Towards 3D and 4D Cadastre in Croatia

Nikola VUČIĆ, Miodrag ROIĆ and Danko MARKOVINOVIĆ, Croatia

Key words: 3D Cadastre, 4D Cadastre, Croatia, LADM, Utility Cadastre

SUMMARY

Cadastral systems need to be designed and supported from three dimensional spatial perspectives. Previous researches of Croatian 3D cadastre through relevant use case examples suggest better real property separate parts registration as well as 3D building visualization (apartments, office spaces, etc.). Next to the 3D aspects of rights and restrictions, the temporal aspect, the fourth dimension of interests in real property, is an important aspect of cadastral registration. History of changes on the cadastral parcels is subject of interest for key users, mostly parties. For this purpose, Croatian Land Administration System was adapted to become a four-dimensional (4D cadastre). In the land book and cadastre all changes since their inception are recorded with the time component and date of the change. Previous researches have shown that Land Administration Domain Model (ISO 19152) is good basis for the Croatian 3D cadastre.

This paper discussed that legal and institutional aspects of Croatian 3D cadastre should be considered in 3D cadastre development for each jurisdiction. Legal support to register and represent 3D properties (legal aspect), institutional support to establish relationships between involved parties (institutional aspect), and technical support to realise 3D cadastre (technical aspect) are basis for 3D cadastre development. This paper presents some 4D cadastre situations in Croatia. Goals of the new Law on Cadastre and State Survey are legal regulation of 3D cadastre, as well as the central repository establishment of Utility cadastre under the authority of the State Geodetic Administration. This paper also suggests better public utility infrastructure registration by overlapping Land cadastre and Utility cadastre and unifying records at the state level, because Utility cadastre in local government despite statutory obligation from 1999 was not developed in the past 15 years.

Towards 3D and 4D Cadastre in Croatia

Nikola VUČIĆ, Miodrag ROIĆ and Danko MARKOVINOVIĆ, Croatia

1. INTRODUCTION

One of the currently used arguments pro 3D cadastres is apart from legal solutions of otherwise unprotected cases like building across highways that is provides better protection of personal interest and land owners. The balance between personal interests of the individual and society needs is delicate and may change with increasing pressure of population growth and shrinking resources. However, this is a discussion that cannot be solved by technicians. It requires involvement of lawyers and political leaders (Navratil 2013).
In the last couple of decades, there has been an increasing demand for property development in urban areas, resulting in the division of property ownership so that different owners can own delimited space on, above or below ground surface. Under 3D cadastre, the 2D cadastre management of data cannot meet the real land management of the three dimension space aspect and property. It is essential to introduce the 3D cadastre (Choon and Seng, 2013). The limited advances in full 3D cadastres implementations throughout the world might be explained by the fact that the implementation of a 3D cadastre requires close collaboration between legal and technical experts in a empirical environment to understand the impact of each other's domain (Stoter et al, 2012).

The solutions for registration of rights with 3D characteristics are very different. Broadly, one can observe that apartments are registered with drawings in the deed registration. But a true 3D registration in the cadastre does not exist anywhere. Most often it was approached by Spain, although the representation uses a standard height per floor layer (Van Oosterom et al, 2011). For example in Norway the 3D property units are established and maintained in the land registers but the surveying and mapping to acquire 3D volume information is not carried out. Accurate geometry of the volume parcel cannot be obtained from land registration. However, in administrative part of cadastral registration, the 3D property units exist. The construction property above the surface are maintained as 3D property units, in most of cases, by the municipalities under Oslo methods whereas the 3D building properties are governed under separate Apartment right (Valstad, 2003).

Establishing a 4D cadastre, which registers and provides access to all required 4D information of real estate, is not simple, since it comprises legal, organizational as well as technical issues. First investigation of a 4D cadastre has been studied based on the ISO 19152 - Land Administration Domain Model (Döner et al, 2010).

This paper is organized as follows. Section 2 describes 3D cadastre in Croatian Land Administration and present most important 3D products. Section 3 describes public utility infrastructure and improvement of this infrastructure in 3D cadastre context. Section 4 describes some 4D cadastre situations in Republic of Croatia. Section 5 introduces the Land Administration Domain Model, with a focus on 3D cadastral functionality. The paper ends with conclusion.

2. 3D CADASTRE IN CROATIAN LAND ADMINISTRATION

Existing Land administration system in Croatia is based on the 2D representation of objects including cadastral parcels, buildings and other structures. Current approach does not cover all situations of the real 3D world. Examples of such situations impeding cadastre and rights registration are: multilevel complexes, intersections of various objects in space, elevated and underground public utility infrastructure. The Croatian Land Administration System is based on two registers: the cadastre and the land books. In cadastral offices, the real properties are registered according to their technical characteristics. The cadastral data on the real property (cadastral parcels) is the basis for the establishment, renewal, keeping and maintenance of land books. In land books, the data on cadastral parcel title holders is associated to the data on cadastral parcels defined by the cadastre. The Croatian Land Administration System has several objectives. The most important ones include the introduction of security in the real property legal transactions and the protection of titles registered in the registers. Other objectives are the statistical support, support for spatial planning and construction, support to agriculture. In past 10 years Republic of Croatia had significant changes in legislation concerning the official spatial data which are also reflected on the cadastral data. The most important changes are the introduction of new geodetic datum and map projection, transition from land cadastre to real estate cadastre, development of the Joint Information System of Land Books and Cadastre and also increasing the use of national network of reference GNSS stations (CROPOS – Croatian Position System).

Croatia has a dual system of real property registration. Land administration institutions in Croatia decided not to get merged into one institution but opted for Croatian solution of linking the institutions at the level of data and business processes to be maintained according to respective jurisdictions. It was precisely the harmonization of business processes in accordance with the jurisdictions in data maintenance between the institutions that presented the biggest challenge during the Joint Information System (JIS) implementation. The amendments to the Land Registration Act of 2007 defined for the first time the JIS establishment. The contract for the JIS development and establishment was awarded in July 2007. Its initial closing date was extended from July 31, 2009, to June 30, 2010. JIS includes the Land Database (LDB) and the Digital Cadastral Map Database (DCMD). LDB manages both - land book and the cadastre run by the electronic data processing. The JIS technical solution enables IT communication with the basic State registers: databases comprising the data on Personal Identification Number, spatial data register, State Geodetic Administration (SGA) digital archives and will be linked to the One Stop Shop system (Markovinović et al, 2013).

