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DIGITAL ORTHOPHOTOS AND MAP REVISION IN NATIONAL LAND SURVEY OF FINLAND

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ABSTRACT

The production system of middle-scaled topographic maps of the National Land Survey of Finland was re-engineered in 1992-1993 when a new Topographic Data System was introduced. After that data compilation has been going on and current coverage of the Topographic Database is over 70 %. Customers need for the currency of spatial data has become more and more important.
This paper presents the current status and techniques used in the National Land Survey in map revision. The paper presents the Topographic Data System in general and methods used when revisioning topographic data. Also some experiences are presented. Production line of orthophotos is described in greater detail.

1 INTRODUCTION

The graphic Basic Map series 1:20 000 containing over 3700 printed map sheets was completed in 1975 and it covered the whole area of Finland, 337 000 km^2. After that until the year 1993 this map series was updated using different methods. The revision cycle was 10-20 years and in populated areas where changes were more rapid Basic Map was updated using overprints in 5-10 years interval. The production of Basic Map was based on the traditional process.
Customers need for the quality of spatial data changed gradually, digital and also more current data became more demanded. The production of middle scaled topographic maps was re-engineered in 1992-1993. A new digital production line was introduced. Today it is still more important to keep existing spatial databases fresh and updated.

2 THE NATIONAL TOPOGRAPHIC DATA SYSTEM

2.1 General introduction

The National Topographic Data System (TDS) of National Land Survey of Finland (NLS) consists of data compilation and updating methods, a Topographic Database (TDB) containing the most detailed general topographic data with nation-wide coverage and the standard products derived from this geographic database (Picture 1). The compilation of data accuraries corresponding to scales 1:5000 to 1:10 000 is now in progress and should be finished in year 2000. Current coverage of the TDB is over 70 %.
The basic idea of the TDS is to collect data only once, not two or three times as it was done earlier. Data compilation is performed in 12 regional offices of the NLS and it is done in vector format with home-made MAAGIS software in OpenVMS environment. The TDS consists of about 230 workstations and about thirty analytical stereoplotters. The number of persons working with the system is about 400.

2.2 Data compilation

Data compilation is divided into two categories. In level A buildings, power lines, fields, water bodies and roads are compiled by analytical stereoplotters using 1:16 000/31 000 aerial photos. Base maps are also used in populated areas if available. After that, other features are digitised from the fair drawings 1:10 000 of the basic maps. Field checking is done after data compilation.
In level B all features are digitised from the fair drawings 1:10 000 of the basic maps. Data is updated by photo interpretation using 1:10 000 enlargements of aerial photos at 1:16 000/31 000. Field checking is done only if needed.
About 60 % of the TDB will be level A on the first round due to limited number of stereoplotters and tight timetables. Quality requirements in level A and B are otherwise the same but level A has stricter positional data requirements.

2.3 The Topographic Database

The data model of the TDB defines 114 object classes, which are divided in nine data groups. Basic data groups are transportation network, transmission network, terrain, hydrography, elevation and buildings. Other data groups are special use areas, protected sites and administrative structure. Data of cadastral structure and ground control points are stored in other databases.

2.4 Data updating and revision

The maintenance of the TDB can be divided into two processes; continuous update and the revision of the TDB. Continuous update of the TDB will be done every year and it is directed to objects which are considered to be most important. Updating is based on the use of existing databases of other authorities. Revision of the TDB will be done in 5 to 10 years interval and all objects will be revised. Revision is based on the use of digital orthophotos.

