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Towards 3D-Real Property Cadastre in Slovenia

Jernej TEKAVEC, Ema POGORELČNIK, Anja KRŽAN and Anka LISEC, Slovenia

Key words: Slovenia, Land cadastre, Building cadastre, Real property cadastre, floorplan, 3D building models

SUMMARY

The article presents the Slovenian land administration system focusing on the cadastral registration of buildings. We present the current structure of the land administration system and the latest upgrades introduced in 2018. In addition, we outline the main changes in the near future as a result of the new legislation adopted in April 2021 that will come into force in April 2022. The ongoing research and development activities led by the Slovenian SMA (GURS) are further presented. In light of recent research, we study the possibilities for long-term developments of the Slovenian cadastral system towards a fully functional 3D cadastral system. We present two case studies related to the registration of buildings. The buildings were recently registered according to the official registration procedures currently in force. We performed additional measurements and 3D modelling required to obtain a 3D representation of the registered real property units. Once we had the 3D real property units available, we investigated the possibilities of storing the data in a spatial database. The current official registration procedure is compared with the presented procedure for obtaining 3D real property units. We conclude that the proposed approach still needs to be optimised in terms of data processing efficiency for operational introduction in the Slovenian land administration system, where each new building needs to be registered. However, it represents a viable option to enrich the registration documentation for complex RRR situations, where clear 3D spatial delineation of RRRs is needed.

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1. INTRODUCTION

Nowadays, many 2D land administration systems face the challenge of limited ability to capture and register complex spatial situations in terms of rights, restrictions and responsibilities (RRR). 3D land administration attempts to address these issues by introducing 3D real property units. The term 3D land administration is very broad. From a technical point of view, there are numerous technical solutions and implementation options, which in general have already been pointed out by Stoter (2004). There is also no single organisational and legal solution, as each system and legislation have its own particularities.

Despite the above-mentioned differences, it is very important to develop solutions for 3D land administration that are as universal as possible. Standards play an important role in this regard, especially the ISO standard in the field of land administration LADM (ISO, 2012), which is currently being revised and will extend its support for 3D land administration. However, LADM is a conceptual standard that does not provide exact technical implementation (van Oosterom and Lemmen, 2015). Countries, therefore, need to find solutions that fit their systems and enable a seamless transition to the newly developed solutions. Many countries are already considering the development of 3D land administration (van Oosterom 2018, van Oosterom et al., 2020). While many countries have some form of condominium or strata title in their legislation, independent 3D real property units are only introduced in some land administration systems (e.g. Sweden, Australia) (Paulsson, 2007; Shojaei, 2018). The Dutch Cadaster, for example, has already implemented 3D technical solutions into its system (Stoter et al., 2017). In Slovenia, the legal system allows for the registration of strata titles, but not as independent 3D real property units. The latest update of the system in 2018 introduced additional height attributes and digital floor plans, but there is neither a legal nor a technical solution for the registration of 3D real property geometries.

At this point, it is important to highlight that Slovenia operates two parallel but linked cadastral databases, namely Land cadastre and Building cadastre. In 2000, when the *Building Cadastre* was introduced by law, Pogorelčnik and Korošec (2001) investigated the potential for using 3D geospatial data. Interesting research was provided by Drobež et al. (2017), who investigated the possibilities of developing the Slovenian land administration system towards the 3D-enabled system, focusing on additional 3D modelling of the external geometry of buildings using UAV photogrammetry. The recent research on 3D cadastre, also related to the Slovenian legal framework, was done by Tekavec et al. (2020).

In the following chapters, the Slovenian land administration system is presented together with the recent upgrades, the upcoming reform and ongoing research. This is followed by the two case studies, in which we use real-world examples to investigate the possibilities for future upgrades of the system towards 3D land administration. In this study, we follow the concept of detailed modelling of indoor building structure that was proposed by Tekavec et al. (2020).

