Processes in Cadastre: Process Model for Serbian 3D Cadastre

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Key words: Processes in cadastre, 3D cadastre, Web services, SOA, OpenBIM

SUMMARY

Identifying the processes in the cadastre enables understanding the principles on which the cadastre works and the needs for its improvement. These processes define the way how the cadastre manages information and what are the prerequisites for the data to be stored in the appropriate data structure. The first step in determining the set of processes is defining business tasks in a cadastre that arise from the needs of different users - internal in the cadastre and external, like right holders, the Government and many other organizations. These needs define business tasks and data sets necessary to successfully perform the task. The next step is to define the process itself, and then implement the process in the appropriate architecture.

Navratil and Andrew (2004) organize processes in the cadastre in two groups: processes that change the data in the system and the processes by which data are downloaded or viewed. The analysis of business processes in the Serbian cadastre shows that such basic process division is applicable as an initial step in the process hierarchy. A top-down strategy was selected for describing the processes. This strategy increases the decomposition of the process from general to specific, thus creating an insight into the elements of the subsystem. At the highest level, a system overview is defined without the introduction of process details. Each subsequent level introduces more details, or processes, as long as the level specification is not reduced to basic processes or activities. The standardization of specific processes for all cadastres in the world is impossible due to the large differences in the way in which certain procedures are implemented from one country to another. However, the first three levels of the described hierarchical process group division can be applied to cadastral transactions in general.

The processes in cadastre can be implemented using the technology of Web services in a Service Oriented Architecture (SOA). The technology of Web services supports automated integration of systems of independent organizations and are in wide use for that purpose. Having this in mind, in this paper we first present a developed model for the processes in Serbian cadastre and then extend it to support data maintenance and transactions in 3D cadastre, including registration and update of 3D spatial units. Considering the ongoing projects in the world on integration of geospatial information with indoor spatial information and building information modeling, we explore the possibilities of implementation of 3D information in the SOA environment. If the information about 3D legal spaces is encoded using buildingSMART openBIM standards we explore the possibility of using these standards including BIM Collaboration Format (BCF), an XML schema and RESTful web service for the exchange of data which is shown on the selected case study of a typical building.

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1. INTRODUCTION

Processes in the cadastre enable understanding the principles on which the cadastre works and provide basis for its further improvement. These processes define the way how the cadastre manages information and what are the prerequisites for the data to be stored in the appropriate data structure. Options for standardization of processes and transaction in land administration have already been considered given developments as Fit-For-Purpose Land Administration, Apps and blockchain (Lemmen, 2018). The processes in cadastre can be implemented using the technology of Web services in a Service Oriented Architecture (SOA). There are already a set of web services in use in Serbia and Montenegro, as described by Govedarica et al. (2018). Cadastral Web services are used by the information systems of other public and private organizations such as banks, different government agencies (tax administration, business registry agencies, anti-corruption agency, agriculture subsides), etc. that use cadastral data. They are also used for the work of the eGoverment portal through which online services to clients are executed. The technology of Web services supports automated integration of systems of independent organizations and are in wide use for that purpose.

Having this in mind, we developed a model for the processes in Serbian cadastre and then extend it to support data maintenance and transactions in 3D cadastre, including registration and update of 3D spatial units. The increasing complexity of modern land use, particularly in the growing urban areas, requires that land administration systems will need a capacity to manage spatial units in three dimensions, and not only in 2D as is now the case through the means of a cadastral map that contains 2D borders of parcels and buildings. The advancement of technology for 3D data acquisition and storage supports such need and it is necessary to evaluate how it fits to the process model. This requires the analysis of types of transactions defined in the law and associated rulebooks and code lists, and possible overlaps of rights in 3D. Cadastral registration of 3D spatial units may be beneficial for activities that relay on land administration, such as taxation, spatial planning or obtaining a building permit and this link with the processes under jurisdiction of other organizations justifies the use of land administration process model and its implementation into SOA. Considering the ongoing projects in the world on integration of geospatial information with indoor spatial information and building information modeling, we explore the possibilities of implementation of 3D information in the SOA environment.

The paper is structured as follows. After the introduction, Section 2 describes processes in Serbian cadastre. It combines both traditional processes based on the exchange of 2D data, with processes that allow introducing 3D to already existing workflows. Section 3 proposes a method for the implementation of 3D data into these processes based on buildingSMART openBIM and discusses advantages and challenges of such approach. Conclusions and future work are given afterwards.

2. PROCESSES IN CADASTRE

The first step in determining the set of processes is defining business tasks in the cadastre that arise from the needs of different users - internal in the cadastre and external, like right holders, the Government and many other organizations. These needs define business tasks and data sets necessary to successfully perform the task. The next step is to define the process itself, and then implement the process in the appropriate architecture.

Navratil and Andrew (2004) organize processes in the cadastre in two groups: processes that change the data in the system and the processes by which data are downloaded or viewed. Processes that change the data can further be divided according to the data group, that is, the processes of changing technical, legal and additional data. The change of data indicates transactions for entering, modifying or deleting the corresponding data. Processes for data review involve viewing, searching, printing and downloading technical, legal and other data.

The analysis of business processes in Serbian cadastre shows that such basic process division is applicable as an initial step in the process hierarchy. A top-down strategy was selected for describing the processes. This strategy increases the decomposition of the process from general to specific, thus creating an insight into the elements of the subsystem. At the highest level, a system overview is defined without the introduction of process details. Each subsequent level introduces more details, or processes, as long as the level specification is not reduced to basic processes or activities.

