Country Profile for the Cadastre of the Czech Republic Based on LADM

Karel JANEČKA and Petr SOUČEK, Czech Republic

Key words: Country profile, LADM, GeoInfoStrategy

SUMMARY

In 2014 the New Civil Code entered into force in the Czech Republic. This Act addresses several aspects of 3D cadastre. In particular, real estates are land and underground construction with a separate special-purpose uses, as well as property rights to them. The Act says explicitly, that the space above and below the surface, buildings established on the land and other facilities (excluding temporary buildings), including what is embedded in land or fixed in the walls, are parts of the land. Furthermore, if an underground construction is not a real estate, then it is a part of the land, even if it affects (lays below) the other land. In connection with the adoption of the New Civil Code, also a new Cadastral Act (law number 256/2013 Coll., the "New Cadastral Act") entered into force as a basic legal cornerstone of the cadastre of real estate of the Czech Republic. This is the set of data about real estates in the Czech Republic, including their inventory and description and their geometric specification and position. Parts of it are records of property and other material rights and other legally stipulated rights to these real estates. Cadastre of real estate contents many important data about parcels and selected buildings and their owners and is administered as the information system about the territory of the Czech Republic mainly by the computer means, where cadastral unit is the basic territorial unit. Despite the fact, that the cadastre of real estates is registered in 2D, some paragraphs of the New Civil Code touches the 3D (e.g. the space above and below the surface is part of the land). There is a difference in definition of "parcel" in the New Civil Code (3D) and the New Cadastral Act (2D). In October 2014, the Czech government approved the conception of The Strategy for the Development of the Infrastructure for Spatial Information in the Czech Republic to 2020 (GeoInfoStrategy), which serves as a basis for the National Spatial Data Infrastructure (NSDI). There is a strong emphasis on the creation of National Set of Spatial Objects. NSSO is defined as the source of guaranteed and reference 3D geographic data at the highest possible level of detail for selected objects of the real world, covering the whole territory of the Czech Republic. A part of NSSO should be 3D buildings. These 3D buildings will serve for several analysis and can also introduce a base for modelling of legal spaces of buildings and units in 3D in the future. The paper presents the country profile for the cadastre of the Czech Republic based on ISO 19152:2012 Land Administration Domain Model (LADM) reflecting the actual production cadastral system. The profile consists of both legal and spatial part. We applied the abstract test suite stated in ISO 19152:2012 – Annex A (Abstract test suite) and the LADM conformance requirements to explore a conformity with this international standard. The profile is conformant with LADM at level 2 (medium level) and can be further modified, especially when the Cadastral Act will be updated in the future towards 3D.

Country Profile for the Cadastre of the Czech Republic Based on LADM

Karel JANEČKA and Petr SOUČEK, Czech Republic

1. INTRODUCTION

In 2014 the New Civil Code entered into force in the Czech Republic. This Act addresses several aspects of 3D cadastre. In particular, according to the New Civil Code, real estates are land and underground construction with a separate special-purpose uses, as well as property rights to them. The Act says explicitly, that the space above and below the surface, buildings established on the land and other facilities (excluding temporary buildings), including what is embedded in land or fixed in the walls, are parts of the land. Furthermore, if an underground construction is not a real estate, then it is a part of the land, even if it affects (lays below) the other land. A landowner must accept the use of space over land or under the land, if an important reason for this is happening and in such a way that the owner can't have good reason to oppose it.

In connection with the adoption of the New Civil Code, also a new Cadastral Act (law number 256/2013 Coll., the "New Cadastral Act") entered into force as a basic legal cornerstone of the cadastre of real estate of the Czech Republic. This is the set of data about real estates in the Czech Republic, including their inventory and description and their geometric specification and position. Parts of it are records of property and other material rights and other legally stipulated rights to these real estates. Cadastre of real estate contents many important data about parcels and selected buildings and their owners and is administered as the information system about the territory of the Czech Republic mainly by the computer means, where cadastral unit is the basic territorial unit. The Cadastre's documentation comprises mainly from the file of geodetic information encompassing the cadastral map (including its digital representation in given cadastral units) and the file of descriptive information including the data about cadastral units, parcels, buildings, flats and non-residential premises, about owners and other justified persons, about legal relations and rights and other facts given by the law.

Despite the fact, that the cadastre of real estates is registered in 2D, some paragraphs of the New Civil Code touches the 3D (e.g. the space above and below the surface is part of the land). There is a difference in definition of "parcel" in the New Civil Code (3D) and the New Cadastral Act (2D).

