

# Current Situation and Prospect of 3D Cadastre in Croatia

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**Key words:** 3D Cadastre, Land Book, Utility Lines, Buildings and Other Structures, Croatia

## SUMMARY

This paper describes method of registering real property and parts of real property (apartments, etc.) in the cadastre and land books. Approach to registering particular structures and corresponding rights is delineated based on existing legislation. For example, tunnels, bridges and other 3D cadastre relevant structures are considered. Bylaw on Utility Cadastre regulates registration of public utility lines in Croatia. The paper portrays development of the utility cadastre and depicts current maintenance and management. The utility cadastre contains data about the type, purpose, basic technical features, and location of built utility lines, and lists the names and addresses of their managers. The following topics are covered: key 3D real world situations, infrastructural and utility networks, buildings, X/Y coordinates and Z coordinates. Legislation regulating that bodies of local government must establish and manage the utility cadastre was passed already in 1999, but few of these bodies assumed this responsibility since. Future development of Croatian 3D cadastre is proposed based on current situation and demand for establishing the 3D cadastre.

## SAŽETAK

Rad opisuje način upisa nekretnina i posebnih dijelova nekretnina (stanova i apartmana) u katastar i zemljišne knjige. Detaljno je na temelju važećih prava opisan pristup upisu specifičnih građevina i prava na njima. Razmatraju se, na primjer, tuneli, mostovi i ostali čimbenici relevantni za 3D katastar. Pravilnik o Katastru vodova regulira upis javnih vodova u Hrvatskoj. Rad opisuje razvoj katastra vodova, te njegovo održavanje i vođenje danas. Katastar vodova sadrži podatke o vrstama, namjeni, osnovnim tehničkim osobinama i položaju izgrađenih vodova, te imenima i adresama njihovih upravitelja. Razrađene su sljedeće teme: osnovne situacije u 3D stvarnom svijetu, infrastrukturne i komunalne mreže, zgrade, X/Y koordinate i Z koordinate. Propisano je da jedinice lokalne samouprave osnivaju i vode katastar vodova još 1999. godine, ali je vrlo mali broj njih preuzeo tu obvezu. Predlaže se budući razvoj 3D katastra na temelju sadašnjeg stanja i potrebe za osnivanjem 3D katastra.

# Current Situation and Prospect of 3D Cadastre in Croatia

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## 1. INTRODUCTION

Traditional cadastre is composed of land divided in 2D parcels. Ownership and other real property rights on land are registered on these parcels. A question can be posed if this “flat condition” is satisfactory today. Extent of property rights on land is not limited to 2D parcel boundaries. These rights also contain a spatial component in the third dimension, above and below the ground level (Stoter et al, 2003). Development of information technology and the demand of users of cadastral data show that 2D spatial representation with limited heights is insufficient and that objects of law should be further spatially defined. Studies show that registration of 3D land data in the cadastre offers significant advantages in the area of legal protection of real property (Van Oosterom et al, 2008).

Changes in the social system (transition) and change in types of ownership rights in the Republic of Croatia in the nineties of the last century have caused many changes in real property. Much real property “lost” an owner through abolition of social ownership. This property was often not officially registered in relevant registers, which created additional difficulties with “identifying” new owners. Herewith, importance of describing real property, registering real property and registering rights on property increased. In Croatia, registers of real property and applicable rights are (still) under the jurisdiction of different public authorities. Registration in the cadastre and land books offering key data about the land management system is based on the civil code. Cadastre offers data about parcels, buildings and other structures and their features. Rights on real property registered in the cadastre are registered in land books. Croatian cadastre and land books spring from the Germanic approach to managing registers of real property and related rights. Responsible institutions of public authority are the State Geodetic Administration (for the cadastre) and municipal courts (for land books).

In the past ten years, a remarkable increase of activity is noted in the area of land administration in Croatia. Project of improving land books and the cadastre financed by a loan from the World Bank and completed in 2010, continues as a new project with a loan from the World Bank, while domestic institutions work on many projects intended to ensure quality, i.e. improve the land administration system. These existing projects have not yet focused on establishing a 3D cadastre, although numerous proposals come from professionals and businesses to more efficiently register buildings, bridges, tunnels, highways, and utility lines – the key elements for establishment of the 3D cadastre. Preliminary information about the current situation of the 3D cadastre in Croatia and some predictions for 2014 are published on web pages of the FIG work group for 3D cadastre (URL-1).

## 2. REGISTERS

Spatial data and data about real property in Croatia are managed in multiple registers with many end users. This section portrays most relevant registers of spatial data and gives a short overview of the state of the data in these registers.

