A CASE STUDY OF 3D OWNERSHIP RIGHTS REGISTRATION AS A BASIS OF SMART URBAN GOVERNANCE

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ABSTRACT:

The Land Administration System (LAS) is of strategic importance to any country. Effective modern LAS should facilitate land management as an important instrument for the implementation of land policy contributing to comprehensive and sustainable land governance. The infrastructure needed to support increasingly complex requirements or urban space management based on three-dimensional register of rights would bring substantial improvement, especially for management of complex 3D situations. Modern cities are increasingly deploying different types of infrastructure under/on/above ground. The Republic of Croatia decided to establish the Register of Buildings, a transitional register combining data about buildings from existing registers towards the 3D cadastre. The transformation from 2D to 3D LAS should follow international standards, firstly the Land Administration Domain Model (LADM): ISO 19152:2012 but also other ISO and OGC standards. This study analyses the possible re-use of cadastral 3D datasets in smart urban governance procedures, the case of public purpose property valuation. To our opinion the establishment of a 3D LAS should facilitate and enable efficient and sustainable management of urban spaces.

The prototype of 3D LAS, based on LADM conceptual model and its extensions, should enable efficient integration of 3D ownership rights register with the data from other domains - other key registers, taxation, and valuation data (property market data) and other sources of linked data. In this paper, the case study is used to assess the current practice of registration of buildings and their particular parts and analyse the differences between different implementation of 3D partitioned parts.

1. INTRODUCTION

This paper provides an overview of current state of 3D ownership rights registration in Croatia. Following the best practices in LAS, this paper also suggests improvements to better facilitate the use of 3D datasets among different urban governance use case scenarios. Here, the LAS is of a strategic importance to any country since its primary purpose is to support the processes of recording and disseminating information about the ownership, value and use of land and its associated resources (UN ECE, 1996). Currently in Croatia, a new official register is being implemented, the Register of Buildings, following the principle of three-dimensional ownership registration of all buildings and their particular parts (flats, apartments and business premises).

The property valuation for public purposes has always been an important part of a LAS. It implies mass valuation methods, which use the statistical analysis of valuation indicators to simultaneously assess the best use of many properties. The establishment of standardized connections between the authoritative land register information systems would enable the creation of a public purpose property valuation system. The need to integrate national information systems and platforms, to increase information-based policy formulation and decision making has been internationally recognised. The Croatian key registers datasets are harmonized and shared using standardized SDI services following European level INSPIRE directive. Although some of the datasets are already available, harmonization of connected legislation is needed due to differently defined criteria for property registration, valuation and construction of buildings and other structures.

The transformation from 2D to 3D LAS should be in accordance with an internationally recognized conceptual model and an ISO standard - the LADM: ISO 19152:2012 provides an internationally accepted standard model for recording and managing cadastral data. However, the LADM considers semantic and physical representation of buildings and their particular parts as external – meaning that it needs to be linked to external class modelled using existing 3D standards: e.g. OGC CityGML or INSPIRE Building. This study analyses the requirements of existing land cadastre records upgrade to 3D ownership rights register, using existing examples of best international professional practices and international property measurements standards. To our opinion the establishment of a 3D LAS should facilitate and enable efficient and sustainable governance of urban spaces.

2. BACKGROUND

The amount and the complexity of the information maintained as per the public authority regulations are constantly increasing and are strongly related to the development of technology. The possibilities of new technologies are also constantly increasing, thus opening the possibility of collecting new, additional information not previously acquired due to technical difficulties. Cadastral data are basic data for land administration systems. Their availability in a digital form makes them interesting for the increasing number of new areas of human activity and is essential

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for their further development, which has led to a constant increase in demand for cadastral information. Therefore, countries must work on improving the information flow by collecting and maintaining 3D cadastral data to keep up with the growing requirements, especially those related to efficient land administration.

