Lessons learned from the Creation of the LADM based Country Profiles

Karel JANEČKA, Czech Republic, Jarosław BYDŁOSZ, Poland, Aleksandra RADULOVIĆ, Serbia, Nikola VUČIĆ, Croatia, Dubravka SLADIĆ and Miro GOVEDARICA, Serbia

Key words: ISO 19152, 3D Cadastre, Country Profile

SUMMARY

A roadmap (consisting of six stages) to adopt the LADM in the cadastral information system has been provided in Kalantari et al (2015). Referring to this six-stage roadmap for LADM implementation, the paper focuses mainly on the stage 4 Data Organization, i.e. how different data entities are linked to each other. The LADM is regarded as a conceptual model that enforces certain relationships between the entities. On principle, there are three main ways in which the LADM based country profile can be developed:
(1) to use LADM classes, attributes, code lists and relationships between classes "as is",
(2) to show an inherited structure between the LADM and the existing cadastral model, or
(3) to show a mapping of elements between LADM and the existing cadastral model.

The last two approaches will be probably used in countries with well-functioning cadastral information system. In this way the LADM based country profiles have also been created for Croatia (Vučić et al, 2015), Czech Republic (Janečka and Souček, 2017), Poland (Bydłosz, 2015), and Serbia (Radulović et al, 2017). Basically, the profiles for these four European countries have been proposed in academia. It means, that an initial activity for creation of the LADM based country profile didn't come from the body or agency responsible for the cadastre (e.g. national mapping agency), but from academia. This activity could be seen as an irreplaceable role of the academia, to demonstrate the usefulness of the 3D cadastre and be a partner for government organizations. The paper explores the issues met during the preparation of the LADM based country profiles for these four countries when the "need" for LADM based country profile came from academia. The description of ways in which these issues were solved could help to those who are going to propose their new LADM based country profiles.

Lessons learned from the Creation of the LADM based Country Profiles

Karel JANEČKA, Czech Republic, Jarosław BYDŁOSZ, Poland, Aleksandra RADULOVIĆ, Serbia, Nikola VUČIĆ, Croatia, Dubravka SLADIĆ and Miro GOVEDARICA, Serbia

1. INTRODUCTION

The ISO 19152 Land Administration Domain Model (LADM) is regarded as a conceptual model that enforces certain relationships between the entities. On principle, there are three main ways in which the LADM based country profile can be developed: (1) use LADM classes, attributes, code lists and relationships between classes "as is", (2) show an inherited structure between the LADM and the existing cadastral model, or (3) show a mapping of elements between LADM and the existing cadastral model. The last two approaches were used for the creation of the LADM based country profiles for example in Croatia (Vučić et al, 2015), Czech Republic (Janečka and Souček, 2017), Poland (Bydłosz, 2015), and Serbia (Radulović et al, 2017). In all these mentioned countries the cadastre is currently based on registration of 2D parcels. However, LADM allows for registration of 3D parcels and recently several prototypes of 3D LADM based country profiles have also even been developed, for example: Russian Federation (Elizarova et al, 2012), Poland (Góźdź and Pachelski, 2014), Malaysia (Zulkifli et al, 2014; Zulkifli et al, 2015), Israel (Felus et al, 2014), Greece (Kalogianni et al, 2016), Trinidad and Tobago (Griffith-Charles and Edwards, 2014) or Turkey (Alkan and Polat, 2016).

The issues met during the creation of the previously mentioned four country profiles were mainly as follows:

- The documentation of the existing cadastral data model. Is documentation of the existing cadastral data model available (known) to public or academia? Such documentation is needed in order to include all the LADM classes, attributes, relationships and code lists where possible.
- The evaluation of the proposed LADM based country profile. Should anybody from the national mapping agency be involved in the process of the creation of the profile? The participation of expert(s) who work daily in the field of cadastre could help especially in situations when the deep knowledge of the cadastre and its processes and the cadaster data model is necessary.
- In which way the LADM based profile for your country was created? On principle, there are three main ways in which the LADM based country profile can be developed: (1) use LADM classes, attributes, code lists and relationships between classes "as is", (2) show an inherited structure between the LADM and the existing cadastre model, or (3) show a mapping of elements between LADM and the existing cadastre model.
- Differences in practice and national regulations. Should LADM country profile include national legislation or common practice, or should it combine both?
- Another issue appears here as well. Usually, it is not possible to include all cadastral classes defined in cadastral model in the profile, so some selection must be done. Apart from obvious choice like "cadastral parcel" or classes representing party or parties, the

selection of many classes seems arbitrary. The question is who should be responsible for this and how it should be done.

Furthermore, an intention of the paper is to share an experience how the proposed country profiles were further promoted and potentially used in given countries with similar history and geographical location. The activity should not stop at the moment when the LADM based country profile is defined. To describe the further promotion and usage of the country profile the following questions were answered:

- How has the country profile been promoted to the bodies responsible for the cadastral system development (e.g. national mapping agency)?
- Has any feedback from representatives of national mapping agency already been received?
- Has the LADM based country profile already been applied in the production environment in your country or is going to be applied in the near future, e.g. in the next five years?

To answer the possessed questions the use of case studies and literature review was considered. The four national case studies (Croatia, Czech Republic, Poland and Serbia) describing the creation of LADM based country profiles were explored in detail and also other related works are referenced. These four national case studies were selected due to the similar history and geographical location of given countries. The important fact is that the authors of the selected four LADM based country profiles were personally involved in this research and contributed with their experience. Based on the shared common experience the conclusions regarding the development of LADM based country profiles and their further application are given.

