USAGE OF GIS TECHNOLOGY IN CIVIL ENGINEERING

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Abstract
GIS technology is more and more used even in the technical practice of a construction industry. In the preparatory phase of the construction, the problems of a spatial positioning (location) of the construction have to be solved jointly with the checking of the feasibility and purposefulness, the traffic projects are worked out, and the alternative, more detailed solutions of technical problems are designed. At project development there are used various forms of initial documents, results of the actual data gathering and surveys, map sheets, photographs, previous documents referring to the problems solved, and appropriate legal and technical standards.
The article presents the experience with the issue of GIS in construction in preparation of buildings, in the implementation phase of the construction in GIS. It presents a model of information system construction and technology of mobile GIS for data collection and use of mobile GIS in water management.

Keywords: *civil engineering, GIS, data warehouse, application of GIS*

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INTRODUCTION

GIS technology is more and more used even in technical practice of civil engineering. In the preparatory phase is focused on spatial allocation of the building structure, check of best its feasibility and usefulness, road structure projects worked out, variant more detailed solution of technical problems of the building structure are projected. In process of working on project various forms of basic source materials as well as the results of actual data capture, map documents previous resources photographs referring to the solved problem and appropriate legal and technical directions have been used. GIS technology is often interconnected with modern technologies of data capture on the base of geodetic methods making use of GPS, total station or other powerful electronic system. Innovative usage of GIS in civil engineering was published in [1], [2]. In the following text you will find further practical possibilities how to take advantage of GIS in the civil engineering.

PREPARATION PHASE OF BUILDING STRUCTURES

Methodology comprises the marking of the boundaries, demarcating of the territory of interest, looking up the transit corridors from the environmental point of view, variant solutions regarding to sensitivity of the environment, achievement of required technical parameters, traffic functions and economic problems are designed. It is followed by the assessment of variants from the ecological point of view, the choice of one or more variants for further stage of documentation and discussions with appropriate authorities of the state administration. With the extensive and technically complicated constructions the selection of a suitable variant is carried out by multicriterial evaluation in which, besides the influence of the individual variants on the environment, mainly the traffic, technical, urban, economic and sociological points of view are assessed. A part of the conclusions is the recommendation of detailed surveys for the following stages of documentation e.g. geotechnical, hydrogeological, biological, mining and archeological research.
An important tool in the sphere of territorial planning and preparation of the building structures is a homogenous territorial plan and territorial analytic document administrated and published by web GIS tools. The basis of information system is database warehouse, the means for creation and data management and mainly the web portal for data presentation. The functional technologies have to ensure the basic data capture process, analyses and data output. A very important part of the system is the quality metadata. Graphical part of data warehouse contains several basic layers out of which the most important one is the cadastral map layer, ortho-photo, digital technical map, territorial plan, territorial analytic documents (land-use values, limits of landscape utilization, intentions of potential landscape changes and involved problems) and basic maps of medium scales. Other thematic layers, passports and others create a specialized thematic subject matter used by specialists. Integration of landscape analytic documents enables their usage by general public designers of landscape plans, municipalities and other subjects.
A high quality portal of unified landscape analytic documents is used in Moravia region, for example the Zlín district (https://juapzk.geostore.cz/portal/) [3]. Data are accessible by standard internet browser. Significant large enterprises such ČEZ [4], O_2, TransGAS, EON and others solve documentation of engineering networks. Illustrations are in Fig 1 – 4.