Implementation of the Joint Information System will have following benefits:

- integrated cadastre and land book data - a unique land database
- integrated spatial and alphanumeric data
- single centralized application for all cadastral and land book offices
- inimitable data maintenance
- avoiding the generation of copies of data due to different applications at cadastral and land book offices
- integration with the Geoportal and the ability to view digital orthophoto data

- integration with the Register of Administrative Units
- JIS is process-oriented application, accelerating business processes and increasing internal transparency
- the ability to review and edit spatial data
- digital signing of electronically generated documents as the basis for the electronic exchange and centralized printing
- VAT (value added tax) system integration.

In September 2014 Joint Information System (JIS) was in full production work on 14,2% of Croatian territory. On 11/4/2013 and 29/5/2014 Croatian Government concluded that Ministry of Justice and State Geodetic Administration will be responsible to continue JIS spreading activities based on strategic plans. October 2015 is deadline for planned JIS implementation in all cadastral offices and land book departments throughout entire territory of the Republic of Croatia. Institutions have agreed about JIS implementation order in other cadastral offices and land book offices.

The Integrated Land Administration System (ILAS) Project is a project of the Government of the Republic of Croatia ratified by the Law on Loan Agreement between the Republic of Croatia and the International Bank for Reconstruction and Development. ILAS Project is launched to modernize the land administration system in order to improve state administration services in terms of efficiency, transparency and cost. The Project is managed by the Croatian Ministry of Justice and the State Geodetic Administration (SGA), and the two institutions are equally responsible for its implementation.

2.1 3D products in current Croatian Land Administration System

The most important 3D products in current Croatian Land Administration system are the Special Geodetic Basis, Surveying Design and Report on Partition of Real Property. Just initiated practice of making Surveying Designs for the construction and physical planning as well as Report Preparation of Utility Cadastre (public utility infrastructure) requires the use of Technical specifications for determining coordinates in coordinate system of the Republic of Croatia. These specifications prescribe correct ways of measuring and writing/expressing 3D coordinates in analogue and digital form for cadastral purpose (land, real property and utility cadastre) as well as detailed topographic surveying, preparation of geodetic bases and all other georeferenced views.

2.1.1 Special Geodetic Basis

Special Geodetic Basis implies digital orthophoto map with altitude display – contours and elevations with embedded cadastral maps or topographical map with embedded cadastral map, all made in the appropriate scale and certified by the competent authority of state surveying and real property cadastre.

2.1.2 Surveying Design

Special Geodetic Basis was used in cadastral offices until 01/01/2014 when package of new laws in the field of Construction and Physical Planning came into force (Building Act, Physical Planning Act and Building Inspection Act issued by Croatian Parliament on

06/12/2013). Ordinance on Surveying Design was based and passed on Physical Planing Act. According to Ordinance on Surveying Design integral part of surveying design is document called Geodetic Situational Draft (Figure 1). Situational draft is made to display position and elevation data on all visible natural and built features of the land surface in the construction area (e.g. buildings and other structures, utility lines with associated facilities, traffic infrastructure, vegetation, water and related objects, relief etc.).

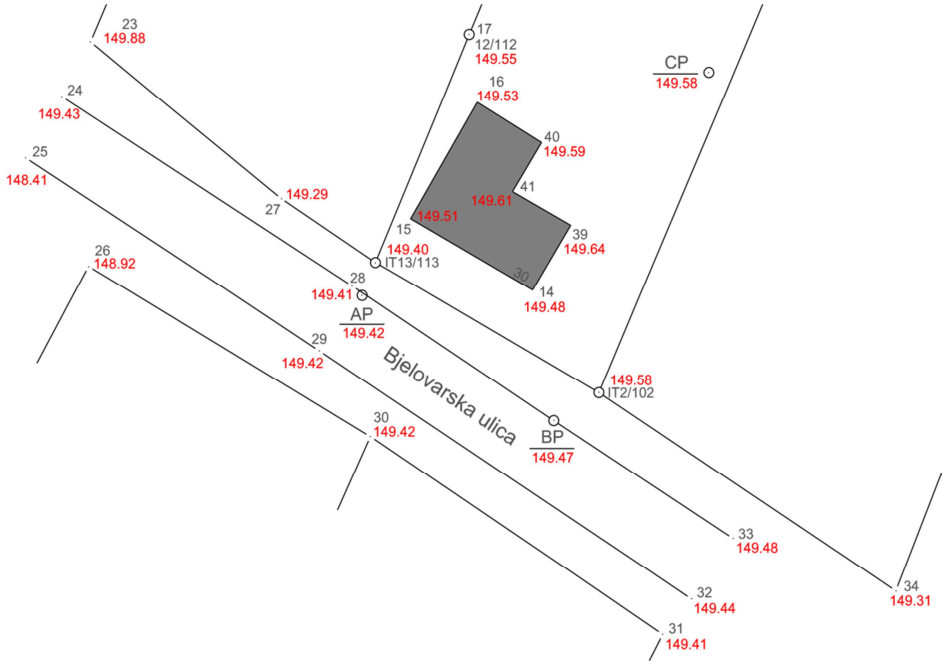

Figure 1. Geodetic Situational Draft (URL 1)

2.1.3 Report on partition of real property

Registration of separate parts of real property in the land book 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 book to formally unify the land which was often publicly owned with the building constructed on that land. Partition of the real property establishes ownership of a separate 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 (Figure 2) establishes size and shape of common and separate 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 separate parts must be technically processed providing drawings of separate and common parts with required labels and areas of separate parts. These drawings are provided in analogue format. Shared ownership contract must also be provided.

