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Initial 3D cadastre registration by cadastral resurvey in the Republic of Croatia

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ABSTRACT

2D Land cadastre on the present territory of the Republic of Croatia has been continuously developed in the last 200 years. Throughout the years, survey methods, needs and purposes of cadastre have changed. This resulted in a variety of cadastral data with different accuracy and completeness. Today, we can collect an enormous amount of data and the need for cadastral data has never been greater. We need to find feasible solutions to make the initial acquisition of 3D cadastral data which would satisfy the needs of stakeholders involved in Land Administration System (LAS).

This paper will present a historical background of the cadastral data acquisition which would help to understand circumstances on how this variety of available cadastral data has been produced and the data available nowadays. Based on the historical overview and the overview of the current state, we will upgrade the data model of a LAS used in Croatia to support the implementation of a 3D cadastre. The model will include its static components but also proposed improvements of cadastral resurvey related processes. The Land Administration Domain Model (LADM), which in 2012 became the ISO 19,152 standard, will be used as the formal basis.

This paper offers a proposal for cadastral resurvey improvements, better registration of public rights and registration of separate parts of real properties. It will identify and explore critical points and make recommendations to bring Real Property Cadastre closer to a real 3D register.

1. Introduction

The development of 2D Land Cadastre on the present territory of the Republic of Croatia begun 200 years ago as part of a comprehensive project of the survey and establishment of Land Cadastre for the entire territory of the Austro-Hungarian Monarchy. It was originally designed to support a tax system where its basic purpose would be a fair collection of taxes based on the capability for agricultural production of the land. By this measure it was intended to encourage the population to work harder and gain higher incomes from agricultural production (Roić, 2012).

During the following period, until the independence of the Republic of Croatia, cadastral documentation of 2D Land Cadastre was renewed for about 25% of cadastral municipalities, mostly large- and medium-sized cities and administrative municipalities, but also some land consolidated municipalities mainly in the eastern part of the country. Following the independence, new regulations were being adopted that initiated the radical reform of the cadastre. Instead of the Land Cadastre with taxation as the primary objective, the Real Property Cadastre has been introduced with primary legal objective, as a register of land parcels, parts of properties, buildings and other structures permanently lying on or below the Earth's surface or public rights established on the Earth's surface. Therefore, the role of the cadastre has changed from taxation to legal multipurpose cadastre (Roić, 2012). The regulations proposed two models for the development of Real Property Cadastre; one being based on cadastral resurveys for the whole or part of the cadastral municipality (Mađer and Roić, 2011) and the second referring to the sporadic upgrading of cadastral parcels from Land Cadastre into the Real Property Cadastre. Although Real Property Cadastre is not explicitly a 3D register, many rights for which the registration must be

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supported are overlapping, e.g. private land and public rights. Cadastral resurveys are being conducted, but with very slow progress. Public rights, although specified by legislation, are still not systematically registered.

There are multiple sources of official (state owned) 3D data in Croatia, including reports on a separate part of real property, digital terrain models and digital surface models, the Basic Topographic Database, the utility cadastre data and the topographic content of cadastral and topographic maps (Vučić et al., 2017). Separate parts of real property in Croatian land administration are registered in 2D diagrams with an indication of the floor where they are located, and one could consider this as a 2.5D approach. This approach temporarily enables registration of rights of separate parts, however, it does not support maintenance of data. Hence, it is necessary to develop a spatial representation component in registration of 3D objects (Vučić et al., 2011). One of possible solutions would be to add 3D data in cadastral maps which would facilitate the registration and better description of 3D objects. Basic information about the Croatian 3D cadastre are defined and described in FIG publication Best Practices 3D Cadastres (Kitsakis et al., 2018). The use of 3D property rights has for many years been a tool for providing secure and lasting rights in space and has become an internationally common feature. In order to efficiently manage complex situations of ownership and other RRRs (rights, restrictions and responsibilities), the procedures for 3D property formation and registration also have to be addressed (El-Mekawy et al., 2014). Also, for the medium- to long-term future, it seems that if the solid foundation of a spatial-temporal partition as cadastral foundation becomes more important, 4D data types should be considered. A transition method from a 2D cadastre to a 3D + time system, based on the official spatial data registers, has been proposed by some authors (Siejka et al., 2014). Further, the true 4D basis might be the cheapest solution in the long run as no special cases need to be treated in other ways (Oosterom et al., 2006).

The first section of the paper is introduction, the second section describes methodology, the third section provides an overview of the historical background of cadastral surveys, the fourth section describes Real Property Cadastre in the Republic of Croatia and the fifth section explores the upgrading of cadastral resurveys to meet the 3D requirements. The paper then ends with a conclusion on the findings.

2. Methodology

This research is built upon the LADM and is following its main concepts. The LADM, which in 2012 became the ISO 19152 standard (ISO, 2012), provides a standardised global vocabulary for land administration. The LADM covers basic information-related components of land administration including those over land, in water, below the surface and above the ground. LADM can help reconcile superfluous government databases and reduce large amounts of redundant data that currently exists (Lemmen et al., 2015). Using LADM will not only provide interoperability, but also achieve a better exchange of international experience (Radulović et al., 2017).

First, we describe the historical background of cadastral surveys in order to show the diversity of land surveying methods for making cadastral maps in the last 200 years in the area of todays Republic of Croatia. This means that the quality of cadastral data varies as well. Then, we describe the Real Property Cadastre which is similar to the Legal Boundary Cadastre in Austria (Ernst et al., 2019). We describe the current workflow of cadastral resurveys and data which are acquired during the cadastral resurvey. Based on the overview of historical background and the current state we propose the upgrade methodology from 2D to 3D cadastre. Also, we explain the possible sources of 3D data which could be collected during the cadastral resurvey. Here we concentrate only on 3D spatial data about buildings, building parts and utilities. Also, we propose the methodology of collecting data about public rights on a parcel level and other rights as well on a parcel, building, building part level.

By analysing and comparing the LADM with the Croatian LAS the objective was to determine which classes and attributes should be introduced into the Croatian LAS that would meet the needs of involved stakeholders (cadastral officers, citizens, companies, state, local government and others). Geodetic, geoinformatic and other professions are more capable than ever (GNSS technologies, LIDAR, crowdsourcing) to quickly collect three-dimensional data on land, buildings and their respective parts. Also, a large quantity of 3D data is already available from previous projects. One of such projects is the project of legalization of illegal buildings in Republic of Croatia. We compare the LADM with the classes and attributes from Croatian LAS recognized through screening of the current state of Croatian LAS. By analysing possible sources of 3D data we try to fill the gap between data collected currently and data that should be collected in order to have a 3D cadastre with basic set of 3D data.

3. Historical background of cadastral surveys

The development of cadastral surveys in Croatia has been influenced by different states where regions of Croatia were historically a part of, listed in a chronological order: Austrian Empire, Austro-Hungarian Monarchy, Kingdom of Yugoslavia and Social Federal Republic of Yugoslavia (Roić, 2012). Therefore, land tenure is registered with diverse dynamics and depending on the social and political system in these states. The Croatian cadastral system is based on the Germanic model of cadastre with land book title system (Enemark, 2010) primarily due to its Austro-Hungarian heritage (Lisec and Navratil, 2014).

Cadastral surveys in the Republic of Croatia have been carried out since 1817 when the establishment of the Land Cadastre started. At that time, when Croatia was part of the Austrian Empire, a cadastre was created for tax purposes. Later, Croatia was part of the Austro-Hungarian Monarchy and cadastral surveys continued for all land parcels. When establishing the cadastre in the 19th century it was applied and, at that time, was the most accurate and fastest plane table surveying (Fig. 1). By the beginning of the 20th century, it was substituted by the offset surveying, which has yielded much better

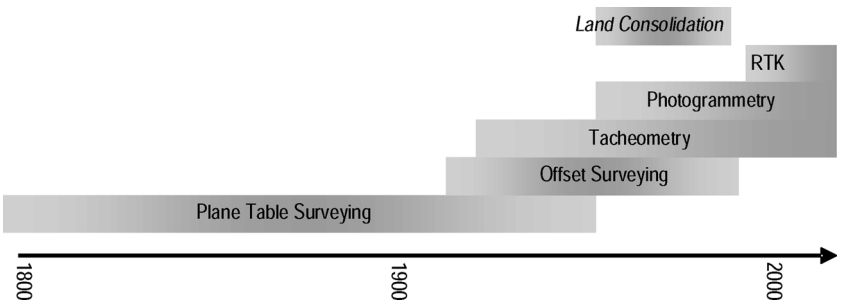


Fig. 1. History of cadastral surveying (Roić, 2012).

precision. Tacheometry and Photogrammetry were used for cadastral surveys in the second half of the 20th century. Using Real Time Kinematic (RTK) technology measuring the third dimension (height) has become faster and more accessible.