In October 2014, the Czech government approved the conception of The Strategy for the Development of the Infrastructure for Spatial Information in the Czech Republic to 2020 (GeoInfoStrategy), which serves as a basis for the National Spatial Data Infrastructure (NSDI). There is a strong emphasis on the creation of National Set of Spatial Objects in the GeoInfoStrategy (NSSO). NSSO is defined as the source of guaranteed and reference 3D geographic data at the highest possible level of detail for selected objects of the real world, covering the whole territory of the Czech Republic.

A part of NSSO should be 3D buildings, optimally at LOD4 according to the CityGML specification. These 3D buildings will serve for several analysis and can also introduce a base for modelling of legal spaces of buildings and units in 3D in the future.

The paper presents the country profile for the cadastre of the Czech Republic based on ISO 19152:2012 Land Administration Domain Model (LADM) reflecting the actual production cadastral system. The proposed profile consists of both legal and spatial part. We applied the abstract test suite stated in ISO 19152:2012 – Annex A (Abstract test suite) and the LADM conformance requirements to explore a conformity with this international standard. To test the conformity we used mapping of elements between the LADM and the tested country profile. In some cases the elements of the country profile are inherited from the LADM. The profile is conformant with LADM at level 2 (medium level) and can be further modified, especially when the Cadastral Act will be updated in the future towards 3D.

The paper describes a feasible "show case" which could be a sort of guideline for others doing or planning a similar application.

2. THE NEW CIVIL CODE AND ITS IMPACT ON THE CADASTRE

A new Civil Code (Act No. 89/2012 Coll.) entered into force on 1 January 2014, replaced the actual one of 1964 (Act 40/1964 Coll., as amended). The new Civil Code defines what the real estate is. According to the new Civil Code, the real estates are land (including 3D space above and below the surface), and underground constructions with separate special-purpose use (e.g. metro, collectors, wine cellars…). If an underground construction is not a real estate, then it is a part of the land, even if it affects (lays below) the other land. In practice, many underground constructions are not registered in the cadastre. The underground construction is registered in a case when some part(s) of this construction is located above the ground (see fig. 1 and 2).

(a)

(b)

Figure 1. (a) Visualization of the underground construction - the archeological park in Pavlov, Czech Republic (Olivová, 2016); (b) Entrance to the archeological park in Pavlov, Czech Republic (photo: Institute of Archeology of the CAS, Brno)..

The new Civil Code explicitly considers the 3D space above and below the land as a part of the land. The Cadastral Law defines then the parcel as a piece of land projected on the

horizontal plane (2D cadastral map). It is not explicitly said there, that the 3D space above and below the parcel is a part of the parcel (3D parcel). However, as published in Stoter and Oosterom (2006), although parcels are represented in 2D, someone with a right to a parcel always has been entitled to a space in 3D; i.e., a right of ownership on a parcel relates to a space in 3D that can be used by the owner and is not limited to just the flat parcel defined in 2D without any height or depth.