### 2.1 Cadastre

Croatian cadastral system is based on the Germanic model of cadastre primarily because of its Austro-Hungarian heritage. Croatian cadastral system is similar to those in Austria and Germany. Development of land data registration in Croatia is conditioned by different countries of which regions of Croatia were a part during the past. This is why land data is registered with different dynamics and according to different conditions depending on the social structures in these countries. Attempts to establish a land cadastre resulted in an unprofessionally made and hence short lived Josephine Cadastre. Formation of the land cadastre in Croatia region under Austria-Hungary began with proclamation of the Imperial Patent (Grundsteuerpatent) on December 23, 1817, ordering surveys, land classification, and preparation of the cadastral record in all lands of the Empire. This date marks the beginning of the Franciscan Cadastre. Basic principles of this cadastre remained in use over a hundred years. Present day land registers are founded in the period from 1880 to 1900 based on these data (Roić et al, 2005).

Land Register Law, not much different than Austro-Hungarian Grundsteuerpatent, is passed in the Kingdom of Yugoslavia in 1929, after World War I. In fact, this law was a translation of the Imperial Patent, so the cadastre merely continued to serve a tax purpose. Advancement of technologies in cadastral surveying, and especially development of numerical methods, sparked in this time period enactment of a number of bylaws regulating these processes, some of which are used in practice even today.

After 1945 and implementation of radical changes in the social structure, attitude towards ownership and other real property rights also changed. The cadastre and land books did not enjoy support in this time period, but were instead neglected and finally terminated when private ownership was abolished and everything became communal. For this reason, the cadastre was not updated all until 1953 when Land Cadastre Legislation was passed. Lack of funds in the treasury caused this legislation since new sources of funding the state budget had to be found. Cadastral office revived owing to this situation, and revision of the cadastral record, content of which has not been maintained in the last circa ten years, was initiated. Land books, however, remained neglected. The cadastre obtained its role in society, but as an institution for registering land ownership in service of taxing income from agriculture. This resulted in mismatch between cadastral land data and ownership data in land books, since land book items corresponding to the cadastral items registered in the new cadastral record were not updated from 1953 to 1991 (Roić et al, 2005).

Croatian Parliament passed the Law on State Surveying and Cadastre of Real Property on November 5<sup>th</sup>, 1999. This law defined the cadastre of real property as a register of land parcels, buildings and building parts, and other structures permanently on land or below the surface. This is the first time when the cadastre becomes a tool for registering real property as

an object of law, and when it ceases to serve exclusively the tax purpose. Private ownership is in the foreground again as foundation for development of society, modern economy and overall progress. This law was in use for eight years when law of the same title is passed in 2007, however, with some changes in terms of defining the real property cadastre, state surveys, and national infrastructure of spatial data. Numerous bylaws were passed alongside the law from 2007 regulating the geodetic report, the Utility Cadastre, the Land Cadastre, the Real Property Cadastre, the administration of tasks regarding maintenance of state surveys and the real property cadastre, labels of country borders, execution of basic geodetic activities, etc. Alphanumerical part of the cadastral record for the whole Republic of Croatia is available at the internet address <http://www.katastar.hr>. Law from 2007 defines real property cadastre as a register of land parcels, buildings and other structures permanently on land or under surface, and of specific public rights and restrictions on land. Accordingly, one can notice that registration of building parts is omitted and public rights and restrictions are added as an entry in comparison to the law from 1999.

Cadastral plans originate from different time periods (Figure 1). First employable plans, most of which are in scale 1:2880, arise with proclamation of the Imperial Patent and preparation of the land cadastre in Croatia region under Austria-Hungary. Seven coordinate systems with different starting points had to be used as surveys were performed without projection in plane rectangular system (Borčić and Frančula, 1969). Instructions for cadastral surveying (Katastral-Vermessungs-Instruktion) with appended legends and topographic keys (ZeichenErklaerung) defined basics of sketch representation of cadastral data in 1820. Few labels and some colours were used to mark building units. Changes and data updates of the cadastral plan according to Cadastre Maintenance Law from 1883 were executed by crossing out old and colouring new condition in red, causing clutter and illegibility leading to systematic upgrade at the beginning of the 20<sup>th</sup> century in the Royal Lithographic Office in Vienna.



**Figure 1. Cadastral plans from different periods (Roić 2011)**

Kingdom of Yugoslavia introduces the Gauss-Krüger projection with plans now prepared in scales 1:500, 1:1000, 1:2000, and 1:2500. Technical purpose of the cadastral system during the Socialist Federal Republic of Yugoslavia demanded preparation of the topographical and cadastral plans and introduction of the new real world features. Bylaw of Cartographic Signs and Collection of Cartographic Signs defined content of these plans in 1976. Collection defined 346 labels classified in different categories defining sketches as dependent on scale.

Poor physical state of cadastral plan pages and development of computer technologies stimulated preparation of scanned and vectorized digital plans in the 90ties of the last century (Roić et al, 2005). Cadastral plans were digitalized for the whole Croatia by 2010.