3.1. Land cadastre initial surveys

Early efforts in the year 1784 to establish a Land Cadastre resulted with an unprofessionally made Josephine Cadastre, hence, it was soon put out of use. More appropriate developments of the Land Cadastre in the Croatian region under the Austro-Hungarian governance began with proclamation of the Imperial Patent (Grundsteuerpatent) on December 23rd, 1817, ordering surveys, land classification and preparation of the cadastral documentation for the entire territory of the Monarchy. This date represents the introduction of the so-called Franciscan Cadastre, which means that a two-dimensional cadastre was established for the entire coverage of the Austro-Hungarian Monarchy. The need for a quick establishment of the cadastre and tax purpose has led to the decision for a simple data model. The data model was limited to a two-dimensional representation of the land features essential for taxation. Basic principles of this cadastre remained in use for over a hundred years. Today's land registries were created in the period from year 1880 to 1900 based on available Land Cadastre data (Roić et al., 2005).

3.2. Land cadastre resurveys

After World War I, Croatia became part of the Kingdom of Serbs, Croats and Slovenians. In the year 1929 a law on Land Cadastre was approved, not much different than the Austrian Imperial Patent. In fact, this law was accepted as a translation of the Imperial Patent, so the cadastre simply continued to serve for tax purposes. The law imposes an equalisation of the cadastre in the Kingdom as eastern regions had only a census cadastre. There were no significant resurveys in Croatia during this period.

After 1945, and the implementation of radical changes in the society by introducing a communist ideology, the attitude towards ownership and other real property rights also changed. The cadastre and land book were neglected with the intention of abolishing them when private ownership disappear and everything becomes common ownership. For this reason, the cadastre was not updated at all until 1953 when the Land Cadastre Legislation was brought into force. Lack of funds in the treasury demanded new sources of funding the state budget. The solution was found in the revision of the cadastre and later served as the basis for taxation. The land book, however, remained neglected. The cadastre obtained its role in society, but as an institution for registering land possession in service of taxing income from agriculture. This resulted in a mismatch between the cadastral land data and rights data in the land book, since the land book was rarely renewed after the cadastral resurvey (Roić et al., 2005).

The legislation from 1953 stipulated the collection of 3D data and the development of a cadastral map with a lot of topographic features which resulted in creation of cadastral-topographic maps. Thus, the cadastral map was to serve for technical and planning purposes. However, by the year 2000, cadastral resurveys were conducted and cadastral documentation renewed only for approximately 25% of the Croatian territory. Topographic content was not maintained, and the stated goals were not achieved. During the digitisation, topographic content of the cadastral map was not vectorised. So, in practice, today's official electronic cadastral map of the Land Cadastre contains only a two-dimensional presentation of the land features.

3.3. Real property cadastre resurveys

The cadastre reform in Croatia, initiated by the law of 1999, planned to replace the Land Cadastre with the Real Property Cadastre by cadastral resurveys per cadastral municipalities within 10 years. The law has established the basis for registration of public rights into the cadastre and enables registration of maritime areas. The registration of apartment and offices in Real Property Cadastre were not clearly defined, and the registration of utilities are prescribed by a separate regulation as a technical matter without the rights registration. Unfortunately, the law did not clearly prescribe collecting data about the elevation/height of the land/property features.

Since 2000, cadastral resurveys projects are being carried out for 408 cadastral municipalities (status as of 24th November 2017) of which 189 projects are completely finished, 38 projects are in the process of geodetic surveying, 12 projects are undergoing quality control, 90 projects are controlled and waiting for public display and 79 projects are in the process of public display.

The total area covered by the cadastral resurveys, intended for the establishment of Real Property Cadastre, is 378.707 ha (Vučić and Šantek, 2018). This is nearly 7% of the territory of the Republic of Croatia.

4. Real property cadastre

In Croatia, there are number of activities proposed for improving the data, business processes, and the organisation of land administration. All of these activities are part of the National Real Property Registration and Cadastre Program known as Organized Land (URL 1, 2019). One of the project's key objectives was to design and implement a Joint Information System of Land Book and Cadastre (JIS) to combine both the land book and a cadastre. The JIS represents a unified system which replaced previously used different databases, data models and associated applications in the cadastral offices of the State Geodetic Administration (SGA), as well as in the offices of the municipal courts. The SGA implemented the JIS in all cadastral offices in Croatia by November 2016. Today, the JIS provides support for the implementation of all regulated business processes and tasks, as well as transparent monitoring and data reporting from the cadastre and land book. This system has special values in its administration and functionalities and is hosted in a highly secure environment. The establishment of the JIS accelerates registration as it:

- integrates the spatial and legal data of real property in both cadastral and land book systems,
- raises the level of security in real property transactions,
- provides better management of both systems,
- streamlines business processes,
- improves customer relations,
- increases the speed and quality of service.

To provide the best speed and quality of services to key users and the general public, the SGA and Ministry of Justice developed (and continue to develop) a public One-Stop-Shop (OSS) web application that represents the link to the cadastral and land book data (i.e. JIS). OSS allows all users to search and access an overview of the basic cadastral and land book data, but also contains a section for registered users who can then view the data, apply for public documents, view their case status and receive issued documents into an electronic mailbox. Other additional cadastral data functionalities (currently being implemented), such as the electronic exchange of data between cadastral offices and licensed geodetic engineers and the delivery of digital geodetic reports in cadastral offices, will standardise and speed up the review and confirmation of geodetic reports as well as accelerate the process of real property registration. Furthermore, this also provided citizens with an easy and quick access to public documents and data (Vučić et al., 2017).

Lisec and Navratil (2014) and Ernst et al. (2019) describe the situation and historical overview in Austrian cadastral system, which is a similar cadastral system like Croatian. In Austria the occasional

resurvey of parcels, called TNA-process (original German name: "*Teilweises Neuanlegungsverfahren*") enable the transfer of individual parcels from the Fiscal Cadastre to the Legal Boundary Cadastre (Ernst et al., 2019). In Croatia we have similar procedures for the transition of cadastral parcels between land cadastre (original Croatian name: *"Katastar zemljišta"*) and the Real Property Cadastre (original Croatian name: "*Katastar nekretnina"*).

When real properties (land parcels, cadastral parcels) registered in the cadastre and land book do not correspond to the actual situation in the field, this situation can be changed based on an appropriate geodetic report. For historical reasons, this lack of harmonisation exists in large areas. The SGA has launched a comprehensive programme of organising the cadastral data and its harmonisation with the actual situation in the field. This programme is financed jointly from the state, county, city and municipality budgets. Furthermore, legal and physical persons who are real property title holders, can also provide financial resources. The cadastral resurveys make the basis of this programme.

Municipal cadastral documentation refers to the total cadastral records kept for a cadastral municipality. A cadastral survey is the process of gathering and processing of all necessary data in order to form cadastral parcels, record buildings and other structures, record special legal status of the land and the land usage as well as the creation of the cadastral documentation of the Real Property Cadastre.

The SGA, in agreement with the Ministry of Justice, conducts the cadastral survey for a cadastral municipality, or a part of it. Specific works within the cadastral survey are conducted by a licensed geodetic companies (Fig. 2), which are selected at public tenders. Since the cadastral survey is conducted for a specific area, all persons affected by the survey on that area must be notified about it. As stipulated by the law, a decision on the cadastral survey is passed by the Director-General of the SGA, and such a decision must be published in the Official Gazette. Along with the abovementioned, information on the cadastral survey implementation is also published in the local media (newspapers, radio). All local government units where surveys are conducted, organise public meetings for citizens where the survey procedure is explained, and instructions are provided regarding the marking of land borders with visible and permanent (boundary) marks. Along the roads passing through the surveyed area, boards are placed which mark the worksite and give a basic information about cadastral survey.