IDEF0 notation was used to describe the hierarchical structure of the process in the real estate cadastre. IDEF0 is the language for functional modeling. It is suitable for top-down modeling, starting from the basic process division in the system, by defining process groups that contain the basic system processes. The basic processes in the system can further combine less complex processes and concrete activities. At the lowest level it is necessary to introduce more details, such as participants, events, branching, activity flows, message flows ... For the description of the workflow, BPMN is more appropriate, so this notation is used to describe the lowest level of the processes.

Figure 1 shows the hierarchical organization of the process levels. Process A decomposes to processes A1 and A2, then A2 to A2.1 and A2.2 ... Adding the appropriate prefix when naming the process marks its parent process.

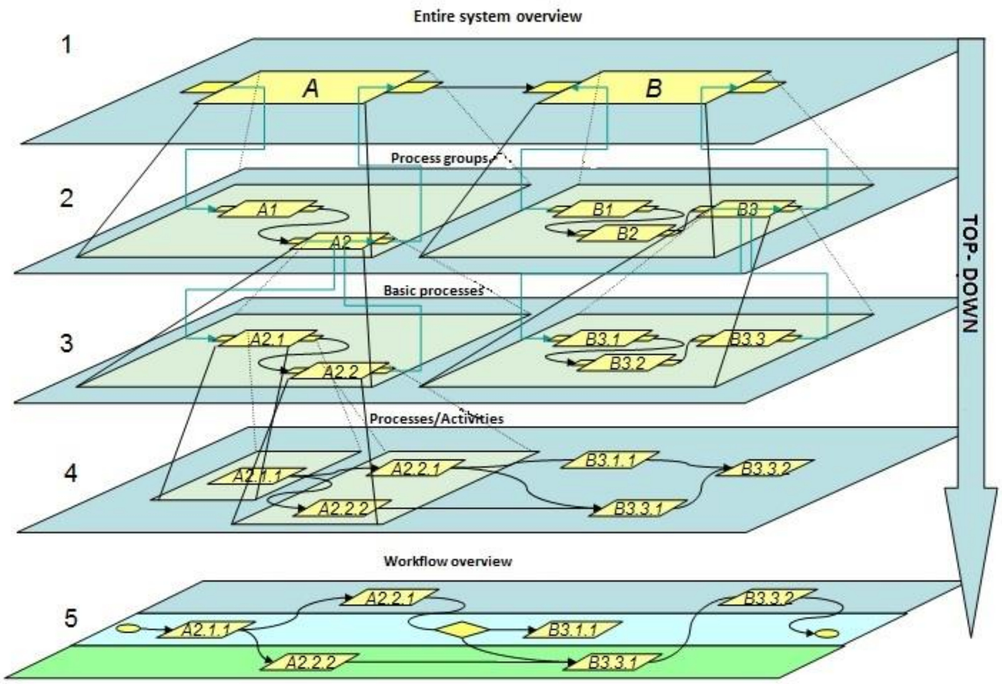

Figure 1. Process levels – top-down strategy

Two basic modeling elements for IDEF0 notations are functions (represented by rectangles) and data that connect functions (represented by arrows). Figure 2 shows the basic semantics of the meaning of rectangles and arrows in the process description (FIPS PUBS, 1993).

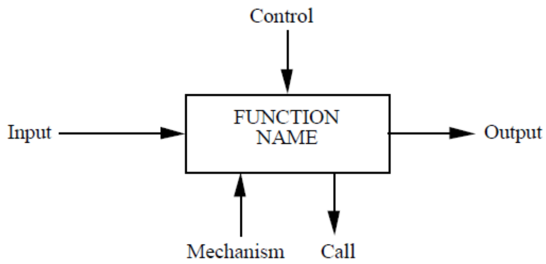

Figure 2. The basic semantics of rectangles and arrows in the process (FIPS PUBS, 1993)

An input refers to events that trigger an activity or data that is transformed within an activity. Control refer to conditions that govern or regulate activity. Unlike inputs, controls do not change during the activity. These may be some documents and materials. Mechanism represent the resources needed to carry out the activities, e.g. people, equipment, financial resources ... Call is a type of mechanism that sends details between the model. Output represents activity results, processed or transformed data.

The highest level of hierarchy is called the context. In the case of Serbia's cadastral system, this is Level 1 which contains an overview oft the entire system. According to the basic division of the process from the beginning, at this level the processes *KN1-Overview of data* and *KN2-Changes on data* are arranged (Figure 3).