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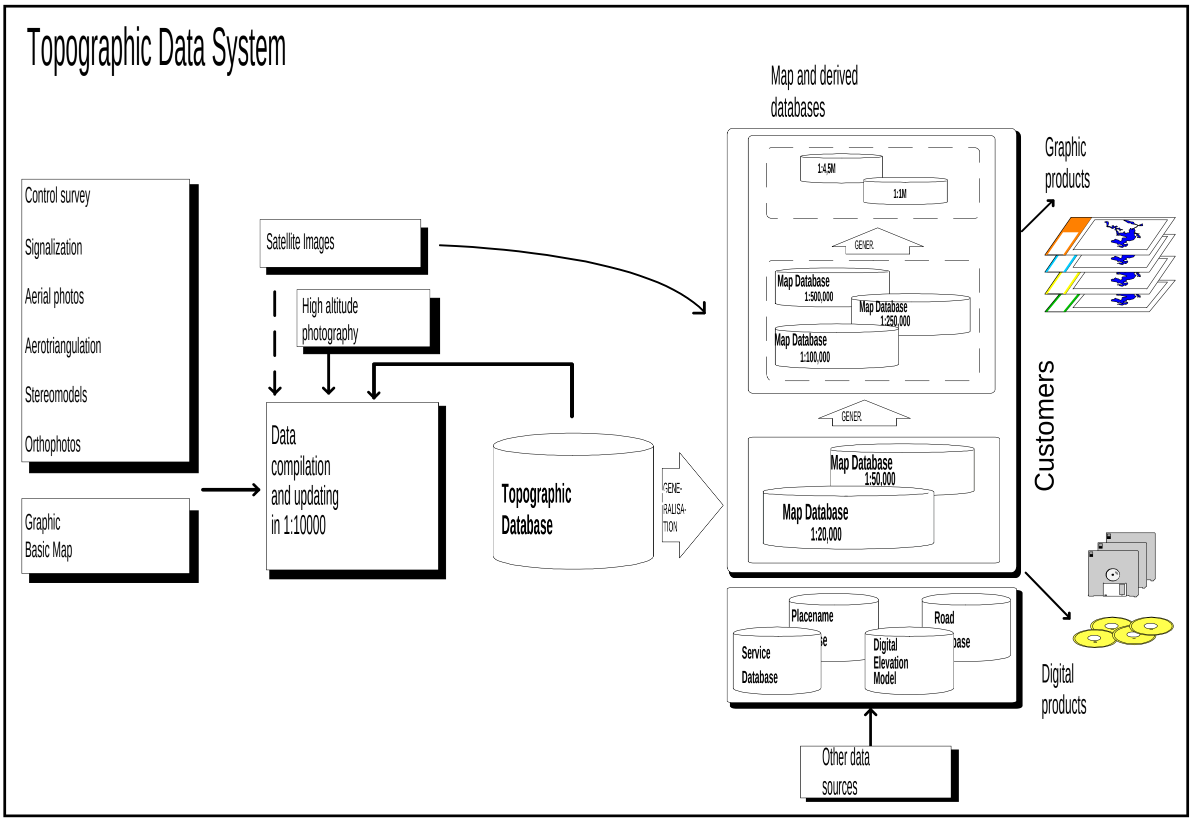
2.5 Products of the Topographic Data System

The TDB is used as a basis for variety of standard products as well as products customised to users' needs. The Basic Map 1:20 000 and the Topographic Map 1:50 000 are both general, printed topographic maps produced from the TDB.
Map databases 1:20 000, 1:50 000 and 1:100 000 are derived from the TDB. There are also map databases 1:250 000, 1:500 000, 1:1000 000, 1:2000 000 and 1:4500 000 but they are produced by digitising old graphical maps so far. Service databases derived from the TDB are the Road Database, the Name Database and the Digital Elevation Model.
Digital products are either in vector format or raster format and the media can be for example CD-ROM. The use of Internet will open new possibilities for the distribution of digital products and enable brand-new map based interactive do-it-yourself-services to the customers.



Picture 1. The Topographic Data System of National Land Survey of Finland

3 CONTINUOUS UPDATE OF THE TOPOGRAPHIC DATABASE

3.1 Principle of updating

Continuous update of the TDB is based on the use of existing databases maintained by other authorities. Object groups that should be updated every year are transportation network, transmission network and administrative structure. Buildings were also planned to be updated annually but it has been abandoned for a time.
Public roads are updated using data of Road Administration and municipalities. Data for the update of private roads is managed by forest companies and forest boards. Electric companies can provide data for the update of power lines. Information about new buildings is managed by the Population Register Centre but this data has not been used to the update of buildings so far.

Because of the use of external data, requirements for accuracy of positional data of updated objects are allowed to be worse than required in data compilation according the quality model of the TDS.

3.2 Update in practice

In Finland there are for example 458 cities and communes, about 200 electric companies, 13 forest boards etc. The number of contracting parties is high. External data can be graphical or digital and digital data can be transferred in various formats. Positional accuracy of data varies very much or is not known. There are also a lot of local coordinate systems used in Finland. The price of external data can be so high that it cannot be used. There can also be problems about copyright matters.
As a consequence of all of these reasons update of the TDB based on the use of external data does not work properly. Adequate completeness of updated object cannot be achieved using external data sources. Unfortunately there are no other alternative data sources.

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For example the interval of high altitude photography 1:60 000 covering the whole area of Finland is 3 to 4 years. So high altitude aerial photos cannot be the only data source to continuous update of the TDB.
In the future external data sources can be used as input data of continuous update if the quality of data is good enough. However, external data can provide information about changes that have taken place in the field. This year a new GPS system with field computer including mapping software will be introduced to the update of the TDB. This system will provide about 1 m accuracy on-line. Quality of updated objects will be much better but the updating process will be slower.