When the cadastral survey is conducted in a cadastral municipality, the land title holders are obliged to mark, using visible permanent marks, the borders of the land they own or hold other rights, at their own expense and within the time period stipulated by the decision on the cadastral survey. The title holders receive a written notification on the delineation and are provided with professional assistance, free of charge, in the delineation process. The delineation is conducted for all breakpoints of a cadastral parcel. Depending on the type of terrain, it can be conducted with a concrete pillar, iron wedge, ceramic pipe, plastic marker with an iron core or by carving a cross in a solid rock. The cadastral parcel breakpoints that are clearly recognisable in the field, such as fences, houses, etc., do not need to be specifically marked.

When all the necessary data is collected and processed in a cadastral survey, a cadastral survey report is produced. Along with all other parts, a cadastral survey report must include the cadastral map and evidential sheets. The cadastral map displays cadastral parcels with their boundaries and numbers, as well as the buildings constructed on these parcels (Fig. 3). The cadastral map also shows the house numbers and borders of different land usages on the cadastral parcel. The evidential sheets show all collected and processed attribute data on the cadastral parcel, data on the real property title holders collected based on available documents (land book and cadastre), as well as the statement of the involved parties.

In urban areas with many buildings composed of many apartments and offices, during the cadastral resurveys 3D data on separate parts of real properties (apartments, offices) are collected to a certain extent. One example is a recently finished cadastral resurvey of the cadastral municipality Velika Gorica. The town of Velika Gorica is one of the larger cities in the Republic of Croatia. An excerpt from a public Land Database (LDB) document, in which the legal and technical data on the property are integrated, shows the ownership data structure describing the separate parts of the property for one apartment from the previous figure (Fig. 4). 3D Cadastral data can be improved and more details can be added as it will be proposed in the subsequent chapter.

5. Upgrading Cadastral resurveys to meet the 3D cadastre requirements

Data in current cadastres can provide a significant contribution as the basis for the development of 3D Real Property Cadastre, nevertheless, some additional data must be acquired (Drobež et al., 2017). On the other hand, Lee et al. (2015) propose upgrading of a LAS into 3D by adjusting the cadastral resurvey process, including the representation of 3D physical properties and 3D rights and also propose inclusion of utilities and superficies information to present the physical and legal information on both buildings and underground features into the 3D cadastre model. In this paper we concentrate on available 3D data in order to collect them during the cadastral resurvey. The procedures within cadastral resurveys can be upgraded to meet the 3D Cadastre requirements. The scope of the data collected during the conventional 2D resurvey would have to be expanded which, on the one hand, would increase the overall expenses of the cadastral resurvey, however, on the other hand, only for a minor additional cost. It is due to the amount of additional 3D data, which is currently not collected but would be beneficial for improved land governance. As a result, the approach with which the ongoing process of the renewal of 2D cadastral data would be used (with minor adjustments) represents one of possible approaches to develop initial 3D cadastre.

This idea can be conceptually described by extending the LADM which already supports 3D cadastre. However, due to the specific data model of Croatian LAS, the LADM needs to be extended to support these

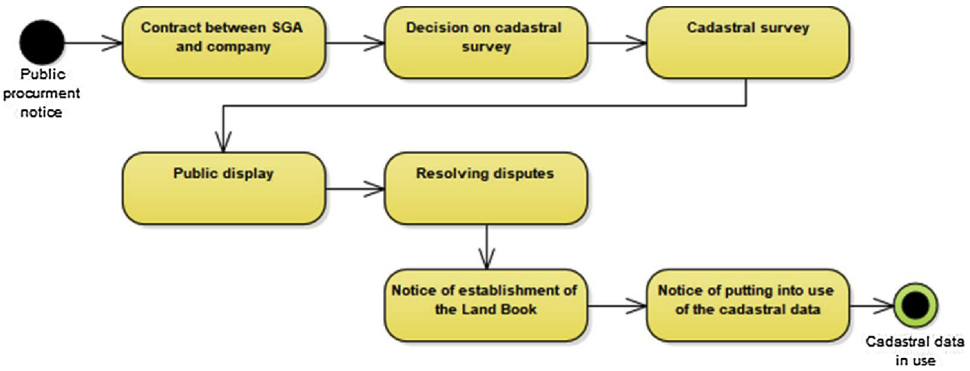


Fig. 2. Existing cadastral survey workflow.

Fig. 3. Results of cadastral resurvey in an urban area (cadastral municipality Velika Gorica) (URL 2, 2019).

particularities. In this section we have compared both LADM and current Croatian LAS attributes in order to detect in which manner LADM should exactly be extended to fit the needs of the Croatian LAS. Since we are dealing only with spatial data and attributes of spatial units, we only examined the Spatial Unit package. First, we extended the LADM to include Croatian LAS attributes with ones that are currently being collected in separate registers (Cadastre, Spatial planning). More specifically, we have added 3D data on buildings into a Croatian LAS data model by extending class LA_LegalSpaceBuildingUnit from the LADM Spatial Unit package.

In Table 1 we listed all the attributes of the LADM Spatial unit package and compared them to the current data model of Croatian LAS in order to recognise which attributes should be collected to represent 3D spatial units. In one column we have marked the existence of the LADM attribute, and in another column the existence of an attribute in a Croatian LAS data model. In last column we have added information whether the attribute should be optional (O) or mandatory (M). A new proposed conceptual model based on LADM should include all attributes from the Croatian LAS data model as well as all LADM attributes. By keeping the LADM attributes we ensure sufficient support for 3D, and by keeping Croatian LAS attributes we ensure the model will fit the needs of the Croatian LAS.

Summarized results of the comparison presented in the previous table can be displayed as diagram (Fig. 5) where it is discovered the significant amount of compliance between Croatian LAS and LADM. However, even though Croatian LAS is very compliant to the LADM, some of the information are not currently collected anywhere (such as volume) and some are currently collected but are not in a suitable form to be collected (such as height, noOfFloors, yearBuilt).

Further analysis of data shown in Table 1 discovers that crucial attributes for the 3D support of the class SpatialUnit from the LADM (volume, surfaceRelation) are missing in Croatian LAS. Also, the LADM SpatialUnit class is missing some Croatian specific attributes, therefore it was extended by a class HR3D_SpatialUnit. This class has two new attributes publicRight. By creating a HR3D_SpatialUnit we enabled the storage of land book area which can be in some cases different than the one stored in cadastre and storing information about public rights to the parcels. For now, it is possible only to assign a public right on an entire parcel. It is not possible to assign public right on certain part of parcel.

