RESEARCH IN SECTION OF THE CADASTRE OF REAL ESTATES IN THE CZECH REPUBLIC

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ABSTRACT:

The first phase of research and development of tools for establishment of the digital cadastre of real estates in the Czech Republic has been finished. It was a part of problems solution of the Information System of Surveying, Mapping and Cadastre as one of the National Information System of the Czech Republic source registers.

The solution was oriented above all to areas of the geodetic control and the cadastre of real estates digitization. The solution results mainly gave technical (hardware and software) and technological tools for creation, management and utilization of the Survey Information File, so as the Descriptive Information File of the cadastre of real estates (digital cadastral map) database. Possibilities of photogrammetric methods application were solved too.

1. INTRODUCTION

The first phase of research and development of establishment of the digital cadastre of real estates (*Czech abbr.* KN - *as used further*) has been finished. In the period 1991-1995 the solution was realized by the Research Institute of Geodesy, Topography and Cartography (*Czech abbr.* VÚGTK) in cooperation with departments of technical development in cadastral offices (*Czech abbr.* KÚ), and also with the Land Survey Office (*Czech abbr.* ZÚ) in Prague. The solution was passing as a part of the state development program "INFORMATIZACE" (*English meaning* INFORMATION PROCESS) according to decree of the ČR government No. 124 dated 17.4.1991 in the form of research and development project "Establishment of the Automated Information System of Geodesy and Cartography" (*Czech abbr.* AISGK). The conception of the AISGK solution which will be introduced in operational practice under the name

INFORMATION SYSTEM OF SURVEYING,
MAPPING AND CADASTRE (*Czech abbr.* ISZK)

(in accordance with the Act No. 359/1992 Coll.) determined the basic prerequisite: ISZK should become one of source registers (information systems) of the National Information System of the Czech Republic (*Czech abbr.* SIS ČR). It is urgently needed e.g. for building Geographical Information Systems (GIS).

There were reached basic targets of the project solution in techniques (hardware - HW, software - SW), technologies, organization, legislation, and economics. Due to the ČR government care and merit of the Czech Office for Surveying, Mapping and Cadastre (*Czech abbr.* ČÚZK) the results are being realized in operational practice [1].

2. ESSENTIAL SOLUTION RESULTS

Results of the project solution have created the basic prerequisities namely for:

- applying the surveying and especially cadastre information as one of the SIS ČR source registers,
- enforcing the integrity of arising databases in the ISZK frame,
- conversion of the ČR geodetic control into the European Terrestrial Reference Frame (ETRF),
- renewal of the cadastre of real estates with its recovery of legal relations, and with its conversion into digital form including tools for the Digital Cadastral Map (*Czech abbr.* DKM) creation and maintenance.

2.1 Current imagination of the SIS ČR model

The current version of the SIS ČR model represents the basic internal and external data flows in two levels - the central and the local ones. To basic data models (data structures stored in selected registers), the common characteristic of them is general respecting the GIS technology, belong [2]:

- **Register of Inhabitants** (*Czech abbr.* ROB), the main identifier of which in the ČR is the uniform series of personal identification numbers. It ensures the uniform identification of citizens.

- **Register of Organizations** (*Czech abbr.* ROR), the main identifier of which in the ČR is the uniform series of identification numbers of organizations with enterprising character (*Czech abbr.* IČO). It ensures the uniform identification of both juridical bodies and physical bodies - entrepreneurs (business undertakers).

- **Register of Spatial Identification** (*Czech abbr.* ÚIR), the main identifier of which in the ČR is the uniform series of space unit numbers on the territory of the ČR as well as the uniform series of building numbers (so called "describing numbers") in regions. It ensures the basic division of the state territory into administration units as well as fulfils function of the Register of Buildings in regions.

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– **Register of Cadastre of Real Estates** as a part of the ISZK, the main identifier of which is the parcel and its centroid. It ensures the uniform localization of territorial phenomena. It describes phenomena related to space structures and represents them as a graphic image. The miscellaneousness of graphic phenomena is characterized by their descriptive and graphic components and integrates them together through a set of identifiers (names, codes, numeral expressions etc.). As a decentralized (local) level of territorially orientated information systems is created, parallel with the SIS ČR, and that is presented by models of district and municipal offices, it serves as a source layer for all territorially orientated information systems of other branches, state administration as well as for map products in the ČR.

