# FUNDAMENTAL GEOGRAPHICAL DATA OF THE NATIONAL LAND SURVEY - FOR GIS AND OFFICIAL MAPPING

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**Abstract**

This report presents the results of investigations at the National Land Survey of Sweden during April 1993 - March 1994 aimed at proposing the establishment of a fundamental geographical database. The task was to define contents, classification, data capture, storage, updating etc. and to describe amendments necessary to produce official maps from the database. In addition, the report describes the preliminary stages of specifying fundamental geographical data as well as co-ordinating production plans and the updating of databases and maps.

Fundamental geographical data are defined as data corresponding to the information used in official mapping at the scales of 1:10 000 - 1:50 000. The Economic (General Land Use) and Topographic Maps place different demands on the data forming the foundation of map production. There are different customers, aims and scales for each map, yielding differences regarding selection and degree of detail, classification, geometric representation and positional accuracy.

In addition, somewhat unsynchronized plans for production and revision result in the need for revision in one and the same geographical area being carried out at different times for the different maps. This, in turn, has generated separate cartographic databases for each map within somewhat different digital production lines. It is therefore difficult to completely co-ordinate field work, data capture and the updating of the databases.

The goal is to establish a co-ordinated production and updating of the cartographic databases by using the fundamental geographical data. However, the efforts will concentrate on creating and updating the geographical database and from this the separate cartographic databases will be created, taking contents, specifications, scale etc. into consideration. Moreover, the fundamental geographical database will meet the demands from other applications, such as transport planning, urban and regional planning etc.

## 1 Background

Within the frame of official mapping, The National Land Survey of Sweden (NLS) has the responsibility to provide society with fundamental geographical data about Sweden's topography and administrative subdivision. These geographical data should be obtainable in such a way that they will satisfy important societal needs by being up-to-date and meeting certain standards.

During the past 15 years official mapping has undergone major changes, it beginning with computer support in map production, an example being the implementation of digitizers and drawing machines for the production of analogue maps. This then led to the establishment of databases containing "map data", whereby the primary goal was to rationalize map production.

However, today the trend is towards regarding map production as just one of the many applications for which the more general geographical databases can be utilized. This new way of thinking was introduced to and applied in NLS in 1987 under the collective term Geographical Sweden Data, GSD, [1]. The first GSD databases were predominantly cartographic, that is, a by-product of the map production, however the new approach is gradually breaking through.

The requirements for co-ordinating production and maintenance of common fundamental data for the production of the Economic Map and the Topographic Map were investigated in a pilot study carried out 1993 - 1994. The Economic (1:10 000 or 1:20 000) and Topographic (1:50 000) Maps place different demands on the data forming the foundation of map production. There are different customers, aims and scales for each map, yielding differences regarding

- selection and degree of detail
- classification
- geometric representation
- positional accuracy.

In addition, somewhat unsynchronized plans for production and revision result in the need for revision in one and the same geographical area being carried out at different times for the different maps. This, in turn, has generated separate cartographic databases for each map within somewhat different digital production lines. It is therefore difficult to completely co-ordinate field work, data capture and the updating of the databases.

## 2 The Pilot Study

The task of the pilot study was to put forth a proposal for the establishment of a common database comprising of fundamental geographical data. This proposal needed to take into consideration the above mentioned differences between the cartographic databases, including how entity types will be classified, captured, stored and updated, as well as describe which alterations and additions are necessary for the establishment of the different cartographic databases from the fundamental database.

The current catalogue of entity types for the Economic and Topographic Maps has been used as a starting point for the project. This catalogue is common to all the official maps and their cartographic databases. The entity types' catalogue classification is hierarchical and is divided into entity classes, entity subclasses and entity types. The catalogue consists of seven entity classes: Height and terrain information, Built-up areas and buildings, Infrastructure, Land use and vegetation, Hydrography, Administration, and Restrictions.

The project began by describing the differences in selection criteria, geometric representation, coding, structural requirements and positional accuracy of the entity types. In addition, it identified the needs of current applications which should be met as well as which of these applications place the greatest demands on the quality of data. How different applications affect access to data, update frequency, description for selection as well as the logical structure were then studied and analysed.

