Renewed Topographic Data System Integrates to Cadastral Data Management in Finland

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Key words: topographic database, cadastral database, digital photogrammetry, intranet information service.

ABSTRACT

In 1992 the NLS of Finland started data collection of the National Topographic Database (TDB) in scale 1:10000. The production has been carried out in all 13 regional District Survey Offices and was mainly completed in 2000.

The new cadastral data system JAKO was introduced in 1998. JAKO contains integrated tools for cadastre and cadastre map maintenance, conducting surveys and information service. Initially, JAKO was lacking sufficient tools for utilising topographic information, since TDB was residing on another system platform.

In 2000 TDB was migrated under the same unified JAKO system architecture. Consequently, the data management was modernized, data quality and quality management improved and work processes re-engineered. Moreover, the aerial imagery in digital form was made the key source of topographic information used - either as background orthophotos or on a stereo workstation.

The unified architecture enables new opportunities for transparent use of topographic and cadastral information and thus improves total efficiency. Smooth availability of TDB brings the latest topographic information to cadastral surveys and customer service. New intranet based information services were also launched, which upgraded and harmonized the customer service in each District Survey Office.

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1. BACKGROUND

The National Land Survey of Finland (NLS) produces and provides information on and services in real estates, topography and the environment for the needs of customers and the community at large. The NLS is responsible for Finland's cadastral system and general mapping assignments. The NLS is a government agency subordinate to the Ministry of Agriculture and Forestry.

2. TOPOGRAPHIC DATA SYSTEM

The Basic Map series 1:20000 was completed in 1975 and it covered the whole area of Finland, 337 000 km^2. The data compilation started in 1947 and the first map was printed in 1948. Data digitising started in early 1970's by automating some steps in the fair drawing process. In 1980's contour lines and field areas were digitised from the printing originals. Meanwhile an own mapping software, called MAAGIS (formerly FINGIS), was developed and used in digitising cadastral boundaries.

The next step was the launch of the Topographic Data System (TDS) and the Topographic Database (TDB) in 1992 [Jakobsson 1995][Pätynen 1995]. The TDB comprises the most detailed and up-to-date general topographic information of the whole Finland. TDB is primarily a vector-based geodatabase containing information of more than 100 geographic features at a nominal scale of 1:5 000-1:10 000.

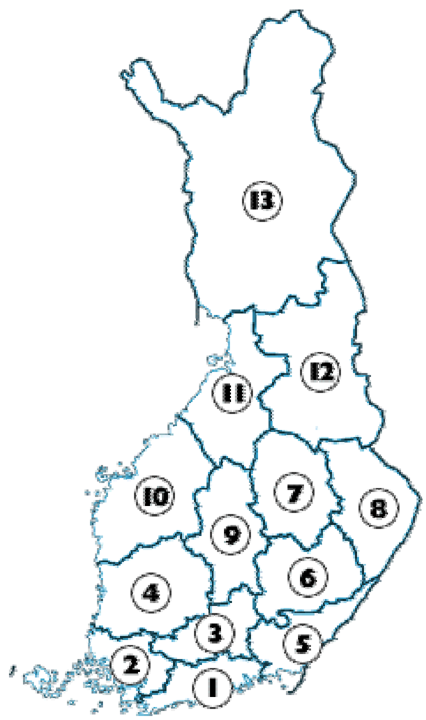

Figure 1. District Survey Offices of National Land Survey of Finland

The in-house MAAGIS software was adapted for the management of topographic information. The production was decentralized in 13 regional District Survey Offices, which are responsible for data capture and management from stereo compilation to map publishing of its own territory. The TDB production engaged 30 photogrammetric analytical stereoplotters and 150 graphics workstations for data capture and management. The initial data collection phase of TDB including about 13 000 sheets in scale 1:10 000 was mainly completed in 2000.

3. CADASTRAL DATA SYSTEM

The automation of the cadastral map was launched as an application of the in-house MAAGIS software in the mid 1980s. The development of a new cadastral information system JAKO began in the early 1990s. The aim was to create an information system where cadastre maintenance, conducting of cadastral surveys and an efficient information service could be carried out in a single system.

Smallworld GIS was selected as the development tool for JAKO 1994. Four years later JAKO was introduced in NLS for 700 workstations (Windows NT) in 42 sites and 1200 staff member were trained to use system as primary means in their daily work [Tuomaala and Uimonen 1998].

