOT imagery was used to produce topographic maps in Nigeria for delineation of Enumeration Areas for the 1991 national population census. Thus the option of using satellite imagery is even much more attractive now that the world will be provided with submetre pixel size imagery.

The Impact of the NCMF on Stakeholders Activities

The NCMF, when realised, must actually become a National Developmental Frame (NDF). All stakeholders should be able to use it for their benefit. It will be a Common Base Mapping Frame (CBMF) as regards thematic mapping and planning/management of all developmental, relief and disaster activities in Zambia. Its expected impact will therefore be:

1. Updating of the Gazetteer will be easy as census data is regularly collected every ten (10) years. All that is needed is an understanding among the stakeholders on how best census data should be collected to encompass that needed by others too [Mwanza, 1997]. Indeed the agreed collection methods would also need to take into account the ease of extraction of such data as for the Gazetteer from collected census data.
2. National Registration will be eased in that SEAs will be the basic unit upon which personal data could be collected as well. The unique ID (National Registration Card (NRC) No.) could easily link persons to their records wherever they may be. Modalities of how this could be done are issues of database creation and management that need addressing separately. This could in fact be used to reduce the huge resources always needed to register voters whenever there is supposed to be an election.
3. Planning and implementation of various educational and healthy activities will also be easy in that catchment areas for schools and clinics will be distinct with their data readily available based on the suggested frame.
4. In the same vein agricultural data, regarding extension services in crop and livestock farming and management of tsetse activities and other animal diseases, can easily be tied to such a frame. Thus agricultural activities will be collected on a known frame to users and can easily be linked to human distribution or indeed any other feature or phenomenon.
5. Elections, which now gobble huge amounts of money to register voters and re-demarcate PDs whenever there is a new district formed, will also be accommodated easily. Re-demarcation of new PDs and re-registration of voters every time there is a election will no longer be necessary under the suggested frame as new District boundaries will follow constituency boundaries within which Wards, PDs, CSAs and SEAs are already defined. With National Registration based on such a frame voter registration based on belonging to a particular PD will be a thing of the past.
6. Disaggregation of data into village or township and Chief or municipality will be simplified. This means that activities based on such subdistrict levels can easily be planned and implemented with data of reliable accuracy.

Conclusion

The New Census Mapping Frame (NCMF), which would culminate into a National Mapping Frame (NMF) for all developmental activities, will be built around the Standard Enumeration Area (SEA) as a basic data collection unit. With the SEA imbedded into all subdistrict levels used in every day activities and common to many a user of such data, the activities outlined under ‘The Impact of the NCMF on Stakeholders’ and others not discussed herein, will become a reality. Government ministries, Non-Governmental Organisations (NGOs) and other agencies (public and private) will be afforded a rare opportunity to work with, exchange their data and network for the common good of Zambia.

The NCMF would also offer a unique opportunity for Zambia to start working on a national wide GIS incorporating both spatial and attribute data. Such a GIS could be fragmented according to the needs of various users but with a possibility to share data easily.

On the whole the NCMF will ensure networking and economical use of scarce resources. In line with this conclusion the Zambia Survey Department (ZSD) should be charged with all mapping related work as opposed to the current scenario where it is just contracted to do this work for other government agencies.

In fact a symbiotic relationship between those responsible for the official description of the country' geography (ZSD) and those charged with collecting geographically differentiated statistics (e.g. CSO & the Electoral Commission) is of great national importance. This importance increases even more as information is increasing stored in computer readable form other than on paper.

Finally, it is gratifying however to note that work in this direction has already started on these lines by trying to fit the SEAs into the wards. But not everything will be done by the time the year 2000 census will be undertaken. The beginning will nonetheless have been made. This work is being undertaken by CSO in conjunction with the Electoral Commission. Other stakeholders such as the Ministries of Education and Health, who are doing their won mapping, need to be convinced into joining so that resources could be pooled for the common good of the country.

References

Akende, P. (1997). *Past Census Mapping Methodology*. Summary Report for the Census Mapping Consultative Workshop, CSO, Kabwe: 2 – 4.

Atilola, O. (1992). *Mapping with SPOT Satellite Imagery: The Nigerian Experience*. International Archives of Photogrammetry and Remote Sensing, Vol. 29, Part 4, Washington DC: 116 - 121.

Bujakiewicz, A. and Mwanza, A. R. (1998). *Present and Future Cartographic Applications of Satellite Imagery in Africa*. The First National Remote Sensing Conference, Lusaka.

Fritz, L. W. (1996). *Commercial Earth Observation Satellites*. International Archives of Photogrammetry and Remote Sensing, Vol. 31, Part B4, Vienna: 273 - 282.

Jones, C. (1997). *Primary Data Acquisition from Ground and Remote Surveys*. In Geographical Information Systems and Computer Cartography, Addison Wesley Longman: 95 – 96.

Meakings, B. and Rhind, D. (1998). *Co-operation and Inter-relationships between the British National Statistical and Mapping Agencies*. Ordinance Survey Web Site, http://www.o-s.co.uk/literatu/external/eurostat.html

Mwanza, A. R. (1997). *Topographic Map Revision in Zambia through the Use of Alternative Data Sources*. MSc Thesis, ITC, Enschede.

Sikanyiti, I. M. (1997). *Planned Census Mapping Strategy for the Year 2000 Census*. Summary Report for the Census Mapping Consultative Workshop, CSO, Kabwe: 4 – 6.

Silanda, E. (1997). *Opening Remarks*. Summary Report for the Census Mapping Consultative Workshop, CSO, Kabwe: 1 – 2.

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A National Topographic Database for the 21st Century - Paradigm Shifts in Business Process and Technology

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Abstract

As national mapping agencies confront the new millennium, they are faced with a dilemma. How to satisfy an increasing demand for digital topographic information while achieving government output targets with reducing resources. Part of the answer lies with the use of "smart" technology.

In the mid-1990s, New Zealand, already equipped with the experience of implementing a national digital topographic database, embarked on a development designed to serve the country into the next century. After rigorous debate the "smart" technology chosen was from the fledgling object-orientated GIS software industry - Laser-Scan's LAMPS2.

This main body of the paper describes the background of topographic mapping in New Zealand, the impact of new technologies and the business drivers that led to the adoption of object-oriented technology. The stages in the radical shift towards more commercial business models are described, together with the resulting organisational and technical changes, the issues associated with building a national topographic database and the lessons learnt. On-demand mapping capability is examined as a measure of its successful implementation. This section concludes with a review of the achievements and attempts to answer the question "where to next for New Zealand's topographic mapping?"

In a postscript, the process from the viewpoint of the technology provider is summarised. Key points include the developments carried out to achieve full automation of cartographic output to national mapping standards, the role of a rich and flexible data model, the need for user/vendor partnership in problem-solving and the critical role of modern communications technology in supporting a complex project on the other side of the world. In particular, the experiences gained in this project and others in 're-engineering' a large topographic database to add value and meet a wider range of business requirements are summarised

The Evolution of Topographic Mapping in New Zealand

New Zealand is a remote cluster of islands about the same size as the British Isles or Japan. It straddles the boundary of two colliding tectonic plates, the Pacific and Indo-Australia plates, hence its rugged topography.

Formal national topographic mapping started in the late 18th Century when Captain James Cook circumnavigated the country. His early charts of New Zealand's coastline and waters have only recently been replaced in their entirety. Cartographers have long argued that Cook, an explorer and cartographer, was the first mapper of the country and not the surveyors employed by the early colonial administration.

The first official topographic map series produced in New Zealand was the New Zealand Map Service (NZMS) 1 at a scale of 1:63 360. The first map of this series was published in 1939 using plane-table surveying methods. In later years this method of data collection was replaced by photogrammetry and aerial photography. The maps were drawn to a national yard grid based on the Transverse Mercator projection, with separate origin coordinates for each of the two main islands. The NZMS 1s formed the basic map series from which all other topographic maps were derived. Complete national coverage was achieved in 1975.

In 1973, the Department of Lands and Survey, as the National Mapping Organisation (NMO), implemented a plan to replace the imperial map series with metric mapping. The metric NZMS 260 1:50,000 map series were produced on a new conformal projection with a single grid. The projection was called the New Zealand Map Grid (NZMG) projection [Reilly, 1973].

Key drivers for the series were the demand for metric maps (New Zealand had officially adopted metrification in 1967), a single grid, improved sheetline coverage of the country, and the need for a product that would increase map sales. The metric series was to be completed in 20 years. Due to a lack of resources brought about by a focus on cost recovery targets the final three maps in the series were not published until 1996.

Impact of Emerging Technologies

The NZMS 260 map series provided the opportunity to improve the accuracy of the national portfolio using aerial photography and data collected with the emerging technology of remote sensing. For reasons well documented elsewhere remote sensing failed to deliver as a suitable alternative data source for basic topographic mapping [Pickering, 1990]. Nevertheless, image processing algorithms developed for remote sensing contributed to the development of processing techniques for digital orthophotographs which were later used in the on-screen field checking and verification process adopted in the early 1990s.

Cartographic techniques remained largely the same throughout the seventies and early eighties. Developments focused on incremental improvements in the photomechanical processing of map compilations. Cartography remained essentially a manual process until the early eighties when computer-aided draughting (CAD) software became affordable. Many countries adopted the new technology and expended considerable energy and resources in converting their national collections to digital files. The main advantages were seen as coming from efficiencies in the ongoing process of map revision.

It was almost a decade later that New Zealand joined the digital revolution. In part this was due to the vision of the Surveyor-General at the time, Bill Robertson, who agreed to a business case to convert the 1:250,000 topographic map series to a digital database. Approval was given on the basis that the work was to be completed within three years. In fact the conversion was completed within 18 months resulting in a fully-structured, topologically correct, seamless database. The converted digital data formed part of a Geographic Information System (GIS) and GeoVision's Vision relational database software was chosen for the GIS.

The success of using a bureau service with SCITEX hardware and software to scan and vectorise the 1:250,000 maps led to the subsequent purchase in 1993 of Intergraph's Mapsetter 400 and Laser-Scan's VTRAK system. The purchase of these systems enabled the in-house conversion of map drawings to vectors [O'Malley and Howard, 1990]. It is worth noting that the VTRAK system incorporated an early version of Laser-Scan's object-orientated Gothic architecture.

Business Drivers Behind Digital Conversion

In 1987, at about the same time as the digital conversion of the 1:250,000 map series commenced, reform of the New Zealand public sector was gaining momentum. The Department of Lands and Survey, after approximately 140 years of mapping service to the country, was restructured. A new NMO called the Department of Survey and Land Information (DOSLI) was established. The major impact of this restructure was to give the new department a greater commercial focus with an initial 40% cost-recovery target. By mid-1995 cost recovery had increased to approximately 80% of revenue.

The restructuring provided the impetus to risk building the 1:250,000 database. The continuing large financial returns from data sales generated by the high demand from a starved market for digital data, coupled with increasing cost recovery targets, forced a change in approach. Instead of adopting a structured approach to the population of a higher resolution topographic database, a decision was made to maximise financial returns by concentrating on the conversion of those priority areas and layers most in demand by users [O'Malley and Howard, 1989]. The population of this new database was based on the digital conversion of the original map compilations at 1:25,000 and cartographic drawings at 1:50,000.

For the next few years the increasing demand for digital data and a user pays principle saw large amounts of 1:50,000 mapping converted to meet the demand, but without a specific programme in place to control the conversion process [Howard, O'Malley and Pickering, 1991]. This was the case for the next 18 months until a sudden demand for Digital Terrain Model (DTM) source data, which had been created by the deregulation of the air waves, saw a formal programme established for the national conversion of contour sheets. This work was completed within twelve months and it provided the first major test for the VTRAK system.

Building a National Topographic Database for the 21st Century

The successful completion of this task, and its financial success, enabled the programme to be extended to include all other 1:50,000 map features. Consequently it became necessary to complete the topographic data dictionary which was based on the United States Geological Survey (USGS) Spatial Data Transfer Standard (SDTS). This work was completed and has recently been converted to Hypertext Markup Language (HTML) and placed on the Internet as a fully indexed data dictionary (www.linz.govt.nz).

Up until this point, the data capture programme operated in parallel with the map production and revision programme. In order to keep the data current it was necessary to move the management of the authoritative topographic source record from the paper map to the digital database. An internal reorganisation merged the responsibility for both map production and database development. This change facilitated the efficient maintenance of the source record and enabled the conversion programme to be aligned with the management of map revision and new edition requirements.

It quickly became evident that the systems were struggling to cope with the complex data structures, high data volumes and functional developments required to provide a well-maintained high-resolution database. The management of data in separate layers and the limited ability to work with rectified imagery started to become a serious problem. At about this time the commercial failure of the GeoVision parent company in Canada seriously threatened the completion of the database. It did however provide a unique opportunity to reassess the database options and direction.

A research programme was established to investigate database requirements and systems and to develop a model on which to predicate future investment decision-making. The research involved an evaluation of both relational and object-oriented systems and included debating the strengths and weaknesses of each system with recognised experts in the industry. At the conclusion of this exercise, it was decided that none of the relational systems fully addressed the issues facing topographic mapping. These issues also included the need for a methodology that would allow the direct output of cartographic quality repromat from an authoritative source database.

The final analysis determined that the object model with its rules and behaviours more accurately reflected geographic reality than the relational model with its layers and networks [Spencer, 1998]. In late 1995, the decision was made to purchase Laser-Scan's LAMPS2 system. The principal factors in its favour were a successful relationship already established with VTRAK and Laser-Scan's knowledge and experience in developing automated cartographic systems.

In 1996 a major restructure resulted in a purchaser/provider split of DOSLI into a new government department Land Information New Zealand (LINZ) and a State-Owned Enterprise Terralink NZ Ltd [Robertson, 1995]. LINZ was tasked with the responsibility for the purchase of land information services on behalf of the Crown. Terralink was given preferred service provider status for a period of two years after which time the services would become fully contestable. It was during this background of organisational change that the LAMPS2 system was implemented.

In making the decision to purchase LAMPS2 a number of issues were identified as critical to the success or failure of the system. These were:

- Polygon formation. Although the design brief had been prepared the software had not yet been developed.
- Vast amounts of topographic data had already been captured. Population of the database with this data would immediately test those aspects of the software that no other users had validated in a production environment.
- It was unclear what issues would arise in the validation of existing data under the strict rules of an object model. The data had already been fully tested in many of the leading relational systems on the market and it had successfully passed rigorous quality assurance procedures.
- System performance. Early experience of object-oriented databases had shown that system performance was the key to a successful implementation.
- New code was required to enable the conversion of New Zealand's topographic data into a format the system could read. It also required that the system support the NZMG projection.
- The ability of the staff to adapt to a new system which was extremely complex and forms oriented.
- The success of the software to protect the integrity of the existing digital data and structures which would be imported into the system.
- The quality of support that Laser-Scan could provide from the other side of the world and their ability to address issues that would arise during the system build phase.

In the final analysis all of the above were major issues to be addressed during the design and build of the database. Some of the above are still of concern today. In spite of this it has been possible to develop a Topographic Database that can deliver topographic mapping to the full national specification. The process has taken three years and recent advances in technology have alleviated almost all the concerns above.

In early 1998 the first of the new generation of 1:50,000 topographic map sheets was produced. Map sheet M35 was generated directly from the database without any cartographic embellishment to the full series specification. The automatic addition of the legend, grid reference, sheet name and number, magnetic declination, etc has also been fully developed. The recent completion of the National Topographic Database now realises the capability to generate a plot of any map sheet in the series.

On-Demand Mapping: Fuzzy Logic or Reality?

This is a term coined to promote the direct output from a GIS of a topographic map sheet that exactly meets a national standard for colour, symbology, content and text. The short time for this to occur is regarded as on-demand or while you wait. The system developed by LINZ and Laser-Scan achieves this output in less than five minutes. However, the process of plotting the resulting postscript file to hardcopy is dependent on the speed and type of plotter available. Printing plates for conventional offset printing can be ready within 24 hours if required.

The key to the process is the availability of a structured database with the necessary rules, representations, methods and data integrity checks already defined. The preparation stage requires a preliminary alignment of text features. Once this has been undertaken no further work is required other than the integration of the latest feature update.

Polygons are processed within the GIS to allow nesting to occur. This enables polygons to be drawn, which would otherwise not display because of the priority ordering of data at the plotting stage. For example a lake may contain an island and the island may contain a lake. If the display priority was set higher for islands than for the lake then the lake would be over-written during output. Should the priority be set higher for lake then the island would be lost. The nesting process enables all of the features within features to be displayed or drawn. This situation of discrete features within features occurs in many instances in the real world e.g. forest classes, land cover classes etc. Laser-Scan were contracted to develop a map frame which would provide this functionality [Fletcher, 1998].

Success factors for the on-demand mapping capability included:

- The requirement for continuous performance improvements. Output time was progressively reduced from 40 minutes to 5 minutes for PostScript file generation.
- Developing the topographic data dictionary and rules for the data model
- Developing the complex display methods for each of the features
- Displaying the grid and graticule

Problems which needed to be resolved included:

- Developing the map frame
- Developing routines to handle nested polygons
- Developing routines to use bitmaps in area infills
- Developing display methods based on object behaviours and relationships
- Methods for handling text

All of the above problems were addressed before the system could consistently generate a result that met the existing specifications. Figures 1-4 are examples of complex cartographic detail in map sheets generated automatically from the National Topographic Database. Only a perfect match was considered acceptable to demonstrate to the cartographic professionals that a full specification on-demand mapping capability was a reality and not the result of “close-enough” fuzzy logic. A failure to deliver to the traditional cartographic specification would have impacted on LINZ’s ability to gain user acceptance of the product and to stimulate its service providers into seriously re-examining methodologies proposed for maintenance contracts.

Figures 1-4 are examples of complex cartographic detail in map sheets that have been generated automatically from the National Topographic Database.

Lessons Learnt

DOSLI like other organisations implementing major technology was faced with choosing a locally supported system or accepting the risks associated with overseas support. The decision was made to purchase LAMPS2 in part because of the excellent service received in support of the VTRAK system and unlike many of its competitors, Laser-Scan's vision for GIS was identical to that of DOSLI. Although there have been the inevitable problems, in general the decision has been vindicated.

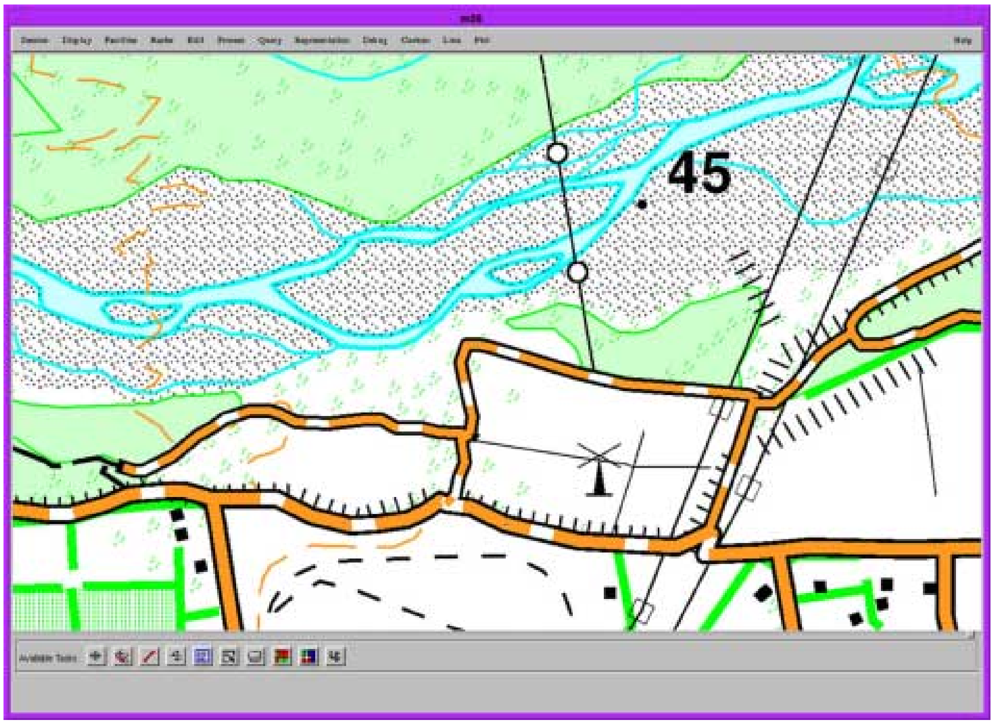

Figure 1. Depiction of railway line from attributes held in the database.

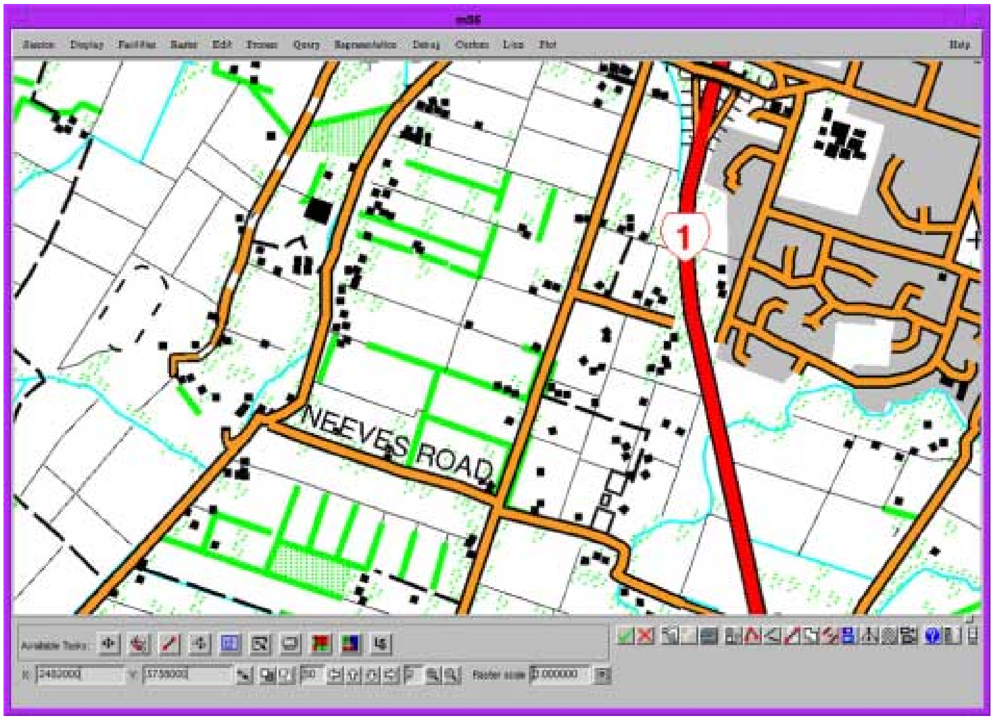

Figure 2. Complex nested polygons (estuary continuous over multiple sheets).

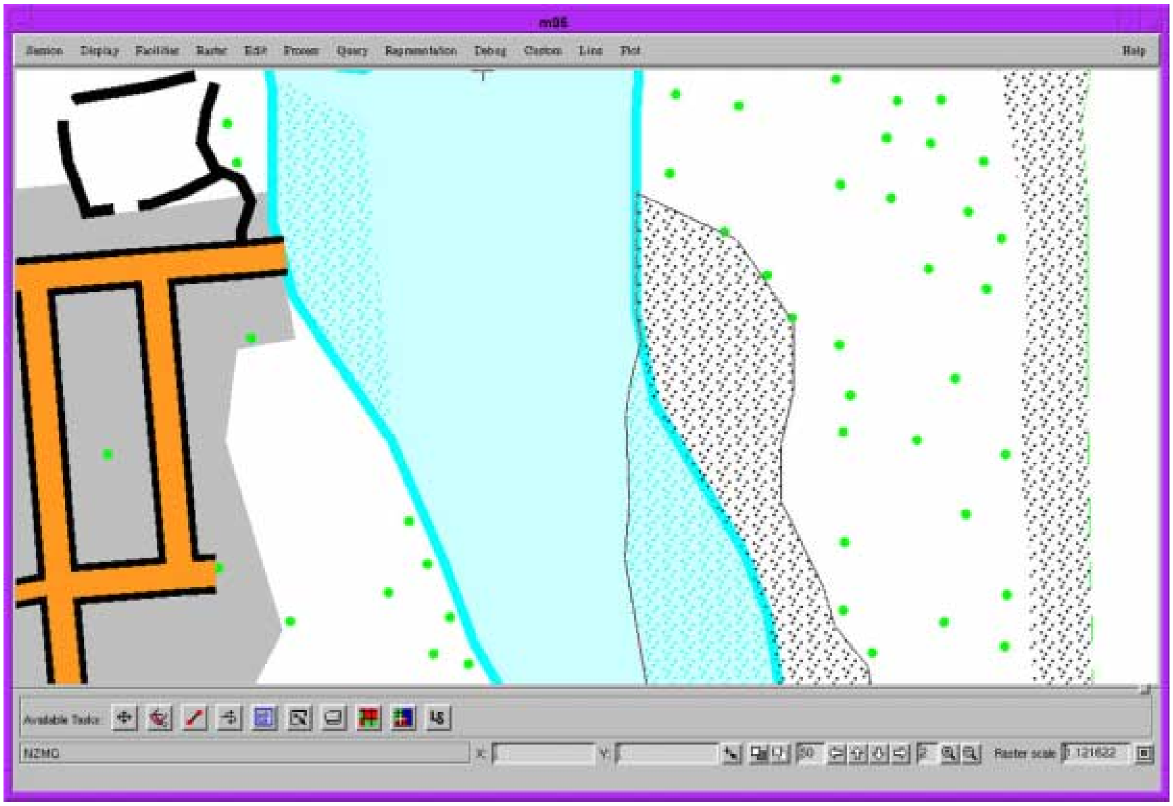

Figure 3. Road symbology and text placement

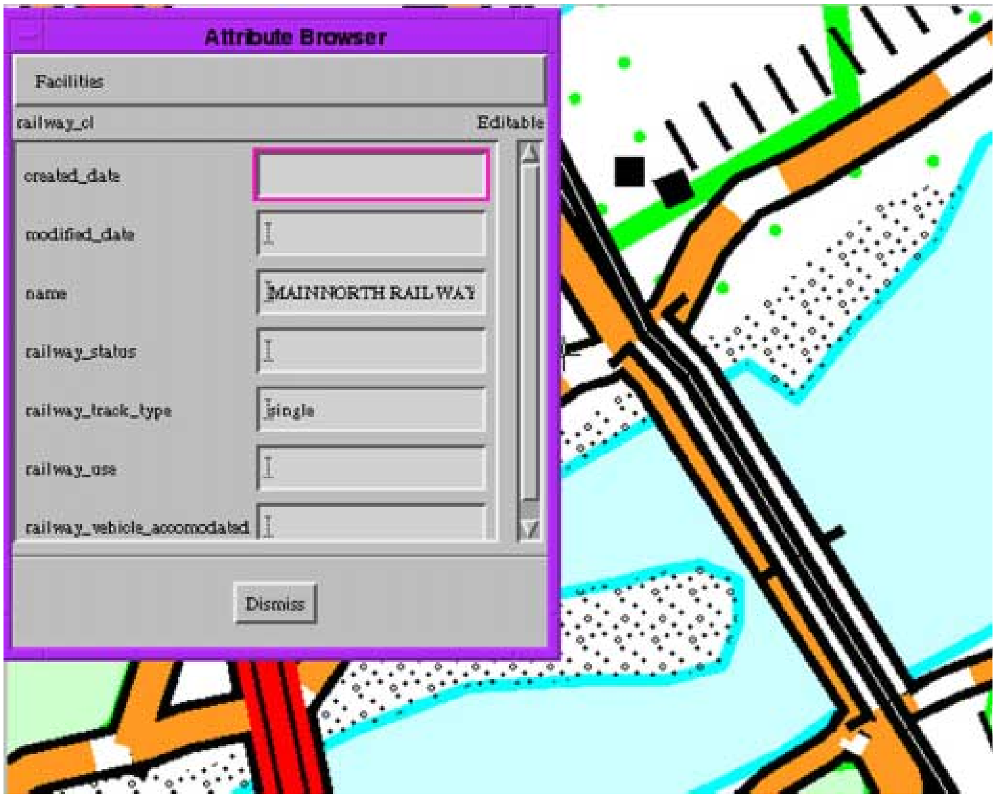

Figure 4. Depiction of land classification (sand) across boundaries.

One important lesson that software developers need to learn is the impact the user interface has on users. There are clearly different styles between the approach adopted by software developers in the United Kingdom and those in the United States. English developers tend to favour a form driven approach which can drive a user to distraction in getting to the menu item of interest as against an American approach which is considerably less user friendly. Developers need to consider a balance between these two approaches in the design of their systems.

The lessons learnt in developing an object-orientated Topographic Database have to some extent been a continuation of the experience gained in developing the 1:250,000 relational database. This experience was particularly invaluable in the early prediction of potentially major problems. For example in identifying when the problem was software and not the data being loaded. The complexity of the polygons was a constant issue. Often the problems were not self-evident given that most software developers never get the opportunity to fully test their systems with a live database. Building a database from scratch is quite different to the conversion of one system to another particularly when the two systems are in different paradigms.

Along the implementation path many issues were addressed and resolved. System performance, at one stage a major problem, was resolved through the later availability of increased processing power. The use of vectors for symbol infills doubled file sizes and was resolved through the use of bitmaps. There are many other examples. However of all lessons learnt in operating within the object paradigm the most important is the need for care and consideration when developing the rules for the system. Of particular importance is the need to understand tolerances and the limitations imposed by the system itself.

The "Achievements"

The New Zealand Government has made a considerable investment in the Topographic Database. It is our belief that the result is the first intelligent, topologically correct, national topographic database in the world. This statement at first may appear presumptuous until you consider what has been achieved.

- All New Zealand's topographic features in structured digital form
- Geographic names data linked to national database
- Fully developed on-demand map production capability

The traditional cartographic process has been replaced providing an opportunity for outsourced facilities management of the database, map publication and distribution and the opportunity to reduce, if not completely eliminate, the need for map stocks. These achievements alone will result in considerable financial savings for the NZ Government. However the authors are also aware that any system is only as good as its future and therefore the question of where to next needs to be examined.

Where To Next For New Zealand's Topographic Mapping?

The pre-eminent American cartographer, Joel Morrison, in his contribution to "Topographic Mapping in the Twenty-First Century" observed that the changes facing cartographers are far greater now than at any time in the past [Morrison, 1997]. As he rightly states, the control has passed from the cartographer as the "interpreter" of geographic phenomena to the user. Enabling technology has provided the user with the tools to develop their own visualisation of spatial reality. LINZ will need to adapt to meet the challenge this paradigm shift will require of NMOs as the stewards of national topographic mapping.

Morrison in examining the future for NMOs of the next century suggests that rather than attempting to answer the question 'Where to next?' a better question would be "What is the status of your responsibility for the Global Spatial Data Infrastructure (GSDI)?"

While not disagreeing with Morrison's view, principals of individual NMOs will need to "map" out their own route towards a global outcome which benefits all nations. Steps for New Zealand are likely to be:

- Development of the national topographic information strategy
- Maintain efficient contract management of outsourced services
- Reduce the cost of topographic information
- Improve data access and delivery mechanisms
- Implement coordinated integration of information technology within government
- Develop greater alignment with globalisation initiatives

Some, if not all, of these steps are being addressed now, with emphasis on the evaluation of particular technological strategies, including:

- Feasibility of Internet connectivity for data distribution
- Generalisation software extensions to the GIS which will enable small scale map production from the source topographic record
- Disaster backup options to enable business continuance in an emergency situation
- Integration of the land and sea interface

Conclusions

While it can be seen from this paper that New Zealand has gained a slight edge in its management of national topographic information, rapid advances in technology are likely to make this short-lived. It is not the dichotomy which should concern LINZ, but the correct selection of the direction to head. One direction is to control further development of the database “in-house” while the other is to move to external facilities management.

While internal development may offer short-term advantages, facilities management is more attractive because given the right incentives, the private sector has the capital and expertise to keep the system at the leading edge of development. Whatever the decision it is likely that the changing environment, both political and social, will conspire to demand improved access to up-to-date topographic information. Government decisions on data pricing will be critical to the future use of topographic information and the ability of NMO’s to contribute to global spatial infrastructure initiatives.

Technological developments will also play their part. It is likely that at the current rate of development it will be early in the twenty-first century when satellites will be able to provide real-time imagery into hand-held map display systems. These intelligent maps may include cartographic interpretation capability, real-time positioning and in-built datum referenced geographic names. Not an Orwellian vision, but perhaps a logical next step for cartographic technology.

New Zealand has developed a national topographic database for the twenty-first century. The real question is, ‘For how long will it be needed?’

Postscript – the Role of the Technology Provider

The account above has dealt with the selection process; here this is passed over but the implementation and support issues are discussed from the viewpoint of the technology provider.

Implementation Issues

The crucial and demanding requirement to achieve an extremely high degree of automation without diluting the cartographic specification could only be met as the result of an exhaustive definition of the data model, the rule base and the associated display methods. This was carried out by LINZ and Laser-Scan jointly. LINZ provided the cartographic inputs and analysis and Laser-Scan implemented the data model and the complex display methods. The existence of a well-defined topographic data dictionary formed a firm basis for this activity, both per se, and because of the underlying experience and discipline it embodied and fostered of arriving at formal definitions. This was an essential underpinning of the ability to work collaboratively at a distance. Success in meeting the requirement depended critically on the precision of the rules base. This was achieved firstly by the quality of the initial analysis and its underpinning cartographic experience, and then as a result of the ability to rapidly prototype and test rules (as methods in the object-oriented environment).

The volume of data and the consequent number of ‘hard cases’ for both the rules base and the topology engine (in its then current stage of maturity) represented a significant challenge. It was of great benefit to the overall success of the project that the users (LINZ) had prior experience of handling such data. They were therefore sufficiently realistic to appreciate that building a very large database, in a more structured paradigm, is not a trivial undertaking. A methodology had to be established for separating system errors from errors arising from imperfections in the input data. This is turn depended on establishing correct values for tolerances and thresholds, so that as much re-structuring as possible is carried out automatically, without allowing unacceptable errors through. Laser-Scan, for its part, had to set up systematic procedures for isolating and analysing potential problems, particularly in handling very complex polygons. In cases where core code had to be modified or extended, a serious level of regression testing on large volumes of realistic data was (and is) an absolute necessity. A powerful topology engine is notoriously prone to perturbation or to the re-introduction of old 'bugs'.

The task of re-engineering data to a more structured specification, with greater added-value, is likely to be more difficult and time-consuming than anticipated. The effect of deficiencies that were previously masked or of no consequence is difficult to predict. A degree of trust in the system tools, and between the user and the technology supplier has to be established, in order for the true nature of problems to be determined, and appropriate courses of action determined. A key element in building such trust is capabilities that ensure the integrity of the database. The Laser-Scan data model is particularly strong in its provisions for handling the object lifecycle and using validation methods [Woodsford, 1996]. Database integrity has to be maintained across the whole life of the database, and across all the processes that interact with it, if the organisation is to be able to meet its production requirements on a consistent and sustainable basis.

An important success factor for the implementation was the provision, beyond the initial training and installation, of an annual support visit of two weeks duration. This was used sometimes for a key member of the LINZ technical staff to visit the company headquarters, and sometimes the reverse. These visits played an important part both in framing and planning the next implementation phase, and in resolving significant support issues (e.g. a major new release of software).

Support Issues

The potential risks associated with the lack of local support were a concern for both Laser-Scan and LINZ. The solution has been found in the following techniques and procedures:

- Extensive use of modern communications technology, including Email and (under suitably controlled conditions) modem access to the LINZ site
- Operational procedures to ensure that responses occur (from both ends) overnight. Being on opposite sides of the world can be an advantage in creating 'round-the-clock' working when necessary
- Centralised responsibility at both ends with clear lines of communication

These have been successful in cutting out unnecessary links in the chain, and putting expert directly in contact with expert when required. In practice, this has only been needed occasionally. Equally important has been the building up of confidence by responsive support and clear communications. Users can feel frustrated and fobbed off by poor support even if it is on their doorstep – support at a distance heightens the perception, for good or for ill.

An important success factor in training and in building up expertise on the part of the user organisation is to correctly assess the initial skills and experience of the staff involved. Automating a substantial cartographic production task demands both cartographic and automation (computing) skills. It is unusual for both to exist to the level needed in a given individual. However, in an organisation the size of LINZ, staffing levels are such that individuals have to carry out both roles. Training therefore has to focus on leading the cartographer to understand the automation tools and conversely on equipping the data modeller/programmer to understand and deal with the cartographic requirements. Time has to be allowed for the necessary learning stages. Time also has to be allowed for the framing and planning of the stages of the implementation – this is greatly eased if the partners share a common initial vision, but the 'devil is in the detail'. The detail has to be worked through for the common vision to be turned into a successful system implementation.

Postscript - Conclusions

A paradigm shift in technology has been needed to match the shifts in business process at LINZ and to meet the resulting escalation in demands upon the organisation and its topographic database. Successful implementation has also needed a shift from the traditional customer/vendor relationship to much more of a long-term partnership. Modern communications have made it possible for such a relationship to be built up and maintained at a distance.

Re-engineering data into the object paradigm provides very substantial operational benefits. Some of these are already realised in the on-demand mapping capability. Others, such as the use of generalisation to broaden the range of scales supported and the flexible use of the Internet, remain to be exploited. However, such re-engineering has a cost, and it is important that the gains made are sustained into the future under the update and value-adding regimes.

References

Fletcher, S.J. (1998), Mapping by Numbers GIS Asia Pacific, August 1998.

Howard, G. M., O'Malley, G.V. and Pickering, R.P. (1991), New Zealand's Topographic Database: Where to Next? AURISA 91 Conference Papers, Wellington.

Morrison, J.L. (1997), Topographic mapping in the twenty-first century. Framework for the World 1st Edition 1997, GeoInformation International, Cambridge.

O'Malley, G.V. and Howard, G.M. (1989), The 1:250,000 Digital Road Network of New Zealand: Capture and Application. Proceedings of the Inaugural Colloquium of the Spatial Information Research Centre, University of Otago.

O'Malley, G.V. and Howard, G.M. (1990), The 1:250,000 Topographic Data Base of New Zealand, An Outline. New Zealand Geographer, October 1990.

Pickering, R.P. (1990), Digital Image Analysis of SPOT Multispectral Data for Topographic Mapping. Unpublished MSc. thesis, ITC, Enschede.

Reilly, W.I. (1973), A Conformal Mapping Projection with Minimum Scale Error. Survey Review No 23, Wellington

Robertson, W.A. (1995). A strategic response to turbulent times. Cambridge Conference for National Mapping Organisations 1995, Conference Papers, Cambridge.

Spencer, B. (1998), Why Object Orientation? GIS Asia Pacific

Woodsford, P.A., (1996), "Spatial Database Update - the Key to Effective Automation", International Archives of Photogrammetry and Remote Sensing. Vol. XXXI, (B4), Vienna, pp 955-61.

Session / Séance 27-A

Legislation of the Russian Federation on place names

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Abstract

In the report a modern system of legislative and normative legal acts in the field of place names is considered. It was created in Russian Federation on the base of Federal law "On names of Geographical Features", reasons are stated for making this system, problems within the competencies of the Russian Federation on the realization of functions in the field of place names, role of state authorities of the subjects of the Russian Federation in settling these problems related to naming and renaming of geographical features, main positions of the specified law and directions of activity, connected with sequencing of use of the place names in the Russian Federation.

In the Constitution of Russian Federation for the first time in history of the Russian state a mentioning of place names is included, which together with standards, geodesy and cartography, are referred to the jurisdiction of Russian Federation. In accordance with the Russian Federation's Constitution on subjects of the federal jurisdiction the Federal Laws are accepted, which are directly valid on the whole territory of Russian Federation. One of them is a Federal Law "On Names of Geographical Features", and on its other legislative and normative legal acts on place names are created and accepted.

Problem of sequencing of using the names of geographical features and settling the problems related to the place names has gained a particular urgency at a period of perestroika, which begun in the USSR in the medium 1980-s and which was accompanied by multiple renaming of cities, other settlements and units of the administrative-territorial division of the country. Wave of renaming was rolling over all the Republics of the former USSR, lasting even after the disintegration of the Soviet Union.

Normative legal acts in the field of place names which had been accepted earlier in the USSR came out of the Union's republic division of the country and it could not be applied in full amount to the territory of Russia under the conditions of the present federate state structure, since the former state authorities had already ceased to exist, but new authorities which appeared on their place were not yet vested with the necessary rights. Besides, legal acts of the former USSR left problems of conservation of place names as the national property without due attention. They also did not prevent to the political system to influence on the scope of names of geographical features which brought in practice a large number of ideological-propagandistic and political place names. Historically established toponimical system of Russia was significantly distorted.