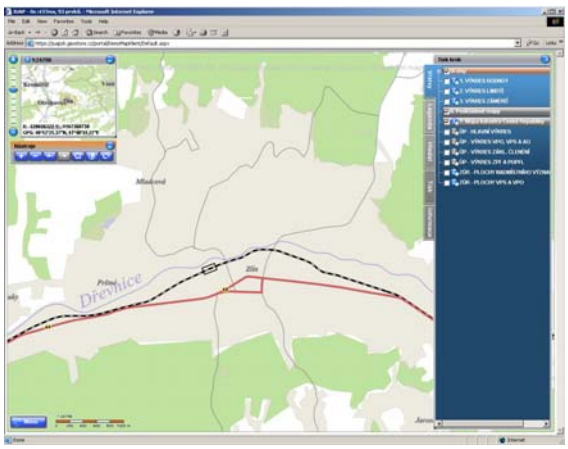

Fig. 1 – Topography map layer

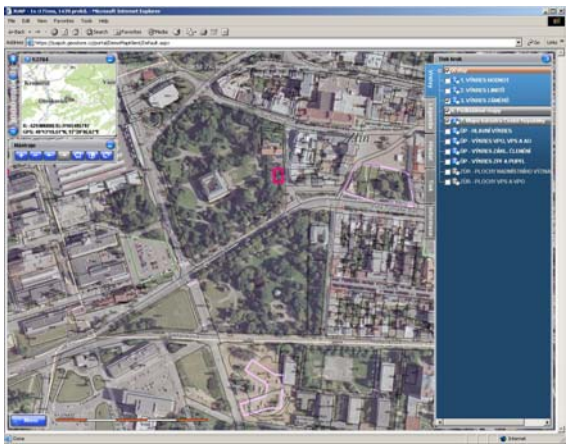

Fig. 2 – Ortho-photo layer

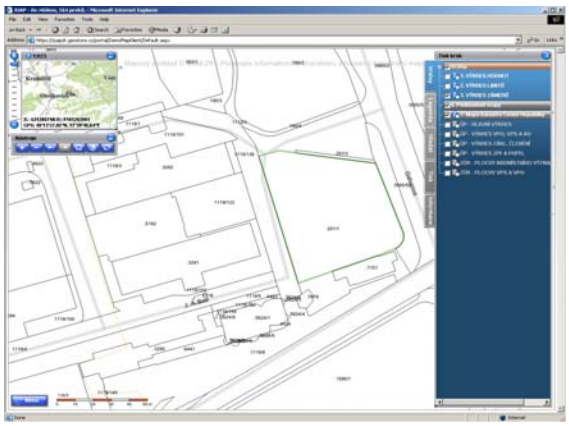

Fig. 3 – Layer of cadastral map

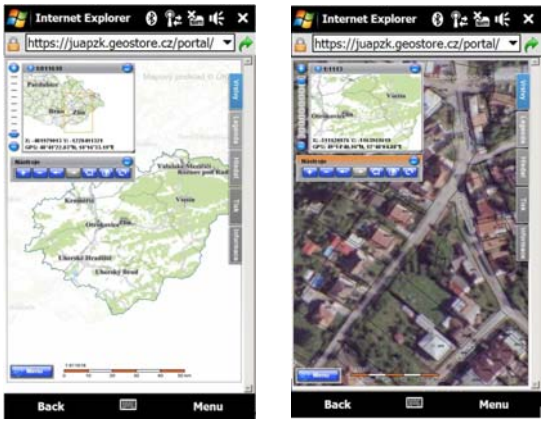

Fig. 4 - Availability of data on mobile PDA

One of the principal papers in the phase of building structures preparations, that mediates direct feedback of prepared construction on landed and real properties proprietors, eventually engineering network managers of the concerned land is the so called confiscation paper, the main goal of which is a documentation of allotments determined for extraction from agricultural soil fund and lands allocated for forest. In addition to the lists and necessary data of lands needed for feasibility of the construction, the documentation contains assessment of confiscation including the plan of recultivation of temporary confiscation and materials for encumbrances namely connected with realization of underground engineering utilities.

The basic data source of preparatory phase of construction is the Information system of cadastre of real estates in the Czech Republic. This system for real estates and legal relations referring to it is guaranteed by the state. Manager of this information system is the Czech Office for Surveying and Cadastre. By the year 2015 all the cadastral maps will be transformed into digital form and will be accessible in the public cadastre of real estates information system [5].

Data from the Information system of cadastre of real estates are accessible at the field work even through technology of mobile GIS using PDA e. g. with the installed ArcPad software. With help of GPS mobile technology we can localize necessary boundary of the interest territory, main profiles necessary for the future detailed geodetic surveying, verify cadastral links through connection of cadastral data by remote access to information system of the cadastre of real estates. For measuring it is recommendable to use calibrated and verified mobile GPS measuring devices with the determined uncertainty. Another subject of our attention is above all the information about landowners, identification of the lands in question, identification of existing engineering networks etc. The selected data in field can be stored through the remote access directly into GIS project on the server and then to work on the homogenous multidisciplinary platform usable for other professions sharing the presentation of the construction. Localization of the interest object of technologies – see Fig. 5, in consequence it is possible to show information on real estates with the printout of information system of real estates cadastre Czech Republic – see Fig. 6.