In its final report [4], based on the above, the project group presented a proposal for the specifications of the fundamental database. The report includes entity types with their respective attribute types and values, new demands on the functionality of the software as well as changes to be introduced to the routines and methods employed in fieldwork, data capture etc.

## 3 Fundamental Geographical Data - GGD

GGD (*Grundläggande Geografiska Data*) is the Swedish abbreviation for the National Land Survey's fundamental geographical data. The goal is to establish a co-ordinated production and updating of the cartographic databases using these data. However, the efforts will mainly concentrate on the creation and updating of the geographical database.

The separate cartographic databases are created from the geographical data, taking into consideration contents, specifications, scale etc. Moreover, the GGD database will meet the needs of other applications, such as transport planning, urban and regional planning etc.

The project group has paid special attention to the amount of work required for producing the Topographic Map from a cartographic database derived from GGD. Figure 1 illustrates the relationship between the fundamental geographical database and the derived cartographic databases.

During the project a number of fundamental principles were defined, forming the basis of the project group's proposal for the specifications of the GGD database:

- GGD shall include data for the official map production at the scales of 1:10 000 - 1:50 000. The database shall be characterized by simplicity as well as a level of detail and a positional accuracy which meet the defined requirements.

- The primary aim will be to carry out data capture, updating and maintenance in a rational manner. This implies that functions currently lacking software support, for example, for certain types of coding and handling of topological relationships, shall not be included in the database.

- User needs, product needs and special requests involving selection, coding, cartographic specifications and generalizations shall be taken into consideration, however as these are many and varied it is not always easy to identify them in advance. Fortunately, most requests are such that after a certain amount of processing, reformatting or enhancements, their needs can be satisfied.

- Last, but not least, it is essential that the structuring and coding of data is performed in such a manner that the database can be further developed when the functionality of the system, or other practical and organizational conditions, have changed. Storage of data should be neither too system specific nor too sophisticated.

## 4 An Ideal versus a Feasible Model for Implementation

Specifying and implementing a geographical database is usually carried out gradually.

First of all, a conceptual, real world model is worked out, defining the contents, geometric representation and classification, amongst other things. This initial stage should be done completely independent of any computer system, that is, without any regard for the possibilities and limitations of processing systems.

Thereafter follows a description of how the model shall be implemented. The project group's ideal model for implementing GGD is characterized by an object oriented approach, there being a clear distinction between the geographical entities and their geometric descriptions, attribute types and attribute values. In addition, the ideal implementation model contains a number of topological relationships, especially between entity types which are represented geometrically by an area.