2. CREATION OF LADM BASED COUNTRY PROFILES

2.1 Croatia

- *Is documentation of the existing cadastral data model available (known) to public or academia?*
  The documentation of the (physical) cadastral data model is not publicly available. The data of cadastre are provided in the Joint Information System of Land Registry and Cadastre (JIS) which combine both land register and a cadastre data. 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 State Geodetic Administration of the Republic of Croatia implemented the JIS in all cadastral offices in Croatia by November 2016 (Vučić et al 2017). The LADM based documentation of the (physical) cadastral data model is publicly available through several scientific papers (Vučić et al 2013) and one PhD thesis (Vučić 2015).

- *Should anybody from the national mapping agency (or similar institution responsible for the cadastral system development) be involved in the process of the creation of the profile?*
  Several scientists from the State Geodetic Administration was involved in the process of the creation of the Croatian LADM profile.

– *In which way (according to the three possible ways mentioned in the methodology) the LADM based profile for your country was created?*
  At the conceptual level, for most of the classes which are included in the Croatian LADM based country profile it was possible to show their inheritance from appropriate LADM classes. Furthermore, the Croatian country profile contains some new classes (e.g. *HR_OldCadastralSurvey* for cadastral municipality in which the survey was made between the 1950 and the 2000 and is recorded in the cadastre, but isn't recorded in the land book).

– *Should LADM country profile include national legislation or common practice, or should it combine both?*
  Croatian LADM profile has implemented currently valid regulations for the cadastral procedures; Law on State Survey and Real Property Cadastre (Official Gazette 2007), Ordinance on subdivision and other geodetic reports (Official Gazette 2007a), Land Cadastre Ordinance (Official Gazette 2007b).

Table 1. Compatibility overview between LADM and Croatian Land Administration System

Classes that can be directly applied to the Croatian land admistration system	Classes that need to be changed to be suitable for the Croatian land management system
PartyMember	Party
RRR	GroupParty
Right	BaUnit
Restriction	AdministrativeSource
Responsibility	SpatialUnit
Mortgage	Level
SpatialUnitGroup	LegalSpaceUtilityNetwork
	LegalSpaceBuildingUnit
	RequiredRelationshipSpatialUnit
	HR_OldCadastralSurvey
TOTAL: 7	**TOTAL: 10**

– *Usually, it is not possible to include all cadastral classes defined in cadastral model in the profile, so some selection must be done. Apart from obvious choice like "cadastral parcel" or classes representing party or parties, the selection of many classes seems arbitrary. The question is who should be responsible for this and how it should be done?*
  Seven LADM classes specified in Table 1 (see above) are directly applicable to the Croatian land management system, while ten classes need to be adapted accordingly. Nine of these ten classes originate from LADM, and one new class HR_OldCadastralSurvey was designed to describe particular situations of the Croatian land management system.

The scientific and professional circles, which wish to apply LADM in their work/practice are responsible for this issue.

Surveying and representation package for the Republic of Croatia is fully compatible with LADM.

2.2 Czech Republic

– *Is documentation of the existing cadastral data model available (known) to public or academia?*
The documentation of the (physical) cadastral data model is not publicly available. The data of cadastre are provided, among others, in cadastral exchange format (NVF). This is an ASCII file containing alphanumerical and graphical data. The exchange format was designed to enhance the transfer of data between the information system of cadastre of real estates and other data processing systems. The NVF's documentation describes the structure of the format. The documentation of NVF is publicly available but one can get only the rough idea about the physical cadastral data model from it.
From the physical cadastral data model would be then possible to get the conceptual cadastral data model by using the reverse engineering (Janečka and Souček, 2017). As the LADM specifies a conceptual model it is important to have the conceptual cadastral data model to enable creation of the LADM based country profile.

– *Should anybody from the national mapping agency (or similar institution responsible for the cadastral system development) be involved in the process of the creation of the profile?*
The person from the Czech Office for Surveying, Mapping and Cadastre (COSMC) in Prague participated in development of the Czech LADM based country profile. The Czech Office for Surveying, Mapping and Cadastre is an autonomous supreme body of the state administration of surveying, mapping and cadastre in the Czech Republic.

As the (physical) cadastral data model is not available to the public, the participation of this person having the deep knowledge of the physical cadastral data model in the process of the creation of the profile was practically necessary for several reasons. At the beginning of the work, he described all the database tables and relationships among them. Also the mandatory attributes (mostly containing the values from corresponding code lists), their multiplicity and constraints were explored. This served as a base for developing a conceptual cadastral data model.

– *In which way (according to the three possible ways mentioned in the methodology) the LADM based profile for your country was created?*
At the conceptual level, for most of the classes which are included in the Czech LADM based country profile it was possible to show their inheritance from appropriate LADM classes. Furthermore, the Czech country profile contains some new classes (e.g. CZ_RightOfBuilding).

LADM package	LADM class	CI[a]	Dependencies
-	*VersionedObject*	1	
	LA_Source	1	Oid, (as a minimum one of the specializations must be implemented [LA_AdministrativeSource or LA_SpatialSource]), LA_AvailabilityStatusType
Party Package			Exist only if Administrative Package is implemented
	LA_Party	1	VersionedObject, Oid, LA_PartyType
	LA_GroupParty	2	Oid, LA_Party, LA_GroupPartyType
	LA_PartyMember	2	VersionedObject, LA_Party, LA_GroupParty
Administrative Package			Exist only if Party Package is implemented
	LA_RRR	1	VersionedObject, Oid, LA_Party, LA_BAUnit, LA_Right (as a minimum, this specialization shall be implemented), LA_AdministrativeSource
	LA_Right	1	LA_RRR, LA_RightType
	LA_Restriction	2	LA_RRR, LA_RestrictionType
	LA_Responsibility	3	LA_RRR, LA_ResponsibilityType
	LA_BAUnit	1	VersionedObject, Oid, LA_RRR, LA_BAUnitType
	LA_Mortgage	2	LA_Restriction
	LA_AdministrativeSource	1	LA_Source, LA_Party, LA_AdministrativeSourceType, LA_AvailabilityStatusType
	LA_RequiredRelationshipBAUnit	3	VersionedObject, LA_BAUnit
Spatial Unit Package			
	LA_SpatialUnit	1	VersionedObject, Oid
	LA_SpatialUnitGroup	2	VersionedObject, Oid, LA_SpatialUnit
	LA_LegalSpaceBuildingUnit	3	LA_SpatialUnit
	LA_LegalSpaceUtilityNetwork	3	LA_SpatialUnit
	LA_Level	2	VersionedObject, Oid
	LA_RequiredRelationshipSpatialUnit	3	VersionedObject, LA_SpatialUnit
Surveying and Representation Subpackage			
	LA_Point	2	VersionedObject, Oid, LA_SpatialSource, LA_PointType, LA_InterpolationType
	LA_SpatialSource	2	LA_Source, LA_Point, LA_Party, LA_SpatialSourceType
	LA_BoundaryFaceString	2	VersionedObject, Oid, LA_Point (if using geometry)
	LA_BoundaryFace	3	VersionedObject, Oid, LA_Point (if using geometry)