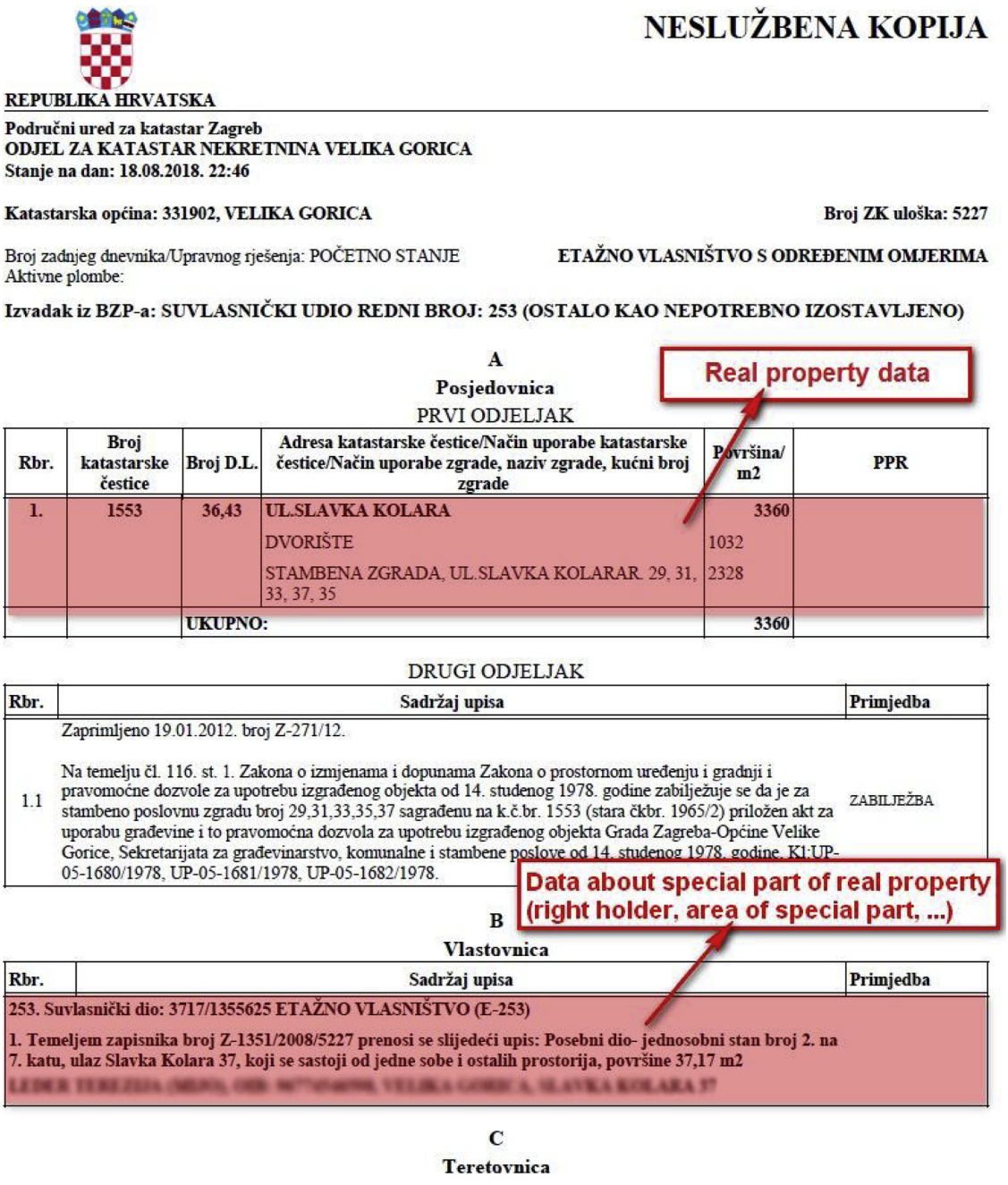
The class LegalSpaceBuildingUnit contains attributes which define the type and relation to actual physical buildings. In the Croatian LAS we propose an introduction of two new attributes: height and noOfFloors, which could help determine approximate volume of buildings. It can be acquired fairly easily and would be a transitional solution until a more accurate 3D geometry is provided. Height could be collected from photogrammetry data or from terrestrial observations made during the cadastral resurvey (e.g. one point per building), from legalization reports, project of the building or it can be determined from number of floors by physical inspection of the building (e.g. counting floors). A lot of data about buildings is available in a digital form due to recent legalization process.

Currently in the Croatian LAS, utilities are maintained in separate registers. Therefore, there is no unique identifier of a certain physical network. Status is also not maintained and, currently, only type is maintained. To efficiently maintain data on 3D RRRs, which are derived from a utility network, all data should be unified within Croatian LAS. But the geometry of utilities is available and in most cases in a digital form. For utilities the third dimension is always available since it has always been collected.

Data regarding condominium units are not collected during the cadastral survey, however, in many cases data exists in the Land Book. It would need to invest a significant amount of effort to create their spatial representation and connect them with buildings and cadastral parcels. However, this effort is needed since data regarding condominium units are currently very poorly maintained in Croatian LAS, which leads to uncertainty in real property market. In Croatia, a lot of spatial data for condominium units is available (Fig. 8) that could be used for creation of 3D geometries from the footprint and the height of the condominium unit since in every room we have a height of the floor. Partly these data are stored in the land book and part of it can be used from the legalization process.

Following the discovery of all attributes required in Croatian LAS to support implementation of 3D cadastre we extended LADM to fit the needs of Croatian LAS (Fig. 6).

Classes HR3D_LegalSpaceBuildingUnit and HR3D_LegalSpaceCondominiumUnit are descendants of LADM class LA_LegalSpaceBuildingUnit which is a descendant of the class LA_SpatialUnit. Class HR3D_LegalSpaceBuildingUnit is an extension of LADM class LA_LegalSpaceBuildingUnit and holds attributes regarding buildings which, according to valid legislation, needs to be collected during the cadastral survey. Currently, data on condominiums is not collected, therefore, the class HR3D_LegalSpaceCondominiumUnit is created which is related via a composition relationship to class HR3D_LegalSpaceBuildingUnit. One of the most important pieces of information related to condominiums are related rights. Since the condominium is a descendant of the spatial unit, the rights can be attached to condominiums via class LA_BAUnit. Due to various sources of 3D data, LADM class LA_Level can be used to model various geometrical



NESLUŽBENA KOPIJA

REPUBLIKA HRVATSKA

Područni ured za katastar Zagreb
ODJEL ZA KATASTAR NEKRETNINA VELIKA GORICA
Stanje na dan: 18.08.2018. 22:46

Katastarska općina: 331902, VELIKA GORICA — Broj ZK uloška: 5227

Broj zadnjeg dnevnika/Upravnog rješenja: POČETNO STANJE — ETAŽNO VLASNIŠTVO S ODREĐENIM OMJERIMA
Aktivne plombe:

Izvadak iz BZP-a: SUVLASNIČKI UDIO REDNI BROJ: 253 (OSTALO KAO NEPOTREBNO IZOSTAVLJENO)

A
Posjedovnica

Real property data

PRVI ODJELJAK

Rbr.	Broj katastarske čestice	Broj D.L.	Adresa katastarske čestice/Način uporabe katastarske čestice/Način uporabe zgrade, naziv zgrade, kućni broj zgrade	Površina/ m2	PPR
1.	1553	36,43	UL.SLAVKA KOLARA	3360	
			DVORIŠTE	1032	
			STAMBENA ZGRADA, UL.SLAVKA KOLARAR. 29, 31, 33, 37, 35	2328	
		UKUPNO:		3360	

DRUGI ODJELJAK

Rbr.	Sadržaj upisa	Primjedba
1.1	Zaprimljeno 19.01.2012. broj Z-271/12. Na temelju čl. 116. st. 1. Zakona o izmjenama i dopunama Zakona o prostornom uređenju i gradnji i pravomoćne dozvole za upotrebu izgrađenog objekta od 14. studenog 1978. godine zabilježuje se da je za stambeno poslovnu zgradu broj 29,31,33,35,37 sagrađenu na k.č.br. 1553 (stara čkbr. 1965/2) priložen akt za uporabu građevine i to pravomoćna dozvola za upotrebu izgrađenog objekta Grada Zagreba-Općine Velike Gorice, Sekretarijata za građevinarstvo, komunalne i stambene poslove od 14. studenog 1978. godine, K1:UP-05-1680/1978, UP-05-1681/1978, UP-05-1682/1978.	ZABILJEŽBA

Data about special part of real property (right holder, area of special part, ...)

B
Vlastovnica

Rbr.	Sadržaj upisa	Primjedba
	253. Suvlasnički dio: 3717/1355625 ETAŽNO VLASNIŠTVO (E-253)	
	1. Temeljem zapisnika broj Z-1351/2008/5227 prenosi se slijedeći upis: Posebni dio- jednosobni stan broj 2. na 7. katu, ulaz Slavka Kolara 37, koji se sastoji od jedne sobe i ostalih prostorija, površine 37,17 m2	

C
Teretovnica

Fig. 4. Excerpt from a Land Database – example.

representations. For example, if 3D geometry is unavailable, a point profile can be used to represent the building or condominium feature. To such a feature, the rights can be attached and, later, geometry can be improved.

The class HR3D_SpatialUnit represents cadastral parcel. It is a descendant of the class LA_SpatialUnit. Public right are important attribute of the parcel for 3D cadastre since it represents an encumbrance in a 3D sense. It applies to both space on, above and below the ground. This can be represented easily in 3D in a liminal form.

After we extended the LADM and proposed an upgraded model of the 3D Croatian LAS we also offered a proposal for the modification of a cadastral resurvey workflow to collect 3D data (Fig. 7). 3D data can be collected from cadastral survey data, or during a public display of the survey results if some data were not collected during cadastral survey. However, 3D geometry of condominium units cannot be created from data which is currently being collected during cadastral surveys. Additional efforts and resources have to be invested to create these 3D geometries. For condominiums that have legal documentation, some kind of 3D data are available. However, these data are mostly on paper meaning automatic or semi-automatic methods must be developed.

