THE USE OF DIGITAL PHOTOGRAMMETRY AND REMOTE SENSING TECHNOLOGIES TO UPDATE GRAPHIC DATA BASES IN A CADASTRAL SPECIALISED

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Abstract: The graphic data base represented by the digital map is one of the essential components in the realization of a GIS specialised for cadastre. The update of information spatially referred is extremely important for the running of the system implemented to take record of terrains under the circumstances of frequent changes due to real estate transactions or modifications related to the dynamics of property laws enforcement. This paper deals with several possibilities for updating by using photogrammetric and remote sensing technologies. *Keywords*: digital map, GIS, multi-structural cadastre, restitution

1. Introduction

The update of digital maps presupposes the establishing of zones where changes related to the boundaries of cadastral parcels took place. It also implies the acquisition of all information in order to position the areas by measurements or similar procedures, on the condition these/zones fall under the precisions established by technical norms so that the areas of the delimited surfaces are correctly determined. When updated, the acquired data must fulfil several conditions (schematically presented in fig. 1) [15]:

- Based on international standards (ISO, OGC),
- Only the data change, instead of a new complete update,
- Information about the object's life cycle,
- Structured attributes with the possibility to add new ones,
- Model of object oriented data with unique IDs,
- Metadata at an object level,
- Distinction between Landscape Digital Model and Mapping Digital Model,
- Discreet data base,
- Insertion of TOP_vector (roads as polygon) and TOP_roads (roads as central line),
- Prepared for automatic generalisation and without scale data base,
- Connection with models of user data (e.g. environment, water) and sets of user data. Base model and sector models



Figure.1 Model of data acquired for update

The The update is realised cyclically (fig.2) according to the changing rate established on the base of information and observations derived from the systems of phenomenon monitorization (Table 1) [15].

TABLE1. UPDATE ACCORDING TO THE IMPORTANCE AND FREQUENCY OF
CHANGES

Importance	Very low	Low	High	Very high
Changes				
Very	Arable vs. Pasture	Gardens	Paths vs.	Houses
frequent	Individual trees	Small	Dirt roads	
		watersurfaces		
		Hedges & Tree-		
		Rows		
Average		Forest type	Road with	Roads,Woods
frequency			Orchards	Factories,
_				Supermarkets
Rare	Culverts	Slopes	Point	High tension, Water
	Sources	Water course	symbols	courses
		width		Railroads,
				Churches, Town halls,
				Hospitals, Schools



Figure.2. Data life cycle

2.Modern methods for updating – photogrammetry and remote sensing

Among all the update possibilities, the most efficient methods are the photogrammetric and remote sensing ones since they can establish the areas affected by changes and, at

Photogrammetry and teledetection are connected domains. This fact is shown by national and international organizations. The International Society of Photogrammetry and Remote Sensing (ISPRS) is a nongovernmental organization dedicated to the progress of photogrammetry and remote sensing as well as to their applications. This was founded in 1910. Its members are national societies represented by professionals and specialists in photogrammetry and remote sensing of some states. Similar to this kind of national organization is also the American Society of Photogrammetry and Remote Sensing (ASPRS).

The main difference between photogrammetry and remote sensing is their application; whereas the photogrammetrists produce maps and determine three-dimensional precise positions of points, the specialists in remote sensing analyze and interpret images in order to get information about the earth and water areas. Both fields of study are connected to the Geographic Information Systems (GIS), to whose structure both contribute with essential information. Very often, the essence in the topographic information is given by fotogrammetry under the form of digital map.



Fig. 3. Modalities for updating graphic data base

The passing from classic photogrammetry to remote sensing happened at the same time with the apparition of colour film (in natural colours) and, especially, of false colour infrared films, photosensitive materials that allowed the diversification of the applications of aerial photography. Having a better sensitivity than the human eye, the infrared film is able to produce images of the reflected invisible energy, which is very useful for getting information about the life of planets.

Afterwards, the use of computers allowed a new way to explore aerial photograms, digital processing allowing the extension of the information range that these can furnish.

Despite the technological advances in the field, it must be pointed out that visual interpretation is limited to the spectral bands visualised in the image, that is one band for white/black representation and three bands for a colour image [9].

