Scandinavian Activities in the LIS/GIS Area

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ABSTRACT: Before a Land or Geographic Information System (LIS/GIS) can be fully utilized for planning and decision making, an integrated database must be developed. The Scandinavian countries are currently building geocoded record keeping systems concerning population, property, topography, and tax records. As these national computerized databases near completion, their immediate and potential usefulness is quickly becoming apparent at all levels of government and industry. Sizable investments, however, are required in order to implement and operate a large LIS/GIS. In addition, datasets are often duplicated for use in different systems or are simply incompatible. Major cost reduction benefits, therefore, can only be realized by standardizing database content and format and by encouraging cooperation and exchange of data between the agencies concerned with their maintenance and use.

INTRODUCTION

THE SCANDINAVIAN COUNTRIES – Denmark, Finland, Iceland, Norway, and Sweden – are all tied together by history and necessity. In these countries, the tradition of keeping registers of land records dates back to the end of the 15th century. This tradition continues with the advent of computerized land and geographic information databases. The dynamic and exciting developments currently unfolding in the area of Land and Geographic Information Systems (LIS/GIS) are due to the changing information needs of society and the rapid evolution of data storage, handling, and presentation technology.

Data acquisition remains the most important task as well as the most labor intensive. Increasingly, the traditional data collection techniques such as aerial photography and geodesy are being supplemented by large volumes of spatial data acquired by satellites and image scanners. In spite of these new acquisition methods, however, the cost of data continues to be a very real limitation in the establishment of large LIS/GIS databases.

For data acquisition it is advantageous to arrange cooperation between agencies to avoid duplicated work. It would be ideal if data were only collected one time and then distributed to all interested users (Runnesto, 1987). This is especially true with regards to topographic information. The exchange must necessarily be based on a standard product referenced to a common coordinate system and having standard formats, attribute codes, and classification rules. The concept of "standards" may be viewed as limiting or bureaucratic. In this context, however, basic coordination is a necessary prerequisite for flexibility and utility. Inadequate coordination between data gathering groups can result in greatly increased costs and even prevent the desired result from being attained.

The questions of how to minimize costs for data collection and obtain compatibility between databases through cooperation, coordination, and standardization are under intense scrutiny in Scandinavia today. Each country is rapidly developing its own LIS/GIS capabilities. Consequently, steps must be taken immediately to unify these efforts. This paper will describe the work of the various countries of Scandinavia towards the development of national and regional LIS/GIS databases.

DENMARK

Land information system management represents a significant component of the Danish administrative structure. The total LIS facilitates the functioning of public administration and planning, tax management, land use planning and zoning, infrastructure development and maintenance, building structure management, urban upgrade and rehabilitation programs, as well as a number of fundamental functions of the credit and capital market. In Denmark, the local government authorities are responsible for the maintenance of the various data bases. However, activities are directed at the national level by the "Standing Coordination Committee" under the Danish Ministry of Housing. Databases tied to the national LIS include land (parcel register and cadastral maps), titles and deeds, property (property values and tax management), building structures, natural resources, demographics, income and turnover of private enterprises, and industry and trade.

The Danish LIS is characterized by a very flexible internal structure (Trollegaard, 1985). A comprehensive organization is made possible through a unique system that includes two data processing agencies, Datacentralen and Kommunedata. These agencies are associated with the central and local governments, respectively. The development of this system began during the "planning era" (1960s and 1970s) when local governments found it advantageous to create independent land information subsystems covering building structures, dwellings, and population statistics. Currently, a nationwide general statistical survey is undertaken every four years and the results reported in two major registers: (1) the Central Population Register (CPR) and (2) the Building and Dwelling Register (BDR). These registers can be used in the LIS to ease the process of evaluating real property and permit fully computerized population and housing censuses.

The CPR system was established in 1968, at which time each individual residing in Denmark was assigned a "person" or CPR number. The CPR system thus consists of census data on age, matrimonial status, address, and family information for each individual in the country. The BDR, on the other hand, was established to form a linkage between all land information subsystems (e.g., the cadastre, the land registry, the municipal property register, and the sales register of property) and all other systems using CPR numbers of address codes as identifiers.