The collection of 3D data represented in previous figures also implies a collection of private and public rights related to 3D units. A workflow needs to be developed in more details, however, it shows that with little effort 3D data can be collected. Also, significant fact that goes in favour is the entire cadastral surveying process is performed in electronic manner: from field data acquisition, through public display of data, and later registration of data into JIS. Also, data in other registers that should support the creation of 3D data are mostly in a digital form. In the following sections, we describe in more detail each methodology for the collection of 3D data.

Table 1
Comparison of LADM attributes with Croatian LAS attributes.

Class	Attribute	LADM	Croatian LAS	M/O
SpatialUnit	extAddressId	+	+	O
	area	+	+	M
	dimension	+	+	O
	label	+	+	M
	referencePoint	+	+	O
	suID	+	+	M
	surfaceRelation	+	–	O
	volume	+	–	O
	publicRight	–	–	O
	landBookArea	–	+	O
	Total	8	7	
LegalSpaceBuildingUnit	extPhysicalBuildingUnitId	+	+	M
	type	+	+	M
	height	–	–	O
	noOfFloors	–	–	O
	yearBuilt	–	–	O
	usageAct	–	+	O
	lastReconstructionYear	–	–	O
	energyClass	–	–	O
	finished	–	–	O
	Total	2	3	
LegalSpaceUtilityNetwork	extPhysicalNetworkId	+	–	M
	status	+	–	O
	type	+	+	M
	Total	3	1	
LegalSpaceCondominumUnit	floor	–	–	M
	noOfRooms	–	–	M
	Total	0	0	

5.1. Registration of public rights within the cadastral resurvey

The incorporation of a specialized classification of RRRs in the LADM is of value more for the inclusion of social tenure in national land administration registers. The LADM allows national profiles to be added to the standard, however, such profiles are relevant within a country. These profiles are needed in cases where detailed data of interests in land have to be exchanged internationally (Paasch et al., 2015).

A public right represents a status established on cadastral parcel or real property which has a cultural, archaeological, historical, economical or ecological significance which is of interest to the Republic of Croatia (Official Gazette, 2018). Within a cadastral survey, the following data is acquired and processed: data on boundaries, address, land use, area of cadastral parcel and its parts. Data on public rights on cadastral parcels is also acquired, as well as data regarding buildings and right holders on the real property. Public rights represent an area with certain encumbrance which imposes certain restrictions to the right holders of real property. A list of by law prescribed public rights is provided in Table 2.

Public rights listed in Table 2 are currently not collected during the resurvey in a satisfying manner because the boundaries of public rights are determined on cartographic maps of smaller scale or described on a paper. But it should be collected in the field for each cadastral parcel. Legislative assumptions have been made for this, but the implementation framework has not been established. Systematic collection has not started yet but should be done soon.

5.2. Registration of separate parts of real property

To progress from 2D to 3D is not only providing insight into 3D via available 3D techniques. Instead, the most challenging aspect is to assign a 3D geometry to legal volumes with possibly the same juridical value as parcel boundaries in 2D. For cadastral registration, this requires a new way of defining, validating and maintaining information

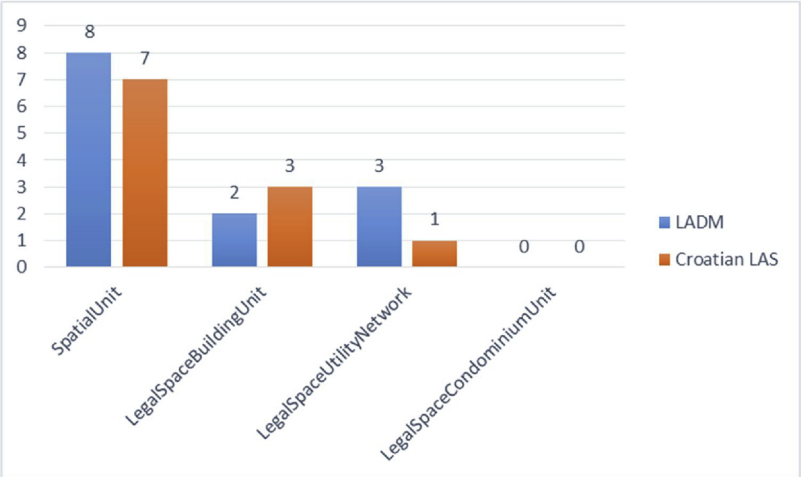


Fig. 5. Comparison of LADM attributes to the Croatian LAS attributes.

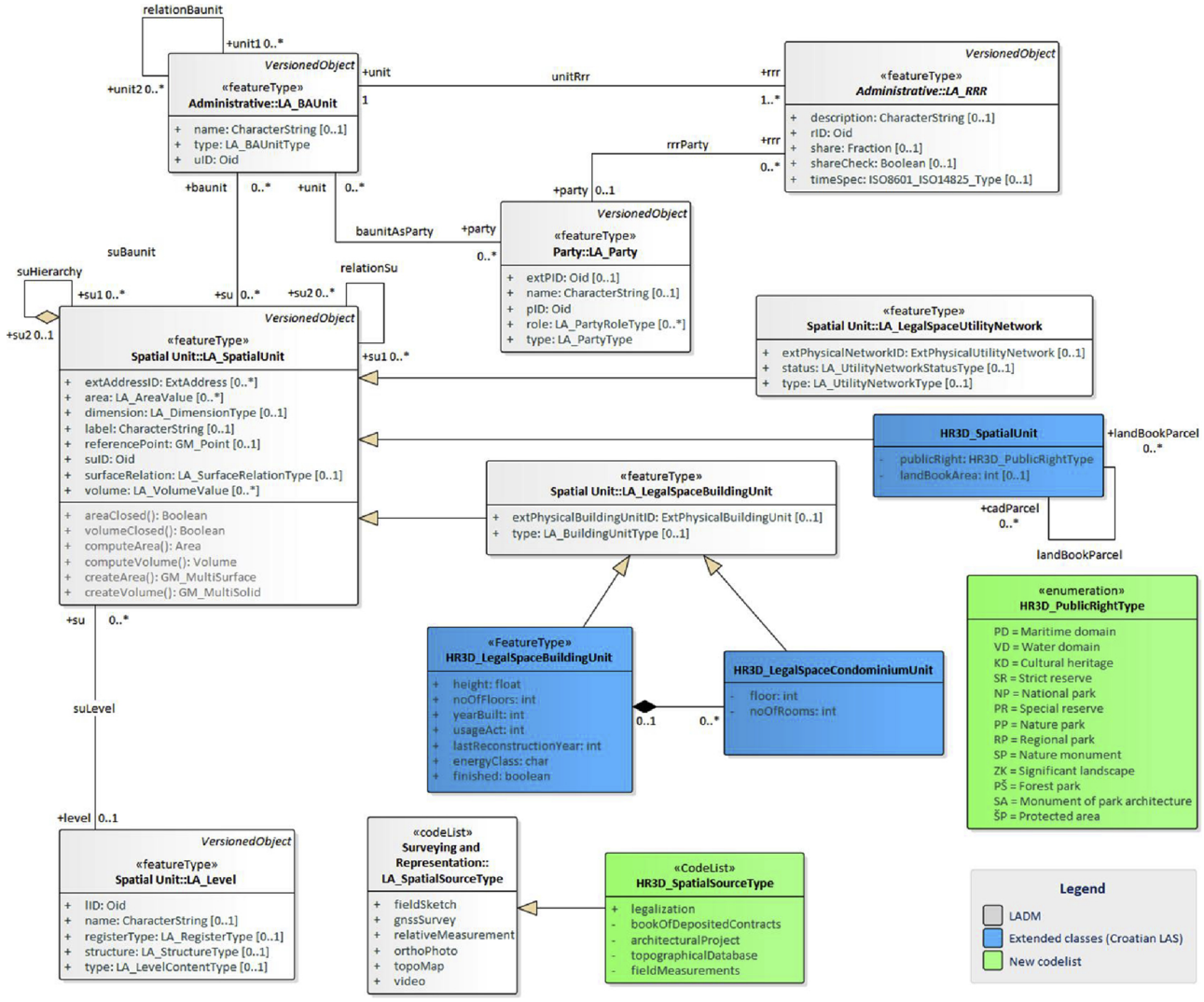


Fig. 6. Extension of LADM to support transition towards Croatian 3D cadaster.

regarding property rights in the cadastral registration (Stoter et al., 2017).