## 2.2 Land books

Land books in present Croatia region have a long tradition. Imperial order was issued in 1850 initiating formation of land books in the Kingdoms of Hungary, Croatia, and Slavonia. Key legislations in this 160-year period are “Gruntovni red”(land book law) from December 15<sup>th</sup>, 1855, Law on Interior Design, Formation and Correction of Land Books from 1930, and Land Book Law from 1996. First attempts to establish land books were unsuccessful, but they were successfully established after land descriptions were transcribed from the cadastre. Land books are in present day available public registers of legal status of real property. Full confidence in accuracy of the registered data is postponed till 2015 for irregular maintenance. Purpose of land books is to enable simple, fast and safe legal transactions of rights registered on real property based on legal regulations. Land books are managed in specific departments of municipal courts. Land books for the whole region of the Republic of Croatia may be found on the internet address <http://e-izvadak.pravosudje.hr/home.htm>.

## 3. REAL PROPERTY

Real property in Croatian real property law is, according to the *superficies solo cedit* principle, a land surface parcel to include everything relatively permanently associated with this parcel on or below the land surface (primarily buildings, houses, etc.). A real property, in legal terms, may consist of more land parcels registered in the land book in the same property sheet, as they are hence legally combined in a single body (registered land unit). Grass, trees, fruits and all valuable commodities the land provides on the surface are parts of this real property until this land is divided. What is on the Earth’s surface - built on or below the ground with intention to remain there permanently or is built in, added to or on top of the real property, or associated permanently in any other way, is a part of this real property until partitioned. However, parts of the land of a building and other land associated features with a temporary purpose are not. Parts of the land of a building and other structures permanently associated with the land, but legally partitioned by real property rights authorizing the owner to have this building or other structure on other’s property (building right) are also not. The same applies to the buildings and other structures legally partitioned from the land or public property by a legal concession authorizing the bearer to own the building or other structure on this land (Official Gazette of the Republic of Croatia, 1996).

Basic spatial unit of the real property cadastre is a cadastral parcel. One cadastral parcel is a unit of a cadastral municipality or cadastral region at sea determined by a parcel number and its boundaries. Unique identifier of the cadastral parcel consists of an identification number of the cadastral municipality or cadastral region at sea and the parcel number. Boundaries of the cadastral parcel may be borders or other boundaries defined by legal relations on the land surface (Official Gazette of the Republic of Croatia, 2007).

### 3.1 Registration of Buildings and Other Structures

Buildings and other structures are registered in the cadastre with the following attributes: area, intended building use, building name, and house number. Land books adopt cadastral data and register listed two-dimensional data about real property parts. Real property may be further divided into common and particular parts and registered in the land book based on the report on partition of real property. Shared owners of the real property remain herewith in a shared ownership over the common parts, while each person becomes an individual owner of particular parts (e.g. an apartment or office space). This method of registering particular parts was introduced in 1996, but much real property remains currently undivided as partition of real property has not been administered.

Buildings are registered in the cadastre at request of a party. Geodetic report prepared by the authorized survey company must be supplied with this request. Competent cadastral office must prior review and certify the report. Survey companies have at their disposal many surveying methods, including the modern GNSS surveying method, while field surveying must be performed with minimally the same accuracy as cadastral surveying or technical supervision used for preparation of the cadastral record for the cadastral municipality where the relevant building stands.

Key parts of the geodetic report are the front page, sketch of survey (Figure 2), list of coordinates, surveying situation, stated areas, cadastre application, land book application, copy of the cadastral plan and the statement on prepared geodetic report as part of which one of the following statements must be included based on the purpose of the geodetic report:

- statement on definition of existing property boundaries and new land partition,
- statement on buildings and other structures,
- field survey statement,
- and technical statement.

Since 2007, cadastral offices partially participated in inspection of legal construction of buildings and other structures by requiring appropriate documentation to be appended alongside geodetic reports authorizing this construction prior to registering buildings in the cadastre and transcription into land books (Official Gazette of the Republic of Croatia, 2007). Legalization of illegally constructed buildings is currently on-going in Croatia according to the Legalization Law of Illegally Constructed Buildings (Official Gazette of the Republic of Croatia, 2011). This law regulates conditions, procedure and legal consequences of including illegally constructed buildings in the legal system. Owners of illegally constructed buildings must file a legalization application latest by end of 2012. Demand for the 3D cadastre will be recognized in this period because numerous real life examples (e.g. one apartment was illegally added on top of a legally constructed garage, or as another example, a building has a permit for two floors, but three floors were built) prove that construction and geodetic professions in Croatia require better descriptions of real property than are currently available in the registers, which particularly applies to the third dimension.