Fig. 5 - Localization

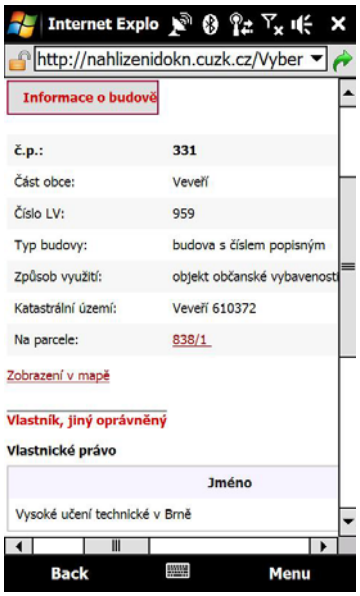

Fig. 6 – Information from cadastre of real estates

With large construction built in forms of public interest it is desirable to publish information and relations through information system of the construction. For example the presentation of the construction of large Brno city traffic ring (http://www.brno.cz/projekty/) is very interesting. Within the framework of the information system the individual details are presented; visualization or video animation, photographs etc. – see Fig. 7 and Fig. 8.

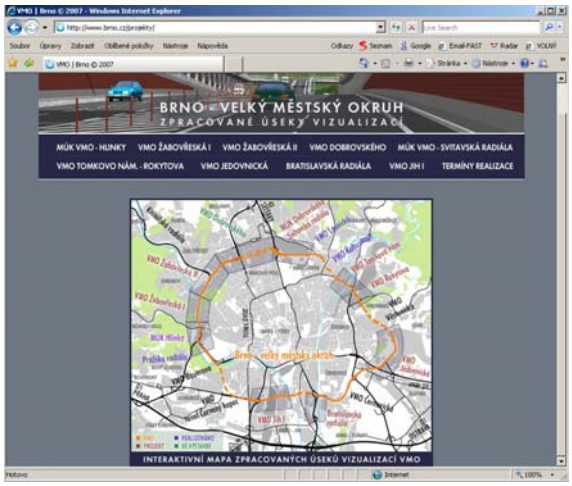

Fig. 7 – Wider context of the construction

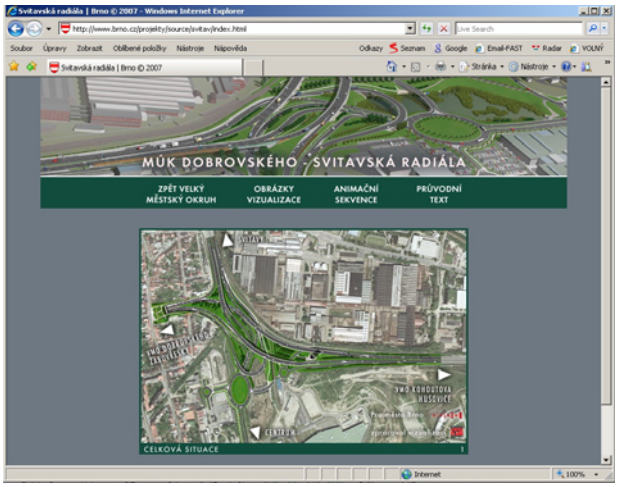

Fig. 8 – Detailed information of construction part, visualization

THE PHASE OF IMPLEMENTATION OF CONSTRUCTION AND GIS

GIS plays a very important role relating to the archiving of the construction documentation. Nowadays the project documentation in all stages of the constructions is used in digital, form mostly in CAD compatible data formats. Very important is the archiving of the official documents and decisions which still have a paper form therefore it is necessary to translate it into raster or automatized text form. EDMS (Electronic Document Management System) tools are made full use of.
A homogenous platform of complex construction documentation on the basis of GIS and EDM values is a significant tool for a successful implementation of the construction; its subsequent commissioning into operation and future reconstruction. In the space of several years (mostly at reconstructions) it is very beneficial to have all complete data sources at our disposal (documentation of actual completion of the construction) containing besides others even the most important part – the geodetic surveying plan of real course of new underground engineering network.