[a] CI = Conformance level.

Figure 1. The classes for conformance Level 2 are highlighted in red rectangles, for Level 3 in blue rectangles (*Janečka and Souček, 2017***)**

– *Should LADM country profile include national legislation or common practice, or should it combine both?*
  The new Civil Code (Act No. 89/2012 Coll.) was enacted within the Czech Republic in 2014. This new Civil Code encompasses numerous provisions from other acts that were recently repealed, e.g., the Flat Ownership Act, the Act on Association of Person, etc. It re-introduces the former Czech legal terminology, which was gradually abandoned by the Civil Codes of 1950 and 1964. The Property Law component regulates the tenure, possession, ownership and co-ownership, encumbrance, lien and heirship of real estate property. Concordant with the adoption of the new Civil Code, a new Cadastral Act (Law Number 256/2013 Coll., the "New Cadastral Act") was enacted as a basic legal cornerstone of the cadastre of real estate of the Czech Republic. The Czech country profile reflects the national legislation, especially the new Civil Code and new Cadastral Act.

– *Usually, it is not possible to include all cadastral classes defined in cadastral model in the profile, so some selection must be done. Apart from obvious choice like "cadastral parcel" or classes representing party or parties, the selection of many classes seems arbitrary. The question is who should be responsible for this and how it should be done?*
  The table "A.1 The LADM conformance requirements table" published in ISO 19152 (ISO, 2012) can help to answer the question which cadastral classes should be included in the national country profile. At the first stage of the proposal of the LADM based country profile one can check if all classes required for conformance (with LADM) at Level 1 are available in the national cadastral data model. The Level 1 includes also the four main LADM classes (LA_Party, LA_RRR, LA_BAUnit and LA_SpatialUnit). It is also necessary to check all the dependencies for every LADM class as required by ISO 19152. The same can be then done also for Level 2 and Level 3.

The country profile for the Czech Republic contains all of the necessary classes for conformance at Level 2 (medium level) and meets all of the required dependencies as mentioned in Figure 1 above. Furthermore, it also contains some classes from Level 3.

2.3 Poland

Even before the ISO 19152 was published, some works based on the Land Administration Domain Model had been made in Poland. The effort to describe main relationships within the land register in Poland applying ISO 19152 draft version was presented in (Bydłosz, 2010). The relationships between Land Administration Domain Model and model of Polish cadastre (both in draft versions) were investigated in (Bydłosz, 2012a), (Bydłosz, 2012b) and (Bydłosz et al, 2012).

The first overall attempt to look at the Polish cadastral model (Regulation, 2013) in the light of the ISO 19152 standard, when both of them had come into power, was made in (Bydłosz, 2013). The similarities and differences of both models were presented there. The former are application of UML notation and logic in construction of the Polish cadastral model. The latter are different scopes of both models. Polish cadastral model concerns only cadastral objects like land parcels, buildings, premises (apartments) and their owners or tenants, whereas Land Administration Domain Model scope includes land register and utilities, as well.

The first research after publishing ISO 19152, where LADM was taken into account is described in (Siejka et al, 2014). The simple models describing real property register (land register), land and building cadastre, utility infrastructure and 3D+time cadastre were presented there. We can notice that the LADM philosophy rather than LADM itself are applied in this research.

The works concerning ISO 19152 were generally connected for creating LADM based profiles of Polish spatial infrastructure components. The researches were conducted in two directions. The first one concerns works performed on official model of Polish cadastre for building LADM based Polish cadastral profile (Bydłosz, 2015). This research started from the Polish cadastral model where the attributes inheritance from LADM was investigated and then classes names were proposed to include in the profile of Polish cadastre. Corresponding LADM classes were included in the profile if identified. Then the main classes and relationships between them were identified in the Polish cadastral model. After some simplifications the final model of Polish cadastre was built (Bydłosz, 2015). The advantage of this work is strict liaison with official Polish cadastral model. The disadvantage is that in the present state the model itself concerns only cadastre, so land register and register of utilizes are not included.

The second directions of works differs from the first one. The LADM country profile for Poland is built applying Land Administration Model Packages (Party Package, Administrative Package, Spatial Package) as well as external classes (Góźdź and Van Oosterom, 2015). Generally, classes of official Polish cadastral model are connected applying inheritance relationships with LADM classes, there. This model is also developed to present 3D-LADM country profile (Góźdź and Pachelski, 2014) and CityGML-LADM Application Domain Extension for cadastral purposes (Góźdź et al, 2014).

The strong point of models presented in the previous paragraph is taking into account not only classes from cadastral model but the classes from land (and mortgage) register as well as register of utility networks. Applying LADM packages and inheritance from LADM classes results in strong ties between them. The weak point seems to be rather poor projection of Polish official cadastral model into presented profile. Moreover, at this stage, the profile described in (Góźdź and Van Oosterom, 2015) seems too complicated when compared with country profiles included in ISO 19152.