2. SLOVENIAN LAND ADMINISTRATION

The Slovenian land administration system is based on a dual registration system consisting of a cadastral and a land registry part. The cadastral subsystem, operated by the Surveying and Mapping Authority (SMA), consists of the *Land cadastre* and *Building cadastre*. While the *Land cadastre* dates back to the *Franciscan cadastre* of the former Austrian Empire in the beginning of the 19th century, the *Building cadastre* is a relatively new system introduced after 2000 and aims at providing detailed data on buildings and parts of buildings needed for the registration of ownership and other rights on parts of buildings in Land registry. The Land registry, which is linked to the cadastral system, is operated by the Court and also has its roots in the 19th century. The cadastral system with the Land cadastre and Building cadastre, provides data on the spatial extent and physical characteristics of real property units, while the Land registry manages the data on RRR (Figure 1). As for the compliancy of the Slovenian land administration system with the LADM standard, no study has yet focused solely on this. The system complies with the core concept LADM to link RRRs, parties and spatial units.

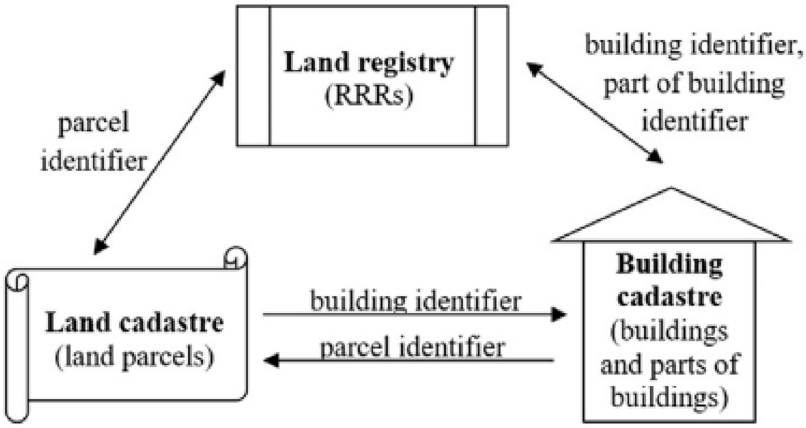

Figure 1: Structure of Slovenian land administration system (Drobež et al., 2017)

2.1 Building cadastre

The Slovenian *Building cadastre*, introduced in 2000, is special compared to other cadastral solutions in the countries in the region. It provides a technical basis for the registration of stratified rights (strata titles) to buildings in the Land registry. Before the introduction of the *Building cadastre*, strata title was registered in the Land registry, where spatial data (sketches of dwellings) was part of the registration documents. A building can be registered in the *Building cadastre* if it can be entered by a person can, if it is designed for housing (permanent or temporary), business activities or any other activities, and it cannot be moved without damaging its substance. A part of a building, i.e. a real property unit, may represent an apartment, office or other parts of a building that can be considered an independent subject on the real estate market.

In the first period of its implementation (2000–2006), photogrammetric acquisition of all buildings was performed, and various attribute data were collected. During this period, the first detailed building entries were made in the *Building cadastre* as part of the creation of the strata titles. Nowadays, the *Building cadastre* contains detailed data on the buildings built after 2006 or on older buildings for which strata titles have been created. All other buildings are registered using basic attributes and geometries, acquired during the first implementation period (2000–2006), and attributes from the mass inventory of real properties. In Slovenia, the strata title is a type of 3D real property where real property units are divided horizontally and vertically. Therefore, the Building cadastre should provide their unambiguous definition with the help of unified documentation containing a georeferenced footprint, maximum building outline, floor plans, and detailed data about the physical characteristics of the building and its parts (Drobež, 2017). Unfortunately, only the georeferenced footprint and the outline of the maximum building extent were recorded in digital vector format at the SMA, while the other data was saved in the form of a scanned document.