4 REVISION OF THE TOPOGRAPHIC DATABASE

4.1 Principle of the revision

Revision of the TDB is performed in 5 to 10 years interval depending on the rate of changes in the field. All of the objects are revised including those which are updated annually. Quality requirements in data revision are same as in data compilation.
Revision is based on the use of digital orthophotos and it is done using heads-up-digitising on MAAGIS workstations. Level B data with worse positional accuracy is upgraded to level A in data revision.
Production process of the revision containing aerial photography, scanning, aerial triangulation, digital elevation model editing, orthophoto generation, quality control and finally revision of the TDB is described in following sections.

4.2 Aerial photography

Annual aerial photography is performed using two aeroplanes equipped with Wild RC20 cameras. Scale of aerial photos for data revision is about 1:30 000. Scale 1:16 000 is also used for specific cases and for data compilation. Most of aerial photos are panchromatic, but also colour and false colour film may be used. Forward and side lap is 60 % so that middle parts of photos can be used in following processes.

4.3 Scanning

Aerial photos are scanned using XL Vision 950 rollfilm scanner. Every photo is scanned using 20 micron resolution. Resulting ground pixel resolution is 60 cm.

4.4 Aerial triangulation

Aerial triangulation is performed using Leica/Helava workstations. Currently there are five Silicon Graphics workstations with Unix operating system and one NT workstation. Orientation is done as a block with digital imagery. Semiautomatic tools of Leica/Helava are used for interior and relative orientation. Stereomodels are created for digital elevation model editing.

4.5 Digital elevation model editing

Currently there are 25 m grid digital elevation model (DEM) covering the whole area of Finland. Resolution of existing DEM is not adequate for the production of digital orthophotos, so it must be recreated. Vector contour lines are used as source data for creation of a new 10 m grid DEM using Arc/Info tools. DEM is checked, edited or recreated on Leica/Helava workstations depending on the quality of height data. Maximum error in height is about 2 m.

4.6 Orthophoto generation

Panchromatic digital orthophotos are created using Leica/Helava workstations. One orthophoto is covering 5 km x 5 km area. Ground pixel resolution is 50 cm. Due to 60 % forward and side lap middle parts of every aerial photo are used. Mosaicing and radiometric adjustments are performed automatically. Size of one digital orthophoto is about 150 Mb containing image pyramids. The format is TIFF or Vitec.
Orthophotos are stored in tape jukebox and they are sent when needed through network without any conversion to regional offices where the actual revision is done.

4.7 Quality control

The quality of orthophotos is checked visually on Leica/Helava workstations. Radiometry and geometry of orthophotos are checked as well as histogram, brightness and contrast of every image.

4.8 Revision of the Topographic Database

Digital orthophotos are used as a back-drop raster image on MAAGIS workstations. Vector data of the TDB is plotted as a overlay on raster image.
MAAGIS is able to select a suitable level from the image pyramid of every orthophoto according the area windowed. Brightness and contrast can be adjusted depending on the quality of the orthophoto.
Operators use photo interpretation to find out the changes that have happened in the field. New objects are added and associated to existing objects. Disappeared objects are naturally deleted.
There are a set of specific functions for editing existing objects developed especially to data revision. They are implemented with WYSIWYG principle so that operators are able to see the result of the function beforehand. Lines can for example be moved, rotated, squared, intersected and joined. Points of lines can be added, deleted and moved. Attributes of objects can be added, changed and derived from other objects.

4.9 Experiences of the data revision

There were hardware and software problems with scanner system and Leica/Helava system in the start but now they have been solved and the production of orthophotos is going well. Due to large image files there have been problems with network capacity and also with archiving the images.
The set of functions for editing individual objects is quite sufficient. There is still need for a tool to edit a group of objects in one time.
Methods to upgrade level B data to level A are still insufficient. There is a need for rubber-sheet shift tool based on finite element method and last square adjustment and also a tool to derive attributes from existing objects to redigitised geometry.
The skill of photo interpretation of operators involved in data revision is not always sufficient if the operator has

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not worked in the field with aerial photos. There is still a need for training.
Digital stereo workstations are necessary in data revision. Integration of a digital photogrammetric workstation and GIS system will offer a proper tool to data revision.

5 FUTURE ACTIONS

The production system of real estate services of the National Land Survey changed radically in the spring 1998 when a new Smallworld GIS based JAKO system was introduced. JAKO is designed for conducting surveys, maintaining the cadastre and enhancing information services. The total cost of the first stage of JAKO is estimated to rise to FIM 70 million.
The decision in principle that TDB will be integrated to JAKO system was made in the end of 1997. Development project will start in autumn 1998. MAAGIS software will be replaced with Smallworld GIS and the TDB will be combined with cadastral databases. The use of stereo workstations in data revision will be evaluated during this project.