Need for a legislative regulation of using of the place names was caused as well by the fact that reorganized state authorities of subjects of the Russian Federation and local municipal authorities quite often started to take decisions on the naming and renaming of geographical features thus violating the Constitution of the Russian Federation. Process of unregulated renaming has created inevitable difficulties in activities of statistical institutions, communication services, transportation facilities, cartography etc., and it was too expensive for the society even in case of a separate renaming. Russia's cartographers felt themselves particularly unhappy, and they became initiators for development of a normative legal act system in the field of place names.

In 1994 Russia's government has formed a Joint Commission on the place names as one of the measures for regulating the use of the place names in Russia. The Commission was entrusted to elaborate the cardinal principles of normalization of place names, consideration of proposals on the naming and renaming of geographical features and realization of the united approach to their solution, as well as normative and methodical work on the determination and cataloging of place names, and regulation of using of the place names. However absence in that time in Russia of a normative legal act, defining in modern conditions an order and procedure of conferring the names and renaming of geographical features significantly constrained the Commission's activity.

In this connection, after the initiative of the Russian governments, a project of the Federal Law was prepared on the problem connected with names of geographical features. In the development of the Law the scientists and specialists of the Central Research Institute of Geodesy, Aerosurvey and Cartography (CNIIGAiK) and of the Federal Service of Geodesy and Cartography of Russia took part. In their work they were supported by scientific foundations of the Russian Academy of Sciences, Geographical Department of the Moscow State University, Russian Geographical Society, as well as by a number of distinguished scientists in the field of Toponimy, Geography and Cartography.

At the end of 1997 the Federal Parliament of the Russian Federation for the first time in history of Russia has accepted the Federal Law "On names of Geographical Features". This Law is valid directly on the whole territory of Russia, but is not subjected to the names of features located in cities and other settlements (streets, squares and etc.), leaving decisions on these questions to the local municipal authorities. The Law is also not valid for the extraterrestrial objects.

The Law is sufficiently laconic. It consists of a preamble, stating that the place names are a component part of the historical and cultural heritage of the people of Russia which is protected by the state. It includes 14 articles. The Law defines a competency of the Russian Federation in the field of names of geographical features and the most general problems, requiring regulations. It provides a status of normative legal acts of the Russian Federation to the instructions, regulations and manuals in the field of place names. The Law stipulates also introduction of specially authorized federal executive authority in the field of names of geographical features. Later by a decree of the Russian government, this authority was determined to be the Federal Service of Geodesy and Cartography of Russia. Decisions on some problems of the Law is granted to the Government of the Russian Federation and to the specially authorized federal executive authority in the field of names of geographical features.

Notions of the Law determine the geographical features as existing or having existed comparatively permanent objects, characterized by a determined location to holistic formation upon the land (continents, oceans, seas, bays, straits, islands, mountains, rivers, lakes, glaciers, deserts and other natural features; republics, provinces, cities of federal value, autonomous provinces, autonomous areas; towns and other settlements, regions, railway stations, seaports, airports and the like). Detailed lists of geographical features will be published in normative legal acts of the Russian Federation, devoted to the normalization of the place names in different languages and for certain territories.

In two articles of the Law problems of determination, normalization and use of the place names in the Russian Federation are revealed, main requirements to the place names, as well as exclusive events, when it is allowed to rename the geographical features are presented. It is necessary to emphasize that unlike normative acts of the past years it is noted by the Law that names of outstanding state and public figures, scientists and artisis, other well-known persons, unrelated to the given geographical features, can be used only posthumously and be assigned only to anonymous geographical features. Considering multinational nature of the Russian state the Law regulates that normalization of place names in Russian is realized in accordance with the rules and traditions of using the names of geographical features in Russian. Normalization of place names on other languages of the peoples of Russia is realized in accordance with rules and traditions of their use in specified languages. Writing the names of geographical objects by letters of Latin alphabet is done on the base of normalized names in Russian which is a state language of the Russian Federation and the language of the international contact. Herewith for instance on the road signs and other pointers in the whole territory of Russia the place names are written in Russian, but if necessary they are written on the other languages of the peoples of Russia, and they can be duplicated by letters of the Latin alphabet.

A special article of the Law defines a procedure and an order of conferring the names and renaming of geographical features. Proposals on the naming and renaming of geographical features can be contributed both by the state authorities and local municipal authorities, as well as by juridical persons and by citizens of the Russian Federation. The Law stipulates the most active participation of local population and of the legislative authorities of the subjects of the Russian Federation in nomination of geographical features of Russia. Decision making on the naming and renaming of geographical objects on the territory of Russia is realized:

- by the federal laws - in part of renaming the subjects of the Russian Federation, cities, as well as conferring the names to capitals and centers of the subjects of the Russian Federation;
- by decrees of the Government of the Russian Federation - for all the rest of geographical objects.

Decision making is preceded by an expert operations of the proposals made by the Federal Service of Geodesy and Cartography of Russia. On features, situated within the internal waters, territorial seas, exclusive economic zones of the Russian Federation, as well as on features, found or explored by Russian researchers in deep sea and the Antarctic the Federal Service of Geodesy and Cartography of Russia contributes corresponding proposals to the Government of the Russian Federation. In order to record and make conservation of the place names, as well as to supply the customers with the official information on names of geographical features the Law stipulates a preparation of a State Catalogue of the place names and publishing the dictionaries and reference books of the place names. It stipulates also an administrative or other responsibility for unnecessary changing names of geographical features and using distorted names.

Law is aimed to ensure a stable using of the names of geographical features, to protect interests of the state, juridical persons and citizens of Russian Federation in the scope of using the place names and to create conditions for the satisfaction of their needs for official information on the established in the country names of geographical features and preservation of the toponimical system established in Russia.

Accepted Law creates a base of a system of the legislative and other normative legal acts in the field of place names, which comprises the following:

- number of federal laws on a contributing the additions and changes to acting legislation of the Russian Federation. For the realization of the specified federal Law there have been already prepared drafts of the federal laws on a contributing the additions to the Code of the RSFSR on administrative offenses and alterations of the Federal Law "On general principles of organization of local municipal authorities in the Russian Federation";
- legislative acts of subjects of the Russian Federation on a contributing the changes and additions in legislation of subjects of the Russian Federation;
- other normative legal acts of the Russian Federation, which define changes in the membership of the Joint Committee on the place names and in its Status, and the following:
- approval and introduction into action of the normative legal acts in the field of names of geographical features;
- consideration by the Federal Service of Geodesy and Cartography of Russia of proposals on conferring the names and renaming of geographical features;
- recording and registrations of names of geographical features, elaboration and permanent work with the State Catalogue of place names;

Besides, at present a normative base for perfection of activities, related to the use of the place names in the state language of the Russian Federation is formed. In particular, there is a need to carry out a number of urgent tasks, and one of most important of them is a revision of the existing normative and methodical base of normalization of the place names.

This base was created during several decennials by the cartographic-geodetic service of the country and at present it comprises more than 120 instructions, manuals and other documents, which include data on nearly all the states and territories, in 140 languages of the peoples of the world, including those of the former USSR and Russian Federation. Six of them cover the general problems of determination of place names and normalization of their spelling, 98 define the general rules of Russian transliteration of place names from concrete languages, 17 denote the terms and other words, taking part in forming the place names of separate countries and languages. The full list of mentioned documents with their detailed abstracts is in references, given at the end of this paper.

Instructions, manuals and other normative and methodical documents on standardization of place names are based on results of detailed studying of the toponimical systems of the concrete territories and languages, regularities of their formation and developments, experience of settling the problems of normalization of place names, accumulated by us and by foreign experts. Perennial practice of using the specified documents by different foundations and organizations, as well as by separate specialists firmly confirms that main notions and rules of these documents have successfully withstood the test by the time, and it convinces us that they can be used and hereinafter.

At the same time changes happened in the world and in our country during the time of action of these documents, can not be ignored in the above documents which must be revised, brought into the correspondence with the Federal Law "On names of geographical features" and republished. Analysis of contents of the documents shows that practically all the instructions and manuals need conversion, as well as dictionaries, published in 1950-1960s (there are about 50 of them), and publications of 1970-1980s need revision (there are more then 70 of them. The work on the normative base revision in the field of place names has already begun. So "Practical manual naming and renaming of geographical features of the Russian Federation", "Rules of transliterations of the place names of the Russian Federation by letters of Latin alphabet", "Manual on normalization of place names of the Antarctic" have already been prepared for republication. They will be followed by conversion of "General instructions on the transliteration of place names on maps" (1955) and "Rules of spelling of place names on maps of the USSR" (1967) and preparation on their base of a new united document "General manual determination of place names and normalization of their spelling"(1999), which will comprise three large sections:

- Determination of place names;
- Orthography Russian toponimes;
- Russian transliteration of foreign place names.

Further work on revision of the interesting for us documents, bringing them into the correspondence with the Federal Law "On names of geographical features" and their republication as normative legal acts of Russian Federation will be realized in accordance with the program of work, approved by the Federal Service of Geodesy and Cartography of Russia and by the Joint Committee on the place names.

One can safely say that acceptance of the Law and a number of other normative legal acts have significantly stabilized and regularized the process of naming and renaming of geographical features in Russian Federation. A work is also conducted within the framework of the Commonwealth of Independent States (C.I.S.). So, for instance, normalization of Russian transliteration of the names, assigned at the territory of countries-members of C.I.S. was conducted and an Information Bulletin "Changing of the place names of countries of the C.I.S." was published as of the 1st January 1996; a second issue of the Bulletin has been prepared with provision for a new data; the Joint

Committee on the place names approved the dictionaries of place names to Russian Federation, foreign Europe, and names of hydrographic objects of C.I.S. countries, which are at present being prepared for publishing.

It is impossible not to note also that the Federal Law "On names of geographical features" and the other legislative and normative legal acts considered above are a reliable base for creation in Russian Federation of the special place names service, which would ensure to the full extend solution of the tasks on the determination, normalization, perfection of the use and preservation of the place names of Russia.

References

Федеральный закон “О наименованиях географических объектов”// Собрание законодательства Российской Федерации. - М., 1997. - N 51, ст. 5718.

Г.И. Донидзе. Стандартизация географических названий. Аннотированный указатель нормативных и методических изданий 1939-1992 гг. - М.: ЦНИИГАИК, 1993. - 79 с.

Г.И. Донидзе. Каталог действующих нормативных и методических документов по стандартизации географических названий. - М.: Картгеоцентр-Геодезиздат, 1995. - 37 с.

Session / Séance 21-B

Bilan cartographique mondial des pays en difficulté analysé à l'aide de l'Indice de Développement Cartographique (IDC).

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Résumé

La présente conférence a pour objet de présenter les résultats de l'application d'un nouvel indice en matière de cartographie. Ainsi à l'aide d'un Indice de Développement Cartographique (IDC) basé sur l'intégration simultanée de cinq paramètres il devient possible de caractériser la situation cartographique des nations. L'indice génère une valeur numérique échelonnée de 0 (faible) à 100 (fort). Donc selon le niveau de développement la note varie pour chacun des pays abordés. L'IDC offre la possibilité d'identifier finement les forces et faiblesses des états et ainsi circonscrit les pistes de développement cartographique les plus propices.

Divers parallèles ont été établis entre la valeur de l'IDC et les causes possibles. Ainsi nous constatons des rapprochements entre les matières exportées et le niveau de développement cartographique. Lors de l'exploitation minéralogique à grande valeur,l'IDC a tendance a être plus élevé. Aussi selon le profil historique (présence étrangère) certains pays possèdent un bilan cartographique plus ou moins développé. La dimension du pays n'est pas l'unique cause qui influence le niveau de développement cartographique. Une multitude de facteurs se trouvent liés au développement de la cartographie et aussi à l'économie du pays.

Introduction

La plupart auteurs s'accordent sur le fait que le développement cartographique connaît un essor très différent selon le pays abordé (Figure 1). Il est complexe de vouloir comparer et caractériser le niveau de développement cartographique sous la base nationale car divers facteurs influencent à des degrés différents le bilan de santé cartographique (*'health cartography'* de Parry et Perkins). Selon la discipline interpellée et les besoins de l'étude certains aspects seront privilégiés. Ainsi dans le cadre de ce projet nous désirions pouvoir comparer le bilan cartographique de divers pays en fonction du volume de production mais aussi en considérant d'autres paramètres qui tiennent compte des périodes de production et des échelles disponibles. Il s'agissait en fait de prendre un cliché d'une situation pour un temps donné et de rendre le tout comparable.

Nous avons décidé qu'afin de formaliser un indice offrant un résultat sous une forme quantitative qu'un nombre réduit de paramètres devait être considéré. Le choix de ces derniers et les poids associés influencent directement la portée de l'indice. Nous croyons qu'il est préférable de réaliser plusieurs indices différents mais complémentaires, que de créer un seul indice qui aurait pour objet de vouloir tout expliquer globalement. En fait si l'indice intègre un nombre trop élevé de paramètres il deviendra difficile d'expliquer et dégager des tendances cohérentes.

Dans le cadre de ce projet nous avons donc considéré cinq paramètres, soit:

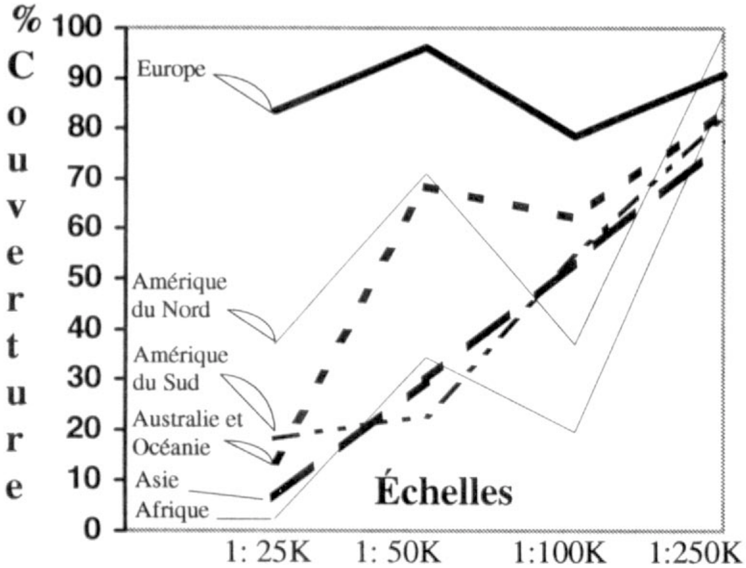

Figure 1: Répartition de la couverture cartographique à l'échelle continentale (en excluant la Russie) selon quatre familles d'échelles (d'après les données des NU, 1993).

le volume de production, les dates de production, la variation des échelles, le niveau de disponibilité des documents ainsi que le nombre de thèmes cartographiques abordés.

Méthodologie

Diverses étapes ont été nécessaires afin de développer l'IDC. Dans un premier temps un inventaire de la production cartographique a été réalisé. Cet inventaire repose au départ sur les travaux de Böhme 1991, Larsgaard 1993, Parry et Perkins 1987, IGN, OS, et de répertoires nationaux. Nous en avons donc analysé les textes et tableaux et avons extrait, sous la base du feuillet cartographique, le nombre de feuillets produits, l'échelle cartographique, la date de production, le thème abordé, les agences de production impliquées ainsi que le niveau d'accessibilité aux documents cartographiques. Ces données ont par la suite été transposées numériquement et intégrées dans une base de données.

Par la suite les données ont été traitées et analysées par différentes techniques dont l'Analyse en Composante principale (ACP), une méthode typologique (basée sur la concaténation d'éléments ordinaux) ainsi que selon une technique utilisant des poids relatifs.

Nous avons opté pour retenir une formule qui appose une priorité différente aux paramètres, des poids relatifs propres seront appliqués. Ainsi le volume de production compte pour 40% de la note finale, les périodes de production pour 30%, la variation des échelles 20%, la disponibilité des documents 5% tout comme le nombre de thématiques produites (disponibles selon l'inventaire réalisé).

Ceci se traduit par la formule suivante:

IDC = ((Superficie couverte*40%) +
(Périodes de production * 30%) +
(Variation des échelles *20%) +
(Disponibilité des documents * 5%) +
(Nombre de thématiques * 5%))

Tableau 1: Résultats issus de l'application de l'IDC.

Afrique	IDC		Amérique Latine et la Caraïbe	IDC
Congo	15,7		Nicaragua	11,2
Cameroun	15,7		Cuba	13,4
Somalie	17,9		El Salvador	14,6
Guinée Bissau	22,4		Argentine	27,0
Bénin	25,8		Honduras	37,1
Guinée Équatoriale	27,0		Grenade	40,4
Mozambique	27,0		Brésil	41,6
Niger	28,1		Paraguay	46,1
Madagascar	30,3		Haïti	48,3
Angola	33,7		Venezuela	50,6
Djibouti	37,0		Pérou	52,8
Éthiopie	40,4		Costa Rica	55,1
Mauritanie	41,6		Antigua-et-Barbuda	56,2
Mali	41,6		Chili	57,3
Côte d'Ivoire	41,6		Uruguay	59,6
Tchad	42,7		Barbade	60,8
Soudan	42,7		Jamaïque	61,8
Cap Vert	44,9		Bahamas	65,1
République Centrafricaine	47,1		Dominique	65,2
Tanzanie	47,2		Équateur	65,2
Gambie	48,3		Guatemala	65,2
Égypte	49,4		Panama	66,3
Sénégal	50,6		Trinité et Tobago	66,3
Comores	51,7		Colombie	73,0
Burkina Faso	52,0		République Dominicaine	73,0
Gabon	52,8		Mexique	73,0
République Démo. du Congo	53,9		Belize	74,2
Guinée	54,0		Bolivie	75,3
Nigeria	54,0		Guyana	77,5
Maroc	54,0		Sainte-Lucie	78,7
Liberia	58,4		Saint-Kitts et Nevis	78,7
Algérie	59,9		Suriname	84,3
Botswana	61,8		Saint-Vincent et Grenade	87,6
Tunisie	61,8			
Kenya	61,8			
Zambie	64,1			
Ouganda	65,2			
Sao Tomé et Principe	65,2			
Sierra Leone	65,2			
Namibie	65,2			
Ghana	67,4			
Zimbabwe	72,0			
Burundi	73,0			
Malawi	75,3,			
Swaziland	75,3			
Seychelles	78,6			
Togo	79,8			
Rwanda	84,3			
Lesotho	88,8			
Maurice Ile	88,8			
Afrique du Sud	89,8			

Résultats

Voici donc les résultats de la production de l'IDC pour les pays de l'Afrique, de l'Amérique Latine et de la Caraïbe (Tableau 1).

Les résultats obtenus à date permettent de constater une hétérogénéité du développement cartographique selon les pays abordés. À l'aide des traitements statistiques appliqués certaines tendances ont été distinguées et diverses causes y ont été précisées. Des éléments historiques, politiques, économiques, stratégiques, financiers, physiques et démographiques expliquent à des degrés divers les tendances rencontrées. Par exemple des corrélations très fortes ont été décelées entre le développement cartographique et les ressources minérales exploitées (particulièrement dans le cas de l'Afrique, voir colonne de droite du tableau 1). Pour d'autres pays il s'agit d'un lien étroit avec le dernier pays étranger impliqué (protectorat, époque coloniale, territoire occupé, etc.). De plus, certaines corrélations qui au départ semblaient quasi tautologiques ont été nuancées, par exemple entre le développement cartographique et la superficie du pays ou encore avec l'Indice de Développement Humain développé par le PNUD (PNUD, 1991).

Conclusion

Il nous apparaît complexe voire impossible d'identifier qu'une et une seule cause qui explique l'ensemble du niveau de développement cartographique. Il s'agit alors de regrouper les profils similaires et dégager les tendances qui apparaissent les plus probables. L'apport de l'IDC apparaît une approche méthodologique très valable afin de caractériser le développement cartographique d'une nation et ainsi permettre analyse et comparaison.

Dans le but de rendre accessible l'ensemble des informations intégrées et générées, un site Web est en cours de développement. Les communautés scientifiques, les agences d'aide internationale, les organismes nationaux et les entreprises privées pourront sous peu consulter interactivement (sous un mode graphique ou tabulaire) l'ensemble de la base de données. De plus le continent Asiatique est en cours de réalisation, ce dernier sera complété d'ici les prochains mois.

Bibliographie

Böhme, R. 1991. Inventory of wolrd topographic mapping., Angleterre: Elsevier Science Publishers Ltd, 520 pages.

Falconer, A., et G. Neuville. 1988. Data requirements and systems for the ERA sustainable development in Africa. Actes de colloque: International Symposium on Remote Sensing of Environment, 22nd Abidjan, p. 20-26.

Fanta, A. 1992. Mapping in Africa: constraints and prospects. ITC Journal, 1992, p.348-352.

Graft-Johnson, K.T. 1988. Les sources de données démographiques en Afrique. dans: État de la démographie africaine, édité par Van de Walfe, E., M.D., Sala Diakanda, et O. Ohadike, p.13-29.

Larsgaard, M. 1993. Topographic mapping of Africa, Antactica and Eurasia. Provo, Utah:Western Association of Map Libraries, 264 pages.

Leatherdale, J. 1992. Prospects for mapping and spatial information management in developing countries, ITC Journal, no. 4, p. 343-347.

Parry, R.B. et C.R. Perkins. 1987. World mapping Today. Toronto, Butterworths, 583 pages.

Session / Séance 18-B

PETIT - mapping across borders

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Abstract

Decision making on cross-border issues requires accessible, compatible, useable and relevant geographic information. The lack of data, at appropriate level and in appropriate formats, has been seen to be a significant barrier to more rapid growth of the European GI market. The need for cross-border data has been addressed by many bodies and the development of global policies is progressing through the discussion of GSDI. In Europe the Commission of the European Communities (CEC) has been actively working to promote the topic over the last few years. Background information is described in the official policy document "GI2000: Towards a European Policy Framework for Geographic Information"[EC, GI2000 1997].

The PETIT (Pathfinder towards a European Topographical Information Template) project is a feasibility study supported by INFO2000 [EC, INFO2000 1994-7] into the establishment of a consistent pan-European topographical base dataset at the scale 1:250 000. The purpose of PETIT is to achieve an understanding of the user requirements, production flow and resources required in producing pan-European base data for civilian use. At the end of the project (September 1999) a business case will have been prepared.

Introduction

High-level decision-making at pan-European level requires accessible, compatible, useable and relevant geographic information. Organisations needing pan-European base data must consider many technical and licensing/supply aspects before they can proceed with their requirements. On the technical side the most common problem today is that of suppliers failing to meet users demands for consistent data. The basic requirement for edge-matched data across national boundaries in a common standard is not fulfilled. Furthermore the problems of the available scale, inconsistent accuracy and detail, poor matching of data from different sources, out-of-date data, lack of metadata and inconsistencies in feature and attribute representation are still to be overcome. The present situation ultimately is inefficient and ineffective, with cost, time and resource implications for potential users. This severely limits the scope of the geographic information market and hinders its development.

PETIT is studying the feasibility of creating a pan-European topographical base dataset. It hopes to achieve an understanding of user requirements, identify individual national data characteristics, resolve technical problems and examine licensing and supply issues. A consistent and maintained base data with single source supply and simplified licensing agreements is the objective, satisfying the spatial reference needs of a European Geographical Information Infrastructure (EGII).

Pan-European Cooperation

CERCO Comité Européen des Responsables de la Cartographie Officielle (Association of European National Mapping Agencies) was founded in 1980 with its main goal defined as: "Mutual information, consultation and co-operation in the field of cartography as defined by the United Nations, with the exception of military mapping and hydrography". It is recognised as the first main pan-European association concerning GI/spatial data and now has more than 30 members across Europe. CERCO also has a significant impact on standards development and access to cartographic data across borders, via its commercial marketing division MEGRIN (Multipurpose European Ground Related Information Network) created in June 1993.

Since its inception, MEGRIN has been working actively for the establishment of quality pan-European datasets and easier access to European national datasets. MEGRIN has also been participating in standardisation and interoperability initiatives at European and global level and has created one of the few truly regional, cross-border spatial data products in Europe - SABE, the Seamless Administrative Boundaries for Europe geographic database.

Information Infrastructure

All European countries have made substantial investments in building national base-maps, which are still the basis on which most modern GI (analogue and digital) is constructed. Europe needs an infrastructure which can be used by all sectors of activities dealing with geo-referenced data and allows those sectors to act and communicate more efficiently, more rapidly, at a lower cost. Building this European Geographical Information Infrastructure (EGII) is a long term issue which needs planning, resources and commitment, composed as it is of various aspects, including institutional frameworks, technical standards, technological frameworks and fundamental datasets [EC GI2000, 1997].

The most significant factor behind the drive for an EGII is the need for European governments and businesses to carry out proper spatial analyses, many of which cross national boundaries. Important areas where GI technology is providing new opportunities include critical trans-national areas, those areas or regions that are shared or affected by several countries, yet must be managed as a whole (see Table 1). Clearly, for these situations it is essential to have shared spatial databases of known quality for major utility networks (oil, gas, water, electricity, telecommunications), defence, transport, marketing, environment and resources (geology, water, soil, renewable energy resources), health care and emergencies, product development and training. [Burrough, 1997]

Table 1. European trans-border regions

	Region	*Countries*
1	The Baltic Sea	Countries with land within the Baltic Sea catchment include Denmark, Sweden, Norway, Finland, Russia, Estonia, Latvia, Lithuania, Czech Republic, Slovakia, Ukraine, Belarus, Germany, Poland.
2	The Rhine	Germany, Switzerland, France, Belgium, Luxembourg, Netherlands
3	The Meuse	France, Belgium, The Netherlands, Luxembourg
4	The Ruhr complex	Germany, Netherlands, Belgium
5	Mediterranean Coastal strip	Italy, France, Spain
6	The Alps	France, Germany, Austria, Switzerland, Italy, (Slovenia).
7	The North Sea	United Kingdom, Norway, Denmark, France, Belgium, The Netherlands, Germany, Sweden.
8	The Nordkap region	Norway, Sweden, Finland, Russia
9	The northeast Atlantic	Portugal, Spain, France, Ireland, United Kingdom,
10	Paris-Brussels region	France, Belgium.
11	Southern Scandinavia	Denmark, Sweden, (Germany, Norway).
12	The Pyrenees	France, Spain.
13	Southern alpine industry	France, Switzerland, Italy (Lyon - Geneva - Milan).

GSDI and ESDI - Views on Interoperability and Spatial Data Infrastructures in Europe Abstract. PETER A. BURROUGH, Utrecht

The EGII concept is based on having data accessible through a basic GI infrastructure, an infrastructure that is no longer inhibited by technical constraints. Identified constraints include data availability, price, quality and technical structure of the data, and legal aspects of data supply such as Intellectual Property Rights (IPR). The key issue is to provide a broad, readily available, high quality platform of base data within a uniform infrastructure across Europe. Fundamental to the development of the required datasets are common spatial reference systems, common technical standards, common policies on data access and use, and common approaches to metadata and data directories. In one corner of the EGII a significant international initiative in establishing a general topographic template, the NATO supported VMap production, is currently underway.

PETIT

PETIT - the Pathfinder - is a feasibility study with the basic aim of giving concrete directions for the creation of a pan-European topographical information template. Co-ordinated by MEGRIN, the purpose of PETIT is to determine the feasibility of using VMap to produce pan-European topographical base data for civilian use, determine user requirements and estimate the production resources required. When the project is finished all elements necessary to establish a business case will be present. The Project is divided into two main phases: The definition phase, which was completed in Spring 1997 and the present phase, the implementation phase. The main results from the definition phase are documented in the final report, which can be reviewed on the MEGRIN website [MEGRIN, PETIT 1997].

The definition phase clearly demonstrated that there is a need for a medium-scale base map covering the whole of Europe. On the basis of the findings from the definition phase, objectives for the implementation phase were defined.

PETIT Objectives

The objectives of the implementation phase are to:

- Create a prototype from VMap data.
- Create a Web demonstrator for the prototype data, to reach a wide audience.
- Assess the market and determine user requirements.
- Create a common set of specifications for the product.
- Estimate required resources to produce the dataset.
- Identify obstacles and recommend solutions for related copyright and IPR issues.
- Produce a business case.
- Create marketing and distribution plans.

The implementation phase has a duration of 20 months, finishing in September 1999.

PETIT source data

The National Imagery and Mapping Agency (NIMA) was established in the US in 1996. NIMA's VMap Level 1 program is designed to provide worldwide vector-based geospatial data at medium resolution. Data are separated into 10 thematic layers, each layer containing thematically consistent data with a reference library provided with general information to orient the user. All data are topologically structured by layer, each coverage containing a set of files that describe the features in that thematic layer. [NIMA, 1999]. The production of

VMap is done on a country by country basis and edgematched at borders. The dataset is expected to cover the Earth by 2005. VMap also contains metadata describing the origin of the data and quality parameters.

The basis on which VMap is produced depends on the availability of existing topographical mapping in a given country. As an example, Germany is producing VMap data by digitising Joint Operations Graphic (JOG) [NIMA JOG, 1999] map-sheets, while France extracts data from their national databases on to a tile-based system. Other national specifics in the data model and content exist because of:

- Original data structure e.g. colinearity between layers, portrayal of flight obstacles, contour line intervals,
- Initial VMap specification did not define all details in the data model and content. Hence different data producers applied different approaches,
- VMap concept allows the name attribute, text attribute and text features for portrayal of information that cannot be portrayed by other means. Thus the usage differs among data producers,
- Different production systems used constrained the content of some national contributions.

Prototype

The PETIT prototype dataset is based on VMap Level 1 [NIMA, 1995]. Being aware of the national specifics in VMap1 content originating from the different sources, the PETIT Consortium initially wanted to limit the prototype specification to the maximum common content. However it has been decided to allow the dataset to contain features, which are not supported by all countries. This is being used in the user evaluation to determine user requirements and required changes and enhancements of the data set. The data model of the PETIT prototype is based on the ESRI Arc/Info implementation of VMap, as defined in the VMap Data Dictionary.

The prototype contains approximately 110 feature types with a multiplicity of attributes. The feature types are classified into the following layers: Boundaries, Elevation, Hydrography, Industry, Physiography, Population, Transport, Utilities and Vegetation. As with VMap, each layer contains thematically consistent data, all data topologically structured within each layer. The prototype includes parts of Belgium, The Netherlands, Germany and Luxembourg. For the prototype harmonisation the original aim had been to wait until the VMap production had reached a stage where data had been checked and validated with edge-matching completed. However, due to VMap production difficulties, some edge-matching has had to be performed within MEGRIN. It is anticipated that by the time the PETIT product is being produced, VMap production will be advanced in major parts of Europe, consequently reducing harmonisation efforts substantially.

A PETIT WWW application has been developed containing basic functions such as; map contents, zoom and pan commands, objects selection, distances measuring and more specialised functions like; network analysis and thematic mapping. This will give the opportunity to make the sample prototype data available to a very large international user-base and also gives the opportunity to evaluate the suitability of the data for use in the WWW environment. With this application users are able to view a part of the prototype area containing all features and attributes of the prototype (see http://www.megrin.org/webpetit/default.htm).

Prototype user evaluation

A key to understanding user requirements is providing a prototype, which can be evaluated in the users own environment. During the implementation phase, prototype evaluation is being undertaken in a representative cross-section of industry sectors across Europe. The user-testing plan requires investigation of a wide range of issues, among a diverse and geographically spread base of potential respondents. The aim is to produce the most reliable results possible within the constraints of the project. This is being achieved by using a combination of research methodologies involving overlapping stages of desk research, telephone interviews, research via a WWW questionnaire and in-depth interviews. The objectives of the research are to understand the market requirements for a pan-European data product with regard to product specification, pricing/

licensing and packaging/documentation. The WWW application invites user contributions and feedback will be used in the final product evaluation. The results of the user evaluation will lead to the preparation of a product specification that is sufficiently detailed to allow for both the accurate costing of production and for the preparation of a technical production plan setting out the processes and production schedules.

Technical evaluation

The technical evaluation of the product specification will give a clear picture of user requirements for data formats, data structure, data currency, variety of features, feature representation and compatibility with other datasets. Already, certain elements have been identified which must be resolved before a PETIT product reaches production. These include:

- Geometric and toplogic consistency between layers not supported by all producers.
- Cartographic names having inconsistent representation.
- Road interchanges, bridges and tunnels with different national representations. For example, many but not all National Mapping Agencies (NMAs) represent interchanges as nodes. Bridges and tunnels may be portrayed as lines or nodes. Criteria for representing tunnels varies between NMAs.
- Generalisation parameters vary between producers and from feature to feature. Examples include national generalisation of railway lines and density of contours shown in particular areas.
- Boundary displacement, either at tile or international boundaries (see Figure 1).
- Portrayal criteria and classification of features different between producers. Examples include river and road classification. Some countries classify rivers by navigability while others classify by width.
- Vertical and horizontal co-ordinate reference systems differ.
- Differing sources and interpolation procedures used for isolines (see Figure 2).
- Lack of connectivity in river networks, particularly in flatland areas.
- Currency and variety of data sources. Almost 50 % of VMap data suppliers source all or part of their information from analogue Joint Operations Graphic (JOG) maps.
- Attributes to multiple polygons. In cases where an area type feature is split into several polygons, for example a town with scattered suburbs, attributes are treated differently by different producers.
- Multiple names have inconsistent rules applied when more than one text string has to be assigned to features, for example roads with two designations or built-up areas with names in two or more official languages.

Legal issues

The legal implications of a project like PETIT are extensive and many issues have to be addressed. By its nature VMap data has a complex production history with associated ownership complications. A general study was undertaken in the definition phase to better understand the legal issues and problems, which may exist using VMap data for the development of a pan-European topographical information template. The issue was

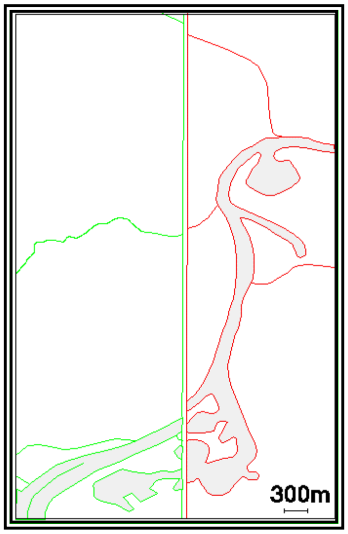

Figure 1. Displacement at tile boundary

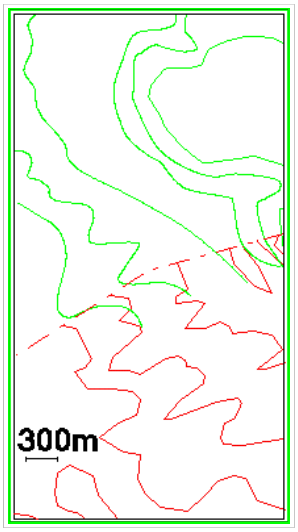

Figure 2. Border Isoline

addressed by sending a questionnaire to European NMAs regarding their involvement in the VMap production. From the answers a more detailed study of the issues has been carried out since there are clear differences between countries in policy, attitudes and understanding of the legal position in respect of exploitation of the VMap product's IPR.

The complexity of the different laws in Europe is a hindrance to the establishment of pan-European datasets. It makes it unclear for the IPR holders as to what extent they are protected, and it makes it difficult to make clear licence agreements. In previous legal investigations [Eechoud, M.M.M van, EUROGI, 1997] it has been pointed out that copyright legislation and neighbouring law in the European countries differ as to what level of protection they provide for maps or datasets. Copyright protection is regulated by international agreements but within Europe there are two distinct groupings, the common law countries (Ireland and UK) and the civil law countries (mainland Europe). Differences emerge in the application and interpretation of copyright within and between these groupings, causing much uncertainty. Ownership of the data, how it was achieved - either by assignment through contract or authorship or statute - has direct implications for onward licensing [PETIT, WP2 March 1999].

Protection afforded by the EC Database Directive [EC, March 1996] is seen as relevant and appears to protect the PETIT prototype data. However, no definitive case has been brought under this directive or its national implementations. The fact that PETIT is pan-European and is anticipated to be widely available at a 'market price' leads to questions other than IPR. Within the EC, Articles 85, 86 and 90 of the Treaty of Rome apply within the context of Competition Law.

The international nature of the project, together with the involvement of NMA and military organisations in many countries, creates a complicated scenario. NMAs often have limited knowledge of the situation concerning their country because they are not involved; the data being produced in another country under agreement from the military survey. Interim project results indicate that many countries are unclear who owns the IPR while others have no ownership of the copyright in VMap.

European NMAs with the rights to VMap data are shown shaded (see Figure 3). Only 6 countries have full rights to the final Vector Product Format (VPF) [NIMA VPF, 1999] data for civilian purposes (see Figure 3, dark shading).

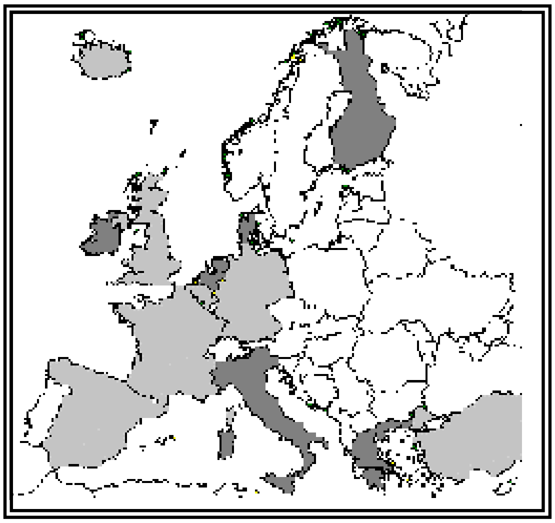

Figure 3. NMAs rights to use VMap

User market

Notwithstanding the technical and legal issues, the success of a pan-European topographical database clearly requires an understanding of the user market. Without such an assessment it would be difficult, if not impossible, to design, plan and successfully market the resulting product. Any future PETIT product must be based on identified user needs. Since no other product is currently available at the scale of 1:250 000 with full European coverage, direct market assessment of the likely take up and use of such data is difficult.

An initial assessment of market sectors was conducted prior to the definition phase of the PETIT project. These included:

International organisations - Such as the European Commission, the United Nations, OECD, etc.

Multinational organisations - Such as retailing, banking, insurance, transport, logistic and telecommunications.

Local governments - Stimulated by the Euroregion initiatives, many of these are considering cross-border GIS.

Consumer market - For use with personal computers, either professionally or privately.

Educational sector - For geography as a discipline and also socio-economic, environmental and medical areas.

As far as the geographical extent of datasets is concerned, the market for geographic information can also be divided into three sectors: The pan-European market which corresponds to datasets covering several entire countries, the cross-border market which is concerned with cross-border areas and the markets for national data. PETIT is primarily concerned with the first two markets. The national market may marginally be influenced by the existence of PETIT.

Product pricing, packaging and distribution are all elements being investigated. Issues being addressed include single and multi-user pricing, update pricing, maintenance contracts, perpetual or annual pricing, Internet licensing, units of supply, packaging, documentation and distribution methods. Given the critical nature of these licensing, pricing and distribution issues to the success of the product, a complete workpackage has been devoted to dealing with these issues.

Conclusion

Currently, a potential requirement for pan-European or cross-border data demands dealing with several NMAs and/or private companies. This is a very time-consuming process, locating appropriate suppliers, negotiating arrangements and licences with individual suppliers separately and finally integrating the datasets. These datasets may be incompatible, with variable content specification, quality, metadata, reference systems etc. Assuming this has been achieved successfully, the problems of data maintenance, licensing and copyright issues still have to be resolved.

Ultimately, the PETIT project is expected to stimulate the European geographic information industry and NMAs in particular, by identifying the prerequisites for European-wide high-quality base data. This is expected to promote initiatives, which will provide new opportunities for businesses in the information market. The project will furthermore aim at simplifying the present organisational and operational infrastructure hindering exploitation of European GI, through the development of standardised agreements for the distribution of PETIT. A future PETIT product - a harmonised and integrated pan-European vector dataset - is expected to be the reference for many other datasets and thereby promote interoperability in European GI.

The present conclusions still support the use of VMap as a basis for producing a Pan-European topographical database. A primary issue exists in the relations between the NMAs and their military colleagues in each country. The legal position of the NMAs with respect to copyright of the VMap data, and the resulting rights to use VMap for civilian and commercial applications is still unclear, and seems to be a key to exploitation of the data.

The definition phase Business Plan identified the need for additional funding before PETIT production could commence. An obvious partner and possible sponsor in that venture would be the European Commission. The present GI2000 discussions do not suggest very strong support. Therefore political actions must be taken to convince the Commission to be more supportive in this matter. If EC funding cannot be secured before the end of 1999, CERCO/MEGRIN members must be prepared to find alternative sources of funding.

Funding by the EC and/or the NMAs must be based on clearly established objectives, weighing the advantages of a homogenised pan-European topographical dataset against the considerable cost and resource requirements. This question of funding must be answered before any production can commence.

References

Burrough, P. et al. *Geographic Information: The European dimension*. Position Statement from the European Science Foundation's GISDATA Scientific Programme, February 1997. http://www.shef.ac.uk/uni/academic/D-H/gis/policy.html

Burrough, P.(Utrecht) *GSDI and ESDI - Views on Interoperability and Spatial Data Infrastructures in Europe* Abstract.