2.1.1 Recent changes

Based on the experience of more than 10 years of operational use, the *Building cadastre* was partly modified in 2018. The changes concerned the classification of the use of building parts, digital data submission and geometric data requirements. Regarding the latter, floor plans are now georeferenced and submitted in digital format (GeoJSON). The floor plans contain the outlines of the real property units for each floor. Additionally, the height attributes for each floor must also be submitted to SMA and are stored in the cadastral database. The main reasons for the introduction of vector floor plans were:

- improved quality control of the submitted data,
- enabling 3D visualisation (Figure 2), which, which, as discussed in Tekavec and Lisec (2020), provides a clearer representation of real property units (2020),
- facilitating changes in the delineation of real property units.

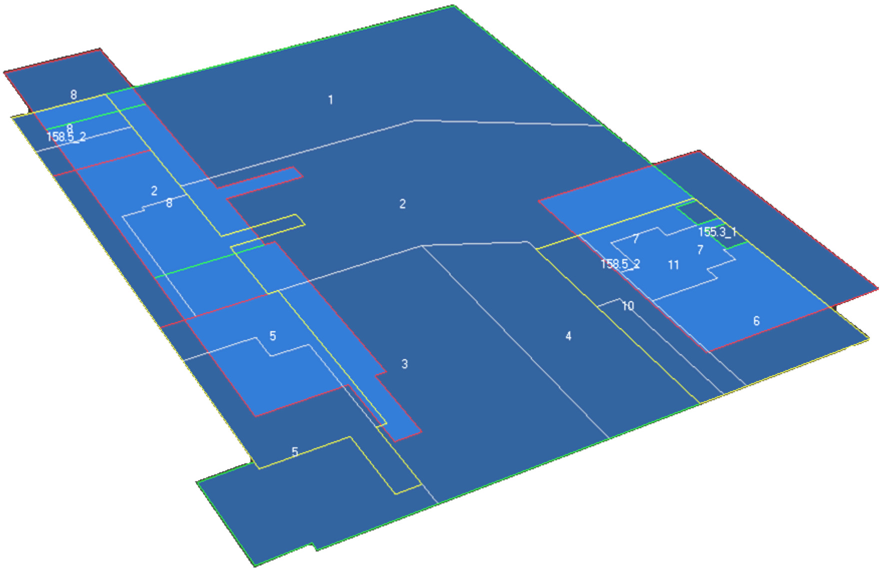

Figure 2: 3D view of GeoJSON floorplans

The changes also affected the authoritative status of the collected data. Many attributes relating to a building or part of a building that were provided by an owner (who also guaranteed for the correctness of the data) prior to 2018 are now verified and provided by the licensed surveyor.

2.1.2 Building registration process and documentation

Under current legislation, the building must be registered in the *Building cadastre* using the detailed documentation (i) if the building is newly constructed or (ii) if the strata title is to be created for an older building. The detailed documentation is prepared by a licenced land surveyor, who is employed in private practice at the request of the owner. The licenced surveyor shall perform the required on-site surveys of the building:

- outline of the maximum extent of the building,
- outline of the intersection of the building with the ground surface,
- minimum and maximum height of the building,
- elevation of the entrance,
- heights of all floors,
- areas of all spaces inside the building,
- outlines of all parts of the building on each floor.

All measurements are performed in the official Slovenian (vertical and horizontal) coordinate system. The documentation for registration consists of several structured forms, an XML file with attributes for database import, georeferenced photos of the building, and floor plans in a GeoJSON file. All documentation prepared by the licenced surveyor is submitted to the Slovenian SMA, where the official administrative registration procedure is initiated. The documentation is then checked and verified. If there are no errors and the legal appeal period has expired (15 days) after the final decision, the new data is transferred to the official database and can be viewed in the public data viewer.

2.2 The upcoming reform of land administration system

In April 2021, the Slovenian government adopted the new legislation (Real Property cadastre Act), which provides the legal basis for the establishment of a new holistic *Real property cadastre*. The act will come into force in April 2022. It is planned to establish a unified cadastral information system that will combine data from the *Land cadastre* and the *Building cadastre*, so that data on parcels, buildings and parts of buildings will be stored and maintained together in one information system. This will enable more efficient management of cadastral data.