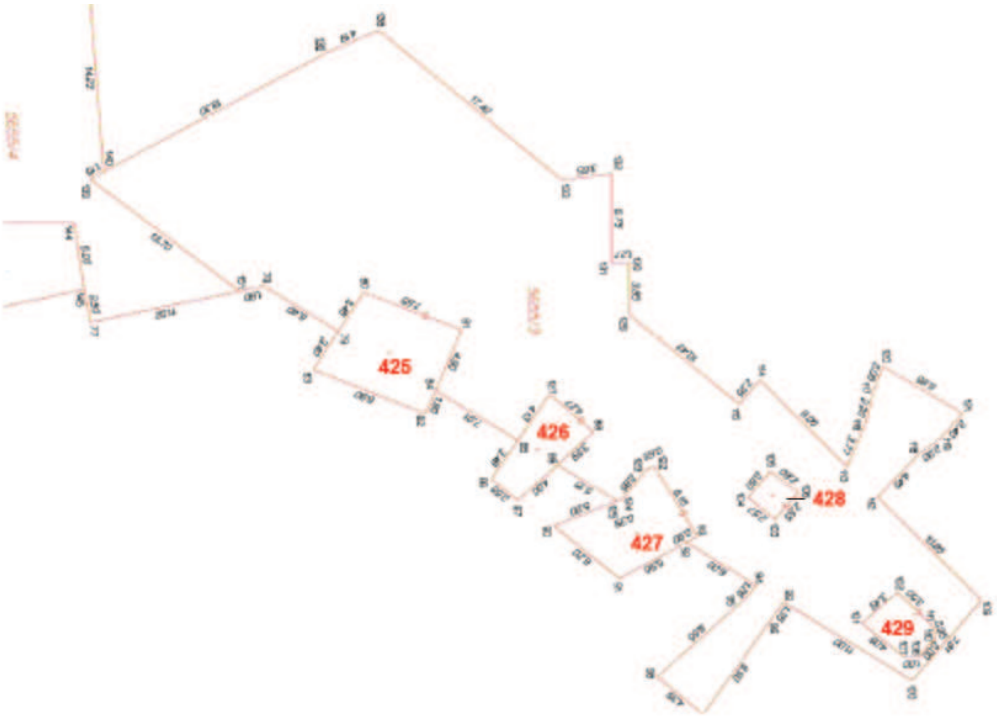

Figure 2. Visualization (in 2D map) of the boundary of the underground construction – the archeological park in Pavlov. Every part of the construction above the ground has to lay on a separate building parcel (here total 5 building parcels with bold red number; after Olivová (2016))

The new Civil Code took over many provisions of other Acts which were at the same time repealed, for example the Flat Ownership Act, the Act on Association of Persons etc. It re-introduces the former Czech legal terminology, which was gradually abandoned by the Civil Codes of 1950 and 1964. The Property Law part regulates the tenure, the possession, the ownership and co-ownership, the encumbrance, the lien, and also the heirship. The following changes had to be considered during the proposal of the LADM based country profile.

Building as Part of Land

After 1 January 2014 a person who owned a building and the land on which it stands, that building became part of the land (the Czech real estate law returned to the principle that structures are part of the land on which they are built - a "superficies solo cedit" principle). Buildings established on land (except for temporary buildings, utility lines and some other exemptions) are no longer be objects of law and only form a part of the land.

If the land owner and the building owner were two different persons at this time, the building remained as real estate, but the land owner holds a pre-emptive right to the building and the

building owner holds a pre-emptive right to the land. The building will then become part of the land when the building and the land first meet in the hands of the same owner. The building will not become part of the land if the building or the land is encumbered by a right in rem (i.e. right associated with a property, not based on any personal relationship).

Right of Building
Based on this new instrument in Czech law it will be possible to construct a building on a third party's land. The right of building is a temporary right (99 year maximum) established by an agreement between the land owner and the developer. From a legal point of view the right of building as a whole is considered to be real estate and is a subject to registration in the cadastre of real estates. The right of building can be subject to a transfer, mortgage, heritage or easement. The right of building is independent of the existence of the structure and can therefore be established even if the construction procedure has not yet started. After expiry of the right, the right of building can be theoretically prolonged, or the building becomes a part of the land.

Ownership of building units
The new Civil Code also regulates the ownership of building units, which was previously contained in a separate act. A building unit remains a separate piece of real estate and does not form part of the land. The owner of the building unit automatically also owns a share of common parts of the building.

Supplementary co-ownership
Supplementary co-ownership is a special type of the ownership. There are owners of their own property, who are allowed to use it only together with some shared property (e.g. a driveway). The ownership of that shared property names supplementary co-ownership. Ownership of property in supplementary co-ownership is inextricably linked with the ownership of properties for whose use property in supplementary co-ownership serves. Separate transfer of such property is not possible.

3. GEOINFOSTRATEGY

The vision of the GeoInfoStrategy is that, in 2020, the Czech Republic is a knowledge society effectively using spatial information. To fulfil this vision, it is necessary that spatial information and services will be used in every aspect of public life. The GeoInfoStrategy is a conceptual material that has a close relation to other strategic documents of public administration and eGovernment. The GeoInfoStrategy defines the principles and strategic aims for effective use of the spatial information in public administration.

The GeoInfoStrategy contributes to fulfill the government priorities as well as the priorities of particular ministries, e.g., in the fields of environmental protection, cadastre, and protection of cultural heritage.

Regarding the priorities in the cadastre, the further development of the basic register of territorial identification, addresses and real estates (RTIARE) is emphasized. This basic

register is the central information source of selected spatial data for information systems of public authorities. Every RTIARE element consists of descriptive and positioning information. The positioning information includes a boundary, definition line and definition point. RTIARE contains territorial elements, i.e. parts of the territory enclosed by boundaries like parcels, building constructions with house numbers or cadastral units. Furthermore, RTIARE contains territorial units without boundaries, such as parts of municipalities, or streets (Čada and Janečka, 2016a). During its further development the more territorial elements should be added.

The GeoInfoStrategy has four strategic aims. The first strategic aim is to ensure guaranteed services of public administration for the effective management and use of spatial information and wide use of these services by society. It is necessary to define the life situations for which it is suitable and useful to use spatial information and services information for society.
The next two strategic aims emphasize to establish the national infrastructure for production, management and interlinking of the spatial data funds of public administration and to improve the quality and further development of spatial data funds. It is necessary to define the spatial data sets that the public administration needs in order to cover all its activities.
The fourth strategic aim is the coordination and development of institutional infrastructure for the field of spatial information. This strategic aim concerns mainly the coordination of legislation issues, ensuring skilled human resources and ensuring financing for research and development in the field of spatial information.