Taking into account the sensors' basic characteristics and the orbital parameters specific to the movement of the platforms on which these are situated, the digital data of remote sensing must go through a specific primary processing which is part of the geometrical and radiometric calibrations category (due to atmospheric influence). These preliminary processes realized at ground after receiving the data have as scope the correction of systematic errors from the acquisition chain. In order to explain these operations, the set of processes can be organised as follows:

a) Radiometric transformations – necessary for error corrections due to gauges and variability of environmental (atmospheric) characteristics, as well as for data absolute calibration with the aim of re-establishing the energetic balance as it has been measured at the beginning of the season.

b) Geometrical transformations – compulsory for the corrections of geometrical distortions introduced by the data collection system or for the user's specific requirements [4].

These operations are obligatory in order to be able to correct the errors and limitations specific to the sensorial system, to diminish the atmospheric effects, but also to correct and adapt the image's geometry so that, afterwards, in the usage phase, this can be integrated in an informational system by using several geographic parameters compatible with the mapping system established by the user. In other words, both photogrammetry and remote sensing allow a general analysis on large areas of the terrain and a highlight by comparison with the anterior images (taken at time intervals $-\Delta t$) of the changes happened in the topography of interest areas. The update of digital maps and cadastral data bases.

The Law no. 7/1996, "The Law of cadastre and land registration", defines the following notions which are fundamental for this activity:

i) the general cadastre is the unitary and compulsory system of technical, economical and juridical evidence by means of which it is done the identification, registration and representation on cadastral maps and plans of all the terrains, as well as the other immobile properties on the entire territory of the country, regardless of their destination and owner :

ii) the basic entities of this system are represented by the lot, the construction and the owner (art.1, alin.2)

iii) by real estate/immobile property it is understood terrain lots, with or without constructions (art.1, alin.3)

iiii) the cadastre is organized at the level of each administrative-territorial unities: commune, city, municipality, county and at the level of the whole country (art.2, alin.1)

The digital map (GIS data base) is a representation at the scale 1:1 of a well delimited geographic territory, the information being localized by real coordinates (on site), in a reference system (geodetic datum), adopted by every country.

In our country the maps are presently realized in the stereographic projection system 1970 on Krasovski ellipsoid and the elevations are established according to the Black Sea 1975 reference system.

The cadastral map is a topographic map whose content has as an objective the precise delimitation of lots, their identification by realizing adequate topologies in order to avoid overlapping and to allow the linking of polygon type entities, which define the lots from the database of attribute type – surfaces, perimeters, owner etc [1].

The cadastral plan is equipped with cadastral codes: the cadastral numbers of the lots, the symbols of the usage categories and terrains' qualities, the denominations of cadastral unities.

Within this context, the organization of thematic layers is the most efficient structure to data of type. At the present moment, it is used one or more spatial data models to represent geographic objects. There are three types of such models: vectorial model, which is very close to the one used for map representation; raster model, which describes the Earth surface as a matrix formed by homogeneous elements, similar to the model used for representing images; and TIN (Triangular Irregular Network) model which represents the surfaces' shape.

In the vectorial data model, GIS objects are represented having a delimitation well defined in space. The objects' position and shape are represented by using a coordination system x, y (Cartesian). A point is represented by one pair of coordinates x, y. A line is drawn by an ordinate sequence of coordinate pairs x, y. A polygon is represented by a sequence of coordinate pairs x, y which defines the linear segments delimiting the polygon.

The vectorial model represents each surface as a set of isolines, for example height measurements are drawn as a set of contour lines.

The vectorial model is very efficient for drawing maps, but is less efficient for the analysis of surfaces which needs complex calculation in order to determine certain characteristics such as the gradient surface in any point or the gradient direction.

The raster data model represents a land area as a matrix (grid) formed by uniform rectangular cells, each cell with a value. The grid is represented in a coordinate system x, y (Cartesian).

The coordinate x, y of a cell is calculated on the base of the coordinates in a reference point, usually one in the corners of the grid, taking into account the cell position in the grid (number line/column) and the dimensions of the cell on x and y.

The value of a cell indicates the object situated in that position. There are three methods to establish the values of a cell: the classification of objects, where each value indicates a certain type of object such as road, urban zone, soil type; the indication of color value (grey level) registered in an image (photo); the indication of a relative measurement such as altitude above sea level, building height above soil level, etc. In the raster model, objects do not have a well-defined delimitation and the spatial relations between objects are implicitly represented. By representing rectangular cells, the shape of the objects is not very exact and depends on the cell resolution.

By cell resolution, it is understood the dimension of the land surface represented by a cell; the smaller the represented surface is, the better the resolution and, thus, more precise data. Nevertheless, at the same time, more memory is needed to store data and, thus, a longer time is required for processing. The same as the vectorial model, the raster model permits the representation of punctual, linear or polygonal GIS objects.