2.4 Serbia

– *Is documentation of the existing cadastral data model available (known) to public or academia?*

  The documentation of the cadastral data model is not publicly available. In the information system of the real estate cadastre, alphanumeric data (data about rights) are separated from graphic (spatial) data. GIS and CAD tools are used for the transformation of analogue cadastral maps into digital vector format. The alphanumeric parts of the information system for real properties in Serbia were implemented in a DOS application, based on FoxDbf tables for a significant part of Serbian territory, while a small part of data is stored in a Microsoft Access database. Data models in these two applications differ from each other, with an evident absence of relationships in the FoxDbf database. It is a non-

relational data model. DBF tables contain both present and history data and the combination of six columns tells in which state is the certain row of data in the table. This method of keeping track of changes in cadastre makes maintenance of data and establishing relations among data very difficult. Each cadastral office collects its data which are stored in DBF files. The data dictionary for the FoxDbf tables is available in the word document, which we got from the mapping agency.
From the physical cadastral data model and data dictionary reverse engineering was used to transform the physical model to a logical model. Then the conceptual modeling was performed to capture concepts in the cadastral domain with the aim of developing a standardized domain model. The developed conceptual model was later transformed into new physical model and relational database schema was generated from it. A tool for data migration from DBF files to database schema was developed as described in Sladić et al (2017).

– *Should anybody from the national mapping agency (or similar institution responsible for the cadastral system development) be involved in the process of the creation of the profile?*
Since the cadastral data model in Serbia is not available to the public it was necessary to work with a persons who know the domain and the existing data model itself. During the development of the Serbian profile, we had a support of the employees of the Republic Geodetic Authority. Existing documentation, a test database and data dictionaries, as well as a description of the existing model, code lists and dependencies between the tables were delivered. After completion of profile it was presented to the employees of the Republic Geodetic Authority. Several comments were received and later taken into account within the data model.

– *In which way (according to the three possible ways mentioned in the methodology) the LADM based profile for your country was created?*
Existing data model encountered with big changes since it was created by the concept of the real estate folio, a legacy analogue document that consists of four sheets. The "A" sheet contains data about one or more parcels. The "B" sheet contains data about parties which have rights over parcels from the A sheet. The "V" sheet contains data about buildings and parts of buildings, such as apartments and business offices, which are located in parcels listed in the A sheet, together with data about their rights. The "G" sheet contains data about restrictions on real properties defined in the A and V sheets. Since these sheets are not actual concepts of any cadastre, our first step in creating a new domain model was the formation of a conceptual model of the real estate cadastre for Serbia. Next step was to analyse the possibilities of fitting the resulting conceptual model in LADM on the low level. Final step was development of complete Serbian profile with all classes and attributes and testing the conformity to the LADM on medium and high level. This step was done by displaying the inheritance between classes and adding new classes (RS_PartOfParcel, RS_Easement, RS_Notice).

– *Should LADM country profile include national legislation or common practice, or should it combine both?*
As mentioned, existing data model in Serbia is based on concept of real estate folio in which one folio consists of more real properties with it rights and restrictions. This is how

the Law on State Survey and Cadastre and the Registration of Rights on Real Estates Cadastre (1992) defined the real estate folio. However, the current Law on State Survey and Cadastre (2009) defines a real estate folio as data about a single real property together with its rights and restrictions. This is big difference since it affects the way of forming implementation schema particularly and maintaining the real system itself. On conceptual level this was done by changing the multiplicity on class that represents real property from 1..* to 1.

– *Usually, it is not possible to include all cadastral classes defined in cadastral model in the profile, so some selection must be done. Apart from obvious choice like "cadastral parcel" or classes representing party or parties, the selection of many classes seems arbitrary. The question is who should be responsible for this and how it should be done?*
The abstract test suite, defined in Annex A of the ISO 19152 standard, specifies the requirements that the development of the country profile has to meet in order to conform to this standard. All LADM classes were tested and the result is shown in the table 2. Table 2 shows the mapping of the Serbian conceptual model, LADM classes, and the resulting Serbian country profile classes. The level of conformance to LADM is also shown. The Serbian country profile conforms to all classes from the low and medium level, and to four of the six classes from the high level of conformance.

Table 2. LADM conformance and mapping table for the Serbian country profile (Radulović, 2017)

Serbian Conceptual Data Model	**LADM Class**	**Serbian Profile Class**	**Conformance Level**
Case	LA_Source	RS_Source	1
Party package			
Parties	LA_Party	RS_Party	1
–	LA_GroupParty	RS_GroupParty	2
–	LA_PartyMember	RS_PartyMember	2
Administrative Package			
–	LA_RRR	RS_RRR	1
Rights	LA_Right	RS_Right	1
Restrictions	LA_Restriction	RS_Restriction	2
Restrictions	LA_Restriction	RS_Notice	2
Restrictions	LA_Restriction	RS_Easement	2
–	LA_Responsibility	-	-
RealEstateFolio	LA_BAUnit	RS_BAUnit	1

Serbian Conceptual Data Model	LADM Class	Serbian Profile Class	Conformance Level
Restrictions	LA_Mortgage	RS_Mortgage	2
Case	LA_AdministrativeSource	RS_AdministrativeSource	1
–	LA_RequredRelationshipBAUnit	RS_RequredRelationshipBAUnit	3
Spatial Unit Package			
RealEstate	LA_SpatialUnit	RS_SpatialUnit	1
Parcel	LA_SpatialUnit	RS_Parcel	1
PartOfParcel	LA_SpatialUnit	RS_PartOfParcel	1
Building	LA_SpatialUnit	RS_Building	1
Cadastral Municipality	LA_SpatialUnitGroup	RS_SpatialUnitGroup	2
PartOfBuilding	LA_LegalSpaceBuildingUnit	RS_PartOfBuilding	3
Pipeline	LA_LegalSpaceUtilityNetwork	RS_LegalSpaceUtilityNetwork	3
–	LA_Level	RS_Level	2
–	LA_RequredRelationshipSpatialUnit	RS_RequredRelationshipSpatialUnit	3
Surveying and Representations Subpackage			
–	LA_Point	RS_Point	2
Case	LA_SpatialSource	RS_SpatialSource	2
–	LA_BoundaryFaceString	RS_BoundaryFaceString	2
–	LA_BoundaryFace	-	-

3. DISSEMINATION AND NEXT USAGE OF LADM BASED COUNTRY PROFILES

3.1 Croatia

– *How has the country profile been promoted to the bodies responsible for the cadastral system development (e.g. national mapping agency)?*
The country profile (and the idea of the 3D Cadastre) is promoted mostly at international scientific conferences and in international scientific journals and also at few national conferences.