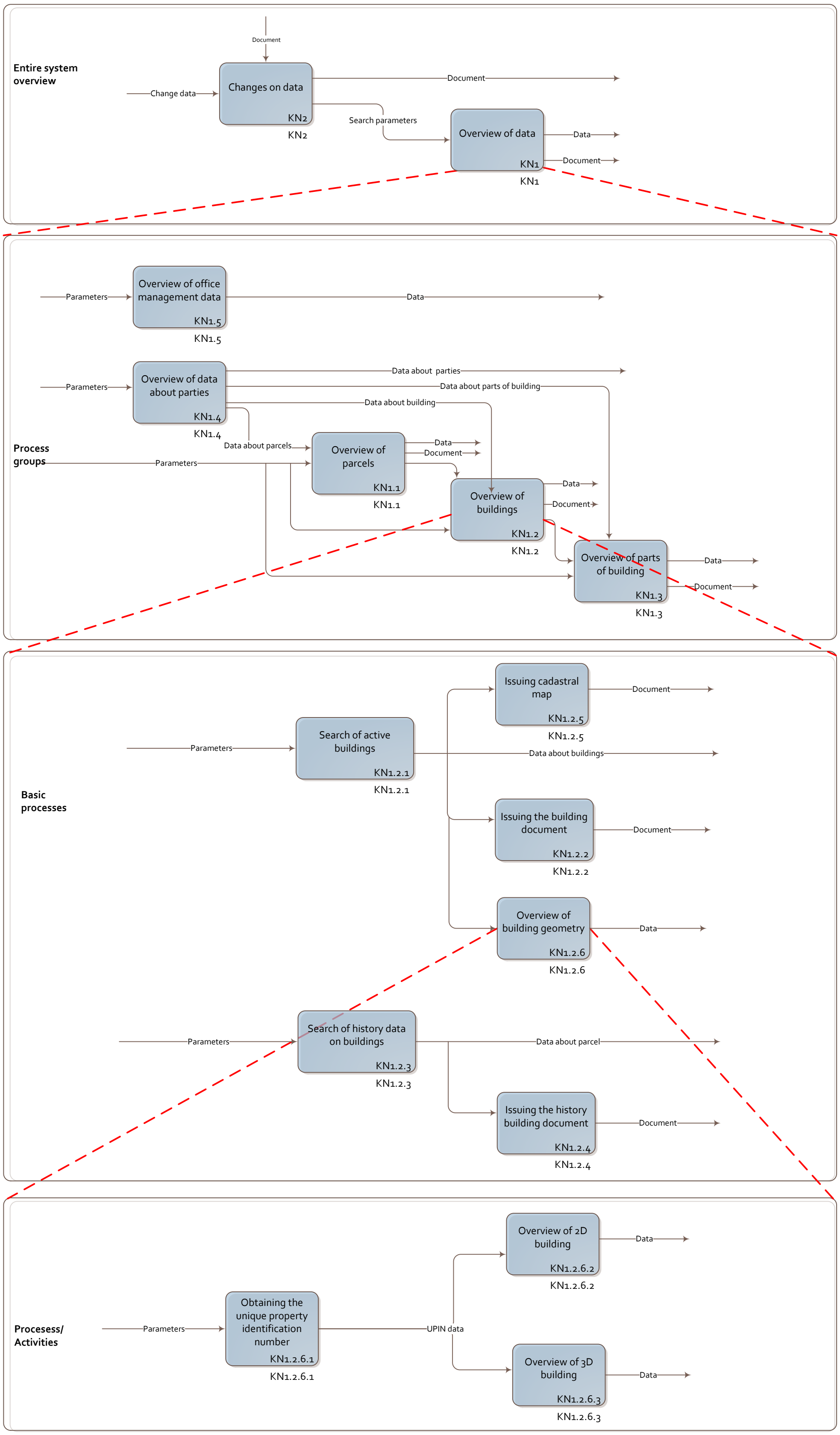

Figure 3. Hierarchical overview for the KN1 process

Process hierarchy for both KN1 and KN2 processes are described by Radulović (2015). Processes and workflows are described according to the Law on State Survey and Cadastre (2009), the Rulebook on Cadastre Survey and Real Estate Cadastre (2016) and the Law on the Procedure for Registration in the Real Estate Cadastre and Utility Network Cadastre (2018). The Law from 2018 introduces the novelty that each property is identified with unique property number. This is particularly important to mark real estate in 3D data sources. Process hierarchy is extended with processes that enable overview and registering 3D data in real estate cadastre.

For the KN1 process Level 2 contains process groups that relate to overview of office management data, overview of parties, parcels, buildings and parts of building. Level 3 shows basic processes of the *KN1.2 – Overview of buildings* process. This level covers processes for searching active and history data about buildings, issuing the documents and overview of geometry (*KN1.2.6 – Overview of building geometry*). Level 4 contains processes and activities that specifically describe a process, while Level 5 contains the workflow in the BPMN notation. Level 4 shows processes that can be executed in order to view geometry of the building. Figure 4 shows the workflow for overview of building geometry. Based on search parameters user obtain unique property identification number (UPIN), which is then checked for the type of geometry. If the geometry of the building is 2D, a process *KN1.2.6.2 – Overview of 2D building* is called. If the geometry of the building is 3D, a process *KN1.2.6.3 – Overview of 3D building* is called. Based on the retrieved data, proper geometry viewer is started and data is displayed to the user.