INFORMATION SYSTEM OF THE CONSTRUCTIONS

By construction documentation we understand a complex of paperwork and design documents. In the phase of working out the design various forms of studies are made. Study --> Documentation for land decision (Preliminary Design) --
>documentation for the permission of construction (Final Design) --> documentation for assignment of the construction (Tender Design).
In the phase of construction making a documentation of construction realization (Working Drawings and Documents) is worked out --> Documentation of construction completion (As built Drawings).
All the phases accompanying relevant documents decisions of respective authorities of state administration and self regulating organizations are included into the information system of constructions.
Concept of the information system of constructions is in Fig. 9.

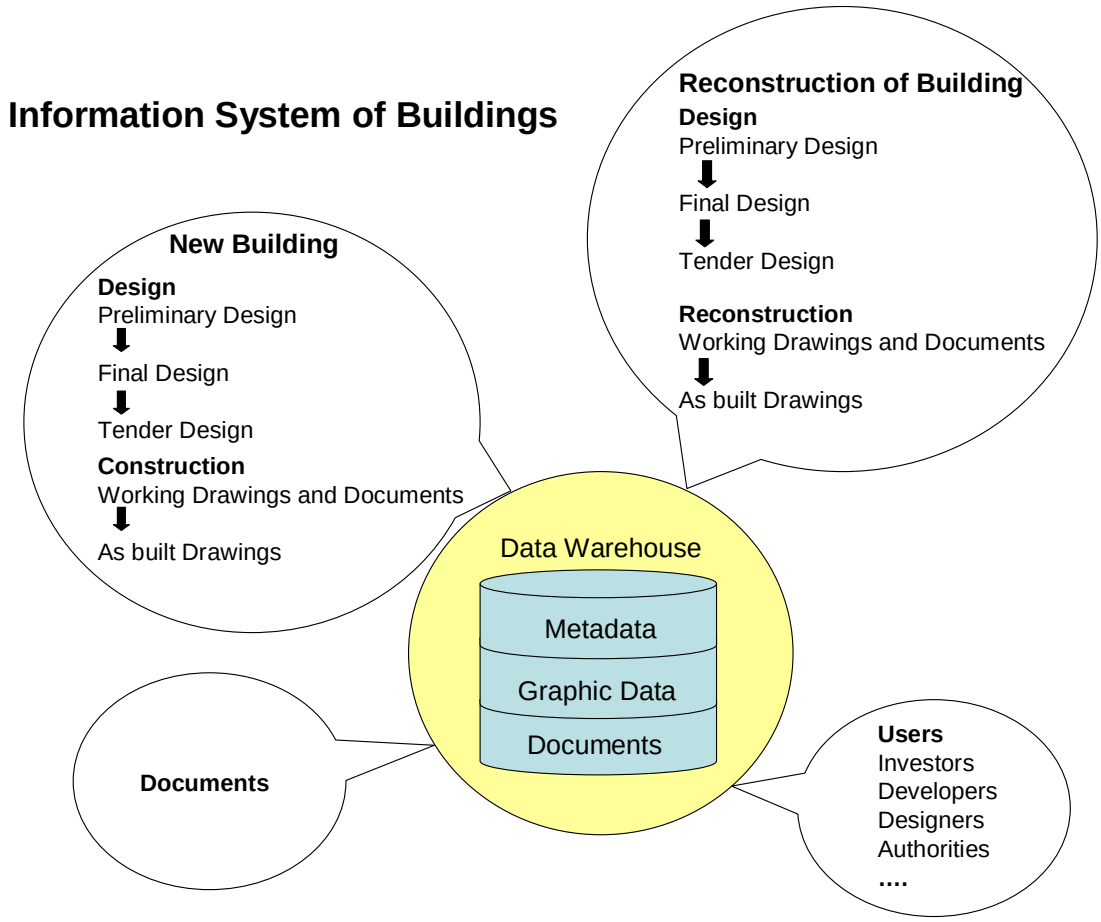

Fig. 9 – Concept of the information system of constructions

TECHNOLOGY OF MOBILE DATA CAPTURE FOR GIS

Technology of mobile data capture has recently been more and more extended and has been used in many branches. These tools support the creation of digital data flow from the initial data capture through analyses to its final visualization. The first studies confirm that making use of mobile GIS technology in field increases the work efficiency and decrease time and financial costs for getting geodata. The development of mobile data capture was according to [7] influenced by:
1) science - research activities in the sphere of cartographic visualization
2) development in computer science (new concepts for processing of visual information).
Some principle problems of mobile GIS data capture given in [8] have become reality these days (e.g. the usage of spatial databases in the internet environment, metadata problems etc.).
Current trends in mobile data capture are in general described in publication [9]. The particular problems are solved by case studies, e.g. in [10], where a concept called "field data streaming" for data capture and storage in real time is tested. The system is formed by a complex of hardware and software enabled wireless mobile data transmission during field work. The problem is that the users without geodetic skills can find a majority of current applications for mobile mapping features very complicated. Further restriction of mobile devices e.g. limited possibilities of text inputs, time aspects, energetic emphasis on durability of the device, manipulation in various scales, limited accuracy and others play also an important role.
Nowadays mobile data capture is grasped as a technology which enables digital recording of geodata directly in the field through a computer represented by PDA with built-in GPS device for positioning. On the basis of current experience in this sphere 3 different methods of access to mobile data capture can be observed – see [9]:
1. Off-line solution – application runs on PDA without connection with the central computer,