2.2 ISZK databases

The **Information System of Surveying, Mapping and Cadastre (ISZK)** is based on the same conception as the SIS ČR, i.e. it has two levels - the central and the local ones. It will be created by databases of three subsystems [1], that will be interconnected, namely through the uniform database system and the software environment. These subsystems are:

1. **Subsystem of Basic Control** (*Czech abbr.* **SZBP**), consisting of spatial data of basic trigonometrical, levelling, and gravimetrical networks of fixed points covering the entire state territory. By these data a uniform system of spatial coordinates and also a uniform projection system on the state territory can be defined.

2. **Subsystem of (digital) Cadastre of Real Estates** (*Czech abbr.* **SKN**) which is formed by two interconnected information files:
   - Survey Information File (*Czech abbr.* **SGI**),
   - Descriptive Information File (*Czech abbr.* **SPI**).

3. **Subsystem of Topographic Information** (*Czech abbr.* **STI**) which contains spatial data of digital medium scale maps on the state territory as a basic (source) topographic database with enforcement of possible connections to above mentioned subsystems.

The simultaneous interconnection of arising databases of individual subsystems is ensured by MS DOS operating system and dBASE IV database system environment, of SZBP already by ORACLE. The consecutive ISZK building assumes above all utilization of available data funds provided by digital surveying, photogrammetric and cartometric methods. By means of modern interactive technologies and data analysis technologies on the computer graphic systems and attached database installations these acquired data could be interpreted in a uniform way, as well as classified, vectorized and processed. At the same time the main purpose of the central database is to ensure (fulfil) the data coincidence with local nets LAN-PC databases, to yield aggregated information of the SPI SKN, as well as SZBP, STI, mainly for the SIS ČR level, and check and archive the SPI data.

Local databases ensure the primary SKN actualization (management) in cadastral offices including information which enable generation of actualizing sentences for the central database. Further task of local databases is a successive creation and management of the Digital Cadastral Map (*Czech abbr.* DKM) and giving information about SZBP, SKN and STI. (Tab. 1).

2.3 Geodetic control

Within the framework of the **SZBP** there has been solved during the project solution till now the creation, management and utilization of the Horizontal and Vertical Basic Controls including automated topography of individual points [3]. Furthermore, the programs for determination of astronomic orientation by measurements to the Polar star and to the Sun [4] were processed as a part of the **SZBP**. In the VÚGTK there were also completed computing programs that will enable the mutual transformation of coordinates of the State Coordinate System of the ČR (S−JTSK) into the European Geocentric Coordinate System (ETRF) with such accuracy level as demanded by the international committee CERCO (Comité Européen des Responsables de la Cartographie Officielle) [5]. It is concerned with processing of results of actual observation techniques utilizing artificial satellites based on the GPS (Global Positioning System) application. The relevant software package and technologies are introduced into operation in the Office of Surveying and Mapping which acts as the manager of these data. At the same time a relatively independent database from GPS observations was solved. This database will serve for registration, distribution and analyses of data acquired with GPS apparatus within the framework of actualization and maintenance of the basic control (*Czech abbr.* ZBP). The database will be connected on the central database level of selected 177 points, so called "Zero order network of the ČR" [6].

2.4 Digitization of the cadastre of real estates

The goal of the SKN solution was to create prerequisities for creation and management of the source database of both graphical and databasic (attributive) information. Spatial units and spatial data are localized in the uniform State Coordinate System JTSK. Spatial data are opened up in a common precisely defined spatial unit, without exception structurizable and identifiable on the entire state territory. It deals with cadastral district. For data transmission (graphical and databasic) the countrywide standardized interchange formats have been advertised [7].

The SKN is based on a common database conception of both survey information file (**SGI** - digital cadastral map - **DKM**) and descriptive information file (**SPI**). The technology of management and yielding of information from the Cadastre of Real Estates in local networks at cadastral offices respects the data (graphical and databasic) storage in a server, different level of data access rights, as well as the data protection and automated outputs in cadastral territories, where the **DKM** will be processed and maintained.

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a) SPI

The result of this research project solution is the transformation of the distributed **SPI** data on personal computers (PC) [8]. The local databases of the SPI are now being maintained operationally in local networks in the database

system dBASE IV. The integrating environment is ensured by MS DOS and Novell NetWare operating systems. The programming system **INFORMACE** (*Engl. meaning* INFORMATION) of the VÚGTK - for information output from the **SPI** and the programming systems **AKTUALIZACE** and **POMOCNÁ EVIDENCE** (*Engl. meaning* ACTUALIZATION and AUXILIARY EVIDENCE) of the Cadastral office at České Budějovice - for information maintenance, are established and utilized in all cadastral offices in the ČR. The identity of central and local databases is secured by batch processed files on magnetic media in regular time periods. The remote transfer of the SPI data is

now being introduced through the Bulletin Board System (BBS/PC).