In JAKO the national cadastre, which includes the basic data of the cadastral units and the cadastral index map showing the location of the units, has been combined to a single information system. The JAKO database is made of a seamless centralised database and geographically distributed workstation sites with local cache servers. Workstation sites and database server set-up are connected with appropriate telecommunication network.

Since its introduction JAKO has been used to conduct more 20 000 cadastral surveys each year. Today the size of the JAKO cadastral database is 50 GB and it contains information about 4 million register units and 5 million map parcels.

From the beginning JAKO information system has enabled versatile products. In addition to standard cadastral register extracts, District Survey Offices provide information service products customized to the customer's needs. Information searches may be carried out on the basis of attributes or location, or both. Full service is available at each NLS customer service point and most of them also via Internet on self-service basis.

Image 1. JAKO is used to conduct more than 20000 cadastral surveys annually

At that point JAKO was lacking sufficient tools for utilising topographic information, since Topographic Data System was residing on another system platform and was not accessible without additional effort.

4. RENEWED TOPOGRAPHIC DATA SYSTEM

In 1997 NLS decided that the Topographic Data System would be renewed and the Topographic Database would be migrated under the same Smallworld GIS system platform as JAKO Cadastral Data System. The unified system architecture would reduce organization-wide information technology costs and gain various benefits in both information systems separately. Eventually, the integration of the systems would enable smooth data sharing and thus improve quality and cost effectiveness.

In 1998 the development work of the new topographic database called JAKO/TDB began. Data uploading from MAAGIS/TDB to JAKO/TDB was started in the end of 1999. A system beta test was carried out in 6 District Survey Offices and in September 2000 after fine-tuning the new TDB was ready for use. Initially, JAKO/TDB was introduced and trained in all 13 District Survey Offices in 2000, but supplement training continued during 2001.

In practice the transition phase from MAAGIS to JAKO lasted the whole year 2001. To keep the data management as simple as possible, it was decided that a mapping project under MAAGIS had to be completed until the data was uploaded to the new system.

The data model of the topographic data remained during the migration without major changes. However, some of the new characteristics of Smallworld GIS were utilized in linking topographic and cartographic features to new joined objects. Additionally, the data from TDB was merged with a separate road database, which contained road geometries and some special attributes such as addresses and traffic restrictions. These adjustments were taken into account in the database design of the new TDB.

- ✓ 9 million polygons
- ✓ 8 million symbols
- ✓ 3 million texts of which 700 000 place names
- ✓ 50 million chains
- ✓ 2 billion line points
- ✓ 5,5 billion elevation values in elevation model

Figure 2. Number of features in Topographic Database

The TDB of Finland containing more than 100 Gbytes of vector data may be considered as a very large database. Thus the data volume was an essential issue in data uploading. In principal the old TDB was in a sheet-based system, so edge matching had to be done before loading in a seamless database. Moreover, data was not loaded as such, but the operation included several automated consistency check-ups and also some interactive work. Therefore the data loading was a laborious operation taking more than 10 man-years of work for the whole data amount, but as a result the data quality was significantly improved.

5. DIGITAL PHOTOGRAMMETRY

As part of the re-engineering process the photogrammetric production line was converted to process and feed digital photoproducts instead of analog ones. However, aerial photography is still performed with means of traditional metric cameras. Aerial photographs are scanned with a resolution of 20 micrometers and stored in an image server (NetApp) with terabyte capacity. Currently, the volume of the digital image production is 10 000 photos per annum, which requires 2 Tbytes of server storage for the images.

Aerial triangulation is carried out using LH-Systems' Socet Set- and Orima-software products. After the final bundle adjustment digital stereo models are resampled on the image server, which takes yearly another 2 Tbytes of server storage for the resampled models. Stereo models are supplied on request via network for further use in the District Survey Offices. This is done usually at night using batch processing. Digital orthophotos are stored directly under Smallworld GIS, where they are accessible from all standard JAKO workstations.