– *Has any feedback from representatives of national mapping agency already been received? Are benefits of adopting the LADM based profiles taken into account?*
The author of Croatian national profile (Nikola Vučić) works for Croatian Office for Surveying, Mapping and Cadastre (State Geodetic Administration) and in general promote LADM country profile as important fact in land administration. There are some benefits of adopting LADM - standardization, better evidence, and harmonization at EU level.

– *Has the LADM based country profile already been applied in the production environment in your country or is going to be applied in the near future, e.g. in the next five years?*
The Croatian LADM based country profile enabled to compare the current cadastral data model with LADM. The profile could be potentially extended to support the implementation of future 3D cadastre in practice and in state evidence. The World Bank insists on data models based on the LADM in the preparation of the new loan (2018-2021) for improving cadastre and land registry (ILAS project). The Integrated Land Administration System Project (ILAS Project) in the framework of the Organized Land national program is a follow-up to successfully completed Real Property Registration and Cadastre Project (RPRC Project) which was implemented by the State Geodetic Administration (SGA) and Ministry of Justice. Through the RPRC Project, the two institutions together with their cadastral offices and land registry offices, successfully completed the first phase of the land administration reform. Above mentioned loan is the third phase of the land administration reform.

3.2 Czech Republic

– *How has the country profile been promoted to the bodies responsible for the cadastral system development (e.g. national mapping agency)?*
The country profile (and the idea of the 3D Cadastre) is promoted mainly in two ways: (1) presentations at national conferences with participation of representatives of COSMC and (2) on the basis of the interviews with representatives of COSMC.

– *Has any feedback from representatives of national mapping agency already been received? Are benefits of adopting the LADM based profiles taken into account?*
The official representative of the Czech Office for Surveying, Mapping and Cadastre referred during her speech at the conference XXIII. International Poland-Czech-Slovak geodetic days (18. – 20. 5. 2017, Warsaw, Poland) to the article by Janečka and Souček (2017) describing the creation of the Czech LADM based country profile. It is important that the research results from academia are taken into account and cited by official representatives of COSMC. The benefits of adopting the LADM based profile were also mentioned in this speech, especially the fact that LADM based profile can incorporate the support for registration of 3D spatial units and also enables international cooperation.

– *Has the LADM based country profile already been applied in the production environment in your country or is going to be applied in the near future, e.g. in the next five years?*
The Czech LADM based country profile enabled to compare the current cadastral data model with LADM. The profile could be potentially extended to support the registration of 3D spatial units in the future, and it could also serve as the basis for an extension of the current data model of the cadastre in a standardized way.

3.3 Poland

As one can notice there has been quite a lot of LADM based researches in Poland. As it is mentioned before they were conducted independently generally in two directions, with differing approach. We can acknowledge that the researches were generally conducted in academia. Although, one of researchers used to work in Polish geodetic administration (GUGiK), the researches on LADM were generally made independently as a scientific activity, not as a government work. The Polish Committee for Standardisation (PKN) performed usual activities concerning ISO 19152 (acceptance and publishing). Presently, there is some interest concerning Land Administration Domain Model and it seems quite possible that the Technical Committee 297 (Geographic Information) of the Polish Committee for Standardisation is going to participate in future works concerning ISO 19152 development.

3.4 Serbia

– *How has the country profile been promoted to the bodies responsible for the cadastral system development (e.g. national mapping agency)?*
The country profile has been presented to the employees in national mapping agency who were involved in the cadastral system development and maintenance and with who we collaborated during the development of data model.

– *Has any feedback from representatives of national mapping agency already been received? Are benefits of adopting the LADM based profiles taken into account?*
The board of Republic Geodetic Agency agreed on the conceptual model, and only remarks were on the implementation level. However, it seems that the adoption of LADM is not their priority, and the Strategy only mentions it as "international trend in geodesy". The mapping agency is mostly focused to develop a new cadastral information system (especially the part containing legal data, usually referred to as land register), since the 30 years old legacy system is no longer capable to respond to increasing users and market demand and to integrate to e-Government environment (development of e-Government services and digital society is considered as one of the government priorities in general). In a new law on cadastre that is planned for 2018, a greater use of electronic services is foreseen, but the current system is not fully operational to support it.
LADM benefits were taken into account and LADM based profiles can produce benefits for the land administration systems (improvements in data and process models). LADM also provides support for three-dimensional (3D) representations and 3D registration of rights, so the creation of a country profile for Serbia is a starting point toward a 3D cadastre. Given the existence of buildings with overlapping of rights and restrictions in 3D, considering expanding the spatial profile with 3D geometries is necessary.

– *Has the LADM based country profile already been applied in the production environment in your country or is going to be applied in the near future, e.g. in the next five years?*

The development of the new cadastral information system in Serbia based on a new data model is planned by the national mapping agency, although the timeframe and weather it will be based on LADM country profile is not known. However, since the development and implementation of the new data model is necessary and already planned by the

mapping agency, the cost to apply the LADM based country profile in the production environment will not cause significant additional costs.

