# TRANSITION OF 2D CADASTRAL OBJECTS INTO 3D ONES – PRELIMINARY PROPOSAL*

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**Abstract**

The 3D cadastral ideas have been very popular recently all around the world. They are also getting attention in Poland. The author proposes three dimensional (3D) cadastral objects, basing on the existing ones, that are "Cadastral Parcel", "Building" and "Premises". "Cadastral Parcels" and "Buildings" objects of Polish cadastre have been used to propose new three dimensional objects. For "Premises", it was suggested to focus on its visualization basing on experiences from other countries. The ISO 19152 "Land Administration Domain Model " is suppose to be helpful in these works, as a reference model. Its application is also required in some way by INSPIRE Directive.

**Keywords**: 3D cadastre, ISO 19152, LADM, UML.

## 1. Introduction

We can assume that interest in 3D cadastre received wide popularity since the first international workshop on 3D cadastre, that took place in Delft, in November 2001 (WWW, 2001). According to the later opinion of its organizers, rising this subject in 2001 was premature, if we take into account technical, organizational conditions and knowledge popularization. The second international workshop concerning 3D cadastre was organized also in Delft, in November 2011 (WWW, 2011). It revitalized discussion on multidimensional cadastre, in both cadastre and GIS communities around the world. Since then, the third workshop on 3D cadastre took place in Shenzhen, in October 2012. The sessions concerning 3D cadastre have been organized at FIG conferences, as well. Many papers having influence on 3D cadastre development have been published recently. They describe either general solutions or give answers for particular countries. The country solutions are too numerous to mention them. If we mean general researches, the important ones seem papers concerning both 3D cadastre and Land Administration Domain Model (Thomson and van Oosterom, 2012) and (Ying S. et al., 2011) and the paper concerning definition of valid 3D parcels (Thomson and van Oosterom, 2012). The very interesting survey concerning 3D cadastre around the world was described in (van Oosterom et al., 2011).

Researches on 3D cadastre are also conducted in Poland. The problems of 3D cadastre objects registration including rules and possible data sources in Poland were described in (Karabin, 2011) and (Karabin, 2012). The present state of cadastre in Poland, situations where 3D cadastre introduction seems necessary and preliminary possible scenarios for future 3D cadastre developments in Poland were presented in (Bydłosz, 2012a) and (Bydłosz, 2012c).

## 2. The Land Administration Domain Model

Works concerning ISO 19152 "Land Administration Domain Model" (LADM) have been conducted since the FIG congress, that took place in Washington in 2002. In 2008, FIG proposed Land Administration Domain Model in the Technical Committee 211 of International Organization for Standardization (ISO). Land Administration Domain Model received status of Draft International Standard in December 2009 and was formally published by ISO on the 1st of December 2012 as ISO 19152 (LADM, 2012). The Land Administration Domain Model has been also proceeded in European Committee for Standardization (CEN) and became a European standard as well.

The Land Administration Domain Model is a descriptive standard. It provides the reference model that is supposed to serve two targets (LADM, 2012). One is providing the extensive basis for development and refinement for efficient and effective land administration systems, based on Model Driven Architecture, while the other is to enable involved parties, both within one country and between different countries to communicate.

The Land Administration Domain Model is a conceptual schema, written with Unified Modelling Language (UML) notation. It is performed according to ISO 19100 series standards methodology. The Land Administration Domain Model is based on four basic classes.

They are class LA_Party (instances of this class are parties), class LA_RRR (LA_RRR subclasses are rights, restrictions and responsibilities), class LA_BAUnit (instances are basic administrative units) and class LA_SpatialUnit (having spatial units as instances). The classes of LADM are grouped in four packages. They are Party Package, Administrative Package, Spatial Unit Package plus Surveying and Spatial Representation Subpackage.

The most significant class concerning 3D situations seems to be LA_SpatialUnit. Instances of LA_SpatialUnit are spatial units. The spatial unit is the single area (or multiple areas) of land and/or water, or a single volume (or multiple volumes) of space. The spatial unit can be 2-dimensional (2D), 3-dimensional (3D), or mixed (2D and 3D) one (figure 1).