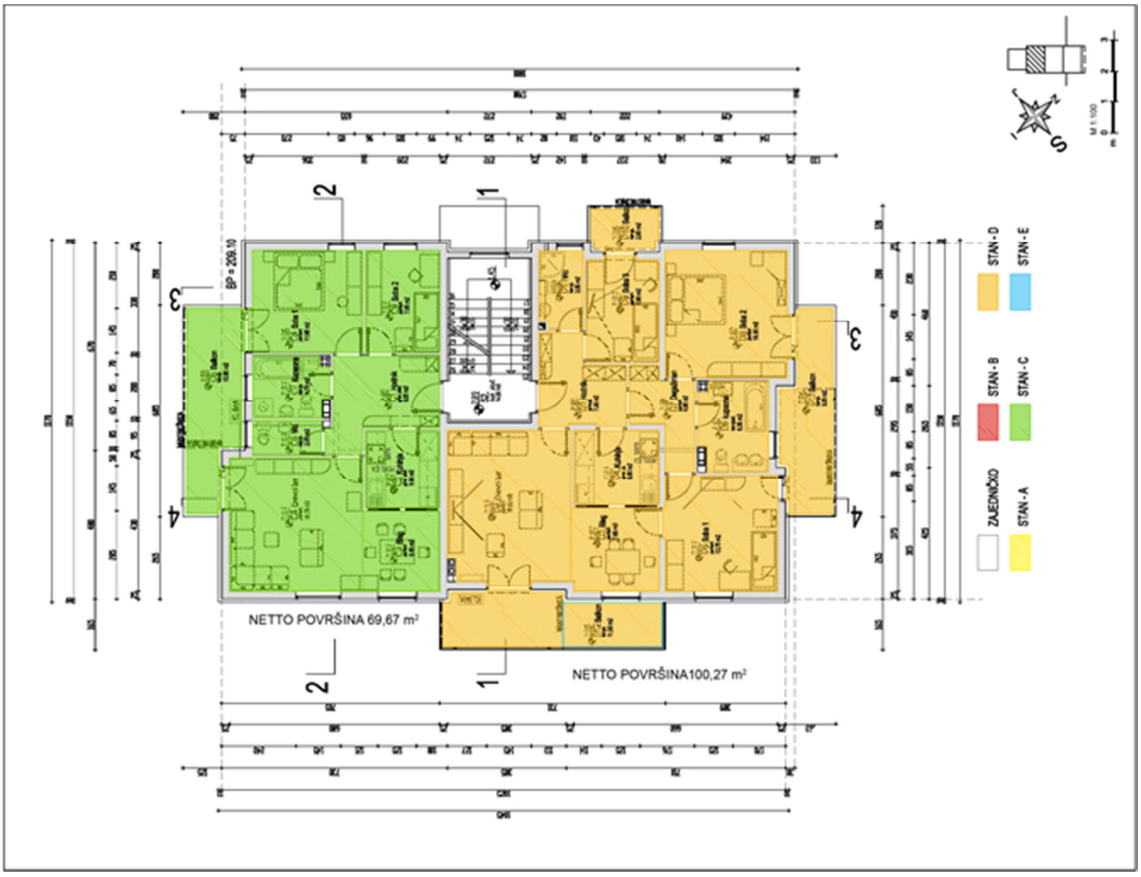

Figure 2. Report on Partition of Real Property (URL 2)

2.1.4 Other 3D products

The production of base topographic sets began in 1996 and ended in 2010. During these fourteen years, all 594 Topographic Map (TM25) sheets were produced for the entire country's territory and the Base Topographic Database was developed, containing topologically processed planimetric data created before the above-mentioned maps were created (Vilus and Landek, 2011). The basic topographic data represents a core set of data that is the basis for making all official maps (digital or analogue) in various scales.

Topographic Map (TM25) is the official state map and is produced at a scale of 1: 25000. The official state map is coded images of natural and human-made objects on the surface to be made for the entire Croatian territory. Topographic maps at a scale of 1:25000 were produced in the period from 1996 to 2010, and the entire Croatian territory is covered with 594 sheets. The surface of one sheet covers an area of 13,745 hectares. The main source for production TM25 is aerial survey, topographic data and digital terrain model. TM25 is made under the relevant product data sheet. Main object groups displayed on the TM25 are permanent geodetic points, construction and other objects, utility lines with associated facilities, roads and transportation objects, vegetation and land types, water bodies and water related objects, terrain and relief shapes, state border, frame and map description with coordinate grid and geographical names. All topographic data in TM25 are presented with the same importance

and certain level of generalization. TM25 is used in spatial planning, conceptual planning and design of infrastructure facilities, professional use in public and private management, planning and maintenance, rescue operations and for tourism and recreational activities, etc.

Croatian Base Map (CBM) is the official state map and is produced at a scale of 1: 5000. The official state map is coded images of natural and human-made objects on the surface to be made for the entire Croatian territory. Croatian Base Map, earlier called the Basic State Map, was produced from the 1954 until 2010 when the last sheet of CBM was released for official use. The entire Croatian territory is covered by the 9802 sheet of the CBM. The surface of one sheet covers an area of 675 hectares. The main source for production of CBM is aerial survey at bigger scale, and the data are displayed on a map with a sufficient degree of generalization. CBM is used in detailed spatial planning, conceptual planning and design of infrastructure facilities, professional use in public and private management, planning and maintenance, rescue operations and for tourism and recreational activities, etc. CBM was drafted in the 5th and 6th zone of Gauss-Krüeger map projection on the Bessel ellipsoid in 1841, and for the display in State Geodetic Administration Geoportal (http://geoportal.dgu.hr/) sheets are transformed into HTRS96 / TM system (Croatian Terrestrial Reference System / Transverse Mercator) using a 7 parameter transformation.

2.2 Digital Terrain Model (DTM)

Data acquisition for development of the Digital Terrain Model (DTM) is made by 3D photogrammetric data acquisition from aerial images (stereopairs) according to the principles of the CROTIS (Croatian Topographic Information System). Basic feature structure of DTM according to the CROTIS is: break lines: 3D lines, as the edges of built objects, roads, watercourses, cuttings, embankments and all the other distinct relief breaches; form lines: 3D lines presenting small changes on the relief; separate distinctive points: the top and bottom spots, hills, separate points defining relief as the supplement to the above mentioned 3D lines, usually in the uneven interspaces.

3. PUBLIC UTILITY INFRASTRUCTURE

Growing pressure on land and rising land values have caused an increasing need for 4D information in management of utilities in land administration systems. These infrastructural objects are mostly located in a part of the parcel and may cross many parcel boundaries, although most of those parcels will be owned by parties other than the network manager. The utilities are often subsurface and have therefore a 3D characteristic. Cadastral registration of utility networks includes temporal aspects such as creation, changes during life time, deletion, splitting and merging etc. (Döner et al, 2013).
Utilities are very important set of spatial data for quality and sustainable spatial management and development of community in general. The utility cadastre in Croatia contains data about the type, purpose, basic technical features, and location of built utility lines, and lists the names and addresses of their managers. Physical registration of the utilities is not organized at national level in the Republic of Croatia. Legislation regulating that bodies of local government must establish and manage the utility cadastre was passed already in 1999, but only few of these bodies assumed this responsibility since.

