THE TOPOGRAPHIC DATA SYSTEM - A NEW WAY TO COMPILE AND UPDATE TOPOGRAPHIC INFORMATION

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Abstract

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. Data compilation is divided into two categories. In Level A compilation buildings, power lines, fields, water bodies and roads are collect by analytical stereoplotters using either 1:16000 aerial photos or in the north 1:31 000 aerial photos. The whole mapping process in National Land Survey is now digital, starting from data compilation and ending to the map production. This paper gives an overview of developing the system and the current status.

1 Background

The Basic Map series 1:20 000 was completed in 1975 and it extended the whole area of Finland, 337000 km^2. Digitising of data started in early 1970's by automating some steps in the fair drawing process. In 1980's we vectorised contours, 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 we used to collect contours and some planimetric details. Photo interpretation in 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.

1.1 The developing process of the Topographic Data System - The re-engineering process

In 1991 National Land Survey appointed a working group, which 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 (Mr. Heikki Hirviniemi, Mr. Kaj Lundell, Mr. Juha Vilhomaa, Mr. Hannu Villman, Mr. Tuomo Lusa, Mr. Teuvo Pajukoski) and also development (Chairman, Mr. Timo Tuhkanen, Mr. Antti Jakobsson, Mr. Jurkka Tuokko, Ms. Leena Salo-Merta). 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 its 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 was introduced in 1992.

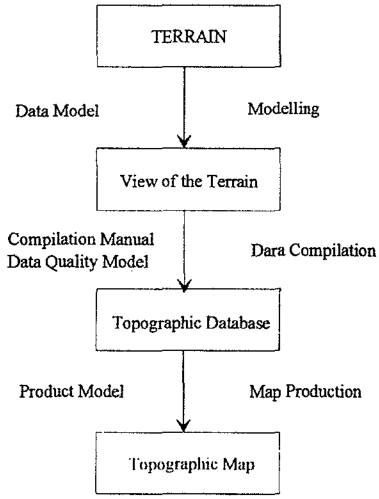

Figure 1 Form Terrain to a product

Next it was time to re-engineer the production of the topographic map 1:50 000, which was done in 1993. The working group (Chairman, Mr. Timo Tuhkanen, Mr. Veijo Pätynen, Mr. Antti Jakobsson, Mr. Jaakko Peltola, Mr. Kaj Lundell, Mr. Markku Toivanen) developed a system that uses mainly the data from the Topographic Data Base (TDB). Generalization is done so that the geolink with the Topographic database can be maintained.

In 1994 there was time to start the development of small scale map databases to be derived from the TDB. New working group was appointed (Chairman, Mr. Risto Talman, Mr. Teemu Leskinen, Mr. Tapio Siltala, Mr. Antti Jakobsson, Mr. Antti Vertanen) and it made the data model for small scale databases.

2 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 map will be collected separately by the year 1997. The Basis of Topographic Data System is to collect the data only once not two or three times as it was done earlier.

2.1 Organization

Data compilation is done in our regional offices, which are located in Helsinki, Turku, Hämeenlinna, Kouvola, Mikkeli, Jyväskylä, Seinäjoki, Kuopio, Joensuu, Oulu and Rovaniemi. In Helsinki we have also a data compilation unit in Geographical Data Centre. This compilation unit collects approximately half all the data. The data compilation should finish in year 2000, which means mapping of about 55 000 km^2 a year.
Topographic Data System consists of about 220 workstations and about 30 analytical stereoplotters. Number of persons working with system is about 400.

2.2 Data Compilation

Data compilation is divided into two categories. In Level A compilation buildings, power lines, fields, water bodies and roads are collect by analytical stereoplotters using either 1:16000 aerial photos or in the north 1:31 000 aerial photos. In populated areas we also use basic maps. After that other features are digitised from the fair drawings of the basic map. Field checking is done, if needed, 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 from aerial photos 1:16000 or 1:31000. Field checking is done only if needed.

Contour lines are already in digital form, but we have to make some corrections, which is very time consuming.

All together 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. This year we are re-engineering that part of the process. Data compilation in level A in an area of one map sheet (10 km * 10 km) takes about 70 days in which stereoplotting takes 18 days, digitising 27 days, field checking 17 days and misc. checking 8 days. In Level B total working time in one map sheet is 35 days in which digitising takes 29 days and checking takes 6 days.

2.3 Data Revision and updating

The updating of the database will be done every year with help of existing database. The updating frequency of the traffic network, buildings and power lines is planned to be less than a year. The Data for buildings are updated for example from Population Register Centre. Public roads are updated from Road administration and private roads (mainly forest roads) are updated using data from Forest Boards and Forest Industry. Electrical Companies have attribute data of power lines, which is also used. Positional accuracy of updated features is not so good as it should be and it is revised every 5 to 10 years. The revision of TDB is under construction. At this moment we are looking for possibilities to use digital photogrammetry in that process.