The level of data processing has increased. Information is yielded on workplaces where it has been acquired and processed. This partial realization means a really remarkable improvement of services for the **KN** users. Extracts of the **KN** can be done automatically in the real time.

In the digitization program of the **SPI** [9] new data will be putted into the existing database in the following period. It means above all the addition of proprietary relations to real estates on the entire state territory, especially in land blocks which were used by so called "socialist" organizations (involving about 10 million of parcels and 3.5 million of owner's folios). Furthermore there must be added qualitative specifications of individual parcels in the form of soil valued ecologic units (*Czech abbr.* BPEJ - about 14 million of parcels) and codes of village-parts in build-up areas

SUBSYSTEM	DATA TYPE	ADMINISTRATION LEVEL	FUNCTION
SZBP subsystem of basic control	ZBP - horizontal cont. - vertical control	Active	Management, central distribution
	PBPP - detailed horizontal control	Distributed SELECTION (net densif.p.)	Check, central distribution
SKN subs. of (digital) cadastre of real estates	SPI - descriptive information file	Distributed	Check, back-up, central distribution
	SGI - survey information file	Distributed SELECTION (of contents)	Check, central distribution
STI s. of topogr. inform.	ZABAGED - fundamental base of geographic data	Active	Management, central distribution

ISZK Central databases

SUBSYSTEM	DATA TYPE	ADMINISTRATION LEVEL	FUNCTION
SZBP subsystem of basic control	ZBP - horizontal cont. - vertical control	Distributed SELECTION (regional)	Regional distribution
	PBPP - detailed horizontal control	Active (ZHB) (net densification points)	Management, regional distribution
SKN subs. of (digital) cadastre of real estates	SPI - descriptive information file	Active	Management, regional distribution
	SGI - survey information file	Active	Management, regional distribution
STI s. of topogr. inform.	ZABAGED - fundamental base of geographic data	Distributed SELECTION (regional)	Regional distribution

Table 1 - ISZK Local databases

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(in reference to ÚIR). Also the implementation of basic identifiers of owners - tenants, i.e. identification numbers of citizens and identification numbers of juridical bodies (connections to ROB and ROR - about 1 million of identifiers) and others will be finished.

The works should be finished in 1998.

b) SGI

The **SGI** (**DKM**) must in future replace actual disponible **KN** map fund. The solution of this research project has been concentrated on creation of programming systems and technologies needed for restoration of these bases and their conversion into the form of the digital cadastral map (**DKM**) and for continual updating (maintenance) of their contents to correspond with the contemporary legal situation documented in the **SPI** database [10].

The programming system for creation, actualization and utilization of the **DKM** database was elaborated in the project solution framework. It concerns the applicative superstructure of ordinary graphic software MicroStation, version 5. The applicative superstructure of this general graphic SW is the **MicroGEOS** system. It is at disposal for all workplaces of cadastral offices in the ČR including user's and reference handbooks and training data [11]. For external **KN** users a commercial programming system of similar parameters has been elaborated which will be distributed under the name DIKAT.

The **MicroGEOS** operates under the database system dBASE IV and the integrating environment is ensured through the MS DOS operating system. Inner format for vector data is DGN, for raster data RLE, event. CCITT or TIFF.

The **MicroGEOS** in user's environment of MicroStation enables in the process of transformation of present map bases into the digital form to establish and maintain the DKM database through the creation of new original maps even using (through rearrangement) original (present) map bases.

The **MicroGEOS** enables to carry out basic functions for creation and updating the **DKM**. It secures standard outputs realization according to state standards. It makes possible to perform check functions for the right geometry and topology of the **DKM** as well as ensures the perfect interconnection between the **SPI** and **DKM** [12].

According to the decree of ČÚZK ref. No. 598/1995-23 dated 30.3.1995 the MicroGeos is applied as a uniform graphic system for the **DKM** maintenance in the ČR.

Application of the programming system **MicroGEOS** and creation of the **DKM** database in workplaces of cadastral offices will remarkably increase the operativeness of their services for the **KN** users. The **MicroGEOS** above all will mediate the direct interconnection of the **SPI** and **SGI** databases. Furthermore it will accelerate and with upgraded precision check the overhanding survey sketches for changes of the **KN** contents and mediates introduction of their veryfied results into the **DKM** digital database. It will enable

to localize operationally the original proprietary boundaries of parcels from maps of former land cadastre especially in land blocks to restore proprietary relations to real estates. Last but not least it will mediate information yielding from the **DKM** database (e.g. KM duplicate) through the form of automated output from a computer in the real time by means of a plotter or a laser printer.