The technological development of various types of sensors, supported by continuous computer performance growth, enables fast and efficient collection of 3D spatial information. These datasets could be used to increase efficiency and usability of LAS through 3D registration of the complex building structures which challenges existing 2D land and property registration system. Nowadays there are many different Integrated Measurement Systems (IMS) available. These systems are using different combination of sensors to overcome specific sensor limitations. Data obtained from these systems may be very different in the terms of accuracy and reliability, due to the nature of the used sensors/combinations, measuring technique specific characteristics, physical characteristics of the measured object and/or lightning conditions. The result is very often an unstructured 3D point cloud or polygonal mesh, containing some additional physical characteristics.

While for visualization or other computer graphics applications these models are very attractive and unquestionably applicable, before application of these datasets in the procedure of 3D ownership rights registration, automatic or semi-automatic classification workflow needs to be developed to reconstruct geometric primitives needed to construct 3D property rights boundaries. This classification often involves different machine learning approaches, but still requires a certain amount of user intervention, e.g. adjustment of error thresholds and identification/removal of physical object that are not subject of registration.

In literature, there are many approaches to the 3D property rights registration (Drobež et al., 2017; Paasch et al., 2021; Tekavec et al., 2018; Vučić et al., 2017), using different methodologies and scope (Karabin et al., 2020). Most of them see the benefits and justifies the costs of establishment through cross domain linkages to other public purpose information systems.

In Croatia, there are number of activities aimed at improving data, business processes, and the organization of land administration, and all of these falls under the National Real Property Registration and Cadastre Program known as Organized Land. One of the project's key objectives is to realize and implement a Joint Information System (JIS) to combine both the land register and a cadastre. The JIS is a unique system which will replace the current different databases, cadastral data models, and associated applications in the cadastral offices of the State Geodetic Administration, as well as the land register databases and applications in the offices of the municipal courts. The SGA implemented the JIS in all cadastral offices in Croatia by November 2016. The Building Register, a newly established 3D ownership rights register, as supplement to cadastral and land registry datasets can be used to develop of a complete and fair basis to determine property tax, improving management of real property, resolving legal issues in multi-residential buildings, housing policy, infrastructure planning, etc.

3. METHODOLOGY

The main task of the research was to assess whether 3D ownership registration datasets can be re-used in the processes of public purposes property valuation. This was achieved using a literature review, analysis of Croatian authoritative land and other public registries – key registers. Although in the domain of national land administration systems there are different drivers and requirements, often complex and changeable, which make it difficult to make single solution for any country (Bennett et al., 2012), our previous research showed that The Land Administration Domain Model (LADM, ISO 19152:2012) as a conceptual model and a ISO standard can be useful in linking of key registers and identifying the missing content and/or data source (Mađer et al., 2015; Tomić et al., 2018; Vučić et al., 2011, 2013). However, the LADM considers semantic and physical representation of buildings and their particular parts as external – our case study examines INSPIRE Buildings 3D standard (D2.8.III.2_v3.0), which adopted many concepts from the OGC CityGML standard.

There are many existing property measurements standards, applicable according to various applications at different levels which has many differences among them (Kara et al., 2018). In the case of public purpose property valuation, the following standards may be relevant to our case study: ISO 9836:2017 Performance standards in building — Definition and calculation of area and space indicators (ISO, 2017), European Valuation Standards (The European Group of Valuers' Association - TEGOVA, 2020), The Council of European Geodetic Surveyors (CLGE) – euREAL Measurement Code for the Floor Area of Buildings (CLGE, 2012), INSPIRE data specifications on Buildings(European Comission, 2013) and OGC CityGML (Kolbe et al., 2021).

4. OVERVIEW OF CROATIAN OFFICIAL REGISTERS

The Croatian LAS is conditioned by different countries which have been, through history, part of the Republic of Croatia. Thus, land information has originated via different dynamics and different conditions, depending on the social organisation of these countries. The Croatian LAS is based on two fundamental registers: Cadastre and Land Book.