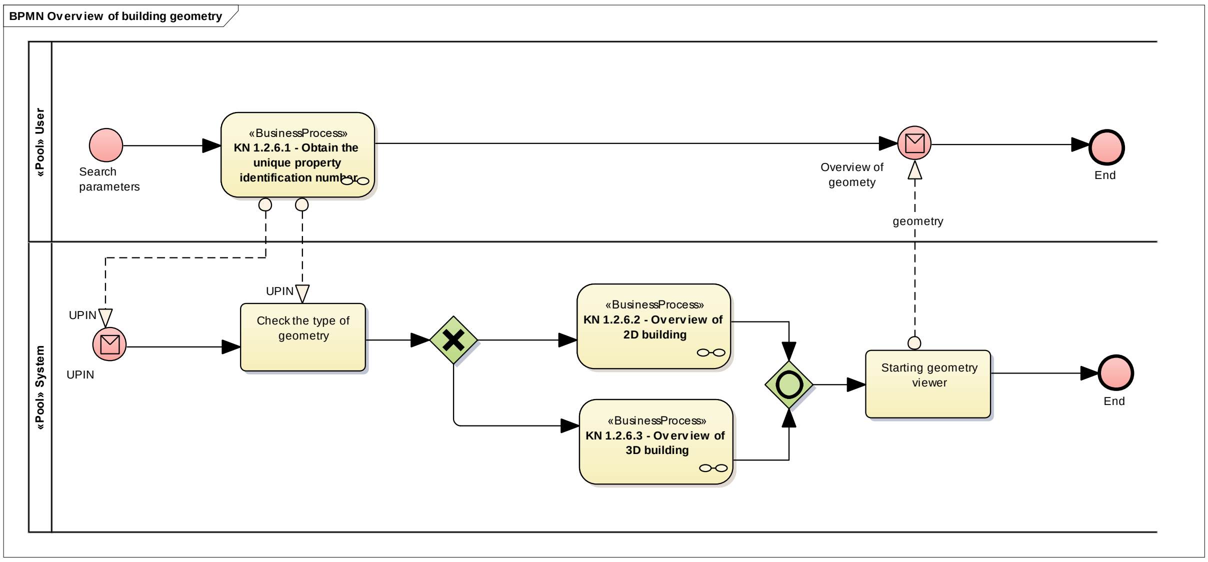

Figure 4. Workflow for overview of building geometry

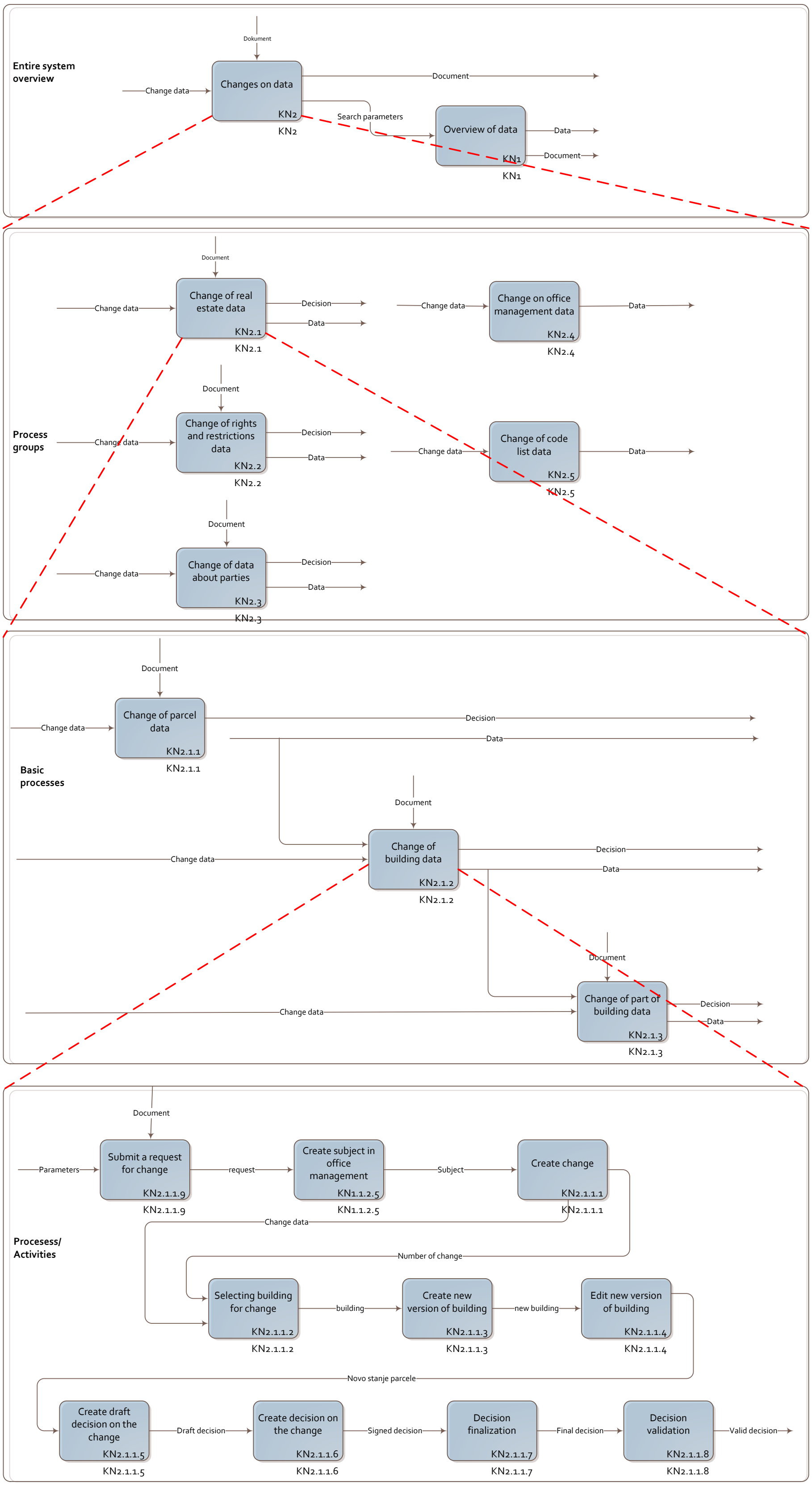

Figure 5. Hierarchical overview for the KN2 process

For the KN2 process, Level 2 contains processes that describe how data can be changed. Processes can be grouped into processes of changing technical data, i.e. changes on real properties (*KN2.1 - Change of real estate data*), processes of changing rights and restrictions on data (*KN2.2 – Change of rights and restrictions data*), processes of changing data about parties (*KN2.3 – Change of data about parties)* and changes on other data such as office management (*KN2.4 - Change on office management data)* or code lists *(KN 2.5 – Change of code list data*).

For the *KN2.1 – Change of real estate* data process, Level 3 contains basic processes that relate to the change of real property data. These processes relate to changes on parcels, buildings and parts of buildings like flats, business spaces... For the Level 4, the process *KN2.1.2 – Change of building data* is chosen to show processes and activities that are performed during the change of building data. Figure 6 shows this process with BPMN notation in order to specify the flow of the processes and activities that make it, the participants and the messages that are exchanged between them.

There are four participants in the process, the User, the Office Management Referent, who registers the request in the form of subject, the Referent who performs the change of the data and creates the draft decision on change, and the Chief who signs the decision, which the Referent prints and forwards to the Office Management Referent. The Office Management Referent sends a decision on the change to the User.