The projects that are going to be realized within the framework of the GeoInfoStrategy implementation will be financially supported from various funds (national, European). Till now, mainly the research projects financed by the Technology Agency of the Czech Republic (TACR) have been realized. TACR also supports the research projects not (directly) dealing with the GeoInfoStrategy. The BETA programme under the TACR is oriented on research, experimental development and innovation for the government. For example, the Czech Office for surveying, mapping and cadastre (national mapping agency) can define its research needs that are then financially supported from the BETA programme. The term "3D cadastre" has appeared as a keyword in one of the recent BETA calls for projects. However, this call was oriented mostly on generalization of the medium scale national map. Considering the GeoInfoStrategy initiative, the situation might change in the (near) future if there is a strong demand for 3D geographic data.

3.1 The National Set of Spatial Objects

There is a strong emphasis on the creation of National Set of Spatial Objects in the GeoInfoStrategy (NSSO). NSSO is defined as the source of guaranteed and reference geographic data at the highest possible level of detail for selected objects of the real world, covering the whole territory of the Czech Republic. Where appropriate, the NSSO should consist of the 3D objects. NSSO will be widely used, mainly in the decision making processes of public administration, by private sector and educational and research organizations. NSSO will be implemented as an information system at the governmental level with guaranteed standards of data quality, data flows and services. NSSO will enable the creation of some derived spatial objects by data model generalization. The main data sources for NSSO are (Čada and Janečka, 2016a):

- the outcomes of land surveying activities in the public interest (e.g., fundamental state map series, thematic state map series or maps of town utilities),
- the outcomes of land surveying activities for own use (e.g., preparation of the large-scale and extensive investment projects),
- the geodic part of the documentation of the actual construction being realized, and
- the information systems of the administrators of underground utilities.

Regarding the fundamental and thematic state map series as a source for NSSO, the most important is mapping of the important and relevant areas of interest (e.g., built-up areas).

3.2 Selected use cases dealing with 3D cadastre

The approved GeoInfoStrategy contains a description of several uses cases theoretically (but closely) dealing with 3D cadastre, e.g. administration of networks of technical infrastructure or creation of models of 3D buildings for noise mapping (Czech Republic, 2014).

Nowadays the information about the location of the networks of technical infrastructure is not registered in the cadastre. However, having this information in the cadastre could help to answer the questions like *show me below which parcels the cable leads* etc. Many parcel owners do not know if some cable or pipeline is located below their parcel. ISO 19152 offers a subclass LA_LegalSpaceUtilityNetwork (of the class LA_SpatialUnit) to support the registration of information (legal spaces) about the utilities together with cadastral data. The study (Döner et al, 2011) explores the characteristics of utility networks as 4D (3D space + time) objects. This study shows, that the 3D space and separate temporal attributes approach is a very promising solution to maintain temporal changes of utility networks. In the Czech Republic the register of passive infrastructure should be established. In the approved GeoInfoStrategy Action Plan the using ISO 19152 is recommended as one of the input documents for creation of the feasibility study of this register.

Another use case considers creation of models of 3D buildings, primarily for strategic noise mapping. The already existing spatial data sources (e.g. 2D digital cadastral map, laser scans) should be used for the creation of these 3D models. The requested level of detail (LOD) for this use case is LOD1 according to the CityGML specification (OGC, 2012). However, from the mentioned spatial data sources also the buildings at LOD2 can be created relatively easy. Such models can then serve for cadastral purposes (Góźdź et al, 2014; Seifert et al, 2016).

In the current version of the GeoInfoStrategy there is no explicit need to have 3D models for cadastral purposes. The situation can change in the future as also in the Czech Republic the newly built (apartment) buildings and constructions are often too complex for 2D registration. If the buildings are modelled with more detail including interior, then such 3D models can serve as a base for modelling of legal spaces of apartments and building units (Atazadeh et al, 2016). To make this operational, it has to be said what level of details are accepted in the national cadastre and how they are planned to be captured and registered. The idea that should be also considered is that it is not necessary to create the 3D model for every building which is registered in the cadastre, but only for those buildings, where the current 2D registration is not sufficient (Kalantari and Rajabifard, 2014).

