

THE HUNGARIAN DIGITAL ORTHOPHOTO DATABASE AS A BASIS FOR 3D VISUALISATION OF WORLD HERITAGE SITES IN HUNGARY

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ABSTRACT:

As a result of the „Aerial Photography Program of Hungary, 2000”, the country was covered by 1:30 000 scale aerial photographs. In the frame of the National Program of adopting the EU “Acquis communautaire”, a high-resolution (5m grid) DEM has been developed from 2000 to 2003 for the whole area of Hungary (93,030 km²) by vectorizing the contour lines of 1:10 000 topographic maps. Based on the results of these two programs, the Hungarian Digital Orthophoto Program was launched in 2002 and finished in the first half of 2003. Having a full coverage of Hungary by 0,5 m resolution digital orthophotos and high resolution DEM, now we are having the possibility of 3D visualization of any existing World Heritage Sites and support the documentation of future WHS applications of Hungary. Using the high accuracy digital orthophoto merged with cadastral maps and having the intranet system of the Hungarian land offices (TAKARNET) operationally running since April 2003, one can easily add information about the owners, users and legal status of parcels of the area of interest to the orthophoto and cadastral map based GIS of any of the WHSs in Hungary. In this paper, the authors describe the technical characteristics of the procedure and the use of products in cases of the World Heritage Sites listed for Hungary.

INTRODUCTION

During the last few years there has been a large development in data infrastructure in the Hungarian Land Management Sector. In 2000 the integrated land information system of the district land offices started to work, the “Aerial Photography Program of Hungary, 2000” was accomplished. Beside the aerial photography program the large resolution (5m) Digital Elevation Model of the country has been developed. In 2000 the raster datasets of the topographic base maps (scale 1:10 000) was made too. In the frame of the Hungarian Digital Orthophoto Program a full coverage of 0,5m resolution digital orthophotos was launched in 2003. The large scale cadastral maps of the rural areas of the settlement also available in raster or vector form for the whole country.

These databases has been used for the elaboration of Land Parcel Identification System (LPIS) of the Integrated Administrative and Control System (IACS). IACS is the system for the management and control of the agricultural subsidies derived from the European Union. There are different usage of these large data infrastructure now. Our clients use these data in different sectors of the economy (e.g. road planning, water management, local governments etc.).

We wanted to find different applications of these integrated data, and one of the possible solution was the integrated GIS management of the World Heritage Sites of Hungary. In Land Management Sector we are able to collect and maintain:

- Land registration data (e.g. land records, ownership and other rights on land),
- Cadastral map data, integrated with land registration data (scale: 1:1 000 – 1:4 000),
- Topographic data (1:10 000 scale raster dataset of topographic maps),
- Digital Elevation Models (5m resolution),
- Digital Orthophotos (0,5m resolution),

- Satellite images,
- 3D visualisation (based on DEM, topographic maps, orthophotos etc.),
- Connection of geometric data between different geodetic reference systems,
- Integrating of the mentioned data into a GIS.

In the paper we will describe the technical characteristics of the different datasets and the procedure of the utilization of these products in the case of the World Heritage Sites of Hungary.

WORLD HERITAGE SITES OF HUNGARY

Hungary has the following World Heritage Sites, with the date of acceptance:

- 1987: Budapest: the Banks of the Danube, the Buda Castle Quarter,
- 1987: Old Village of Hollókő and its surroundings,
- 1996: Millenary Benedictine Abbey of Pannonhalma and its Natural Environment,
- 1999: Hortobágy National Park — the Puszta,
- 2000: Early Christian Necropolis of Pécs (Sopianae),
- 2002: Tokaj Wine Region Historic Cultural Landscape,
- 2002: Budapest: extension with the Andrásy Avenue,
- 1995,2000: Cross-border World Heritage Site in Hungary and Slovakia: Caves of Aggtelek and the Slovak Karst.

These World Heritage Sites, except of the Slovak Karst, is covered by the mentioned products.

CHARACTERISTICS OF THE USED DATASETS

Land Registry and Cadastral maps

The history of the Hungarian Land Registry goes back to the ages of Austrian-Hungarian Empire. This old registry has been modernized during the 90's. All land registry data converted into digital form, and now available and open-accessible for everyone. Land Registry data are collected and maintained at the District Land Offices, integrated with cadastral map data. District Land Offices has a Land Information System — called TAKAROS — which provides a daily up-to-date registry throughout the country. All actor of the Land Management Sector (Ministry, Land Offices and the Institute of Geodesy, Cartography and Remote Sensing) is connected into an intranet type network — called TAKARNET (network of TAKAROS) —, so every land records are accessible from any point of the network. The network also has access point from Internet side for the registered users. Approximately 10 million land records are available through the network. Cadastral maps are available in paper, raster or vector format, from scale 1:1 000 up to 1:4 000. Approximately 60% of the cadastral maps are accessible in vector format.