3.1 History of utility cadastre

The analogue utility cadastre register was first regulated in 1969 with the "Regulations on methods and methodology of work in surveying underground installations and facilities" (Official Gazette (hereinafter OG) 49/1969). This was followed by the 1973 "Law on Utility Cadastre" (OG 44/1973), the 1988 "Law on Utility Cadastre" (OG 50/1988), resulting in the "Regulations on Utility Cadastre" (OG 52/1989). Pursuant to the "Law on Utility Cadastre" (OG 50/1988), lines are recorded in the utility cadastre that are laid on the ground, above ground, under the ground and under water, as all the related object are also considered utility lines. Responsibilities for managing utility cadastre registers have changed over the years. The establishment of utility cadastre registers, pursuant to the "Law on Utility Cadastre" (OG 44/1973), was passed on cadastral offices, which at the time were part of the local government. The 1988 Law treats the utility cadastre registers kept by utility lines managers and those kept by municipal authorities equally.

3.2 Current status of utility cadastre

The "Law on State Survey and Real Estate Cadastre" (OG 128/1999) stipulated that Utility cadastre registers are under the responsibility of future surveying offices in the bodies of local government, while the Republic of Croatia should adopt a new "Regulation on the content, method of production and Utility cadastre management". That was not made before the adoption of the current "Law on State Survey and Real Estate Cadastre" (OG 16/2007) 2007. Pursuant to the current "Law on State Survey and Real Estate Cadastre" (OG 16/2007), Utility cadastre registers remain under the jurisdiction of the bodies of local government.

3.3 Utility cadastre in 3D cadastre context

State Geodetic Administration is considering that physical registration of the utilities must be organized at national level in the Republic of Croatia. The proposed new Croatian Utility Cadastre when incorporated in Croatian Land Administration System should streamline the provision of essential services such as water, sewerage, electricity and communication network.

Based on the current status of the Utility Cadastre in the Republic of Croatia, the new implemented Utility Cadastre should achieve the following goals:

- obtaining information about the "occupancy of space" with regard to the underground utility and other infrastructure,
- prevention of infrastructure related negative publicity, preventing and reducing the cost of direct and indirect damages,
- management of the infrastructure, implementation of conditions for keeping records of the utility infrastructure,
- developed in such a way that infrastructure data will be merged together with land cadastre data (Figure3) and available in the same projected coordinate reference system - Croatian Terrestrial Reference System 96 (HTRS96) to all interested parties.

Figure 3. Utility lines on the digital cadastral map – overlapped with digital orthophoto image (town of Beli Manastir)

4. TOWARDS CROATIAN 4D CADASTRE

Cadastre is a model of Earth surface and its content ensures an overview of its current state. Due to ensure an overview of current state in reality changes are made in cadastre. Changes are carried out in compliance with the principles of conservation of historic data states. In this way it is possible to get insight into the present and historical states of the data. Analogue environment, in which the cadastre was originally created, provides a simple insight into the current state of the data. The search and insight into historical data states is rather difficult. Through the application of spatiotemporal databases, modern technology enables temporal queries over the data which became easily accessible regardless of time of their creation (Stančić, 2013).

4.1 3D cadastral registration

Today's computer technologies enable advanced methods of real property registration in official registers (for example cadastre or 3D city models in those countries where they exist as official registers). There is also the possibility of connecting to services which visualize 3D space such as Google Earth, Google Street View, CityGML, 3D Warehouse (Figure 4) and

other advanced and worldwide publicly accessible technologies. High-quality 3D building representations can be quality made out of the building plans that were used for registering separate building parts.

Figure 4. 3D model of Shopping mall - Avenue Mall, Zagreb (source: URL 3)

Along with publicly available services such as Google Earth and Google Street View and others which for some time now deal with spatial modelling and free providing of these data to users, there is also the need for an official register. As a private foreign company Google can always withhold the data or charge them. Also, for its need the country needs higher reliability of data and cannot fully depend on the above mentioned products. Therefore it has to develop its own 3D data register based on well defined regulations which will guarantee the legal security of registered facts and to meet the technical preconditions for a 3D cadastre.

Practice of 3D registration for connection building over the street is not implemented yet, but we can find 2D registration of connection building on the cadastral map (Figure 8). The tunnel, which was built under many cadastral parcels, in a vertical sense it would belong to those cadastral parcels. Functionally, it is permanently connected to the land where the entrance to the tunnel is, and not to the cadastral parcels that extend above it. Accordingly, the tunnel is permanently connected only to the land with entrance and makes one property.
Apartment and office space volume is important factor in the formation of 3D cadastre. The Croatian land administration system has not scheduled enrolment volume of apartments and commercial spaces yet. But in the last 7 years cadastre actively controls legality of the building constructions in two dimensions. Next step in the transition from 2D to 3D cadastre can be implementation of the volume data of apartments and commercial spaces in the cadastral database. The basis for the volume data exists in the form of Regulation on the method of calculating area and volume in the building projects (Official Gazette, 2010).

Available underlying regulations are Law on state survey and real property cadastre and Law on ownership and other real rights. These laws should be changed for full 3D cadastre implementation. State Geodetic Administration currently works on preparing a new Law on state survey and real property cadastre.
According to the Technical specifications for determining coordinates in coordinate system of the Republic of Croatia we have possibilities to capture, process, and store 3D coordinates in SGA database (FME Server). SGA FME Server is a platform that provides the procedures for conversion, transformation, preparation for migration and quality control of spatial data.

4.2 4D cadastral registration

The need for 3D representation of cadastral data is identified. The next dimension is time: there is a need to include time to reconstruct history, to manage events in maintenance processes and to reflect reality in case of temporal rights. Spatial units with different accuracies, dimensions and representation should be possible to include. This implies a range of spatial units should be possible. One more reason to include the temporal dimension (3D + time) is the need for information assurance within the NSDI: both current and historic versions are always accessible (Jeong et al, 2012).
In Croatia history of changes on the cadastral parcels is subject of interest for key users, mostly parties. For this purpose, Croatian land administration system was adapted to become a four-dimensional. In the land books and cadastre all changes since their inception are recorded with the time component and date of the change.