To efficiently support the land management procedures, additional data from different public registries are required. The analysis included all available registers (and some additional important data sources) containing information about the land (and connected buildings or other structures and their characteristics) and/or the parties who have an interest in it (Table 1).

Authority	Register/data source
State Geodetic Administration (SGA)	Cadastre / (Land Register – Land Book) Address register Utility cadastre
Judicial Authority/Ministry of Justice	(Cadastre) / Land Register – Land Book Register of non-natural persons
Tax Administration (TA)	Register of personal identification numbers Collection of real property purchase prices
Ministry of Public Administration	Register of natural persons
Ministry of Construction and Physical Planning	Physical Planning Information System (Register of physical planning documentation) Register of Buildings' Energy Certificates

	Real Estate Market Information System
Local Self-Government Units	Communal fee data
Croatian Bureau of Statistics	Price trends and indexes, regional development index (RDI)

Table 1. Land and other registers data sources

The Croatian legal system is built on Roman law, which is common in Western European countries. Public registers can be classified into registers of persons, registers of properties and registers of rights.

The Real Property Registration and Cadastre Joint Information System (JIS) is a unified database and application for keeping and maintaining the land/property and rights/charges data (Land Book and Cadastre). Jurisdiction over the JIS is divided between two institutions (the State Geodetic Administration and the Ministry of Justice) through a steering committee including members from both institutions.

The Address Register (Croatian abbrev: RPJ) contains various types of units: administrative, cadastral, and statistical units, etc. For each unit type, there is a registered ID, name, boundary, and some connected attributes data.

Those two registers – the Real Property Registration and Cadastre Joint Information System (JIS) and the Address Register (RPJ) – are the Croatian LAS key registries.

The Physical Planning Information System (Croatian abbrev: ISPU) stores and administers spatial information related to physical planning. It keeps information on the intended land use, conditions, and limitations of the usage of space, infrastructure, and programmes for protection of the space.

The Tax Administration (TA) is an administrative organisation within the Ministry of Finance. Its primary task is the application of tax regulations. The TA records the data relating to real property transactions and rental prices which are copied into the Real Estate Market Information System (eNekretnine) operated by the Ministry of Construction and Physical Planning. The TA carries out tasks related to the determination and assignment of a personal identification number (Croatian abbrev: OIB). A personal identification number is assigned to both natural and non-natural persons.

4.1 Buildings and their Particular Parts

In Croatia, buildings are registered in the cadastre at the obligatory request of a party. A geodetic report prepared by the authorized surveying company must be supplied with this request. The responsible cadastral office must first review and certify the report. Buildings and other structures are registered with the following attributes: location (2D coordinates), area, intended building use, building name, and house number. A land register takes over two-dimensional data on real property from the cadastre. Real property may be further divided into common and particular parts and registered in the land register based on the report on the particular part of the real property (Figure 1). In this way, co-owners of a real property have a co-owner relationship on the common parts, and each of them becomes an individual owner of a particular part (for example an apartment or office space) (**Figure 1**). This way of registering particular parts began in 1996 and has yet to be implemented for the majority of real properties, as land register registration is purely voluntary (Vučić et al., 2017).

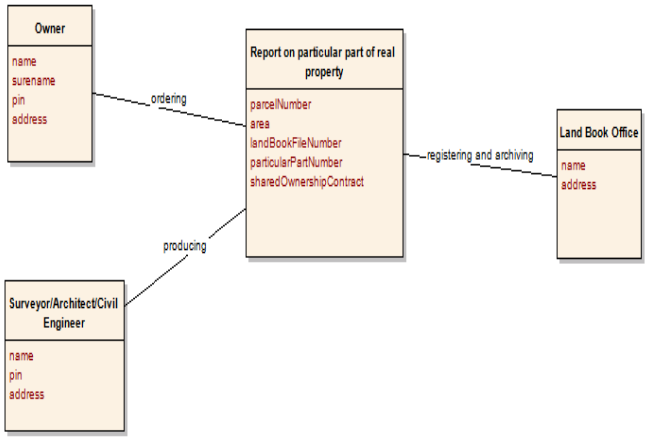


Figure 1. Presentation of creating a report on a particular part of a real property

A good way to introduce the basic settings of the 3D cadastre (in the domain of buildings) is to prescribe the manner of condominium special parts of real estate by ordinance or similar act. It is necessary to standardize the appearance and methods of creating building subdivision maps.