A punctual object is represented by a value in a sole cell of the grid. A linear object appears as an adjacent cell series that renders the object's length and shape. A polygonal object is represented as an adjacent cell series that renders the object's surface and shape.

The raster model is very efficient for representing images and for implementing spatial analytical functions overlapping of objects, identification of a phenomenon extent, operations on boundaries). In this model, the surfaces are represented by indicating in every cell the value of the elevation corresponding to the point in the centre of the cell (a lattice). Therefore, the raster model allows an easily implementation of the operations on surfaces (grade calculation, grade direction, contour interpolation).[8]

In our country, the introduction of general cadastre is at its beginning, the updating of maps has not been done from the 1980s till the present.[11]

Thus, it is needed to do, in the shortest time, the update of existing cartographic products as a support for cadastre. At the same time, it is necessary to take into account the tendencies in the field at the European level, such as the INSPIRE directives regarding the administration of cartographic information.



Fig. 4 indicates the changes occurred in the past years.

Fig.4 The dynamics of the changes from the topographic plan realized by photogrammetric stereo restitution from 1984 and the orthophotoplans from 2005 and 2008 (source CNC)

Keeping the cadastral plans up to date implies not only the updating of the lots' shape and dimensions, but also the updating of all cadastral data, such as owner's name or terrain's usage category.

The next example proposes a program that updates cadastral data implemented at a firm specialized in cadastre.

The program has the following characteristics [2]:

a) The text documents (annexes regarding cadastral data) respect the formats established by ANCPI (The National Agency of Cadastre and Land Registration)

b) The graphic data are represented by the same symbology (layers, dimensions, colors)

c) The entry data are introduced once and are automatically transferred at the intermediary documents and final reports (data uniqueness and redundancy elimination)





Figure 5. The schema of the technological flux for update



Figure 6. The content of the technological flux

e) The separation of operations according to types of works (see Fig. 7)



Figure 7. The separation of work operations

f) The creation of a structure for relational databases (see Fig. 8)



Figure 8. The structure of a database

A special attention is given to the introduction of initial data, which in this case is made standardized by diminishing the formal and logic errors on the base of filtration criteria (see Fig. 9).

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Figure 9. The filtration of entrance data

The structure of the cadastral data according to INSPIRE previsions contains the following elements: theme code, code, object class, geometry, attributes and predefined values for each thematic layer.

Among all the cadastral data that integrate in a GIS, the primary role belongs to position data. Tesseral data (raster), either primary or secondary, have important advantages as far as collecting, processing and operating are concerned, but have the disadvantage that the point (dimensionless) is extended to the pixel dimension, surface unity belonging to a sole geographic element. The vectorial model presupposes punctual determinations. It is unanimously accepted the idea that in GIS should coexist both types of data, but all the common determinations impose the existence of vectorial data. These data can result from: topographical determination on site; automatic digitalization by following details from site; analogical exploitation of photogrammetric recordings; digitalization of maps or orthophotomaps etc. Many of these types have common problems to solve. It is important to point out that at a GIS realization the data collecting has the highest cost, around 70-75% of the cost of the entire system.

Photogrammetric and remote sensing data are obtained in the analogical and digital shapes. The usual analogical shape is the film take-up spool with white-black or color negative aerial photograms after which the diapositives are realized. These can be exploited at devices specialized for analogical and analytical stereo restitution or can be scanned, obtaining digital raster image data. There are also digital aerial photogrammetric cameras, by which raster data are directly obtained.

The satellite systems of remote sensing (for example Landsat, SPOT, Quick Bird etc.) allow the direct getting of raster data, in different bands of the electromagnetic spectrum. The data are received by receiving stations disposed in different places on Earth. In special processing systems, different are applied to these data. Together with the raw data in GIS, also the metadata are defined.

3.The update of digital elevation model – DEM

The models are used for the study of real or abstract physics phenomenon and for the creation of some images of precise of possible of reality. Moreover, they create a virtual prototype that describes the structure and behavior of natural phenomenon in different conditions. In mathematics, the realization of the model is defined by means of transfer functions which establish the one-to-one relation between the modelled object/phenomenon and the model:

 $M = \pounds(p_1, p_2, p_3, ..., p_n)$ where the parameters p1, p2, ..., pn are characteristic to every object or phenomenon apart, and the transfer functions £, in the field of land measurements, are determined on the base of very precise measurements so that the definition error of the realized model can be defined. [3]

The digital terrain model is very used around the world.

The definition of some common technical specifications in order to realize a topographical database composed by a high number of orthophotograms and digital height or elevation model (DEM) as well as vector-type data usable in more types of applications based on cartographic products. [7].