As well as bringing together the now separate information systems, the new legislation will also bring improvements to registration processes and documentation. All documentation will be digital, with an emphasis on structured digital data (fewer scanned documents). This will allow more checks and validation procedures to be carried out automatically when the licenced surveyor uploads the registration documentation to the cadastral information system. This will reduce both the need for manual validation of documents and the possibility of errors passing through the registration processes.

In addition, the new legislation allows for the registration of easement and building rights geometries in the cadastral information system. Currently, sketches of the spatial extent of these rights could only be added as appendices to the documents in the Land registry. However, the new legislation will not change the legal definition of 3D real property or the legal definition of easements and building rights. This means that strata title will remain the only option to delineate real property vertically. The same applies to easements and building rights. Here, the new legislation in the cadastral domain, together with the new IT solutions will make it possible to model and include the geometric and attribute data on easements and building rights in the cadastral information system.

For buildings, new geometric properties of buildings will be added to further improve their spatial representation. Outlines of the maximum above-ground extent and maximum underground extent will be added in addition to the currently required outlines of maximum extent and intersection of the building with the ground.

2.3 Research and development activities

The introduction of digital floor plans and additional height attributes in 2018 enables 3D visualisation of the registered real property units. Slovenian SMA has developed a 3D viewer for both floor plans and the external geometry of buildings. Both viewers are already operationally implemented in the internal information system. The main advantage of the 3D viewer for floor plans is the link to the attribute data, which enables combined identification and clear representation of building parts for each owner (Figure 3). The 3D viewer of the external geometry provides a better spatial representation of the data and also helps to identify errors, among others, in height attributes (Figure 4).

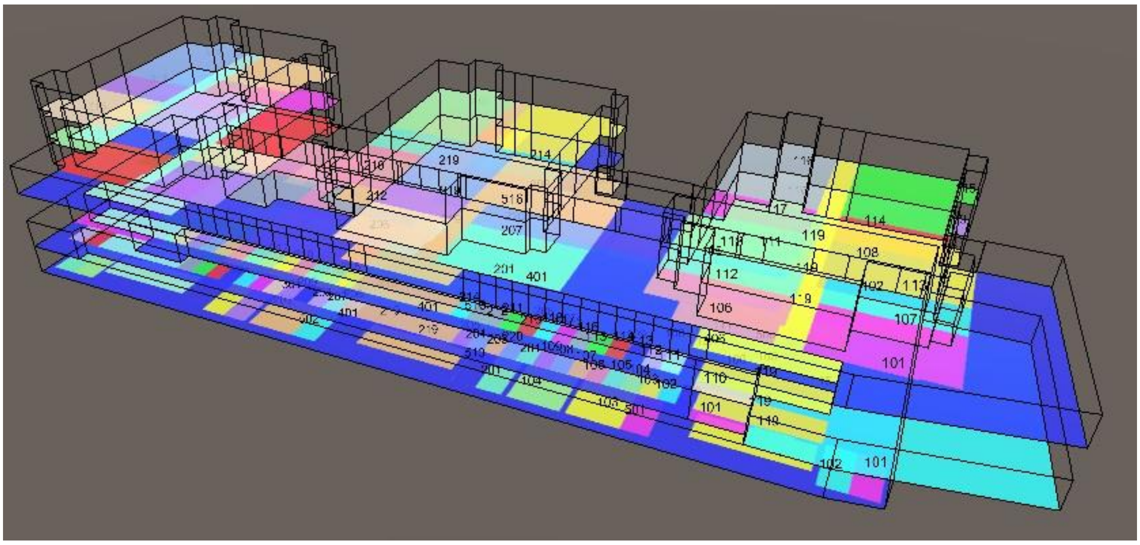

Figure 3: 3D view of GeoJSON floorplans

Prior to 2018, floor plans were submitted to SMA in the raster format, with no height attribute for each floor. The Slovenian SMA launched the pilot project to investigate the possibilities of vectorising these raster floor plans, obtained from cadastral documents. Altogether, 574 buildings were selected for the pilot project.