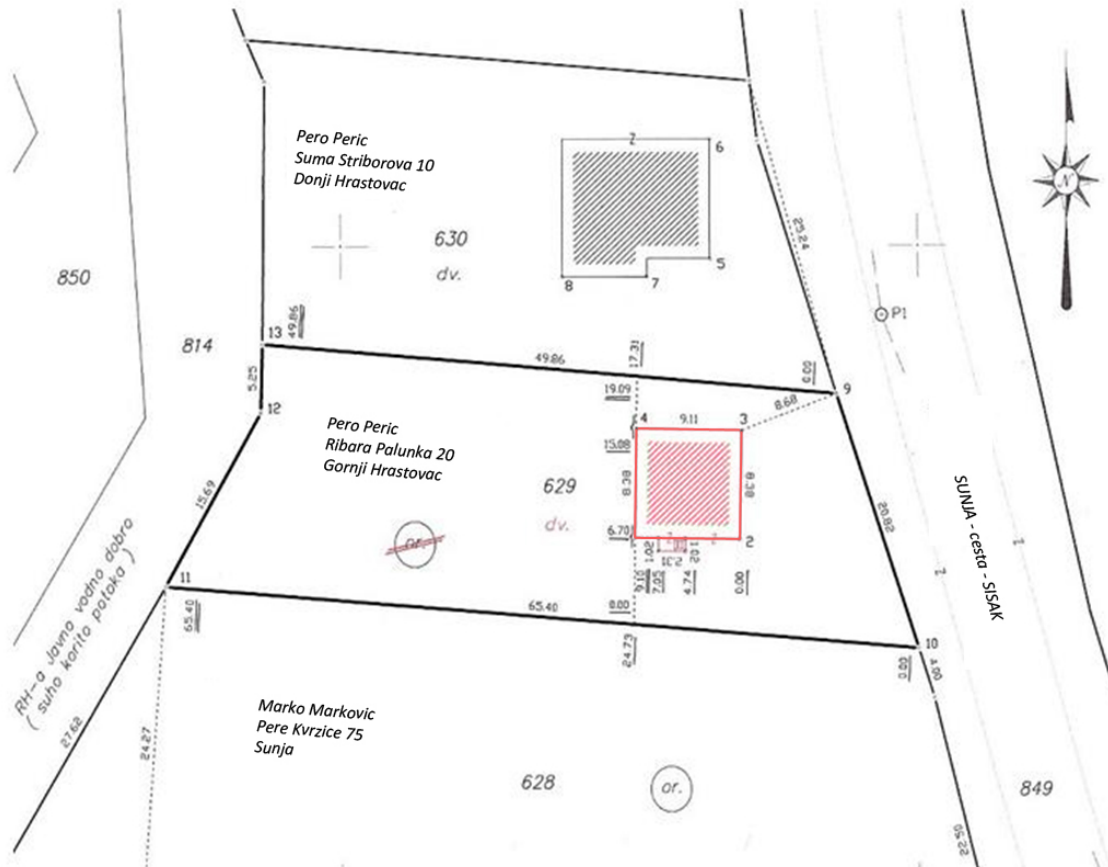


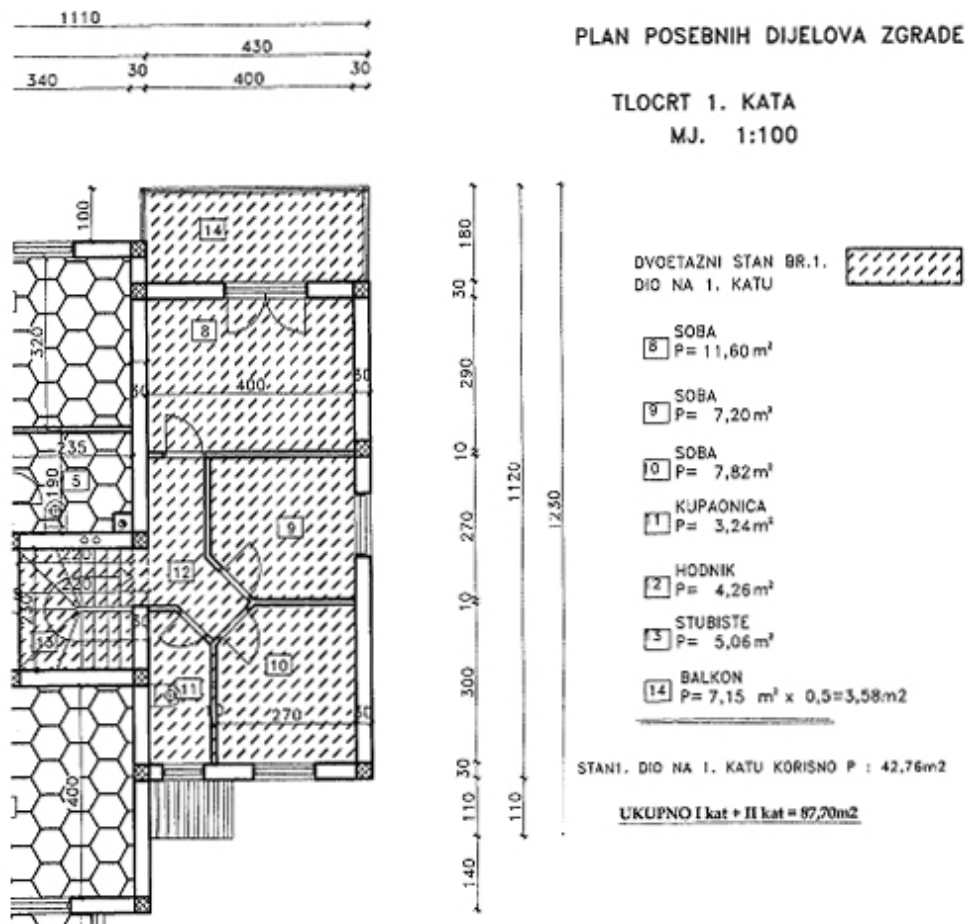
Figure 2. Sketch of survey from a geodetic report for registration of a building in the cadastre