According to the Regulation of the Connecting Land Register 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 register with the Book of Deposited Contracts. According to the mentioned regulation, the description of the particular part of a real property contains the data on intended use (office space, apartment, or other), number of rooms, position of particular part in a building, and the surface of the particular part (for example, a two-bedroom apartment on the first floor, right side, with the usable area of 52,35 m^2). In Croatia entries of flats, apartments and office spaces in the land registry are entered in square meters, but the value is almost always expressed with two decimal places.

4.2 Current state of 3D ownership rights registration

Croatia does not have the complex buildings and structures like in Japan, China, or the Netherlands, but certain 3D situations exist which cannot be modelled in a 2D plane. One of the main problems in Croatia is that building data are scattered in several places including the topographical database, the registry of spatial units, the documentation acquired during building legalization process etc. Unfortunately, one direct consequence of such a state is the high level of data redundancy, which further may cause additional errors in the data.
A 2D geometry profile includes 2D or 2.5D, i.e., a 2D footprint and height. A base profile only contains a fundamental set of building attributes while an extended profile has additional attributes including construction materials, installations, and relationships to other classes such as building units or cadastral parcels, addresses, and so on. Since a large number of buildings in Croatia does not have any kind of technical documentation, information on these buildings needs to be collected from existing data sources and represented in a 2D extended profile using LoD 0. For such buildings, a 3D model (LoD 1) could be created as explained in Reference [20]. Buildings and building parts that have technical documentation (for example, new buildings which have valid construction and usage permits) will

be represented in 3D profile (LoD 2), while building units will be represented in 2.5D (footprint and height).

A great source of 3D data could be gained from the building legalization process, which has been in progress since 2012. More than 800,000 households have initiated the process of building legalization. From that data, LoD 3 (for larger buildings) and LoD 1 or LoD 2 (for simpler buildings) could be created depending on building size.

Based on the principle of reusing public sector information, data on buildings and other man-made structures could be obtained from the subtraction of DTM and DSM as both models are available in the SGA. However, it can only currently be used for general or statistical purposes. For more specific purposes regarding 3D cadastre requiring higher demands of accuracy and precision, this method for obtaining quality 3D data is still not adequate.

5. CASE STUDY DUGO SELO

To assess the current practice of property registering and compare data from different registers, the authors selected a well-known location for which it is convenient to collect all the necessary data, and it is also accessible for the measurement for the purpose of checking the recorded data.

Figure 2. Cadastral map data: land parcel boundaries and buildings

Dugo Selo is a town in Zagreb County, located 20 kilometres east of Zagreb. The selected property is built in 2008, and it is registered on cadastral parcel No. 947/1, cadastral municipality "Dugo Selo II" (**Figure 2**).

Cadastral data – land parcel boundaries and buildings were collected using WFS (available to all users, with authorization) but can be downloaded in GML format (for authorised professionals). This current cadastral records data can be considered as a LoD 0, because buildings are registered using their footprints, there are no 3D information available. The same official cadastral database data can also be freely downloaded as PDF excerpts (**Figure 3**).