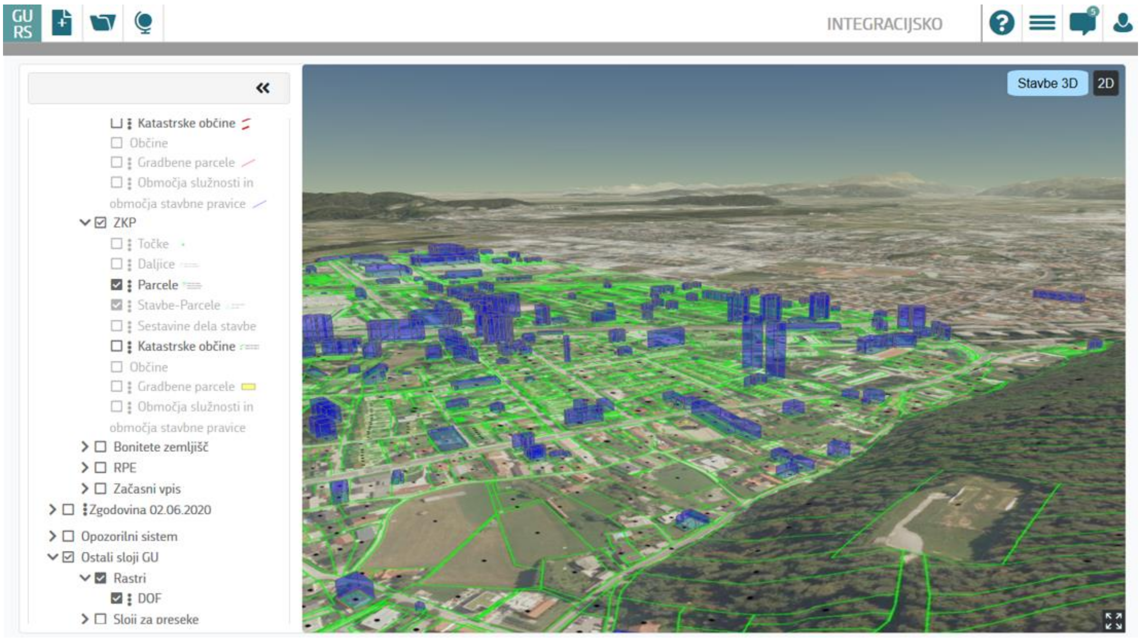

Figure 4: 3D viewer for external building geometry in the Slovenian cadastre

The criteria for the selection aimed to cover all possible variants of the stored data and assure the spatial distribution of the selected buildings over the entire Slovenian territory. As a result of the pilot project, the vector floor plans and height attributes for all buildings were acquired. Several problems were identified during the project:

- misplacement (swapped positions) of building part numbers in the floor plans,
- the shape of the floor plan not matching the shape of the external building outline,
- inconsistency between the attribute data and the graphical representation of the building part (mainly inconsistency between the calculated area from the geometry and the attribute for the building part area)
- missing building part numbers,
- unclear subsequent changes to the building parts,
- missing floor plans,
- illegible floor plans.

All these problems were considered and solved to the best of our abilities. That is, the outcome of the project was also comprehensive quality control and processing, e.g. editing, of the registered data. In the following EU funding scheme (2021-2027), it is planned to extend the pilot project to all buildings registered in the *Building cadastre* before 2018, with the exception of buildings that have only one building part. There are still 155,282 buildings with floor plans, which are not yet vectorised.