It is extremely difficult to accelerate the conversion of present map bases of the **KN** into the **DKM** form due to a large number of acquired data. Actually, the whole map fund of the **KN** is needed to be transformed into the digital form and to be checked as to correctness of introduced data, to be updated its contents, and to be created conditions for continual maintenance of the created **DKM** database. Respecting the immediate needs of accelerated forming of this source localization database such conditions have to be created, so that **all disponible capacities would be employed** for transformation of present map bases into the digital form [13], [14], [15], consequently also capacities of potential users of this database. The works would be finished till about the year 2010 [9].

One part of the project solution in the VÚGTK was the mutual interconnection of the **KN** database with the **SZBP** and **STI** data [16]. The interconnection of the **SPI** and **SZBP** databases facilitates e.g. procedure of the ZBP points protection and maintenance. The join of the **SGI** and **SPI** **KN** databases to **STI** information efficiently raises the use value of the **STI** databases, especially for users from municipal sphere [17]. The **STI** database utilization as a graphic environment for processing and maintenance of basic control nets survey raises again the operativeness of the **SZBP** data utilization [3].

The proper solution of the STI ensures ZÚ. It resulted in elaboration of the Fundamental Base of Geographic Data (*Czech abbr.* ZABAGED) with utilization of Basic Map 1 : 10 000. The raster form of colour map image has been elaborated for the entire ČR territory and is presented as ZABAGED 2 [18]. ZABAGED 1 will represent the vector form of Basic Map 1 : 10 000 image with appropriate classifiers and other attributes of individual elements of the topographic database contents. ZABAGED 1 shall be realized on the entire ČR territory in the century break.

3. APPLICATION OF PHOTOGRAMMETRIC METHODS

Till now we are not succeded in the full extent to restore great traditions of the ČR in operational application of photogrammetric methods for creation and maintenance large scale digital maps, especially the DKM. In the period 1987-1995 the utilization of photogrammetric methods strongly receded, above all in the state administration. It was due after the year 1990 especially to an enormous motion and division of parcels during the real estates restitution process. That is why the general renovation of cadastral maps by new mapping had to be temporarily stopped. The only one photogrammetric activity in operation of the state administration is the maintenance of topographic maps at the scale of 1 : 10 000 with graphical restitution on universal

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analog plotters. Most of activities in the creation of ortho-photomaps and large scale thematic maps spheres is passing after an expressive privatization of photogrammetric activities in the enterprise area. Owing to modern equipment in specialized private firms also the operativeness of aerial photogrammetric survey has increased. The remote sensing activities are being developed mostly out of state administration as well.

The application of photogrammetric methods to creation and actualization of DKM for the state administration needs has remained only at the research and development level till now. The solution results however brought valuable knowledge and recommendations for successful applications in the future [19].

In a research form there were applied the analytic and the 2D digital methods. From acquired results the main conclusions at least can be pointed out:

— Photogrammetric methods should be instantly oriented to selection, verification and determination of map contents identical elements of the former cadastre of lands, contemporary KM, and terrain - they represent one of the best methods of identity verification by the area.
The goal is to keep the KN map products continuity.

— For elimination error influence coming from different identification levels of individual detailed points being determined so in terrain as from aeroplane, for restriction to minimum the beaconing before flight, and for minimization surveying-in after restitution, there must be utilized images at the optimal 1: m_s scale. It is recommended to determine the maximal utilizable scale figure magnitude by the empirical formula

$$m_s = \frac{\Delta \, xy}{0,025 \text{ mm}} \quad ,$$

where Δ xy is the deviation in mm corresponding to relevant class of required precision [10], i.e. the required resultant value of mean coordinate error of points that are determined.

— If renovating the photogrammetric instrumental fleet, it is recommended to replace analog plotters (at the present time 19 instruments) by equipment for 3D digital photogrammetry only, e.g. by the ImageStation system, with direct output for the DKM database in DGN format [20].

4. CONCLUSION

The result of the research and development project solution is very useful and valuable without any doubt, although it would mean only the initial step on the way to enforcing the fully operational ISZK, and the digital cadastre of real estates. Relatively in a short time it contributed to overcome the backwardness of former operational practice behind the situation in developed countries on the field of informatics, and through this it created basic conditions at least, for coming back also our branch into the Europe's conditions.

It offered to operational practice the basic tools for creation and management of databases, the filling of that is the necessary condition of system functionating, and it represents the largest time consumption and charges of the whole system. It secondarily enabled to state administration to improve their services provided, already in this initial phase [21].

In the next period the research and development in this section should aim at further inovations of automated system, which should enforce still the better consistency in integration of the individual ISZK subsystems including the management of descriptive and map parts of the KN, and also ensure the direct access of users to the whole system data.

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