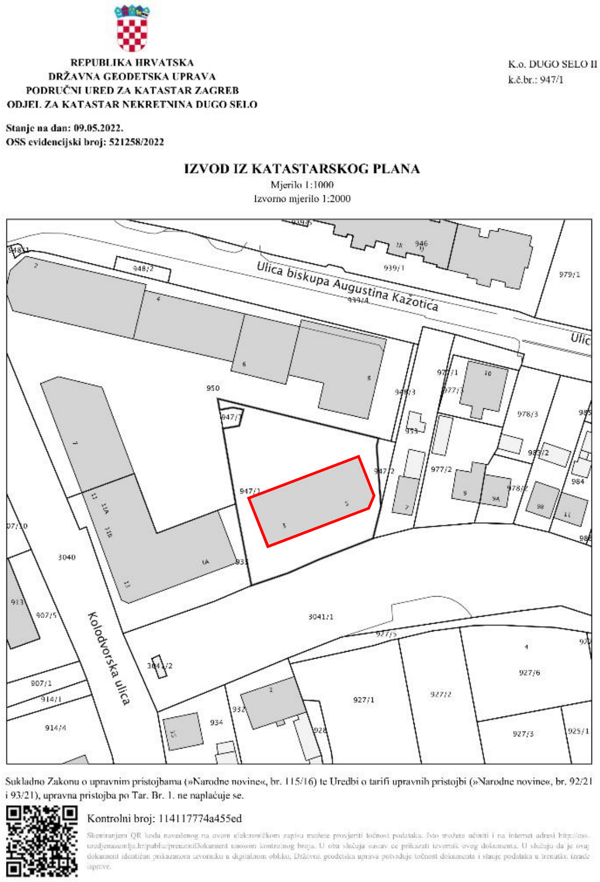
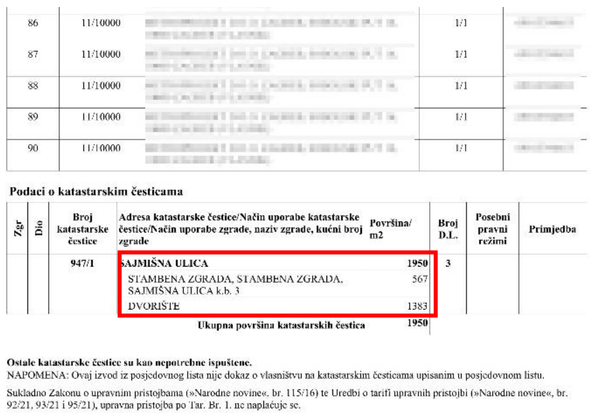


Figure 3. Excerpt from a Land Database – cadastral map

In the cadastral records, the building is registered with a surface area of 567 m^2. Co-owners share are registered accordingly to net useful values of their particular building parts (**Figure 4**).



86	11/10000	[illegible]	1/1	[illegible]
87	11/10000	[illegible]	1/1	[illegible]
88	11/10000	[illegible]	1/1	[illegible]
89	11/10000	[illegible]	1/1	[illegible]
90	11/10000	[illegible]	1/1	[illegible]

Podaci o katastarskim česticama

Zgr	Dio	Broj katastarske čestice	Adresa katastarske čestice/Način uporabe katastarske čestice/Način uporabe zgrade, naziv zgrade, kućni broj zgrade	Površina/ m2	Broj D.L.	Posebni pravni režimi	Primjedba
		947/1	SAJMIŠNA ULICA	1950	3		
			STAMBENA ZGRADA, STAMBENA ZGRADA, SAJMIŠNA ULICA k.b. 3	567			
			DVORIŠTE	1383			
			Ukupna površina katastarskih čestica	1950			

Ostale katastarske čestice su kao nepotrebne ispuštene.
NAPOMENA: Ovaj izvod iz posjedovnog lista nije dokaz o vlasništvu na katastarskim česticama upisanim u posjedovnom listu.
Sukladno Zakonu o upravnim pristojbama (»Narodne novine«, br. 115/16) te Uredbi o tarifi upravnih pristojbi (»Narodne novine«, br. 92/21, 93/21 i 95/21), upravna pristojba po Tar. Br. 1. ne naplaćuje se.

Figure 4. Excerpt from a Land Database

Co-ownership is registered in the Land Register according to interests determined in relation to the registered land unit as a whole and expressed as fractions. Co-owners are registered in the Land Register as the individual owners of particular building parts accordingly to the Report on the particular part of the real property. For the studied property, the Report was made in 2007 and the surface areas of registered parts were calculated using useful area values using the HRN U.C2.100 norm (**Figure 5**).