4. THE PROPOSAL OF THE LADM BASED COUNTRY PROFILE

There were several points which motivated us to work on a proposal of the LADM based country profile. The set of measures for development of the regulatory framework in the field of spatial information were defined in the GeoInfoStrategy Action Plan. This Action Plan considers the adoption of the ISO 19152 standard in various government initiatives. In particular, using ISO 19152 is recommended for further development of the Register of territorial identification, addresses and real estates and for the feasibility study of the Register of passive infrastructure. It means, that during the implementation of the GeoInfoStrategy Action Plan there will be a demand for deep knowledge and understanding of LADM concept. Both mentioned registers could be considered as the cornerstone of the Czech National Spatial Data Infrastructure (Čada and Janečka, 2016b).

The Czech version of ISO 19152 exists since October 2013. The National Mirror Committee 122 Geographic information/Geomatics was responsible for translation. Both authors of the paper are members of this committee. During the work on translation the members of the committee had been discussing about using ISO 19152 in the Czech Republic. The conclusion was, that as the first step the country profile for the Czech Republic based on LADM should be created and then tested against the LADM concept.

An important incentive was also the feedback from the professionals like surveyors who are in touch with cadastre every day. During the presentations on 3D cadastre that were given on several national events and conferences by the first author of the paper the very positive feedback was received. For example, the Czech Union of Surveyors and Cartographers (a member of FIG) declared an interest in the field of 3D cadastre and demonstrated the need for 3D cadastre on several examples (registration of complex buildings, underground constructions, etc.)

As approved in the GeoInfoStrategy, where possible, the NSSO should consists of the 3D objects. It is not explicitly said in the GeoInfoStrategy that the parcels should be registered as 3D parcels. However, the proposed LADM model can be potentially extended to support the registration of 3D parcels (spatial units) in the future. It could serve as a base for an extension of the current data model of the cadastre in the standardized way.

The important part of the NSSO should also be 3D buildings. At the moment it is not decided what levels of detail will be required for all the use cases that should be covered by the GeoInfoStrategy. In other words, it will be necessary to define the appropriate level of detail of all objects from the NSSO to meet the requirements of public administration services.
There are many already existing sources of spatial data for creation of 3D buildings (e.g. digital surface model, the basic register of territorial identification, addresses and real estates, laser scans...) Having such source data available, mode precise 3D models than only LOD1 can be constructed (Góźdź et al, 2014; Seifert et al, 2016). If the buildings are modelled in 3D, then 3D spatial units can be stored in the cadastral database according to the LADM concepts (Thompson et al, 2016).

Considering the proposal of the LADM based country profile we aimed to have the LADM based country profile reflecting the current cadastral registration (with possible extension to 3D in future) and also to determine a compatibility between LADM and Czech cadastral data model.

4.1 Design of the Czech profile based on LADM

The LADM specifies a conceptual model. To use the LADM requires that an application scheme (country profile) is developed. We applied the reverse engineering, i.e. the first step in the creation of the national profile was an exploring of the physical model and then the logical model was created. In the next step the conceptual model of the cadastre was created based on the logical model. Having the conceptual model completed then we applied a mapping of the Czech tables (classes) on the LADM classes where possible. In some cases the Czech tables (classes) could be inherited from the LADM classes. It was also necessary to consider all the used code lists and compare them with the ones stated in the LADM.

Table 1. The used LADM classes in the Czech country profile. Additionally, the four new subclasses (with CZ_ prefix) were defined

LADM Package	*Used LADM class*	*New CZ subclass*
Party	LA_Party	
	LA_GroupParty	
	LA_PartyMember	
Administrative	LA_RRR	
	LA_Right	CZ_RightOfBuilding
	LA_Restriction	
	LA_Mortgage	
	LA_BAUnit	
	LA_RequiredRelationshipBaUnit	
	LA_AdministrativeSource	
Spatial Unit	LA_SpatialUnit	CZ_Parcel CZ_LegalSpaceBuildingUnit CZ_LegalSpaceBuilding
	LA_SpatialUnitGroup	
	LA_Level	
	LA_RequiredRelationshipSpatialUnit	
Surveying and Representation	LA_Point	
	LA_SpatialSource	
	LA_BoundaryFaceString	

Table 1 above contains the LADM classes used in the proposed Czech profile and the newly defined subclasses. The four subclasses (with CZ_ prefix), reflecting the needs of the new Civil Code, were added into the country profile:

- CZ_RightOfBuilding - the subclass serves for modelling the right of building that was returned into the Czech law by the new Civil Code (see fig. 3);
- CZ_Parcel - the subclass serves for modelling the 2D parcels. According to the new Civil Code, the owner may newly establish servitude of one of his own parcel to another parcel he owns. The new Civil Code also modifies an indivisible co-ownership. Using the LADM concept then it can be seen as a serving parcel (see fig. 4);
- CZ_LegalSpaceBuildingUnit – the subclass serves for modelling the building units. The owner of the building unit automatically also owns a share of common parts of the building;
- CZ_LegalSpaceBuilding - the subclass serves for modelling the buildings prior the effectiveness of the new Civil Code. It means that such buildings are considered as a separate things (real estates) and not part of land.