Eechoud,M.M.M van, EUROGI, *Legal protection of geographic information*, June 1997. http://www.geog.uu.nl/eurogi/forum/legrpt2.html

European Commission (DG XIII/E), *GI2000 Towards a European Policy Framework for Geographic Information*, 1997. http://www.echo.lu/gi/gi2000/en/gi2000dd.html

European Commission (DG XIII/E), *INFO2000 Programme, 4-year Work Programme* 1996-1999 http://www2.echo.lu/info2000/en/infowkpg.html

Luzet et al., *A First Answer to the needs for a Seamless European GI Infrastructure, EC GIS Conference 1998*

Eggers, O. PETIT - the pan-European solution MEGRIN, GIS Planet 1998

NIMA JOG, 1999 Joint Operations Graphic http://164.214.2.59/gic/products/jog.html

NIMA, *Specification for VMap Level 1*, (June 1995) http://www.nima.mil/publications/specs/printed/VMAP1/vmap1.html

NIMA Vmap Level 1 (1999) http://164.214.2.54/guides/dtf/vmap1.html

NIMA VPF, 1999 Vector Product Format http://164.214.2.59/vpfproto/index.htm

PETIT Consortium, *Definition Phase Final Report, INFO2000 Project, INFMM3035-PETIT*, August 1997 http://www.megrin.org/petit/report.htm

PETIT Consortium, *Final Report on Prototype Creation IMP/3035/WP3/MEG/014*, January 1999

PETIT Consortium *Final Report WP2 IMP/30335/WP2/OS/010*, March 1999

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Geoinformational Mapping

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Definition

Geoinformational mapping (GM) is defined as automated map making and map using based on GIS and cartographic databases and bases of knowledge. The informational and cartographic modeling of geosystems is the essence of GM.

As any other form of mapping GM may be branch and complex, analytical and synthetical. According to the presently accepted classifications it may be subdivided into several kinds (for example social and economic GM, environmental GM, etc.) and types (inventory, evaluation and so on). GM may be also divided on the basis of spatial coverage, scale, map functions, degree of synthesis etc.

The Features

Among the characteristic properties of GM suggesting testify the principally new level of mapping the most important are as follows:

- the high degree of automation, wide application of the cartographic digital databases and bases of geographical (geological, ecological etc.) knowledge;
- the system approach to geosystems mapping and analysis;
- the interactive mapping ensuring the close interrelations between map compilation and map use techniques;
- the operational efficiency close to the real time scale with the widespread use of remote sensing data;
- the multivariation of mapping which allows the diversified assessments of situations and a spectrum of alternative decisions;
- the multimedia mode which admits the iconic, text and audio combinations;
- the new graphics and design application;
- the creation of new kinds of geoimages (electronic maps, 3D computer models and animations, iconomaps and so on);
- the predominantly problem-oriented mapping focused (?) on decision making.

The young line has been built up not at once and not at blank. GM integrates a large variety of modern cartography branches bringing them to a new technological level. The origination and development of GM is a further evolution of complex, synthetic and, after all, – system mapping in the new geoinformational environment. GM was formed at the crossing point of computer cartography, GIS-technology, cartographic method of research, and remote sensing in its broad sense including image interpretation and digital photogrammetry. In the present state of the art GM is progressively becoming the main trend of cartography as the science and the production.

Spatial Levels of Mapping

The spatial levels and relevant scales of mapping could be divided into several groups:

- Global level – 1:10, 000, 000 – 1:45, 000, 000;
- National level – 1:2, 500, 000 – 1:20, 000, 000;
- Regional level (large natural and economic regions) – 1:500, 000 – 1:4, 000, 000;
- Local level (districts, national parks, crisis areas etc.) – 1:50, 000 – 1:1, 000, 000;
- Municipal level (towns, suburbs areas) – 1:1, 000, 000 and larger.

Practical Applications

It is not possible to give an exhaustive list of all fields of GM application. It was correctly stated that all spheres «from geology to ideology» are open to GM. Geoinformation presented in the cartographic form has come nowadays among the expensive goods and the important resources which give the chance to optimize the mode of life, environmental conditions, the politics, etc.

We are in a position to state the most actual lines of GM application:

- the prospecting and management of natural fossils;
- planning of industry, agriculture, transport, energetics, finances and
- others branches of national economy;
- development of communications and electronic nets;
- the complex and branch cadastre support;
- monitoring of environmental situation and natural risks, the environmental impact assessment, the support of ecological security and stability, ecological inspection and so on;
- the living standard, business activity, public health, recreation and
- social service control;
- the activity of legislative bodies, executive authorities, political parties, mass media provision;
- the law machinery and natural security support;
- the education and culture development;
- the scientific investigations and prognosis maintenance.

This means that the GM application covers all aspects of nature and society life and their interactions. The totality of experience reveals that many economic losses, environmental crises and political lapses may be associated with deficient and inadequate geoinformation including cartographic one.

Geographical Basis of GM

It becomes more and more obvious that the geographic basis of GM does not keep pace with the progress of hardware and software and informational support of GM. However it is of primary importance that cartographers and geographers focus their attention on the geographical foundation of GIS-technologies and GM. Nobody else is capable to perform this work.

There are two fundamental points:

- experience of multipurpose geographical investigations;
- experience of system thematic mapping and, particularly, atlas compilation.

The wide set of techniques of geosystem analysis has been elaborated which applicable for GIS-technologies. These techniques include methods of spatial and temporal simulation of phenomena structure, dynamic, interrelations and functioning. Simulation is indissolubly related to differentiation and integration of phenomena, zoning and classification of territory, structural and typological analysis, revealing of the principal factors of processes development – all adding up to overlay, trend analysis, spatial correlations, clustering and other GIS-technologies.

The fundamentals of geographical interpolation and extrapolation, methods of case studies, principles of combination and optimization of information sources, i. e. maps, images, field data, statistics – are the major methodological achievements that are very useful in many GIS applications. And widespread methods of geographical indication are particularly promising for GM and GIS technologies.

There are a lot of common features in geographical atlases as system cartographic products and GIS. Traditional and electronic atlases were often the wherever possible progenitors of GIS. The inner integrity and complexity of atlases are guaranteed by the following prerequisites:

- the suitable selection and limited number of map compositions and scales (preferably, multiple ones);
- the common geographical basis and base maps;
- the coherency of legends, descriptive data and graduations;
- the common degree of generalization and rates of selection of map content, wherever possible;
- the unity of map design;
- the synchronism of map elements.

At the way of GIS designing and making all these rules remain in force and the most important and complicated of them is the provision of strict geographical coherency of thematic layers which controls the reliability of GIS and credibility of decision-making.

The Operative Mapping

This is a branch of GM, which means the real-time map making and map use with the goal of rapid (timely) putting the user in the picture and control of the process.

The operative maps are designed for solving a large spectrum of problems, and first of all, for the inventory, prevention of natural risk or disasters, their monitoring and control, development of recommendations and prognoses, choice of alternative ways of monitoring, stabilization or modification for a variety of events – from environmental to political ones.

In the last few years not only the structure of phenomena but the dynamic nature of processes in the Earth's crust, atmosphere, hydrosphere, biosphere and their contact zones have become the subject of particular interest. And the dynamic GM was found to be the most effective tool of their study.

Animations

The development of peculiar dynamic sequences of maps (images, scenes), i. e. cartographic animations providing for moving or multiplication effect brings into existence a new form of representation of geosystem dynamics. The modern software involved the sets of modules that allows different animation modes and combinations:

- displacement of cartographic picture over the screen;
- temporal sequences of maps and 3D representations;
- change in the exposition rate, frame by frame viewing, the recurrence to a certain frame, reverse motion;
- moving of different map elements (objects or sings);
- presentation of changes of different map elements (objects or signs), their form, size, orientations, signs blinking, topological transformations and so on;
- color variation (pulsation or defilation), saturation changing, color oscillation effect;
- modification of ground-color illumination, lighting and shading of particular of map;
- panning, transformation of projection, aspect, point of visibility, rotation of 3D pictures;
- scaling (zoom in or zoom out) of the whole image or its part;
- effect of flying over the map with different velocities.

For the purpose of cartographic animations and movies special temporal scales can be used, for example:

1: 86,000 means that 1 second of demo corresponds (approximately) to one 24-hour day;

1: 600,000 means approximately 1 second :1 week;

1:2,500,000 means 1 second : 1 mouth;

1:31,500,000 means 1 second : 1 year

Therefore one can define slow-, medium-, and fast-scale cartographic animations and movies.

GM and Telecommunication Networks

The 18th ICA International Cartographic Conference which was held in Stockholm, 1997 has made it apparent that mapping and notably thematic one was brought to the new level and its prospects are associated with computer networks.

All geoimages currently available in Internet could be divided into four groups:

- static geoimages - the maps, atlases deduced from digitalization or images incoming in digital form;
- interactive geoimages compiled and updated on user's requests;
- animations, movies and multimedia;
- GIS geoimages.

The static maps and images are the most widespread considering that siting the color map into Internet is much cheaper that its edition. The general maps, weather charts, maps for navigation and traffic, satellite maps of environmental conditions and hazards, maps of political events and «hot» points, tourism and recreation are the most frequent among Internet cartographic documents. Among them the education maps form a distinctive group.

It is commonly to point the chance of atlas publishing in Internet and first of all of national atlases. In this way the actualization of information and a peculiar kind of monitoring was rendered possible and it means in reality the establishing of the national information system.

The superfluity of information is a severe problem for Internet users, then a vital issue is the creation of convenient and user-friendly navigators for computer network. Virtual atlases that are created in line with the fixed WWW system may be considered as an appropriate user interface for working with the Internet maps and other geoimages. Virtual atlases are capable to support the user access to spatial data of different levels - from general global to small areas.

In Russia the commencement of the computer networks elaboration falls on the 80th and now comparatively developed academic networks have been formed with the regional centers in Moscow, St. Petersburgh, Ekaterinburg, Novosibirsk and Khabarovsk. They follow TCP/IP protocol and have the outcomes to Internet. And it should be stressed that these centers are in complete agreement with the location of regional geoinformational centers created by Federal Service of Geodesy and Cartography of Russia (Roscartography). This is no surprise because these big towns are just the main economic, cultural and academic centers of Russia. In process of creating the national GIS-infrastructure and GM development it is particularly promising to attain such correspondence at regional, local and municipal levels.

Mapping of Networks

The computer networks open the new possibilities for mapping and at the same time they need the cartographic representation. Here, we are dealing with a new branch of cartography that falls at the intersection of mapping of communications, public services, science, and international cooperation and division of labor.

The subjects for mapping are highly diversified and covers the inventory, evaluation and prospects of networks development. The maps can present the location of lines and centers of telecommunication, the network infrastructure, traffic, the capacity and loading, the operation statistics, the network environment, and geographic peculiarities in network configuration and density. Here, the mapping of telecommunications is a mean for networks optimization. For example, several map sets of Russian academic networks at national (Russia), municipal (Moscow) and local (Moscow University campus) levels have been recently compiled.

GM, GIS and telecommunication have many domains for cooperation, and in any case cartography is not running into the danger to be taken up by Internet.

Changes in Cartography

The new theoretical conception was evolved from geoinformatics basis. Now ***cartography can be considered as a science dealing with the system informational and cartographic simulation and cognition of geosystems***, and ***map – as an imaginative and sign geoinformational model of reality.*** Geoinformational concept integrates two views on the nature of map: on the one hand — as a model of reality with unique heuristic potential, and on the other – as a tool for accumulation, transformation and communication of spatial and temporal data.

Many branches of cartography experience a profound reconstruction now. This is especially true for technology of map compiling and map use, the distinction between them diminishing progressively. The choice of projections and cartometric measurements have become the simple technical operations. At the same time the new branches, such as digital cartography, database making, global spatial positioning and other, have evolved.

The is a great deal of evidence that cartography and geoinformatics are deeply intertwined in the state and international organizations, scientific editions and conferences, professional education and training, terms and definitions.

New Geoimages

Many new maps, iconomaps, electronic block-diagrams, cartographic animations, composites, holograms and other geoimages have became usual and this is the major outcome of GM development. A new term *geoimage* (or georepresentation) we can define as any spatial-temporal generalized model of terrestrial (planetary) objects of processes which has a scale and is presented in graphic patterns. Major properties common to all geoimages - scale, generalization and presence of graphic elements (signs, patterns) - are highlighted by this definition. Currently 3 classes of geoimages are distinguished:

- plane or 2D (and 2.5D) geoimages: maps, electronic maps, scanner,
- radar, TV imagery, etc.;
- volumetric or 3D images: stereomodels, anaglyphs, block diagrams,
- holograms, etc.;
- dynamic 3D or 4D images: animations, motions, computer films, movies atlases, etc.

Within each of these classes there are dozens of variations: maps having various contents, photos in different spectral bands, 3D models of different foreshortening. Besides there are many combined images characterized by features of different classes and types, such as photomaps and ortophotomaps, iconomaps, TV photographs, display stereophotographic models and anaglyphs, TV holograms and others. And many complex graphic models which combine to varying degree properties of maps, photos, 3D and dynamic models are of considerably current use. It seems worthwhile to introduce a new term *hypergeoimages* (or, shortly, *hyperimages*) for them.

The use of various geoimages (especially in GIS environment) requires studying their advantages and shortcomings, as well as a possibility of combined use and techniques permitting to gain qualitative and quantitative information. This favors elaboration of *a new branch of science - geoiconics*, as a synthetic discipline representing the theory of geoimages and methods of their analysis, transformation, recognition, perception and application for scientific and practical purposes. The rise of geoiconics linking cartography, remote sensing and computer graphics can also be regarded as a major result of GM development.

Geoinformational Education

In 1995 the State Committee of the Russian Federation for Higher Education has approved the State Education Standard for the higher professional training in the *informatics*. On this basis the requirements for training the specialists in *geoinformational systems* have been elaborated.

According to the Standard among the objects of professional activities of the specialist in geoinformatics are the geographical information systems and networks, their program and information support, methods and techniques of their design and operation.

If one summarizes the Russian and the foreign experience, it becomes obvious that at present there are at least 4 models of geoinformation training focused on different problems, namely:

- technical and applied aspects of GIS design and operation;
- digital topographic and thematic mapping;
- integration of GIS-technologies with remote sensing;
- wide cooperation with geographical and cartographic disciplines,

Earth's sciences and related social and economic sciences.

There are the following blocks of disciplines in the resulting model of optimal training in geoinformatics and GIS which is applied in Russian universities and based on the experience and traditions of the Russian cartographic and geodetic school:

- Introduction to GIS;
- Basics of computer graphics;
- Databases and knowledge bases;

- Geoinformational mapping;
- Mathematical simulation and map using;
- GIS designing;
- GIS application.

High professionals in the sphere of GIS and GM are trained at 7 Russian universities, namely Moscow, St.Petersburg, Irkutsk, Izhevsk, Saransk, Tver', Saratov, as well as at the Moscow University of Geodesy and Cartography (former MIIGAIK). Other universities, such as Altai, Voronezh, Kazan, Perm', are actively introducing the GM. Methodological coordination of the geoinformational education is provided by the Teaching and Methodological Association of Russian Universities with its center at the MSU.

None Can't Provide...

Electronic maps and atlases do not smell now of printer's ink, but twinkle with bright signs from the screen and change their colors according to user's option and feeling. It is quite possible that In a short way the cartographic holograms will give the illusion of real terrain, animations will allow us to fly across it, and computer landscapes will reduce almost all distinctions between map and painting. It seems reasonable to say that the map of future will be an complex ***Intelligent geoimage*** integrating the multi sources information in real time, with 3D or 4D variable scale and spatial-temporal resolution.

But the attempts to forecast the physiognomy of GM products in the distant future are doomed to failure, because the prognosis of this sort can not overcome the level of straightforward extrapolation. This is no question that scientific headway will present us something radically new, unseen and unpredictable.

At the confines of millenniums cartography is subjected to a painful but irreversible transformation. It is therefore vital to keep the orientation and not to destroy the former cartography having no time to create a new one and not to devaluate the great art of map compiling while sinking into technocratic digital chaos. How can we escape this distress? The recipe is not new: GM should be based upon the fundamentals of geographical cartography.

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Session / Séance 21-D

The tendencies of developing the geoinformation system for bodies of state authority in Russia and CIS

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Nowadays the great attention is given to questions of creation of the spatial databases infrastructure at the national and international levels. In 1994 the Decree of the President of USA about a national infrastructure of the spatial data was signed, the similar works are conducted in the European community.

In Russia since 1995 developing the geoinformation system for bodies of state authority (GIS OGV) is conducted. The creation of GIS OGV will speed up supplying the bodies of state authority of Russian Federation by the urgent, authentic, complex information for an operative estimation of conditions and supporting making administrative decisions in the field of economy, finance, ecology, agriculture , industry etc.

In 1997 the Concept of developing the geoinformation system of the states - participants of the Community of Independent States (CIS) was developed. According to this concept National Mapping Agenciess as the responsible holders of the base geographical information on their territory should be the main coordinators of departmental information flows and integrating parts of a state geoinformation infrastructure. The concept determines that realization of coordinated geoinformation policy should provide:

- development and coordination of the standards in the field of GIS-technologies and formation of uniform normative base;
- development of legislative support for creation and functioning of a geoinformation infrastructure;
- development and realization of uniform policy in the field of a technical, program and information supply, and also policy of information exchange at an interstate level;
- development and coordination of the requirements to the contents and quality of the geoinformation, its control and guarantees;
- development of certification system and maintenance state digital cartographic and thematic databases in up-dated forms etc.

The subjects of Russian Federation are interested in creation of geoinformation systems for regional bodies of state authority very much also. The Federal Service of Geodesy and Cartography of Russia signed the agreements with administrations of 21 subjects of Russian Federation on GIS developing. The special importance by the subjects of Russian Federation is given to creation of a uniform basis , databases with the ecological information and databases under the real estate . The financing of these works is supposed to be carried out on the parity conditions.

Session / Séance 33-C

The New Israeli Regulations for Surveying and Mapping: Standardization of Digital Cartography

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Abstract

The government of Israel, through the Survey of Israel, periodically publishes regulations for surveying and mapping. All surveying activities should be performed according to these regulations. The latest version of these regulations was published in June 1998.

The regulations are concerned with several aspects of mapping activities. The core three chapters cover geodetic control, topographic mapping and cadastral surveying. All three are related to the state-of-the-art of instrumentation and technology. This paper deals mainly with the topographic mapping aspect, with respect to its impact on digital cartography in Israel.

The topographic mapping chapter of the regulations presents several new aspects of modern digital mapping. These are mainly aimed at standardizing the use of modern instrumentation, the working methods and the digital cartographic products. Mapping equipment, especially photogrammetric instrumentation, is categorized into levels of accuracy and resolution. Digital Elevation Models are classified into accuracy levels and are linked to the map-scale. An orthophoto is recognized, for the first time, as a mapping product and is graded according to the sources of information and production methods. Finally, the use of digital mapping in general and its link to the Geographical Information Systems environment in particular are specified.

Introduction

The Survey of Israel (SOI) is the governmental agency responsible for geodesy, topographic and cadastral mapping and the National Geographic Information System, as well as for licensing and instructing the geodetic and mapping professionals in Israel. These responsibilities were basically determined by the Survey Ordnance, published in 1929 during the British mandate in Palestine, and were applied to the surveying activities by the Survey of Palestine, the agency that preceded SOI. This document still serves as a valid law in the State of Israel.

Based on the mandatory ordnance, the Israeli Government, through SOI, periodically publishes surveying and mapping regulations. The latest version, confirmed by the minister of construction and housing (as required by the law), was published in June 1998. These regulations are in fact a law, and all surveying and mapping activities should be performed according to them.

As a result of the fast technological changes during the past decades, the regulations have been updated approximately every ten years. The rapid progress is clearly demonstrated by a long list of the professional issues, which have been regulated in 1998 but had not been even mentioned in the previous version, published in 1987. Among these issues are:

- Utilization of GPS technology for geodetic control.
- Adoption of the New Israeli Grid, which is based on a new datum, a new projection and a new coordinate system, and therefore requires careful attention.
- Emphasizing the use of photogrammetry in general, and digital photogrammetry in particular for topographic and cadastral mapping.
- Promotion of advanced digital mapping, with an emphasize on geographical-topological databases.

In order to avoid a large gap between the regulations and state-of-the-art future technology, detailed operational guidelines were published in conjunction with the regulations. These guidelines obviously follow the regulations. However, they may be modified by the Director General of the SOI, in particularly when new technology comes in. Such a modification will enable quick response to new technology without a need to change the regulations themselves.

The regulations contain five chapters. The core three of them deal with geodesy, topographic mapping and cadastre. This paper deals mainly with the topographic mapping aspect, with respect to its impact on digital cartography in Israel.

Transition toward Modern Mapping

Mapping is gradually passing from the domain of graphics to the domain of numbers. This transition can be characterized divided into three generations:

- Conventional (graphical) mapping.
- Computerized (digital) mapping.
- Database (topological) mapping under geographical information systems.

In the far past, conventional mapping was completely based on field surveying and analogue photogrammetric systems, with the output being ordinary paper maps. The transition to what is called today computerized mapping (or automated cartography) began during the 60's and 70's. Analytical photogrammetry was introduced, and the maps were drawn from digital data, using computers and peripheral equipment (e.g., plotters and digitizers). It should be emphasized that the final product of mapping processes was and still is the plotted map. During the second generation, i.e., the digital mapping era, the data was characterized only by its graphical nature, although being stored digitally. Structured capabilities to retrieve and merge a combination of separate layers of relevant or required information were almost impossible.

In the past decade there have been a clear trend toward the third generation of mapping - the geographical information systems. Here the main purpose of mapping is building geographical databases in digital formats, and not drawing paper maps. Paper maps are produced from these digital data ad-hoc. Therefore a special attention is given both to the geometrical accuracy and for collecting and maintaining topological relations, as well as to descriptive alphanumerical information.

While mapmakers have professional cartographic background, which is based on relevant education, map-users are not necessarily cartographers and may not have cartographic training. In the past, for many decades, the paper maps were almost the only cartographic products, thus enabling a very simple and common language between mapmakers and map-users. The modern mapping, cartography and GIS domain changed this mutual understanding between the expert mapmakers and the layman map-users.

Two simultaneous processes characterize the modern high-tech cartographic domain:

- Massive expansion of the need for digital cartographic products by users from different professions and human activities (engineers, planners, managers, marketing executives, etc.).
- Standardization of products, modern equipment and new methods, such as digital photogrammetric 3D workstations, accurate photogrammetric scanners, orthophotos, Digital Elevation Models (DEMs) and others.

Apparently, the transition toward digital mapping procedures facilitates simple access to and processing of data. This fact opens a wide gap for non-professionals to produce low quality products. However, the mapping community must maintain the high standards that have been set along the past decades. These standards are maintained by up-to-date regulations and guidelines.

Regulations for Topographic Mapping

The new regulations (and especially the topographic chapter within the regulations) through their professional dictionary of terms, definition of standards, and level classifications of the different cartographic products, form the basis for a common and fruitful dialog between the different members of the cartographic community. The topographic mapping chapter of the regulations consists of three major aspects:

1. Content and scale values, standards for the accuracy of the details and relief appeared in the map, and surveying methods.
2. Equipment to be used, classified by accuracy properties.
3. Intermediate and final products, classified by their quality.

Since most topographic mapping is performed nowadays by photogrammetric means, a clear trend in this direction is reflected in the regulations. This is a major change compared to the previous version of the regulations, where photogrammetry did not play a major role. Furthermore, digital photogrammetry and digitally generated maps, which are common in the surveying arena, are noticeable along the entire chapter.

Map content, accuracy standards and surveying methods

A topographic map contains details and relief (ground shape). Details can be classified into two types: (i) details that are part of the ground surface, such as cliffs, quarries and water bodies; (ii) man-made objects, such as buildings, roads and electric poles. The amount of details depends on the scale of the map, i.e., in smaller map scales a generalisation is made. Relief is usually represented by contour lines, with vertical interval depending on the scale.

The regulations set a standard for map scales, spanning from 1:100 to 1:10,000. While in early versions there were different sets of allowed map scales for topographic and cadastral mapping, the two sets were unified, allowing overlays between these two types of maps without a need to change the scale. For the convenience of mapmakers (and readers), some of the map scales are assigned 2-3 possible values for the vertical interval between contour lines. The regulations permit for the first time the preparation of background maps for cadastral purposes. As accuracy in the cadastral environment is critical, a special consideration was given in order to differentiate between topographic and cadastral mapping.

Topographic information can be obtained by field or aerial surveying. All topographic maps should be connected to the national horizontal and vertical coordinate frames. Additional control points should be surveyed where necessary, in order to facilitate the surveying procedure. Control points for aerial surveying can be marked in the field a-priori, or identified in the photographs and measured in the field a-posteriori.

The accuracy of both locations and elevations of map features is defined. Standards are expressed as the difference between coordinate values of a point obtained from the topographic map and the values measured independently for quality control. Upper bounds of differences are set for 90% and 100% of the checked points.

Classification of equipment for topographic mapping

Photogrammetric mapping should be based only on photographs that were obtained by a *photogrammetric camera*. Cameras are characterised into three classes based on their properties and performances, and must be certified a-priori. Proper calibration is required every five years or less.

Classification of *stereoplotters* has been modified to include digital photogrammetric workstations. In general, analogue, analytical and digital stereoplotters are classified into four quality levels. This classification is dominated by two factors that specify the upper bounds for the flying height based on the vertical interval of contour lines, and the flying height based on the scale of the map. Similar to photogrammetric cameras, stereoplotters must be certified, and periodically calibrated.

Scanners are considered in the regulations for the first time. They are classified into three levels: (i) scanners with minimum resolution of 1600 dpi and accuracy better than 4 µm, to be used for scanning photographs for digital photogrammetric mapping; (ii) scanners with minimum resolution of 1000 dpi and accuracy better than 20 µm, to be used for scanning photographs for orthophoto generation; and (iii) scanners with minimum resolution of 250 dpi and accuracy better than 100 µm, to be used for all other mapping purposes. Scanners should be also certified, and calibrated every six months according to manufacturer's instructions.

Classification of intermediate and final products

A topographic map is classified into one of the following levels:

1) A map for which all the details, including their line of intersection with the ground and their external perimeters were surveyed in the field.
2) A map for which all the details, including their line of intersection with the ground and their external perimeters were surveyed by photogrammetry and completed by field surveying.
3) A map that was surveyed by photogrammetry only (without any complementary field surveying).

Although ordinary digital maps (vector or raster) with a graphical representation of the mapped area are still common, the regulations set standards for preparing a topographic map that is part of a geographical database (GIS map). In such maps, all digital data are organised in a form of points, lines, arcs and closed polygons, ordered entirely in a topological structure. A specific declaration whether a digital map is a GIS map or an ordinary map should be included.

In light of the trend toward digital mapping, *a digital elevation model* (DEM) is considered as a major source for the relief part of a topographic map. DEMs are classified into two quality levels. The lower level contains only elevation points. The higher level contains, in addition to the elevation points, topographic discontinuity lines such as breaklines and formlines. Another characterisation classifies DEMs into three accuracy levels, with maximum distances between elevation points of 10, 25 and 50 m, and maximum error values (for all checked points) of 0.5, 3 and 10 m, respectively. For all three levels, the error values for 90% of the checked points should not exceed half of the maximum error values. The regulations distinguish between two types of DEMs: elevation points on an evenly spaced grid, and scattered elevation points in arbitrary locations, which properly define the terrain. Both types should agree with quality and accuracy standards mentioned above. The regulations also set direct relations between the density of the DEM and the scale of the map (or orthophoto) derived from it. These relations range from 4 m maximum spacing (minimum 62,500 points per square km) for 1:100 scale, to 50 m maximum spacing (minimum 400 points per square km) for a 1:10,000 scale.

Orthophotos are recognised and standardised as a map product for the first time, terminating the previous status in which orthophotos were often generated inappropriately. Specific enlargement factors between the scale of a photograph and the scale of a hardcopy orthophoto produced by digital means have been set. These are ranged from a factor of 10 for orthophoto scale of 1:500, with maximum ground pixel size of 7.5 cm, to a factor of 4 for orthophoto scale of 1:10,000, with ground pixel size of 100 cm.

An orthophoto is classified into one of four levels. These levels are based on the information utilised for producing the orthophoto:

1) A properly spaced DEM, with all topographic discontinuity lines (breaklines, formlines etc.) and spot heights. In addition, selected details from the digital mapping, apparently man-made objects, are also considered.
2) A properly spaced DEM, with all topographic discontinuity lines and spot heights.
3) A properly spaced DEM.
4) Selected spot heights, which must include points near the corners of the orthophoto.

A final orthophoto product must be printed by a raster plotter with maximum pixel size of 32 µm and accuracy better than 0.1 mm. In order to ensure long-term accuracy, it should be printed on a proper material, similar to topographic maps. As an orthophoto is considered as a map product, it must be endorsed by a licensed surveyor.

Summary

The mapping profession has been on the transition from the analogue, man-made mapmaking, through limited digital environment toward fully automated digital databases and mapmaking processes. Standards and regulations must take changes into consideration. The new Israeli surveying and mapping regulations, published on June 1998, were prepared in light of this tremendous transition.

Although digital cartographic data seem easy to obtain and manipulate, the mapping community must maintain the high standards that have been set for years in order to generate high quality products. The regulations impose the high level standards that were widely accepted for conventional mapping on the new equipment, methods and products.

The new concepts within the regulations constitute a “common language” between mapmakers and map-users, thus enabling the selection and design of appropriate products for different engineering, fiscal and other activities. The impact of these regulations on digital cartography is significant and effectively contributes to a high quality digital mapmaking in Israel.

Session / Séance 24-A

Implementation of a new military topographic production system into the Army Topographic Support Establishment, Bendigo Australia

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Abstract

In April 1996 I was tasked with the responsibility of raising a new 150-person Department of Defence organisation whose responsibility is to produce digital topographic support to the Australian Defence Force (ADF). The organisation formed was the Army Topographic Support Establishment (ATSE) and it is located in Bendigo a regional city 150 kilometres north west of Melbourne, Australia.

In providing this support to the ADF the recruiting of trained personal and replacing the ageing computing system were of the highest priorities. The new computing system known as Project Parare is now in the implementation phase.

The Parare system is based on ESRI suite of products using Leica digital photogrammetric workstations linked with Socet Set software. Hewlett Packard hardware is used with film writing provided by a Barco scanner/plotter and management information system will track the daily production performance. The installation of this system will enable the ADF to have a digital production system to produce Military Geographic Information (MGI) for the ADF. The digital data will be required for the ADF simulation systems and tactical requirements. Where hardcopy maps are required then they will be printed on the large format Roland and medium format Heidelberg printing presses. ATSE is responsible for printing all of the maps and charts for the ADF.

The challenge has been to change the culture existing from the previous organisation known as the Army Survey Regiment. Seventy-nine staff were transferred to ATSE and then other personnel were recruited into the new organisation. During this time we have had a change in Federal government which necessitated the adoption of a new Defence Reform Program requiring digital MGI. A refurbished production facility has been provided and staff will work a 2-shift rotation compared to the extant 3-shift system. The third shift will be used during surge capacity and routinely for batch processing and periodical system maintenance.

Without the assistance of a new computing system it would not be possible to provide the type and quantity of products that the ADF require. The training of all staff with the new system will be fundamental to the success of the organisation. The significant change will be to populate the database with DIGEST compliant data and then extract products from the database.

This paper describes the transition from a digital production system through to a fully automated digital military topographic production system.

Background

The Army Topographic Support Establishment (ATSE) is a new organisation formed on 29 April 1996 as a result of the Australian Defence Force (ADF) review into the provision of map, chart and digital topographic support to the three services, Army Air Force and Navy. ATSE conducts its digital mapping activities at the heritage listed Fortuna, Bendigo where the Army Survey Regiment (ASR) was formerly located for a period of over fifty years.

From a historical point of view it is imperative that the organisation builds upon the significant skills and knowledge base developed in the previous organisation. ATSE was the result of a successful Department of Defence tender for the Commercial Support Program (CSP) activities for the non-core mapping of sovereign territory. In having a group of people whose future is determined by their own performance provides the necessary catalyst for success.

Introduction

The initial period of the agreement is five years with two, one-year extensions before the next review is conducted.

The successful tender for the new Parare computer system was awarded to RLM systems a Lockheed Martin/ Tenix joint venture company. They are the prime contractor and will provide a new digital military topographic production system able to produce the full suite of DIGEST compliant military geographic information (MGI) products. Contract negotiations were concluded in September 1998 and commissioning of the system will occur in late 1999. The new system will be capable of providing digital products in early 2000. Parare is now in an advanced stage of implementation and by the time this paper is presented, training on the new system would have commenced. The smooth transition from our existing system to the new one is a challenge that confronts all personnel at ATSE. Every area of endeavour will be affected by the change and so our new refurbished production facility building has been designed to accommodate a logical production flow.

Facility

Fortuna is set in eighteen acres of grounds of a historical mansion. The production areas are in a separate building and it is only senior management and administration area that is housed in the mansion. There is a 3-shift rotation of production staff but with the advent of Parare it will allow production on two shifts.

Fortuna Mansion

Tasking

ATSE receives all of its tasking from the Directorate of Strategic Military Geographic Information-Army (DSMGI) who in turn receive their direction from the Geographic Review and Policy Committee (GRPC).

ATSE tasking is based on a three year rolling plan, which is determined well in advance and on 1 July of each year, we commence our annual tasking.

ATSE supports three levels of activity

Regular where production is planned and it is required to meet military standards and specifications. Special where production may or may not be planned and is generally to non-standard or ad-hoc specifications. Contingency where production is needed for crisis support and rapid response requirements, where there are changes in priorities, irregular surges in demand and a requirement for non-standard specification production

Organisation

Key groups **of ATSE :**

General Manager

Product Group is responsible for the digital production including acquisition of satellite imagery and aerial photography, through sub-contractor support and for the compilation of digital topographic data from a range of source material for entry as terrain information.

Production Control Group is responsible for the production management of all tasks within the Army Topographic Support Establishment, including the use of sub-contractors. Included in this management is reporting and technical liaison with the tasking authority. The Group is also responsible for the acquisition, storage and preparation of source material needed to support the range of production tasks.

Strategic Development Group is involved in the development and exploitation of new technology.

ATSE is staffed by Department of Defence civilians employed under the terms and conditions of the Australian Public service. The organisation structure is flat with only 4 levels so that it can provide more direct and immediate control over the organisation. The cultural change for the ASR personnel was quite pronounced since they are now able to focus completely on their tasks and no longer other military duties. Within ATSE a 3-shift rotation is required to meet the production requirements.

Vendors and equipment

The success of ATSE is predicated upon the delivery of Parare. It will provide ATSE with the operational capability to produce digital geographic products that are increasingly necessary in the rapidly developing defence weapon systems.

The vendors and the information they supply is as follows

ESRI Australia Pty Ltd GIS services and software
Leica Pty Ltd
GDE Systems- Socet Set DPW software
Hewlett Packard – hardware
Technical workstation specifications - PII 350 Mhz, 256 MB RAM, 9 GB HDD
Image Processing workstation - PII 450 Mhz, 256 MB RAM, 9 GB HDD, High End Graphics Card
Photogrammetry workstation - PII 450 Mhz, 256 MB RAM, 18 GB HDD
RIP - PII 350 Mhz, 256 MB RAM, 9 GB HDD
Bogong Technologies for the Management Information System
Oracle systems database
Scientific Management Associates for training
Barco Graphics megasetter film writer

With our existing system ATSE are not capable of providing the full suite of DIGEST products that are required by the ADF. One of the aims of the new system is to provide military geographic information to ADF simulation sites. Softcopy photogrammetry has been introduced to the site in 1997 and with Leica digital photogrammetric workstations to be introduced the technology learning curve will not be as steep as the change from analogue to digital technology.

An important addition is the use of a Management Information Ssytem to be able to provide “what if “ scenarios so that the customers can receive realistic timeframes in the first instance.

The Oracle Database will provide the ability to tailor make products rather than the extant method of placing mapping data into the database.

Sourcing of information has been a constant requirement and the lead times for delivery of data is critical to our production. The use of the internet has been a great advantage to regional areas.

Products

VMap1	Vector Smart map Level 1 approximate scale 1:250 000
VMap2	Vector Smart map Level 2 approximate scale 1:50 000
DTED 1	Digital Terrain Elevation data with a uniform matrix spacing of 100metres of elevation data
DTED 2	Digital Terrain Elevation data with a uniform matrix spacing of 30 metres of elevation data
DFAD	Digital Feature Analysis Data
JNC	Jet Navigation Chart scale 1:2 000 000
ONC	Operational Navigation Chart scale 1:1 000 000
TPC	Tactical Pilot Chart scale 1:500 000
TLM	scales from 1:10 000 – 1:100 000
ADRG	Arc Digitised Raster Graphics
CADRG	Compressed Arc Digitised Raster Graphics

There is an ongoing requirement to print maps and charts for the ADF and ATSE has a large format Roland printing press capable of printing the large format charts ONC and TPC as well as the Navy charts. ADF projects include mapping and charting systems, command support systems, weapons systems, navigation systems, war games, simulation and intelligence systems designed to use spatial geographic data.

Education and Training

ATSE places considerable importance in having a well-trained workforce, which is flexible and multi-skilled. The field of geomatics now encompasses cartographers, photogrammetrists, surveyors, graphic arts and remote sensing scientists and it fits comfortably within our plans. However, it is still expected that entry level staff will have to be trained immediately in digital mapping procedures at ATSE.

Fundamental to the success of the new system is that training must be completed in phases so that all staff have the opportunity to exploit the new technology.

Change Management

With any major change let alone the formation of a new organisation, a balanced management of the change is crucial to the survival of the organisation. It is inevitable that the introduction of a new system will cause changes to the organisational structure and responsibilities. Staff were consulted in the way that they undertook their work and they were given an opportunity to have an input into the decision making process. A local workplace consultative council group was formed to address various issues that arose through the formation of a new organisation.

ATSE has recently restructured prior to the introduction of the Parare system. The reason for this is to ensure that staff are employed in relevant areas so that production efficiencies are maintained and further change will likely take place with the commissioning of the new system.

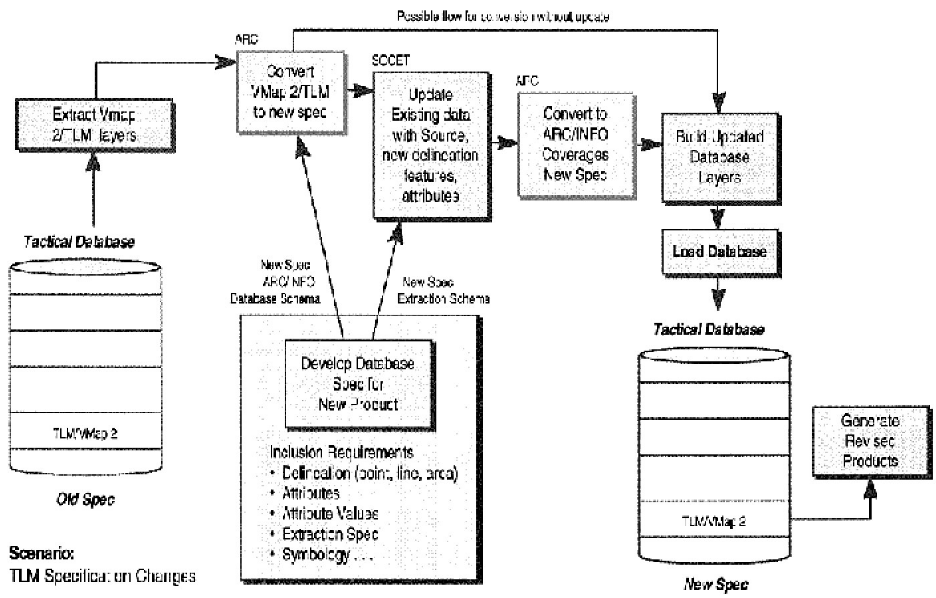
The phasing in of the equipment will mean that staff have to transition to the new from the old and the planning of our production will have to take this into account

The intent of the transition is to minimise the impact of change particularly with staff. To facilitate this requirement considerable training and re-training is required. The intent of the training is to provide a flexible workforce by broadening the skill base.

Production Efficiencies

The greatest production efficiency will be the ability to extract derived MGI from the database to produce DIGEST compliant products. Due to the existence of some legacy systems within the ADF it is not always possible to provide the latest military geographic product and so products such as ADRG are still required. CADRG will supersede ADRG due to its compression ration of 1: 55, which obviously requires considerably less storage space.

A simplified workflow is indicted in the diagram below



Production Flow

Another area of production efficiency will be the broad band transmission of data between production agencies and the users. In a regional area the tyranny of distance can be overcome by efficient digital communication systems.

ISO 9002 accreditation

Within twelve months of the commissioning of the new system ATSE must achieve ISO 9002 accreditation. ATSE will attain accreditation with the existing system and then implement the new standard operating procedures and apply for accreditation with the new system.