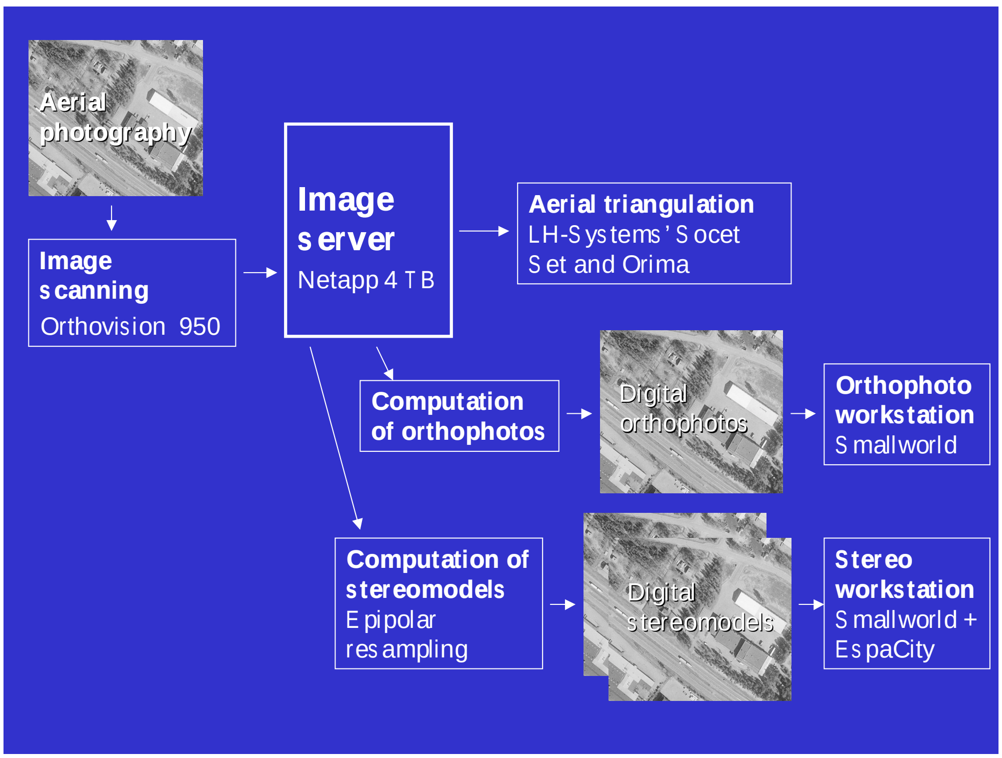

Figure 3. Digital photogrammetric production line of NLS

The digital stereo workstation is based on EspaCity software package from a Finnish company EspaSystems Ltd. The stereo workstation is set up of a standard Window NT system equipped with a dual 21-inch display system. Stereoscopic viewing is enabled with a stereo panel on the other display and light polarized stereo glasses. Black-and-white and colour images may be used. The price level of an EspaCity stereo workstation unit lies around 10000 €, which includes both software and hardware.

EspaCity and Smallworld GIS are running on the same NT-workstation simultaneously. Smallworld is used on the standard display and EspaCity is on the stereo display. Current topographic data from TDB is superimposed on stereo model. The stereo operator manages the data capture commanding both EspaCity and Smallworld GIS via EspaCity interface. Three-dimensional (3D) topographic data from the stereo model is stored and updated directly to TDB via 3D-trail (geometry). The topographic data is stored as it is seen on the stereo display and there is no need for post-processing or file translation at all.

Image 2. Managing Topographic Database on a digital photogrammetric stereo workstation by using EspaCity and Smallworld GIS.

In addition to topographic data capture, EspaCity stereo workstation is used in the cadastral map upgrading. The measurement of targeted boundary marks uses the guidance of boundary information from JAKO cadastral map for automated approach. Cadastral map information is also superimposed on the stereo display for easy reference.

6. NEW TOPOGRAPHIC WORK PROCESSES

The introduction of the renewed Topographic Data System (TDS) implied changes in work processes. Partly, ongoing processes were adapted to the new environment, and partly, totally new processes were introduced.

6.1 Upgrading of Elevation Data

The upgrading of elevation data is perhaps the most challenging new process. It includes the examination and improvement of existing contour line data and measurement of additional height points on stereo workstation. Finally, a New Digital Elevation Model (DEM) with 10 m grid is computed. The upgrading of the elevation data is not an independent work process, but it is employed, when other topographic work processes are in progress in an area.