2. On-line solution, no application on the mobile computer and the user communicates through internet browser with the application on remote server,
3. transaction data processing, which is a combination of 2 previous solutions. On the mobile terminal runs an application which communicates with the central server taking advantage of web services through mobile connection.

USING OF MOBILE GIS IN WATER MANAGEMENT

Essential source of information in solving the problems of water management are the data derived on the basis of field survey. During the field survey it is necessary to know the actual position and have the possibility to update data from the field control. All of these functions provides us with the mobile geographic information system (GIS), which is a rapidly evolving technology with the possibility of applications in a wide range of fields of human activity. This is due to the current technical level of computer technology, which enables the portability of GIS to mobile devices such as laptop, handheld computer, etc. In general, the mobile GIS consists of these devices and software:

- Mobile Hardware (Pocket PC - hanheld, notebook, etc.).
- Software (eg. ArcPad, Terra Sync, etc.).
- Additional equipment for the field data collection (GPS receiver, digital camera, barcode reader, laser rangefinder, etc.).

This configuration of mobile GIS provides the following basic functions:

- the possibility of updating and collection of data directly in the field (the positioning of points, lines and polygons, input attributes);
- source of information for the purposes of navigation, decision making, etc.

Using mobile GIS in the field control is mainly related to the following significant advantages:

- user can input data into GIS in the field (ensuring data timeliness);
- data are stored in digital form, thereby reducing the risk of errors when copying data from paper-based notebook, for example;
- user has access to GIS data from anywhere in the field (it is possible to use data stored directly in the pocket computer or use the possibility of remote access such as via the Internet, etc.).

One important application area of mobile GIS technology is an already-mentioned water management. Given the scale of the problem is it possible to illustrate only selected examples of water management applications, concretely flood protection. Here is a mobile GIS application in particular for the following purposes:

- Localization of water structures and collection attributes.
- Flood extent survey.
- Collection of data for hydraulic calculations of water flow in streams and floodplains (eg information about surface roughness, field verification of the results of calculations, etc.).
- Flood marks positioning - localization for the purpose of later accurate geodetic survey.
- Flood crisis management.
- Collecting data on the structures in the floodplain to estimate the potential flood damage.