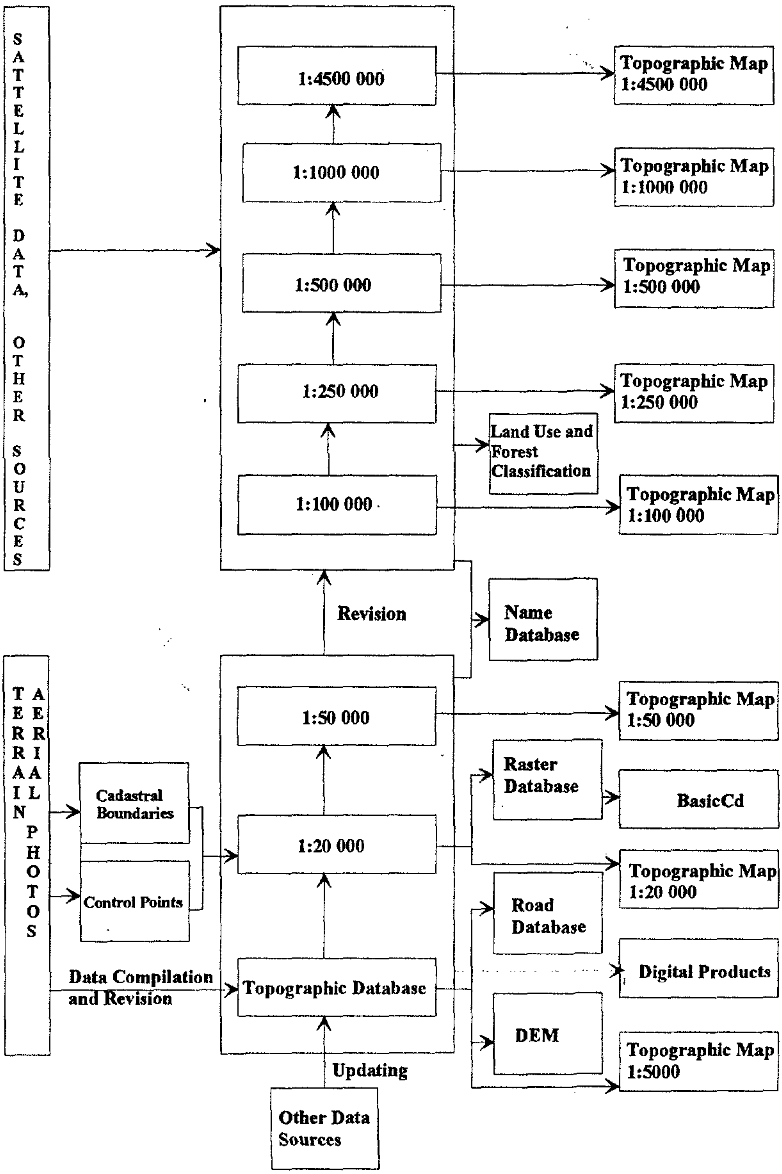

Figure 2 The Topographic Data System

3 The Data Model

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. The data model represents in this context the reality so we presume that the definitions of features are correct when we define the quality of a feature.
All features have a geometric representation that can be a point, a line or an area. A Feature can have one or more attributes that can be discrete or continuous.

Feature name:	Building
Data group:	Buildings
Data definition:	A construction like a house, a church, a public-, industrial-, commercial- or other building.
Selective criteria:	All buildings except those of minor area or temporal use. Foundations are noted collected.
Data type:	Area
Attribute data:	Usage of building: *a dwelling,a commericial or public, holiday, industrial house, church or other use*. Storey height: *One to two floors, three or more floors , undefined.* Name of the building Explanation of the building

Figure 3 : Example of the data model

4 The Quality Model

The quality model defines qualitative criteria that can be collected to a database or transferred to a client. It also defines acceptance levels to data compilation and verification methods.
The role of data quality in digital databases is growing and our goal is to fulfill our customers' requirements. One good method to assure a customer is to use available standards.
The international standards we have used in making our quality model are ISO 9000 series (quality systems) and ISO 2859 and ISO 7362 (Sampling procedures).

There is also European standard development going on in European Committee for Standardization (CEN), which one goal is to give guidelines to quality of data transferring between different producers and clients.

4.1 Qualitative criteria

Qualitative criteria we have used are: accuracy, lineage, consistency, completeness and identifiablity.

4.2 Quality requirements

We have divided our data compilation in two major groups: *LEVEL A* has a tighter quality requirement than *LEVEL B*. Level A is based on stereoplotting allowing map output up to scale of 1: 5 000. Level B can be digitised from updated existing maps allowing output in scales 1:20 000 to 1:50 000.