4.2.1 Case study (Avenue Mall)

In this chapter a seven years old office building (shopping centre with three underground floors and several levels above ground) is displayed as use case example. The figure acquired from Google Earth shows the land before and after construction (Figure 5).

Figure 5. Historical changes of land use - Avenue Mall, Zagreb, left 2002 year, right – today (source: Google Earth)

If we searched for cadastral data in 4D terms, we could get a cadastral map (Figure 6) and Digital Ortophoto Map at scale 1:5000, both from period before and after construction. Cadastre and Land book have every spatial information about changes on the land, from undeveloped construction land to registered building with Report on Partition of Real Property. Utility lines attached to the building are also surveyed and recorded in three-dimensional way (X, Y, Z) and time component can be assigned too.

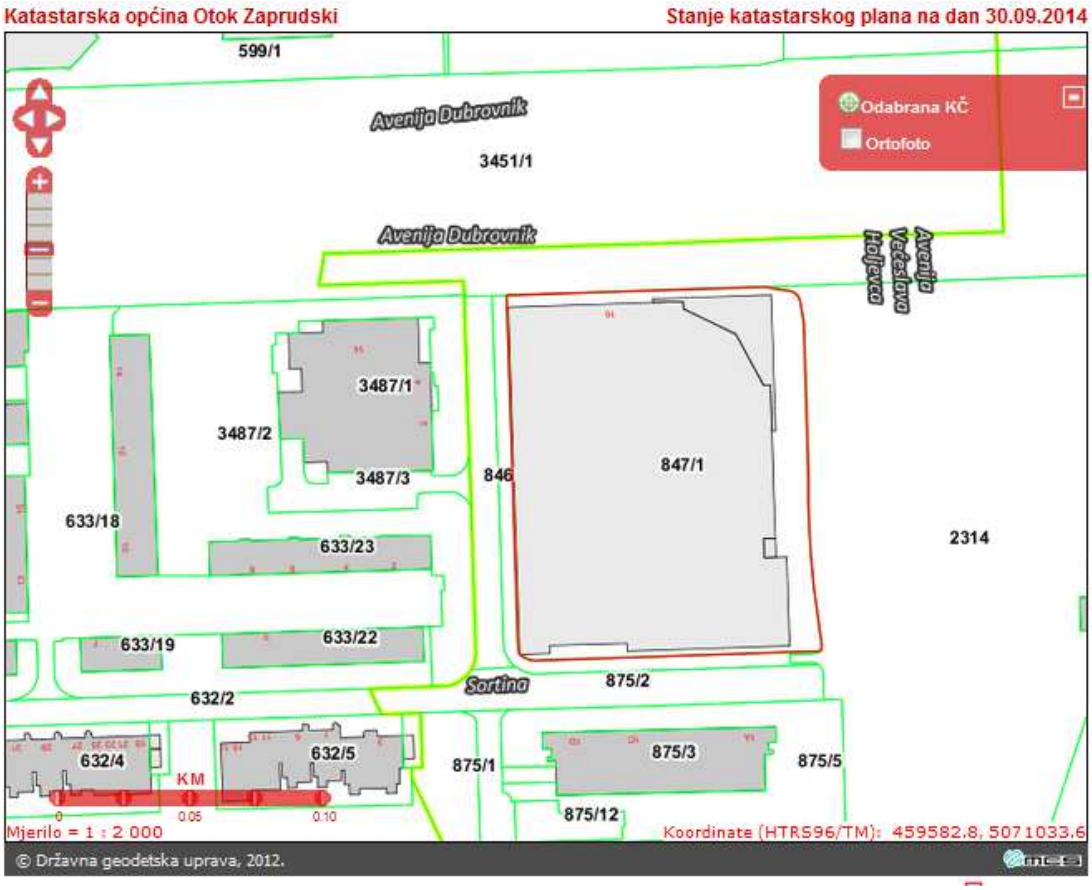

Figure 6. Avenue mall, Zagreb, current state on digital cadastral map

4.2.2 Case study (building over highway)

Cadastral offices can issue the history of changes in cadastral parcels for variety of purposes, usually in a descriptive form as an official certificate. However, many cadastral offices substantiate standard form with official documentation such as archive cadastral maps, parts of geodetic reports etc. Today almost all Croatian cadastral offices maintain digital cadastral maps overlapped with orthophoto images from different time period, so it is easier and faster to obtain history of changes in spatial terms than it was when cadastral maps were analogue. In the following figure it is evident that in 1968 there was no building above the highway and according to the current regulations it is necessary to attach a corresponding building permit or occupancy permit when registering the highway and mentioned building in the cadastre and land book. (Figure 7).

Figure 7. Aero-photogrammetry image from 1968 overlapped with Digital cadastral map

Recording date of buildings in the cadastre or other SGA documentation is crucial in the process of proving the building legality. Year 1968 is a milestone in the construction industry and buildings constructed before 15/02/1968 are considered as buildings with occupancy permit. Significant number of buildings older than 1968 still exists in Croatia.
Established SGA's Geoportal (available at web site: http://geoportal.dgu.hr/) and National Spatial Data Infrastructure (NSDI) can also assist in the better development of 3D and 4D cadastre (available at web site: http://www.nipp.hr). Following figure represents digital cadastral map overlapped with digital orthophoto map with a building over highway on SGA Geoportal (Figure 8).

Geoportal consists of the following sets of data:

- 1:5000 digital orthophoto map (Geoportal basis), recorded and produced during 2011.
- Croatian Base Map 1:5000 (topographic)
- Topographic Map 1:25000
- Digital cadastral map (cadastral offices, cadastral municipality, cadastral parcels, buildings, house numbers)
- Central Registry of Spatial Units (counties, cities and municipalities, towns, local government)
- Generalized content 1:100000 topographic map (roads, railways, ferry piers, lakes, waterways).