Figure 7 shows the workflow for the process *KN 2.1.1.4 – Edit new version of building*. An input to this process is the data on selected buildings for the change. Depending on the type of the change, there are two basic flows of execution. If only the attributive data of the building are changed, such as the address, legal status, usage, number or area, the geometry of the building is not changed, and after the submitting, the process ends or starts from the beginning if there were more selected buildings. The second flow of the process relates to changes of geometric data. Two flows of activity are distinguished. The first flow consists of activities that are performed if the 2D data is changed. This flow implies entering, editing and deleting a 2D building. If it is necessary to change building's descriptive data, the flow leads to this set of activities, after which the process ends. The second flow consists of activities that expand the process to support 3D data. First step is to obtain uniqe property identification number. This flow relates to insert, replace and delete 3D spatial source of the building. If the data is inserted or replaced it is necessary to link the new source with the unique property identification number. This flow also enables the change of attributes, after which the process ends.

This method can be used to describe all processes of the system starting from the process groups of the second level. After the process decomposition, an individual processes can be obtained on fourth level and appropriate workflow can be modeled. The standardization of specific processes for all cadastres in the world is impossible due to the large differences in the way in which certain procedures are implemented from one country to another. However, the first three levels of the described hierarchical process group division can be applied to cadastral transactions in general.