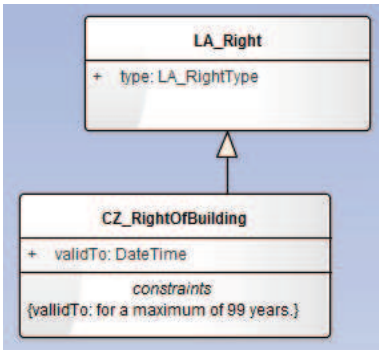

Figure 3. Right of building. The right of building can be established for a maximum of 99 years

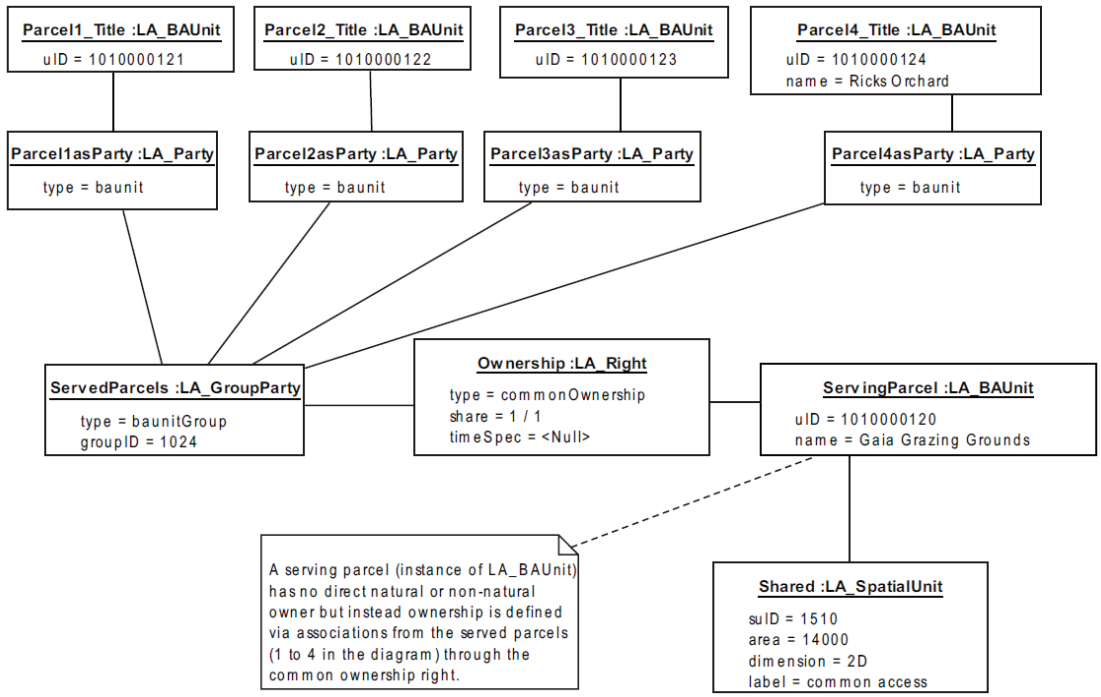

Figure 4. Serving parcel – owned by neighbours (ISO, 2012)