Future Direction

The transition to completely digital technology for all mapping operations will provide the main focus for ATSE. The aim of having a fully integrated, automated defence mapping capability is imperative if we are to meet the ever-increasing demands for digital military information geographic products. The weapon systems to be used in the field will depend upon accurate and current digital data, which will meet fast evolving standards being developed by the international Defence geomatics community. ATSE will need to remain apprised of emerging military digital data formats and standards.

Significant productivity improvements are required to increase the digital support capability to the ADF. The lifecycle of some traditional map products must be reduced from a period of greater than one year in their production cycle. For the GIS user it is a definite requirement to have reliable, sustainable digital topographic data bases to enable them to add their own specific thematic layers.

The delivery of the new computer solution to ATSE is expected to be operational by December 1999 and this will provide a significant increase in production capability.

ATSE will concentrate on providing digital geographic data to satisfy DIGEST compliant along with feature coding scheme (Feature and Coding Catalogue - FACC). On delivery of project Parare ATSE will be able to produce Vector Smart Map (Vmap) Level 1 products so that it will fall into line with other production agencies within NATO where there is a 11 nation Digital Geographic Information Working Group (DGIWG).

Acronyms

ADF	Australian Defence Force
ATSE	Army Topographic Support Establishment
ASR	Army Survey Regiment
CSP	Commercial Support Program
DGIWG	Digital Geographic Information Working Group
DIGEST	Digital Geographic Information Exchange Standard
DMGI-A	Directorate of Military Geographic Information Army
FACC	Feature and Attribute Coding Catalogue
GIS	Geographic Information System
GRC	Geographic Review Committee
ISO	International Standards Organisation
NIMA	National Inagery Mapping Agency
VMAP 0	Vector Smart map Level 0
VMAP 1	Vector Smart map Level 1
VPF	Vector Product Format
WGS84	World Geodetic System 84

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Establishment of Government GIS and Its Application

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Abstract

Application of GIS in government agencies is called Government GIS. It forms a special research and application field of GIS. In this paper, the following problems are discussed in detail: distinguishing features of government GIS, system design, establishment of comprehensive data base, software development, data communication and system application.

Introduction

Recent years, GIS has been widely used in the field of social and economical sustainable development. Application of GIS in government agencies is called Government GIS. The specialists of Information Sciences indicate that more than 85 percent of government business information applied in the central and local government agencies have close connection with the Spatial Data Infrastructure (SDI). Application of GIS in fields of natural resource management, population investigation, environment monitoring and disaster control prove that Government GIS is a powerful tool for government business management and decision making. That is the reason why Government GIS develops so fast and creates a special research and application of GIS. Since 1992, National Bureau of Surveying and Mapping in cooperation with Secretariat of the State Council of China started to set up "Government GIS of Comprehensive National Economy for the State Council"(9202 Project). Up to now, several professional government GIS has been established and put into routine application.

Distinguishing features of Government GIS

Practice of establishment and application of Government GIS proves that Government GIS is of the following characteristics:

Government GIS possesses the mergence characteristics of GIS and government OA(Office automation). At the moment, OA is the basic working model to the government agencies, while GIS can provide OA with the additional function of spatial retrieval and spatial analyses. And therefore, Government GIS is an effective tool to raise OA' application level and to expend its application domains.

Government GIS is a contributed information system based at internet or intranet. This is because all the government business information should be obtained from different professional units located in different places.

Government GIS is a social-technical engineering project. Establishment GIS not only depend on the advanced technology and authoritative data, but also relies on the operation and management mechanism without which government GIS can not run successfully.

Government GIS is a routine application system. To fit this feature, Government GIS should work with high stability and reliability, and the data must be updated on time.

Safety of Government GIS is extremely important. To meet the requirements, it is necessary to take various technical measures.

Target of Government GIS

In view of complexity of Government GIS and fast development of hardware and software, the objectives of 9202 Project can not be realized at one step. And therefore, the overall objectives of Government GIS will be reached by several phases:

The objectives of Government GIS at the first phase (1992—1993) is to develop an Electronic Map System of National Comprehensive Economy based on 1:1 million NSDI and comprehensive national economy situation. The concrete research subjective can be summarized as follow:

To set up database of the National Comprehensive Economy based at 1: million topographic maps, government business information and statistical data.

To develop software system of Electronic Map System used specially for Government GIS.

To establish data communication network between National Bureau of Surveying and Mapping and Secretariat of the State Council.

The objectives of Government GIS at the second phase (1994—1997) is to set up the coordinated information system of national comprehensive economy which is used to provide the officers of government agencies with computer-aided analyses and decision making in fields of economical analyses, flood control and government business management. The concrete research tasks are listed below:

To develop the software system "Geo/Windows" based at client/server which provides the government GIS with good continuation and entirety.

To set up the Flood Control Information System under support of which the government agencies can get the water situation, rain fall information and flooding disaster messages . This system has made possible to cope with flood disaster on time.

In cooperation with the secretariat of provincial government agencies and Provincial Bureaus of Surveying and Mapping, to establish electronic map systems of thematic information.

The objectives of government GIS at the third phase (1998—2000) is to set up the Disaster Control information system and the Information Systems of comprehensive government business management based on the internet and analyses models. The concrete research tasks are:

To build the Distributed Disaster Control Information Systems including flooding, earthquakes, forest fire, agricultural insert— illness disaster and hailstone disaster. Under support of this systems the officers of government agencies can master the necessary situation mentioned above on time.

To establish the Information System of Comprehensive Business Management for government agencies.

Development of distributed software system and analyses models.

Integration of GIS and high resolution remote sensing data and its application.

Establishment of government GIS

Overall design of government GIS.

Logical structure design.

The government GIS (9202 Project) is composed of rear data supporting subsystems and front displaying subsystems. The rear data supporting subsystems are set up at National Bureau of Surveying and Mapping and relative provincial Bureaus of Surveying and mapping where spatial data collection, data editing, establishment of database, graphic matching, data format transforming and data revision are carried out; while the front displaying subsystems are built at Secretariat of The central and local government agencies where gathering of government business information and national economy development are completed, and the government GIS are put in application. Data communication between rear data support subsystems and front displaying subsystems are realized by means of intranet and internet.

Physical structure design. In consideration of the current working models of government agencies, at the first stage of project, the multi-branch tree structure is used to store data entity. Each entity is a specific administrative region, such as continent, country, province and county. All the geographic data, government business data and statistical data closely connected with entity can be added and deleted dynamically on multi branch tree. In this case, the system is very flexible and convenient to retrieve the necessary messages. At the second stage of project, government GIS is divided into 2 categories of central government and local government agencies. The central government agency is able to get the necessary data from local government agencies. Information communication among information centers of local government agencies makes possible to share information. To this end, standard software and data specification is available. At the third stage of Project, it is aimed to set up GIS of comprehensive government business management and disaster control information system, the software Geo/Windows will be improved and upgraded. Configuration of hardware and software: SUN workstation, SUN Servers, high-quality microcomputers, digitizers, printers, large size displaying devices etc; Geo/Windows, ARC/INFO, MAP/INFO etc.

Establishment of comprehensive data bases

During past 7 years, a series of thematic database have been set up

Construction of NSDI (national spatial data infrastructure). So far, the following spatial data bases have been established:

1:1 million topographic database of China,
1: 1million DEM of China
1:1 million data base of geographic names of China,
1: 250 000 topographic database of China,
1: 250 000 DEM of China,
DEM of the larger river basins in China.

Data base of comprehensive national situation.

The contents of data base consist of : description of provinces, regions and counties, industries and agriculture, national economy and the people's livelihood, spatial distribution of poorly developed counties, distribution of large and middle size national enterprises, economical development areas, telecommunication and transportation, forestry, tourism, foreign trade business, population, culture and education, environment, foreign affaires and the hot-spot information etc.

Data base of the flood control information system

The contents of database include:

a. Water information: real time messages about main rivers, reservoirs, main hydrographic stations, situations of flood control engineering projects, and special technical reports on flood development and flooding disaster.
b. Meteorological information gathered from NOAA/AVHRR, FY(Feng—Yun) satellites made in China and meteorological stations, such as: information about meteorological clouds, precipitation broadcasting, precipitation forecasting and digital meteorological forecasting.
c. Flooding information extracted from data of TM satellites, SPOT satellites, radar satellite and other space satellites, such as: flooding areas, flooding loses and flooding prediction etc.
d. Database of social and economical information of 7 bigger river regions in china, including population, household by regions, areas under cultivation, sown areas of farm crops, members livestock, hospitals, schools, industry infrastructure, industrial output values by region etc.

Development of software systems

The software system “Geo/Windows” used for government GIS in China is developed by Chinese Academy of Surveying and Mapping. Besides the common used functions of commercial GIS software system, Geo/Windows has the following technical characteristics:

a. Linkage of spatial data with thematic information is realized by means of geographic coding driving techniques.
b. Multi-size reading of spatial data is solved by means of application of multi-scale and multi-sheet data management methods.
c. Multi-layer operation interfaces are provided.
d. Integration of vector and raster data at large areas and simultaneous display are realized.
e. The response speed of Geo/Windows is fast.

Data communication

Based on the internet and intranet, data communication between rear data supporting subsystems and front displaying subsystems have been built.

Application of Government GIS

Since 1993, the government GIS has been put in application at central and local government agencies.

The Electronic Map System of Comprehensive National Situations has been used in the central government agency. It has been an effective tool for the officers of the Secretariat of the State Council to retrieve the necessary information and to make some economical analyses.

The Electronic Thematic Map System of Comprehensive Provincial Situations are applied in more than 14 secretariat of provincial government agencies. System application proves that these systems can be used in many fields, such as: regional economical planning, environment monitoring, population analyses, distribution of educational infrastructure, planning of economical development areas and so on.

The Flood Control Information System has stalled at the central government agencies. It is a real coordinated GIS. It creates a new working model that all the authoritative institutions can provide the cooperative information services to the government agencies under the support of internet and intranet. During flood period, this system is used to offer the important messages about water situations, meteorological data, precipitation data, flooded areas, disaster information and future development of flooding. Based on these data, the government agencies may carry on the macro analyses of flooding and do some decision- making.

References

Liu Jiping, (1997), Research and development of regional information system for preventing floods, Proceedings of IEAS ’97 and IWGIS’97, Beijing.

Zhang Qingpu, (1998), Application of remote sensing data in flood control information systems, 5th Australian Space Development Conference, Sydney.

Zhang Qingpu, (1995), The analytical and retrieval system of electronic maps based on GIS, ICA Proceedings 1, Barcelona.

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Geographic Information Systems Censual Rural Cartography of the Argentine Republic

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Abstract

Censual field-works require an adecuate spatial support for the planification and recopilation of data provided by cartography.

Having as aim the National Agropecuary Census and lacking a uniform rural cartography covering the whole country (2.791.810 km^2) we developed one in digital format using satellital images.

The CEPIS (Centre of Exploitation and Processing of Satellital Images), which was created to carry out this purpose, worked out 3679 maps for the different spatial censual units, from LANDSAT TM and SPOT-P images. The scale of the maps varies from 1:100000 to 1:50000, depending on the detail of the area to research.

This paper wishes to convey the experience adquired in the development of censual cartography with raster and vector information using software for Geographic Information Systems such as Arc-Info 7.1.2, Erdas Imagine 8.3 and Arc-View 3.0

Introduction

In order to carry out the 1998 National Farming Census, the need of having digital cartography, suitable for the development of censual activities and for the later display of the data obtained was posed.

The first step taken consisted in preparing an inventory of the cartographic material, aerial photographs and satellite images available at different national, provincial and private agencies, specifying the year of the data capture or production, scales, surfaces covered and media type.

The analysis and assesment of said material confirmed the lack of homogeneous cartography in Argentina in its 2,791,810 Km^2 (American Sector); and for said reason a project was prepared in order to manufacture rural censual cartography as of using Landsat TM and Spot P satellite images. Besides, the GIS softwares: Arc Info 7.1.2, Erdas Imagine 8.3 and Arc View GIS 3.0 were selected as they happened to be the most adequate ones having in mind the time available.

The cartography produced consisted in 3679 image charts of censual districts and fractions, their scales ranged from 1:20,000 to 1:400,000. The new product allowed the coverage of the whole national territory with a homogeneous cartography which contained the necessary information to locate and identify the farming exploitations that are the aim for the National Farming Census survey.

The INDEC and its functions

The INDEC - National Statistics and Census Institute - is the national agency, depending from the Ministry of Economy and Public Works and Services, in charge of census (Farming, Population, Economic) and the specific sector surveys

(permanent household, industrial, economic, farming, tourist, vital surveys) in the Argentine Republic.

Its specific functions are jointly carried out with the DPE -Provincial Statistics Directorates- which represent each of the 23 provinces in the Argentine Republic.

Each province is administratively divided into districts, and censually speaking each district is divided into censual fractions or sectors.

Within the Updating of the National Statistics System, the INDEC is carrying out a Development Program called National Cartography Plan being its main purpose the production of a national Unique Cartographic Frame. For said reason, the urban and rural censual cartography of the whole country is being updated with an INDEC centralized methodological criterion, and the decentralized work in the DPE.

The CEPIS and its functions

In our country, a population and household census is performed every 10 years, and the idea is to perform a farming census at the same period of time. Within this operational frame, the INDEC Cartography and GIS Department (depending from the National Statistics Methodology and Technology Directorate of the National Statistics System) put the CEPIS -Satellite Images Exploitation and Processing Center- into operation through the completion of the following stages:

1. CEPIS Equipment.
2. CEPIS Operation.
3. CEPIS cartographic products.

1. CEPIS equipment

The Center has got 7 workstations running under Windows NT, 3 workstations running under Sun, and two workstations running under Windows 95.

3 SUN WORKSTATIONS	7 WINDOWS NT WORKSTATIONS	2 WINDOWS 95 WORSTATIONS
Arc Info 7.1.2. Erdas Imagine 8.3.	Erdas Imagine 8.3 Arc View Gis 3.0	Arc View Gis 3.0

5 technical coordinators and 15 operators participated. They have organizedly done the job in 2 shifts.

2. CEPIS operation

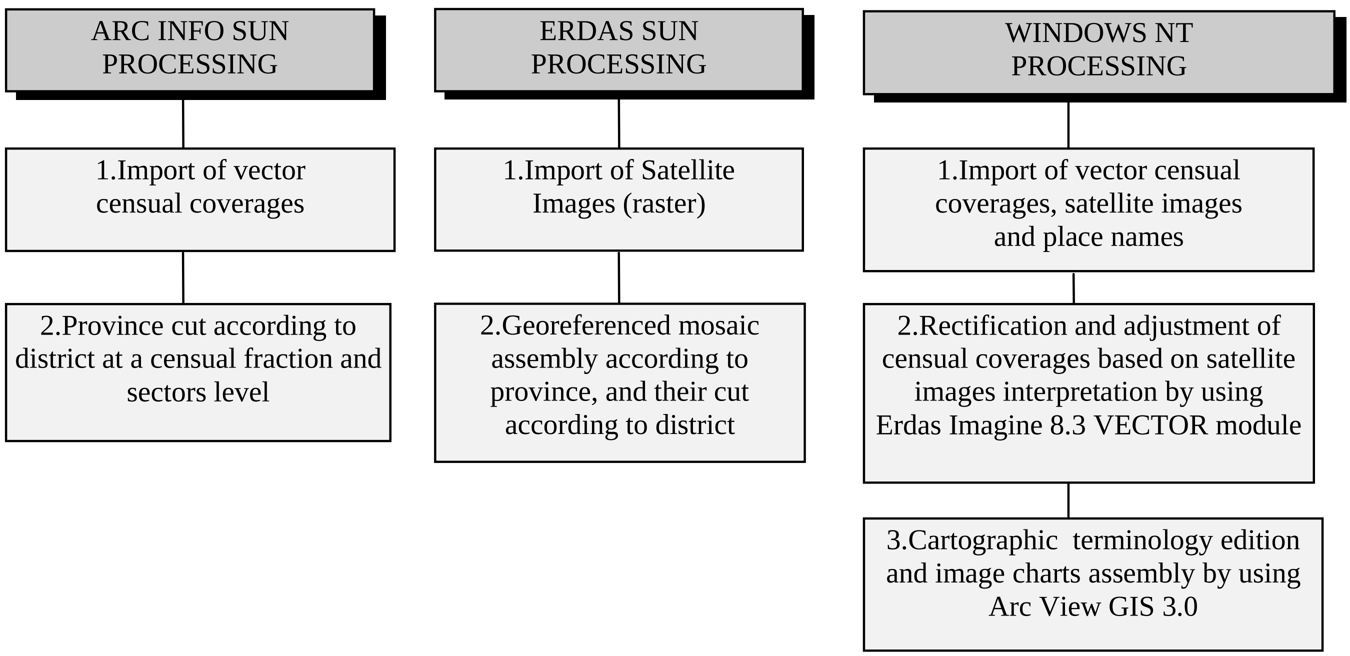
This Center has a double purpose:

2.1. *Perform the digital census cartography for the rural area* of 13 provinces: Buenos Aires, Córdoba, Entre Ríos, La Pampa, La Rioja, Catamarca, San Juan, Mendoza, San Luis, Salta, Jujuy Tucumán and Santiago del Estero.

2.2. *Standardize and and supervise the cartography performed in a decentralized way by the DPE* of the provinces of Tierra del Fuego, Santa Cruz,, Chubut, Rio Negro, Neuquén, Corrientes, Santa Fé, Chaco and Formosa.

Besides, both purposes needed staff training and the preparation of a working methodology and informative brochures for the different stages of the censual image mapping production.

In order to perform the first part (2.1), the activities were organized according to the following sequence:



Vector coverages are imported by using Arc Info (SUN) and are cut according to province and district; said coverage is exported to the SUN workstation, which has got ERDAS for satellite image processing.

The Landsat-TM satellite images come -due to cooperation agreements- from CONAE (National Commission of Space Activities) and IGM (Military Geographic Institute).

The images that have been received -most of them georeferenced- cover the country in band 3 (selected band owing to equipment and time available to perform the rural area censual cartography).

Spot-P images were also bought in order to perform the Tucumán Province and Metropolitan Area of the Buenos Aires Province image cartography.

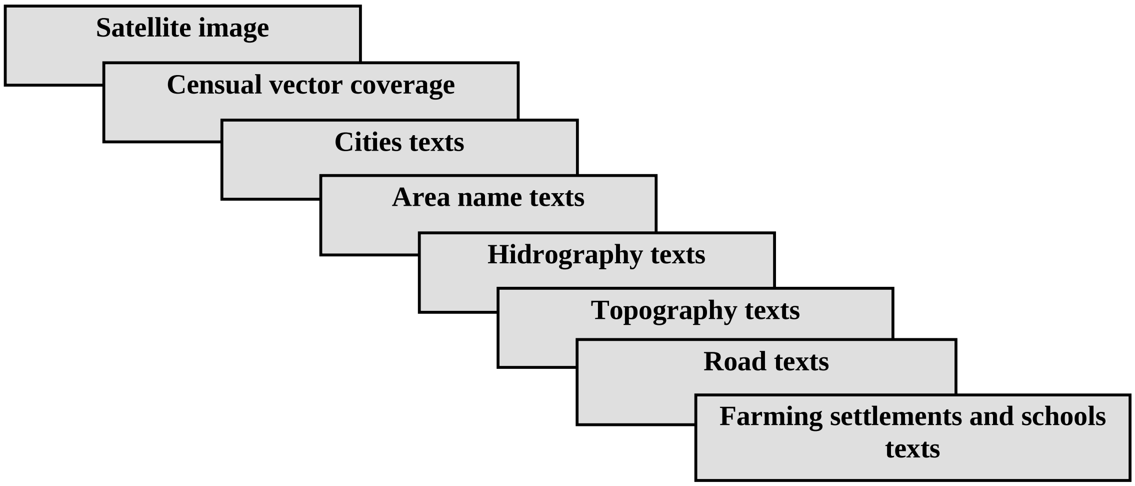
By using Erdas, the rest of Landsat and Spot images were georeferenced. After histogram modifications and image improvement by means of filters, the image mosaics were assembled according to province. Each one of them was cut by districts and was exported to the server for a further edition in the workstations (Windows NT).

The province vector coverage cut by district is also sent to the server; said coverage also contains the censual fraction and sector division.

Finally, the satellite image and vector coverage are imported to the workstations. This is edited by using Erdas Imagine 8.3 Vector module, and it is adjusted to the satellite image according to the coincidence with physical features (hidrography, topography) and with man built features (routes, roads, railways) which can be seen after the image visual interpretation.

Once the fraction and sector vector coverage edition is over, it is imported from Arc View 3.0 together with the satellite image and text coverage which contains: cities, roads and railways, hidrography, topography, farming settlements, schools, stores and rural houses, and terminology of the censual divisions (number of fractions and sectors).

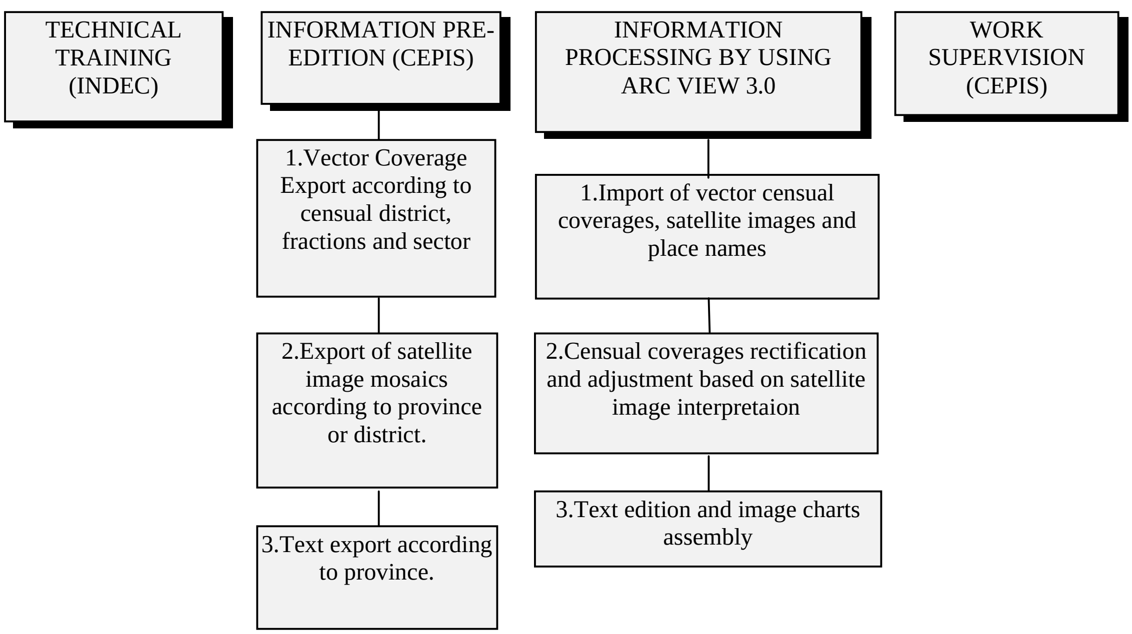
By using Arc View 3.0 a project is generated, which contains the following information layers:



The information layers belonging to text are edited, and the censual districts and fractions image charts are produced.

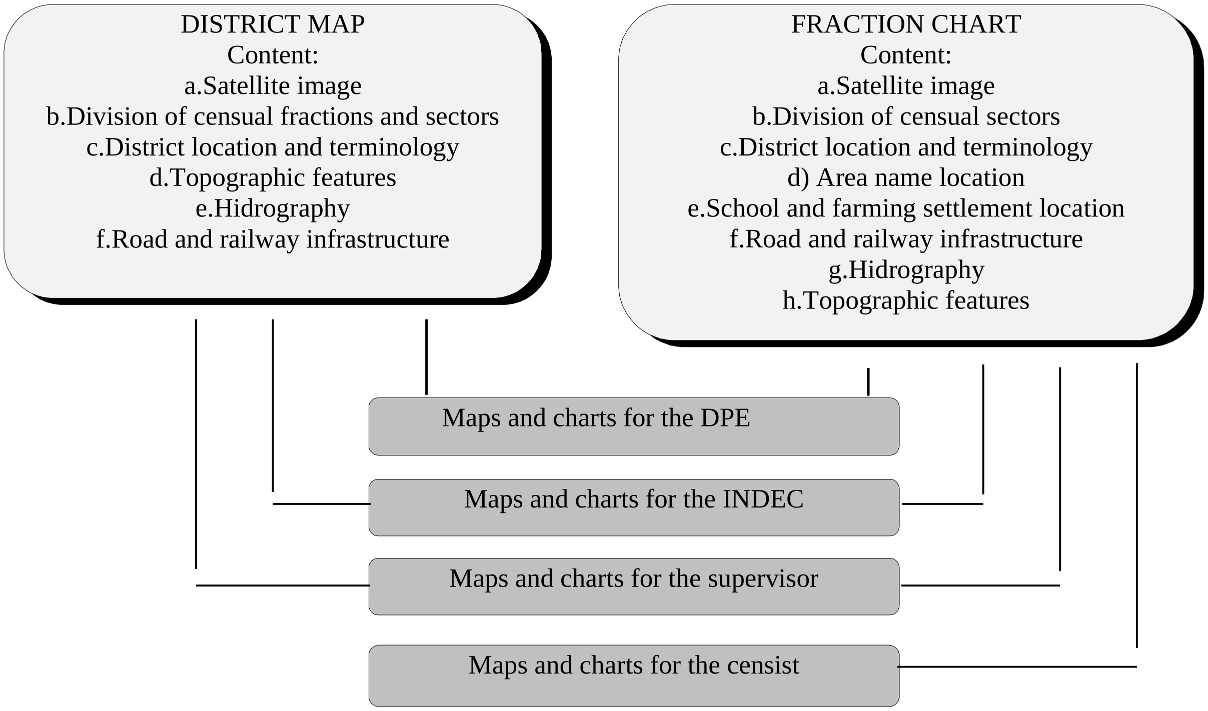
When finishing each district, an exhaustive inspection is performed by printing a district chart and a fraction sample. Later on, from one of the CEPIS Windows 95 workstation, two different coordinators check them independently in order to avoid mistakes before the final printing.

As regards the second stage (2.2), the activities were organized this way



Having satellite images and vector coverages, the procedure that follows by using SUN workstations is the same as the one used when cartography is entirely produced at CEPIS. Images, vector and text coverages are sent, by means of a magnetic media, to to the DPE which edit text by using Arc View, produce the image charts and send to the CEPIS the digital files which contain the projects for a further correction and supervison.

3. CEPIS cartographic products.



The cartography generated in the Windows NT wokstations, and by using both Erdas Vector module and Arc View is further printed after the Arc View project edition and supervision inspection; after that, copies of the district maps and fraction charts are sent to the INDEC, to the DPE. These agencies deliver said maps and charts to supervisors and censists during census planning and performance.

References

Bosque Sendra, J (1997). Sistemas de Información Geográfica. RIALP, Madrid.

Comas, D. And Ruiz, E. (1993). Fundamentos de los Sistemas de Información Geográfica. ARIEL, Barcelona.

Corine Land Cover. Guide technique. (1993). Commission des Communautés Européennes, Luxembourg.

Chuvieco, E. (1996). Fundamentos de Teledetección Espacial. RIALP, Madrid.

INDEC (1988). Manual del Censista Censo Nacional Agropecuario 1988. Buenos Aires.

Marlenko, N. et al (1998). Las potencialidades de los Sensores Remotos para el análisis del ambiente urbano. Estudio de caso Area Metropolitana de Buenos Aires. Resolución CS 1411. Universidad de Buenos Aires. Buenos Aires.

Pinilla, C. (1995). Elementos de Teledetección. RA-MA, Madrid.

Pujadas, R. And Font, J. (1998). Ordenación y Planificación territorial. Síntesis, Madrid.

Robinson, A. et al (1987). Elementos de Cartografía. OMEGA, Barcelona..

Vapnarsky, C. (1998). El concepto de localidad: Definición, Estudios de casos y Fundamentos teóricos. Serie D Nº4. INDEC, Buenos Aires.

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GEO-INFO - The Polish System of Detailed Land Information

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Abstract:

The article describes a Polish digital mapping system GEO-INFO in terms of its application as a detailed land information system database for a variety of users operating on large-scale geodesy maps. The paper presents the potential of the system as for data entering, processing and usage.

A System for Everyone

Speaking of GEO-INFO one should say "imagine a map" rather than "look at a map". Compared to a regular map (either on paper or screen), the GEO-INFO system reveals its huge potential for a user endowed with imagination and ability to think in terms of databases. The GEO-INFO system, through its friendly interface and a possibility of mutual communication gives its users a working environment that facilitates the process of replacing traditional tools with computer-assisted techniques. The user of the system does not plot a map anymore. Data entering is based on defining an object in a database, in the case of which the system plots the map for him.

A digital map in GEO-INFO is a mathematical model of the surrounding world created as a virtual reality described by rules and interrelations of the objects comprised in a database. In GEO-INFO there are no drawings made by the user. There are interpretations of text information presented as a projection of maps and related reports.

The GEO-INFO system is designed for accumulation and data presentation concerning terrain objects. Its content equals that of a large-scale area-development map in the scale 1:500, 1:1000 and less. The system is founded on a database that comprises graphic information (geometrical) as well as descriptive information about the objects, thus, creating an ideal model of a digital map independent of the CAD drawing. The image of the map is a projection of the database information presented in any given graphic form with any number of objects in any terrain defined by the user. The textual form of the information provides compatibility and unlimited dynamics of presentation (see Figure 1).

The system has been designed for a single Pentium-class terminal as well as for network use, where it operates under DOS, Windows 95 or Windows NT and the networking is based on Novell or Windows NT server. AutoCAD by Autodesk and InteliCAD by Visio have been used as the graphic interfaces. GEO-INFO consists of several modules which allows the user to fully customize the system.

The GEO-INFO system was designed in 1992 for the Department of Geodesy and Land Administration at the Wielkopolska Provincial Office. Ever since, the GEO-INFO digital mapping system has been introduced by Provincial Geodesy and Land Administration departments on a significant area of Poland (30%), thus creating a uniform structure for all the users of large-scale survey maps. The system is also employed as a tool for digital map edition and turned to be useful in training future users of the system in the domestic universities. A gold medal at the M.T.P. Infosystem '93 fair (see Figure 2) and a nomination for the product of the year in geodesy at GEA '98 is a sufficient proof of its outstanding quality.

What Makes GEO-INFO Different?

The system presented here has a multitude of features different from typical GIS systems. It has the following characteristics:

- it is a Polish system for land information with a built-in large-scale digital map development and edition logic,
- it is an object-focused system ready to work on full map content with special content modifications,
- it is a highly specialized tool for data development and processing forming a geometrical base of the land information system.

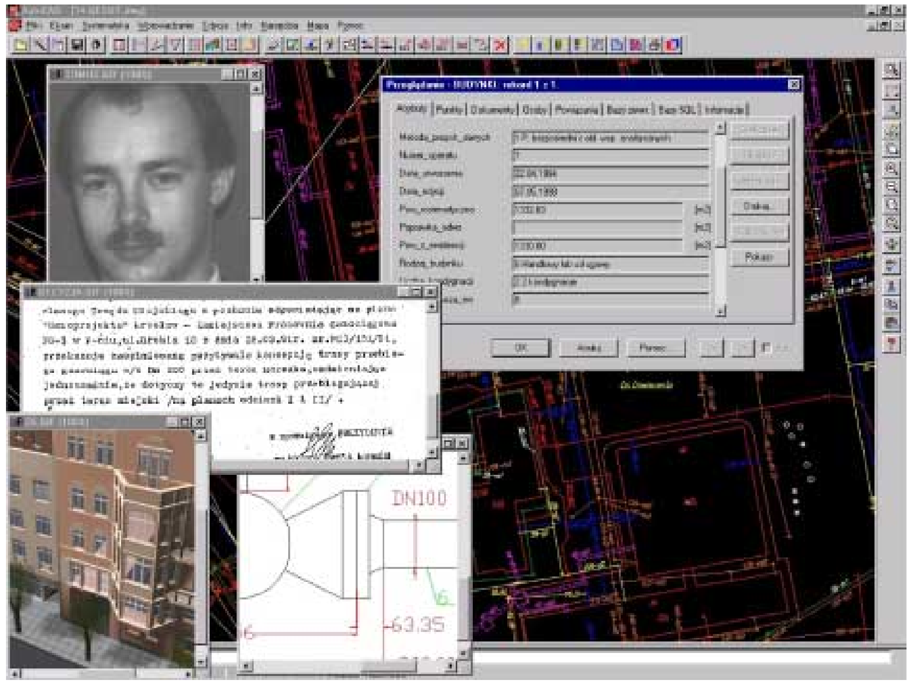

Figure 1. GEO-INFO, a system of land information

The system offers a reliable standard that guaranties complete digital documentation compatibility in any part of the country irrespective of the local map making methods. The basis for this standard is its original numeration style, full control and self-orientation in the coordinate systems. GEO-INFO is also capable of controlled standard modification so as to satisfy its users. The system has been designed for a variety of applications. Currently it is used by surveyors, State Department of Geodetic Supervision, local self-government authorities, railway and road administration, schools and other branches.

Selected Functions of the System

Operating GEO-INFO comes down to processing of data previously accumulated in its own database. Every object on the digital map has a corresponding record in the database. The system is supplied with tools that allow entering, edition and data compilation as well as map and report generation. The system can collect data from the direct survey, map digitalization, vectorization and those imported from other LIS systems. Geometrical data can easily be updated with descriptive information, text information and multimedia. The majority of objects in focus already have a complete geometrical and descriptive data package, however, there are objects lacking geometrical data supplied only with the descriptive ones. These are used to enlarge the bulk of land information with connection to the geometrical ob-

Figure 2. The gold medal for GEO-INFO

jects. Records created in dBase, Paradox, Oracle, Microsoft Access and other ODBC compatible databases can further expand the data package about the objects. The system can also work in the on-line mode with other non-standard databases. These are MSEG –The Land Registration Database (cadaster), ZUD – Department of Project Documents Coordination and OSRODEK – Geodetic Documentation Center. The connection to the above databases goes through special interfaces.

Map Making

Since the GEO-INFO map is a projection of a database content it can be created in any given moment. Thus, in the system, there are special mechanisms that generate (automatically draw) maps on the screen. Kinds and number of objects, the scale of symbols and the area the map covers depend on the user (see Figure 3). The user, somewhat, automatically becomes an editor of the map through his own choice of the information from the database. The following maps can be created using the system:

- land and buildings registration maps,
- individual house-building maps,
- multi-storey housing blocks focused maps,
- manhole location maps,
- forest maps,
- water supply grid maps etc. (see Figure 4).

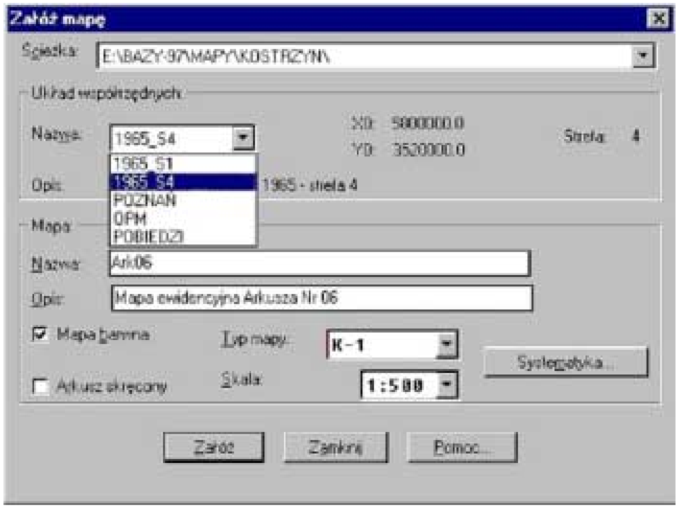

Figure 3. Creation of a particular map

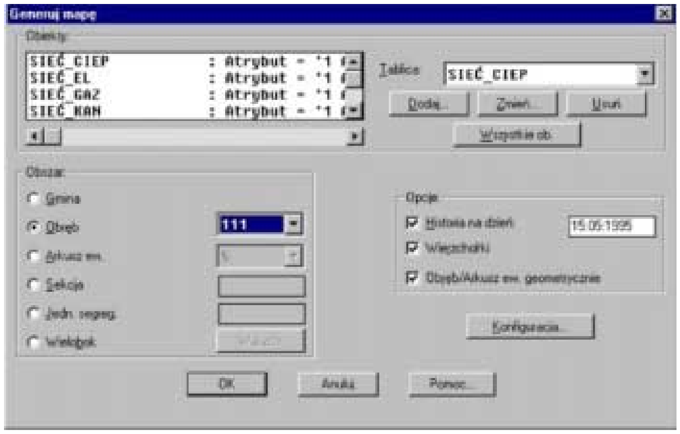

Figure 4. Options for creation a contents of a map

Similar mechanisms are used to create thematic maps with special effects of database processing additionally introduced there i.e. residents location (number of tenants in the buildings), terrain utilization, issue date focused construction permit specifications, topically arranged billboard placement, road condition info, land development maps, land cultivation maps, historic object maps etc. Thanks to the edition-time information stored in the database it is very easy to create a map of any historical time.

Before generating the map is possible one has to define the objects in the GEO-INFO database. Hence, there is yet another method of making a map like this. It is created alongside with the process of data input concerning location and shape of the objects. Defining the objects in the database is supported by source documentation such as: sketches, field books and coordinate lists. One can also develop the database using batch-files, map digitalization and raster drawings. The user can observe the on-going process as the data input goes simultaneously with the map making procedure.

System Control

The system controls the whole process of data input through a set of analyses and automatic or manual object control mechanisms. There are special functions that generate “geometrical and information error” reports. The errors are immediately corrected or a solution is prompted. Any user in the same network, irrespective of who made the modification, immediately recognizes any data modification in the system. A modification like that can be easily generated on a current map.

Each of the users has his/her own system configuration and each object stores information about the user who made or modified it. All the operations are supervised for GEO-INFO standard compatibility. If any error occurs a message pops up on the screen. Many of the functions work in the “warning“ mode, thus helping the user make a right decision. You can store the map that was created along with data input for further use or quit it. In the GEO-INFO system there is no such thing as a map loss. It remains as a virtual net founded on the objects in the database.

Methods of Collection and Processing of Information about Objects on Digital Map

The information about objects saved in GEO-INFO can be obtained by:

- pointing a cursor to one or more graphic elements that represent objects on the map,
- a semi-SQL with filters and object interrelations to a system database
- an SQL to external SQL databases through a system base

Additional descriptive information about the objects can be obtained from other non-standard GEO-INFO related databases in the on-line mode through special interfaces (see Figure 5).

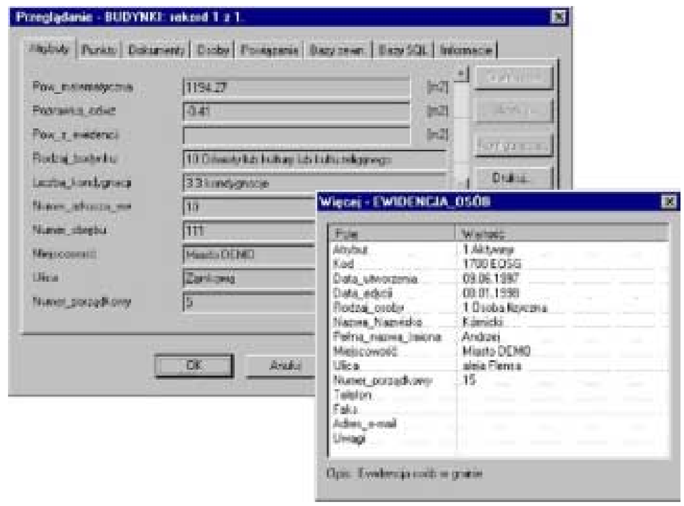

Figure 5. Information about an object

Management of the map sections, location and their emblems are available attributable to the mathematical rules of coordinate systems active in GEO-INFO. In order to identify a section all you have to do is choose a spot on the map.

GEO-INFO provides information, which is a result of data processing in the system. Here are a few examples:

- the locations of water, energy supply grids etc. in the surface objects (e.g. electric conductor location and its length in particular lots),
- mutual relations of surface objects (e.g. presentation of cultivation plan or location of buildings in the lots with respect to the number of storeys),
- finding the shortest way between two points,
- finding a common way for two linear objects (e.g. water supply grid failure),
- land registry formation in the cadastral survey renewal,
- 3D digital terrain model and any sections of the terrain with network junctions (underground and overhead networks, curbs, boundaries, buildings etc., see Figure 6),
- ground mass calculation and ground works optimization.

A variety of analyses and checkups can, too, be carried out thanks to this system. These are:

- land registry checkups and reports (e.g. identification of lots that belong to one proprietor, land location with respect to register groups etc.),

- reports and checkups in Geodetic Registry of Land Development (GESUT) management,
- automatic control over geometrical digital map cohesion,
- interrelation of objects analysis (closely situated objects or repeated objects detection),
- importation, batch-files (digital resource automatic update in the documentation center).