The class LA_LegalSpaceBuildingUnit is destined to represent legal spaces concerning buildings. The class LA_LegalSpaceBuildingUnit is a subclass of LA_SpatialUnit. Classes LA_SpatialUnit and LA_LegalSpaceBuildingUnit and connection between them are shown on the figure 2.

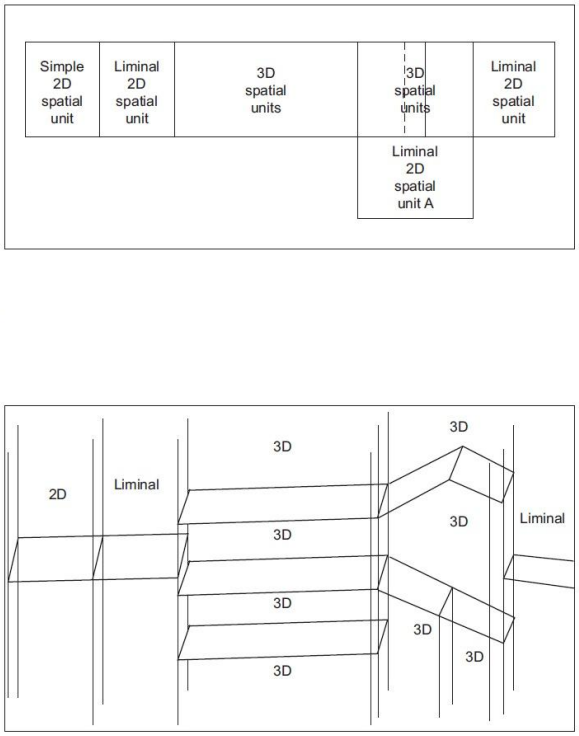


**Figure 1.** Top and slide views of mixed 2D and 3D representations (source: (LADM, 2012)).

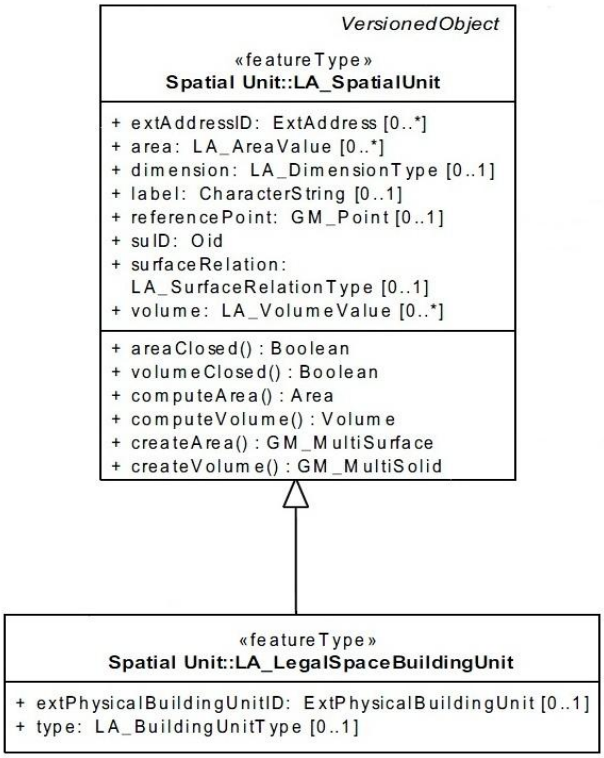


**Figure 2.** Classes LA_SpatialUnit and LA_LegalSpaceBuildingUnit with its attributes (source: (LADM, 2012)).

The 3D parcels can also be represented by volumes, that have non vertical boundaries. In such cases the boundary face strings may be used for boundary representations. Such a representation let us to describe various real 3D objects. For example, we can describe objects having wider top than bottom using boundary face strings. The concept of boundary face string is presented on the figure 3.