6.2 Periodic Revision

The periodic revision of topographic data is employed to keep TDB up-dated with the ground truth. Aerial imagery is used either on a stereo workstation or based on orthophotos on a standard workstation. The upgrading of the elevation data is done, if needed. When periodic revision is done using orthophotos in 2D, the height information for TDB is derived from DEM. The work is done mostly indoors, but uncertain things are checked in the field. The revision cycle is 5 –10 years depending on the density of changes.

6.3 Upgrading of Topographic Data

The upgrading of topographic data is employed to improve the overall quality of TDB of an area. The goal is to homogenise TDB during the next five years. The upgrading is the most extensive topographic work process and it includes naturally the upgrading of the elevation data. The process is based on the use of aerial photographs on stereo workstation. The work is also mainly done in the office, but the amount of field checks is reasonable.

6.4 Annual Revision

The annual revision covers the whole Finland, but it deals only with certain themes. Roads and streets are revised once a year based on gathered information from aerial photographs, satellite images, municipalities and other sources. New information is field-checked and measured with GPS in a vehicle. Part of the task is the maintenance of address data, which is stored in each road segment. Annual revision also comprises updating of administrative boundaries and power lines.

6.5 Upgrading of Cadastral Index Map

The upgrading of cadastral index map data is not a topographic work process as such, but it is closely involved with topographic processes and data. The goal is to homogenise the spatial quality of the cadastral index map during the next five years. The upgrading is based on aerial photography and targeted boundary marks, which are measured on stereo workstation as described earlier. Supplemental measurements are done with GPS.

Cadastral vector data is overlaid on orthophoto display and supporting topographical vector data may be retrieved. The final adjustment of the cadastral map is done based on measured boundary marks, archived documentation and topographic information. After the upgrading the cadastral surveys process will again take over the maintenance and updating of the cadastral index map as a part of CDS.

The main output of the above-mentioned topographic processes is an up-dated - revised or upgraded - digital TDB. This dataset is the source for further processes concerning the use of the information.

6.6 Map Publishing

Map publications in scales 1:20000 and 1:50000 are produced from the TDB. For the time being these map publications are still prepared using old MAAGIS-software. The Basic Map 1:20000 quite closely corresponds to the TDB, but it also contains cadastral boundary information. Topographic map 1:50 000 has a more generalized presentation, and it is usually published without boundaries.

Map publishing also creates raster format digital maps as side products. These raster maps are stored and used for instance as close-up maps in JAKO system. A revised TDS of an area does not lead automatically to a new printed topographic map 1:20000, but a fresh raster format digital map is nevertheless prepared.

7. CUSTOMER INFORMATION SERVICE

As a part of the new TDS, an integrated information service was also launched for external and internal customers. This intranet-based service is available at each customer service desk and it is in fact accessible from any workstation in the NLS network. Printout maps and geographical data on digital format are produced from up-to-date topographical (TDB) and cadastral information (CDB).