These technical specifications include, on one side, the basic requirements to realize DEM, but at the same time consider also the technical possibilities for the elaboration of this model, using already existing cartographic data.

In general terms, the orthophotograms must have superior qualities so that they can be used in more types of applications, such as: design in the field of civil constructions or communication networks, floods prevention, soil erosion and other aspects of planning and control in the field of environment.

At the elaboration of these technical specifications, the standards already existing were considered and the modern technologies laser scanner-type have also been taken into account. These technologies can also be useful to elaborate new standards, so that the resulted cartographic and topographic products can be used in risk and calamities prevention maps, for engineering design and for getting orthophotograms at large scales.

The topographic maps usually contain the planimetric details, as well as, the layouts of the topographical contour lines and the points in the field with representative or dominant elevations (spot heights). These mapping products apparently seem not to indicate that the topographical maps must contain also a type of digital elevation data (such as DEMs and TINs converted to contour lines) in accordance with the elevation production, which represents a critical element of the essence of topographical maps.

All the requirements of topographic mapping can be satisfied by stereo photogrammetry or combined with digital elevation data produced by IFSAR (Interferometric Synthetic Aperture Radar) or LIDAR equipments. In this sense, another relevant example is represented by the bathymetric contour lines produced on the base of digital bathymetric data, obtained by means of the airborne LIDAR and the digital data coming from the sonar-type equipments. [5]

The digital orthophotomaps do not include the elevation data themselves, but they cannot be efficiently produced, from the point of view of costs, without the digital elevation data contained in the DEM. As previously mentioned, the planimetric maps are based on images (aerial photographs or photograms) which are practically perspective views of the land.

When these images are digitalised, they still include the movements due to landscape and inclination of the platform carrying the image processing sensor. The aerotriangulation produces the six elements of exterior orientation, for each image (photogram), and the digital photogrammetric station (computer) can compensate (correct) the movements due to platform inclination, while the ones due to the terrain's landscape are still present in the image. By designing the image over the DEM corresponding to the area of terrain contained in the image, the image "draped" over the DEM compensates a lot the movement due to landscape, offering an approximate orthographic projection, which is very similar theoretically to an orthogonal view from space. But this is genuine (real) only for the planimetric details situated at the terrain elevation from the used DEM. The high planimetric details, such as buildings or towers are still moved outside or towards the exterior, while the lateral sides belonging to high buildings are seen in the image both according to their height and their distance from the centre of the image "draped" over the DEM – Fig. 10.



Figure. 10 – Draped digital orthophoto image

Due to the fact that the lateral sides belonging to the constructions are seen, many digital orthophoto images used in the present are not "real digital orthophoto images". In a real digital orthophoto image, the roofs of very high buildings must appear exactly over their foundations, and the pixels corresponding to the lateral sides must not appear in the image. Practically, the lateral sides afferent to the constructions must not appear in the image, which is equivalent to an orthogonal image. However, the lateral sides of high buildings are registered on the images of aerial photograms. It must be pointed out that the solutions applied for deleting the pixels from the image are not simple ones, which practically should miss from the orthophoto image.

Even if there are different programs designed for the production of "real digital orthophoto images", the production process is still very complex and highly expensive [5]. For this reason, many digital orthophoto images do not represent rigorously orthogonal images, practically equivalent with views of the terrestrial surface taken from the photographic infinite, which would represent a very important element of GIS. In the expected future, the use of DEM will continue, more exactly the support on their digital data for the production of different digital orthophoto image forms commonly used in the present. The digital shaping of the terrain represents an important operation within the diverse applications of geospatial information. The digital terrain models, especially those referring to the altimetric digital modelling of landscape, are presently used to realize a wide range of applications, such as: creating orthophoto products (orthophotoplans and orthophotomaps), 3D shaping of cities, simulating different flight categories of the aerial and spatial vehicles or instructing in the virtual battle field (theatre), in fact the number of digital model applications are virtually unlimited. Recently, Digital Earth (DE), for example Microsoft Virtual Earth and Google Earth, explored and implemented, as an organizational work frame for informing about the Earth, by facilitating the users' authorization to interact, research and even create simulations on the planet's virtual representation. Therefore, the digital terrain models will become critically permissive for the anticipated diverse applications of Digital Earth (DE).

In this context, the analysis realized within the research indicated, in the first part, the present stage of photogrammetric technology and its possibilities to offer and model digital data, by means of which a very wide range of digital models and products can be generated.