The BDR was implemented in under two years time from questionnaires distributed to property owners. It now contains data on 1.8 million properties (defined as one or more buildings), 2.1 million buildings (of one or more units), and 2.1 million dwellings or trade units. The organizational structure of the BDR is the responsibility of the Ministry of Housing and which also determines the guidelines and framework for the entire LIS system. Actual implementation and continual updating, however, is delegated to the municipalities who use the BDR for housing and building statistic compilation, energy planning, and urban renewal planning and design.

FINLAND

Finland is perhaps the Scandinavian country in which the most concentrated work has been done with respect to coop-

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eration and standardization. The most significant information systems under development at the national level are for real estate, forests, water and waterways, environment, and digital terrain and map data. Although most of the information systems are created to serve only one application, users typically need information that has been collected in conjunction with other systems. Without spatial data exchange standards, therefore, there is potential for redundant data collection and maintenance.

In 1985, the Ministry of Agriculture and Forestry set up an LIS Project which is administered by the National Land Survey of Finland (Raino, 1986). The LIS Project is tasked with developing standards for classifying and representing data. Two phases were defined in which the data would be accessible through a batch mode environment by 1987 and interactively using a simple and uniform query language two years later. The procedure for integrating the LIS system was outlined as having the following steps: (1) integration of decentralized data sets (or registers) using a common coordinate reference system; (2) linkage of objects according to their locations; (3) representation of both spatial and nonspatial data (e.g., population) in a standard exchange format; and (4) development of a data dictionary describing the character of the spatially organized systems. In this way, each system remains independent as to its contents and identifiers, and periodic updates can be made without effecting the integrity of other systems. Data redundancy is thereby minimized through the transfer of standardized data between systems. In addition, no limitations are imposed as to the configuration of the basic equipment and software of each system, the absolute number of systems, or the utilization of the data.

The integration of land information systems is not just a technical problem. Other problems include licenses and prices of data. Coordination of the systems must be organized to avoid redundancy or lack of information. The LIS Project in Finland has set the goal of creating an integrated national LIS through standardized exchange of spatial data between decentralized land information systems. It will be interesting to see whether or not this task can be accomplished successfully. Under any circumstances, much will be learned about spatial data and LIS management.

NORWAY

The primary LIS in Norway is known as the GAB system and consists of three different registers. The G-register contains information about all land properties in Norway; the A-register contains addresses; and the B-register contains information about the buildings which have been constructed since 1 January 1983.

The most important features in the G-register are the property unit numbers, types of property, owners' names and addresses, property areas, previous designations, coordinates, archival references, and property addresses. The A-register includes street codes and building numbers for each address; its location within administrative units such as property, election, school, and postal districts; its coordinates; and the buildings and properties at that address. Finally, the B-register contains information about individual buildings, including the building I.D. number, use, type, age and size, the builder's name and address, and other technical information about the building such as drainage, water supplies, coordinates, and address.

The different parts of the GAB system can be linked together by means of their reference units (i.e., the identification number of the real property, or the address or number of the building). Thus, it is possible to compute statistics for these units based on the data contained in any or all registers. Through these reference units, the GAB system also can be linked to other computer-based datasets such as the Land Use Account System, The Resister of Land Resources, and the Register on Water Systems (Engebretson, 1987).

SWEDEN

Historically, official Swedish mapping activities were focused on the production of printed maps, and information handling was designed expressly for that purpose. Some years ago, however, a broader approach was adopted to include responsibility for providing basic geographical data suitable for the activities of other users and producers of land information. The National Land Survey (NLS) of Sweden is responsible for directing and coordinating the establishment of geographical databases by central and local authorities (Ottoson, 1987). This task is performed through discussions with other organizations and by initiatives in standardization, research, and development. The most important topographical databases today are discussed below.

The NLS has established two gridded national elevation databases of differing resolutions. These data are obtained primarily through photogrammetric methods and are used for such tasks as orthophoto mapping and visibility studies. The first grid was established during the 1970s and covers the entire country at a 500-m grid interval. Elevations are stored in 25- by 25-km blocks corresponding to Topographic Map sheets. The second elevation database, with a 50-m grid spacing, is tied to 5- by 5-km Economic Map sheets and is now about 65 percent complete. Full coverage (19,000 grids) will be achieved in 1989.