Paasch et al. (2016) conclude in their study that 3D property is differently perceived worldwide, which means that comparative studies should consider differentiations in national legislation. This also means that the 3D property concepts should be clarified concerning the terminology that is used and the fields of application. In this way 3D property should become familiar to the public and professionals instead of being a complicating factor in real property management.

The registration of separate parts of real property in the land book is not possible without the partition of real property which establishes ownership on its separate parts (apartment, office space, garage, etc.) that become associated with a proportionally shared part of the whole property. Shared owners of real property remain herewith in a shared ownership over the common parts, while each person becomes an individual owner of separate parts (e.g. apartment or office space). The method of registering elaborates on condominium partition of real property (Fig. 8) was introduced in 1996. For all newly constructed

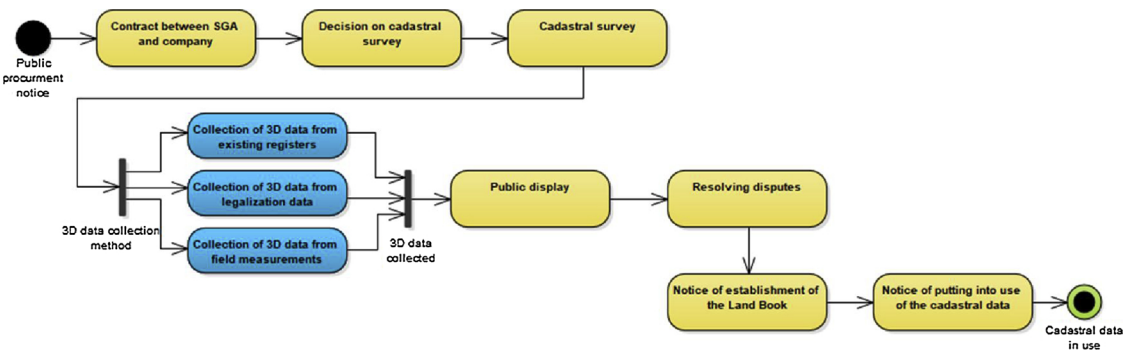


Fig. 7. Proposal for improvement of cadastral survey workflow.

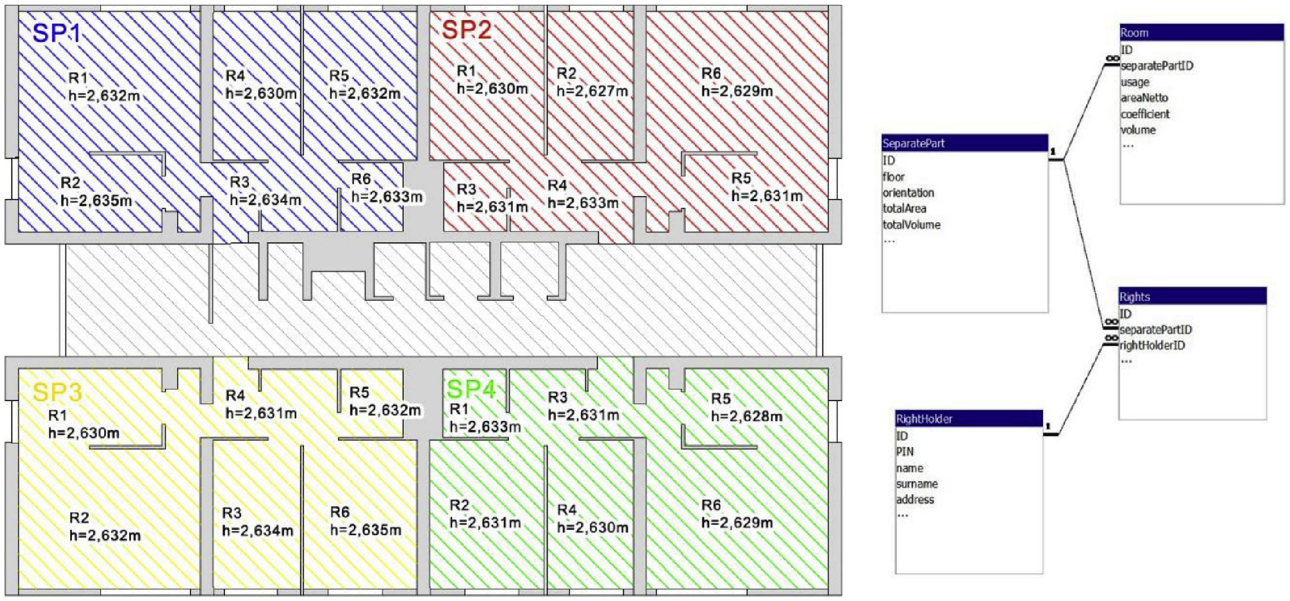


Fig. 8. Part of an elaborate on condominium partition of real property.

Table 2
Public rights on cadastral parcels.

Public rights	Acronym	Public rights (Croatian translation)
Maritime domain	PD	pomorsko dobro
Water domain	VD	vodno dobro
Cultural heritage	KD	kulturno dobro
Strict reserve	SR	strogi rezervat
National park	NP	nacionalni park
Special reserve	PR	posebni rezervat
Nature park	PP	park prirode
Regional park	RP	regionalni park
Nature monument	SP	spomenik prirode
Significant landscape	ZK	značajni krajobraz
Forest park	PŠ	park šuma
Monument of park architecture	SA	spomenik parkovne arhitekture
Protected area	ŠP	štićeno područje
Special purpose land used for active defence needs	PO	zemljište posebne namjene koje se koristi za djelatne potrebe obrane
Border crossing area	GP	područje graničnog prijelaza

buildings from 1996 onwards, all real properties are registered. But, there are many real properties, within existing older buildings, which have not yet been registered according to that method. Several initiatives and legal commitments were initiated, but without satisfying results.

Fig. 8 shows a graphical overview of several separate parts. The drawing contains measures of every wall (omitted for the sake of simplicity) and each room contains a measured height (shown in the figure). From the footprint and measured height, a 3D model of a separate part can be made. Also, every separate part (SP1, SP2, …) and every room have an identifier within the separate part (R1, R2, …). The identifiers are the association to the alphanumerical part of the elaborate where all required information is contained such as: areas (net/gross), volumes (actual, usable, …), orientation, floor. Every room has an association to the separate parts and every separate part has an association to the right holders. In that way, all required information is prepared in order to register rights on a separate part in the land book.

5.3. Utility cadastre

Utility cadastre is defined by the State Survey and Real Property Cadastre Act in the Republic of Croatia. The SGA is responsible for the establishment and maintenance of utility cadastre (Official Gazette, 2018). In the previous period, from 2000 till 2018, utility cadastre registers were under the jurisdiction of local governments (cities and municipalities) and did not have any positive effects as cities and municipalities did not even establish it, even though they were obliged to by law.

The SGA is in the process of creating a single information point system required for the development and management of a single database on infrastructure at the state level, which will contain electronic data on the infrastructure and notifications on planned construction works (Fig. 9).

The implementation of Directive 2014/61/EU of the European Parliament and of the Council of 15th May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks in Croatian legislation enabled the SGA to become the competent body for the establishment of the single information point.

The establishment of the Utility lines system and single information point is ongoing project in the Republic of Croatia. Single information point is connected with Utility lines system and it will provide data on the existing physical infrastructure and notifications regarding current and planned construction works. As a result, the efficiency of using the existing physical infrastructure will increase and the costs incurred in carrying out new construction works, as well as costs arising from direct and indirect damages, will be reduced. The SGA partly fulfilled its legal obligation for single information point establishment with an application of e-Oglasna ploča (e-Bulletin Board) providing a publication of information on current and planned construction works. Network operators are obliged, according to the Act on Deploying High-Speed Electronic Communications Networks, to publish notifications through the single information point for construction works coordination (Abaza Núñez et al., 2018).