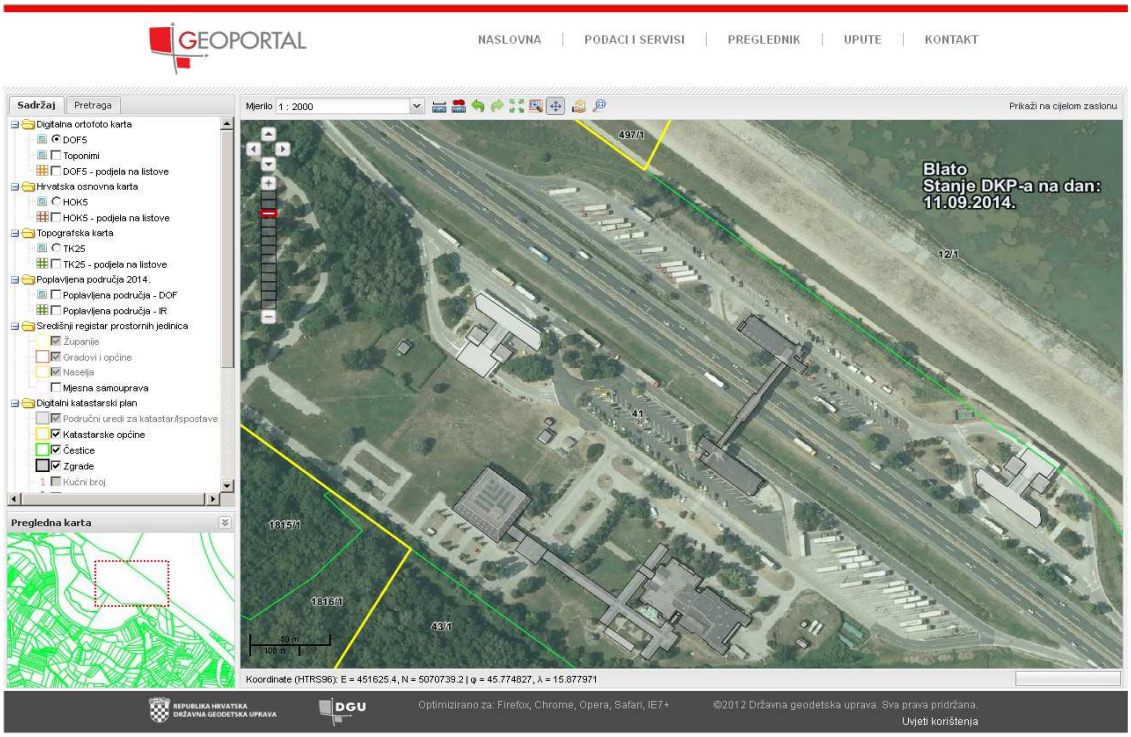

Figure 8. Building over highway

The next figure represents digital cadastral map on SGA service www.cadastre.hr (Figure 9).

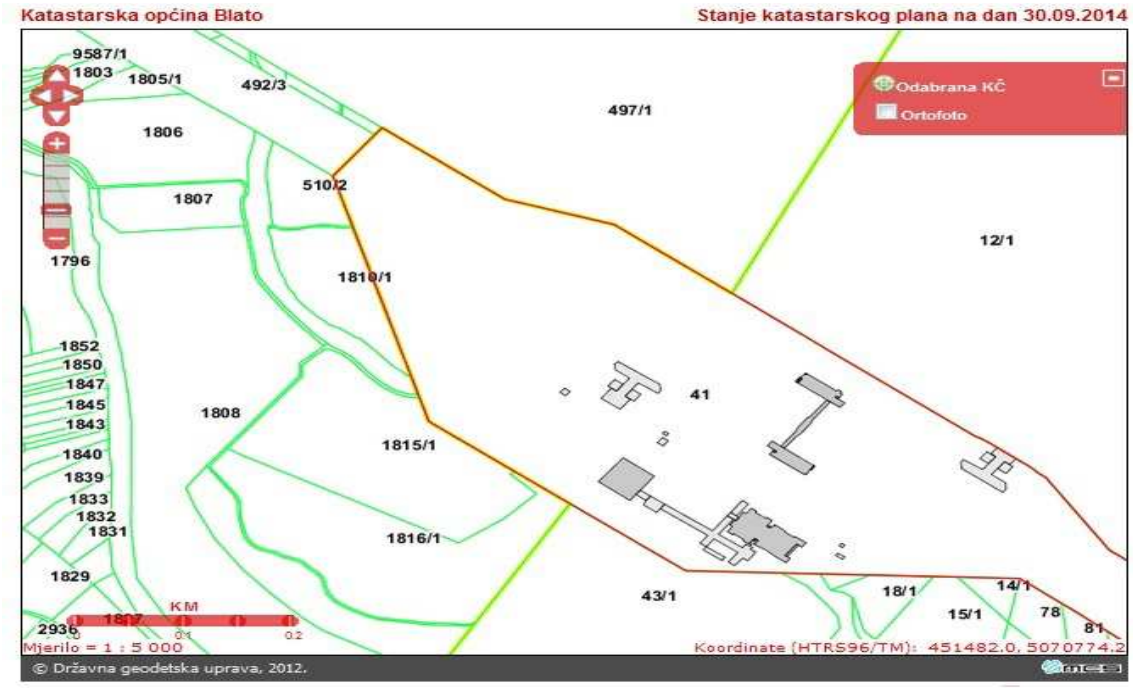

Figure 9. Digital cadastral map with building over highway

5. LADM IN CROATIA

Land Administration Domain Model (LADM) can be extended and adapted to local situations; in this way all People to Land relationships may be represented. This can be supportive in the development of software applications built on database technology. LADM describes the data contents of land administration in general. Implementation of the LADM can be performed in a flexible way; the standard can be extended and adapted to local situations (Lemmen, 2012).

The LADM is developed according to the rules for application schema as defined by ISO 19109. The geometry and topology (2D and 3D) are based on the ISO/TC 211 standard classes. The model is specified in UML class diagrams and it is indicated how this UML model can be converted into an XML schema, which can then be used for data exchange.

In any effort to reform of existing Land Administration System, or to create a new one according modern technical and methodological capabilities, a key point to consider is the modelling of the legal framework concerning Real Rights. Or simply, land related Rights, where Roman law concepts are absent. This follows naturally from the fact that, in the majority of Land Registration system and in Croatia, the Basic Administrative Unit represents the extent of ownership rights (Hespanha, 2012).

First version of Croatian country LADM profile was developed 2012 (Vučić et al, 2013). It is based on LADM and adds some new classes, attributes and types to the code list (to differentiate LADM in Croatia from other models, their names are given with HR_ as prefix). Design a land information system for the Croatian land administration system complying with LADM can be possible by methodology that includes a Model Driven Architecture process where the LADM supplies just the starting point in a transformation chain to a country Platform Independent Model. To express modelling constraints over a diversity of possible data structures, the UML extension mechanisms were used through the specifications of spatial profiles and patterns. The model (Country profile Croatia) is designed according to current legislation which regulates cadastre, land books, construction and spatial planning area.