In 2021 the Slovenian SMA has published an open call for a 2-year application-oriented research project entitled *GeoBIM and national surveying data*. The project aims to promote research on the adaptation of information systems, legislation, data structures and processes to support BIM data at the SMA. The focus of the project is on the utilisation of BIM data for the registration of buildings and public infrastructure. As the project is relatively short and has a small budget, its results are expected to provide a basis for future projects, which are already planned as the continuation of this project.

3. POSSIBILITIES FOR UPGRADE TO 3D CADASTRE

Our aim was to investigate the potential for upgrading the Slovenian cadastre to a 3D cadastral system for the buildings that were recently registered in the *Building cadastre* (and *Land registry*) using the current official procedure. The concept for the 3D cadastre (Tekavec et al., 2020) essentially uses the 3D modelled indoor spaces, each of which is associated with a corresponding real property unit. In addition, we performed in-situ measurements and incorporated the data into the 3D modelling process to obtain a detailed 3D model of the building. We also evaluated the current capabilities of 3D technology to store the case study data in a database.

3.1 Case study data

The first selected building is a typical Slovenian single-family house (Figure 5), while the second is a more complex commercial and shopping centre that is divided into several real property units (Figure 6). In both buildings, we additionally acquired data on the thickness of the walls and ceilings, the locations and dimensions of the passages. In the more complex spaces (sub-roof spaces, stairs), we measured additional heights to allow for proper 3D modelling of the spaces.

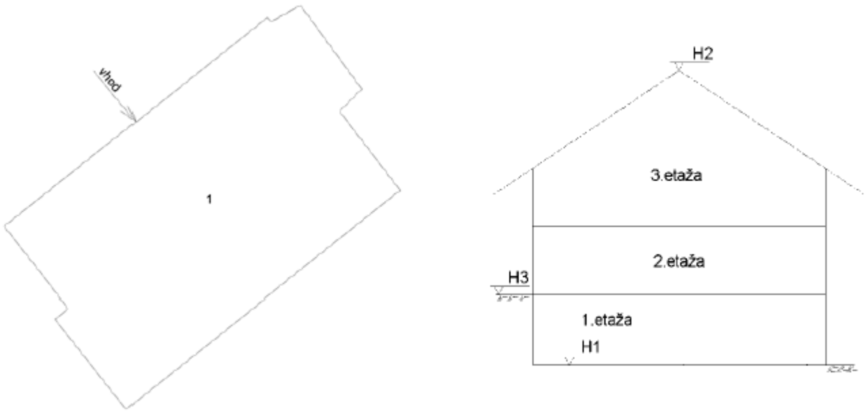

Figure 5: Floor plan and cross-section from the official documentation of the first building