This norm is basically a norm taken from the former state, with the purpose of property works and property assessment and it dates back to 1966. However, it is still widely used although was replaced by ISO 9836. The biggest problem lies in the fact that particular parts shouldn't be registered using valuation coefficients, meaning there are huge differences in the making of reports on the particular parts. Practice showed that different parts of the Republic of Croatia often made completely different report areas, depending on the understanding of the professionals involved and interpretations of the municipal or city servants involved in the building parts registration process.

REPUBLIKA HRVATSKA

Općinski sud u Sesvetama
ZEMLJIŠNOKNJIŽNI ODJEL DUGO SELO
Stanje na dan: 07.06.2021. 19:05 — Verificirani ZK uložak

Katastarska općina: 308048, DUGO SELO II — Broj ZK uloška: 801

Broj zadnjeg dnevnika: Z-6612/2021 — ETAŽNO VLASNIŠTVO S ODREĐENIM OMJERIMA
Aktivne plombe:

IZVADAK IZ ZEMLJIŠNE KNJIGE

POSEBNI IZVADAK: SUVLASNIČKI UDIO REDNI BROJ: 44 (OSTALO KAO NEPOTREBNO IZOSTAVLJENO)

A
Posjedovnica
PRVI ODJELJAK

Rbr.	Broj zemljišta (kat. čestice)	Oznaka zemljišta	Površina jutro	Površina čhv	Površina m2	Primjedba
1.	947/1	STAMBENA ZGRADA BR. 3 U DUGOM SELU, SAJMIŠNA ULICA			1950 567	
		DVORIŠTE			1383	
2.	947/3	DVORIŠTE U DUGOM SELU, SAJMIŠNA ULICA			35	
		UKUPNO:			1985	

DRUGI ODJELJAK

Rbr.	Sadržaj upisa	Primjedba
1.1	Zaprimljeno 20.09.2011. broj Z-1904/11 Na temelju čl. 116 Zakona o izmjenama i dopunama Zakona o prostornom uređenju i gradnji NN 90/11 ZABILJEŽUJE SE da je za građevinu sagrađenu na čkbr. 947/1, priloženo uvjerenje za uporabu izdato po Upravnom odjelu za prostorno uređenje, gradnju i zaštitu okoliša-isp. D.Selo kl. 361-05/08-02/48, urbroj 328/1-18-03-08-02 od 20.02.2008.	

B
Vlastovnica

Rbr.	Sadržaj upisa	Primjedba
	44. Suvlasnički dio: 199/10000 ETAŽNO VLASNIŠTVO (E-44)	
	Dvosobni stan u potkrovlju oznake /P44/ neto korisne površine 52,00 m2, sa spremištem oznake /S12/ u podrumu neto korisne površine od 1,99 m2, ukupno sa 53,99 m2	

C
Teretovnica

Rbr.	Sadržaj upisa	Iznos	Primjedba
	14. Na suvlasnički dio: 44 (199/10000)		
14.1	Zaprimljeno 14.05.2021.g. pod brojem Z-6242/2021 UKNJIŽBA, ZALOŽNO PRAVO, UGOVOR O STAMBENOM KREDITU POSL. BR. OV-2842/2021 11.05.2021, radi osiguranja novčane tražbine u iznosu od 500.000,00 HRK (slovima: petstotisuća kuna), uvećano za sve ugovorene kamate i troškove te prema uvjetima iz Ugovora, za korist:	500.000,00 HRK	vezano uz B 44 (1.2)

Zemljišnoknjižni izvadak (datum i vrijeme izrade) 07.06.2021. 19:05:00 Stranica: 1