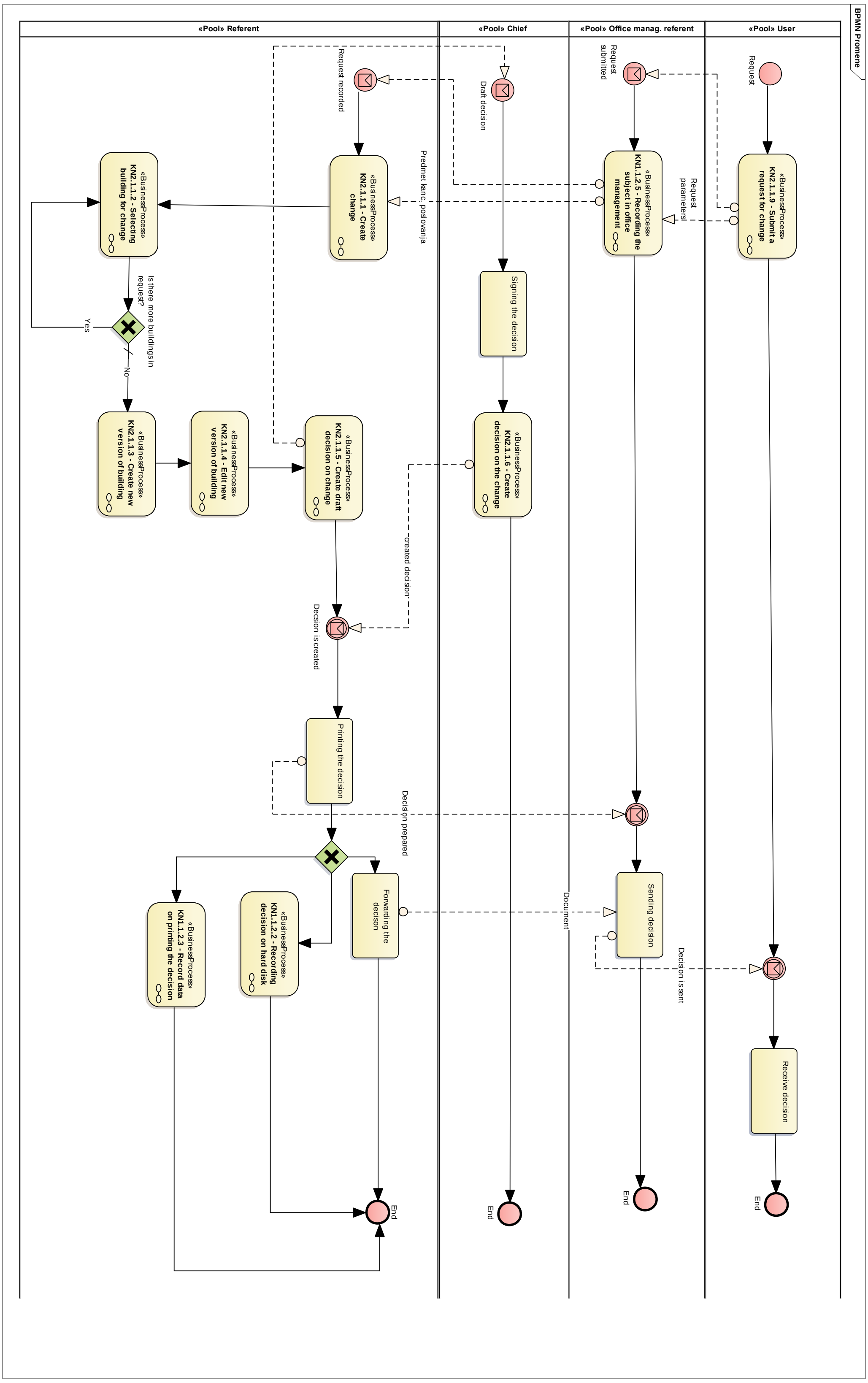

Figure 6. Model of the business process for changing building data

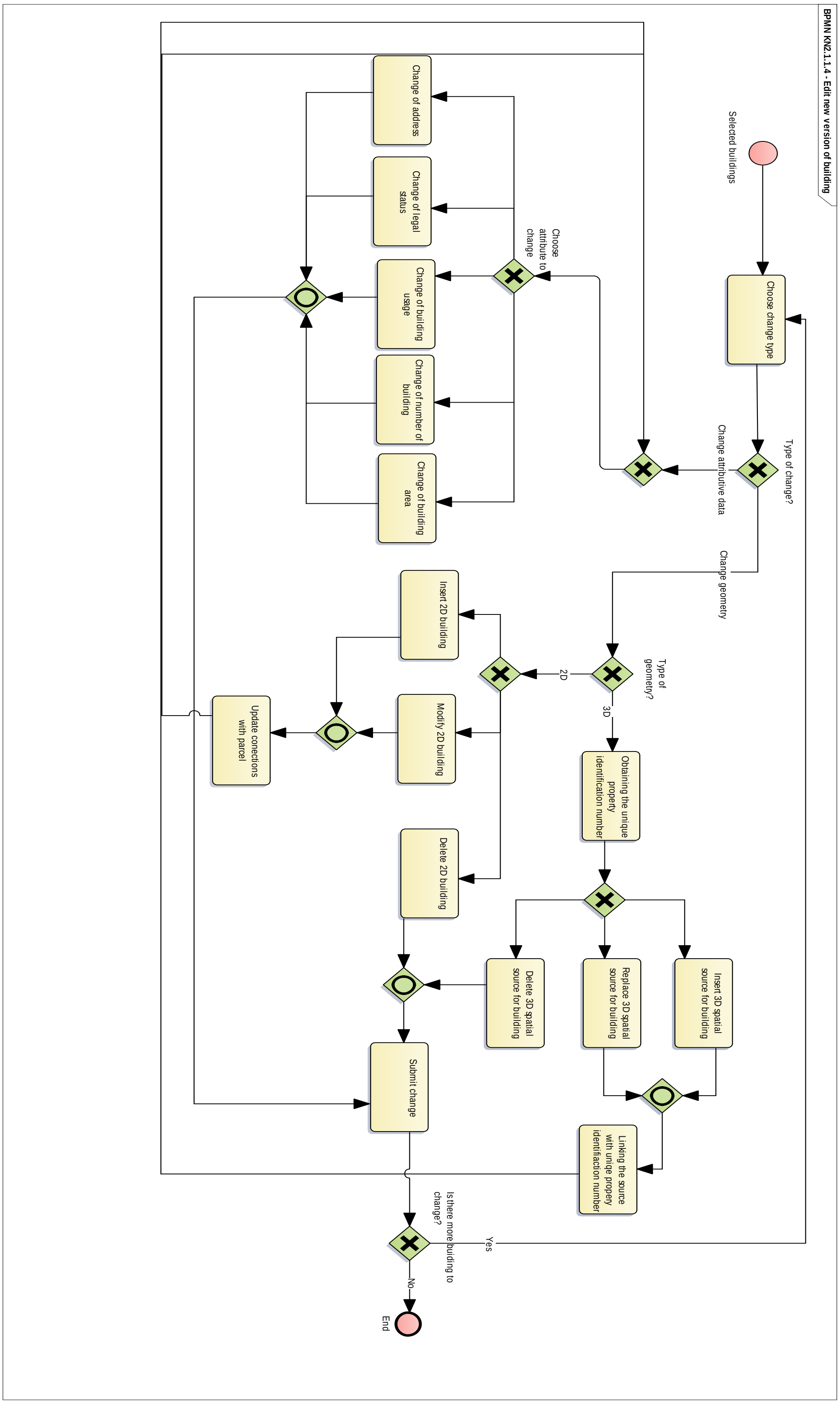

Figure 7. Model of the business process for editing new version of building

3. USING OPEN BIM STANDARDS TO SUPPORT PROCESSES IN 3D CADASTRE

For the implementation of 3D processes in Serbian cadastre we analyzed the possibility of using buildingSMART Open BIM standards. The reason for this is that BIM data is already available about buildings that are planned for construction or restauration. These BIM models are produced in different proprietary software and usually contain very detailed information about buildings that is not necessary for the purpose of rights registration, so it is necessary to identify what subset of BIM data is required for this purpose. buildingSMART has adopted five basic methodology standards that may be used for this purpose. First to mention is Industry Foundation Classes (IFC), a common data schema for the exchange of relevant data between different users and software applications with the goal to enable interoperability. Second standard, the Model View Definitions (MVDs) is used to define the subset of the IFC data model that is necessary to support the specific data exchange requirements, since IFC is very rich semantic model with a large number of classes, but only subset is needed for a specific purpose such as mapping legal spaces within a building. Mapping of terms is supported by International Framework for Dictionaries (IFD) to support multilingualism. Information Delivery Manual (IDM) is a process standard used to capture and integrate business processes that provide detailed specifications of the information that a user fulfilling a particular role would need to provide at a certain moment, e.g. processes of registration of 3D spatial units, viewing property rights in 3D, etc. Finally, BIM Collaboration Format (BCF) is an open standard XML schema that encodes messages to enable workflow communication between different BIM software tools, as well as RESTful webservice "bcfAPI" that enables software applications to exchange BCF data seamlessly in BIM workflows and coordinate changes in the project. However, we investigate whether it can also be used by the employees in cadastre to exchange and view data about 3D spatial units and request changes if necessary.

It is worth paying special attention to the process model Information Delivery Manuals (IDM) whose purpose is to specify processes and information flow during the lifecycle of a facility. Considering that the lifecycle of a facility is highly related to land administration activities in the sense that land administration provides means to secure tenure and make large investments possible, and even to begin a construction project it is necessary to obtain building permit, that requires several requests to local cadastral office, it makes sense to link cadastral processes to this methodology. The methodology can be used to document existing or new processes and describe the associated information that have to be exchanged between parties. The output from the standard can afterwards be used to specify a more detailed specification that can form the basis for a software development process. It is important to state that in order to make an information delivery manual operational for intended exchange scenarios it has to be supported by software. Therefore, existing software solutions used in cadastral offices in Serbia would require either a new tool or extension of existing tools to support 3D cadastre activities. We investigated whether existing open source solutions can be used for this purpose and concluded that they can form the basis for this implementation but further development is needed.