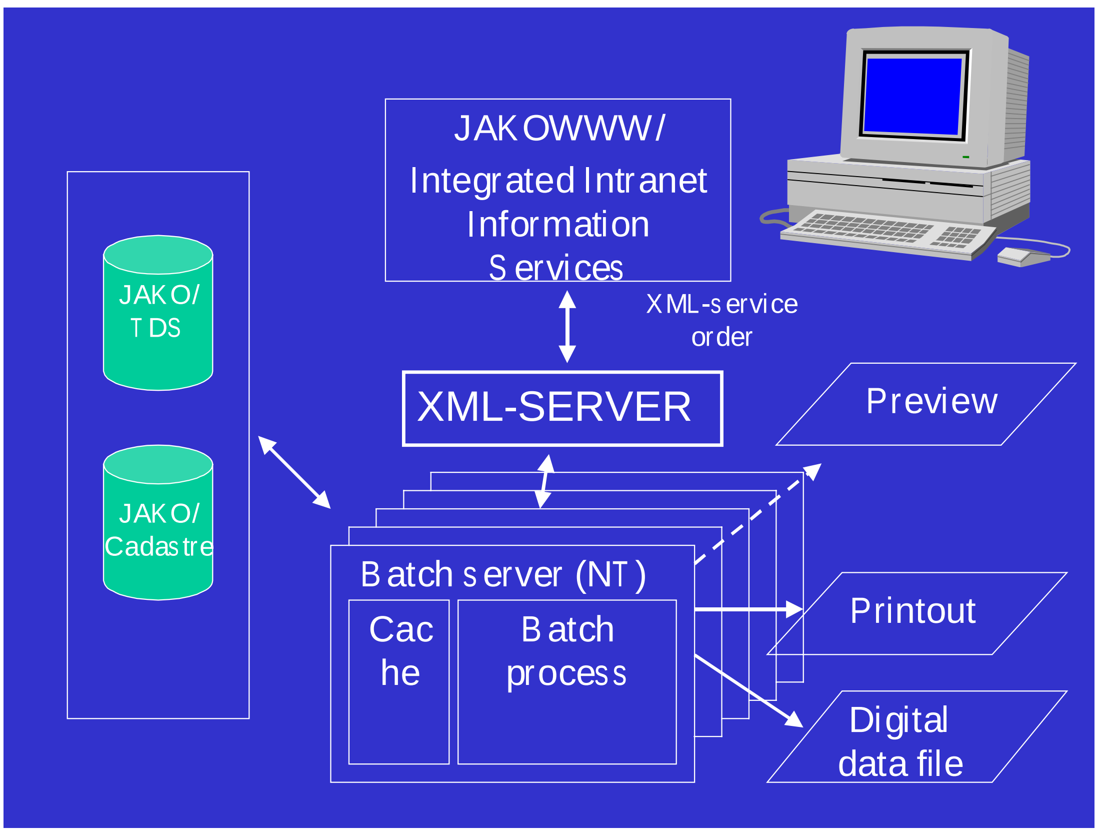

Figure 4. Structure of the Integrated Intranet Information Services

The user selects one of the various predefined products and defines the location of interest, which can be anywhere in Finland. For graphic products also plot size and scale are required. At service desk a www order form is filled and a batch process is activated. The requested data is accessed via a scalable set-up of batch servers from appropriate data storage.

If a printout map was chosen, a preview is available in a few minutes to support visually the customer's decision making. Finally, the printout map can be output on any plotting device on NLS intranet. A typical processing time from order to plot is 60 minutes for an A1-size plot. The plotters used are large format HP inkjets, which produce near print quality. The appearance of the graphic products is close to printed maps, but the durability is not so good. A high quality film printing facility (Purup ImageMaker) is also available.

Image 3. Printout maps containing topographic and cadastaral data are also available in PDF or JPEG formats

Digital data requests are usually processed during night time. Conversion to various data formats is obtainable via MID/MIF and FME conversion software. Prepared datasets are downloaded to preferred digital media for delivery on daily basis.

8. CONCLUSION

The unified architecture has enabled new opportunities for transparent use of information in the NLS. Now it is possible to access the latest cadastral, topographic or image data smoothly to your own workstation and application. The development promotes that all available information should be looked after in NLS work. Gradually, the quality of the whole database will be improved. Finally, customers will be offered more coherent and consistent datasets and other products covering the whole Finland.

The main organization-wide benefits achieved regard synergies by standardized it-infrastructure (workstations, servers, network), synergies in systems development and maintenance, in user training and user competence and in support functions.

The usage of aerial imagery has been extended. Digital orthophotos on workstation are available to anyone in the organization. The solution applied to digital stereo workstation is so affordable, that it is nowadays a standard tool for everyone in topographic work.

The JAKO system including the CDS and TDS is daily used by 1600 employees, of which about 1200 make database transactions. The new TDS has expanded the number of stereo workstations from 30 to about 140 units. The number of stereo operators has increased equally. Obviously, this has been a major training activity, which still continues. However, production is now going on at full strength and it is soon expected to overcome the previous efficiency in quality and quantity.

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BIOGRAPHICAL NOTES

The author, **Mr. Jurkka Tuokko**, holds a M.Sc. in Eng. and he has been employed by the National Land Survey of Finland since 1984. Mr. Tuokko was one of the main designers of the MAAGIS software in the 1980s. Currently, Mr. Tuokko is the Head of Cartography in the NLS District Survey Office of North Karelia. The author was involved in the development and installation projects of the new Topographic Data System (TDS) as an internal client and a member of the management team.