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Stručni članak

One Method of Renewal of Stereographic Survey Data in Čoka Municipality

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ABSTRACT. This research presents an approach to solving the problem of establishing the real estate cadastre in real estate cadastre services in Serbia, where stereographic survey still exists. These problems are analyzed, set the goal and solutions are proposed. Old, damaged and not updated plans, the impossibility of detecting changes in the missing parts of the plan or map are characteristics of the cadastre based on stereographic method for over 25% of the province of Vojvodina. Without up to date and current topographic data, there is not, nor is possible to simply, fast and accurately reach necessary data to establish and maintain the real estate cadastre. The main goal of this research is to propose the procedure for achievement of real estate cadastre throughout the territory covered by the stereographic projection. Proposed procedure is based on the implementation of new technologies for collecting and processing of graphic and alphanumeric data, using geographic information systems technology, digital technology and photogrammetry. Photogrammetric survey of the whole country (made in 2007), provides digital orthophoto plans to become the main source of data acquisition, especially in damaged cadastral maps. The new methodology used and tested on nearly 60% of the Čoka municipality area provides easy, fast and accurate data acquisition.

Keywords: survey, stereographic projection, digital orthophoto.

1. Introduction

In the real estate cadastre in Čoka old stereographic projection is in use. The state of cadastral register, especially the state of the working originals of cadastral plans, the equivalence of the terrain data and data in the cadastre register, require an updating of documents on the land and acquisition of new spatial data and

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their presentation in an appropriate form (photographic, graphic, 3D etc.). Working original of cadastral plan mean a copy of the archived original in analogue and digital form certified by the Administration authority and shall serve for maintaining survey. Photogrammetric survey of the entire country (done in 2007) provides that digital orthophoto plans can be used as the main source of data acquisition, especially in damaged cadastral plans.

2. One Renewal Method of the Stereographic Survey in Area of Čoka Municipality

2.1. Actual (Current) State

Čoka municipality is placed in the northern part of the Republic of Serbia, in northern Banat. The plans for cadastral municipalities of Jazovo, Ostojićevo, Sanad, Crna Bara and Čoka are produced in scale of 1:2880 using graphic method in stereographic projection, based on the survey from 1876-1903 in Budapest coordinate system. Cadastral plans in stereographic projection, which cover about 70% of the municipal territory, are almost (90%) unusable for qualitative implementation of spatial changes in real estate or for activity and maintenance of real estate cadastre. Besides the plan sheets from that time period, which are in daily use, the land registers with parcel's areas are saved in *hvat* measurement system (analogous to fathom). It can be concluded that the lack of updated and digital cadastral records prevents any further development of information systems which would use geodetic data and prevents the effective usage of modern computer technologies in the process of real estate databases.

Fig. 1. *The actual state of scanned cadastral plan, part of Čoka municipality.*

The main reason for choosing cadastral municipality of Čoka as a pilot area for the application of this method was poor condition of the original plans, in which the maintaining and updating has been impossible for many years.

The actual state of scanned cadastral plan which presents the construction area of Čoka municipality is shown in Fig. 1. The state of graphic survey in stereographic projection suggests the need for emergency reaction on making appropriate decisions regarding its further usage. Any delay would just further deepen existing problems. Data about new changes-updates are placed on the sketches of surveying maintenance, or are recorded on tracing paper in scale of copied plans of individual parcels. This all mean that mapping errors in the maintenance of surveying are evident. Another problem is the fact that there are graphical and numerical data missing for some parcels which are placed in database of real estate cadastre (the basic parcel is divided in parts, parcelling data do not exist). There are also reverse situations in which the trace of change exists but the change is not implemented in the land register. All these problems affect the work of the service for real estate cadastre (administration authorities), as maintenance was reduced to the assessment and management of the individuals. The survey conducted in the end of 19th and in the beginning of 20th century could satisfy users in that time period. Today, such register not only fails to meet the user's needs, but presents a major problem with its total unreliability (Ninkov and Bulatović 2011), both in the field of geodesy and in all areas which base their work on survey data (planner and design organizations, citizens, tax administration, banks, etc). One of the tasks which the state institutions have to fulfil in this area is to create and establish the real estate cadastre throughout all the state territory by the end of 2011. Since up-to-date and current topographic material do not exist and it is difficult to create it easily, quickly and accurately, in order to establish real estate cadastre there is a need to find solution that solves the existing problems (Trifković 2003).