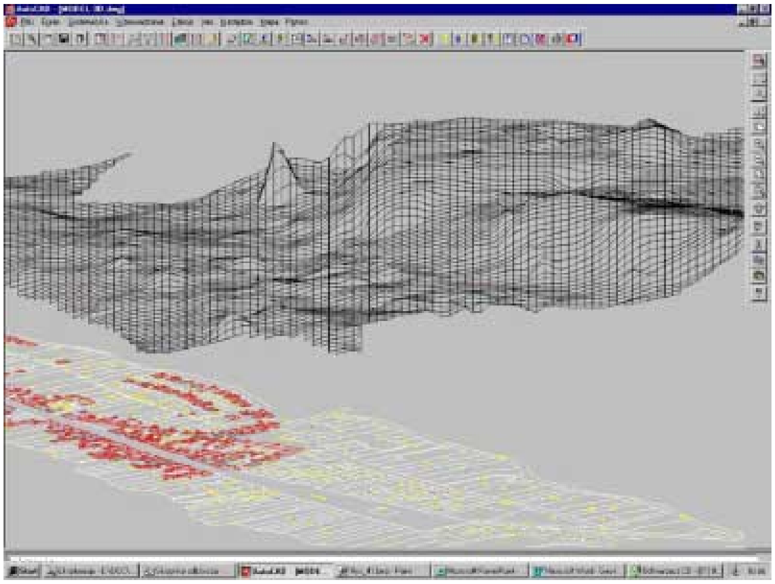

Figure 6. Digital Terrain Model created using system tools

There is a significant function in the system called "operating a map without a map". As already mentioned all the operations in GEO-INFO take place in the database. This means that from the point of view of the system a map in its graphic form is unnecessary and can only be perceived as an additional feature. A user with some experience and, of course, some imagination can work on schematic maps of cities or communes getting all the descriptive and graphic information from a "clean" map. If there is a need of plotting the map on paper it is simply generated from the database.

The generated reports can have manifold graphic and text forms. You can give a system dispositions such as:

- text report preparation in a pre-defined form (e.g. reports GESUT compatible, see Figure 7),
- report preparation in the universal data exchange standard SWING (Geodetic Information Exchange Standard)
- compound database operation report (batch-files, export, import, analyses),
- search and print of object-related documentation (photographs, sketches, drawings, copies of original material and text files),
- preparation of a document called "map and description" (graphic information about the lot together with cadastral information),
- data processing based graphic report preparation with a legend.

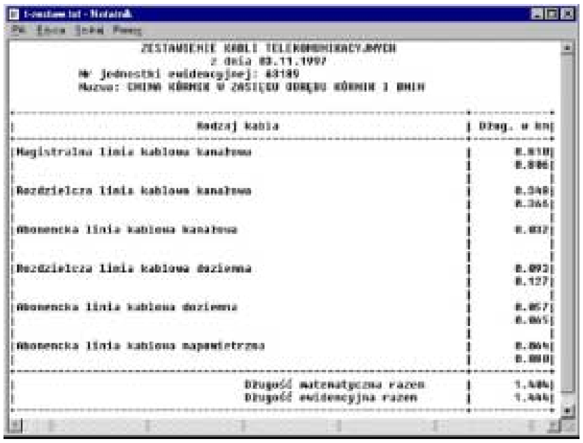

Figure 7. Report in pre-defined textual form

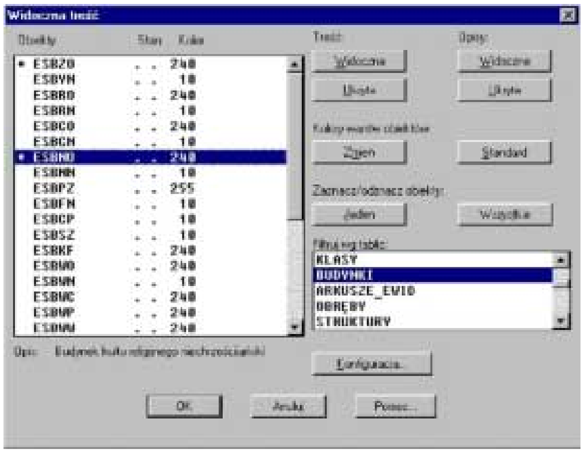

Figure 8. Creation of non-typical map

You can moreover:

- define your own format and make it a standard for further use (configuration of specifications),
- make a report in any format for temporary use,
- make a report for spreadsheets (MS Excel),
- print the content of any record/s together with related information.

Examples of tasks carried out by the system

It is, of course, impossible to name the manifold applications of the data in the system. The tasks usually are realized after a command has been given. Here are a few examples of tasks that the system can perform:

- create a map in the scale 1:500 of a selected land along a street containing buildings, lots and the water supply grid,
- create a dominion map in the scale 1:2000 for any record map sheet highlighting the undeveloped real properties and give their size,
- create a map of the terrain assigned for individual house-building in the local plan of land cultivation (see Figure 8),
- provide information about a given lot with respect to its size, proprietorship, distance from the street and value,
- show details about land and mortgage register pinpointing to the areas they refer to in relation to the lots,
- provide information about the building concerning the basement area, distance from the boundary, its main function, its functional area, front elevation, internal gas supply scheme etc.
- provide information about a water supply hook-up with respect to kind of material used, its length, building proprietorship, survey data allowing the circumscription of the grid on location, contractor and build date,
- provide information about a sewer system e.g. a gutter and show specific data from inventory documentation (survey data allowing localization of a buried gutter or date of last cleaning),
- disclose the main investor of the gas grid shown on a map,
- show divergence between designed location and real location of a building,
- show the function of a building in the local plan of area development,
- find and highlight on a map buildings that meet specified requirements or find and highlight lots belonging to one proprietor,
- show a sewer pipeline of specified diameter on a map,
- show disabled water pipelines only or pipelines of specified characteristics on a map
- prepare a calculation of telecom network length in particular lots etc.

GEO-INFO Standard and Technology

The idea, construction solutions and new techniques have led to the creation of the GEO-INFO standard fully integrated with the manufacturers and users of large-scale digital maps. The GEO-INFO makers and users have spent many years collecting documentation, programming computer systems, thus gaining invaluable experience leading to the creation of that standard. Continuous care and supervision over it gives all its users reliability and full compatibility of the system. Such a standard provides uniformity of the database and digital maps especially for the users for whom the map is the basis of their professional work. The GEO-INFO standard is an application compatible with current instruction types ready to work without reconfiguring your PC, installing any additional software or any interference of specialists. The standard allows further use of the

GEO-INFO database information and drawings in other applications.

The GEO-INFO standard includes:

- a complete set of codes for every objects of the digital map,
- reference format of the records of all the objects,
- a clear division of graphics and text information,
- an original way of numeration and its full control,
- automatic operation on coordinate systems,
- automatic operation on area division: a commune- region- record map sheet,
- checkups and standard verification,
- five Polish uniform graphic map standards.

Despite the fact that GEO-INFO standard formation seems to limit non-typical operations there is a possibility of controlled modification. This function aims at allowing a user to enclose documentation, create graphic objects and enter his/her own information to the database. Additionally you can enclose information concerning people related to given object, modify already existing legend and change record configuration. The changes are recognized by the system and, what is more, it updates the standard rather than breaks it. The changes can, too, be transferred to any user of the system.

GEO-INFO Technology

Preparing a tool for map making in GEO-INFO is not the only prerequisite for a flawless implementation and functioning of the system. A specified operation technology based on many years of experience is essential as well. It assures consent of the orderer, performer and user of the database resources.

GEO-INFO technology includes:

- uniform digital map standard creation in a given region (methods of collection, updating and edition),
- specifications of technical terms in digital map making agreements,
- additional materials and technology description as an update to the user's manual (see Figure 9),
- exchange of experience (seminars, training and on-going service),
- an independent GEO-INFO module OMEGA as an additional tool for GEO-INFO data processing in "read only" mode (no possibility of modification).

Figure 9. Technology description and user's manual for GEO-INFO 97

Session / Séance 33-D

Revision of Maps Registrating only True Changes

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Abstract

For the past 4 years National Survey & Cadastre in Denmark has been producing a new vector map in scale 1:10.000 covering Denmark. The map carries a promised 5 years revision cycle. The updating procedure is based on the direct registration of changes. If an object has changed the operator should registrate only the part of the object that has changed. The new registrates are only 'plus/minus' and there is no need for external producers to know or hold actual database-keys to excisting database objects. After the 'plus/minus'- registration automatic computer-programs will add or subtract the new objects and create the new map.

Introduction

Over the last 5 years, KMS has produced a vector map in the scale of 1:10,000 (TOP10DK) which is to cover the whole of Denmark. Last year, the updating of the map began in some areas and it continues this year in new areas.

When we were about to start on the updating task, it was the first time that we had to update such a well-defined, well-structured topographical data set and we therefore had the opportunity to construct a new updating method from scratch.

We chose a method which is exclusively based on the registration of changes. Previously, for example, [Langran, 1993] proposed an equivalent method. The method we chose is described below. It differs primarily from the method described in [Langran, 1993] in that, in addition to saving the original data and change data, it also saves updated objects corresponding to each time of validity. Therefore, at the time of extraction, there is no need to perform any special geometrical data manipulations to obtain the finished map.

The Danish TOP10DK standard

TOP10DK is a highly organised vector atlas which covers Denmark in a resolution of 1 metre or better. All TOP10DK registrations are made on the basis of new aerial photographs and a subsequent field examination.

TOP10DK has very strict specifications both for what is to be registered and how it is to be registered, and the registrations are all subject to a strict completeness check and topological check to ensure that the rules laid down are complied with.

Since the establishment of some of the first areas and up to now, when the first updates are being performed, the TOP10DK standard has remained relatively unchanged. A few new subjects have been added and there have been a few other modest changes, for example in the handling of the z co-ordinate, but in general the standard is unchanged.

In relation to the updating process described here, TOP10DK can be regarded as a purely topographical atlas which does not contain references to external databases, added names, etc. The map is a "naked" registration of the topography of Denmark.

After the establishment of the topographical atlas, names and external database codes are added, but this part of the process is not described in this paper.

For the following, it is also essential to know that all object categories (codes) in TOP10DK have a 4-digit object code in the range 1000-9999.

An example of a TOP10DK map is shown in Figure 1.

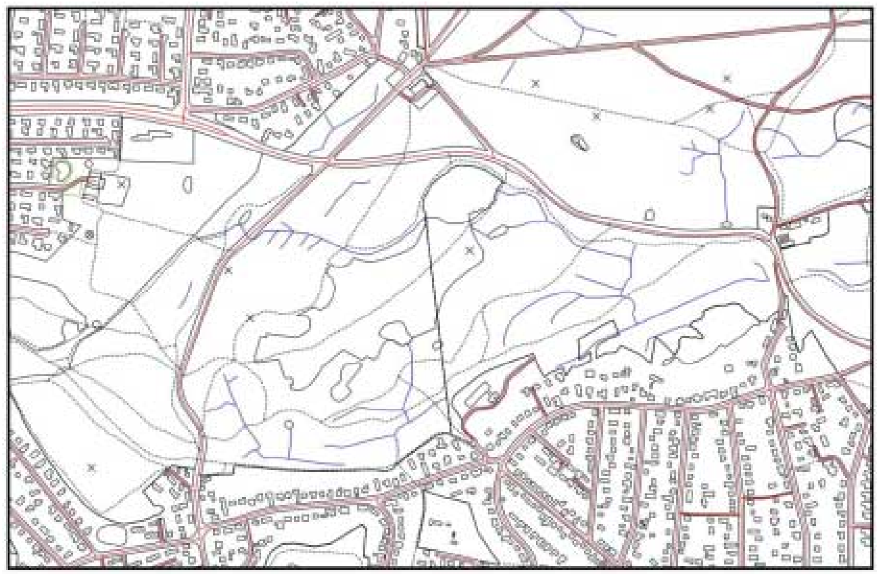

Figure 1. Example of a TOP10DK vector registration.

5-year updating

When a decision was made to establish TOP10DK, it was also decided to update TOP10DK every 5 years. This means that, at the latest after 5 years, new aerial photographs will be taken and a new field examination will be performed on the basis of which the vector atlas will be updated.

The first updating time for various parts of Denmark is shown in figure 2.

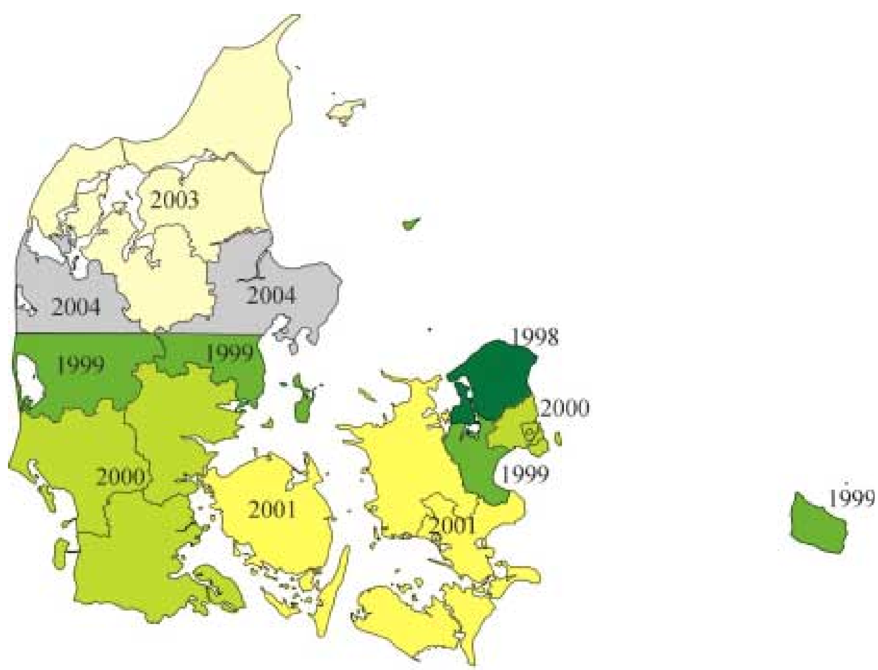

Figure 2. Updating plans for the TOP10DK vector map

At an early stage, it was decided that the taking of aerial photographs and the subsequent registration of changes would be performed as contract work outside KMS. The process is, therefore, that KMS invites tenders for the updating of an area, receives tenders from various possible producers, chooses a producer and then receives updating data for the area in question from this producer.

After receiving the producer's data, the change data undergoes an automatic topological check and a manual check for completeness, and the total resulting data set after updating is examined in a field examination. These processes are performed by internal staff.

Requirements concerning updating

Before choosing the updating method, various requirements were made both for the updating process and the updated data.

There was a strong requirement for KMS itself to be in control of the whole updating process, including for all the problems regarding database-keys both to external databases and to the topographical TOP10DK objects themselves to be handled by KMS itself. I.e. no database-keys to the data producers.

One of the main requirements for data was that the final data material should show which points had been newly measured and which stemmed from previous measurements. In TOP10DK, lineage information is attached to each point in each object, which makes it possible to see when, with which instrument, with which accuracy, by which operator, etc. the point was measured. It was required that this information be saved in points which were not newly measured and changed in points which were newly registered within the same object.

Moreover, it was required that the updating process should, as far as possible, support the transfer of attached database-keys and names from the old topographical objects to the updated topographical objects.

The updating process chosen

New objects

Where completely new objects (i.e. objects which were not present in the old registration) are ascertained in the aerial photographs, the new object is measured and assigned an object code equivalent to the TOP10DK object code for the object type in question + 10.000 to indicate that it is a new object.

Objects to be removed

Where the aerial photographs show that registrations which exist in the old registration no longer exist, the producer must make a copy of the old registration and assign the copy the object code for the object category in question + 20.000 to indicate that it is an object to be removed. By having the entire geometry of objects to be removed returned from the producer to our database, it is possible in the database unambiguously to identify the equivalent object and have it removed without using the database-key for the objects.

Corrections to line and area objects

The above procedures concern objects which are either completely new or are to be completely removed. Where it is necessary just to make a correction to an old object, the procedure outlined in Figures 3-5 is used.

Area objects

If there are changes to area objects, the parts in which a change has occurred are registered anew. If, as in Figure 3, the changes are in a forest, firstly, therefore, those areas which are now forest but are not registered as forest in the old material are registered, and, secondly, those areas which are registered as forest in the old material but are not forest in the new photoes are registered. The registration process therefore requires that the operator has simultaneous access to both the new material and the old registrations. In order to ensure that the subsequent linking of existing objects and change objects can take place automatically, it is important that the lines at which the two objects adjoin one another are identical in the two objects. In this way, the programs can immediately see that these objects are to be handled together.

In order to be able to distinguish between additions and deletions, the two change object types are assigned codes for new and objects to de removed, i.e. + 10.000 and + 20.000.

The method can produce special problems where several area objects which are not to be combined adjoin the same change object (see figure 4). This case occurs seldom in TOP10DK. The only area objects of the same category which may adjoin one another without being combined are buildings where there is a change in building height of over 5 metres. If nothing special is done, the two existing objects and the change object will all be combined to form one new object. In order to solve this problem, in this case it is necessary to mark not only the addition of the object but also the object to which the addition is to be added. We have chosen to mark this using a line object which is marked with a special object code and runs along the line(s) which is(are) *not* to be removed.

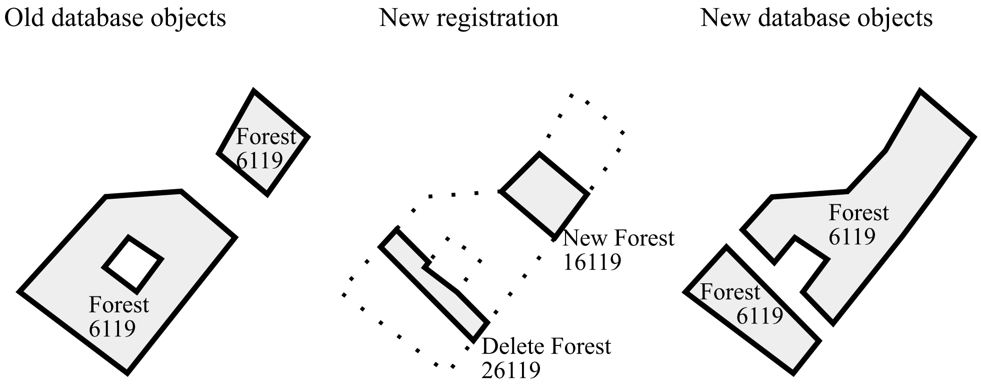

Figure 3. Updating process for area objects

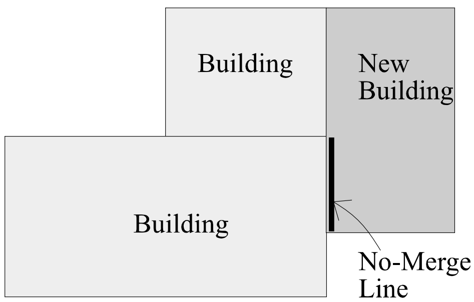

Figure 4. Updating process for area objects. Change registration should affect the minor building only

Line objects

An equivalent method is used for changes in line objects. Parts of a line object which are to be removed are registered as removed with the object code + 20.000 and parts which are to be added are registered with the object code + 10.000 (see figure5). Where there is a changed course of part of a line object, it is registered as two changes, firstly as an object part which is to be removed and secondly as an object part which is to be added. The objectparts to be removed can be in the centre of an object so that the object is divided into two objects, and new object parts can link two existing objects which then become one object.

Updating z co-ordinates

In particular in the previous TOP10DK registrations, there may be errors in the z co-ordinate while the xy co-ordinates are satisfactory. In these cases, the producer does not need to update the whole object to replace the z co-ordinates but needs only to make a point object with the correct z value in the layer for the corresponding object category + 30.000.

Computer programs will subsequently, on the basis of a database extract, search for an object point in the same object category - 30.000 close by and automatically transfer the new z value to this point in the object.

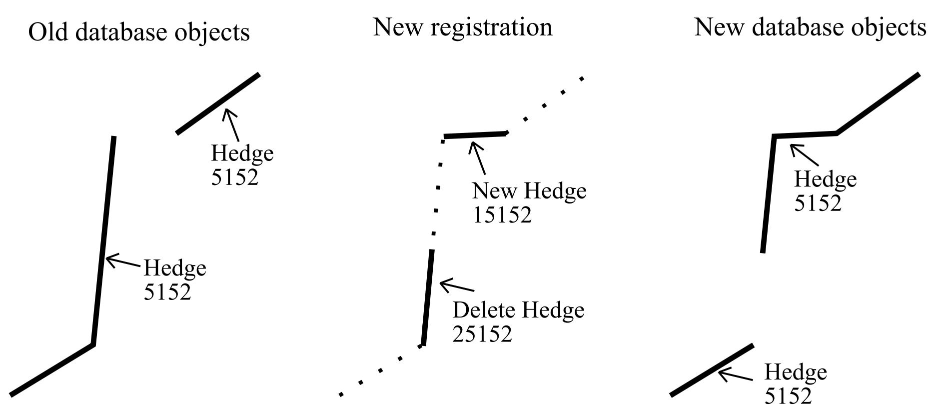

Figure 5. Updating process for line objects.

References between new and old objects

To update other databases which are based on the geometry of TOP10DK objects, it can be expedient to have references between old registrations and new registrations which are expected to represent the same object.

In updating via change objects as described above, there is direct designation of which old objects have become which objects by means of which change objects. As an integrated part of this updating process, the computer programs therefore create references between the new and the old objects. The updating strategy directly supports this link and the link does not need to be established via special programs (see figure 6).

Computer programs find these references and use them in a subsequent updating of the names, where the object names are automatically moved from old to new objects. However, these references are not currently saved in our databases. The lack of storage is on account of a lack of programming resources and we expect to return to this matter within the next year.

Objects in which the only change is the insertion of an interpolated point (see Figure 7), or a change in the z co-ordinate in accordance with the procedure described above, are entered in the TOP10DK database as a new version of an object under the same database-key as the previous object. For these objects, it is not, therefore, necessary to establish references between old and new objects as both are stored under the same database-key but with different time marking.

Topological relations between new and old object parts

Generally, intersection points are inserted in TOP10DK objects where objects overlap one another, and a registered point must not lie within 1 metre of another registered point or line unless snap has been performed and the points or the point and line coincide.

These snap and intersection rules do not, however, apply between objects which do not coincide in time. Updated objects may, therefore, intersect with removed objects without an intersection point having been inserted, and co-ordinates may be close to removed co-ordinates without being coincident. This strategy has been chosen because we do not think that users have any great need for these intersections and snaps and that the extra points would, on the contrary, be regarded as superfluous.

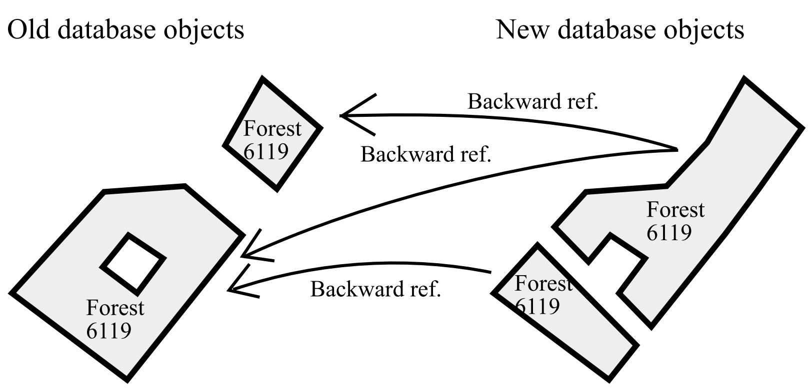

Figure 6. New objects carry references to old objects.

Edge matching

Updating data is received today in batches which cover an area of 10 km x 10 km. Large objects can pass through several such blocks. With the method chosen, the updating of all objects (and therefore also the large objects) takes place locally. This means that two operators/producers may produce updating data on the same object at the same time but in different blocks.

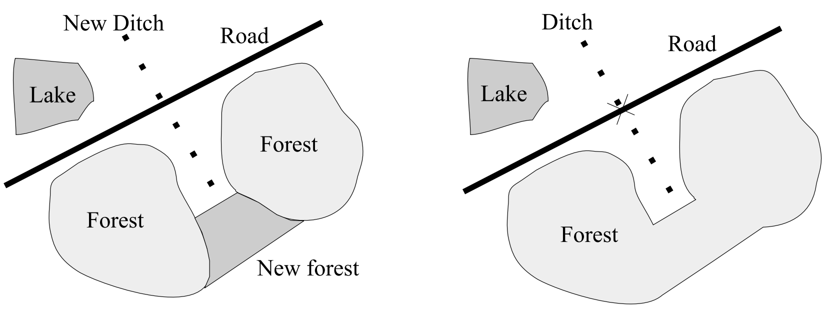

Figure 7. The updating process. Illustration to be used with Figure 8.

Only if the actual change concerns the border between areas with different operators/producers is it necessary for co-ordination to take place in order to ensure that the two updating objects match. If this matching has not taken place, it will usually be obvious when the data is received and it will often be possible to repair data without gathering further information.

Organisation of the database

The database structure will not be described in detail here but, in order to understand certain overall principles, figure 7 and the accompanying diagram in figure 8 illustrate the entries which can be made and the times of validity which the resulting objects will have.

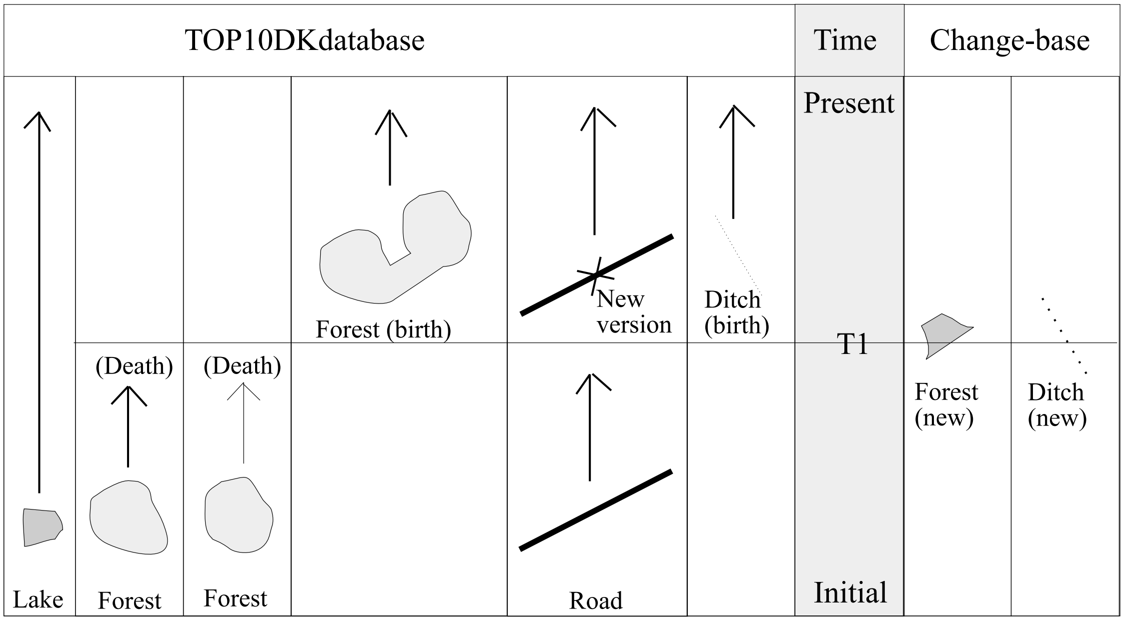

Figure 8. The updating process in the database. The scheme illustrate database changes caused by the map updates illustrated in figure 7.

The example shows two forests which, at the time of updating, have grown together to form one forest. At the same time a new ditch has been added which runs under an existing road. The diagram shows that the two existing forest objects in the database are marked as removed at the time of updating and that, at the same time, a new forest object and new ditch object have been added to the database. At the time of updating, the road object has been replaced by a new version of the same object. The new version contains an intersection point with the ditch.

In a separate database, the new forest areas and the new ditch are stored as change objects. Please note that the objects in the TOP10DK database have a period of validity while the objects in the change database only have a time of entry.

Experience of the new updating system

Updating the two first areas of TOP10DK had the problem that the areas were used as commissioning and test areas during the establishment of TOP10DK. On the basis of the experience of these areas, changes were subsequently made in the TOP10DK specifications, and our internal check tools had not yet been prepared. For these areas, there was therefore a very high number of both corrections and errors, which made the updating of the areas disproportionately expensive.

In general, data producers thought that the new updating method is good and some even said that it is a realisation of the method about which they had been talking for years. However, at the same time we have had to note that the producers are unaccustomed to the method and that even producers which previously supplied establishment data for TOP10DK require a considerable commissioning period.

To support the commissioning, we have therefore prepared a package of check tools which enable the producer to check his updating data himself for a wide range of common errors. With this package and with the build-up of more experience by the producers, we expect the prices of the updating data to fall drastically in the year to come.

Reference

Langran, G. (1993). Time in Geographic Information Systems.Taylor & Francis, London.

Session / Séance 30-B2

New Methods to Meet New Demands on Small Scale Databases at the National Land Survey of Sweden

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Abstract

To meet changing client demands and to adapt to the changing economic environment the National Land Survey of Sweden (NLS) has, during the last decade, further developed as a highly technical surveyig, mapping and cadastral agency. Using the latest technologyfor the acquisition of aerial photography , orthophoto production and for data storage and maintenance, the production and revision of the Fundamental Geographical Data (Grundläggande Geografiska Data - GGD) is today completely digitally based. This database provides the source material for the production and revision of the small scale cartographic databases at the scales of 1:50 000 and 1:100 000. This paper describes the measures taken to develop this system and the initiatives taken to support further development of an efficient and cost-effective production line for small-scale database revision.

Introduction

The National Land Survey of Sweden (NLS), originating from 1628, is a Government agency under the Ministry of the Environment. The mission is to give support for creating an efficient and sustainable use of Sweden´s real property, land and water. The organisation has three main activities, which also form the organisational structure: Cadastral services, Land and Geographic Information Services, and Metria (working on a competitive, commercial basis). Support for these activities is provided by Corporate services. Swedesurvey is the overseas agency of the National Land Survey of Sweden.

The total staff amounts to 2 400. The headquarters is situated in Gävle. The annual turnover is approximately 1 400 million SEK. 1 000 million SEK are generated through fees and invoiced costs for real property formation, the use of information from databases and for consultancy services; core grants from Government amount to approximately 400 million SEK. Core grant financing is primarily used for producing basic data and managing and maintaining registers and databases.

To fulfil its responsibilities with respect to national mapping, NLS provides cartographic data in several, colour-coded map series. The Yellow Map series contains basic geographic data in cartographic form at a scale of 1:20 000. The data is extracted directly from the GGD database (c.f. below). The digital version of the Green Map series at a scale of 1:50 000 currently covers about 25% of Sweden and contains general topographic information and the Blue Map series at a scale of 1:100 000, also called the “road map”, contains up-to-date information about the road network. In addition to this main series several small-scale map series are also available as well as vegetation data [Näslund-Landenmark, 1997].

New Methods to Establish Databases

Background

Starting with computer-aided map production some 20 years ago, in the late 1980´s it became increasingly accepted that it was the databases that were the foundation for the map production and for other applications whereas previously it had been the maps that formed the basis for the digital data. The cartographic work required for producing the maps would, however, still for a long time be integrated with the data capture. The databases were built up over a long period of time, each period having its type of base material, methods, prerequisites and priorities. This naturally resulted in a certain degree of heterogeneity regarding content, currency and production routines.

In the early 1990's NLS produced two different databases at the scales of 1:10 000 and 1:50 000. Each database was produced separately, with somewhat different content and in different production lines with separate field-work. Since this was neither a rational nor cost effective way of working it was decided to move towards the establishment of one co-ordinated database.

Fundamental Geographical Data (GGD)

In 1995 the creation of the Fundamental Geographical Data (Grundläggande Geografiska Data - GGD) database commenced. The main goal was to co-ordinate the production and updating of cartographic databases based on the GGD database (see Figure 1). Efforts would concentrate on the creation and updating of the GGD database from which the separate cartographic databases would be created, taking contents, specifications, scale etc. into consideration [Persson, 1995]. It was also recognised that it would be necessary to develop methods for updating and automating cartographic editing. Moreover, GGD could meet the demands from other applications, such as transport planning, urban and regional planning etc.

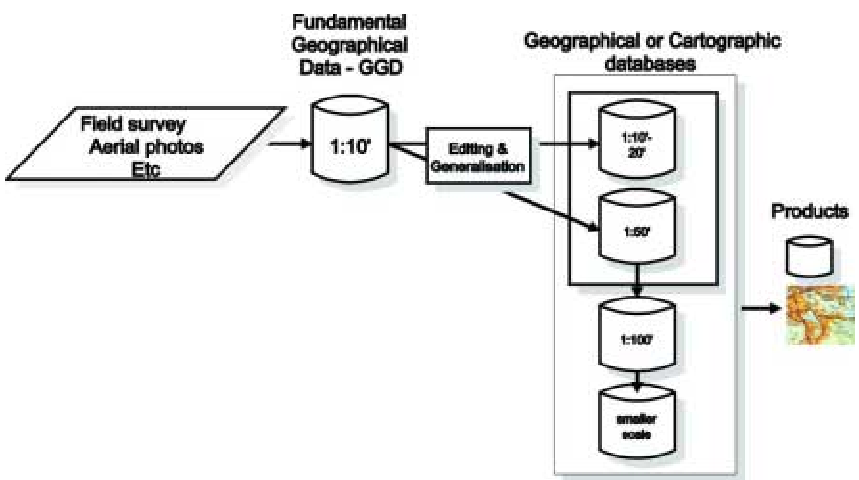

Figure 1. The concept of GGD as defined in 1995.

GGD has now been in production for almost four years and, so far, the database contains almost 4 000 map tiles and over 10 million map objects. GGD is planned to be completed by 2003 and will contain a total of 19 000 tiles.

Did we Succeed in Creating the GGD Database?

The work with the GGD database can be divided into three major parts. These are:

- Specifications
  - Creation of a specification for the fundamental geographical database.
  - Creation of a specification for the cartographic database at the scale of 1:50 000.
- New routines and methods
  - Integration of data capture (fieldwork).

- Establishing new routines for compilation of the GGD data to produce a cartographic layer for the Green Map at the scale of 1:50 000.
- Updating

Specifications

The first important step to be taken was the creation of specifications including entity catalogues. This meant many intensive and important discussions about the content of GGD. The result was the creation of specifications that were very well established in the organisation.

Each object in the specification has information about the following:

- Definition.
- Classification code.
- Selection criteria.
- Geometric representation.
- Positional accuracy.
- Topological relationships.
- Data source.

The specifications are updated at a regular basis (at least once a year).

New Routines and Methods

Another important step to be taken was the co-ordination of fieldwork. It was recognised that a necessary step to make this possible was a more integrated planning for the production of the different databases.

The fieldwork is followed by compilation and storing of data. New routines for compiling and generalising GGD have been developed. To create the database at the scale of 1:50 000 the compilation is done automatically for some objects such as land use and buildings whilst for other objects, such as roads and boundaries, manual editing is still needed.

A result of the co-ordinated production line is that a new organisation has been introduced. Earlier, production of the two different databases was carried out by different groups. These groups are now integrated and benefit from each other's knowledge and experience.

Updating

A goal for GGD was to improve updating and update only one database. Since the integration of the production lines has been introduced and some automatic routines have been developed for the compilation to 1:50 000, the goal has partly been achieved.

Work Still to be Done

Although we have taken a major step towards a more cost-effective production line, there are still improvements to be done. These include:

- Improvement of the specifications with more examples of topological relationships between objects, how to collect data and how to perform generalisation of objects.
- Methods for data capture for some of the objects, such as clear cuts and roads.
- Improvement of methods for updating of GGD such as routines and co-operation with other authorities.

New Demands

NLS is now involved, at the broader national level, in the generation of specialised data sets of importance in several sectors of Swedish society. One such involvement is the establishment of a national road database, another is the conversion of historic map treasures to digital form. NLS is the authority responsible for completing the Swedish CORINE Land Cover which will be produced by 2002, [Syrén, 1999]. These new data sets are often based on existing data held by NLS together with data from other sources. This may have an impact on the specifications for, or the information in, the existing databases.

During the past two years NLS has undergone major organisational changes. At the same time government funding has decreased and a part of the production has been out-sourced. The production of the GGD database has high priority, and, at the same time, the need for updating is high, both concerning the GGD database and other small scale data.

As a consequence of the constraints imposed by decreased funding, different steps will have to be taken to meet demands regarding the quality and currency of the different databases. One is, as mentioned earlier, co-operation with other authorities in updating.

The production lines, both for GGD and for the smaller scale data, will also have to be rationalised. Some parts of the production processes are still based on analogue methods and the different parts need to be further co-ordinated. In reality, smaller scale data will still, for some time, be updated both from GGD and in separate production lines. One reason for this is that some features are not represented in GGD but only in other databases.

New Methods for Database Revision

A revision policy incorporates the determination of mapping needs, the selection of suitable revision techniques and evaluation of the resources needed to undertake a practical revision programme. As a concept the present GGD cannot satisfy all the requirements for the present small scale databases. For example:

- the revision intervals for some objects are shorter than for revision in GGD.
- there are objects in the small-scale databases that are not included in the GGD database.
- the GGD database still does not cover the whole of Sweden.

To satisfy these demands revision procedures that focus directly on the revision of the small-scale databases have, therefore, been developed.

The demands placed on these production lines included; decreased cost, increased productivity, maintained high quality combined with a capability to produce the same even quality of output from a variety of data sources. These four factors, together, have steered the choice of the technology that has been introduced to meet the demands for efficient methods for partial revision of the Swedish small-scale databases. The end result should be a working system that adequately supports the present GGD concept with respect to information gathering, storage and dissemination. Some of the initiatives taken by the NLS to meet these requirements are outlined below.

Decreased Costs

Against the background of the current financial constraints under which NLS and most other Swedish government agencies operate, decreased costs is one of the most dominant requirements. Traditional analogue map revision is a resource-intensive exercise that does not utilise the benefits of modern digital technology. However, to fulfil some of the needs for rapid and cost-efficient revision of the Green and Blue Map series, NLS has recently begun to test a fully digitally based production line for revision of forest clear-cuts and roads [Rydén et. al, 1998]. The model has been the digital photogrammetric systems that are in use at many mapping agencies for the creation of large-scale databases.

However, it was considered that the installation of such systems would be “overkill” in terms of costs and training requirements considering the database specifications for forests roads and clear-cuts. As Arc/Info applications had, for some time, been used for editing digitised map data, it was decided to develop application based on the Arc/Info software. This made it possible to integrate the digital revision line into the established working environment without making too many changes to the workflow. Using NT workstations the operator can link himself to the databases containing the data needed for the revision and all editing can then be done on-screen (see Figure 2).

Production lines of this kind can be based on any standard GIS platform to which special applications can be added. By moving away from highly specialised analogue and analytical instrumentation and, instead, using GIS production tools, it has been possible to considerably shorten the learning curve, thereby promoting a balanced and efficient mapping procedure.

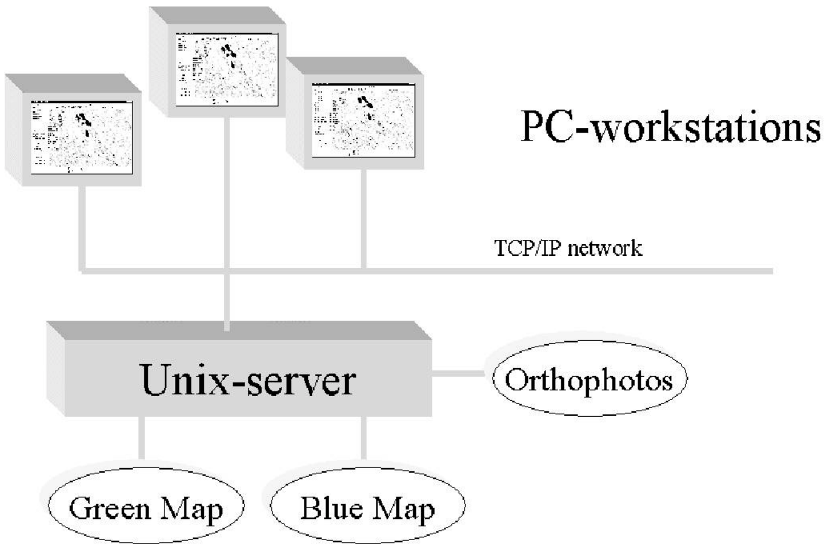

Figure 2. Using NT workstations the operator can link to the databases containing the data needed for the revision and do all editing on-screen.

In the new production line, digital orthophotos are used as backgrounds to the existing vector databases that are interactively edited on-screen by the operator. Changes that are made are directly added to the database which is then instantly updated. In the case of road revision, this methodology has been most proved its worth. New roads are identified and digitised on-screen thus minimising all former analogue steps in the revision procedure. Compared with the conventional way of revising the road database this method reduces the time needed by 50%. It is also expected that the time saved will increase as the operators get used to working directly on a computer screen.