4. DISCUSSION AND CONCLUSION

4.1 Creation of the LADM based country profiles

To fully understand the international standard like ISO 19152 LADM requires not only the technical knowledge (e.g. principles of data modeling, UML notation, etc.) but also deep knowledge of the domain of cadastre. Therefore a team consisting of members from various sectors (academia, government, industry) could work very well. As the data model of the cadastre is not always available to public (incl. academia), the experience of professionals who utilize the cadastre on a day-to-day basis is necessary, as it helps to better understand not only the data model itself, but also the related processes (e.g. data from external sources).

On the principle, for countries with the well-developed cadastral systems, the LADM based country profile could be created in the way that one demonstrates an inherited structure between LADM and the existing cadastral model. This is also the case of all the four elaborated countries. The LADM is regarded as a conceptual data model that enforces certain relationships between the entities. The first step in creation of the LADM based country profile is to describe the existing physical data model (tables, attributes, code lists, relationships), the existing cadastral data structures are formulated in UML. The methods for reverse engineering can then be used to get from the physical data model into the conceptual data model to enable depicting the inheritance between the existing classes and LADM classes. In this way, i.e. considering the current cadastral data model, the created LADM based profile has a strict liaison with official cadastral model.

The created profile could then be extended for the new classes which have no equivalent in LADM. These classes enable to capture all the requirements coming from legislation of particular country. This is also the case of elaborated LADM based country profiles. Later on, the LADM based country profile can be also extended for LADM classes which have no corresponding class in the existing cadastral data model. For example, if the utilities are not (but are going to be) registered in the cadastre, then LADM class LA_LegalSpaceUtilityNetwork can be considered as the extension of the created LADM based profile. Another example, in case that legislation will allow for registration of 3D spatial units, the LADM class LA_BoundaryFace will be most probably considered.

4.2 Dissemination of the profiles

The described LADM based country profiles were promoted via scientific journals or international conferences. Such activities are needed, it could be used as a type of guideline for others conducting or planning a similar activity. Furthermore, the profiles were promoted at the regional or national level. These dissemination activities are of the same importance as it is also important to present the ideas of the 3D cadastre and LADM to the government bodies responsible for the cadastral system development. It is understandable that the official representatives of these bodies are often saying that there are still many issues to be solved in the existing 2D cadastre, but the arguments for the 3D cadastre should be continually presented. The creation of the LADM based country profile could be one of the first steps on

the way to establish the 3D cadastre as there are the benefits of adopting LADM – a standardization, support for registration of 3D spatial units and harmonization at international/EU level.

The described profiles were compared with existing cadastral data models. It can be concluded that LADM based profiles of the examined countries contains the necessary classes for conformance Level 2 (medium level according to the ISO 19152 LADM) and even some classes for the Level 3.

Based on the defined LADM based country profiles the new cadastral systems can potentially be developed or further modified/extended in a standardized way. The World Bank insists on data models based on LADM in the preparation of the new loan (2018-2021) for improving cadastre and land registry. In Croatia, the Integrated Land Administration System Project (ILAS Project) in the framework of the Organized Land national programme is a follow-up to successfully completed Real Property Registration and Cadastre Project (RPRC Project) which was implemented by the State Geodetic Administration (SGA) and Ministry of Justice. Through the RPRC Project, the two institutions together with their cadastral offices and land registry offices, successfully completed the first phase of the land administration reform. Above mentioned loan is the third phase of the land administration reform.

Even the LADM based profiles have not (yet) been implemented in the production environments, the situation might be different in the future. In the Czech Republic, the Strategy for the BIM implementation was approved by the Czech government. From 2026 the Czech Office for Surveying, Mapping and Cadastre is obliged to ensure the reusing of the BIM data for 3D cadastre purposes. It can be expected that this Strategy will enforce the change in the existing cadastral data model towards the registration of 3D spatial units. In Poland, presently there is interest concerning LADM and the Technical Committee 297 (Geographic Information) of the Polish Committee for Standardisation is going to participate in future works concerning ISO 19152 development. In Serbia, the development of the new cadastral information system based on a new data model is planned by the national mapping agency. Despite the fact that it is not known if the new system will be based on LADM it is important to have Serbian LADM country profile available and to argue that its implementation in the production environment will probably not cause significant additional costs. However, the further research dealing with LADM implementation should elaborate more on the cost analysis, especially in case when 3D spatial units are going to be included in the profile and implemented in practice.

ACKNOWLEDGEMENTS

The first author of the paper was supported by the project LO1506 of the Czech Ministry of Education, Youth and Sports. The second author provided his research within the Statutory Researches conducted at the AGH University of Science and Technology, Department of Geomatics, no. 11.11.150.006.

REFERENCES

Alkan, M. and Polat, Z.A. (2016). Design and development of LADM-based infrastructure for Turkey, Survey Review, doi: 10.1080/00396265.2016.1180777.

Bydłosz J. (2010). Modelowanie systemu ksiąg wieczystych z zastosowaniem Land Administration Domain Model (Modeling of land register with the use of Land Administration Domain Model). Roczniki Geomatyki. Polskie Towarzystwo Informacji Przestrzennej. t. 8 z. 5, pp. 43–50.

Bydłosz J. (2012a). Preliminary works on leading Polish cadastral model into conformance with LADM. GIS for geoscientists: scientific monograph. Zagreb: Hrvatski Informaticki Zbor, GIS Forum, 86-92.

Bydłosz J. (2012b). Uwarunkowania implementacji katastralnego modelu administrowania terenem w Polsce (The conditions for implementation of land administration domain model in Poland). Roczniki Geomatyki, Polskie Towarzystwo Informacji Przestrzennej. t. 10, z. 2, pp. 17‑24.

Bydłosz J. (2013). Polski system katastralny w aspekcie ISO 19152 (Polish cadastral system and ISO 19152). Roczniki Geomatyki. Polskie Towarzystwo Informacji Przestrzennej. t. 11, z. 2, pp. 15–23.