2.2. Photogrammetric Survey of Serbia

In time period 2007-2010 aerial photogrammetric survey of the territory of the Republic of Serbia was carried out with the aim of producing a digital orthophoto of the Republic of Serbia. Digital orthophoto (DOP) of Čoka municipality was produced in resolution of 10 cm, in Gauss-Kruger projection; for the urban area of Čoka the recording period was September 2007. Single DOP's in resolution of 10 cm are produced in *tiff* format with associated *tfw* files. Dimensions of a single DOP for the urban area of Čoka are 900 m x 600 m, a total number of produced DOP sheets is 16.

2.3. The Integration of Graphic Data from Stereographic and Photogrammetric Survey

The integration of graphic data from stereographic survey (plans in scale of 1:2880) and photogrammetric survey in Gauss-Kruger projection (in scale of 1:2500) is necessary for obtaining qualitative base material for the digitizing of missing data.

2.3.1. Existing Data

Plans in stereographic surveying have scale of 1:2880. Urban construction area of Čoka covers four map sheets numbered 14, 15, 22 and 23 in the sheets numeration for the whole cadastral municipality of Čoka. The plans are scanned in the Republic Geodetic Authority (RGA), Department of Geodetic Information System, according to the official procedure applicable in plan sheets of *tiff* extension. Scanned plans are geocorrected (georeferenced).

Fig. 2. *Geocorrected map sheets and plans of maintaining the construction area of Čoka.*

As shown in Fig. 2, there is missing part of 30% of city territory which has none of original data, due to damaged maps. Working originals of this area exists, derived from old original data at some time point by combination of copying and using old laminating sketches. Those working originals are in use today, updating is applied on them. The quality of the data used in the maintenance of the cadastre does not need further comment.

When overlapping working originals with the original plans from stereographic projection, deviations occur in various directions which mean that both linear and nonlinear deformations are presented and in such a way the data can hardly be useful.

Proposed methodology emphasize digital orthophoto, produced in 2007 in resolution of 10 cm in Gauss-Kruger projection as the most important source of collecting the missing data. Produced othophoto plans are parts of orthophoto mosaic generated from very large blocks of images where aerial triangulation was performed using a minimum number of control points (Pajić and Govedarica 2010). Although first comparison seemed good, the control measurement of same (identical) details in the plans in stereographic projection and orthophoto plans showed inconsistency of Datum in these two graphic data. In order to improve the scale of orthophotos and stereographic plans and to determine the translation and rotation, both images are placed in Gauss-Kruger projection, control measurements were carried out in the area of interest and the coordinates of points identified in both images were and determined. In order to determine the coordinates of identical points identified in both graphic data and control points for improved geocorrection of orthophotos, GPS fast static method was used with the calculated transformation parameters for deter-

mining the local Datum for the area of interest (territory of the project). The measurements of control profiles were carried out by the method of continuous kinematics using corrections from AGROS permanent station network from Republic Geodetic Authority RGA. Measured control profiles along horizontal signal lines (visible in orthophoto), had the spatial coordinates calculated in every ten meters, approximately. Measurements were carried out by using GPS device fixed to the vehicle, with fixed GPS height and the vehicle was moving in a way that the vertical axis of GPS was above the street centre line with an accuracy of 3-5 cm, vehicles are shown in Fig. 3 (Ninkov et al. 2010). The vehicle was moving at the speed up to 30 km/h, registering points every second, providing coordinates of points on centre line with a distance of less than 10 m. Achieved accuracy of locations in the horizontal signal lines, after numerical processing and setting the regression line, was within 3-5 cm provided by AGROS network of Republic Geodetic Authority and navigated driving along the lines of horizontal traffic signalization.

Fig. 3. *Vehicles with fixed GPS.*

Computer image processing was done based on information on determined control points and the data of recorded centre street lines, using Erdas Imagine software tool. Photogrammetric blocks, bordered by recorded centre street lines, were scaled in fixed frame in accuracy of 3-5 cm. This significantly increased positional accuracy of every pixel in orthophoto and eliminated residual distortions from the classical photogrammetric processing of large blocks.