Increased Productivity

To increase productivity in map revision methods for detection, identification and delineation of revision objects must be effective. In this context, the use of semi-automatic methods for revision is of great importance. For example, in the new production line, NLS has built in an Arc/Info application that gives an operator on-screen suggestions for identification and delineation of clear-cuts. The suggestion made by the application is displayed on-screen in a vector format and the operator can then accept or reject the suggested delineation and also make cartographic adjustments to it where necessary.

As the revision of clear-cuts was formerly a tedious procedure automation has made a significant contribution to increasing the cost-effectiveness of the revision. In fact, the actual procedure of detecting all potential clear-cuts takes only some few minutes as compared to hours with conventional methods. Totally, including on-screen editing, revision time is cut by half as compared to revision using conventional methods. The operator can also adjust the application to a desired mapping scale simply by changing the minimum mapping area that is to be detected. This makes the application independent on scale and map specifications.

Although many mapping organisations adopted monoscopic solutions for rapid and cost-efficient production of large and medium scale databases long ago, semi-automatic object detection has, so far, not been reported as being in operation at any national mapping agency. At NLS, the development of a revision line that also incorporates semi-automatic methods is, therefore, seen as a major break through in map revision using digital data. This is not only because it shortens the revision time but also because it will prepare the way for semi-automatic detection and delineation of other objects of interest for our databases.

Maintained High Quality

It is important that the new methods do not compromise the quality of the output, regarding both the methods themselves and the data that is used for the revision. The increased interest in using high-resolution satellite data as a source for partial revision of roads and clear-cuts has also emphasised the need for defining data quality. In this respect, NLS collaborates with the Royal Institute of Technology in Stockholm and the Swedish Space Corporation. Studies that have been carried out have shown that interpretation of satellite imagery yields results that are as accurate as those obtained from the interpretation of digital orthophoto for revision of roads and clear-cuts [Engberg and Malmström, 1992]. The potential for detecting clear-cuts using semi-automatic methods in different types of satellite data has also been researched. The results show that the satellite data available today is fully adequate for partial revision of the medium scale databases both in terms of detection and completeness [Mahlander et. al, 1996; 1997; Willén, 1998].

Alternative Data Sources

As the use of aerial photographs for partial map revision can be an expensive option and unsuitable in a low-cost strategy, the revision lines that have been developed must be capable of producing output of the same quality from a variety of data sources. We are promised a series of high-quality, very high-resolution satellite data in the very near future and the development of digital revision lines based on digital data has prepared the way for substituting digital orthophotos with satellite data where photographic coverage is not available. Satellite sensors also provide digital data directly from the source for a fraction of the cost of producing ortho-recitfied aerial photographs.

To this end, central WWW sites with information and links to data distributors and producers are becoming increasingly available [Rosenholm and Mahlander, 1998]. On these sites, users have the possibility to search for archived satellite data and also to identify different alternatives to digital orthophotos. On-line quick-looks can be displayed for a first inspection of each individual scene together with data concerning coverage, registration date, registration angle, etc. As guidance in the selection of data, the coverage of the different data can often be displayed as vectors on a map over the area of interest. There is also the possibility to place on-line orders for data together with relevant information about desired geometric corrections. These developments may result in that future revision of roads and clear-cuts in the Swedish medium scale maps may not necessarily be based on orthophotos.

Concluding Remarks

Examples of some other on-going development work in the field of database maintenance at NLS include cartographic generalisation [Davidson, 1999] and data storage techniques. There is also a great need for the development of metadata systems and quality control systems considering standardisation work associated with these fields.

Today, the accuracy of the data is, to a great extent, determined by the type of production line in which the data is produced. Measures need to be developed to assess data quality independently of the type of input data and methods or instrumentation used during the production or revision of the database.

At NLS, smaller scale data will still, for some time, be updated both from GGD and in separate production lines. However, as a result of the work described in this paper, production lines have been rationalised. There will also in the future be a need for testing and developing different data capture and updating methods along with generalisation procedures.

We foresee the implementation and further development of the GGD concept for the small-scale databases (see Figure 3). For example, if lower resolution image data is used in production, a question that must be answered is whether the resulting data, for instance concerning road networks, should be stored in GGD, in the smaller scale databases or as an autonomous thematic database.

Further work with the concept will also involve the use of data from other authorities, other image data sources and the harmonisation of other national data sets, such as the Swedish CORINE Land Cover in this model.

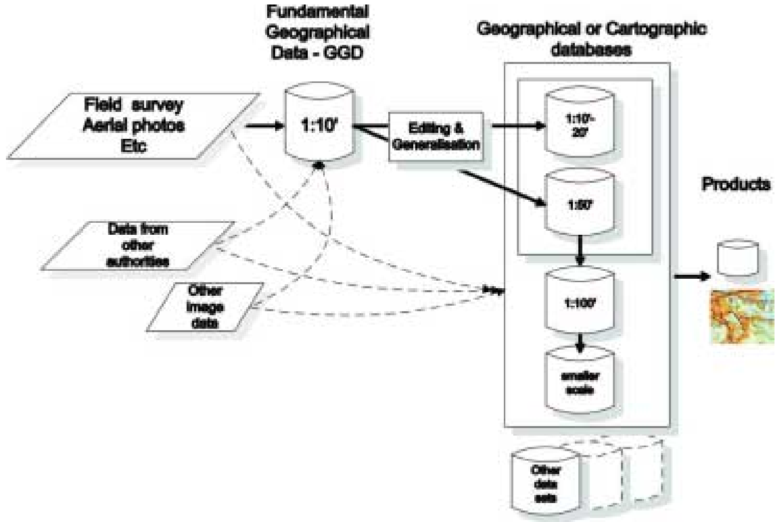

Figure 3. The geographical and cartographic model for production and updating as it is visualised today. The GGDconcept needs to be further developed for the small-scale databases.

References

Davidson, F (1999). Swedish Fundamental Geographic Database and Cartographic Databases, Generalisation and Visualisation. In *Proceedings of Ottawa ICA 1999*.

Engberg, A and Malmström, B (1992). Evaluation of SPOT Data for Topographic Map Revision at NLS of Sweden, In Proceedings of the XVII:th Congress of the International Society for Photogrammetry and Remote Sensing, (ISPRS) Comm IV, Washington DC. *International Archives of Photogrammetry and Remote Sensing*, vol XXIX, (B4), pp 557-562.

Mahlander, C, Rosenholm, D and Johnsson, K (1996). Semi-Automatic Identification of Revision Objects in High-Resolution Satellite Data. *International Archives of Photogrammetry and Remote Sensing*, vol XXXI, (B4), pp 534-539.

Mahlander, C, Rosenholm, D and Johnsson, K (1997). Rule-Based Identification of Revision Objects in Satellite Images. Paper presented at the *10th European Colloquium on Theoretical and Quantitative Geography*, Rostock, Germany, September 6-10 1997.

Näslund-Landenmark, B (1997). Vegetation Classification for Databases and Mapping at NLS of Sweden, *Proceedings of Stockholm ICC 1997.*

Persson, K (1995). Fundamental Geographical Data of NLS - for GIS and Official Mapping. In *Proceedings of Barcelona ICA 1995*.

Rosenholm, D and Mahlander, C (1997). Requirements on Image Data and Distribution for Revision of Topographic Maps. In *Proceedings of From Producer to User, Joint ISPRS Workshop*. Boulder, Colorado, October 1997.

Rydén, A, Engberg, A and Sundström, O (1998). Better by half. In *GIS Europe* November 1998.

Syrén, M (1999). Swedish CORINE Land Cover: A New Mapping Completed by 2002. In *Proceedings of Ottawa ICA 1999*.

Session / Séance 24-C

CEP, CIMIC and GIS. Co-operation in order to do the right things on the right spots.

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Abstract

After the end of the cold war an increasing interest has been focused on Civil Emergency Planning and Civil-Military Co-operation. While the needs for geographic information and systems are well defined within the armed forces, there might be a lack of understanding within civil authorities concerned with emergency planning and military co-operation. The modern society demands an ad hoc geographic information for civil authorities. The information should be compatible with information used in the armed forces. The use of military forces and civil government and non-government organisations for international peace support and humanitarian operations increase the necessity of accurate and parallel geographic information. The Swedish concept of Total defence offers a possibility for co-operation between the armed forces and the most important public functions of society. Recently, a co-operation, under the CEP resolution, concerning major floodings, dam and dike failures" involving geographical, geological, hydrographical and hydrological information has been established.

CEP

"Civil Emergency Planning, CEP, has been the quickest expanding area of the co-operation with the eastern countries within the framework of NATO and the Euro-Atlantic Partnership Council, EAPC", Mr Herpert van Foreest said in an interview for a Swedish magazine. He served 1992-1998 as NATO's Assistant Secretary General for Infrastructure, Logistics and Civil Emergency Planning. "Disasters generally have transborder implications. Civil Emergency Planning is something that combines us, an area where we can work together" Mr van Foreest said.

CIMIC

Civil-military co-operation, CIMIC, has grown both more central and more complex. Today military forces are most likely to be deployed as integral parts of multi-dimensional and multi-national peace support and humanitarian operations together with national or international, government and non-government, aid-organisations. One of the most important lessons learnd by the Swedish forces in Bosnia was the civil-military interdependence. Co-operation between armed forces and civil units has to start early and at the highest level. The exchange of information is by far the most important area for such a co-operation. Accurate geographical, geological, hydrographical and hydrological information, presented in an understandable and useful way to all involved, is one of the basic information needs to be fulfilled. (In the following paragraphs the expression "geographical information" includes geological, hydrographic and hydrological information).

The Swedish concept of Total Defence

The principle of responsibility

The Swedish concept of Total Defence has been the base of the national defence planning since WW II. The general background to this approach is the conviction that a modern or future war will affect every sector and every individual in a country at war. The concept of Total Defence is thus based on the peacetime structure of society. Total defence planning is based on a principle of responsibility; a body with responsibility for a certain public function in peacetime carries the same responsibility in wartime. For instance, The National Land Survey of Sweden, NLS, is responsible for land geographic information in peacetime as well as in times of war. There is no Military Survey Organisation in Sweden. The Total Defence concept is usually defined as *all the activities required to prepare society for external threats and for its reorganistion to wartime conditions should the need arise. Under wartime conditions Total Defence comprises all the activities that society must fulfil under those conditions.* There are three specific advantages with the Total Defence concept:

- It is in line with the demands of modern and future wars
- It is rational from an economic point of view
- It offers possibilities to organise a wide support to society in the event of severe peacetime emergencies.

In the wars of today, and most certainly even to a wider extent in future wars, aggressors will exploit the vulnerable aspects of the modern and future societies, for instance the infrastructure systems. This is one of the reasons why it is important to have a system of preparedness that spans not only military defence but all important sectors of society as well. Another reason is the economic aspect. Modern and future armed forces require huge, expensive resources and knowledge in wartime. Examples of such resources that may be more or less available in the civilian society under ordinary conditions are transport facilities, health and medical supplies and the knowledge of specific and detailed geo-graphical information. To exploit such resources and knowledge, instead of procuring them specifically within the normal defence budget and storing them on a continuous basis in military depots and headquarters, offers possibilities for a better cost-benefit-ratio of defence spending. Although a national defence in the immediate vicinity of a country's territory will profit from such a concept to higher degree than a worldwide used military force, there are resources and knowledge available for the use overseas.

National and international use of Total Defence resources

Until the Parliament passed the "1996 Total Defence Resolution" the Swedish Total Defence concept exclusively was meant for use in a wartime situation. In this resolution it was stated that a new task for the Total Defence organisation should be "to support society in the event of severe peacetime emergencies". This has always been a more or less informally agreed task for the Armed Forces.

International peace operations under UN or on behalf of the UN tend to increase. Since 1956 units from the Swedish armed forces, more than 80 000 men and women, have taken part in peace operations around the world. The "1996 Total Defence Resolution" also stated that the capability of the Total Defence organisations should be able to participate in international peace support and humanitarian operations and deal with civil emergencies. Today the Swedish Agency for Civil Emergency Planning (www.ocb.se) directs and co-ordinates domestic CEP preparations and to some extent Swedish parts in international operations. Other agencies, for instance Swedish Rescue Services Agency, carry out the operative work.

Topographic and Property Information, an important civil function for CEP and CIMIC

Eighteen different functions in society have been identified to be of special importance during a crisis or wartime situation. An agency has been appointed to be responsible for each function. One function is the Topographic and Property Information, TPI. The National Land Survey of Sweden - NLS - (www.lm.se) is the responsible agency for the TPI function. Two other Government agencies take part in the TPI function, The Geological Survey of Sweden - GSS - (www.sgu.se), The Hydrographic office of The Swedish Maritime Administration - SMA - (www.sjofartsverket.se) and The Swedish Meteorological and Hydrological Institute – SMHI - (www.smhi.se) is on the way to join to function. Within the NLS the Total Defence Unit is responsible for the TPI function (www.svenskgeoinfo.lm.se).

Geographical aspect on CEP and CIMIC

The need for geographic information

Almost any activity within CEP and CIMIC has a geographical aspect. An emergency or a state of war can be defined as a situation which deviates from what is considered to be normal, occurs many times rapidly and with few or no warnings. The situation threatens basic values and requires quick decisions and co-ordinated joint action by many parties. In order to do the right thing, on the right spot and at the right time under such circumstances one of the most valuable assets is the access to accurate geographical information. This information must be at hand at short notice. In order to use the large numbers of available information it must be stored, prepared, analysed and presented in a Geographical Information System.

Military needs of geographic information

The days are gone when a printed map was sufficient for commanding officers and soldiers to get an overall view of the battlefield, roads and rivers, forests and built-up areas, plains and mountains. Instead of yesterday's use of almost unlimited force in area bombardment, modern weapons are extremely accurate. You will surely hit the target you want - your enemy's weakest point - if you know where it is. So the demand for accurate and well-timed geographic information combined with high-tech intelligence has increased dramatically. The number of units in the armed forces have decreased due to the effectiveness of modern weapons and the high price of a well-equipped, well-trained and high-alert unit. The fewer units, the more geographical information on various areas are needed. The tempo on the battlefield increases rapidly and lack of information is lethal. The combination and analysis of geographical information from various sources, the fast updating of all units' geographical information systems and a continuous supply of information makes the day.

Civil needs of geographic information

Civil Emergency Planning must follow the same principles. Modern societies tend to grow more and more vulnerable and the access to accurate geographical information might be one of the differences between a scaring incident and a disaster. Rescue operations become more complicated in modern societies and the demands on rescue teams are increasing. Ad hoc geographic information can match some of the demands. The following events have been chosen for emergency planning in Sweden:

- Radioactive fallout
- Serious disruptions to technical infrastructure (i.e electricity supply, water supply, telecommunications, vital computer systems).

- Major floodings, dam and dike failures.
- Mass influx into Sweden of people seeking asylum or help.
- Serious contagious diseases.
- Terrorism.
- Chemical accidents and the release of dangerous substances.

The demands of geographical information due to the impact of these events differ of course immensely. Still there is a need in every event. Another parameter is the time aspect. There is an unknown lap of time before the event, a time during the event - which to some degree might be estimated, and a time to come after the event. Longer or shorter, in almost every lap of time and in every event there is a need for some form of geographical information.

On the issue of major floodings, dam and dike failures a co-operation between NLS, GSS, SMA and SMHI has recently been establish under the Civil Emergency Planning resolution. A two-day seminar and case study in March this year where high-ranked officials from each agency worked together with regional and local authorities paved the way for further and extended co-operation, development of new inter-agencies concepts and in the end a safer society. The use of such a concept on coping with natural or manmade disasters does not stay within the Swedish borders. As well as disasters have transborder implications, preventing disasters, rescue activities during disasters and reorganisation after disasters must be transborder activities and they will all need accurate geographic information.

References

Werger, Svante (1998), The Change is always in the little things. Beredskap, The international Magazine from OCB ISSN 1403-1043.

Session / Séance 30-C

Experiences in Quality Management and Quality Control in Topographic Data Production at National Land Survey of Finland

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Abstract

This paper gives an overview of the developments in quality management and quality control efforts that have been made in the National Land Survey of Finland (NLS) since re-engineering the map production in 1992. In general we have found that the quality system is required and the quality should be one of the key factors when developing geographical information systems. First the paper explains data quality concepts and quality management ideas (ISO 9000, quality awards) and also what is special in the quality of the geographic information. The reality is transformed to the dataset by abstraction using data specifications. All features must be defined and compiled according the data specifications. The quality is defined as difference between the abstract view of the reality and the dataset. Therefor the data specification has a significant role in the data quality.

The paper also explains the quality management implementation at NLS. The Topographic Data System consists of the topographic database (TDB) containing the most detailed general topographic data with nationwide coverage and the map databases, which are generalised using the data from TDB. NLS has an organisation wide data manual which documents the general requirements for quality management. NLS has a quality policy that we call quality guidelines. The Topographic Data Quality Manual defines the processes and responsibilities for sub-processes. The manuals are available in the intranet.

Lastly the paper discuss the current status of standardisation of the data quality at European (CEN) and international level (ISO). Finally the implementation of quality testing at NLS is explained.

Quality in GI - why it's important

Geographic information is used in various purposes. More and more often geographic information is in digital form and the source's of the data can be various. The data producers have fulfilled the need of the customers by digitising the paper map into digital form. Most often the producers have monopoly so the customers have to use what is offered. Developments in GPS-technology and geographic information systems (GIS) have meant that the data products have to be more accurate and the quality has to be documented. Especially when different data are combined the need for quality information is obvious.

The producer may think that the quality improvements costs too much or it will increase the workload but in fact the good quality will decrease the costs. Typically the cost of 'bad' quality is about 15-35 per cent of all cost in a company.

Data Quality is part of the Quality Management

Quality is defined to be the totality of characteristics of a product that bear on its ability to satisfy stated and implied needs [ISO 8402]. The quality of the product is defined on the other hand by customers' expectations and by requirements that have been defined by the producer. The customer defines the quality of the product by those criteria. Expectations can be influenced by earlier experiences, product information and company image. It is very essential for the producer that the information about the product is correct in order to achieve customer satisfaction.

The quality indicators that can be measured from the product are part of the quality management.

The ISO 9000 Standards series was developed from the basis of the need to control the quality of production. There was a clear need to move from product inspection to inspect the ability to produce products that meet the specifications. The recent developments of the series have been towards process management control. The organisation can also certificate that it's quality system meets the requirements of ISO 9000.

There has been a lot of criticism of ISO 9000 because the development and the updating the quality system can cost a lot especially if you certificate the system. There is clear difference between European and United States in popularity of ISO 9000. The self assessment has been very popular in United States using the criteria by quality awards. The Malcolm Baldrige quality award in USA and European quality award are both given every year and the criteria are very similar.

The common goal seems to be good quality of excellence for the customer. Overall with the motive of enhancing competitiveness the quality movement seems to progress along the way of continuous improvement toward the end of customer satisfaction [Savolainen, 1997].

What is special in the Quality of the Geographic Information

Geographic information or data consists of geographic location (e.g. coordinates) and attributes that are linked to it. Geographic location is often very stabile but defining it causes errors. The positional accuracy is often the thing that comes in mind when you think about data quality.

Geographic information is a reflection of an object in the reality. In order to collect the data to the database you have to define the object or feature by data specification. Data compilation is done according to the data specification. The abstract view of the reality is the truth when we define the quality of the data. Everything that is not defined by the data specification does not exists in the abstract view of the reality. The data specification is then one of the most important part and can be the most important part of the data quality because errors made in modeling are often difficult or impossible to correct. The quality information that is given from the data is reported against the data specification. For example a building can have restrictions that you don't collect; small details or very small areas. It will be an error to collect those objects that don't meet the criteria even thought they are buildings in the reality.

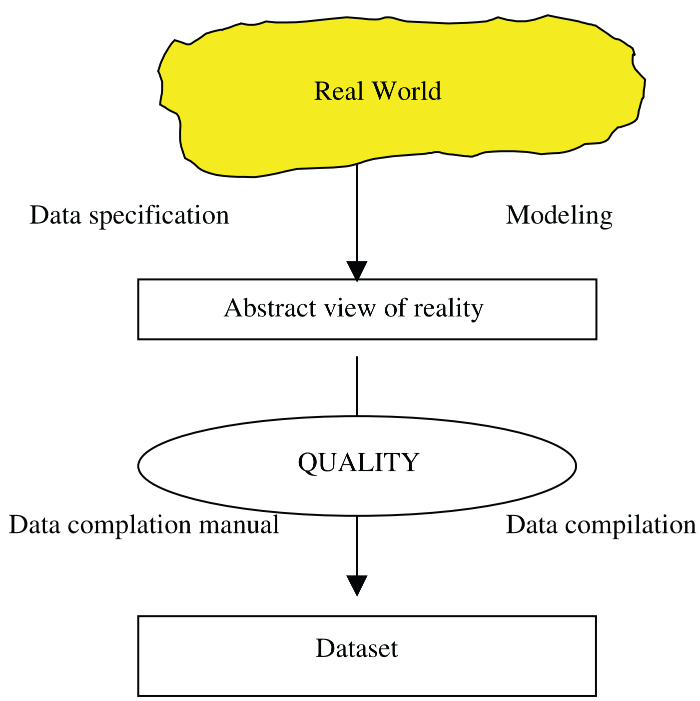

Figure 1. From the reality to the dataset

Time is one of the specialties of the geographic information. It is often a case that when the data has been compiled the information is already changed in the reality. Data compilation processes can last several years and that can cause reliability problems. For the producer it is of cause also a never-ending information source.

The data compilation from several different sources often requires very good quality. The positional accuracy for example can be the same in both datasets but the results when combined can still be wrong. Combining the datasets that have no quality information can be very difficult or impossible.

The equipment that has been used in data compilation does not guarantee the results. The user of data must be very careful in interpretation of the quality results. The measure that has been given can mean anything if there is no indication how the quality results have been achieved. For example positional accuracy can mean RMSE or precision or something else. The producer can give the accuracy of the scanner but does not give the accuracy of the original map. It is often the case that the accuracy of the dataset is not checked in the field because of the costs and the customer has to relay on estimated value.

The Implementation of the Quality Management in re-engineering of the Map Production

In this chapter it is explained how current map production system was developed in the National Land Survey of Finland. The working group chose the ISO 9000 as basis for it's work and the results have been excellent. The productivity rose from 24 000 km^2 per year to 54 000 km^2 per year (1994) and the same time the amount of people in production have declined.

The National Land Survey of Finland

The National Land Survey of Finland produces and provides information on and services in real estate, topography and the environment for the needs of customers and the community at large.

The NLS is responsible for Finland's cadastral system, registers pertaining to real estate and general mapping assignments. It also promotes the shared use of geographic information.

The NLS consists of 13 District Survey Offices, five national operational units and the central administration. The offices report to the Director General of the NLS direct. The organisation changed in the beginning of 1999 and the strategy was to emphasize the unity of NLS so that all district survey offices will have all functions of the NLS. The last major change in the organisation was made in 1991 so 90's has been called the decade of change at NLS.

The operational units are Development Centre (formed from the Cadastral Information Centre, the Geographic Data Centre, and the Geographic Information Centre), Aerial Image Centre, Sales and marketing services, Administrative Services and the Computing´Centre, which are all in Helsinki. The NLS has a staff of over 2000. The District Survey Offices employ 81 per cent, the seven national operational units 17 per cent and the central administration 2 per cent of the staff.

The NLS is a government agency subordinate to the Ministry of Agriculture and Forestry. It has introduced a result management system with net budgeting.

History of the Map Production and GI in the NLS

The Basic Map series 1:20 000 was completed in 1975 and it covered the whole area of Finland, 337000 km^2. The first Basic Map was published in 1948 so the product had it's 50th anniversary last year. Data digitising started in early 1970's by automating some steps in the fair drawing process. In 1980's we digitised contours and fields from the printing originals. Meanwhile we had developed our own mapping software FINGIS (now MAAGIS), which was used in digitising cadastral boundaries.

First we started the production of topographic map 1:50 000 with FINGIS by digitising planimetric details from the Basic Map and updating them with photo interpretation.

However the production of the Basic Map was still based on the traditional process. Analogical stereoplotters were used to collect contours and some planimetric details. Photo interpretation on the field was the main part of the process. The Basic Map was printed in 5 colours, which meant that the fair drawing from the field manuscripts was time-consuming and we had to introduce overprinting in populated areas where changes were more rapid. The revision cycle was 10-20 years and the updating with overprinting 5-10 years [Jakobsson, 1995}.

The Development Process of the Topographic Data System - The Re-engineering Process

In 1991 The National Land Survey appointed a working group, whose task was to develop and introduce a new system to Basic Map production. There was already a FINGIS-based application used for stereoplotting, but the digital data was not used in the fair drawing process. The working group (NPK) had a good knowledge of the current production and also The original purpose was to introduce a new production line for digital Basic Map and to have it started already in 1991. However, when the working group had started it's work, it realised that first of all it had to develop a data model, a data quality model and a process model. At the same time the author was responsible for developing the data compilation process using MAAGIS-software. The new system, now called the Topographic Data System (TDS), was introduced in 1992.

Next it was time to re-engineer the production of the topographic map 1:50 000, which was done in 1993. The working group developed a system, which uses mainly data from the Topographic Database (TDB). Generalization is done so that the geographical link with the Topographic Database can be maintained.

In 1994 it was time to start the development of small-scale map databases to be derived from the TDB. and it made the data model for small scale databases [Jakobsson 1995]. The data compilation of the small-scale map databases is made with ARC/INFO.

The next re-engineering phase of the TDS has already been planned. The next step will be the modernisation of the Maagis-software. The plan is to use the same software that is already in-use in our real estate and cadastral services. The system is based on Smallworld GIS and called JAKO-system. The main benefits will be from license costs and organisation change.

The Topographic Data System

The Topographic Data System consists of the Topographic database containing the most detailed general topographic data with nationwide coverage, and the map databases, which are generalised from the TDB. Currently we have map databases in scales 1:20 000 and 1:50 000. Service databases are the Road database and the Digital Elevation model. The Name database will have all the names of map databases. The names from the basic maps were collected separately last year. The Basis of Topographic Data System is to collect the data only once, not two or three times as it was done earlier.

Organisation

Data compilation is done in our district survey offices, which are located in Helsinki, Turku, Hämeenlinna, Kouvola, Mikkeli, Jyväskylä, Seinäjoki, Kuopio, Oulu and Rovaniemi. In the beginning of this year we have also two new units in Kajaani and Tampere. The data compilation should finish in the year 2001, which means mapping of about 55 000 km^2 a year.

The Topographic Data System consists of about 220 workstations and about 30 analytical stereoplotters. The number of persons working with the system is about 400.

Data Compilation

Data compilation is divided into two categories. In level A compilation buildings, power lines, fields, water bodies and roads are collected by analytical stereoplotters using either 1:16 000 aerial photos or in the north 1:31 000 aerial photos. In populated areas we also use base maps. After that, other features are digitised from the fair drawing of the basic maps. Field checking is done after the data compilation.

In Level B we mainly use the basic map as a basis for data compilation with photo interpretation using 1:10 000 enlargements of aerial photos at 1:16 000 or 1:31 000. Field checking concentrates to the most important feature types.

The contour lines are already in digital form, but we have to make some very time-consuming corrections.

All things counted, the whole process from ground control to the topographic database can take as long as 3 years. The main reason for this is, that in some areas we also signalize the cadastral boundary marks, and the aerotriangulation of those marks takes time. Data compilation of one map sheet area (10km * 10km) at level A takes about 70 days, of which the stereoplotting takes 18 days, digitizing 27 days, field checking 17 days and misc. checking 8 days. At level B the total work time for one map sheet is 35 days, of which 29 days is taken by the digitizing and 6 days by checking.

Data Revision

The update frequency of the traffic network, administrative borders and population names is continuos. Buildings, power line and fields may also be introduced to a continuous revision plan. Public roads are updated from Road Administration and private roads (mainly forest roads) are updated using data from Forest Boards and forest industry. We use also the high altitude photographs in scale 1:60 000 to update the road data. The update frequency of these images is every 3 to 4 years. This information is then used to evaluate the need for more accurate positioning with GPS-hand held PCs in the field. Positional accuracy of the updated features is not as good as it should be, and it is revised every 5 to 10 years. The revision of the database is based on digital orthophotos and head's-up- digitising. The new Jako-based system will also use digital photogrammetric workstations in the periodic revision process.

The Data Specification

The data model of the Topographic Database defines more than a hundred feature classes, which are divided in eleven data groups. Basic data groups are buildings, transportation network, terrain and hydrography, power lines and elevation. Other data groups are administrative boundaries, ground control points, protected features, real estate boundaries and special areas.

All data must fulfill the selective criteria to be compiled to a database. In this context the data model represents the reality, so we presume that the definitions of features are correct when we define the quality the of a feature.

All features have a geometric representation, which can be a point, a line or an area. A feature can have one or more attributes, that can be discrete or continuous.

Quality management

The quality management can be based on ISO 9000, self assessments using quality award criteria or practical experiences within the company or combination of those. Also there is a number of gurus in quality management (Deming, Juran, Crosby).

ISO and quality award criteria require that the quality system is documented. This means that the processes and responsibilities for quality are documented.

At the National Land Survey of Finland we have a organisation wide quality manual, which documents the general requirements for the quality and quality policy, which we call quality guidelines. Then the organisation wide processes have their own quality manuals. Those manuals are updated in operational units. The Topographic Data Quality Manual defines the processes and responsibilities of the different part of the processes. District Survey offices can have their own quality manuals which goes to even more details. The manuals are updated in intranet and every person in the organisation have access to them. Also a printed version has been made which will be reprinted when major changes will be made.

The Chief Director has a main responsibility for the quality. The management team will audit the main processes each year. The surveying counselors are responsible for the quality of the main processes. There are no special persons for the quality management. The operating management has the responsibility.

After implementing and re-engineering the TDS we have made a quite big investment in team organisation . All persons have had team training and the results have been very good. In the beginning of 1999 the organisation is based on processes.

Defining the Data Quality

In this chapter it is explained, how the data quality is defined in forthcoming standards and how we have defined it at NLS. The data producer can choose at least two different strategies. One is two have a defined data quality as we have at NLS in our data quality model and test the datasets against that level or only report the quality level that has been achieved. In the first choice a customer can make decisions even if the data has not yet been collected. That is of course the case in data revision.

The Data Quality Definitions at NLS

In the data quality model the quality factors are: 1) **Lineage**, which means the source of data compilation, the data compilation date, the currency of the source material, the history of the data compilation and the name of the persons who were in charge of the compilation. 2) **Completeness**, which means how complete each data objects were compiled in the dataset. 3) **Currency**, which means how well the datasets meets the required up-to-dateness. 4) The **accuracy of geographic location** is defined by positional accuracy, geometric accuracy and topological accuracy. The positional accuracy is defined by root mean square error (RMSE). The geometric accuracy means how well the geometric description (line, point or area) defines the real object. The topological accuracy means how well each object is compatible with other objects. 5) The **thematic accuracy** is defined by object class accuracy, attribute accuracy and temporal accuracy. The object class accuracy defines how well each object class is compiled. The attribute accuracy defines the quality of each attribute class and the temporal accuracy means accuracy of time measurement of the objects. 6) **Logical consistency** means whether the objects meets the logical requirement that are defined in the data specification [Jakobsson, 1994].

The quality requirements are defined for positional accuracy, completeness, and thematic accuracy. The requirements for logical consistency are defined by test that should pass. The positional accuracy requirement for a road is 3 meters (RMSE) in quality level A and the requirement for completeness for a road is that only 4 errors per hundred unit is allowed (acceptable quality level) and for object class accuracy only 4 errors in classification of the road type is allowed. Each object class and attribute class can have a different requirement [NLS, 1995].

The Data Quality Definition in the European Standard for Geographic Information

European standardisation committee (CEN) has made a European prestandard that defines the data quality elements: 1) **Lineage** is the description of the history of the geographic dataset in terms of source material, dates, processing applied and responsible organisations. **2) Usage** means that a geographic dataset can have a set of records describing its previous usage and **3) Quality parameters** that describe the performance of the geographic dataset compared with its nominal ground. The quality parameters that are defined are: 3.1) **Positional accuracy**, which is a quality parameter describing accuracy of geographic position within a geographic dataset. Positional accuracy can be either relative horizontal accuracy (RMSE and vertical bias or vertical threshold) or relative vertical accuracy. 3.2) **Semantic accuracy** which is a quality parameter describing the accuracy of semantic aspects of a geographic data. Possible quality indicators are accuracy of classification and agreement for an attribute. 3.3) **Temporal accuracy** is a quality parameter describing the accuracy of temporal aspects of a geographic data. The quality indicators are accuracy in time measurement, Last-update, rate of change, temporal lapse and temporal validity. 3.4) **Completeness** is a quality parameter describing the presence and absence of entity instances, relationship instances and attribute instances. The quality indicators are omission and commission. 3.5) **Logical consistency** is a degree of conformance of a geographic dataset with respect to the internal structure given in its specification. Last quality element is 5) **Homogeneity** that is a textual and qualitative description of expected or tested uniformity of quality parameters in a geographic dataset. The standard also allows the user to define own quality parameters, indicators and measures [ENV 12656, 1998]

The Data Quality Definition in International Standard for Geographic Information

The international standardisation committee (ISO) has made committee draft for quality principles which defines following quality elements and sub-elements:

Table 1. Quality elements and sub-elements

Completeness
- Commission
- Omission
- User defined (data quality subelement or subelements)

Logical consistency
- Domain consistency
- Format consistency
- Topologic consistency
- User defined (data quality subelement or subelements)

Positional accuracy
- Absolute or external accuracy
- Relative or internal accuracy
- Gridded data position accuracy
- User defined (data quality subelement or subelements)
- Positional stability
- Relative positional stability

Temporal accuracy
- Accuracy of a time measurement
- Temporal consistency
- Temporal validity
- User defined (data quality subelement or subelements)

Thematic accuracy
- Accuracy of a value given to a quantitative attribute
- Classification correctness

User defined (data quality element or subelements)

User defined (data quality element or elements)

User defined (data quality subelements or subelements) [ISO TC 211,1999]

The main difference between CEN standard is that ISO allows the user to define own quality elements. Also a separate standard will be made for quality evaluation procedures that CEN does not have. Also the wordings and some of the quality subelements are different but the basic concept of quality is the same.

Quality Requirements and Quality Evaluation

From the point of view of the user it is important how well the producer is able to guarantee the quality he has reported. The customer, of course, can go to the ground himself and can check some targets but usually it will not come into question for technical reasons, a cost or other reasons. On the other hand, it is important for the producer that the quality information is accurate , otherwise the compensation for damages can come into question. The statistical tests are a good method to secure that the requirements are met at moderate costs. For example Ordnance Survey of Great Britain uses statistical methods for their test procedures. Also NLS uses statistical test for completeness and thematic accuracy.

In practice we have found out that the customers tend to evaluate different quality requirement in following order: Coverage, Up-to-Dateness and Completeness, Accuracy (positional, attribute), Logical completeness, Lineage and Usage. As the requirement in the top has been met the more important the next one comes.

Testing of Completeness and Thematic Accuracy at NLS

Testing for completeness and thematic accuracy is carried out by applying the principles of standard SFS 4010 (Sample test procedures and tables. Attribute inspection), which corresponds to standards ISO 2859-1974 (E) and IEC 410 (1973). The standard defines the sample programs and procedures for attribute inspection.

All the features collected are checked from the data source used if the quality requirement for the feature type is one nonconformity per 100 units (AQL=1) (AQL = Acceptable Quality Level). Inspection based on sampling is made when the AQL of the feature type is 4 or 15. The inspection level is the general inspection level 1, the single sample program for normal inspection (NLS 1995).

Test for Completeness

The lot must consist of map databases produced as far as possible at the same time and with the same methods. From the lot, an area of so many 1 km x 1 km squares is sampled that the number of features with AQL=4 is sufficient.

The sampling is made using the default weights of the features. The weighting can be changed if necessary. In weighting, default value 1 is given to features of which there are many in the lot or for which no AQL for completeness has been set. Features whose completeness AQL is 4 or 15 are given a weight of 2 or 3. A weight 3 is given to features that are sparse in the lot. Otherwise a weight of 2 is used.

Should the required sample size not be achieved, the program selects from the sampled squares those with the greatest number of stereoplotted features fulfilling the required sample size. At the same time, features with AQL=15 are tested according to the inspection level achieved.

All features in the sampled squares are checked in the field. A feature does not conform if it is lacking or if the feature in the 1 km x 1 km square does not exist in the field.

Test for Thematic Accuracy

The test for thematic accuracy is made on the same material as the test for completeness. The number of errors permitted and the inspection level achieved are given on the test form, if the completeness AQL is not 4. The quality supervisor inspects each item of attribute data on the basis of the source material. Attribute data are erroneous if they differ from the source material or are lacking.

Processing Nonconforming Units

If in the test of feature types the number of nonconformities is greater than permitted, all features in the lot must be checked. The method is chosen on the basis of the source of information used, and it is carried out on all features in the lot.

Experiences of the Performed Tests

Results of performed tests provide information about functionality of the data compilation processes and also about the quality of TDB data. Data digitized from graphic basic maps may contain also the errors made during the previous mapping process. All of the features are not checked in the field in data compilation process.

About 15 % of the annual production was tested during the year 1996. There were 33 tests made by regional surveying offices. Two or three 1 km x 1 km test squares can be checked in the field during one working day on an average.

Test results show that the biggest problems in completeness concern buildings, waters with current width under 2 m, light-traffic routes and agricultural lands. All of the features can not be seen in stereoplotter because of trees or shadows, for example. Time used in field checking is minimized and so all of the unseen features can not be checked in the field.

Test results of thematic accuracy have been mostly good. There have been errors with use-attribute of buildings and classification of agricultural land.

Results of performed tests have come up to expectations in general. As result of the tests quality requirements of some objects have been changed and instructions for data compilation have been adjusted.

Quality tests provide information for the maintenance of the TDS and its quality management. They also help data compilation units to improve the quality and efficiency of their work [Pätynen et.al. 1997].

Testing the Positional Accuracy

In 1996 and 1997 NLS made positional accuracy test in order to evaluate the accuracy of the TDB. The quality requirement that are set in the data quality model were tested already in 1994. That test covered about 1000 object instances [Jakobsson, 1994].

In 1997 11 test areas where chosen for the positional accuracy test. The test was made with differential GPS. Only the most accurate object classes were tested which have good identifiabilty in the field. Those object classes were buildings and roads which according to quality model should have positional accuracy of 3 meters. 500 buildings and 200 road crossings were measured and the result showed that the average positional accuracy of those object classes were 2,2-2,3 meters [Tätilä 1997].

Logical Consistency Tests

Starting 1993 NLS has made logical consistency tests and figure 2 shows the results. Figure shows that the number of errors per 1:10 000 map sheet has decreased from the high 2,5 to less than 1 error in the 1998. This includes all kinds of errors that are possible in a dataset.

Customer Satisfaction

What kind of demands should the user of the geographic information make to the producers? The producer should, of course, be reliable and it would be good if the producer had a quality system.

The company, which has got the quality award would be an excellent partner. Also the quality certificate would be nice or it can be required in some cases. The Ordnance Survey is the first national agency that has one. In practice everything mentioned above cannot be required but it is clear that customers are coming more and more quality aware so the producers have to meet the challenges.

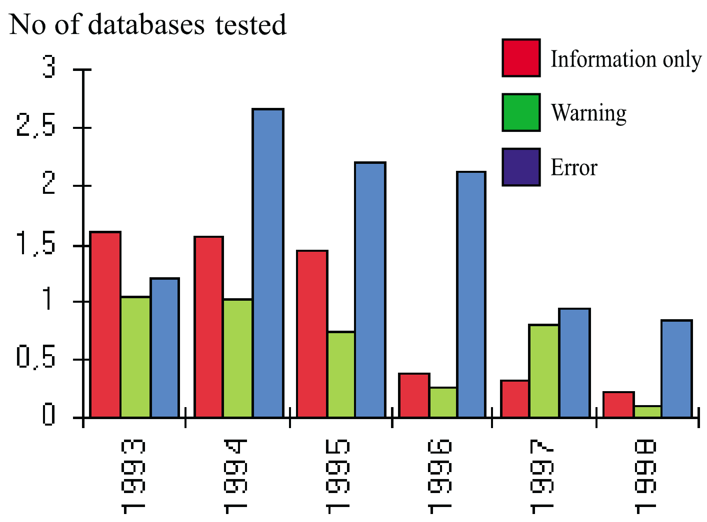

Figure 2. The logical consistency test 1993-1998

Most geographic information systems can't handle the quality information or even the metadata information that is currently available. The standards come in that sense at the right time. Also the Open GIS consortium can give a lot to GIS community if the quality comes one of the main topics.