The Hungarian Land Registry contains land records for each land parcels and an individual land record for each real-estate within the parcel, which has different owner than the parcel's owner (e.g. flats, shops). Each land record contains three parts:

- General description: lot number, land use, area etc.,
- Ownership rights
- Other facts and rights: mortgages, land use rights, easement rights etc.

Raster Datasets of 1:10 000 scale topographic maps

The rasterisation and georeferencing of 1:10 000 scale topographic sheets of Hungary had been carried out in 2000. Raster datasets contain the raster files of colour prints, contour lines, hydrographic and planimetric layer of 1:10 000 scale topographic maps. Colour prints at 300 dpi, and the other layer at 400 dpi had been scanned. Therefore the resolution on the ground is 0,85m and 0,635m respectively. Images of colour prints in 24 bit colour and of the other layers in 1 bit are available. All images are geocoded, and available in GEOTIFF format.

Digital Elevation Model

Based on the mentioned databases and infrastructure FÖMI has capacity for the 3D visualization of World Heritage Sites.

The development of the high resolution digital elevation model of Hungary has been carried out in the frame of National Program of adopting EU "Aquis Communautaire". The base of the DEM was the digital contour lines of the 1:10 000 scale topographic maps, with 1m-5m major contour interval. Since the date of the different topographic sheets covers a 30 years period, first a so-called preliminary DEM has been generated, only from contour lines. After the generating of preliminary DEM the changes of the relief has been worked into the preliminary DEM by stereo-photogrammetric measurements. The format of the DEM is a 5m GRID. Therefore the database contains approximately 3,7 billion height points for the whole country. The geometric accuracy of the DEM has been tested by photogrammetric, GPS measurements and by the comparison of the heights of horizontal ground control points (approx 60 thousand points) and the DEM. From these measurements and comparison the root-mean-square error of the DEM arose 0,7m.

Digital Orthophotos

Digital Orthophoto Database of Hungary has been created in the frame of the Hungarian Digital Orthophoto Program (2002-2003). In the program a 0,5m ground resolution digital orthophoto mosaic has been created for the whole country. For the orthorectification the 1:30 000 scale digital aerial photos from the "Aerial Photography Program of Hungary, 2000" has been used, with the high resolution DEM. The geometric accuracy for the projection centers of the photos in the aerial triangulation was 25cm in XY and 45cm in Z direction. The geometric accuracy of the orthophotos was measured by GPS on the ground. From these measurement the approximate rms error of the orthophotos arose 60-70 cm.

Satellite Images

Institute of Geodesy, Cartography and Remote Sensing (FÖMI) is the alone distributor of satellite images in Hungary. Remote Sensing Center of FÖMI has different developments and operative systems based on satellite image technology, for example:

- Operative Crop Monitoring and Yield Protection System (NÖVMON),
- Up-to-date Land Cover Program at scale 1:100 000 and 1:50 000 (Corine Land Cover Database),
- Flood Analysis based on NÖVMON.

Based on the results of these environment FÖMI is able to give very useful data for a World Heritage Site GIS system.

3D VISUALISATION OF WORLD HERITAGE SITES

The base technique of 3D visualization is the draping of digital orthophotos onto the DEM (see Figure 1).



Picture 1.: Digital orthophoto draped onto the high resolution DEM (Millenary Benedictine Abbey of Pannonhalma and its Natural Environment)

Draping technique is known in many softwares, FÖMI is using MicroStation®* and MicroStation® Descartes®**. This environment provides very flexible solution for draping and rendering in 3D. There are possibilities to make different flythrough sequences, movies etc.

The following step of 3D visualization would be a “real” orthophoto database creation based on a Digital Surface Model (DSM). DSM can be extracted from automatic measurement grid points by digital photogrammetric techniques. In the further development terrestrial photogrammetry also can be mainly for the observing of architectural situation within an World Heritage sites. 3D visualization of terrestrial observations also available with the already used techniques (Figure 2).



Picture 2.: Old Village of Hollókő

* MicroStation is the Registered Trademark of Bentley Systems Incorporated.

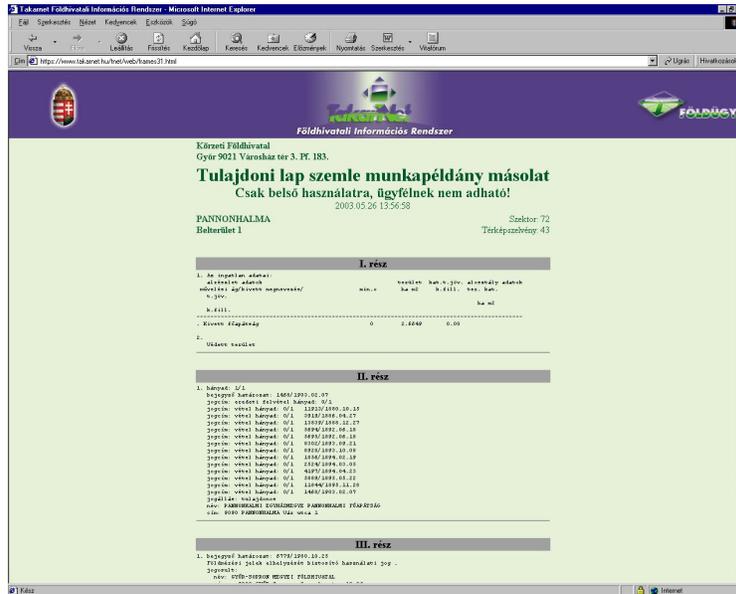
** MicroStation Descartes is the Registered Trademark of HMR Incorporated