Figure 5. Excerpt from a Land Register

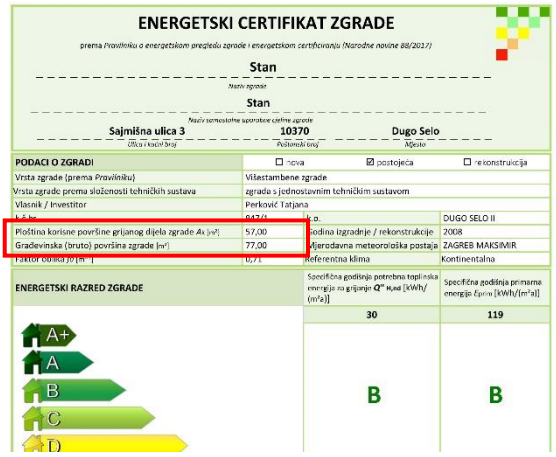


Figure 6. Building Energy Certificate

The building Energy Certificate states the surface area different from the one registered in the Land Register, taking into account the physical characteristics of the particular part: heated surface area and the total surface area with included external walls – gross area (**Figure 6**).

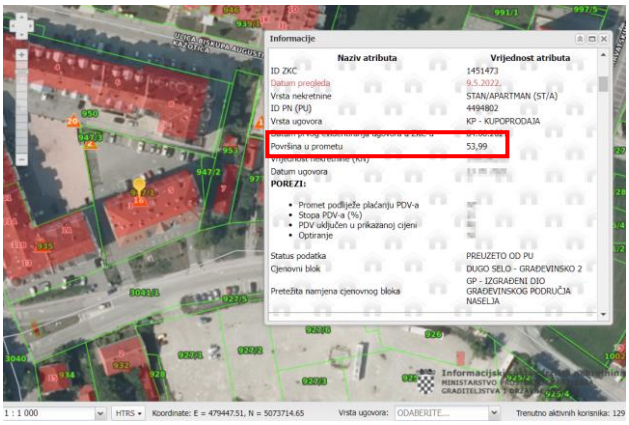


Figure 7. Property market information system

The Property market information system eProperties (In Croatian: eNekretnine) (**Figure 7**) takes data from the Land Register and the surface area of a particular part is identical. This database is based upon Property Valuation Act and it is intended to be used by certified persons. Based on property transaction prices of various property types, price blocks are constructed, and average prices are determined.

Although the Building Register is still in development phase, based on the previous research and published connected legislation it is possible to assume that the LoD 1 would look like Figure 8. The height of the buildings were taken from the construction documentation, buildings are modelled as Boundary Representation Solid (BRep) consisting of composite surfaces, formatted and stored in CityGML format.

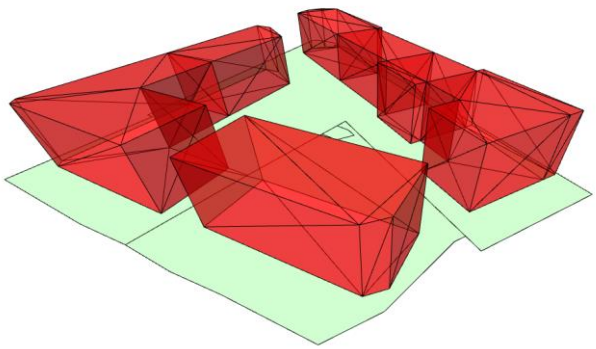


Figure 8. CityGML constructed from building footprints (LoD 1)

For the observed particular parts (units E-44 and E-31) detailed 3D representation was made using the measured 3D datasets (**Figure 9**). These data were used to compare with the data registered in the official registries.

The particular parts registered in the Buildings Register can be created using measurements or existing Report of particular parts (**Figure 10**) or other project documentation.