Bydłosz, J. (2015). The application of the Land Administration Domain Model in building a country profile for the Polish cadastre. Land Use Policy, 49, 598–605.

Bydłosz J., Góźdź K., Radzio W. (2012). Model pojęciowy polskiego systemu katastralnego na tle rozwiązań ujętych w „Katastralnym modelu administrowania terenem" (LADM) (A conceptual model of the Polish cadastral system with reference to solutions of "The Land Administration Domain Model" (LADM)). Przegląd Geodezyjny, nr 6, pp. 9-15.

Elizarova, G., Sapelnikov, S., Vandysheva, N. , Pakhomov, S., Van Oosterom, P., De Vries, M. Stoter, J., Ploeger, H., Spiering, B., Wouters, R., Hoogeveen, A., Penkov, V. (2012). Russian-Dutch Project "3D Cadastre Modelling in Russia", In: Proceedings 3rd International Workshop 3D Cadastres: Developments and Practices (P. van Oosterom, R. Guo, L. Li, S. Ying, S. Angsüsser, eds.), Shenzhen, pp. 87-102.

Felus, Y, Barzani, S., Caine, A., Blumkine, N., Van Oosterom, P. (2014). Steps towards 3D Cadastre and ISO 19152 (LADM) in Israel. In: Proceedings of the 4th International Workshop on 3D Cadastres. 9-11 November 2014, Dubai, United Arab Emirates. ISBN 978-87-92853-28-8.

Góźdź, K., Pachelski, W. (2014). The LADM as a core for developing three-dimensional cadastral data model for Poland. The 14th International Multidisciplinary Scientific GeoConference SGEM 2014. Albena, Bulgaria, 17-26 June 2014.

Góźdź, K., Pachelski, W., Van Oosterom, P., Coors, V. (2014). The Possibilities of Using CityGML for 3D Representation of Buildings in the Cadastre. In: Proceedings of the 4th International Workshop on 3D Cadastres. 9-11 November 2014, Dubai, United Arab Emirates, pp. 339-362. ISBN 978-87-92853-28-8.

Góźdź, K.J., Van Oosterom, P.J.M. (2015). Developing the information infrastructure based on LADM - the case of Poland. Survey Review, Maney Publishing, 48 (348), pp. 168-180.

Griffith-Charles, Ch. and Edwards, E. (2014) Proposal for Taking the Current Cadastre to a 3D, LADM Based Cadastre in Trinidad and Tobago. In: Proceedings of the 4th International Workshop on 3D Cadastres. 9-11 November 2014, Dubai, United Arab Emirates. ISBN 978-87-92853-28-8.

ISO (2012). ISO 19152, Geographic information – Land Administration Domain Model (LADM), ed. 1. ISO, Geneva, Switzerland.

Janečka, K., Souček, P. (2017). A Country Profile of the Czech Republic Based on an LADM for the Development of a 3D Cadastre. ISPRS Int. J. Geo-Inf. 2017, 6, p. 143.

Kalantari, M., Dinsmore, K., Urban-Karr, J., Rajabifard, A. (2015). A roadmap to adopt the Land Administration Domain Model in cadastral information systems. Land Use Policy, 49, pp. 552-564.

Kalogianni, E., Dimopoulou, E., Quak, W., Van Oosterom, P. (2016) Formalizing Implementable Constraints in the INTERLIS Language for Modelling Legal 3D RRR Spaces and 3D Physical Objects, In: Proceedings of the 5th International Workshop on 3D Cadastres (Peter van Oosterom, Efi Dimopoulou, Elfriede M. Fendel, eds.), Athens, pp. 261-284, 2016.

Official Gazette of the Republic of Croatia (2007a). Land Cadastre Ordinance, No. 84.

Official Gazette of the Republic of Croatia (2007b). Ordinance on subdivision and other geodetic reports, No. 86.

Official Gazette of the Republic of Serbia. The Strategy of Measures and Activities for Increasing the Quality of Services in the Field of Geospatial Data and Registration of Real Property Rights in the Official State Records (2017).
Available online:
http://www.rgz.gov.rs/o-nama/strategija-razvoja//(accessed on 08-02-2018).

Official Gazette of the Republic of Serbia. The Law on State Survey and Cadastre (2009). Available online:
http://paragraf.rs/propisi/zakon_o_drzavnom_premeru_i_katastru.html (accessed on 24-08-2017.

Official Gazette of the Republic of Serbia. The Law on State Survey and Cadastre and Registration of Rights on Real Estates (1992). Available online: http://notarisrbija.rs/wp-content/uploads/2014/09/zakon_katastar_nepokretnosti.pdf (accessed on 24-08-).

Radulović, A., Sladić, D., Govedarica, M. (2017). Towards 3D Cadastre in Serbia: Development of Serbian Cadastral Domain Model. ISPRS Int. J. Geo-Inf. 2017, 6, p. 312.

Regulation of Ministry of Administration and Digitization from 29th of November 2013, changing the regulation on land and building cadastre (Journal of Laws from 2013, item 1551, with later changes), published in Polish.

Siejka, M., Ślusarski, M., Zygmunt, M. (2014). 3D + time Cadastre, possibility of implementation in Poland. Survey Review, 46 (No 335), pp. 79-89.

Sladić, D., Radulović, A. Govedarica, M. (2017). Cadastral Records in Serbian Land Administration. In: Proceedings of the FIG Working Week 2017, Helsinki, Finland, 29 May-2 June 2017.

Vučić, N., Markovinović, D., Mičević, B. (2013). LADM in the Republic of Croatia-making and testing country profile. In: Proceedings of the 5th FIG International Land Administration Domain Model Workshop 2013, Kuala Lumpur, Malaysia, 24-25 September 2013.

Vučić, N., Roić, M., Mađer, M., Vranić, S., Van Oosterom, P. (2017). Overview of the Croatian Land Administration System and the Possibilities for Its Upgrade to 3D by Existing Data. ISPRS International Journal of Geo-Information, 6 (7), 223-1. doi:10.3390/ijgi6070223.