The requirement is based on a feature. All features have individual quality requirements based on the identifiability of a feature. We have four identifiability classes: *Excellent identifiability* (feature typically made by man), *good identifiability* (a point or a line feature made by man), *satisfactory identifiability*.(a line or area feature) and *poor identifiability* (a natural feature).

Table 1:Positional accuracy requirements

RMS	LEVEL A	LEVEL B
less or equal *2 m*	roads, railroads, buildings	
less or equal *4 m*	fields, electrical network	
less or equal *8 m*	paths	roads, railroads, buildings
less or equal *20 m*		fields, electrical network
less or equal *40 m*	elevation	elevation, paths
less or equal *80 m*	administrative boundaries	

Table 2 : Attribute accuracy is controlled by error rate:

one error / hundred unit:	road numbers, railroads class, administrative boundary class, voltage class
four errors / hundred unit:	road class, field class, use of building
fifteen errors /hundred unit:	path class

Table 3: Completeness:

one error /hundred unit:	railroads
four errors / hundred unit:	roads, electric network, fields, buildings
fifteen errors /hundred unit:	paths

4.3 Quality Tests

Quality tests are now in progress. Last fall we tested the *positional accuracy* by field surveys. Those tests were done in four locations and were based on 12 randomly chosen areas (1 km * 1 km squares).
We made control surveys in order to link field surveys to national grid coordinate system. Control points were temporal GPS-points in eight areas and permanent control points in two areas. Measurements were done directly from those points using total stations with data recorders.
Before the field survey, we selected potential features, which we would like to check in the field. Our purpose was that the total test should have at least twenty objects of each feature class. In analysis of the results we used two different methods. First we used an artificial neural network (240 neurons) to have a clear view of the data. The idea of using the artificial neural network was first of all, that all observations are included and it doesn't assume normal distribution. A plunder can cause serious annoyance to our customers. It is also possible to build a user friendly interface where it is easy to examine individual observations with real topographical data. Secondly we examined the observations traditionally assuming normal distribution. The results showed that our anticipations explained earlier were quite good. Some modifications will be done to positional quality requirements e.g. buildings could have tighter requirements and fields should have looser requirements. The total number of features were 1004.
After first round the data compilation unit will do the positional accuracy tests.
Testing of attribute accuracy and completeness is based on ISO 2859-1974(E) standard. Data compilation units each have quality supervisor who selects number of databases (area 10 km*10km) to be tested. The minimum area is 120 km * 120 km. After that the software will randomly choose 1km * 1 km areas so that there will be sufficient amount of features in each class. The quality supervisor reports attribute and completeness errors in the field. If acceptable quality level (AQL) has not been achieved, the quality supervisor will report this and the compilation unit must check the whole test area again.

5 Products

The topographic database is used as basis for variety of standard products as well as products customized to users' needs.
The quality of a product is derived from the topographic database in digital products. Cartographic quality is ensured by manual checking before the product is printed. However, there should not be any modifications of data in production.
The Basic map 1:20 000 is produced from this data. Real estate boundaries and some small cartographic editions are done to make a printed product. The vector data is transferred to cartographic publishing system (Intergraph) to create colour separated films for printing in 4 + 1

colours. This fall we changed the system so that colour separated films are done from vector-PostScript converted later to raster. Also the colours used are reduced to four process colours (CMYK) [1] [2].
The production of Topographic Map 1:50 000 is also based to TDB. Some generalization is done in production of a map database. The printed map process is similar to basic map production [1].
A 1:5000 Photo Map will consist of digital ortophoto, features from steroplotting, real estate boundaries and geographical names. This product will be either a colour plot or a printed map on customers demand.
Small scale products will also use some data from TDB. There will be products covering one municipality in scale 1:50 000 to 1:100 000 and products in scale 1:250 000 to 1:500 000 to cover counties. These products will have their own quality classes named *LEVEL C* and *LEVEL D*. Level D products are done from existing material by scanning and Level C will be done from TDB. The change of positional accuracy level from A/B to C is due to generalization.
Digital products are either in vector format or raster format and media can be e.g. CD-ROM. The BasicCd product is a raster product on CD-ROM, which will be updated from the map database 1:20 000 [3]

6 Conclusions

The Topographic Data System started in 1992. In 1995 all our staff is working with this system and the training is still going on [4]. We have published data model, data quality model and quality manual. Quality auditions will start this year.
Data revision will start in 1997. Digital photogrammetry should give as the right tools to do the revision. The continuos updating of important features should give the correct attribute data.
Topographic Data management system will be introduced this year as well as the Product Management and the Delivery system. New medias e.g. Internet look promising.

References

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