### 3.2 Registration of particular parts of real property

Data about buildings are transcribed into land books based on the data delivered to the land books by the cadastral office. Ownership of a specific particular part of property (e.g. an apartment or office space) is realized through registration in land books. These particular parts may be registered if they make independent units of use. Particular parts may include balconies, terraces, basements, and attics, under condition that they serve exclusively a single particular part and if they are clearly separated from other real property parts. Registration of particular parts of real property in the land books is not possible without partition of real property, which in legal terms means retention of real property as a single body. The same procedure is commonly used in land books to formally unify the land which was often publically owned with the building constructed on that land. Partition of the real property establishes ownership of a particular part of real property (apartment, office space, garage, etc.) that becomes associated with proportionally shared part on the property. Fair relationship in financing maintenance of a building is furthermore made possible by establishing ratio of each party's ownership in the real property and hence each party's proportional share in shared ownership of common parts.

Report on partition of real property establishes size and shape of common and particular parts of a single real property (apartment, office space, etc.) and draws connections for reference purposes against the real property as a unit. Additionally, data about particular parts must be

technically processed providing drawings of particular and common parts with required labels and areas of particular parts (Figure 3). Shared ownership contract must also be provided.



**Figure 3. Part of a plan of particular building parts**

The cadastre registers in the alphanumeric part of the cadastral record data on parts of real property (apartments, common areas) identical to those in land books. Separate management and transcription of real property data often causes redundancy. Development of the Joint Information System of Land Books and Cadastre is on-going in Croatia (Figure 4) with aim to reduce redundant data through single data storage of aforementioned registers. Most important purpose of this system should be, that once real property data is synchronized in the cadastre and land books, they no longer diverge (Pahić 2008).



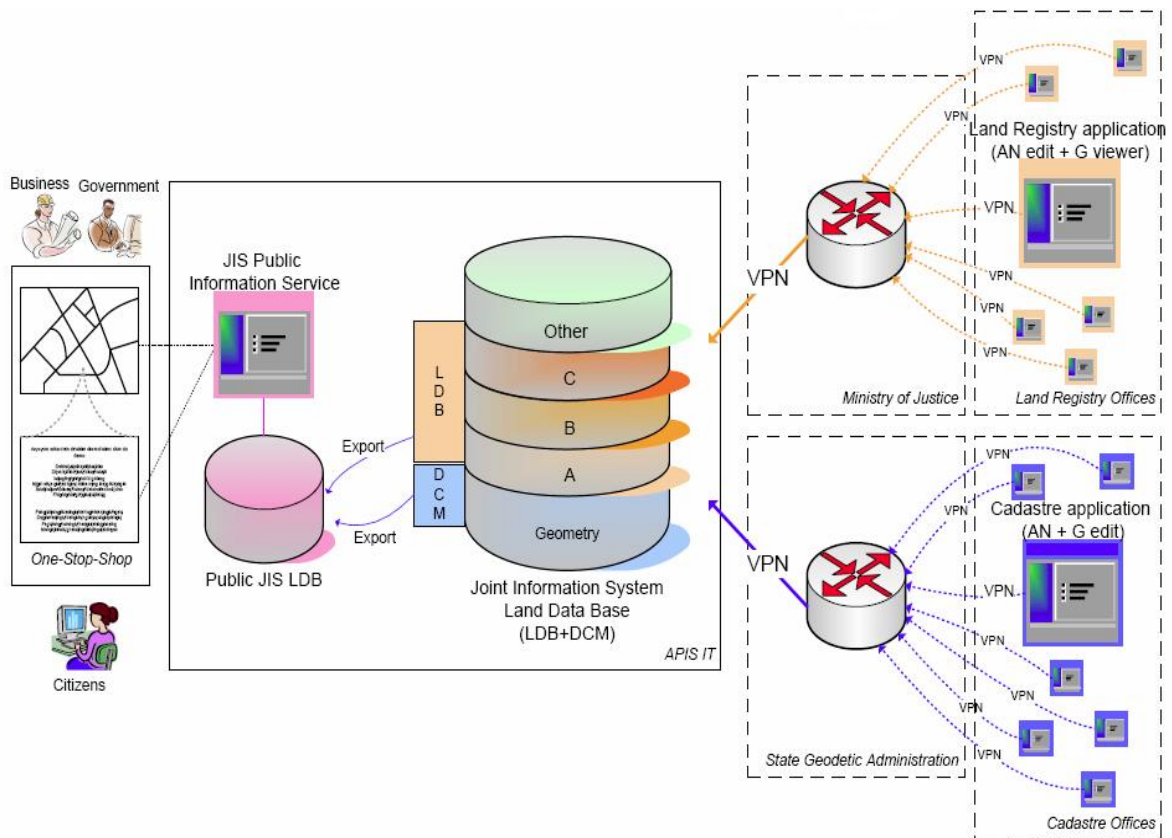
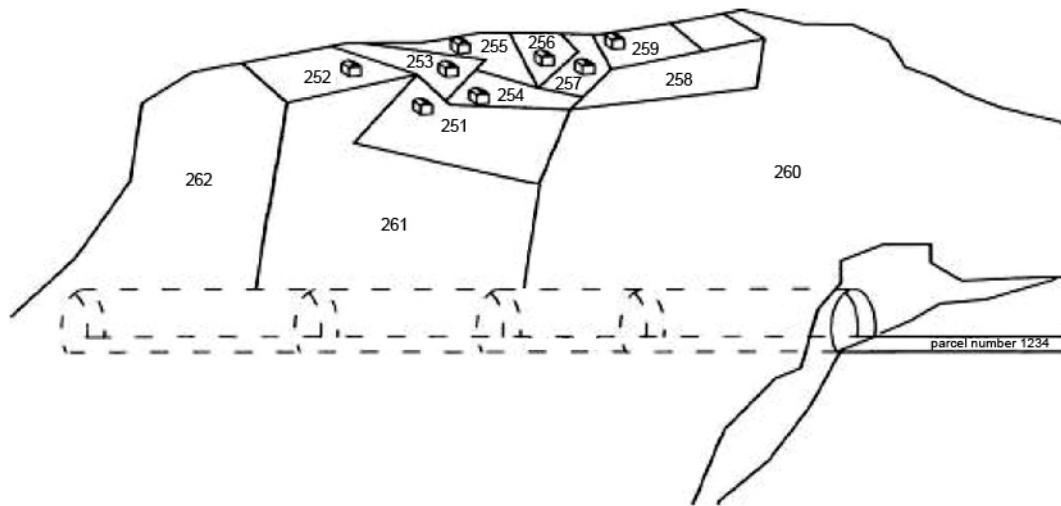