Basic topographic information on Sweden is also provided in digital format by the NLS. One of these databases covers the entire country and is used mainly for the production of small scale thematic maps (1:1,000,000 and smaller). It contains (1) administrative boundaries of the counties, municipalities, and parishes; (2) hydrographic details such as shorelines, lakes, islands, and rivers; (3) urban area outlines; and (4) public roads and railways. Another dataset used for map presentation at scales of 1:200,000 to 1:500,000 contains the same features but in greater detail, plus place names and some other planimetric information. Although the entire dataset is not yet complete, some of the features are available for all of Sweden.

The NLS employs computer-assisted methods in the production of feature separates for the official Economic and Topographic Map Series at scales ranging from 1:10,000 to 1:100,000 as well as for general maps at smaller scales. The digital information collected for these maps is stored in databases which are available to any user. Large scale mapping (greater then 1:10,000) is a responsibility of the municipalities, but is normally carried out using digital methods by the NLS or private companies. These maps typically include features such as geodetic points, buildings, and property boundaries.

The NLS produces a database of all place names found in the 1:50,000-scale Topographic Map Series. The costs for these data are shared equally by the NLS, the Defense Forces, and the Swedish Alarm Company. The database is now completed, and contains about 500,000 place names, coordinates, category codes, and administrative affiliations.

A hydrographic database is being established through cooperation between the NLS and the Swedish Meteorological and Hydrological Institute (SMHI). It will contain boundary data on all water bodies, basins, and islands (larger than 1 km^2) and rivers, streams, and brooks. This database was completed during 1987 and constitutes the geographical reference in the SMHI information system known as the Swedish Water Archive.

The National Road Administration's national highway database contains technical and administrative information on the Swedish highways and the coordinates of road intersections. An extension of this database to include accurate X, Y, and Z

coordinates of the highway center lines is now under development. Data are acquired from small scale aerial photographs (1:150,000) using analytical stereoplotters. The database will probably be completed in two steps, first the primary highways and then all other roads.

A national flight information data bank covering the whole country is maintained cooperatively by the NLS, the Air Staff, and the Board of Civil Aviation. It includes the information needed to produce air navigation charts and background for flight supervision equipment. Finally, the NLS and the Defense Forces have established raster-formatted land use/cover databases by scanning the 1:50,000-scale topographic map feature separates.

The Land Data Bank System

The registration of real property and land is currently being automated in Sweden (Piscator, 1987). An electronic data processing (EDP) system called the Land Data Bank System (LDBS) is being implemented to facilitate the registration of real property and land and to make the information more readily available for other purposes such as urban and regional planning and taxation. A government agency, the Central Board of Real Estate Data (CFD), was established to develop, implement, and operate the new system. The NLS and National Court Administration, on the other hand, are responsible for LDBS content and maintenance.

The LDBS includes coordinates for each individual real property unit but not for the property lines. Property line bases, however, have been built for the 1:10,000-scale Economic Maps for use in digital large-scale mapping. A standard concept for a National Property Line Base is now under discussion. The database will include not only the property lines but also topological data so that each individual property unit and adjacent units can be defined. By October, 1987, approximately 2 million of the 3.5 million real property units in Sweden were registered in the LDBS. The remaining real property units are currently being transferred to the system at a rate of 330,000 units per year so that the whole country will be entered by the mid-1990s at an estimated cost of 240 million SEK (40 million US$).

The LDBS runs on a central computer and is divided into two main registers: the Real Property Register (RPR) and the Land Register (LR) . The RPR contains facts on area, centroid coordinates, land use, and plans. The LR stores information on legal and economic matters including the real property units, ownership and mortgages, and assessed property values. Registration is made on-line, checks are performed, and stamp duty and fees calculated automatically. In addition, the information contained in the Real Property and Land Registers is available to the public. Thus, local authorities, brokers, insurance companies, planning groups, and other organizations that deal with real property information can get direct access to the LDBS by renting equipment from CFD or by connecting their own EDP systems. As of January, 1987, some 1500 terminals and printers were connected to the system.