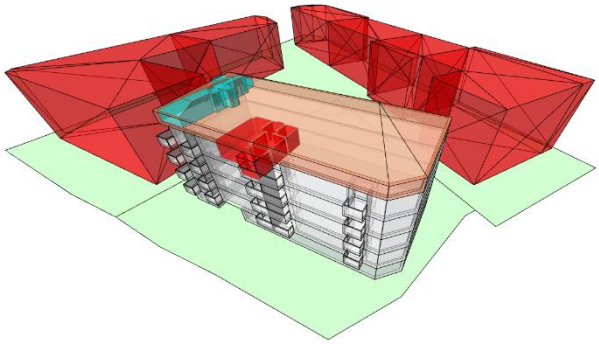


Figure 9. Part of the building modelled accordingly to Report of particular parts

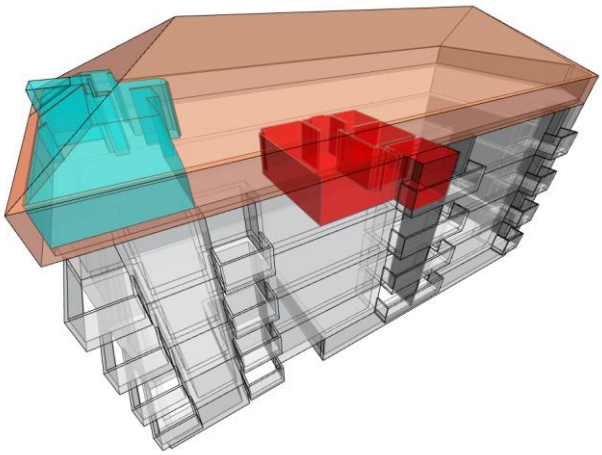


Figure 10. Part of the building modelled accordingly to the Report of particular parts – units E-44 (cyan) and E-31 (red)

As the biggest differences in surface area coefficients are in attics, terraces, balconies and other sheltered spaces, two particular parts that include such areas were deliberately chosen (**Figure 10**). Building unit No. E-44 is an apartment in the attic that includes an un-covered terrace and building unit No. 31 is the apartment on the fourth floor of the building and it includes a loggia (covered terrace with one open side).

6. DISCUSSION

This paper compares differences between registration of building surface area across different Croatian key registers. The case study showed that there are differences between the registered data not only due to different purpose of the register but also to the time when it was registered. However, to our opinion the careful modelling of the Building Register (which is currently still in the development phase in the Republic of Croatia) can enable efficient and sustainable governance of urban spaces. One of the important use cases is the public purpose property valuation, the data of which depends on input data from several registers.

In our previous research papers (Roić et al., 2017; Tomić et al., 2018, 2021) we used schema matching to identify matching classes and attributes of current standards and norms against identified classes and attributes identified in current Croatian authoritative land and other public registries. The analysis showed that in the case of the building registration there are relatively large number of attributes necessary for the assessment which are not recorded in any of key registers.

The case study shows that there are differences between registered surface area and they are mostly due to the registration of the total usable surface area of whole unit, taking into account the coefficients, the amount of which, depending on the purpose, differ significantly. The above can be solved by creation of 3D unit subclasses which share the same characteristics. In this way it would be possible to store additional attributes for the final determination of the total useful value for different purposes and to maintain the existing linkages.

The limitations of used procedure of creation 3D data representation of building units – particular property parts by combination of 3D measurements and use of Report of particular parts (floor plans) stem from the fact that the Report of particular parts is not available for the vast majority of the buildings in Croatia.

7. CONCLUSION AND FUTURE WORK

The surface area and volume of building and their particular parts has been used in many different applications using different norms and standards and methods of determination.

Although our findings in this paper are limited to selected case study, our previous research shows that there are some inconsistencies in the processes of buildings registration in authoritative land and other public registries. The current building registration practice is not fully in line with the re-use of public sector information directive (PSI Directive), meaning that there are no functional linkages between different geoinformation systems established with the aim of collecting data on buildings for various purposes, e.g. valuation, taxation, energy certification. The integration between distributed databases, maintained by different organizations, can be achieved by the means of spatial data infrastructure (SDI).

Our future work will be focused on the schema matching of building data and the intersection of all the available coefficients used in different building registration use cases with the aim of reusing the building data for various public purposes, enabling efficient, information-based decision making.

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