5.4. Collecting the 3D data in cadastral resurvey from the existing registers and other relevant sources

According to the Rules on the Connecting Land Book and the Book of Deposited Contracts (Official Gazette, 2010), the legal obligation of the building manager is to start the procedure of connecting the Land Book with the Book of Deposited Contracts. The Book of Deposited Contract was imagined as a transitional solution for registering the

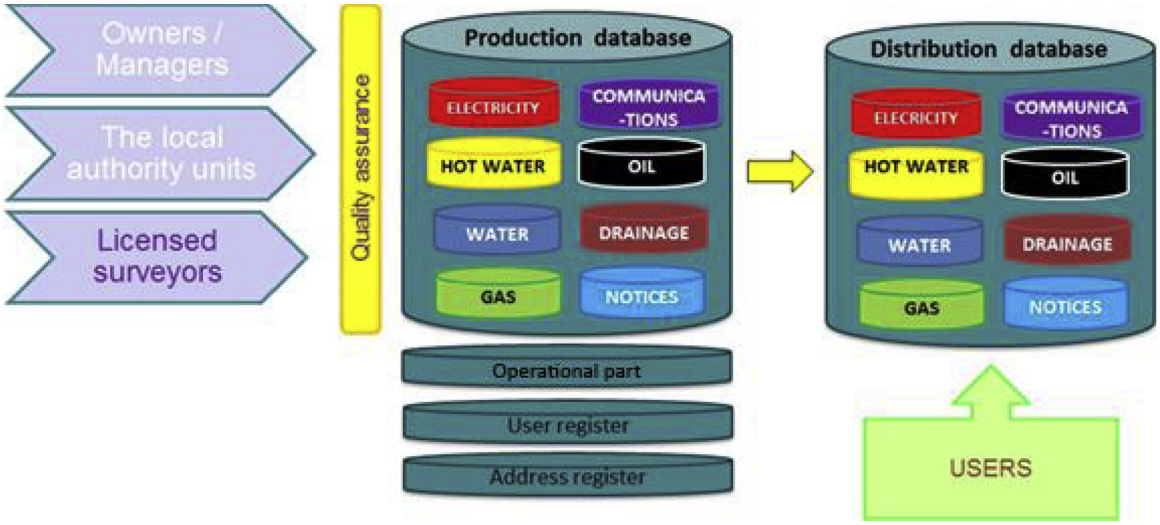


Fig. 9. Croatian utility cadastre (Abaza Núñez et al., 2018).

rights on special parts of buildings where contracts are only deposited but the right is not registered in the land book. However, it remained permanent because the land book wasn't able to process and register these rights. This regulation was brought forward as it was noticed that many buildings built several decades ago were not registered in the cadastre or the land book and have not been partitioned. According to the mentioned regulation, the description of the separate part of a real property contains the data on use (office space, apartment, or other), number of rooms, position of separate part in a building and the area of the separate part (for example, a two-bedroom apartment on the first floor, right side, with the usable area of 5200 m^2). Furthermore, the description of a separate part of a real property also refers to the additions (for example, a woodshed, a garage, a parking space, a balcony, a garden, a terrace, and similar), along with their area, if there is such data. Data on separate parts of a real property are the most interesting 3D data for the land administration.

In the cadastral resurvey, data on separate parts of buildings (apartments and offices) are collected from existing cadastre and land book, but also from other records and statements of property rights holders involved in the process of the cadastral resurvey. For the apartment buildings it is proposed by this paper to collect data such as height of the building, number of floors, year when the building was built, type of usage, year of the last reconstruction, energy class of the building, the completion status and data on right holders of separate parts of buildings. Most of these data can be found in construction building plans, reports on partition of real property or can be gathered from real property holders on the field. Built construction can vary from the project. This is checked by a licensed surveyor upon built construction. According to the Rulebook on the geodetic project (Official Gazette, 2014) it is allowed to have discrepancy under 30 cm between the project and built construction. If the discrepancy is above 30 cm construction cannot get use permit and it needs to be removed or new construction permit needs to be issued (if this is allowed according to the spatial planning). In this way it is ensured that built construction, use permit and cadastral data are referring to the actual state on the field.

SGA is currently preparing the methodology for systematic collection of data about buildings and its parts within the project of e-Registry of buildings. The project is ongoing from March 2019 till March 2022. This is a pilot project within one region (pilot area) of Croatia. Besides data collection the project activities include establishment of information system, education of SGA employees and promotion of results. After the March 2022 the plan is to collect data for the entire country. Registry of buildings will be a new register that will be connected to the existing cadastral system.

5.5. Collecting the 3D data in cadastral resurvey from the Legalisation report

The legalisation of buildings was the process of registering illegally constructed buildings which recently took place in the Republic of Croatia. The interest of real property holders has been substantial and by the year 2013 resulted in more than 800.000 claims for the initiation of the legalisation process. A lot of these buildings were built for agricultural purposes or as upgrades of existing residential buildings. In the year 2018 a new round of legalisation processes started. The current status of those cases is available at the Ministry of Construction and Physical Planning portal (URL 3, 2019). During this process legalisation reports have been produced for illegally constructed buildings and, based on those reports, the registration into cadastre and land book were enabled for such buildings. Due to the large number of claims, the legalisation process represents a significant source of 3D data and contains detailed information on buildings which can further be used as a fundamental data for building 3D cadastre (architectural survey of the as-built situation with calculation of the volume of buildings and parts of buildings, geodetic survey of the as-built situation). Licensed architects and civil engineers have made these projects for illegal buildings and local government officials have gone to the field and checked what has been measured and displayed in the project. This means that information produced during legalisation have passed through a basic quality control.

The following example presents a family house that has gone through the process of the legalisation of illegally constructed buildings (Fig. 10).

An integral part of the legalisation report is a geodetic survey report and the architectural survey report which contains general information on the location of the building (coordinates, street and house number, cadastral parcel number and cadastral municipality name), additional attributes of the building (area, number of floors and the height of the building), volumes (Table 3) of the building according to special regulations for the calculation of the municipal contribution and the water contribution.

Data on volume, precisely calculated in the process of legalisation, could also be delivered through crowdsourcing over a mobile application, web service or web portal of the company which is conducting the cadastral resurvey (Vučić et al., 2015). Similar temporary web services are already developed (only for the use of cadastral resurvey) enabling the two-way communication between all interested subjects of the

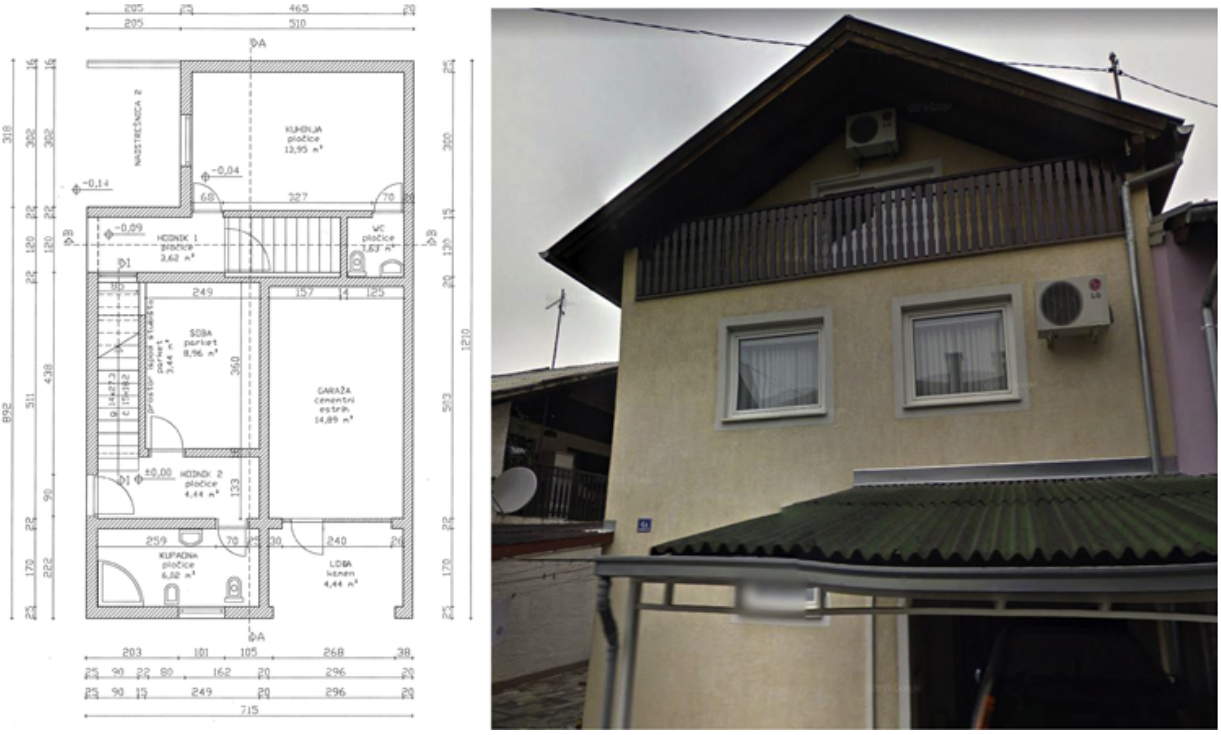


Fig. 10. Example – family house (part of architectural survey report).