Modern techniques facilitate the handling and integration of large volumes of data from different sources. Consequently, the introduction of an official designation for real property units has made it possible to integrate different official registers for general use. With respect to the LDBS, integration with registers, including the Land Taxation Register and statistical registers from the National Tax Board and Statistics Sweden (census and housing data), is achieved in the production stage. The results are either stored in the LDBS and become an integral part of that register or are displayed as thematic maps and used for planning and reports.

Sweden has 284 local authorities who are responsible for the management of units as large as 19,000 km^2 in the far north and as small as 20 km^2 in densely populated areas. These authorities administer social services and public utilities and play a key role in the provision of housing. Information on real property stored in the LDBS can be valuable in decision making and planning on the local level. For this reason, local authorities are capable of obtaining LDBS data by direct access by means of remote terminals, by ordering extracts or maps for specific purposes, or by subscribing to the LDBS update service.

To make use of the unique fact that official statistics on population, housing, and agriculture can be geocoded, CFD has developed a system for computer-assisted cartography. These statistics are output for presentation as dot, grid, or isarithmic maps accompanied by geographically structured tables and lists. As an example, the LDBS was employed to assist in planning for commuter transportation into a municipality in rural southeast Sweden. The general problem was to locate bus routes, prepare time tables, and organize complementary transportation for those living in areas not served by the buses (Szegö, 1987).

The Swedish Land Information R&D Program

A working group studying land information research and development (R&D) recently published a report which described the most important needs as pertaining to the collection, analysis, and presentation of land information (Aglinfou, 1986). The ultimate goal was to provide a basis for planning R&D collaboration between governments, universities, and private companies in the area of LIS. Although certain parts of the field have been discussed in association with research in remote sensing and information technology, this is the first time a unified program for LIS research has been proposed in Sweden.

Research on GIS is considered to be of vital importance at the present time. Areas targeted as needing significant R&D are database construction, digitizing, standardization problems, presentation systems, data communication, and system and cost-benefit analysis. Research and development is necessary within all these fields if future GIS will fullfill the expectations of the user community. Second priority areas include various methods for data collection such as geodetic and photogrammetric measurements, aerial photographic interpretation, microwave techniques, and global positioning systems (GPS). Of lesser priority are concerns about training, working environment, and data security.

Sweden spends approximately 80 million SEK (13 million US$) annually on R&D activities, or approximately 4 percent of the total public costs for land information. It is envisioned that, as databases are completed, demand for products based on these data will stimulate developments by industry in the land information sector. This potential is made even more apparent as different phases of data handling from collection to reproduction have been increasingly more integrated through technical development.

THE ECONOMICS OF LIS/GIS

Municipal engineering is an important social activity because it is basic to civil needs and consumes large economic resources. In the Nordic countries, the expenses incurred in the management of municipal utilities are estimated to exceed 15 billion US$ per year. These enormous sums indicate that even modest improvements in efficiency will be of great economic importance. Preliminary investigations in Scandinavia estimate that a benefit-cost ratio of at least 3:1 can be realized by investing in good analog mapping systems. Indeed, there are reasons to believe that benefit-cost ratio for digital spatial information would be even more favorable than for the analog system (Bernhardsen and Treitdal, 1986).

Economic methods to calculate community benefit from digital information systems have been developed at the Stockholm School of Economic and Business Adminstration in cooperation with Moere forskning in Norway. It is known that there is often a positive correlation between a change in technology and profitability. That is, it may be more profitable to change the technology instead of investing more money in existing systems. Thus, changes in time constraints, problem dimensions, and ambition levels are important considerations when deciding whether or not to introduce a digital GIS. The speed of change in technology is also crucial to the present day value of benefit-cost factors.

Often, benefit is not fully realized until at least one category of data is fully converted to digital format. At that time, the typical benefit-cost ratio for spatial information systems lies between 1:1 and 3:1. Whereas the ratio for a single effort such as automation of map production can be only 1:1, a fully integrated information system can be rated as high as 7:1. Thus, benefits are derived in all organizations from an external coordination and exchange of information.

It has become obvious that more effort has to be spent on establishing digital databases and on optimizing their organization and content. Rather than continuing to build databases in connection with ordinary map production or statistical evaluations, integrated regional bases should be established in standard formats that can be accessed and used by all concerned parties. It is then that the true potential of LIS/GIS can be realized by those who have invested so heavily in their development.

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