It is the purpose of an IDM to capture processes and exchange requirements while MVD is aiming at mapping exchange requirements to a data schema (IFC), and potential constrains to the used data model, so the business processes can be supported or automated through the use of information technology. The development process starts with identifying user needs in Information Delivery Manuals, which are used to create more technical specification called Model View Definition. The requirement specification is used to implement a software solution that preferable should be certified before they are released for use and it should also provide BIM data validation. Figure 8 (adapted from See et al., 2012) shows how this development process can be applied to processes in 3D cadastre. BIM data validation enables the end user to verify that a BIM that has been exported from a certified application meets all the requirements defined in the original IDM and MVD for the exchange of 3D data. IDM should be developed on the national level for the purpose of 3D cadastre, preferably supported by international standards, and followed by appropriate software solution. The proposed IDM should be submitted to buildingSMART members in order to get an official status. However, our purpose is to test whether the method is appropriate for the use of mapping 3D legal spaces in Serbian land administration procedures and an official IDM is out of scope at this moment. For the development of IDM at a national level, processes from the level 4 described in the previous Section can be used, since IDM also requires using BPMN notation for the processes specification.

Figure 8. Transformation of needs into operational solutions

Model View Definitions are encoded in an XML based format called mvdXML. Software applications may make use of MVDXML to support functionalities such as: exporting data that is automatically filtered to include only data within a model view, prompting users to provide missing information, e.g. if unique property identification number (UPIN) is missing, providing attribute editing functionality for high-level concepts instead of low-level data, etc. mvdXML files may be generated and edited using a tool called ifcDoc, or any other XML editor.

Subset of IFC classes to be used for the purpose of registration of 3D spatial units is shown on Figure 9 It represents spatial structure of a building which can be used for mapping legal spaces. A spatial structure element (IfcSpatialStructureElement) is the generalization of all spatial elements that might be used to define a spatial structure. That spatial structure is often used to provide a project structure to organize a building project. Spatial structure element types are: site, building, building storey and spaces. Spatial structure hierarchy uses ifcRelAggregates which is a special type of the general composition/decomposition (or whole/part) relationship to establish a spatial structure including site, building, building section and storey. IfcProject indicates the undertaking of some design, engineering, construction, or maintenance activities and establishes the context for information to be exchanged or shared, to provide the root instance and the context for all other information items included. It optionally provides the map conversion between the project coordinate system and the geospatial coordinate reference system which is important to georeference the data and link them to geographic information systems to provide better understanding of surrounding of a particular project. A site (ifcSite) is a defined area of land on which the project construction should take place and it can contain zero or more buildings (ifcBuilding). A site can be linked to one or more parcels on which the construction project started. The building storey (ifcBuildingStorey) has an elevation and represents a horizontal aggregation of spaces that are vertically bound, such as apartments on a single floor. A space (ifcSpace) represents an area or volume bounded actually or theoretically. Spaces are areas or volumes that provide certain functions within a building. A space is associated to a building storey (or in case of exterior spaces to a site). A space may span over several connected spaces, such as rooms in an apartment. Therefore, a space can be used to represent parts of buildings under homogenous rights (legal spaces) such as apartments, business units, etc. Unique property identification number (UPIN) may in that case be mapped to globally unique identifier (GUID) of the ifcSpace that represents it. In case of a building, GUID of an ifcBuilding will be mapped to UPIN of a building. IfcBuilding, IfcBuildingStorey, IfcSpace and IfcSite are subtypes of IfcSpatialStructureElement and represent spatial structure of a building project.

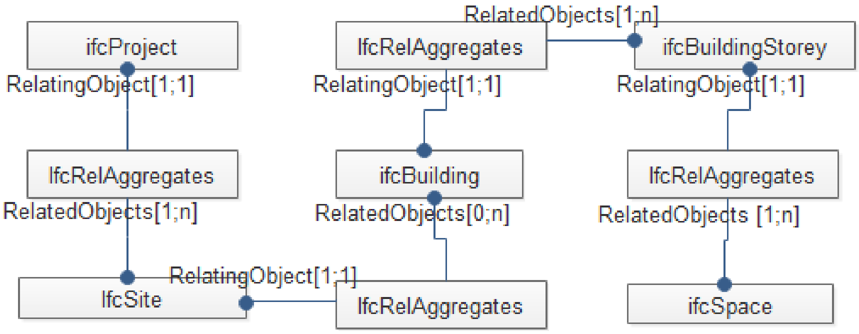

Figure 9. Spatial structure of buildings and parts of buildings

Figure 10 represents a typical building whose BIM model was developed in Sketchup and then exported in IFC and loaded in BIM server. Most of the proprietary BIM tools support export to IFC functionality. However, this process leads to loss of information and therefore there is a growing trend to allow connectivity between the tools directly.

Figure 10. BIM model of a typical building

The following listing represents an extract from the obtained IFC file representing classes from figure 9 (ifcProject, ifcSite, ifcBuilding, ifcRelAggregates).