## GGD Database

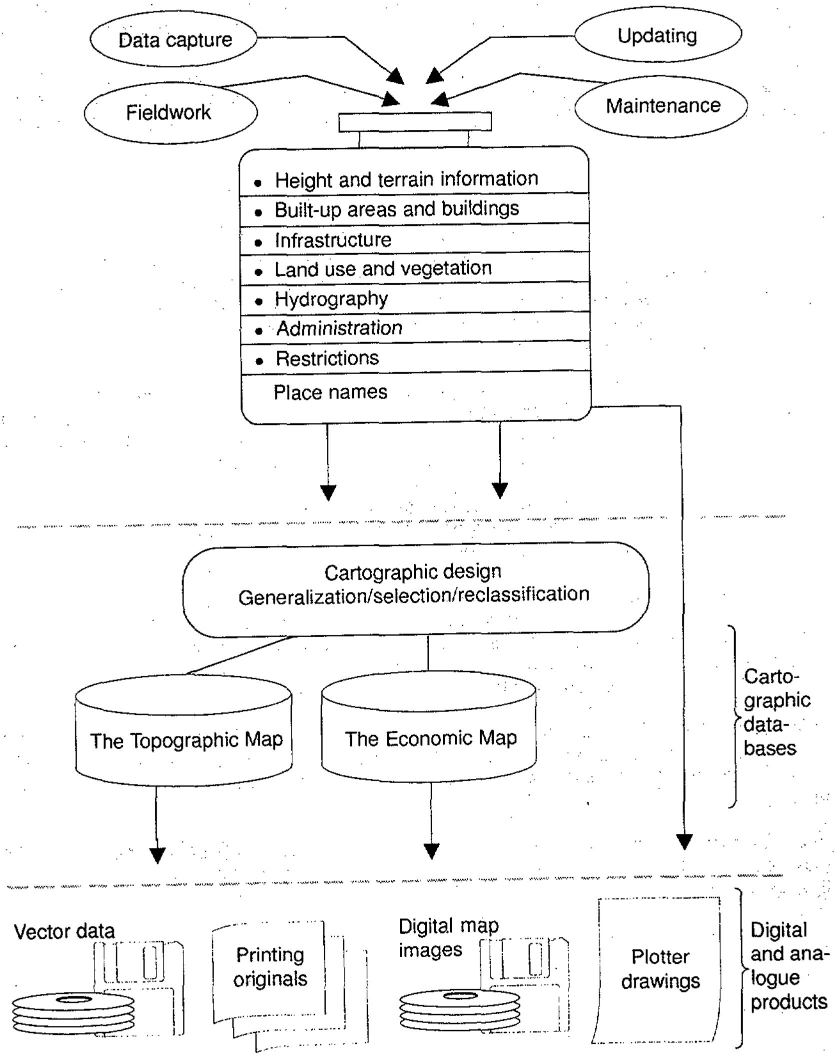


Figure 1: Fundamental geographical data and cartographic databases.

However, the software employed by NLS today for the managing of cartographic and geographical data lacks such a functionality for implementing this model to its fullest extent. The system is undergoing further development, aiming for a more pure object orientation and improved management of attributes, polygons and topology. For the time being a modification (simplification) of the ideal model is necessary in order for it to be fully implemented.

Therefore the project group has also suggested how these modifications ought to be performed so that a transition to the ideal model, as well as other changes regarding the contents and management of the database, can be carried out at a later stage with a minimal amount of work.

## 5 An example: Land Cover - Definition and Implementation

The following is an example of the project group's proposal for the definition and physical implementation of the "Land Cover" layer into the database. This contains a number of different entity types and can be regarded as a contiguous background layer made up of water bodies, built-up areas, cultivated areas, other open areas and forests, upon which roads, power lines, buildings, administrative boundaries, and more, are built. The Land Cover layer therefore plays a central role in GGD.

The Economic and Topographic Maps have different classification, structure, contents, and degree of detail. As the GGD database is to fulfil the needs of both these maps, as well as those of other applications, the aim is to define contents, classification and degree of detail so that Land Cover can, by the best possible means, serve all these purposes.

The first problem the project group faced was to identify the entity types that should be included in Land Cover. One entity type that caused many headaches was "Wetlands"; should it be included or stored separately?

If "Wetlands" was to be stored separately there was, on the one hand, a risk that registration problems would arise between the boundary lines of the wetlands and other Land Cover data. On the other hand, the process of data capture and updating would be simplified as information about wetlands is compiled from digitizing orthophotos, whilst all other types of Land Cover data are collected via photogrammetric methods.

In addition, storing "Forest" and "Wetlands" in the same layer implied the definition of a large number of combination codes, as wetlands can either be open or covered by forests. The project group's conclusion was that "Wetlands" should not be stored in the Land Cover layer.

In its proposal the project group recommended that the following entity types should be included in Land Cover. These entity types are geometrically represented in the form of contiguous, non overlapping areas:

- Water bodies
- Built-up areas (adjoining blocks of buildings, high buildings, low buildings, and industrial)
- Cultivated land (agricultural and orchards)
- Other open areas
- Forested areas (coniferous, deciduous, mixed coniferous and deciduous, mountain birch and clearings).

All Land Cover entities are supplied with a reference/identification point. As they are not represented as closed polygons in their current form, their boundary lines are also arranged according to priority, thereby simplifying editing, selection and display. The order of priority is as listed above in descending order, with water bodies' boundary lines having the highest priority and forested areas the lowest.

## 6 The Consequences

The building up of fundamental geographical data from which cartographic databases will be developed will have consequences for both development and production as well as the staff. The following describes what the consequences will be, regarding

- production of the Topographic Map's database
- modifying existing data
- the need for staff training
- the benefits in relation to costs.

The proposal for GGD specifications means that the Economic Map's database will be extended to include even the Topographic Map's entity types. A substantial amount of work will therefore be necessary to develop a cartographic database from which the Topographic Map can also be produced. Some procedures can be automated, for instance selection, but most will still require manual operations, some examples being

- generalizing and reclassification, e.g. of buildings
- displacement of certain objects, such as roads, with a cartographic representation which requires more space when displayed
- placement of text, taking into consideration sheet divisions, scale, text fonts and text size.