Table 3
Part of documentation provided by licensed architect in legalisation process.

Volume of building	
Basement	V1 = 28,59 m^3
Ground floor	V2 = 221,93 m^3
I. floor	V3 = 208,12 m^3
Attic	V4 = 148,14 m3
Total	**V = 606,78 m3**

cadastral resurvey (Fig. 11). By using this specific web service owners and right holders can see the information about cadastral resurvey: the licensed geodetic company which performs the cadastral resurvey, data from the resurvey (alphanumerical and graphical), survey phases and frequently asked questions for stakeholders of cadastral resurvey. In this way, geodetic company can get quick feedback on the validity of data resulting from the resurvey and owners and right holders check the schedule of resurvey by phases. This kind of two-way communication aims to increase the speed of cadastral resurvey process and to ease the communication between geodetic companies and right holders.

5.6. Collecting the 3D data by field measurements in cadastral municipalities for which the land book is not established

In the Republic of Croatia the land book is not established for 150 cadastral municipalities out of an approximate total of 3390 cadastral municipalities. At the same time cadastral data exist for all cadastral municipalities, in digital form for both alphanumerical and geometrical data. Croatian legislation (Official Gazette, 1996) recognises the

Fig. 11. Private geodetic company service for cadastral resurvey project (URL 4, 2019).

establishment of land book (in cadastral municipalities where it does not exist) and renewal of land book (in cadastral municipalities where it already exists but cadastral resurvey has been undertaken so land book can be renewed with up-to-date data). The establishment of the land book can be done so according to the data resulting from cadastral resurvey or even from old cadastral data. This mostly depends on the need for up-to-date data and economical resources of the local government (city or municipality) since they are financing the resurvey in a larger share. Technically, establishment of the land book from old cadastral data is feasible. When the cadastral data, land book data and data in the field are substantially different it results with the following: difficulties in doing business, real estate market insecurity, long procedures in land book, owners and right holders have difficulties in case of inheritance, etc. Another problem in such cases is a large number of dead people listed as owners and right holders. The cadastral office performs the analysis of cadastral and land book data and compares them to the actual state in the field. This analysis is not extensive, and it doesn't result in a set of precisely determined indicators. It is merely an indication whether the discrepancy rate is low, moderate or high. Based on this analysis the local government can send a request to the SGA to initiate the cadastral resurvey in case of high discrepancy rate.

The existence of land book is a basic prerequisite for legal security in real property transactions as the registration in land book is the most credible proof of ownership. It is therefore the duty of the state to establish land book for those cadastral municipalities where it does not exist. The state would have many benefits since the right holders, citizens and companies would have the same opportunities as those in the areas where land book exists, which would ultimately result in increased real estate market security and increased business activity.

During the cadastral resurvey, besides the 2D data on cadastral parcels and buildings which are collected according to the current legislation, it can be defined by investors of cadastral resurvey (SGA and Local government) which additional data should also be collected. Besides the accurate data on right holders, which are missing due to the lack of land book, other real property 3D data mentioned in subSection 5.1 can also be collected. Since the majority of these 150 cadastral municipalities, for which the land book has not yet been established, are mostly in rural areas and it would be a rather easy task with today's modern surveying technologies to upgrade to 3D cadastre as there are few complex 3D situations with overlapping rights like the ones as shown in Fig. 12. This figure presents 3D situations located in cadastral municipalities with land book (for example; a wine cellar that extends below other cadastral parcels, an underground shopping mall, a house built above a pond). But these 3D situations are not registered in the land book in a satisfying manner. Spatial representation of these rights cannot be accurately shown on the cadastral map.

6. Conclusion

The overlapping rights represent the most complex real-life situations handled by the LASs which are traditionally 2D orientated. Incorporating the 3D data into those systems is one great task that has to be accomplished for them to both be able to cope with the requests of today's society and to become modern Multipurpose LAS. The lack of systematically collected 3D data, well-structured, organised and maintained in land registers according to the latest technological achievements is the main obstacle for efficient registration of overlapping rights.

One way to improve this is to try to use the current ongoing processes for the renewal of land data. In the situation, where cadastral resurvey is selected as the best practice for improving the land administration data, we estimate that with a small extra cost it would be possible to adjust and improve this process so it would also be suitable for the systematic establishment of 3D cadastre in the most efficient way. In order to achieve this, it is necessary to partially update the regulations and to improve the data model of the JIS, which is currently the basic tool for land administration. Croatian LAS already has a lot of data scattered in different registers and a great share of these data are stored in a digital form. Croatian government is making reforms by publishing a large number of services for sharing data among people and organisations. This makes easier analysis of data across different registers (cadastre, land book, spatial planning) in order to connect and integrate this related information with purpose of forming 3D cadastre. Some of these data will be used in the project e-Registry of buildings aiming to systematically collect data about buildings and its parts in a new register that will be connected to existing cadastral system.

For the complete implementation of the 3D cadastre through cadastral resurveys, it is necessary to systematically record the height of the measured feature points, instead of only the plane coordinates. Currently this is not the case as there are no legislations making it obligatory for surveying companies. Making this obligatory would, in a short time, import a great amount of legally approved 3D data into

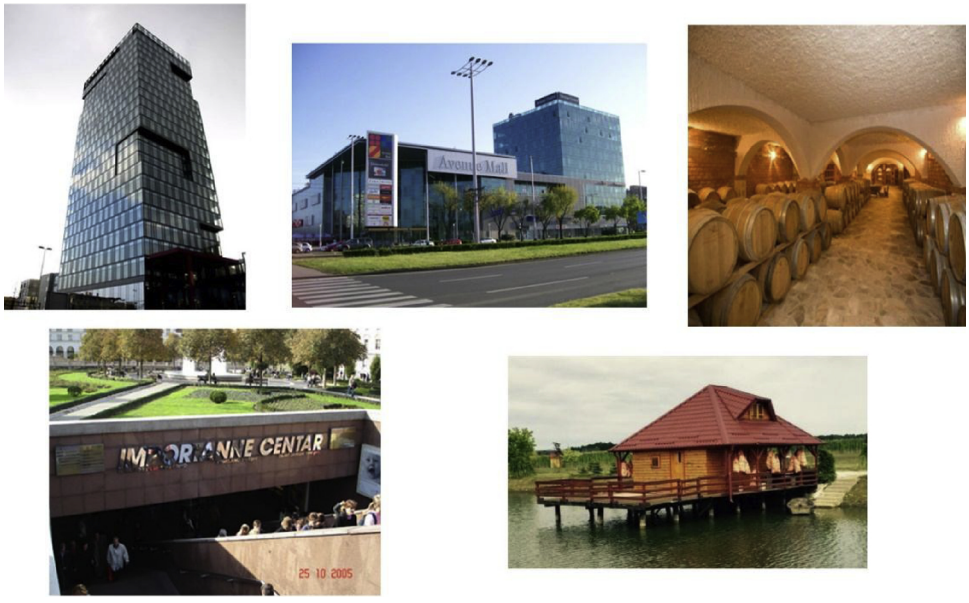


Fig. 12. Example of complex 3D situations.

current LAS, which would complement existing 3D data on properties and would serve as a strong basis for development of initial 3D cadastre. The quality of existing 3D data is different. Data collected through formal procedures in last 30 years have satisfying quality as they have gone through double control procedure, by licensed surveyor and by cadastral or local government officials. The quality of cadastral data from Franciscan cadastre (100–200 years old) should be analysed and estimated.

Also, a major obstacle for the faster development of 3D cadastre is the lack of proper registration of separate parts of real property. The current registration in the land book within the book of deposited contracts contains only a descriptive definition of the extent of ownership rights and no real spatial supplemental data, which is inadequate for clear definition of 3D rights. Therefore, it is necessary to systematically register separate parts of real property into cadastre as it already contains full or partial resources (infrastructure, personnel, knowledge) for handling geometry spatial data.

Acknowledgements

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