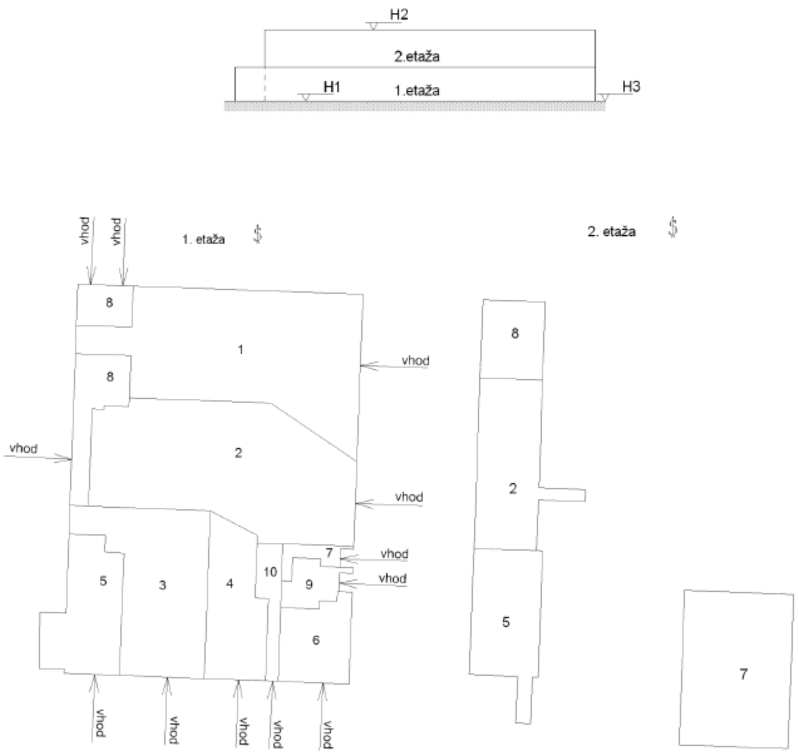

Figure 6: Floor plan and cross-section from the official documentation of the second building

3.2 3D modelling

We used Trimble SketchUp software for 3D modelling of indoor spaces. Each space was modelled as a solid component (Figure 7). The passages between spaces were modelled with a touch relationship. During modelling, we can also assign attributes to each indoor space. The most important is the real property unit to which the space corresponds. SketchUp does not allow adding multiple attributes to the component, so additional attributes can be added using the delimiter character. An attribute can be later parsed into multiple attributes in the FME.

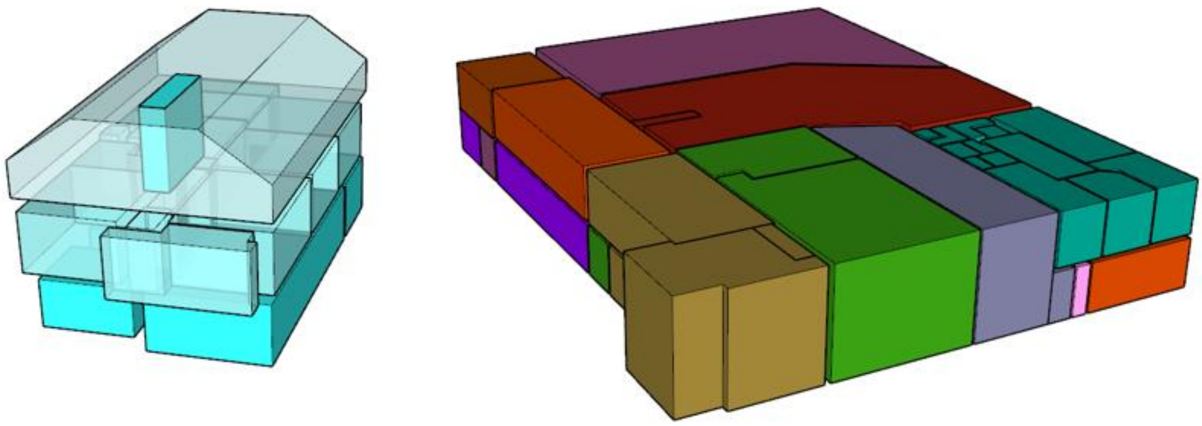

Figure 7: 3D models of indoor spaces for the first (left) and the second building (right)

3.3 DBMS storage

The 3D model has to be pre-processed to be suitable for DBMS storage. We used Safe Software FME to transform the geometries and prepare the attributes, and a PostgreSQL database for data storage. The geometries are imported as one feature, so we first needed to remove the aggregation with the *Deaggregator* transformer. The attributes were extracted using the *GeometryPropertyExtractor* transformer. Then the individual attributes contained in that attribute and separated by delimiter were extracted using the *AttributeSplitter* and *AttributeManager* transformers. The geometries were transformed into solids using the *SolidBuilder* transformer. If errors were made in modelling solid geometries in SketchUp, the *SolidBuilder* transformer identifies these geometries and rejects them. The geometries and attributes are inserted into the PostgreSQL database using the PostGIS writer. Such data can be linked with current data in the official Building cadastre database.