NEED FOR THE INTEGRATION INTO A GIS

As mentioned, the data infrastructure is available in Hungary, for the 3D visualization and analysis of World Heritage Sites of Hungary. The main purpose of this project to represent, that these data help the maintenance and management of any Cultural Heritage Site. One of the solutions is to give these data to the Heritage Site management and nothing else. It is the cheapest solution, but not effective. The effective solution (Figure 2)

is only the integration of these data into a GIS system, which is working like a helpful tool in decision making related to the daily management of World Heritage Sites. Therefore our goal is to expand these project to the production of such a GIS system.

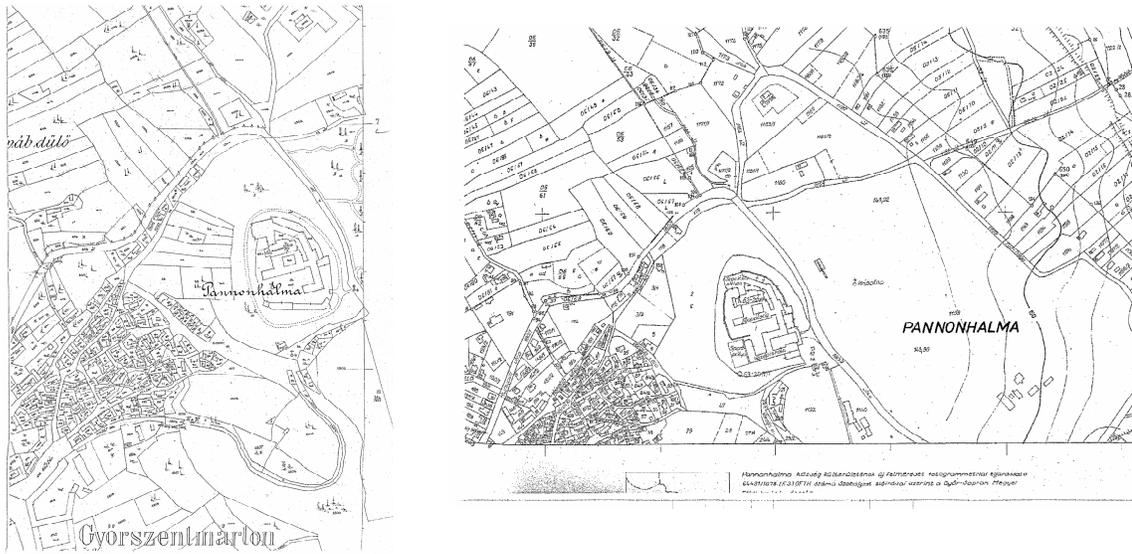
In this system all the mentioned information would be accessible from alphanumeric databases up to the orthophotos and DEM data. The daily update of land registry data is available through TAKARNET network



Picture 3: Land record of Millenary Benedictine Abbey of Pannonhalma from TAKARNET network

Another advantage of a GIS for World Heritage Site management is the historical tracking of the site. This historical tracking belong to both alphanumeric (e.g. land

registry, books, etc.) and geographic data (e.g. cadastral maps, Picture 4).



Picture 4: Cadastral map of Millenary Benedictine Abbey of Pannonhalma a) from 1908 b) from 1978

CONCLUSIONS

During the last few years the Hungarian Spatial Data Infrastructure has been strengthened to a great extent. The Digital Orthophoto Database, the high resolution digital elevation model, cadastral and topographic maps, satellite images are a good base for the development of any countrywide GIS system, like a GIS for the World Heritage Site management. At the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) there are the required techniques for 3D visualization of the sites. On-line

accessibility of land registry data is a good facility for the up-to-date management of sites. Based on our historical background the historical tracking of the sites from geographic point of view also available.

Another interesting use of 3D visualization of World Heritage Sites is the application period of a sites. For achieving of the title (World Heritage Site) the applicant must present the site and show the condignity of it. One of the most important tool for this procedure is the 3D visualisation, which had been used in the case of Tokaj Wine Region (Picture 5):



Picture 5.: 3D representation of Tokaj Wine Region (2002)

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