Fig. 4 shows all streets with measured centre lines and the identical control points identified in the stereographic and orthophoto plans.

The same procedure was applied to the processing of old plans in stereographic projection in scale of 1:2880, but all recorded control profiles were used for positioning the middle between the constructing lines identified in these plans (Popov 2011).

Fig. 4. *Scale improvement of orthophoto using control points and profiles recorded by GPS (– control points).*

A large number of identified points (a church, a castle, different objects, some roads, crossroads) from the period of measurement in stereographic projection in scale of 1:2880, was transformed using ERDAS software based on a set of coordinates in both coordinate systems (Budapest and Gauss-Kruger) to scale of 1:2500 and Gauss-Kruger projection. In this way the stereographic plans were transformed into the same coordinate system and the same scale as orthophoto plans of the territory of the project (area of interest).

Integrating geocorrected orthophotos, stereographic plans transformed to Gauss-Kruger projection and scaled copies of working original (further on will be used only for digitization of parcel's numbers which correspond to numbers in land cadastre) provided the material for digitization and updating of existing cadastral data (with the information on data which were missing) and produce of new digital cadastral maps (Ninkov 2004) as illustrated in Fig. 5.

Fig. 5. *Orthophoto, cadastral plans and copies working original of identical Datum.*

2.3.2. Digitization

Digitization of the missing data from valid cadastral plan and the produce of new digital cartographic plan (DCP) are done using software for digital topography MS Cad (Ver. 2010) and GIS software ArcGIS (Ver. 9.3.). New DCP is produced in accordance with valid Regulation for design of DCP and adjusted to the methodology of real estate cadastre establishment.

Primary digitization is performed on undamaged parts of the cadastral plan, considering the control of parcel's topology and objects in copy of the working original. If the differences in the geometry of parcels and/or objects are identified, then the factual state of the geometry is adopted from the orthophoto plans. Such combinations of active graphical levels for digitization are possible owing to the possibilities of used software tools that one or more graphics layers can be transparent.

Digitization of parcels and objects in damaged parts of cadastral plan is implemented from orthophoto plans, with the topology control on copies of working original.

Since the final processing of digitized parcels and objects was performed by using GIS technology, all parcels and objects in new digital cadastral plan have defined dimensions and polygons. The numeration of parcels was carried out in new DCP, in accordance with the numbers in the copy of the current working original. Comparing the parcel's areas in new DCP and areas of the same parcels in land registry databases, it is asserted that the difference between the areas, on the territory defined in the project, in app. 85% of cases is within the accuracy of area determination by calculation methods used in primary mapping. In cases where the major differences were noticed, the field survey was done so that the number of conforming areas had risen to app. 92%.

The numeration of objects within the parcel, in accordance with the Regulation of the RGA (Fig. 6), provided the conditions for the use of object's areas in the process of design of the real estate cadastre.

Fig. 6. *Digitization of missing parcels and objects.*

Fig. 7. *New digital topographic plan with the numeration of objects within parcels.*

The table below shows the differences in areas obtained from new updated digital plan and parcel areas from land cadastre. It is concluded that 90% of these differences are within the boundaries of permissible deviations.