Zulkifli, N.A., Abdul Rahman, A., Jamil, H., Teng, C.H., Tan, L.C., Looi, K.S., Chan, K.L., Van Oosterom, P. (2014). Development of a prototype for the assessment of the Malaysian LADM country profile. In: Proceedings of FIG Congress 2014, Malaysia.

Zulkifli, N.A., Abdul Rahman, A., Van Oosterom, P., Choon, T.L., Jamil, H., Hua, T.Ch., Seng, L.K., Lim, Ch.K. (2015). The importance of Malaysian Land Administration Domain Model country profile in land policy. Land Use Policy 49, pp. 649-659. http://dx.doi.org/10.1016/j.landusepol.2015.07.015

BIOGRAPHICAL NOTES

Karel Janečka has a PhD (2009) Geomatics, University of West Bohemia in Pilsen. He had been working as a database programmer at the Czech Office for Surveying, Mapping and Cadastre in Prague in Section of Cadastral Central Database between 2006 and 2008. Since 2009 he has been a researcher at University of West Bohemia, Department of Geomatics. His research activities are spatial data infrastructures (SDI), geographical information systems (GIS), spatial databases, spatial data mining, and 3D cadastre. He has experience with coordination of several European research projects and is also reviewer of several international geoinformation scientific journals. Since 2012 he has been the President of the

Czech Association for Geoinformation and member of ISO/TC 211/WG 9/Information Management.

Jarosław Bydłosz (PhD) is the Senior Researcher (Assistant Professor) at the Department of Geomatics, Faculty of Mining Surveying and Environmental Engineering, AGH University of Science and Technology in Cracow (Poland). Jarosław Bydłosz obtained PhD in 1997 and postdoctoral degree (habilitation) in 2016. His scope of interests are Geographic Information Systems, cadastre and standardization. The recent activities concern 3D cadastre and issues concerning ISO 19152 "Land Administration Domain Model". He is a member of Polish Real Estate Scientific Society and Polish Association for Spatial Information. Since 2010, Jarosław Bydłosz has been an active participant of FIG Joint Commission 3 and 7 Working Group on 3D Cadastres.

Aleksandra Radulović (PhD) is an Assistant Professor at the Faculty of Technical Sciences, University of Novi Sad, Serbia. She has published several papers in international and national journals and conferences. She has also participated in several research projects including GIS (geoportal) for the Ministry of Environmental Protection and Ecology of Serbia, Information system of the real estate cadastre for Republic Geodetic Authority of Republic of Srpska, Information system of the real estate cadastre in Montenegro and Information system for user requests submission in the cadastral system in Republic of Serbia.

Nikola Vučić graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. In 2015 he received a PhD from the University of Zagreb for the thesis "Support the Transition from 2D to 3D Cadastre in the Republic of Croatia". He is the Head of Sector for cadastral programs and special registers at the State Geodetic Administration of the Republic of Croatia. His main research interests were and still are land administration systems, 3D cadastres and geoinformatics. He is researcher on the scientific project Development of Multipurpose Land Administration System (DEMLAS). He is a member of the Croatian Geodetic Society.

Dubravka Sladić (PhD) is an Assistant Professor at the Faculty of Technical Sciences, University of Novi Sad, Serbia. She has published 7 papers in ISI journals and more than 20 papers in international and national journals and conferences. She has also participated in several research projects and projects including design and implementation of cadastral information systems in Republic of Srpska in Bosnia and Herzegovina, Montenegro and Serbia. Her domain of interest are Geographic Information Systems, Spatial Data Infrastructures, Service Oriented Architecture, Cadastral Systems, etc.

Miro Govedarica (PhD) is a Full Professor at the Faculty of Technical Sciences, University of Novi Sad, Serbia. His practical and theoretical results belong to disciplines such as object-oriented software engineering, databases, database with spatial extensions, development of service-oriented information and geoinformation systems, photogrammetry, laser scanning, remote sensing, global navigation satellite systems. Special attention in his work is dedicated to the development of software components and implementation of GIS systems and research and development of cadastral systems.

CONTACTS

Karel Janečka
University of West Bohemia
Technická 8
Pilsen
CZECH REPUBLIC
Phone: +420 607982581
E-mail: kjanecka@kgm.zcu.cz
Website: http://gis.zcu.cz

Jarosław Bydłosz
AGH University of Science and Technology
Al. Mickiewicza 30
30-059 Kraków
POLAND
Phone: +48 12 617 22 67
Fax: + 48 12 617 45 88
E-mail: bydlosz@agh.edu.pl
Website: http://www.geomatyka.agh.edu.pl

Aleksandra Radulović
University of Novi Sad, Faculty of Technical Sciences
Trg Dostiteja Obradovića 6
Novi Sad
SERBIA
Phone: + 381 21 485 2260
E-mail: sanjica@uns.ac.rs
Web site: http://www.ftn.uns.ac.rs

Nikola Vučić
State Geodetic Administration
Gruška 20
10000 Zagreb
REPUBLIC OF CROATIA
Phone: +385 1 6165 439
Fax: +385 1 6165 454
E-mail: nikola.vucic@dgu.hr
Website: http://www.dgu.hr

Dubravka Sladić
University of Novi Sad, Faculty of Technical Sciences
Trg Dostiteja Obradovića 6
Novi Sad
SERBIA
Phone: + 381 21 485 2260
Fax- + 381 21 458 873
E-mail: dudab@uns.ac.rs
Website: http://www.ftn.uns.ac.rs

Miro Govedarica
University of Novi Sad, Faculty of Technical Sciences
Trg Dostiteja Obradovića 6
Novi Sad
SERBIA
Phone: + 381 21 485 2258
E-mail: miro@uns.ac.rs
Website: http://www.ftn.uns.ac.rs