Figure 4. Joint information system concept chart

### 3.3 Registration of tunnels and bridges

Tunnels and bridges in Croatia are integral parts of public land (roads, railways). Public land is not registered with sufficient detail in the cadastre and land books. Separate registers of public land existed in the past (e.g. Book of Railways). Such registers no longer exist today, however, intensive efforts are invested in registration of public land in the cadastre and land books. Land intended for construction of public structures (roads), is often acquired from private persons without follow up registration in the cadastre and land books. This land is often still registered under former owners.

Bridges, tunnels, and other structures are presented merely graphically (topographical signs) on the cadastral parcel where they stand. Bridges above sea and other waters are a special case, as public property for common usage – bridge as part of a public road – crosses over public property. Bridges and tunnels are, as a rule, parts of the public land, but legislation does not differentiate bridges and tunnels as separate modes of use. Cadastral parcels above a tunnel are not permanently associated with that tunnel. The tunnel is permanently associated in a functional sense with the land where its entrance starts, and in a legal sense, the tunnel is the part of that real property. Tunnels are also not separately registered in cadastral plans which are two-dimensional (Figure 5).



**Figure 5. Registration of a tunnel in a cadastral plan**

#### **4. PUBLIC UTILITIES**

Formation and management of the Utility Cadastre is responsibility of the local government bodies (Official Gazette of the Republic of Croatia, 2007). It contains data about type, purpose, basic technical features, and the location of built utility lines, and it lists the names and addresses of their managers.

##### **4.1 Historical overview**

Representation of utility lines in geodetic maps and plans marks the beginning of the present day utility cadastre. The utility register, or the utility cadastre based on geodetic principles, is a legal obligation established when Bylaw on Surveying Methodologies of Underground Installations and Objects was published in former Yugoslavia in 1969. Laws of the republics and autonomous provinces of former Yugoslavia follow in the period from 1973 to 1977, and are further followed by applicable bylaws. These bylaws identified technical and technological foundation for surveying existing and future utility lines. Coordinates (X, Y, and Z) are established for the first time as constant data about spatial location of utility lines. The bylaws regulated geodetic surveys of electric, telecommunication, water, sewage, heat, gas and oil networks and belonging features. Some technological data were also gathered: pipe profile, cable capacity, construction year, etc. Every social organization, either through state, military structure, or as in present day, through survey companies, seeks a standardized register as basis for comprehensive control over all systems. It is evident that construction of utility lines has been tracked in some form from the beginning. Utility lines above ground and underground utility lines with many above-ground features, constructed linear, require no great accuracy in spatial representation. Lesser frequency of underground lines and standard materials enabling differentiation of one line from another also pose reduced demand for registration of utility lines. First registers of underground utility lines track location of utility lines by measuring distance from existing features and by tracking relative depth of installation. These registers were used for protection and exploitation of utility lines.