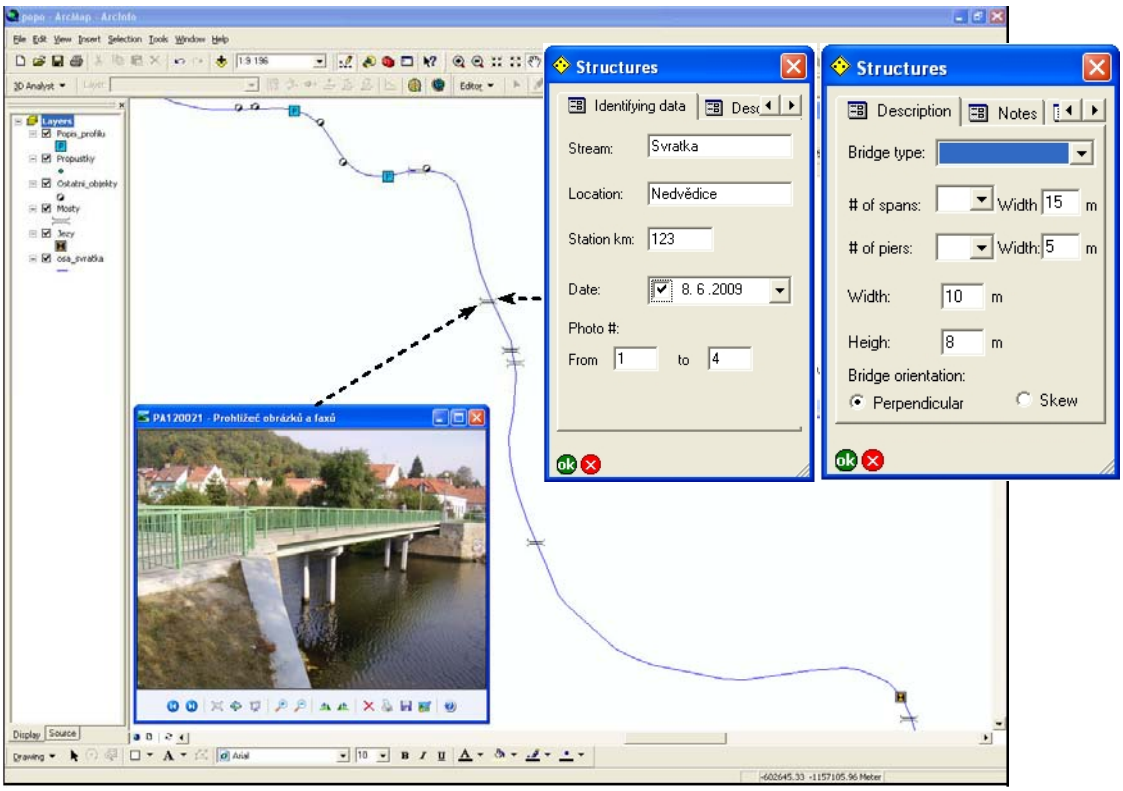

Fig. 9 - Example of structures localization – bridges

Fig. 10 Example of data collection on the structures in the floodplain to estimate the potential flood damage.

CONCLUSIONS

GIS technology in civil engineering is widely used at present. It is mainly due to the accessibility of modern measuring and information technologies. GIS phenomenon consists in data presentations through web portals on the internet. GIS products are accessible to the general public. GIS and records of electronic documents working on the database principle enable to make use of information more effectively. In the state administration and self-rule authority the usage of GIS leads to the simplification of decision processes and thus lowering the administration bureaucracy. The accessibility of complex information concerning the locality in the preparatory phase of the building structures leads to possibility of their maximum usage or specification and completion, and time and financial costs are indirectly lowered. The efficiency of the whole process of the building structures preparation is increased. Great complex building

structures intentions require a wider social consensus of admittance which can be presented with the help of computer in model variants and can get wider support among the users.
Mobile GIS, mainly with on-line internet connection and possibility to make use of data resources in field, becomes a strong tool in the whole construction process.
Taking into consideration the complications and long-term period of the construction process it would be effective to store all documents designs and information in a unified platform – information system of building structures. The efficiency of this homogenous platform would excel mainly during the process of structures reconstruction.
Currently in force in the Czech Republic Act No. 380/2009 Coll. on the right to environmental information, which raises the need for standardization of geographic data within the public administration information system.
Necessity and position of technical maps and their digital equivalents in contemporary planning, decisive and registration activities have been analysed [11].

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