FURTHER DEVELOPMENT OF THE HUNGARIAN DTM AND LAND COVER TELECOMMUNICATION DATABASE

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Commission IV, Working Group 4

KEY WORDS: Geomatics, Land_Use, Updating, Database, DEM/DTM, Quality

ABSTRACT:

The increasing importance of complex telecommunication systems take into focus the efficient spectrum management techniques. In the past the conventional radio and broadcast systems have been planed based on empirical wave propagation models. The limited radio frequency spectrum and upcoming digital services set considerably hígher requirements in wave propagation models.

In the period from 1990 until 1993 the Hungarian Digital Terrain Model (DTM-50) and Land Cover Database was realized.

The paper discussed the possibilities of revision, updating and quality control of the database in a complex digital photogrammetric environment.

1. Historical background

At the end of the last decade based on the available data sources and relatively poor east-European technical background a robust technology was developed to stand up the Hungarian Digital Terrain Model (DTM-50) and Land Cover Database. The key words was the following: time effectiveness, limited cost, limited technical background, limited technical expertise, robust technology, homogenous global accuracy.
In the period from 1990 until 1993 the Hungarian Digital Terrain Model (DTM-50) and Land Cover Database was realized. The Frequency Management Institute of Hungary (FGI) cooperation with the Military Mapping Agency (MHTATI), Department of Photogrammetry TU Budapest and Geomatik Ltd. realized the integrated GIS based DTM and Land Cover Database of Hungary.
After the initial data capturing the next step was the integration of the digital database to the different application systems.
The technology "GIS" gives an unique possibility to solve complex tasks. In the telecommunication the GIS systems managed the land surface dates and the different technical dates connected to it in solving wave propagation problems of government tasks and engineering planning. Land surface data types can be modeled by complex structures. The tasks of telecommunication need the reflection properties of the surface besides the height data of the land. The reflection properties of surface is determined by the land covering. The height and covering of the surface give enough information together to solve the telecommunication tasks. An user environment to solving government controlling or planning tasks can build up on an information system, which is using these data together.

Up to now the following areas applied the DTM and Land Cover Database:
- Government frequency management
- Point-point microwave planing
- Microwave broadcasting
- Radar planing optimization
- Flying object visibility simulation

1.1. The countrywide DTM-50 database.

One main element of the information system is the countrywide elevation database of Hungary, DTM-50*50 m^2. It is a raster structuring database, of density 50 and contains about 40 million grid points. The grid net is parallel with the axes of Unified National Mapping System (EOTR). The DTM-50 system was derived from 1:50.000 scale topographical maps. MHTATI made the data collection, using scanner techniques. The height values was derived from the digitized contour lines, computing in the intersection points of the grid net. The derived height values were filling into the database across more controlling phase. The requirements of accuracy were changing by the character of land surface. The topographical map sheets were classified into categories, based on the represented relief.

1.2. The Land cover Database

The natural and artificial terrain object's height and character determine the reflection of land surface. In this project 14 different covering type were determined. There were point, line and surface type elements among them. The determination of the different elements were made by topographical maps, aerophotos and field control.

The different covering types: singular object (chimney, antenna, tower, ect.), river, road, electrical aerial line, bridges, meadow, low vegetation, water surface, low-medium-high vegetation, low-medium-high buildings.

The covering information stored in two different database structure. One is the vector and the other is raster. The vector covering database is include the point and line elements coded with symbol key, according to their position on the map, area elements with their borderlines. The raster covering database - in keeping with the structure of height database - projects to the 50x50 grid network and include the covering information.

The user environment integrate the height, the vector covering and the raster covering database constitutes as a complex unit. Their formation's aim was to give a suitable base to the different government and technical tasks.

2. New technical possibilities

The new application areas increased the requirements of the data quality and information complexity. For global geographic modeling and analysis the airborne and satellite-born sensors provide much primary data. In the last decade drastically increased the hardware performance, the memory and secondary storage capacity. The remote sensing and the digital photogrammetric methods become practical parts of the industrial data capturing and analysis production technologies.

The new technical developments give a chance to integrate the remote sensing and digital Photogrammetry in the GIS applications.

In our case we analyzed the following issues:

- merging remotely sensed data, digital photogrammetric images and data from other sources
- data acquisition and processing of huge amount of image information
- image classification based on available land cover database

3. Proposed technologies

3.1. Hardware background

In the TU. of Budapest an Intergraph ImageStation Digital Photogrammetric Workstation was installed in 1995. The configuration give a possibilities to solve the secondary data entry (manual digitizing, scanning), image processing, digital photogrammetric stereo compilation and analysis tasks. The Weitek graphic board and the real-time JPEG card give a possibility to solve the real time image manipulation problems.

3.2. Software background

The Intergraph ImageStation is a spatial 3D Digital Photogrammetric Workstation with a standard UNIX based operating system (CLIX). On the ImageStation the MicroStation (Bentley-Intergraph) as the standard graphic engine and the Modular GIS Environment with ORACLE database management system (with input, management, analysis and presentation modules) as an application software can be used.
The digital photogrammetric and remote sensing modules embedded in the standard graphic engine.

3.3. Revision and updating of the data base

The following methods was tested as 'real production' technologies.

Application of Landsat TM images with unsupervised and supervised classification the interpretation of the different covering types: river, road, meadow, low vegetation, water surface, low-medium-high vegetation, low-medium-high buildings can be solved.