The joint use of geographic information from different producers sets strict demands to the quality of the information. Even in NLS there are datasets that currently can't be used together even it would be possible in theory (for example the scale is the same). There is no scale when we use digital datasets and if there is no quality information available the user may do grave mistakes. Even if the quality information is available the user may misinterpret the information and there the geographic information systems and the GIS community has a challenging task.

The quality management and the quality information together form the significant competitive advantage to producers. Even more the improvement of quality still often saves costs and intensifies process output.

References

ENV 12656 (1998), European Prestandard Adopted European prestandard

ISO TC 211 (1999), ISO/CD 15046-13, Geographic Information – Part 13: Quality Principles, International Standard Committee Draft subject to vote

ISO TC 211 (1999), ISO/CD 15046-14, Geographic Information – Part 14 Quality Evaluation Procedures, International Standard Committee Draft subject to vote

Jakobsson, A, (1995), The Topograhic Data System -A new way to compile and update topographic information. Proceedings of the 17th International cartographic Conferencd, vol 1, pp. 993-1000

Jakobsson, A, (1994), Quality Procedures of the National Topographic Data System in Finland, GIM, International Journal for Surveying, Mapping and applied GIS, October 1994

National Land Survey of Finland (1995), Topographic Data Quality Model

Pätynen, V., Kemppainen, I., Ronkainen R. (1997), Testing for completeness and thematic accuracy of the National Topographic Data System in Finland, Proceedings of the 18th ICA Interbational Cartographic Conference, pp. 1360-1367

Tätilä P. (1997), Report on postional accuracy tests, in finnish

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Quality needs more than Standards

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Abstract

Standards are good. Quality is better. Standards help make producers and users of geographic information aware of quality concerns, but without enforcement mechanisms or incentives, determining quality in use remains difficult. In the sense of the "fitness for use" paradigm, standards should be seen in terms of their use. This paper makes the argument, following work on information quality in corporate information systems, that content standards only address an aspect of geographic information quality. Measures of intrinsic data quality must be complemented by use related concerns involving access, representation and context. Based on this broad understanding of data quality that involves the producer and user, I propose two approaches to integrate quality measures in data sets and make existing metadata catalogs more accessible. Embedding pertinent data quality information can make fitness for use evaluation easier, but faces several hindrances. An extension of hypertext, Information Space, employing spatial metaphors, opens a means to improve the access to existing metadata inventories in a highly flexible manner for producers and users.

1. Standards do not make Quality

Standards are good. Quality is better. This juxtaposition might seem utterly obvious, but given the numerous efforts to standardize geographic information (SAIF, FGDC coordination, OpenGIS, CEN TC287, SDTS etc.), people in the GIS community should pause to reflect how current content standards improve quality for users, or in many cases data consumers before committing an over proportional amount of resources.

Standards aim to improve quality. However, the connection between standards and quality remains elusive. Standards are certainly important and crucial to the definition of accurate data, descriptive metadata, and assuring cross-platform consistency. Alone they do not guarantee quality. First off, standards cannot consider all possible uses. Quality depends on use and can only be evaluated in context. A soils data set at a map scale of 1:500,000 providing sufficient quality for national mapping purposes will be unsuitable for distinguishing podsols in a village park. Second, content standards for metadata do not consider access. These standards define requirements for distinct levels of accuracy and use. The fulfillment of a metadata content standard actually only says what the producer knows about the data. A producer's stamp of approval may provide helpful hints about successfully passing internal verification routines, but certification alone is not enough to determine if data is suitable for a particular use.

Content standards are guidelines or requirements that establish minimal documentation and procedures, but, without context, they cannot define quality. Take the common issue of considering scale based error in the selection of specific analysis techniques. Useful quality information requires knowledge about intended uses. If the scale of one data set approximates the scale of another data set, then this data set will likely have sufficient quality. If there are substantial differences in scale, then the positional accuracy differences between data sets could preclude accurate analysis. The data would, in such a case, lack sufficient quality. 'Substantial' and 'approximate' are obviously application, task, or purpose specific, and beyond the purview of content standards. The fulfillment of a content standard does not assure quality, nor make metadata accessible in a form suitable for decision making. What good is such metadata if users and consumers of spatial information products have difficulties to access and understand it?

Users and consumers determine quality in use. The well known aphorism, "Quality is fitness for use" [Chrisman, 1984] refers to the essential connection between quality and use. Metadata is helpful in assessing quality only when it is connected to use. To often important metadata is underutilized because users cannot easily find it, understand it, or navigate the complex organization and acronyms. Making decisions about quality must overcome these barriers. Only accessible metadata aids the user in determining quality. Research in the Alexandria digital libraries project proposes a tighter linkage between metadata and geographic data (http://alexandria.sdc.ucsb.edu/public-documents/metadata/) that vastly improves accessibility to metadata and shows possible paths for providers and applications [Smith, 1996a; Smith, 1996b].

This paper makes the argument that standards are one of the right starting points for addressing quality issues, but since users and consumers determine quality in connection to use, other issues, particularly access and comprehension, must receive attention. These are broad issues, in many ways beyond the scope of a paper. Accessibility to metadata can be readily addressed when metadata exists or is in preparation. Designing a system from the ground up offers the advantage of starting from a blank slate, but the disadvantage of requiring additional work for the final implementation to incorporate 'legacy' data. The approaches I describe in this paper consider this issue.

After reviewing information science literature and the geographic information technology field on quality, I consider two approaches to making metadata more accessible: embedding metadata directly in geographic data sets and providing tools to navigate existing metadata inventories. Although these two proposals are distinct, they present useful ways for making metadata more useful. Embedding metadata makes it more accessible to users carrying out common operations on geographic data. Algorithms can directly access metadata bound to the standard data structures for determining of tolerances, display scale, resolution and so on. In cases where substantial amounts of metadata have already been collected, making it more accessible will also provide significant improvements. The conclusion describes an agenda for future research and lists important questions.

2. The Limits of Content Standards

The focus of content standards on conformance to particular values is one way to understand quality. Developed in the manufacturing industry, using inspection to achieve quality leaves users and customers out of the picture. For production line staff, engineers, and managers, quality may be readily manageable in this form, but it can readily turn into a self-fulfilling system of measurements void of any relationship to user and consumer requirements. This understanding of quality as fulfilling important traits or characteristics misleads because it makes the purpose for assessing quality implicit, and cannot include user needs in determining quality.

Practical purposes demand a more mundane and pragmatic understanding of quality. This is known in GIS as "fitness for use" [Chrisman, 1984]. Widely accepted, this expression asserts that the quality of spatial data is only known in terms of a specific use. Isolated metadata is not sufficient for determining geographic information quality. Quality is what is important in a situation, "Quality information is the key to putting GIS products into an understandable form" [Paradis & Beard, 1994]. If the data to evaluate quality is not available, metadata is not fulfilling its primary purpose.

This is perhaps the most grievous shortcoming of content standards. They contain the knowledge of a data producer, all other information pertinent to determining quality must be added by the user. Self-contained, cloistered in a metadata catalog or inventory, metadata cannot optimally fulfill its *raison d'ê tre*: aiding the determination of quality.

Efforts to standardize metadata contents and data quality make important steps towards overcoming the cloistering of metadata, but as these efforts focus on minimal requirements, exchange requirements, and documentation guidelines their outcomes may actually open up several small closets to place the collected metadata resources in a newer, larger closet. Data providers following these standards can rightly claim that they prepare and make metadata available, but to many users of geographic information the simple inventory of metadata will be about as understandable as a technical reference on C programming. Merely having metadata is not enough to aid decisions involving quality if the barriers to access remain in place.

Beyond the accessibility argument, it is also important to bear in mind the contentious nature of standards. Why aren't good standards guaranteed successes? Standards are the results of discussions and negotiations that explicitly and implicitly bear the mark of the dominant institutions and disciplines involved in their preparation. Standards empower some groups, while at the same time excluding other groups' legitimate interests. The development of technologies is often mainly a process of struggles between divergent interests who seek to assure economic benefits through standards [Bijker, Hughes, & Finch, 1987; Bijker & Law, 1992]. Standards are often contentious vehicles for institutional and disciplinary struggles that can deflect attention from other substantial problems as 'leaders' vie for better positions like generals on the battlefield.

A look at quality in a neighboring discipline, software engineering, may offer impulses for a broader understanding of geographic information quality, necessary with the growing role of GIS users as producers of information, not merely the users of data provided by national mapping agencies, etc. The IEEE standard for software engineering defines quality as the "totality of features and characteristics of a product or service that bears on its ability to satisfy given needs" [IEEE, 1989]. Clearly, this broader concept requires a paradigm shift. Approaches reflecting this shift like Total Quality Management (TQM), contain important concepts for the producers of data.

In GIS, most users are also producers. But they are users of another producers data, and producers of data for another user. The hybrid role of users and consumers in GIS presents an unusual conundrum for most of these quality approaches where collection, processing, distribution, and use are all within the same organization. The following section describes an approach that opens a new way of understanding the quality of geographic information in terms of use.

This section looks at the usefulness of standards in terms of efforts to make data quality information accessible.

3. Using Geographic Information Quality

A starting point to address the broader framework of data quality than content standards permit, is reconsidering the framework for evaluating data quality. As the "fitness for use" underscores, any data product's quality can only be determined in relationship to use. Use is a rather vague term that only takes on meaning in distinct context. It may be impossible for producers to determine data quality without some application. A benchmark application would help, but exploring this issue lies outside this paper. At this point, to refine the understanding of "fitness for use", I will differentiate various categories of data quality (DQ) and their dimensions.

These categories and dimensions come from literature that is closely affiliated with Deming's work on Total Quality Management [Deming, 1989], with the central observation that quality can only be evaluated with the people choosing and using data. As more and more commercial geographic data providers offer data (for example: high resolution satellite data), the user, as consumer, will play a much more important role, than when geographic data was largely a monopoly of national mapping agencies and surveyors.

In this light, there are various suggestions of data quality categories, none of which agree. As with many terms, quality is seen in different ways, as even fundamental terms like accuracy are too [Wang, Storey, & Firth, 1995]. They range from 4 to 6 categories with up to 40 attributes. The categories from 3 studies is presented in table 1.

Table 1: Disagreeing categories of data quality

Name and Source	Data Quality Categories					
Zmud [Zmud, 1978]	information quality	relevancy	format quality	meaning quality		
Taylor [Taylor, 1986]	ease of use	noise reduction	quality	adaptability	time saving	cost saving
Fox [Fox, Levitin, & Redman, 1994]	accuracy	currentness	completeness	consistency		

Following Deming's tenet and the "fitness for use" principle, this paper applies the practical interpretation that quality is what users define to be data quality. Usefulness and usability are central here, and in this light quality consists of four categories:

- intrinsic DQ
- accessibility DQ
- contextual DQ
- representational DQ [Strong, Lee, & Wang, 1997]

These categories come from the qualitative analysis of 42 DQ projects at an airline, a hospital, and a Health Maintenance Organization (HMO). Focussing on problem-solving strategies, the analysis grouped DQ issues in the four categories.

The first category, intrinsic data quality, is the result of production processes. The user may not know the source of the quality problem, but over time, gains enough information to make comparisons between different data sources. The sources of inaccuracy may be traced back to interpretation or coding errors, for example. Certainly, interpreted databases are viewed more negatively than raw data. Less accurate data receives a poor reputation and is considered to provide little added value. Such data is used less frequently by knowledgeable users.

Accessibility data quality consists of several interrelated issues. First of all, poor accessibility and access security obstructions reduce the perceived data quality. Second, difficulties interpreting and understanding data categories, or finding imprecise or inconsistent representations, untimely data, or unwieldly amounts of data will also lead to the user negatively evaluating data quality.

Contextual data quality refers to problems with lower relevancy and value-adding arising from incomplete data or inconsistent representations. Contextual DQ is directly linked to representational data quality.

Finally, representational data quality accounts in more specific ways for the problems that users encounter interpreting and understanding data. Specific problems users encounter that undermine data quality are deficient representations or inconsistent representations. Incomplete and inconsistent data does not support user tasks [Strong et al., 1997].

Strategies to resolve problems in these categories involve iterative processes and a dialog with all participants. Corporate cultures and institutional arrangements play a significant role in influencing the choice of strategy. This may be the most difficult aspect of data quality management to realise for many GI data providers.

Certainly, an important starting point for GI data providers is improving accessibility. With better accessibility a wide range of DQ problems is immediately addressed, and the foundation laid for wider-reaching dialogues with users to improve other DQ aspects.

4. Fitness for use requires accessible metadata

From this perspective, one of the first steps is improving access to existing data quality information contained in metadata. This can mean many things, but two principles should guide these efforts. First, when possible metadata should be embedded directly with source data. Second, available metadata catalogs or inventories should be made more accessible. The following sections focus on these two approaches. Embedding is bottom-up strategy that requires rethinking GIS data structures and processing. Obviously, only the most pertinent metadata should be included to minimize processing and storage demands. Navigating suggests a potential way to make existing metadata inventories more accessible and useful for users.

4.1 Embedding Metadata

Although in practice difficult to realize because of the necessity to get vendors to support this approach, it has strong merits due to the integration of quality information directly into the data structures. However a data set is processed, essential metadata would be transferred too. For instance, it would then be possible to limit positional creep if the original coordinates of features are available. A simple parameter could warn the users upon selecting an overlay operation that the resulting data would lie outside of a specified tolerance level.

Two types of quality information may be embedded. First, quality indicators, like the original x, y, z, and epsilon tolerance, provide important information for comparing consecutive changes to the data set with the original. Quality measures, such as RMS, other positional error measurements, attribute verification, could additionally provide information for assessing quality. Their inclusion would be far more dependendent on specific application requirements due to storage and processing considerations. This could readily follow on object-orientated approach, where inheritance would help reduce storage requirements.

The primary question at this point regarding the embedding of metadata is what amount of quality information is required. This will certainly vary by use, but minimal guidelines should be established. It would seem that at least the original x, y, and where applicable, z coordinate values should be included, but this hypothesis and additional questions remain to be evaluated through field studies.

4.2 Navigating Metadata Inventories

Clearly, given the considerable efforts to organize and provide metadata inventories, improving the accessibility would be a first significant step to improving data quality evaluation. Since this data is already widely available, linking navigation tools would be much easier than altering data structures and processing routines required for embedding metadata.

For this aspiration to come to fulfillment, an available, practical, and readily implemented interface is called for. Hypertext comes to mind immediately, but it is too static. Users coming from different backgrounds with different purposes will never be completely pleased by the set of hypertext links the designer created. A similar concept to hypertext, but far more flexible, called information space or meta content framework (MCF) [Guha, 1997a; Guha, 1997b; Guha, 1997c] presents a possible solution to these issues.

This concept is attractive for several reasons. Recognizing that people understand metadata in a wide variety of ways, but, on the other hand, content is a relatively clear idea, the meta-content framework builds a flexible interface to content of multiple metadata catalogs or inventories. This flexibility permits the structuring of content in user-defined three dimensional information spaces. Through the hierarchy and spatial arrangement the user can associate contextually similar metadata (see example below). Whereas a hypertext link on WWW page is often without context, the spatial organization of MCF supplies important indications.

Basically, an information space flexibly links and organizes metadata contents in a hierarchical format with a spatial dimension. The designer groups elements of an information space, proposing a framework for generic use. Each user can modify the organization of these elements to fit their specific needs. This flexibility is further enhanced by the tools provided for constructing information spaces. Based on first order logic, it uses “contexts mechanisms” as arguments for predicates [Guha, 1997c]. The MCF tools can be used for query processing and inferencing metadata and source data. The language can also be machine read.

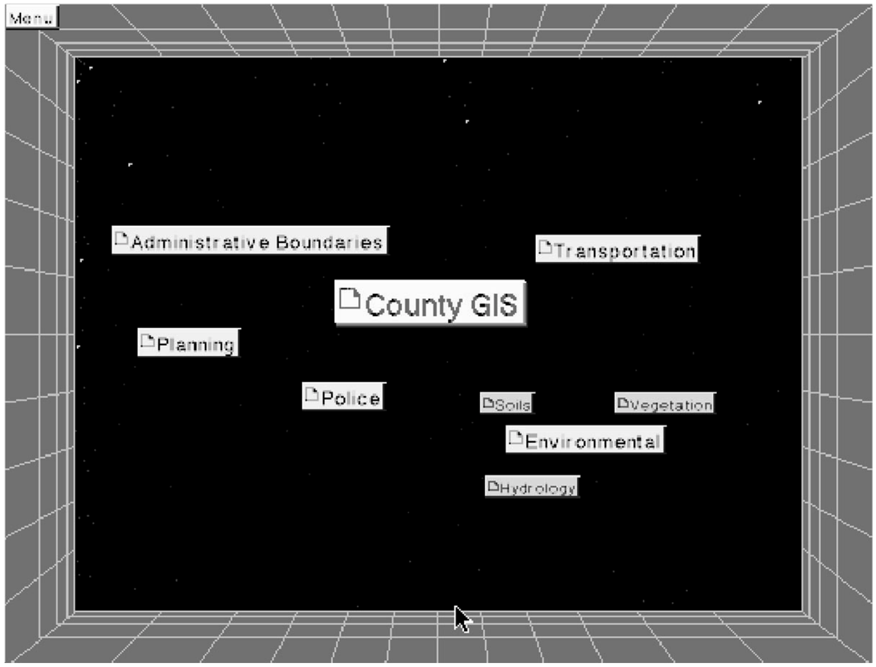

Figure 1 A sample information space for a county GIS showing the top three hierarchical levels

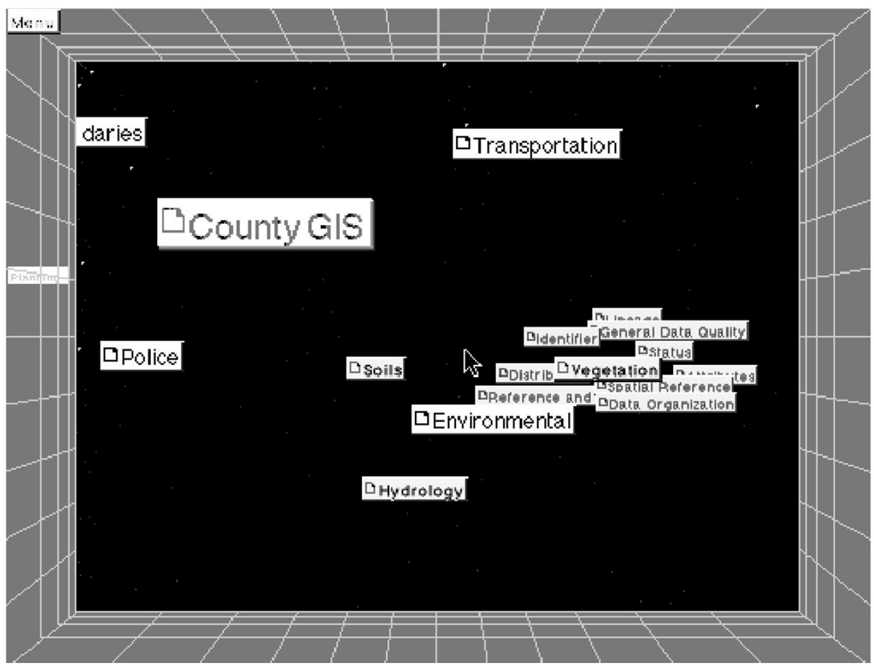

Figure 2 Flying in, lower levels of the hierarchy become visible

The hierarchical 3-D information space is navigated using a fly-through analogy. Holding down the cursor (mouse) button goes deeper into the information space, shift-click goes towards the top. By left-right and top-down movements, the user can move towards elements. When starting at the top of an information hierarchy, usually only the top-most elements are visible. Going towards and element, lower levels of the hierarchy will become visible. A click selects an element, which can be moved to a new position as a user desires. These changes are saved in a local information space. A double-click on a element opens that element just like a hypertext link.

An information space is fundamentally a contextual ordering. Whereas metadata is well structured through standards, the myriad aspects of GIS application are not standardizable. Context is unique, and information spaces facilitate the individual organization of metadata to develop a thorough understanding of quality in connection with use.

While information spaces may not provide the penultimate solution to accessibility issues, the meta-content framework presents the means to address relatively easily this problem. Certainly, this concept cannot resolve technical or organizational problems with metadata catalogs and inventories. For these issues additional work is required, beyond the scope of this paper.

5. Standards are Good. Quality is Better.

Quality is what is important in a situation, if the data to evaluate quality is not available, metadata is not fulfilling its primary purpose. Access is fundamental to quality. This paper shows ways how embedding metadata and providing tools to contextualize and navigate existing metadata inventories can vastly improve the accessibility.

Content standards will always be necessary, but conformance to intrinsic quality measures is only one part of geographic information quality. Quality can only be determined in use: “fitness for use”. For metadata to facilitate the evaluation of geographic information quality, it not only needs to be standardized, but, equally, made accessible.

Ultimately, quality evaluation procedures need to include user demands. For commercial geographic information products, it may be even more apt to speak plainly of customers. In building market positions, they will undoubtedly be able to distinguish different groups of users and recognize typologies of quality demands. Geographic information professionals and researchers will need to go other ways than most information system developers who find themselves in relatively clear corporate and institutional frameworks. Since collection, processing, distribution, and use are usually in the same organization the motivation to improve quality is largely self-serving. Perhaps, this applies as well to most instances of geographic information technology, but often geographic information data users are distinct from providers. Collection, processing, and distribution are frequently performed without precise knowledge of future uses. Finding patterns will require at least as much effort as the evaluation of needs does in GIS implementation projects.

World-wide there are increasing numbers of metadata inventories, but frequently they are separate from the source data, or, even worse, completely decoupled. Such inventories can readily become, simply said, useless data. Questions arising in digital library research programs and addressed by the same research groups point in towards possible solutions involving different kinds of interfaces who utilize gazetteers to provide a more generic view of spatial data [Smith, 1996a; Smith, 1996b]. Combining thematic views with spatial seems to be a promising path to pursue substantial improvements in improving the evaluation of data quality in practice.

References Cited

Bijker, W. E., Hughes, T. P., & Finch, T. J. (Eds.). (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Bijker, W. E., & Law, J. (Eds.). (1992). *Shaping Technology/Building Society*. Cambridge, MA: MIT Press.

Chrisman, N. R. (1984). The role of quality information in the long term functioning of a GIS. *Cartographica, 21*(2), 79-87.

Deming, E. W. (1989). *Out of the Crisis*. Cambridge, Mass: MIT Center for Advanced Engineering Study.

Fox, C., Levitin, A., & Redman, T. (1994). The notion of data and its quality dimensions. *Information processing &*

management, 30(1), 9-19.

Guha, R. V. (1997a). Meta Content Framework. *http://mcf.research.apple.com/hs/mcf.html*.

Guha, R. V. (1997b). Meta Content Framework: A Whitepaper. *http://mcf.research.apple.com/wp.html*.

Guha, R. V. (1997c). Towards a theory of meta-content. *http://mcf.research.apple.com/mc.html*.

IEEE. (1989). *Software Engineering Standards*. (Third Edition ed.). New York: IEEE.

Paradis, J., & Beard, K. (1994). Visualization of spatial data quality for the decision maker: A data-quality filter. *URISA Journal, 6*(2), 25-34.

Smith, T. R. (1996a). A brief update on the Alexandria digital library project. *D-LIB Magazine (http://www.dlib.org/dlib/march96/briefings/smith/smith03.html)*.

Smith, T. R. (1996b). The meta-information environment of digital libraries. *D-LIB Magazine (http://www.dlib.org/dlib/july96/new/03smith.html)*.

Strong, D. M., Lee, Y. W., & Wang, R. Y. (1997). Data quality in context. *Communications of the ACM, 40*(5), 103-110.

Taylor, R. (1986). *Value added processes in information systems*. New York: Albex Publishing.

Wang, R., Storey, V. C., & Firth, C. P. (1995). A framework for analysis of data quality research. *IEEE Transactions on Knowledge and Data Engineering, 7*(4), 623-638.

Zmud, R. (1978). Concepts, theories and techniques: an empirical investigation of the dimensionability of the concept of information. *Decision Design, 9*(2), 187-195.

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How the Cartographer Can Address ISO-9000 Element 20, Statistical Techniques

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Abstract

The ISO-9000 is a template for establishing a quality system that can be of great benefit to cartographic production operations developing and implementing a quality program. The success of this approach has been demonstrated with suppliers to the U.S. Geological Survey. Of the 20 major elements of ISO-9000, element number 20, Statistical Techniques, is perhaps the most difficult to achieve. Element 20 is vague, provides no implementation guidance, has little precedent in cartography, and as a result, can be easily dismissed as not applicable to the cartographer. However, element 20, when used properly, can be a powerful tool, serving as the leading indicator of the success of cartographic quality and guiding all quality efforts. In many industries, statistical techniques are central to the quality program. Process capability statistics are used as a quantitative prediction to determine if the production process is capable of meeting product specifications. Various forms of this statistic can simplify the measurement of quality, thus improving the accuracy of decisions on quality. The concept of six-sigma quality, a popular slogan in industry, can contribute to philosophies for achieving quality in cartography, but hidden complexities must be taken into consideration, such as the effects of offcenter processes. Control charts form the backbone of statistical process control with wide-ranging internal and external applications. The P-chart, X-bar-chart, and R-chart are fundamental techniques that demonstrate whether a process is in control. They are key factors in eliminating rework, increasing productivity, and sustaining profitability by giving the cartographer immediate notice of problems, the magnitude of those problems, and the ability to determine the need for corrective resources without overreacting. Statistical techniques can allow the cartographer to meet deadlines, operate profitably, and meet map specifications. Rather than dismiss element 20, the cartographer can transform this vague requirement into a powerful management tool.

The Application of ISO-9000

ISO-9000 is simply a definition of a foundation for quality. It provides an environment conducive to sound quality practices, allowing the full exploitation of technical and managerial expertise. The quality foundation, or quality system, as it is often known, is an often unappreciated but fundamental component of a successful production program. Rather than invent a new quality system for cartographic production, the cartographer can adopt an "off-the-shelf" strategy from industry, such as ISO-9000. These standards, first published in 1987, were developed by a consortium of quality experts from around the world and represented a global consensus of thought on the definition of a quality system. The emphasis was on defining the fundamental building blocks of quality. The ISO-9000 standards required that all production operations be firmly rooted in sound quality principles. ISO-9000 is a simple outline breaking quality operations into individual components that can be systematically addressed. With the components of quality soundly developed and these building blocks pieced together, a comprehensive foundation to quality is created. By not only building, but also continually maintaining the ISO-9000 principles, the map producer is well positioned to make huge strides forward in achieving quality. It should be noted that the criteria for the Malcolm Baldrige National Quality Award should be explored as a supplement to ISO-9000. Because it is a more elaborate system, its implementation may be more self-guided.

The importance of these standards cannot be underestimated. They are often dismissed as being too simplistic and lacking substance. But in a large mapmaking operation, problems can often be traced back to a breakdown of fundamentals. With the establishment and enforcement of those fundamentals, a significant cause for quality problems is eliminated or at least brought under control. Improving quality is a systematic and often painstakingly slow process, but a process that can yield impressive results. ISO-9000 is the first step in that process. The use of ISO-9002 by U.S. Geological Survey contractors has shown a remarkable improvement in sustainable quality [Simley and Buser, 1997].

Statistical Process Control

A particularly vital component of a quality system is the ability to measure quality and its dynamics. This is the field of statistical process control, which is addressed by ISO-9000 in element 20, statistical techniques:

(20) Statistical Techniques -

(20.1) Identification of Need - Identify the need for statistical techniques required for establishing, controlling, and verifying process capability and product characteristics.

(20.2) Procedures - Establish and maintain documented procedures to implement and control the application of the statistical techniques.

In applying statistical techniques, four fundamental concepts must be accepted: (1) The cartographer must define expectations through the use of measurements. Examples of measurements are attribution accuracy, positional accuracy, and metadata accuracy. (2) It is not possible to effectively manage what is not measured. (3) The measurements are typically distributed normally, and normal distributions have a “tail.” The “tail” contains the imperfect maps. Managing the number of imperfect maps means managing the “tail.” Although the distribution may be affected by kurtosis or skewness or may even be bimodal, and some distributions may be binomial, the distribution almost always has a “tail.” (4) There is a need for descriptive statistics. The cartographer must take sample measurements of the map. These sample measurements must be adequate to describe the actual population.

The following discussion is a proposal to address ISO-9000 element 20 and represents the mainstream of statistical process control. ISO-9000 element 20 is not specific on the approach to be used, but the cartographer should find the mainstream strategy to be fully applicable to map production.

Normal Variation

Producing a quality map requires professional expertise, and generally, the greater the expertise, the better the map. However, there are limits to the degree of quality this expertise can produce because there will be variations in the level of expertise within to the workforce, variations in the performance of the workforce, variations in equipment, variations in the ability of algorithms to handle anomalies, as well as many other sources of variation. In the 1920’s

Walter Schewhart, an engineer at Western Electric, demonstrated that production under the best of circumstances will yield results that meet specifications about 99.7 percent of the time, or three standard deviations from the goal, and call this normal process variation [Schewhart, 1931]. This discovery recognizes a degree of inherent error in all process, even very good ones. Achieving 100-percent quality is unrealistic, but achieving almost 100-percent accuracy is entirely possible. This is a premise carried through in modern manufacturing. It is important to note that product quality naturally follows a normal distribution, and therefore some error will always occur in the "tails" of the distribution beyond three standard deviations. It can be assumed that cartographic production exhibits the same characteristic. In 1997, digital line graph production by USGS suppliers, a highly refined process, typically exhibited conformance to requirements at the level Schewhart described as normal variation, that is 99.7 percent accuracy, also known as three-sigma accuracy.

Process Capability

The first statistical technique is to measure process capability. Process capability studies (1) determine whether a process is unstable, (2) investigate sources of instability, (3) determine their causes, and (4) take action to eliminate such sources of instability [Gitlow et al, 1989, p. 427]. A process must have an established process capability before it can be improved. This is a measure of how well a process meets specifications. It is used as a quantitative prediction to determine if the process used is capable of meeting expectations. Its measure will clearly indicate the magnitude of a problem, if there is one, and its measurement following corrective action will clearly measure the effectiveness of such action. A capability of a process is defined as the range in which most of the product measurements will fall for a process that is in control. It can be characterized as +/ - 3 s from the mean, where sigma, s, is one standard deviation, and the sample mean, _, acting as an estimate for the population mean µ, falls on the target specification [Juran and Gryna, 1993, p. 394]. More simply, it can be thought of as the ratio between the specification and actual production. A useful measurement is the process capability ratio, C_p, computed as,

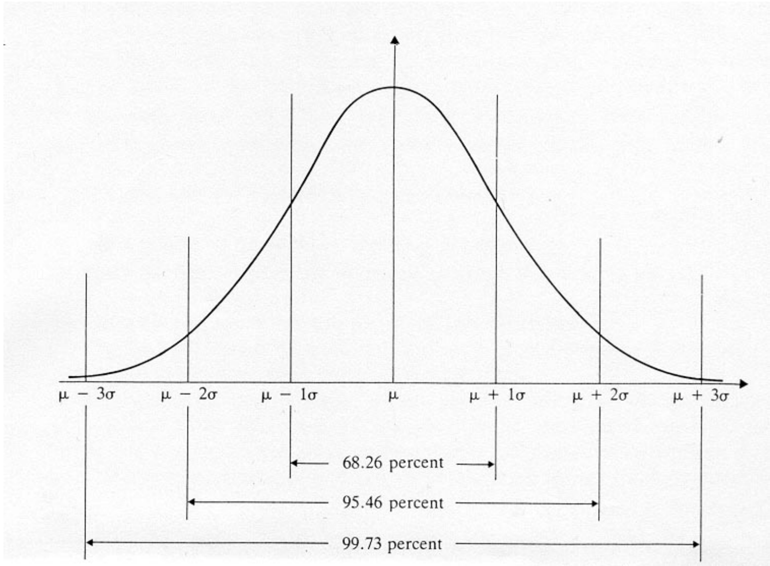

Figure 1. Diagram of normal variation with 1st, 2nd, and 3rd standard deviations indicated. The "tail" is that portion of the measurements at the far ends of the distribution.

$$C_p = \frac{USL - LSL}{6s}$$

where *USL* is the upper specification limit, *LSL* is the lower specification limit, *s* is the sample standard deviation, an estimate for s when the entire population is not known, and 6s represents the range in which most of the measurements will fall [Juran and Gryna, 1993, p. 395].

For example, when a line is plotted, a specification may call for a 0.010-inch line with an upper limit of 0.012-inch and a lower limit of 0.008-inch. Actual measurements of the line may be distributed about the specification in a normal distribution such that 6*s*=.004.

$$C_p = \frac{0.012 - 0.008}{0.004} = 1.0$$

This means that the line plotting met specifications and can be characterized as C_p =1.0. In other words, a process capability of 1.0 means that specifications are met 97.73-percent of the time. If the actual measurements were distributed beyond 6*s*, 6*s* would be greater than 0.004 and C_p would be less than 1.0. A C_p less than 1.0 means that the process does not meet specifications, and a C_p greater than 1.0 means that the process exceeds specifications.

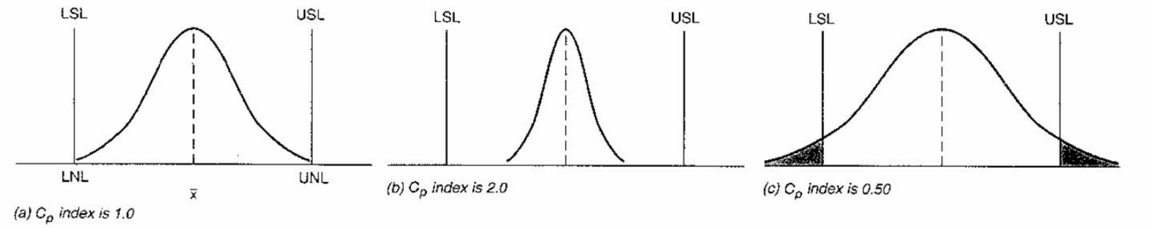

Figure 2. Examples of a process that (a) meets specifications, (b) exceeds specifications and (c) does not meet specifications. Note the location of the distribution with respect to the *USL* and *LSL*.

But what if the process was not in control, that is the mean of the measurements was not centered on the specification, say the line width averaged 0.011-inch. The C_p would not indicate a problem. To account for such out-of-control processes, the more rigorous capability index, C_{pk}, is calculated as,

$$C_{pk} = C_p - \frac{|m - \bar{\bar{x}}|}{3\sigma}$$

where m is the target specification, x-double bar is the process average that is the mean of the sample means _, and 3 s represents the natural tolerance limit found in the process [Gitlow et al, 1989, p. 455]. Essentially, the C_{pk} penalizes the C_p for x-double bar being offcenter. In the example for C_p above, but with a process average that is 0.11-inches,

$$C_{pk} = 1.0 - \frac{|0.010 - 0.011|}{0.002} = 0.5$$

The C_{pk} is considerably less than 1.0 and tells the user that there is a problem.

Similar techniques, such as the Cpu index, measure how far off the process average is from the upper specification limit. These may be applicable to the accuracy of map digitizing, where the target value is zero with an error limit that has a one-sided normal distribution.

The cartographer can use C_{pk} to characterize the adequacy of a process. Merely calculating C_{pk} forces the cartographer to measure and analyze the process, which in itself is a constructive step in improving quality and will inherently yield results. If the capability index is taken seriously, the value of C_{pk} will guide the quality improvement process. Certainly, the capability index should be used in customer-supplier relationships. A general rule in industry is that a C_{pk} greater than 1.33 indicates excellent quality, with a rate of noncon-

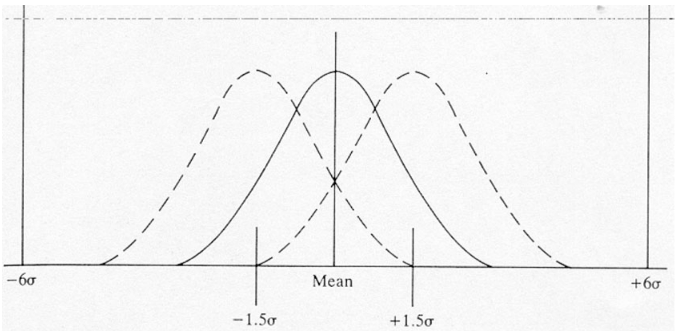

Figure 3. The effect on the distribution when the process is off center, in this case by +/- 1.5 s.

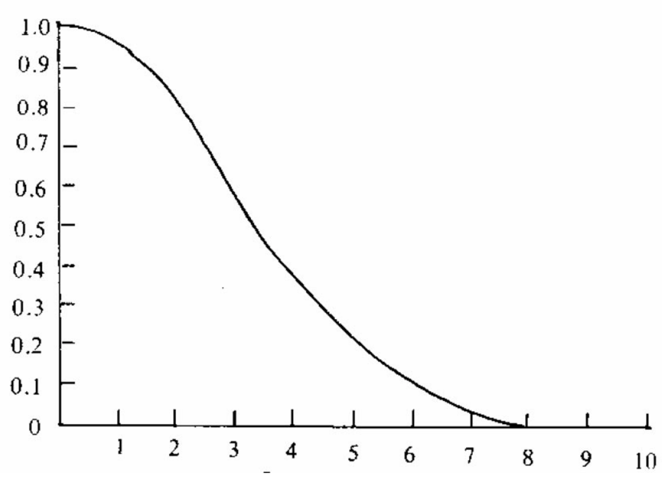

Figure 4. An example of a single-sided distribution where the x axis is the distance between the digitized point and the target and the y-axis is the probability of its occurrence .

formance of 1/31,250, and should be the minimum accepted by the customer of a well-established process [Crossley, 1998]. Obviously, the customer should always demand a C_{pk} of 1.0 or greater, and the supplier should be able to demonstrate that result. There are other techniques to measure the adequacy of a process, such as root square mean error in positional measurements. The relevance of the capability index measure must not be oversimplified, but the capability index does provide a universal and simplified measure that summarizes the true capability of a process. Its use will allow the cartographer to conduct a process capability study and further pursue quality engineering techniques.

Six-Sigma Quality

Six-sigma has become a popular although abused cliche in industry. The concept has considerable merit and quality engineers are much happier with the idea than with the ill-defined total quality management trend of years past. The six-sigma statistic measures the capability of a process to perform virtually defect-free work. It is simply an extension of Schewhart's "natural" three-sigma concept, except that, six-sigma now sets a new standard. The competitiveness of modern world technology, not unknown to cartographers, demands quality at the six-sigma level. As production moves toward six-sigma, the cartographer will find that map quality improves, the need for testing and inspection diminishes, rework is reduced, work in progress declines, costs go down, cycle time goes down, and customer satisfaction goes up. Six-sigma characterizes world-class quality, four-sigma quality is considered a manufacturing industry standard, and two-sigma quality is considered non-competitive [Harry, 1998]. It is worth noting that the domestic airline industry has a fatality rate of between six and seven sigma (0.43 ppm) [Harry, 1998], which apparently meets customer requirements.

The expression K identifies how many standard deviations of actual production will fit within the specification:

$$K = \frac{\frac{USL - LSL}{2}}{s}$$

where _-bar=T; that is, the mean equals the target specification, so the process is centered [Tadikamalla, 1994].

For an example of six-sigma quality, suppose a line width had a target specification of 10 mm with a tolerance of +/- 1.2 mm, and actual measurements showed a mean of 10 mm with a standard deviation s of 0.2:

$$K = \frac{\frac{11.2 - 8.8}{2.0}}{0.2} = 6.0$$

Thus the linework achieved a six-sigma quality level. The problem is, as Motorola has found and as is now generally accepted throughout industry, processes are often off center by as much as +/- 1.5s, or K-1.5, which has a profound effect on quality [Harry, 1998]. If K initially equals 6.0 but is then reduced to 4.5 because of a 1.5 s shift, the process will produce 3.4 defects per 1 million items, which is considerably worse than the theoretical 2 defects per *1 billion* with a centered process [Tadikamalla, 1994]. Motorola claims six-sigma but always adds the qualifier that it yields 3.4 defects per million. Obviously an effort to bring the process to center will yield significant results.

Four implementation steps are necessary to make the six-sigma philosophy effective: (1) measure the product and production performance, (2) analyze those measurements for adequacy and find the root causes for unacceptable measurements, (3) improve those operations adversely affecting performance, and (4) control those improvements to ensure that they are sustained [Hoerl, 1998].

Control Charts

All processes exhibit variation to some degree. That is why 100 digitized maps, will each yield varying degrees of quality, despite being produced using the same hardware, software, procedures, and personnel. A goal of the cartographer managing a production operation must be to bring the variation under control and minimize it. This can be accomplished by using a suite of tools known as control charts. Control charts are statistical tools used to analyze and understand process variables. The significant utility of the control chart is the ability to detect and analyze temporal changes in quality, an early indicator that a process that was in control is now going out of control. The goal is to detect and correct the change before the customer is affected.