5.1 Previous research

Most of LADM classes can apply directly to Croatian Land Administration System (LAS). The types in some code lists have been changed and added to suit to the Croatian LAS. Previous researches have been explored in detail; Party Package, Administrative package and Spatial unit package (Vučić et al, 2013a).

5.2 Surveying and representation subpackage

An instance of class HR_point is a point. An instance of class HR_SpatialSource is a spatial source. HR_SpatialSource is a subclass of class HR_Source. An instance of class HR_BoundaryFaceString is a boundary face string. HR_BoundaryFaceString is associated to class HR_Point and class HR_SpatialSource to document the origin of geometry. An instance of class HR_BoundaryFace is a boundary face. HR_BoundaryFace is associated to class HR_Point and class HR_SpatialSource to document the origin of the geometry. Surveying subpackage has one data type (HR_Transformation) and four code lists (HR_Monumentation-

Type, HR_SpatialSourceType, HR_InterpolationType and HR_PointType). The surveying and representation subpackage shows the data related to technical features about land use (ISO 2012). All classes of surveying and representative sub-package can be applied directly to the Croatian Land Administration System (Figure 10).

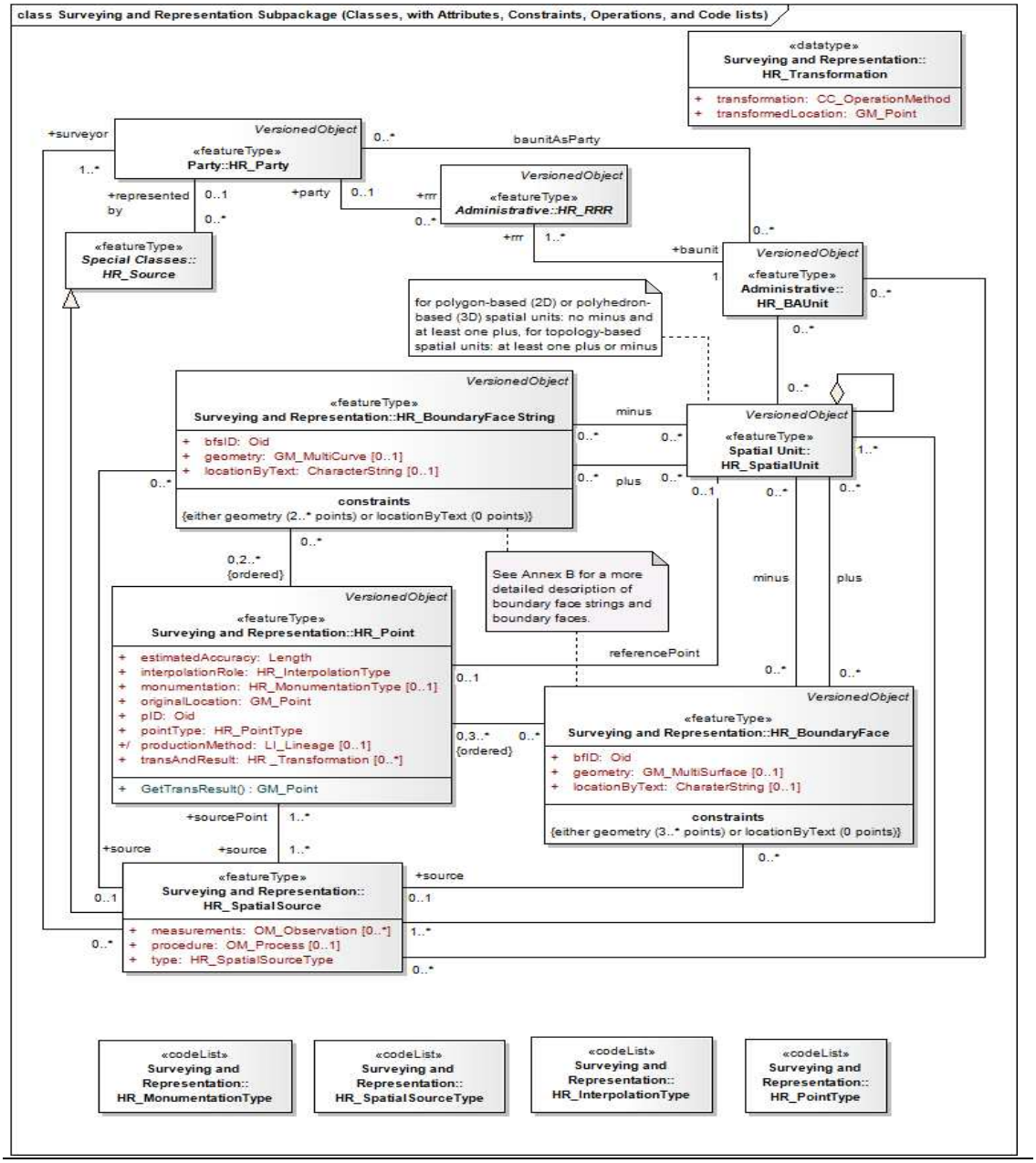

Figure 10. Surveying and Representation Subpackage for the Republic of Croatia

6. CONCLUSION

Today, related issues about 3D cadastre are widely discussed all over the world in legal, logical, organizational and technological aspects. But also there is no country which has built a full 3D cadastre on the whole territory. So the focus must be how to design a spatial data model for 3D and 4D cadastre.
Goals of the new Law on Cadastre and State Survey, which is being prepared, are legal regulation of 3D cadastre in the Republic of Croatia (building cadastre), as well as the central repository establishment of Utility cadastre under the authority of the State Geodetic Administration, because Utility cadastre in local government despite statutory obligation from 1999, was not developed in the past 40 years.
Expected benefits of new Utility cadastre implementation in Croatia are:

- for the owners, the data about the type and location of infrastructure situated on their land and about the nearest possibility of connecting to the network,
- for the public administration, easy access to the basic data about the entire infrastructure in a given area,
- for the owners of infrastructure, improved protection of public utility infrastructure against damages.

Establishing 3D/4D cadastre is not an easy task as seen in Croatian example and we shall see if it will be accomplished with another new law.