#### 4.2 Current situation of the utility cadastre in Croatia

The utility cadastre is established and managed based on registers, which responsible managers have the responsibility to establish and manage by utility line type (Official Gazette of the Republic of Croatia, 2007). Municipal cadastral offices established and managed the utility cadastre in all municipalities of former Yugoslavia according to regulations of that period. Municipal cadastral offices were transferred under the state jurisdiction, while responsibility to manage and maintain the utility cadastre was handed over to the local government bodies. Smaller number of these local authorities took over the responsibility, while cadastral offices certify cadastre reports for the rest, but these remain in the end unexecuted. This is not a suitable situation. Utility line managers hired land surveyors for preparation of utility reports that are became a foundation for entering in contractual relations with land owners. Spatial location of utility lines was in this way legally regulated, but unfortunately only partially and separately for each utility line type. This practice distances us completely from the utility cadastre model as a unified and comprehensive spatial representation of utility lines. These reports would be, however, useful in locating utility lines during all future activities and digging for maintenance or replacement purposes, or during installation of new utility lines. To avoid possible adverse consequences of digging close to utility lines, the utility cadastre must be reviewed, and existing lines located prior to such activities. However, since data is not tracked in the utility cadastre, all utility managers must be contacted for collection of data from their cadastres. This is very tedious and expensive work, resulting in digging often being performed without collecting data, thus causing damage (Figure 6).



**Figure 6. Water pipe perforated during survey activities for underground garage in Zagreb city centre – October 2010**

#### 4.3 Registration of utility lines

Horizontal and vertical location of utility lines is surveyed using geodetic methodology since their location is a key component for registration in the cadastre. All utility lines in the area and other surrounding landmarks (poles, sewage pits, trenches, ducts, etc.) are measured while surveying a specific utility line. All utility line features must also be surveyed. New utility lines are surveyed at an open trench, while existing unregistered utility lines are surveyed using visible external features. Surveyed lines are, as a next step, mapped in existing geodetic or cartographic maps – nowadays most commonly in the cadastral plans (Figure 7).

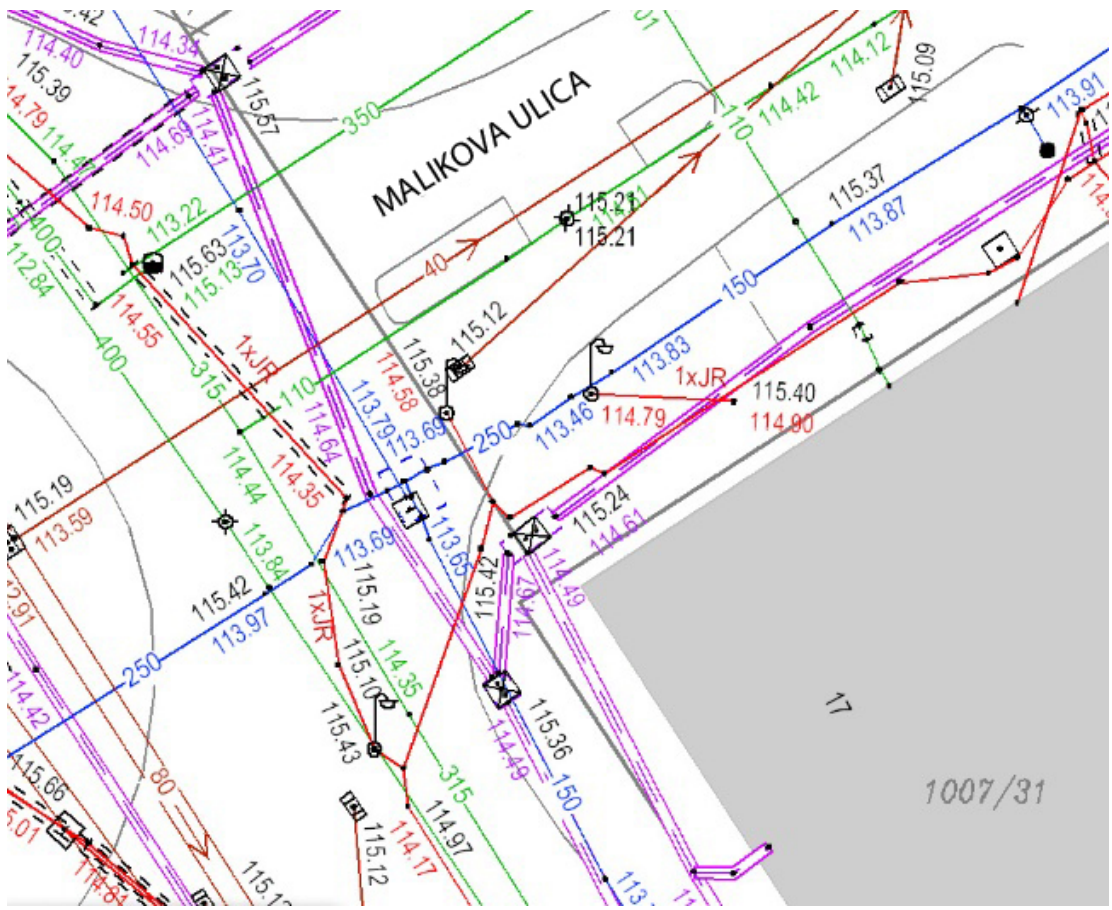


Figure 7. View of public utility lines in a cadastral plan

The utility cadastre is a register of technical features of utility lines bearing no legal significance. Legal relations regarding utility lines are registered in land books - most commonly as an easement right on land where these lines are laid. An easement right is a real property right on the real property owned by another based on which authorized person may use this real property in a designated way.