The result is excellent for the 50x50 m raster database, but the high precision vector database required more precise technology. The original vector database was derived with the manual digitalization of analog maps. The high resolution applications (GSM telecommunication planing) required 3D object database. The 2D planimetric mapping object can be get the elevation information with a simple interpolating technique based on the 50x50m DTM database. After these elevation interpolation step the derived 3D element can be superimposed in the digital photogrammetric images.
In the same graphic environment the operator can be modified, updated the vector database and real stereo photogrammetric observations can be used to stand up the 3D object database.

A quite efficient and simple method the mono-plotting technique. With application of aerial photographs and the DTM data base in a low-end environment can be solved the database updating. The first case use contact copies of the air photos take to a digitizing tablet, the DTM database and the orientation parameters of the images. After the orientation of the contact copy a common digitizing table the required revision task can be done by real-time projection of the image coordinates to the ground. With a simple 2D device we can get precise 3D coordinates of the objects. The self-developed mono-plotting software used the MicroStation as a graphic engine.
The second case of monoplotting use the rectified ortho images. With applications of the ortho images and the DTM data base 3D data capturing can be done.

4. Data quality

Generally in a GIS the final quality depends on source quality. Four aspects of data acquisition comprise the criteria for selecting data quality (Bernhardsen,1992):
(1) need,
(2) costs,
(3) accessibility,
(4) time frame.
In the project the data quality was determined in an iterative process, where the possible technology of data acquisition and the data quality were analyzed.
The *needful quality* of the Land Cover Telecommunication Database can determined by the analysis of wave propagation models. It is necessary to distinguish between two cases:
-the radiation of the waves in all directions (isotrop case),
-the radiation of the waves between two telecommunication stations (anisotrop case).
In the second case it is necessary higher data quality than in the first case. From economical point of view it is better the realization of the Land Cover Telecommunication Database only for the first case. The

necessary data for the waves propagation between two stations can be acquired in a special process.
The analysis of the *cost* is generally an important factor of the determination of data quality. The proposed methods of data acquisition and the data sources (e.g. monoplotting of aerial and satellite pictures) are relative not expensive in comparison with other possible method of data acquisition (e.g. stereoplotting). The necessary data quality can be guaranteed by the proposed method.
The *accessibility* of the data sources and the data was not problematical by the proposed technology.
The *time* of the realization of the Land Cover Telecommunication Database was the shortest by the proposed technology. In our case the need is keeping with the time.
In the project were used the well known *data quality model* (NCGIA 1990) with the following factors of data quality:
(1) lineage,
(2) georeferencing,
(3) attribute data,
(4) consistency of links between geometry and attributes,
(5) geometry link consistency,
(6) data completeness,
(7) data currentnes.
Some remarks about the factors 1, 2, 6, 7 will be discussed in the following. The *lineage* of the data was well documented. We used the data of the original Telecommunication Database (Mélykuti, Szabó 1993) or data of known origin (e.g. monoplotting).
The *georeferencing* was characterized by the accuracy of geometrical data. In the design period of the Database we used the following inequality (Detrekői1994):

$$a \leq A \quad (2)$$

where a is the a priori estimated value of accuracy,
A is the required value of accuracy.
The a priori estimated value of accuracy of the data were determined using the literature. The required value of accuracy was deduced from the wave propagation models. In the determination of required accuracy were included experts of telecommunications too. The required accuracy of geometrical data is in the order of some meters.
The various objects included in the Database have various *attribute data*. Very important are the elevation data of the objects. The design of accuracy of the elevation (and other metrical) data was made in a similar way as the design of the accuracy of geometrical data. The required accuracy of geometrical data is in the order of 1-4 meters.
The determination of required accuracy of nonmetrical attribute data (e.g. type of object class) was relatively difficult. In the end we decided to use the percent of misclassification. The value of this percent is depended on importance of the object for telecommunication. Two values were used: 1% for important object (e.g. radiostation), 5% for other objects.
The management of *data completeness* is formally very similar to the management of nonmetrical attribute data. The measure of the quality is the percent of misclassification. The required values are 1% and 5% too.
For the determination of *data currentnes* we can use formally the percent of misclassification too. From practical point of view it is necessary the determination the frequency of data acquisition. An average value of frequency of data acquisition for Hungary could be e.g. 5 years. The evaluation of various telecommunications technologies is very quick. So it is necessary the permanent observation of the opinion of the users. It is possible that the introduction of new telecommunications technologies requires shorter frequency in the all country or in a part of the country.
The *control* of the data is an important part of quality management too. We have various possibilities:
-the visual comparison of the original Land Cover Telecommunication Database and the new Database,
-the visual comparison of the new Land Cover Telecommunication Database and the aerial and satellite images,
-the field control of geometrical and attribute data.
The first experiment of the various methods were realized. The technology of the control methods and the documentation of results are now in the development period. The possibility of the application of the ISO 9000-9004 Standards is studied too.

5. Further tasks - data revision, updating

After finishing the capture of mass data, the main task to manage the data base updating procedures. Based on the data quality requirements and the real accuracy of the data necessary to update the DTM and the Land Cover Database referring the variations that happen in the natural scenery. We developed a complex updating technology founded on remote sensing and digital photogrammetric method to solve the revision, updating, correction and control procedures.

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