Hence, the photogrammetric models used to realize DEMs, the images sources and georeference are basic elements of digital technology, which facilitate a very high level of automation, efficiency and preciseness. The support technologies that include image scanning systems, the airborne GPS (ABGPS), the inertial measurement unit (IMU) and the automatic aerotriangulation have become essential elements of the technological set .

The methods of initial data collection afferent to DEMs are directly conditioned by the equipments used. Within these, the digital photogrammetric stations have become nowadays the dominant equipment. Nonetheless, also the analytic stations are used, taking into account that they integrate in their structures strong calculation platforms with a high level of achievement. But in Romania, the acquisition of these types of equipment is not justified anymore since they are technologically outdated. Practically, the part dedicated to software is now the main element.

The types of sensors have varied; the main sensors used to take images from which the data of digital models are extracted are the electronic ones. However, a high number of projects is still realized on the base of the images taken on photographic film, considering the fact that images assure a corresponding level of precision and performance and the rendition in digital format can be realized by scanning. The images taken on film will drastically decrease along with the massive replacement of classic photogrammetric cameras with digital ones. At the same time, another aspect that must be highlighted is the growing number of

satellite platforms equipped with electronic sensors of very high resolution that can furnish data for the generation of altimetric digital models. [4]

A major importance factor to get the digital model data is conditioned by the design of image getting within which the focus is on image resolution, vegetation's phenologic status and support or reference points. In addition, referring to the design of image getting, considerations regarding the airborne GPS (ABGPS) and atmospheric conditions are imposed.

Evidently, photogrammetric technology has important qualities and its limitative aspects can be clearly distinguished by comparison with concurrent or complementary technologies. The technological set is completed with aspects related to quality control, main users' applications and technological progresses [5].

The majority of remote sensing data (see Fig. 11) are nowadays in a numeric format, so their integration will be done by a common interpretation and analysis method. Data integration implies the combination of date taken from different sources. Data combinations include multi temporal data, different resolution data, taken from different sources and of several types.



Figure. 11 Remote sensing data

Multi temporal data are images acquired in different time periods but containing the same area on the terrestrial surface. The detection of multi temporal changes is made either by comparison or by more complex procedures that consist of comparison of multiple classifications or set classifications of multi temporal data.[13]

The incorporation of data coming from different sensors requires a geometric link between these or with a common coordination system, for example, the altimetric data coming from topographic measurements and having a numeric shape, named Numerical Terrain Model (DTM) – Fig. 12.



Figure. 12 Digital terrain model

DTMs can be used to realize classifications and to correct errors in mapping representation due to variations of terrain inclinations. In addition, DTMs are also employed to produce images with 3D perspective. The image obtained by remote sensing is then overlapped over the altimetric data, increasing thus the visualisation capacity of the image.

The combination of data from different sources and of different types represents just the beginning of their process of integration and analysis. In a numeric framework, the potential to exaggerate information is very high. This is how is defined the numeric analysis principle in a Geographic Information System (GIS). All data that can be referenced to a common geographic coordinate system can be used in a GIS framework – Digital Terrain Model. Maps about soil types, forest types or about communication networks represent just a small part of the data that can be used in a GIS. Remote sensing data are usually employed to update existing maps.

4.Conclusions

The update of digital maps by photogrammetric, remote sensing and modern mapping methods has a data structure that allows its use in diverse applications:

a) the inspection of areas vulnerable to earthquakes, floods or earth flows that will be run through;

- b) the identification and localisation of vulnerable areas (monitoring of crisis factors);
- c) the inspection of 3D terrain model;
- d) the visualization of the position of vulnerable areas in real 3D way;
- e) the monitoring of water level;
- f) the identification of hazard areas;
- g) the advertising functions etc.

The existence of the Digital Terrain Model (DTM) represented in Fig. 12 is very important for the realization of geometric and radiometric corrections on the remote sensing images. These models allow the creation of contour lines and terrain modelling, providing, thus, other necessary information for the realization of further analyses.

The requirements in DTM realization are related also to its use in GIS. The incorporation of altimetric and landscape data is compulsory for very many application types and, especially, in the realization of topographic and cadastral maps and plans. Altitude data used together with the processed remote sensing images can produce views in perspective which are very useful in observing the visibility between points, in telecommunication applications, in resource management, etc. There are several methods of DTM generation. A series of elevation points can be created by terrain works or by photogrammetric works and then, thickened by interpolation, obtaining an optimum density of points with known elevations. Another method is to transform in digital format existing plans and maps and to realize contour lines in vector format, but even this method implies substantial costs and work force.



Fig. 13 Digital Terrain Model

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