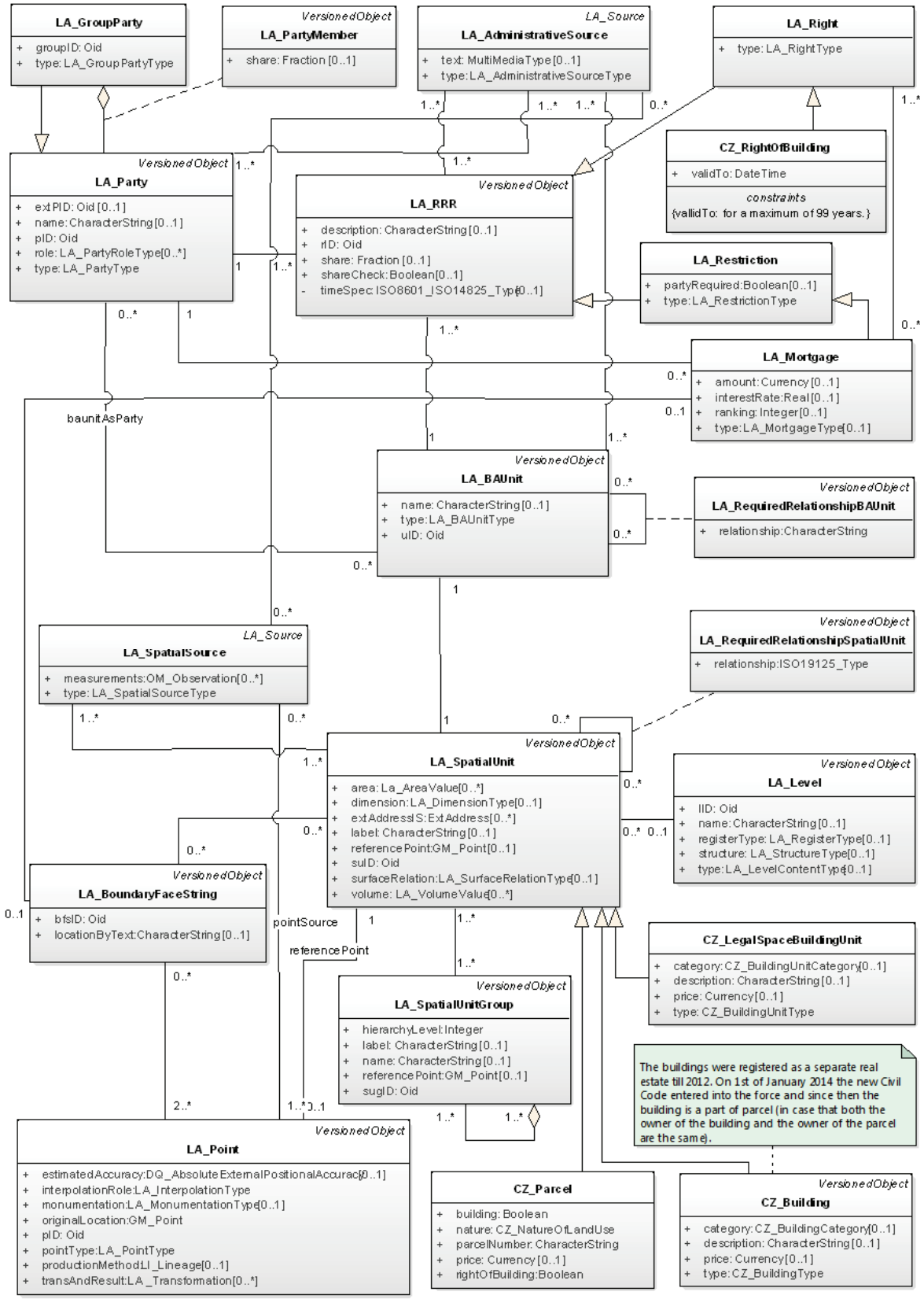

Figure 5. Country profile for the cadastre of the Czech Republic based on LADM

4.2 Conformity with ISO 19152

The LADM consists of three packages and one subpackage, and for each of them a conformance test is specified in Annex A – Abstract Test Suite (ISO, 2012). Three conformance levels are specified per (sub)package: level 1 (low level), level 2 (medium level), and level 3 (high level). Level 1 tests the basic classes per package and level 2 also includes the more common classes. Level 3 includes all classes. Any LADM claiming conformance to the ISO 19152 standard shall satisfy the requirements of Annex A.

The possible ways how to test the conformity are:

1) show inheritance structure between the LADM and the tested model (elements), or
2) show mapping of elements between the LADM and the tested model.

Table 2 gives an overview per package to check for LADM compliancy. The proposed country profile for the Czech Republic contains all the necessary classes for the conformance level 2 (medium level) and meets all required dependencies as mentioned in table 2.

5. CONCLUSIONS

The paper describes a creation of the LADM based country profile and its basic characteristics, especially the profile has to consider the requirements of the new Civil Code (e.g., Building as Part of Land, Right of Building or Supplementary co-ownership). We also explored a conformity with ISO 19152.

The approved GeoInfoStrategy contains a description of several uses cases theoretically (but closely) dealing with 3D cadastre, for example an administration of networks of technical infrastructure. Nowadays the information about the location of the networks of technical infrastructure is not registered in the cadastre. However, having this information in the cadastre could help to answer the questions like *show me below which parcels the cable leads* etc. Many parcel owners do not know if some cable or pipeline is located below their parcel. ISO 19152 offers a subclass LA_LegalSpaceUtilityNetwork (of the class LA_SpatialUnit) to support the registration of information (legal spaces) about the utilities together with cadastral data. In the Czech Republic the register of passive infrastructure should be established. In the approved GeoInfoStrategy Action Plan the using ISO 19152 is recommended as one of the input documents for creation of the feasibility study of this register.