#1 = IFCPROJECT('0Zequko5z5vu_B$C4UB5IG', #2, Default Project', 'Test Project', $, $, $, (#20), #7);
#24 = IFCSITE('2LzsEEckP7iQYgAdPrs9Ch', #2, Default Site', 'Description of Default Site', $, #25, $, $, .ELEMENT., (24, 28, 0), (54, 25, 0), 10., $, $);
#30 = IFCBUILDING('0uOhb3aHb2y8PoQEojUUyd', #2, Default Building', 'A typical building', $, #31, $, $, .ELEMENT., $, $, #36);
#43 = IFCRELAGGREGATES('1Z5ZnpU3HCWvojujA0Cquy', #2, 'BuildingContainer', 'BuildingContainer for BuildingStories', #30, (#37));
#44 = IFCRELAGGREGATES('010sss83TBHujDpv8a5dTU', #2, 'SiteContainer', 'SiteContainer For Buildings', #24, (#30));
#45 = IFCRELAGGREGATES('2e6Vrkn$j1GfJt6w5R17jQ', #2, 'ProjectContainer', 'ProjectContainer for Sites', #1, (#24));

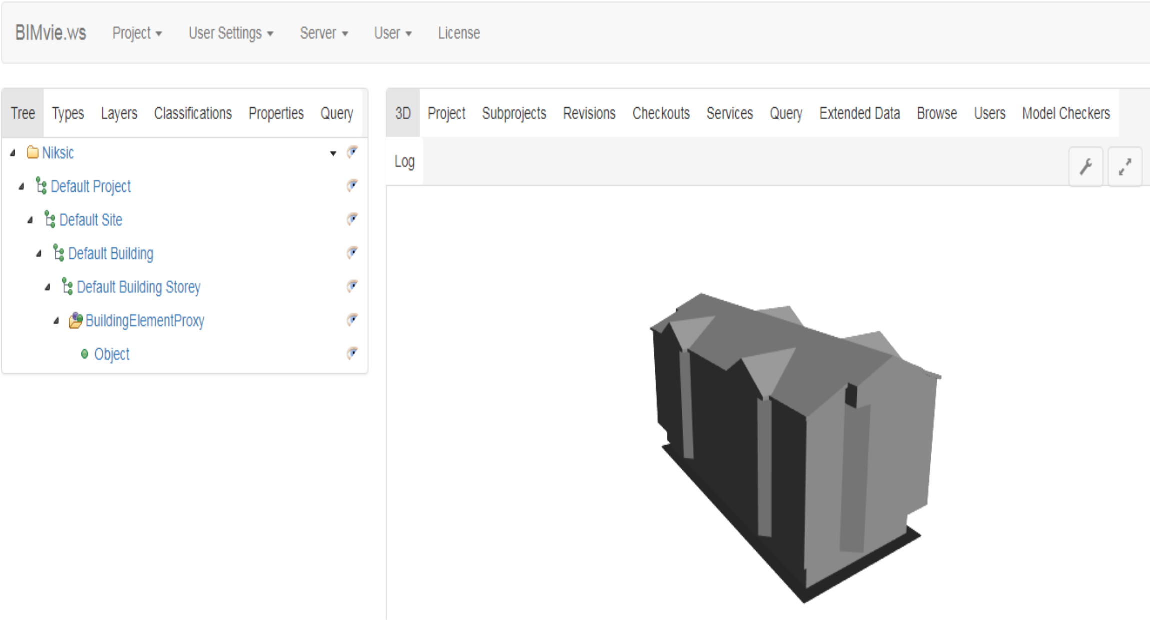

Figure 11. IFC model imported to a BIM server

BIM Collaboration Format (BCF) is an open file XML format bcfXML that supports workflow communication in BIM processes and the RESTful webservice bcfAPI enables software applications to exchange BCF data seamlessly in BIM workflows in SOA environment. It provides the possibility to exchange machine readable BCF-Topics with attached BIM-Snippets (small components of a BIM-model), attached multiple viewpoints, etc. BCF is mainly used by the collaborators on the project to communicate about the issues of a BIM model during its design cycle. BCF issue holds a description of the issue, a status, links to a BIM model and objects, a picture of the issue and a camera orientation. The BCF standard is based on the file exchange. BCF issues are packed into a ZIP file (.bcfzip) and sent to project partners, while van Berlo and Krijnen (2014) developed BCF server software as an extension to bimserver for the centralized exchange of BCF issues, instead of sending it via email. BCF services provided in BCF API include HTTP GET requests to retrieve the project, a collection of topics related to a project, possibly with a snippet of the issues, collection of IFC files of file references, comments related to a topic, viewpoints related to a topic and related documents such as legal requirements, etc. The BCF standard proposes Comment, Issue, Request, Solution as the enumeration values for TopicType, where in land administration domain the mostly used topic type would be a request, but also in the process of retrieving a building permit other topic types would also be usual, since issues often arise during this process that need further processing.

Land administration workflows can make use of BCF server and bcfAPI in general by exchanging issues during property registration, requests for changes, viewing of data, etc. As mentioned before, this could also be useful in the process of acquiring building permit, which requires several requests toward cadastral office and it would facilitate employees to view issues and propose resolution. By linking BCF server to bimserver it is possible for a topic/request to visualize data retrieved from IFC file in bimserver and zoom directly to required part of building based on camera and viewpoint parameters. The existing deployment of the web services could be improved with this data sharing/viewing mechanism, although further development is needed. This way, already developed SOA environment in this domain would be enhanced with the workflows that include 3D data. Web services that are already developed in Serbia and Montenegro (Govedarica et al., 2018) can be integrated with the web services providing access and visualization of 3D data.

4. CONCLUSION

The paper presented the process model for Serbian land administration. Many processes in Serbian land administration have already been implemented as web services and these include exchange of legal and spatial 2D data. However, to bring these processes on a 3D level, an extensive further work is required which includes a development of new specifications and new tools. In this sense it is important to follow technological trends that go more and more toward the integration of GIS and BIM, since GIS provides visualization and analysis at a city scale, while BIM enables very detailed insight at a project scale and both approaches are needed to support decision making in many areas concerning urban development. An important step toward achieving this goal would be standardization in the field of 3D cadastre to provide guidance and facilitate further work on a national level.

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BIOGRAPHICAL NOTES

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