ACKNOWLEDGEMENTS

The authors of this paper would like to express their gratitude to colleagues from State Geodetic Administration Maja Ilijanić and Dubravko Župan. Invaluable comments and suggestions from the three anonymous reviewers are greatly appreciated. This paper is supported by the Croatian Science Foundation (HRZZ) under grant I-2485-2014. DEMLAS.

REFERENCES

Choon, L. T, Seng, L. K, (2013), Towards a Malaysian Multipurpose 3D Cadastre based on the Land Administration Domain Model (LADM) - An Empirical Study, Proceedings of the 5th Land Administration Domain Model Workshop, Kuala Lumpur, Malaysia, FIG, Copenhagen, Denmark.

Döner, F, Biyik, C, (2013), Conformity of LADM for Modeling 3D/4D Cadastre Situations in Turkey, Proceedings of the 5th Land Administration Domain Model Workshop, Kuala Lumpur, Malaysia, FIG, Copenhagen, Denmark.

Döner, F, Thompson, R, Stoter, J, Lemmen, C, Ploeger, H, Van Oosterom, P., Zlatanova, S. (2010): 4D cadastres: First analysis of legal, organizational, and technical impact – With a case study on utility networks. Land Use Policy, 27, pp. 1068-1081.

Hespanha, J. P, (2012), Development Methodology for an Integrated Legal Cadastre, PhD thesis, Publications on Geodesy 79, Delft, the Netherlands, Netherlands Geodetic Commission.

ISO 19152, (2012) Geographic information - Land Administration Domain Model (LADM), Switzerland, International Organization for Standardization.

Jeong, D, Jang, B, Lee, J, Hong, S, van Oosterom, P, de Zeeuw, K, Stoter, J, Lemmen, C, Zevenberg J. (2012), Initial Design of a LADM-based 3D Cadastre - Case study from Korea, Proceedings of the 3rd International Workshop on 3D Cadastres, 25-26 October 2012, International Federation of Surveyors (FIG), Copenhagen.

Lemmen, C. (2012), A Domain Model for Land Administration, PhD thesis, Publications on Geodesy 78, Delft, the Netherlands, Netherlands Geodetic Commission.

Markovinović, D, Bilić, V, Lučić, M, Fučkar, M. (2013), Joint Information System of Land Registry and Cadastre in the Republic of Croatia. Lessons Learned, Annual World Bank Conference on Land and Poverty 2013, Washington, USA.

Navratil, G. (2012), Combining 3D Cadastre and Public Law, Proceedings of the 3rd International Workshop on 3D Cadastres, 25-26 October 2012, International Federation of Surveyors (FIG), Copenhagen.

Official Gazette of the Republic of Croatia (2010) Regulation on method of calculating area and volume in the building projects, No. 90.

Stančić, B, (2013), Modeling archival space-time cadastral data in the modern technological environment, PhD thesis, University of Zagreb, Faculty of Geodesy, Zagreb.

Stoter, J, Van Oosterom, P, Ploeger H. (2012), The Phased 3D Cadastre Implementation in the Netherlands, Proceedings of the 3rd International Workshop on 3D Cadastres, 25-26 October 2012, International Federation of Surveyors (FIG), Copenhagen.

Valstad, T. (2003), The Oslo Method – A Practical Approach to Register 3D Properties, Proceedings of the FIG Woking Week, Paris, France.

Van Oosterom, P, Stoter, J, Ploeger, H, Thompson, R, Karki S. (2011), World-wide inventory of the status of 3D Cadastres in 2010 and expectations for 2014, FIG, Article of the month - May 2011.

Vilus, I, Landek, I. (2011), Updating of the Base Topographic Database and Official Topographic Maps, Proceedings of the 3rd Croatian NSDI and INSPIRE Day and 7th Conference Cartography and Geoinformation, Split, 14-16 September 2011.

Vučić, N, Roić, M, Kapović, Z. (2013), Examination of Compatibility Between the Croatian Land Administration System and LADM, Developments in Multidimensional Spatial Data Models, Lecture Notes in Geoinformation and Cartography, pp 155-171, Berlin, Springer.

Vučić, N, Mičević, B, Markovinović, D. (2013a), LADM in Croatia - making and testing country profile, Proceedings of the 5th Land Administration Domain Model Workshop, Kuala Lumpur, Malaysia, FIG, Copenhagen, Denmark.

URL REFERENCES

URL 1: State Geodetic Administration,
http://www.dgu.hr/assets/uploads/Dokumenti/Novosti/Geodetski%20projekt/Geodetski_projekt_primjer_2.pdf, page view 29.7.2014.

URL 2: Adriatic Homes,
http://www.adriatic-homes.com/etaziranje-makarsk/, page view 29.7.2014.

URL 3: Trimble 3D Warehouse,
https://3dwarehouse.sketchup.com/model.html?id=c7038d711f571426bd1c18526cfc3fdf, page view 28.8.2014.

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 Geoinformation at University of Zagreb, Faculty of Geodesy. The topics that he specializes in are land administration systems, cadastres and geoinformation. 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 2011-2015. 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.

Danko Markovinović is director general at the State Geodetic Administration of the Republic of Croatia. In 2009 he received a PhD from University of Zagreb for the thesis "Gravimetric Reference System of the Republic of Croatia". He has been employed at the Faculty of Geodesy of the University of Zagreb since 1995 till 2012. He is chartered geodetic engineer at Croatian Chamber of Chartered Geodetic Engineers. He is vice-president of the Council of European Geodetic Surveyors.

CONTACTS

Nikola Vučić
State Geodetic Administration
Gruška 20
Zagreb
REPUBLIC OF CROATIA
Tel.: +385 1 6165 439
Fax: +385 1 6165 454
E-mail: nikola.vucic@dgu.hr
Website: http://www.dgu.hr

Miodrag Roić
University of Zagreb – Faculty of Geodesy
Kačićeva 26
Zagreb
REPUBLIC OF CROATIA
Tel.: + 385 1 4639 229
Fax: +385 1 4828 081
E-mail: mroic@geof.hr
Website: http://www.geof.unizg.hr

Danko Markovinović
State Geodetic Administration
Gruška 20
Zagreb
REPUBLIC OF CROATIA
Tel.: +385 1 6165 444
Fax: +385 1 6157 389
E-mail: danko.markovinovic@dgu.hr
Website: http://www.dgu.hr