Table 1. *The area differences; areas from DCM vs. areas from land cadastre.*

Parcel No	Area (DCM)	Area (cadastre)	$\Delta(m^2)$	Parcel No	Area (DCM)	Area (cadastre)	$\Delta(m^2)$	Parcel No	Area (DCM)	Area (cadastre)	$\Delta(m^2)$
2167/5	375	352	23	893	933	893	40	952	427	443	–16
977	501	518	–17	894	1645	873	772	951	584	605	–21
976/1	212	229	–17	895/2	478	527	–49	950	384	378	6
975/1	234	256	–22	897	1040	1045	–5	949	199	209	–10
972	374	421	–47	898/2	311	316	–5	948	291	274	17
973	430	410	20	899/1	337	320	17	947	375	400	–25
974	427	396	31	903/3	378	398	–20	946	443	450	–7
978/1	335	324	11	904/1	469	427	42	945	403	414	–11
979/2	182	144	38	905	1136	712	424	944	419	428	–9
971/1	448	399	49	907	439	417	22	943	532	547	–15
860	763	766	–3	906	739	744	–5	941	585	585	0
861/1	475	478	–3	908	413	417	–4	942	458	469	–11
864	1223	1219	4	909	777	817	–40	939	571	576	–5
868	1416	1435	–19	913	615	626	–11	940	432	461	–29
869	1807	1668	139	911	426	417	9	936	297	342	–45
862/1	700	719	–19	915	425	417	8	937	292	295	–3
863	749	748	1	914	697	712	–15	938/1	215	227	–12
867	557	511	46	916	1567	1650	–83	938/2	262	267	–5
871	1957	1949	8	917	1532	1539	–7	925	1094	787	307
873	942	942	0	910	863	978	–115	923	419	421	–2
872	1133	1021	112	912	419	417	2	921/2	488	468	20
876/1	354	334	20	969/1	268	220	48	702	738	723	15
875	1695	730	965	967	384	349	35	704	694	939	–245
878	1156	1140	16	968	257	263	–6	703	1140	935	205
879	532	539	–7	965	486	410	76	705	1180	1194	–14
880	920	945	–25	966	354	407	–53	706	640	644	–4
881	755	759	–4	964/1	375	371	4	709	381	874	–493
882	1016	985	31	963	327	345	–18	710	1057	1007	50
883	761	737	24	962	372	349	23	711	346	399	–53
885	1024	1029	–5	961	439	446	–7	711	480	399	81
884	719	730	–11	960	257	259	–2	681	1502	1529	–27
887	1012	981	31	959	425	450	–25	716/1	651	565	86
886	762	773	–11	958	336	320	16	719/1	549	579	–30
889	1069	1054	15	957	399	385	14	718	899	870	29
888	702	730	–28	956	426	421	5	721/1	584	554	30
890/1	515	353	162	955	414	414	0	722	480	475	5
891/1	355	349	6	954	366	360	6	723	2032	2032	0
892	1808	1039	769	953	344	353	–9	725/1	742	719	23

Analysis of data on parcels with uneven surface areas leads to conclusion that those are mostly rough errors occurred as a consequence of the fact that needed changes have not been applied (parcel division, parcel merger, etc.), but there are probably some undetected technical errors occurred during primary survey and/or mapping. Non-permissible deviations which are detected will be corrected in the maintenance of cadastral data. The existence of non-compliant positions of objects in relation to the parcel's borders is also noted and recognized as a consequence of the inhomogeneity of the network, in which the primary recording was done, or as a consequence of errors made due to damaged plans. Such problems will have to be resolved through the process of maintaining the land cadastre or real estate cadastre. Final and good solution will be obtained through the renewal process of terrain survey during the process of land consolidation.

Permissible differences in digitized and cadastral areas are calculated using following formula, which is fundamental and which is often referenced in professional literature that deals with this issue:

$$\Delta p = 0.7\ M\sqrt{p} \tag{1}$$

where:

- Δp – permissible difference
- 0.7 – empirically adopted coefficient
- M – scale denominator/1000
- p – parcel's area.

According to some studies and research, higher value can be adopted as a coefficient and those experiments are considered in many research papers (Boc 2009, Ivković and Vlašić 2006) and in the latest draft Regulation on maintenance and renewal of the.. This project researched whether there is a correlation between the deviation and parcel's area and how permissible deviations affect the number of parcels with an acceptable difference of nominal areas and areas obtained in the process of digitization.

From presented tables and diagrams, the following can be noted:

- the deviation value comparing cadastral and digitized area does not depend on the size of parcel's area
- if the coefficient increases by 20% and 35% respectively, it increases the quantity (the number of parcels) within the permissible deviations for 5% (77%, 82% and 85%) whereas further coefficient increase by 50% does not increase the number of parcels within the permissible deviation.

When analyzing the values, better indicator is the relative deviation of areas comparing to total parcel's area with ranges of (-9%, +10%), (-11%, +10%) and (-13%, +12%) for the coefficients 0.7, 0.85 and 0.95 in the formula (1) respectively. It is concluded that the relative area deviations are proportional to the increase of coefficients in the formula (1) which means that special caution is needed when using coefficients in dealing with expensive land, and every deviation should be analyzed with great care.