As also approved in the GeoInfoStrategy, where possible, the NSSO should consists of the 3D objects. It is not explicitly said that the parcels should be registered as 3D parcels. However, the proposed LADM based country profile can be potentially extended to support the registration of 3D parcels (spatial units) and also networks of technical infrastructure in the future. It could serve as a base for an extension of the current data model of the cadastre in the standardized way.

Table 2. The LADM conformance requirements table (ISO, 19152). The classes for the conformance level 2 are highlighted in red rectangles

LADM package	LADM class	CI[3]	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)

[3] CI = Conformance level.

REFERENCES

Atazadeh, B., Kalantari, M., Rajabifard, A., Ho, S. and Ngo, T. (2016). Building Information Modelling for High-rise Land Administration. Trans. in GIS. doi:10.1111/tgis.12199.

Czech Republic (2012). The Civil Code, Law No. 89/ 2012 Coll.

Czech Republic (2013). The Cadastre of Real Estates, Regulation No. 357/2013 Coll.

Czech Republic (2014). The Strategy for the Development of the Infrastructure for Spatial Information in the Czech Republic to 2020—Annex 3: Services working with spatial data – use cases; Ministry of the Interior of the Czech Republic: Prague. (In Czech).

Čada, V. and Janečka, K. (2016a). The Strategy for the Development of the Infrastructure for Spatial Information in the Czech Republic. ISPRS International Journal of Geo-Information. Vol. 5, Issue 3:33. doi: 10.3390/ijgi5030033

Čada, V. and Janečka, K. (2016b). The Fundamental Spatial Data in the Public Administration Registers, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLI-B4, 171-174, doi: 10.5194/isprs-archives-XLI-B4-171-2016.

Döner, F., Thompson, R., Stoter, J., Lemmen, Ch., Ploeger, H., van Oosterom, P. and Zlatanova, S. (2011). Solutions for 4D cadastre – with a case study on utility networks. International Journal of Geographical Information Science. Vol. 25, No. 7, pp. 1173-1189.

Góźdź, K., Pachelski, W., van Oosterom, P. and 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.

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

Kalantari, M. and Rajabifard, A. (2014). A Roadmap to Accomplish 3D Cadastres. In: Proceedings of 4th International Workshop on 3D Cadastres. 9-11 November 2014, Dubai, United Arab Emirates, pp. 75-82. ISBN 978-87-92853-28-8.

Olivová, K. (2016). Visualization of untypical buildings in the cadastre of real estates. In: The cadastre of real estates currently. Czech Union of Surveyors and Cartographers, Prague. (In Czech)

Open Geospatial Consortium (2012). OGC City Geography Markup Language (CityGML) Encoding Standard. Version 2.0.0, 2012.

Stoter, J. and van Oosterom, P. (2006). 3D Cadastre in an International Context. Legal, Organizational, and Technological Aspects. CRC Press, Taylor & Francis. ISBN 978-0-8493-3932-5.

Thompson, R., van Oosterom, P., Soon, K.H. and Priebbenow, R. (2016). A Conceptual Model Supporting a Range of 3D Parcel Representations Through all Stages: Data Capture, Transfer and Storage. In: Proceedings of the FIG Working Week 2016. Christchurch, New Zealand. ISBN 978-87-92853-52-3.

ACKNOWLEDGEMENTS

The first author of the publication was supported by the project LO1506 of the Czech Ministry of Education, Youth and Sports.

BIOGRAPHICAL NOTES

Karel Janečka – Ph.D. (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 Section of cadastral central database between 2006 and 2008. Since 2009 he is 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 EU projects and is also reviewer of several international scientific journals. Since 2012 he is the president of the Czech Association for Geoinformation and member of National Mirror Committee 122 Geographic information/Geomatics.

Petr Souček – Ph.D. (2008) Geodesy and Cartography, Czech Technical University in Prague. He is working at Czech Office for Surveying, Mapping and Cadastre in Section of cadastral central database as a head of Section of programming and analysis. He is head of technical working group for data, which was established by INSPIRE National Contact Point (CENIA) in the Czech Republic. He has took a part in the whole process of creating, testing and validating data, metadata and services of INSPIRE themes AD, AU and CP in Czech Office for Surveying, Mapping and Cadastre. He participated in the design, testing and validation of INSPIRE view and download services (for the themes CP, AU, AD) as specified by INSPIRE Technical guidelines and OGC standards. He is registered expert in the group INSPIRE Maintenance and Implementation Framework.

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

Petr Souček
Czech Office for Surveying, Mapping and Cadastre
Pod sídlištěm 1800/9
Prague
CZECH REPUBLIC
Phone: + 420 281041574
E-mail: petr.soucek@cuzk.cz
Website: http://www.cuzk.cz