Registered data are sometimes unclear since method of registering three-dimensional legal relations remain undefined. Cardinal points and features of cadastral parcels are used to descriptively describe scope of the easement right. Example of a one register entry reads: “the easement right is registered on the real property, identified as land parcel 1000/1, in the cadastral municipality of Šuma Striborova, since water and sewage pipelines lie there in favour of Vodovod AB d.o.o., in length of 15m in direction northeast-southwest from southwest side of the features constructed on the east side of the real property, and in length of 30 m in direction northeast-southwest from the north side of the features constructed on the west side of the real property”. This is a very complicated description. Hence, it is difficult to pinpoint the location in the field. These kinds of register entries confirm the need to better describe 3D objects of law in Croatian registers.

## 5. CONCLUSION

System of registering 2D cadastral parcels in the cadastre and land books is traditionally well developed in Croatia, although many registers remain obsolete and, as a result of poor maintenance, some registered conditions do not correspond to existing conditions in the field. 3D descriptions of land features are poor. Particular parts of real property are registered in 2D diagrams with indication of the floor where they are located. One could consider this as a 2.5D approach. This approach temporarily enables registration of rights in strata, but it does not support changes. Hence, it is necessary to develop spatial representation component in registration of 3D objects of law. Best solution would be to add 3D data in cadastral plans. This would facilitate registration and better description of particular structures (bridges and tunnels).

Utility lines are registered in separate registers with location identified and height indicated as an attribute. However, even this register is merely technical since registered data do not have legal significance in comparison to utility lines that are registered in land books. Easement right is crudely registered in land books. Under development and incompleteness of the utility cadastre identifies demand for exploration of new approaches. Many small local government bodies have not established cadastres as they lacked capacities. Legislation changes are needed. Representation of data about utility lines with regard to land would become reliable if data was layered in cadastral plans. This would also ease registration of legal rights as data would become associated with respective land parcels.

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URL-1 Web page of FIG joint commission 3 and 7 Working Group on 3D Cadastres, <http://www.gdmc.nl/3DCadastres/>, 20.07.2011.

## BIOGRAPHICAL NOTES

**Nikola Vučić** graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. He is the Head of the Department for Administrative and Professional Supervision at the State Geodetic Administration of the Republic of Croatia. He is a PhD student in Geodesy and Geoinformatics at University of Zagreb, Faculty of Geodesy. The topics that he specializes in are land administration systems, cadastres and geoinformatics. He is a member of the Croatian Geodetic Society.

**Miodrag Roić** graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. In 1994, he received a PhD from the Technical University Vienna for the thesis “Surveying of Natural 3D-Structures with Video-theodolites”. Since 1996, he is a professor at the University of Zagreb, Faculty of Geodesy. He was Vice Dean of the Faculty, Head of the Chair of Spatial Information Management and the Institute of Engineering Geodesy, and he is appointed as Dean for 2011-2013. The topics that he specializes in are land administration systems, engineering geodesy, cadastres and geoinformatics. He was an editor-in-chief of “Geodetski list”, an internationally recognized Croatian scientific geodetic journal. He is a corresponding member of the German Geodetic Commission (DGK) and many other national and international scientific and professional institutions.

**Zdravko Kapović** was born in 1948. After graduating from the University of Zagreb, Faculty of Geodesy, he worked three years in the City Bureau for Cadastre and Geodetic Activities in the City of Zagreb. He arrived to the University of Zagreb, Faculty of Geodesy, in spring 1977. He earned a PhD in 1993 for the thesis: “Contribution to Identification and Analysis of Bridge Movements and Deformations with Detailed Review of Temperature Effects”. He climbed a standard ladder from an assistant professor to a full time professor. He received tenure in 2008. He headed two scientific projects: “Optimization of Specific Geodetic Networks and Deformation Analysis” in 2005 and “Geodetic Management and Tracking of Large Building Structures” from 2007-2011, and he participated as a researcher in two other scientific projects. He also led three scientific and professional projects financed by the State Geodetic Administration. He participated in preparation of more than 800 scientific and professional expertises related to surveying various building structures (bridges, viaducts, utility lines, cranes, buildings, and various beams). He published some ninety written pieces in foreign journals, in collections of papers from international scientific conferences, in domestic journals, in collections of papers from domestic conferences, and the university textbook (“Surveying in Civil Engineering”, 2010). He was a thesis mentor to five PhD candidates, three M.Sc. candidates, and 194 undergraduate students at the Faculty of Geodesy. He was the Dean of the Faculty of Geodesy for two terms, president of the Croatian Geodetic Society (for two terms), and the president of the Technical Council at the University of Zagreb.

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