Process variation has two components, (1) common causes and (2) special causes [Deming, 1982]. The common causes account for about 85 percent of variation [Gitlow et al, 1989, p. 163] and are the result of inherent process errors, such as the limited resolution of a digitizing tablet. Special causes account for the remaining 15 percent of variation and are normally caused by factors outside the process, such as a dead spot in the digitizing tablet. Special causes typically account for the greatest magnitude in process variation and must be eliminated first. Control charts can be used to differentiate when special causes exist, and the cartographer can then concentrate on these problems. The control chart should be used in an iterative process to eliminate problems of the greatest magnitude first and then to work through the problems in order of decreasing magnitude [Crossley, 1998]. When the special causes are eliminated, the process is said to be in control. The control chart needs to be continually maintained to detect any new special causes. It also may be desirable to use the control chart to reduce common cause variation [Juran and Gryna, 1993, p. 109]. When fully exploiting control charts, the cartographer will move from a philosophy of meeting specifications to a philosophy of continuous improvement. At this point, the journey to six-sigma quality becomes very realistic.

Following are the basic rules for constructing and using a control chart: (1) collect historical data; (2) calculate a location statistic, which is the mean; (3) calculate control limits, which are +/- 3 standard deviations; (4) construct the chart by plotting 1, 2, and 3; and (5) analyze the chart [(Crossley, 1998].

The first and most fundamental control chart is the P-chart. *P* is simply the ratio of the number of defects in a batch to the total number of items in the batch. Values of *P* are plotted with time. A centerline is plotted, which is the mean of the *P*'s, the process average. Upper and lower control limits are also plotted, which are three times the estimated standard error, known as three-sigma limits [Gitlow et al, 1989, p. 170].

$$UCL_{(p)} = p + 3\sqrt{\frac{p(1-p)}{n}} \qquad LCL_{(p)} = p - 3\sqrt{\frac{p(1-p)}{n}}$$

If an individual value of *P* falls beyond the control limits, which are a "natural" specification based on probability, the process is said to be out of control, and it is theorized that this is a special cause variation. Other out-of-control signs are when a long run of consecutive points (five-seven) are above or below the centerline, two out of three consecutive points are in the outer third zones of the chart, or there is an obvious trend or shift [Western Electric, 1956]. The cartographer must then investigate the cause of the magnitude for that value of *P*. The cartographer must focus on the specific factors that caused the problem, and eliminate them. If these efforts are successful, subsequent values of *P* should fall within the control limits, unless there are other initial special causes. Of course, subsequent calculations of the control limits will narrow those limits, and so new values of *P* may

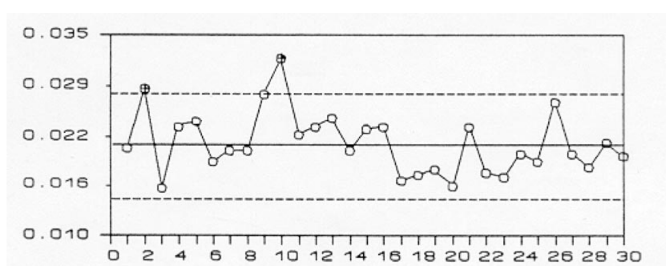

Figure 5. An example of a P-chart. Each sequential value of *P* is plotted and the points connected. The mean is plotted with a solid line and the upper and lower control limits with a dashed line.

then fall outside, leading to additional improvement efforts. If continually successful, all special causes will be eliminated and only common causes will remain. The production process will stabilize, and all values of *P* will fall within the control limits.

P-charts work on what is known as attribute data; that is, whether or not a measurement meets specifications, a binary measurement. Another concern is what is known as variables data; that is, the degree to which a measurement does not meet its target specification [Crossley, 1998]. This is a second phase of process improvement, and uses the _-chart to control process average, and the R-chart to control process range.

If 10 maps are digitized in 1 day, and they require that the first standard deviation, or 67 percent, of the vertices of the line strings fall within 3 mils of the actual centerline, and our actual measurements show that the minimum first standard deviation is 1.2 mils and the maximum is 4.6 mils, the range, *R*, of measurements is 4.6 - 1.2 = 3.4 mils = *R*.

$$R = \chi_{max} - \chi_{min}$$

where x-max is the maximum measurement and x-min is the minimum measurement [Gitlow et al, 1989, p. 102]. If *R* is calculated for each of 10 days of work, the average of the *R*'s is R-bar.

$$\overline{R} = \sum \frac{R}{k}$$

where *k* = the number of subgroups, or in this case, each day's work [Gitlow et al, 1993, p. 179]. If the *R* for each day was 3.4, 3.5, 3.5, 3.3, 5.5, 3.1, 2.2, 2.8, 3.0, 3.2, then R-bar would be 3.35. This would be the centerline of the R-chart. The control limits are three times the standard error:

$$UCL(R) = \overline{R} + 3\sigma$$

$$LCL(R) = \overline{R} - 3\sigma$$

[Gitlow et al, 1989, p. 180] The R-bar chart is used much like the P-chart. The goal of the R-chart is to control the range of variables data and to create continuously improving consistency in the process. Values outside the control limits indicate that the uniformity of the process has changed, typically caused by change of personnel, source maps with increased variability (wide mixture of low-frequency and high-frequency line work), hardware problems, poor documentation, or lack of training.

Another variables factor that must controlled is the value of the mean of the measurements. This is known as the X-bar chart and is perhaps the best known of the control charts used by quality engineers. The measure x-bar, _, is simply the mean of the measurements in a batch, and x-double-bar is the mean of the batch means:

$$\overline{\overline{x}} = \sum \frac{\overline{x}}{k}$$

The upper and lower control limits are calculated by adding and subtracting the average of the sub group

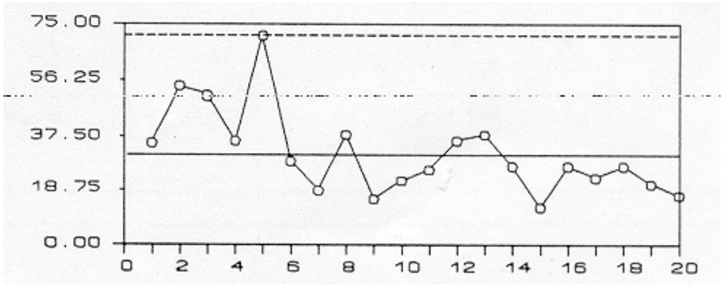

Figure 6. An example of an R-chart. Sequential values of R are plotted and connected. The mean of the R's is plotted with a solid line and the upper limit with a dashed line. There is no lower limit because it is less than zero.

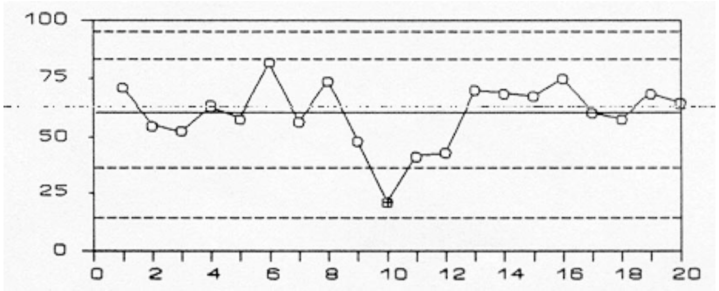

Figure 7. An example of an X-bar chart. Sequential values of x-bar are plotted and connected. X-double bar is 59.4, UCL is 82.2, and LCL is 36.6. Also plotted in this example are the upper and lower specification limits at 95.0 and 15.0.

standard deviations from the average of the sub-group means. We divide this average s by the square root of the total population to properly weight the dispersion of measurements:

$$UCL(\bar{x}) = \bar{\bar{x}} + 3\frac{\sigma}{\sqrt{n}} \qquad LCL(\bar{x}) = \bar{\bar{x}} - 3\frac{\sigma}{\sqrt{n}}$$

[Gitlow et al, 1989, p. 183] X-bar charts are used similarly to, and in conjunction with, R-charts. Values outside the control limits on X-bar charts indicate that all maps in the batch have been affected by a change, typically caused by new software releases, a uni directional bias in registration, parallax in an eye-piece, or new personnel. The X-bar chart should be used in conjunction with the R-chart, but it is only truly effective when the R-chart is in control.

Key to the effective use of control charts is the ability to analyze them. A series of well-established rules can alert the cartographer to a problem [Crossley, 1998]: (1) A single point is outside the control limits (_ +/-3s), (2) seven consecutive points are above or below the mean, _, and inside the control limit, (3) seven consecutive points are increasing or decreasing, (4) two of three consecutive points are between the second and third standard deviation (2s>x>3s), (5) four of five consecutive points fall between the first and third standard deviation (1s>x>3s) with no points outside the control limit, and (6) eight consecutive points are outside of the first standard deviation (x>1s). These rules are based on the unlikely probability of these characteristics naturally occurring.

Realize that the upper and lower control limits are a "natural" limit based on process capability. It is entirely possible that the product specification is not based on the "natural" limits and that a specification may be impossible to maintain with the process used. A cartographic producer must advertise specifications on the basis of the process, or "natural" limits. A cartographic customer must accept a producer on the basis of whether the "natural" limits fall inside the product specification. The customer must also question whether specification limits should be absolute, for then it might be necessary to utilize 100 percent inspection, which would greatly drive up costs.

The three control charts presented here serve only as an introduction to statistical process control. These techniques are widely used in industry throughout the world and helped to give Japanese companies the ability to produce consistently high- quality goods, which won consumer support while cutting manufacturing costs. The same is now occurring in many companies in the United States. In the U.S., it has been estimated that 15-40% of the cost of manufacturing involves rework [Wheeler, 1993]. The effects on cartographic production are likely to be similar. By cutting the rework, costs will go down. That is a fundamental factor in business success achieved through statistical process control. These techniques can help quality significantly, but there is much more to learn about the characteristics of statistical parameters and considerable insight to be gained on the use of statistics from the teachings of Schewhart, Deming, and Juran.

Conclusion

The statistical process control tools presented here have had an enormous impact on world industry and the benefits of their application to cartography are clearly evident. The designers of ISO-9000 understood the application of statistical techniques and required that their use be addressed, but did not specify a specific approach. By turning to standard practices in industry, the cartographer can find a wealth of techniques to measure the dynamics of quality in production. Understanding these dynamics allows the cartographer to identify and solve problems before the customer is affected. The cartographer can then continually improve production operations, producing data correctly, cutting rework, saving time, lowering costs, satisfying the customer, and maximizing profits.

References

Crossley, Mark L. (1998). *Statistical Process Control.* American Society for Quality. Milwaukee.

Deming, W.E. (1982). *Quality, Productivity and Competitive Position*. Center for Advanced Engineering Study. Massachutetts Institute of Technology, Cambridge, MA, Chapter 7.

Gitlow, Howard S., Gitlow, S., Oppenheim, A. and Oppenheim, R. (1989). *Tools and Methods for the Improvement of Quality.* ASQC Press. Milwaukee.

Gunter, Bert (1998). Statistics Corner. *Quality Progress*, v. 31, no. 6, pp. 113-119.

Harry, Mikel J. (1998). Six Sigma: A Breakthrough Strategy for Profitability. *Quality Progress*, v. 31, no. 5, pp. 60-64.

Hoerl, Roger W. (1998) Six-Sigma Quality and the Future of Quality. *Quality Progress*, v. 31, no. 6, pp. 35-42.

Juran, J.M. and Gryna, Frank M. (1993). *Quality Planning and Analysis; From Product Development through Use.* Third Edition. McGraw-Hill, Inc. New York.

Schewhart, Walter A. (1931). *Economic Control of Quality of Manufactured Product.* D. Von Nostrand Company. New York.

Simley, Jeff and Buser, Marcia. (1997). *The Application of ISO-9000 in Map Digitizing.* International Cartographic Association: International Cartographic Conference, 18th, Stockholm, 1997, pp. 848-855.

Tadikamalla, Pandu R. (1994) The Confusion Over Six-Sigma Quality. *Quality Progress*, v. 27, no. 11, pp. 83-85.

Western Electric (1956), *Statistical Quality Control Handbook.* American Telephone and Telegraph Company, Chicago.

Wheeler, Donald J. (1993). *Understanding Variation; the Key to Managing Chaos.* SPC Press. Knoxville, TN.

Session / Séance 27-D

IGAC'S Quality System 'Design and Implementation'

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Abstract

The Colombian Geographic Institute 'Agustín Codazzi' (IGAC) as many geoinformation production organizations in the world, nowadays, is starting change the way of doing business. In one hand the trends of moving government capacity to the private sector are forcing the organization to compete with those in the private sector. The emphasis in the needs of customers and customer satisfaction becomes a very important aspect within in IGAC. To achieve this goal it has to make great changes in his production strategy.

The new policy directions of IGAC as a multidisciplinary organization, open to new ideas, customer focused and with new trends to create new information and services required by the customers is to design and implement a quality system capable to improve the existing production line, improve product quality, and implement standards whose impact determine the success of the organization.

Implementing Total Quality Management in IGAC, is expected to increase its competitive power in the GIS market in Colombia. The IGAC'S quality system must be the result of the disciplined and structured design, implementation and maintenance of the complete quality actions by the people, hardware, software and products which will assure quality to the customer and lower cost production for the organization.

To introduce ISO9000 in IGAC will provide a foundation for continuos improvement. Documenting the quality system clarifies how the Institute really works, enables critical process measurements and facilitates process improvement and increased customer satisfaction.

On the other hand the institute have been starting to develop a politic for the human side, which include discussions, seminaries and courses for motivation, culture change, reward and recognition of the staff and in general cover the whole employees in the technical and administrative level.

In conclusion the top management of IGAC is very supportive and committed to the implementation of Total Quality System in the Institute. If this trend continues into the actual implementation the project will be finished successfully.

Introduction

The Colombian Geographic Institute 'Agustín Codazzi' (IGAC) has defined five strategic objectives, within its strategic plan 1999-2002, in order to accomplish its mission. This plan reflects several strategic shifts in focus such as:

- Change to a business organization: The Institute aims to generate more income and control its expenses (improve efficiency, reduce staff redundancy, etc.) without violating its national mandate.
- Change from the production of conventional base maps, covering the entire country, to the satisfaction of the changing needs in the GIS market (in private and public sectors)

- Participation in the international market, with emphasis on Latin America.

One of the most important objective is to design and implement a Quality System which permits supply quality products according to the requirements and necessities of the customers and users.

Although in IGAC some quality control checks exists for the products made by digital techniques, adopting the Total Quality Management (TQM) approach is necessary in order to assure the quality of those products.

The main elements considered in the accomplishment of TQM are the following:

- Quality policy: Frameworks of the general quality intentions of the organization
- Quality management: Those actions, which permit to set up the policy intentions
- Quality system: The operational techniques and activities used in order to fulfil requirements for quality in the organization
- Quality assurance: Involve the necessary actions to provide adequate reliance that a product will satisfy the given requirements for quality.

Quality Policy

The main activity achieved was to formulate a quality policy for the Institute. These quality policy shows the principal actors of the quality system such as: human resource, processes, products and customers/users.

Figure No. 1 summaries the quality policy of IGAC within the external customer (who pays for the product) is also an internal customer. The internal customer (user) can be the people of the organization who must be satisfied with the product or service. This product (or service) needs adequate processes and total involvement of the team who work together to get the job done.

Quality Management

The interrelation between people, organization and processes require a head that defines the roles of the different actors in the quality system. Figure No. 2. shows a general description of the structure of the IGAC's quality system.

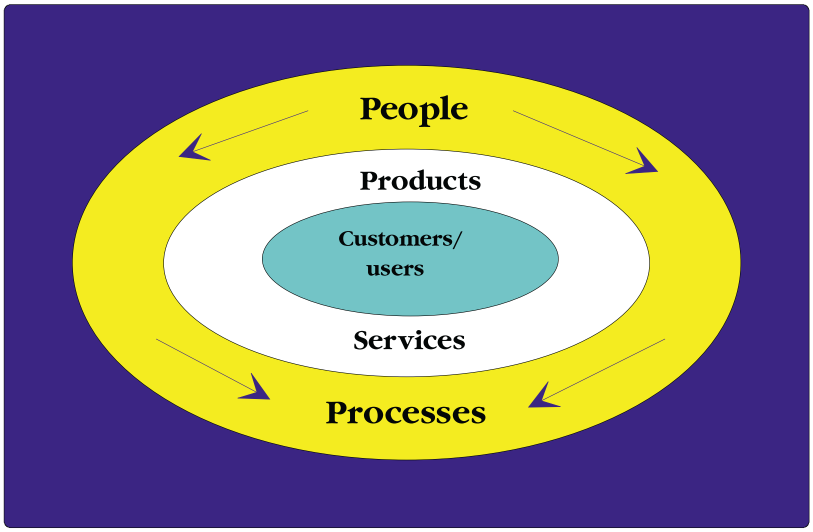

Figure 1. IGAC Quality policy scheme

Process Improvement

For any organization involved in the production of geoinformation products, achieve customer satisfaction require a system of collecting and processing good and relevant data to determine what customer requirements are, how well the production system accomplish these requirements, and how well the products and services satisfy the customer needs.

To introduce the quality system in IGAC is framed in a institutional project where one of the most important challenges is 'process improvement'. For these purpose a quality team was in charge to accomplish these mission.

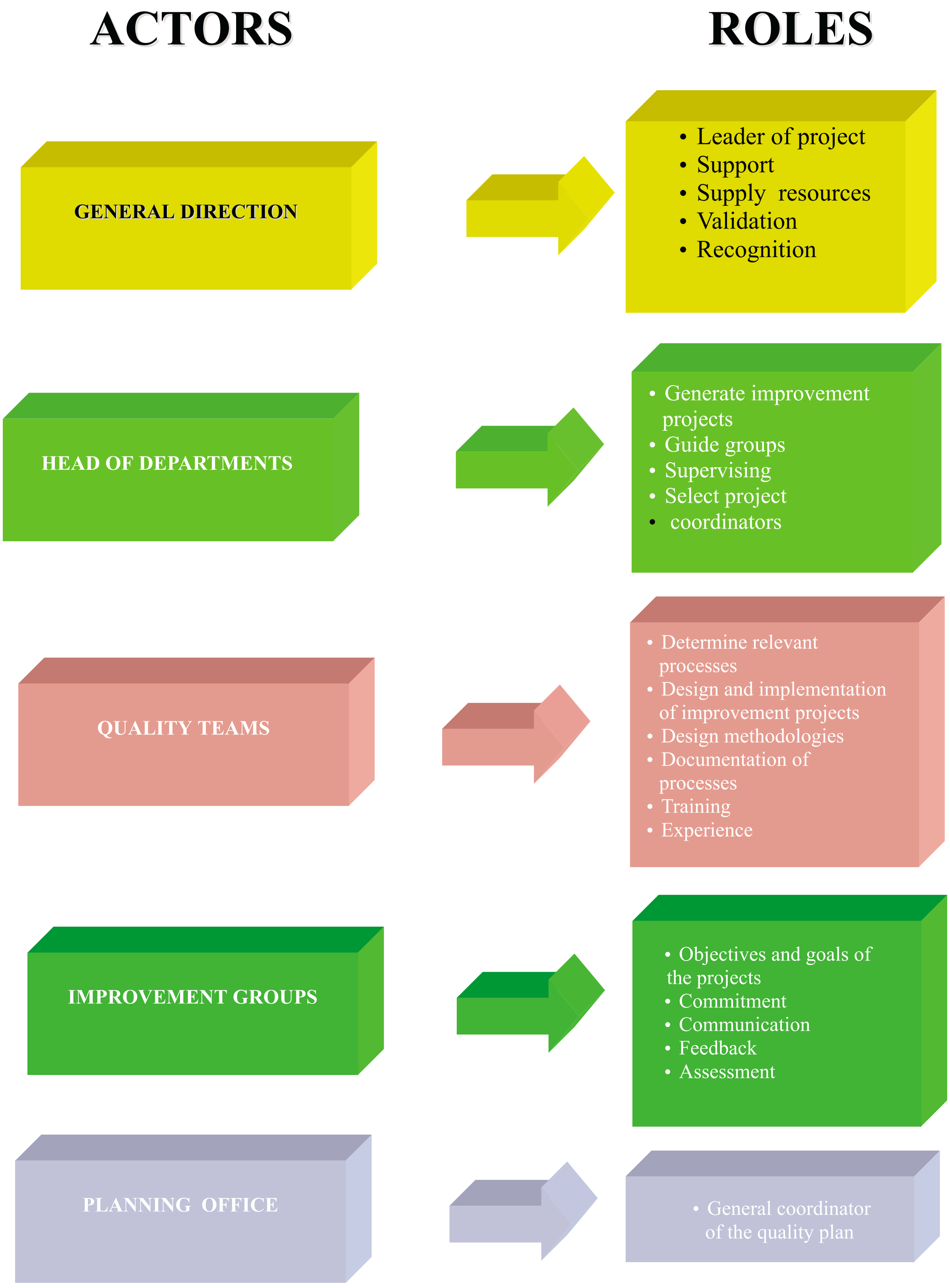

Figure 2: IGAC´s Quality System structure

The main activities defined in the process improvement project are the following:

1. Requirements definition
2. Relevant process selection and identification of problems
3. Design and implementation of Improvement Plan

1. Requirements definition:

The firsts and most important principle of TQM is the customer focus which implies meeting and supply customer requirements and expectations every time. In the department of Cartography, for instance, some interviews were made to the internal users such as Cadastral department and Soil department in order to know their necessities of spatial information. The conclusion was that some of those requirements are still not completely satisfied.

2. Relevant process selection and identification of problems

2.1 Processes identification

This work was made for all departments within IGAC. The first step was the selection of technical functions within technical departments. Afterward for each function their processes were defined and finally the owner of the processes described in detail the main activities developed by the group work process. Figure No. 3 shows the used methodology for selection of relevant process regarding to the mission of IGAC.

2.2 Relevant process selection

In these step the relevant processes were identified by workshops inside technical departments. Firstly the processes were rated according the following variables

- Without importance
- less important
- Necessary
- Important
- Essential

Following each process were rated by a certain number of points between 1 and 5 according the following problem variables:

- Late delivery
- Low quality
- Excessive documents
- Excessive steps
- Misunderstood of processes
- Low dissemination of the process
- Errors in the procedures

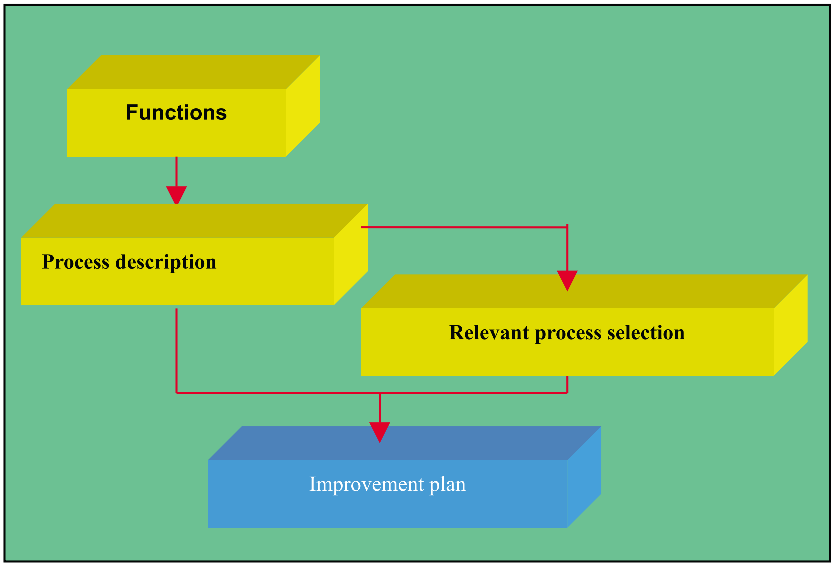

Figure 3. Methodology for production line optimization

Marks were based in the following factors: 1: never occur, 2: sometimes occur, 3: several times occur, 4:often occur, 5: always occur.

The relevant processes defined in the technical areas of IGAC according to the last qualification are the following.

Table 1. Relevant processes

Process	*Technical area*
Data Quality Control	Cartography
Editing and Output	Cartography
Photo laboratory	Cartography
Elaboration of soil homogeneous areas	Agrology
Field work preparation	Agrology
Data entry in the Cadastral information system	Cadastre
Cadastral maintenance	Cadastre
Administrative border delimitation	Geography
O.T. Methodologies	Geography

2.3 Problems identification

In order to determine the main problems of the relevant processes the Ishikawa diagrams were used, such as in the department of cartography, showing in figure No. 4.

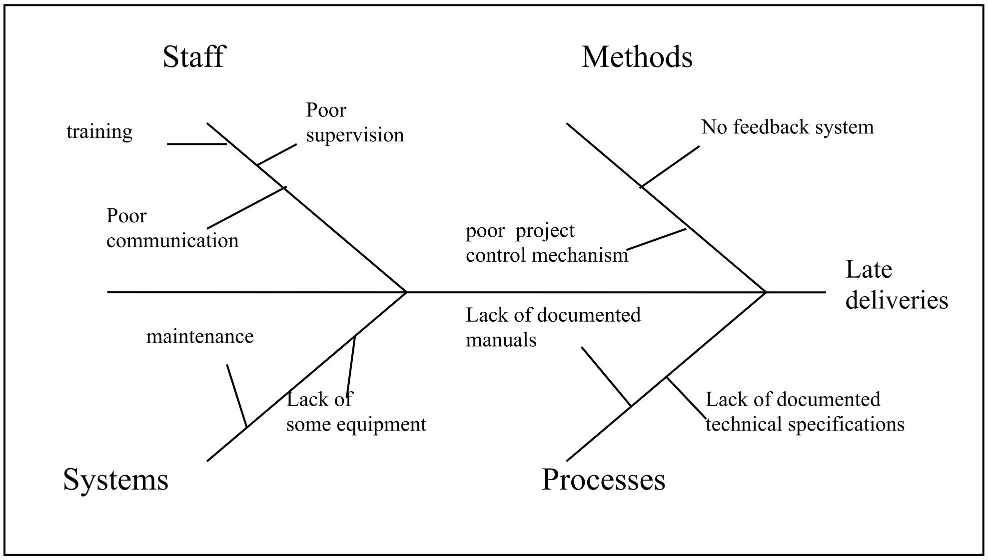

Figure 4. Ishikawa diagram for late deliveries

3. Improvement Plan

Once the main problems were identified, we define and describe the ´Improvement plan´ which involve the following activities:

- Documentation and settle of technical specifications
- Documentation of procedures
- Product quality assurance
- Process quality assurance
- Implementation of standards

Implementation of standards

IGAC has leading the development of standards in Colombia. Nowadays the goal is to implement quality standards for spatial data. Therefore, since 1996 the Institute coordinate a committee addressed to standardization of geographic information in Colombia sponsored by ICONTEC (ISO-like organization in Colombia). One of the main objective of these team is to implement a metadata standard

On the other hand the Geographic Institute is leading the Colombia Spatial Data Infrastructure (ICDE), which the goal is that the major spatial data producers (public and private) join their efforts in order to develop a regional geographic information infrastructure. The aim of these team is to improve access, sharing, integration and use of spatial data.

One of the project framed below these context is the implementation of ISO-9000 standard in the production line and data quality certification. Actually the Institute is in the level of training in ISO-9000, the challenge is to implement these standard within two years.

Introducing IS0-9000 in IGAC is expected:

· Improve competitive power

· Enhance quality control in production

· Improve quality products

· Improve customer satisfaction

· Continuous improvement

Sensitize IGAC to quality

In this project several workshops sessions are doing about TQM. The aim is sensitize the administrative and technical people and introduce this people in the theme of quality. The materials used for these workshops are videos and pictures of TQM in the central office (Bogotá). This year is expected to start these workshops in the different branches of IGAC around the country.

Conclusions

It has been shown that implement TQM is absolutely necessary for IGAC as a competitive asset on the market and to improve the quality of the products and services.

The top management is very supportive and committed to the implementation of Total Quality Management in the Institute therefore the actual implementation of the project will be finished successfully.

It is necessary to increment the quality sensitive sessions in order to achieve more commitment from the people involved in the different processes.

Introducing ISO-9000 standards in the production process of IGAC, it may be anticipated that substantial process improvement will be made in a short period of time.

References

Alvarez, O. (1998) Administración del Sistema de Calidad del IGAC, Plan desarrollo 1995-1998. Revisión anual. IGAC.

Rocha, L.A., (1997) Applying concepts of Business process redesign and Operations Management in a Geoinformation production organization. Case study 'Instituto Geográfico Agustin Codazzi'(Colombia), ITC Msc. Thesis , Enschede.

Session / Séance 30-B

Standardization of Spatial Data for Exchange in Japan

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Abstract

In the trend of informationalized society, the needs of spatial data infrastructure as a basic information infrastructure and standardization of spatial data for exchange are rapidly increasing.

Actually, the International Organization for Standard (ISO) attends to standardization on geographic information, and Japan also has needs of standardization which aids to exchange geographic information. In such a situation, The Geographical Survey Institute of Japan (GSI) has made a research on "Spatial Data Exchange Standard" from the fiscal year 1996 to 1998.

This research on "Spatial Data Exchange Standard" was composed of seven items, schema and structure of spatial data, quality of spatial data, spatial reference method, metadata, encoding, cataloging, and terminology.

This paper reports the results of the research and the basic concepts of development of "Spatial Data Exchange Standard". Also, related activities of Japanese Government are introduced.

1.Introduction

For GIS users, one of the most serious problems is its huge cost to introduce. In particular, it is very expensive to produce and update spatial data, so reduction of its cost is an important problem to be solved. On the other hand, for the spatial data that should be shared with other systems, it is difficult to transfer. Therefore, many users produce and maintain only for themselves in these days, so they want easier ways to exchange spatial data.

To solve such condition, we have developed a standard of spatial data for exchange from any GIS to other one. In this research, we have invited some partners for joint study, because standardization requires wide opinions. Through this public invitation, 53 companies from the field of survey or computer software joined to the research with the Geographical Survey Institute.

The scope of Spatial Data Exchange Standard includes basic geographic object which is commonly used in GIS (or by the terms of paper products, features drawn on basic maps). In other words, the target data include data in maps and images, and statistics as attributes related by spatial reference. The target users include both of producers of spatial data and users of spatial data, because the producers often exchange their data with users.

Regarding Spatial Data Exchange Standard, we discuss as follows:

1) Schema and structure of spatial data
2) Quality of spatial data

3) Spatial reference method
4) Metadata
5) Encoding
6) Cataloging
7) Terminology

We studied for 3 years from the fiscal year 1996 to the fiscal year 1998. In the fiscal year 1996, we had discussed frameworks and basic concepts of Spatial Data Exchange Standard, and defined its first draft. In the next fiscal year, we got the second draft. In the last fiscal year, Spatial Data Exchange Standard had been developed. The results of each work item were as follows:

2. Schema and structure of spatial data

This work item defines schema and structure of spatial data as conceptual schemes and logical schemes for the purpose of aiding spatial data exchange among different systems with analyzing and arranging spatial, temporal and thematic attributes. We researched existing formats in domestic and foreign standards including ISO 15046, with listening wide opinions by a questionnaire for users, and defined the conceptual schema and logical schema. These are described by EXPRESS and EXPRESS-G (see Figure 1). Also, we defined the application schema describing the structure of spatial data.

3. Quality of spatial data

This work item defines quality of spatial data and its evaluation procedure for Spatial Data Exchange Standard. It defines constituent elements of quality of spatial data for describing how the data is based on its product specifications. It also defines quality metrics for constituent elements, these estimation methods, total evaluation methods, and report format of these results.

We researched on quality defined in existing standards for spatial data. We found methods of measurement, methods of conversion, scale, date of production, and so on. They correspond to lineage, resolution of position, accuracy of time, and so on. Consulting with the draft of ISO 15046 standard, we defined quality of spatial data as a difference between the dataset which would be evaluated and an ideal dataset which completely followed its product specifications, but not a deference between the dataset and the real world.

In addition, we defined constituent elements of quality as two types of elements. One consists of elements of quality, which describe evaluation results as values, and the other is appearance of quality, which describe estimation without any values. Former includes sub elements which define quality metrics.

Regarding evaluation procedure, we researched contents of quality evaluation in existing standards, and defined basic flows of evaluation procedure, quality metrics, quality evaluation measures, quality evaluation method such as computer automated test or sampling test, and report formats of quality evaluation results.

4. Spatial reference method

Spatial reference method defines the frameworks and necessary items for direct reference, based on coordinate system such as plane rectangular coordinate system, and indirect reference using geographic identifiers such as administrative district names, Standard Grid Square, and zip code district, which help exchange of spatial data produced by different GIS.

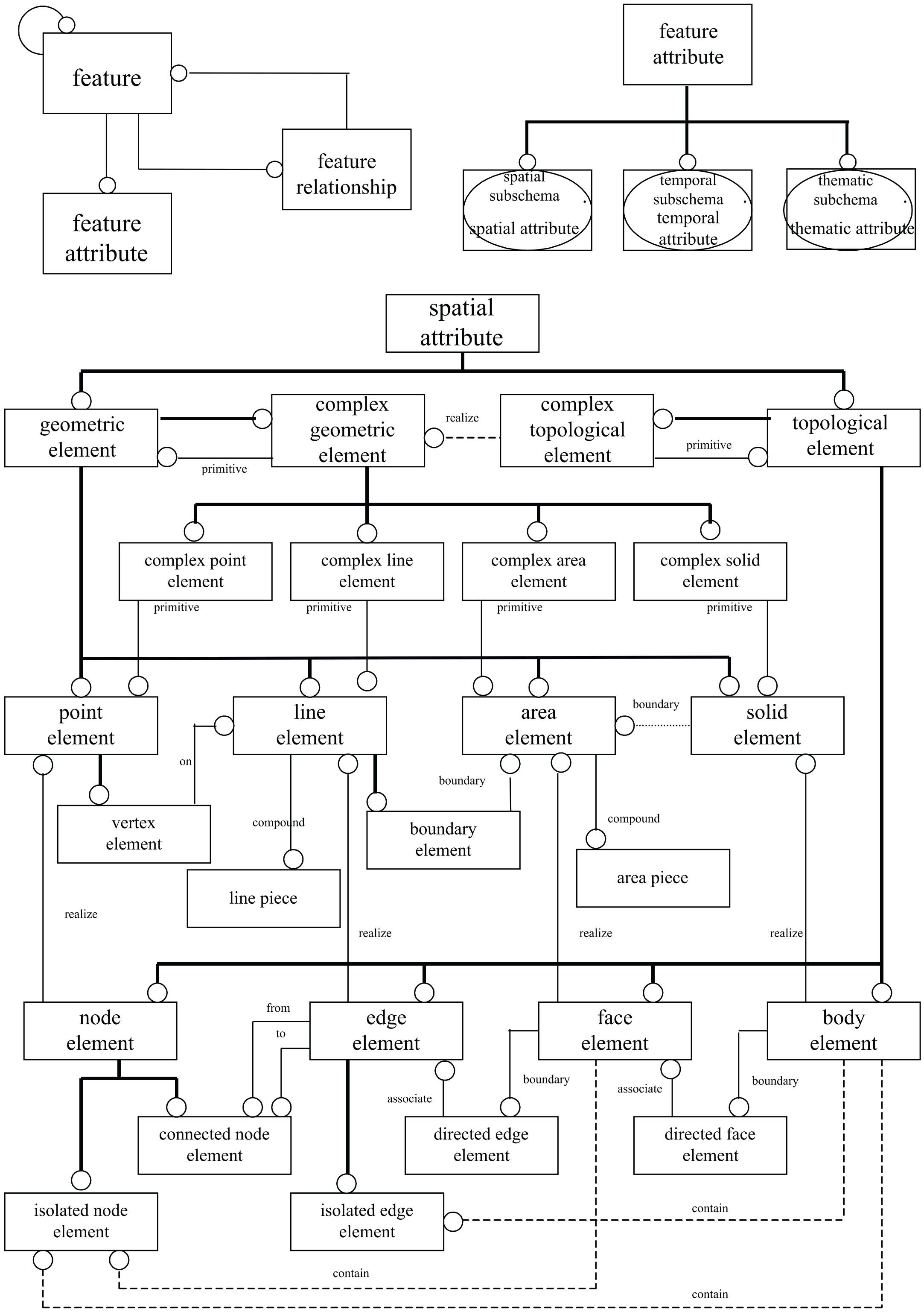

Figure 1. Schema of spatial data (Extract)

Regarding direct reference, there are two ways. One is to keep existing frames and to standardize its conversion, and the other is to recommend a single frame. We selected the first way to define conversion method between different frames. Description to enable easier operations between different coordinate systems was defined.

Regarding indirect references, we defined the framework and items to specify the feature location using geographic identifiers. The framework is composed of spatial referencing system and gazetteer. Spatial referencing system defines location types necessary for location retrieval. Gazetteer defines geographic identifiers correspond to location types defined in spatial referencing systems.

5. Metadata

Metadata standard defines the schema required for describing spatial data and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of spatial data.

The standard is applicable to spatial datasets, dataset series, and individual features and attributes.

Metadata standard is applicable to the cataloging of datasets, clearinghouse activities (level 1), and the full description of datasets (level 2).

The standard defines mandatory and conditional metadata sections, metadata entities, and metadata elements. They are the core or minimum set required to serve the full range of metadata applications for data discovery, determining data fitness for use, data access, data transfer, and use of digital data. Also, this standard defines optional metadata elements to allow for a more extensive standard description of spatial data. A method for extending metadata to fit specialized needs is defined, too.

Metadata sections consist of identification, data quality, lineage, spatial data presentation, reference system, feature catalog, distribution, and metadata reference.

Generally, the standardization was based on the first committee draft of ISO 15046.

6. Encoding

In this item, description in conformity to standard encoding rule for exchange of spatial data recorded on electronic media is defined. Examples of the implementation are also presented. The standard adopted ISO 10303-11 (STEP-EXPRESS) for the definition of a profile. Also, ISO 10303-21 (STEP-PART21) was adopted for implementation of the profile.

7. Cataloging

A spatial data catalog is a set of definitions of feature type, feature attribute, feature relationship, and feature functions. The feature catalog promote the dissemination, sharing, and use of spatial data through providing better understanding of the content and meaning of the data.

In this standard, we presented the concept of catalog definition, guideline of catalog making, and sample feature catalog.

8. Terminology

For the unification of terminology in this research, the thesaurus composed of terms used in the standard were compiled. Each term has Japanese term, reading, equivalent English term, related work item, and definition.

9. Conclusion

To come into wide use, it is important to adopt many opinions. We plan to review the Spatial Data Exchange Standard, so we ask wide opinion about it. Any comments will be gratefully appreciated by your reading specific contents from the homepages of GSI.

10. Related activities of Japanese Government

A Liaison Committee of Ministries and Agencies Concerned with GIS was established in September 1995 to promote efficient development and effective utilization of GIS within the Government under close cooperation between Ministries and Agencies. The Cabinet Councillor's Office, Cabinet Secretariat, is designated as the secretariat of the Liaison Committee with assistance from the Geographical Survey Institute (GSI) and the National Land Agency (NLA). The Committee has two task force groups, i.e. Spatial Data Framework Task Force Group and Basic Spatial Data Task Group, each of which has a few working group to discuss more specific topics in detail.

The Liaison Committee developed a Long-term Plan in 1996 for the development of NSDI in Japan. The Plan Specifies actions to be taken by the Government during two-phase period starting in 1996 up to the beginning of the 21st Century. The first phase focuses on the definition of the National Spatial Data Infrastructure in Japan as well as standardization of geographic information including metadata standardization and clarifying the roles of the Government, local governments and private sectors, rather than actual spatial data development. The implementation of NSDI including spatial data set development for NSDI is expected in the second phase. Approximately three years are assigned to each phase, i.e. the first phase (1996-99) and second phase (1999-2001).

Spatial Data Exchange Standard has been adopted as the first edition of "technical" geographic information standard within the Government by the Liaison Committee of Ministries and Agencies Concerned with GIS in March 1999.

Moreover, at the end of this March, GSI has released geographic metadata retrieval system on the homepages of GSI concerned with 117 kinds of CD-ROM or FD digital map data unit being supplied to public. The metadata are based on the ''technical'' standard according to committee draft of ISO 15046, and consist of 61 items, which are called conformance level 1 ''catalog information'', among the about 450 items in all. The system is a prototype in itself, so there are many incomplete functions. In the future, we are going to expand a limit of metadata release from level 1 to level 2.

References

Akeno, K. (1997). Present status of standardization on geographic information. *Theory and Application of GIS*, Vol.5 No.2, 43-51 (in Japanese).

Inaba, K. (1998). International standardization of GIS and the activities of Geographical Survey Institute of Japan. *Technical Report of Geographical Survey Institute of Japan*, A-1-No.199, 30-38 (in Japanese).

Murakami, H. (1997). Development of spatial data infrastructure discussed by the Liaison Committee of Ministries and Agencies Concerned with GIS. *Chiri*, 42-12, 39-45 (in Japanese).

Sato, J. and Okuyama, S. (1997). Development of standardization on spatial data. *Journal of the Geographical Survey Institute of Japan*, No.88, 41-47 (in Japanese).

ISO/TC211: http://www.statkart.no/isotc211/.