4. DISCUSSION AND CONCLUSIONS

The current ongoing modernisation of the Slovenian land administration system will be completed in April 2022. There are still some difficulties in the implementation of the information system, as the system is to be integrated into the common digital environment of the Ministry Public Administration. Difficulties are also expected in the timely training of both private sector surveyors and SMA staff to properly use the new system. As far as the introduction of 3D geometry into the Slovenian cadastral system is concerned, some steps have already been taken and are presented in this paper. For georeferenced 3D building models, the vector floor plans introduced in 2018 have to be georeferenced to represent the actual position of a real property unit in the national reference geodetic system. For a building model, as suggested in this research, e.g., indoor spaces as the core elements representing 3D real property units, measurements inside the building have to be performed in the official Slovenian coordinate system. Since a line is delineating two real property units, there is also a well-known dilemma regarding the position of the line in relation to the walls.

We have found in the case studies that the amount of additional data and work required to obtain correctly modelled 3D real property units cannot currently be introduced for all buildings. The biggest problem is the acquisition and combination of additional data and 3D modelling. Usually the missing measurements/data in the current building registration process are found when performing 3D modelling. Also, 3D modelling is much more complex than creating a 2D floor plan and takes more time. However, the proposed approach could be used to solve complex RRR situation, where 2D floor plans a cannot clearly represent the situation clearly. Last but not least, new technologies (e.g. SLAM scanners) will become more widespread and will allow more efficient 3D spatial data acquisition and modelling for indoor environment. This will reduce the additional costs of the processes, and consequentially make the operational implementation of 3D technologies, as presented in our case studies, more feasible.

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BIOGRAPHICAL NOTES

Jernej Tekavec graduated from the University of Ljubljana, Faculty of Civil and Geodetic Engineering (UL FGG) in the field of Geodesy. Currently, he is employed as assistant researcher at the Chair of Geo-informatics and Real Estate Cadastres, UL FGG, and is a PhD candidate at the same faculty. His research is focused on real estate cadastres, 3D city modelling, and 3D spatial analyses. He is actively involved in current national and international projects and activities of the chair.

Ema Pogorelčnik Graduated from the University of Ljubljana, Faculty of Civil and Geodetic Engineering. She continued the postgraduate studies at the Faculty of Law in Ljubljana. Employed at the Surveying and Mapping Authority of the Republic of Slovenia (GURS), currently as the head of the sector for the building cadastre. She managed all projects in the field of building cadastre in the Republic of Slovenia. She is currently leading a project of information modernisation of real estate registers.

Anja Kržan Studied and recently received a Master's degree from the University of Ljubljana, Faculty of Civil and Geodetic Engineering. Her work was related to 3D modelling of cadastral data with the focus on buildings.

Anka Lisec Since completing her PhD in 2007 Anka Lisec has been employed at the University of Ljubljana, Faculty of Civil and Geodetic Engineering (UL FGG), currently as Associate Professor and researcher. She has been the head of the Chair of Geoinformation and Real Estate Cadastres since 2016. Beside her research work within national and international projects in the fields of geoinformatics and land administration, she is currently actively involved in the preparation of new cadastral legislation as well as in developing strategic guidelines for the national mapping and surveying service.

CONTACTS

Jernej Tekavec, PhD
University of Ljubljana, Faculty of Civil and Geodetic Engineering
Jamova cesta 2, 1000 Ljubljana
SLOVENIA
Phone: +386 1 4768 561
E-mail: jernej.tekavec@fgg.uni-lj.si

Ema Pogorelčnik, MSc
Surveying and Mapping Authority of the Republic of Slovenia
Zemljemerska ulica 12, 1000 Ljubljana
SLOVENIA
E-mail: ema.pogorelcnik@gov.si

Anja Kržan
University of Ljubljana, Faculty of Civil and Geodetic Engineering
Jamova cesta 2, 1000 Ljubljana
SLOVENIA

Assoc. Prof. Anka Lisec, PhD
University of Ljubljana, Faculty of Civil and Geodetic Engineering
Jamova cesta 2, 1000 Ljubljana
SLOVENIA
Phone: +386 1 4768 560
E-mail: anka.lisec@fgg.uni-lj.si