3. Methodological Scheme of Proposed Method

The above explained method of transforming the cadastral plans of stereographic projection to Gauss-Kruger projection with the establishment and development of new DCM can be generalized and applied to all areas where the stereographic survey is still in use.

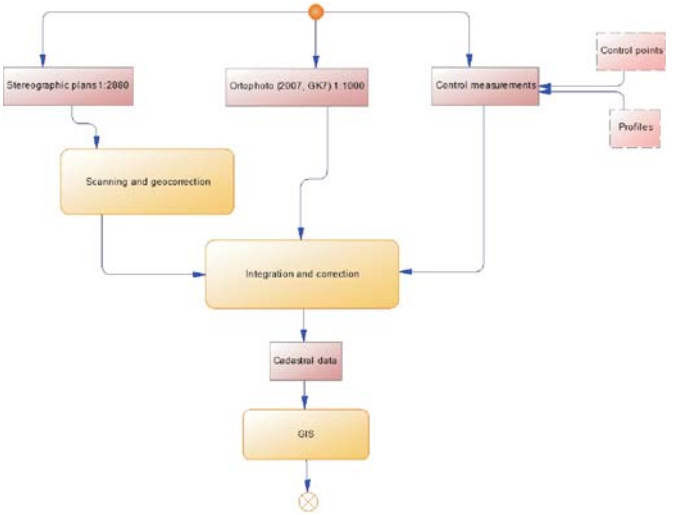

Fig. 8. *Scheme of proposed method.*

4. Conclusion

This research presents an approach to solving the problem of establishing the real estate cadastre in real estate cadastre authorities in Serbia, where stereographic survey still exists. In practical part of this research, the main aim was to propose a procedure for the establishment of the real estate cadastre in the territory of stereographic projection and it was achieved and verified on a sample which contains 60% of the area of Čoka municipality. Proposed methodology provides easy, fast and within the limits of the accuracy, acquisition of geometric and other necessary data. Depending on the specific terms and conditions in which some sheets in stereographic projection are, in some territories other technical requirements which are not discussed in this paper may occur, but they can certainly be solved using one of modern methods and technologies of graphic and alphanumeric data processing. In order to find the optimum solution for every particular case, detail analysis of the quality and state of the base material have to be done carefully, which would provide the geodetic profession with the qualitative tool to define an appropriate methodology. A new survey would be the best solution for providing a graphical bases (graphical data) for real estate cadastre registry but this solution requires substantial financial resources which are very difficult to provide in the state budget in time of world crisis. In Serbia, the problem of updated survey is solved by the projects of consolidation which are mostly important in the last few years.

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Jedna metoda obnove stereografske izmjere na području općine Čoka

SAŽETAK. U radu je prikazan jedan pristup u rješavanju problema uspostave katastra nekretnina u Službama za katastar nekretnina na području Srbije gdje još uvijek postoji stereografska izmjera. Analizirani su problemi koji se pojavljuju u ovom postupku i predložena su rješenja. Stari i oštećeni planovi, neažurnost, nemogućnost evidentiranja promjena na nedostajućim dijelovima planova ili karata karakteriziraju katastar zasnovan na stereografskoj izmjeri za preko 25% područja pokrajine Vojvodine, a bez ažurne i aktualne topografske podloge nema, niti se jednostavno, brzo i dovoljno točno može doći do potrebnih i dovoljnih podataka za izradu i održavanje katastra nekretnina. Ovim radom želi se predložiti postupak za izradu katastra nekretnina na cijelom području koje je pokriveno stereografskom projekcijom. Predloženi postupak je zasnovan na primjeni nekih od suvremenih tehnologija za prikupljanje i obradu grafičkih i alfanumeričkih podataka, korištenje tehnologije prostornih informacijskih sustava, upotrebi tehnologija digitalne fotogrametrije i topografije. Fotogrametrijska izmjera cijele države (izvedena 2007. godine), daje mogućnost da digitalni ortofoto planovi budu osnovni izvor prikupljanja podataka, pogotovo na oštećenim katastarskim planovima. Nova metodologija, koja je korištena i testirana na skoro 60% područja naselja Čoka, omogućava jednostavno, brzo i dovoljno točno prikupljanje tih podataka.

Ključne riječi: izmjera, stereografska projekcija, digitalni ortofoto.

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