Development of the work flow and application ought to focus more on cartographic editing so that it can become increasingly automated. However, the belief is that manual handling will still be necessary in order to create a cartographic database from GGD data, and above all that cartographic experience is essential.

An extensive input of labour is of course necessary when the cartographic database is initially built up. However there will be considerable savings at the revision stage, partly due to the very efficient functions that the NLS database management system has for handling changes in data. Information regarding which data has been changed is provided from this software, and only these GGD data are required for updating the cartographic database.

NLS already manages a large amount of digital data today. This implies that part of the existing databases will need to be converted and modified, but most of this work should be made possible with the help of automated procedures.

Traditionally, every cartographic product and its corresponding database has been produced separately. Therefore both personnel and production methods have been specialized and the responsibility for these products has been organizationally separated. Therefore an important task is to "spread the message" within the organization, in order to create insight and understanding for the changes in routine and approach. Up until now the staff involved have been continually informed and undergone training conducted in conjunction with different case studies, for example, of new procedures in fieldwork and data capture.

Investment in new equipment has been regarded as being unnecessary for the compilation of fundamental geographical data. However, there will be additional costs associated with the purchase of software, hardware and training.

As substantial costs are related to the construction, maintenance and updating of geographical data, the benefits of co-ordinating the capture and maintenance stages will be considerable. Up until now the cartographic work required to produce maps at the scale of 1:50 000 have been integrated into the data capture stage. This has resulted in databases which are completely independent of any other cartographic product's data.

Co-ordinated efforts provide greater possibilities for accessing updated data, which in turn increases the reliability of data and even that user needs other than map production will be satisfied. In conclusion, a positive result will become evident when costs of data capture and maintenance will have been reduced whilst applicability will have increased. However, the benefits depend to a large extent on how upgrading data quality, that is, increasing the contents of the database and the data being up-to-date, shall be evaluated.

## 7 Ongoing Work and Maintenance of Data

In September 1994, NLS decided to co-ordinate data capture, storage and maintenance of databases at the scales of 1:10 000 - 1:50 000. The co-ordination of these stages has been organized as a project, the goal of which is to have a complete, national coverage of databases by the year 2004.

The main task will be to specify fundamental geographical data, based on the project group's proposal, as well as co-ordinate the updating of the database and map production. Furthermore, the functionality requirements of the processing systems shall be formulated and implemented so that the establishment of GGD and cartographic editing for the Topographic Map will be more efficient.

A very important task will be to further develop methods for updating the GGD database. Technical, economical and organizational conditions must be created in order to establish a rational and efficient method for updating. Updating shall include administrative and cadastral boundaries as well as the central themes of the topographic information.

The administrative and cadastral information shall be continually updated, it commencing no later than one year after it having been entered into the database. The topographic information shall be updated at regular intervals. It is hoped that these plans will be achieved with the assistance and co-operation of other governmental bodies and local authorities.

The idea of "updating at the source" is the basis of discussions and studies currently being held with other organizations, aiming to find suitable methods and agreements of co-operation for the updating of data. Examples of such discussions are those being conducted with The Central Board for Real Estate Data and local authorities (buildings and property information), The National Administration of Shipping and Navigation (hydrography), The Central Office of National Antiquities (ancient monuments), The National Environment Protection Board (nature conservation areas), The National Road Administration (public roads) and forestry companies (private forest roads).

The fundamental geographical database shall be the basis for the future management of geographical information within NLS and should be able to be accessed by many different users. It is therefore important that the database is also prepared for GIS applications and that the official maps can be revised more often. It is, of course, also important to find new means of presentation and distribution of information, for example the use of modern distribution systems and storage media.

## 8 Conclusions

In conclusion, there are great gains to be made from co-ordinating the capture and maintenance of data for a fundamental geographical database. The successful implementation of such a database requires NLS as a whole to accept and adopt a somewhat new way of thinking regarding the contents, application and status of a geographical database as opposed to the more application oriented cartographic databases.

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*Acknowledgement: The author would like to thank the members of the project group for their valuable comments, and especially Inna Nögeste and Clas-Göran Persson for their assistance with the English translation of this paper.*