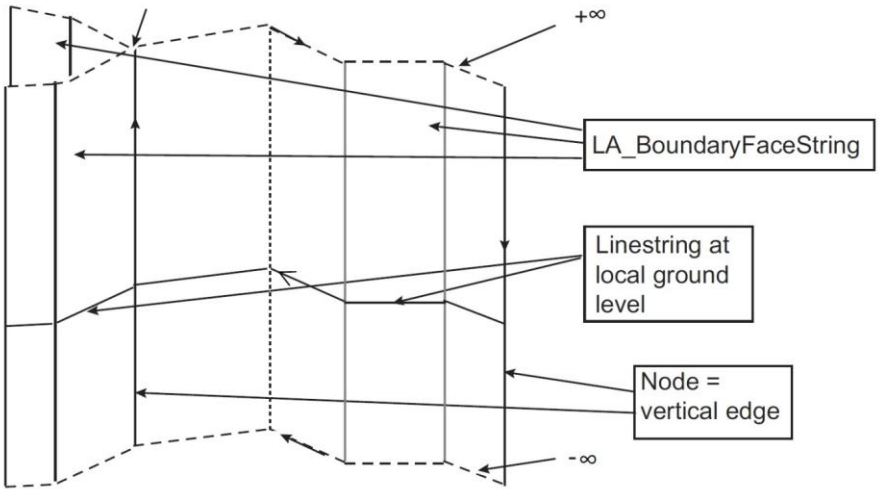


**Figure 3.** Boundary face string concepts (source: (LADM, 2012)).

The Land Administration Domain model also includes mixed spatial profile configurations. The 3D topological based profile is among them. This profile include pure 3D topology structure. The instance of 3D spatial unit is also given in informative annex of LADM.

The European Union member states are obliged to implement the Directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE, 2007). According to the article 7 of the Directive, implementing rules laying down technical arrangements for the interoperability and, where practicable, harmonization of spatial data sets and services, designed to amend non-essential elements of this Directive by supplementing it,

shall be adopted. The international standards, that are in favour for the harmonisation of spatial data sets shall be taken into account in the development of implementing rules. Moreover, where organizations established under international law have adopted relevant standards to ensure interoperability or harmonization of spatial data sets and services, these standards shall be integrated, and the existing technical means shall be referred to, if appropriate, in the implementing rules mentioned in this paragraph. So the ISO 19152 should be taken into account, when building the 3D cadastral system in European Union Countries. The 3D cadastre aspects in international standards and legal acts are described in (Bydłosz, 2012b).

## 3. The cadastral system in Poland and its objects (including UML description)

There are two systems containing information on real estates in Poland. The first is the Land Register, whereas the other is the Cadastre for Grounds and Buildings.

The Land Register in Poland (The Act, 1982) captures, keeps and reveals information concerning legal objects (real estates). This information generally concerns description and designation, rights, responsibilities and restrictions (including mortgage). The Land Register is managed by the courts of law. The Land Register objects in Poland are mainly real estates. The real estate may consist of land parcels, buildings or premises. The most typical real estate includes land parcel (parcels) and building (buildings).

The Cadastre for Grounds and Buildings (The Act, 1989) data are mainly objects spatial description, cadastral objects attributes, values and corresponding official documents. The Ground and Building Cadastre is managed by the local authorities at the county (*powiat*) level. The Ground and Building Cadastre objects are cadastral parcels, buildings and premises being separately owned estates. The most common cadastral objects are land parcels. The cadastral objects definitions in Poland are as follows:

The cadastral parcel – continuous area of land, situated in one cadastral precinct, legally homogenous, separated from surroundings with boundary lines.

The building – it is such the building construction, that is permanently attached to the ground, separated from space with separating barriers. It has foundations and roof. Buildings are the roofed objects, that have built-in installations and technical devices, used for permanent human needs. They are adopted for staying of people, animals and protection of property.

The premises are independent dwellings used for housing or other purposes. Independent premises consist of room or set of rooms, separated by permanent walls contained within one building, that are intended for human residence and together with auxiliary spaces meets their housing needs.

We can distinguish several types of real estates being either single object or the set of cadastral objects with relations between them. They are:

- cadastral parcel or set of parcels,
- cadastral parcel and building (the same owner),
- cadastral parcel and building (different owner) – parcel and building connected with long-term lease (perpetual usufruct) right,
- premises being separately owned estates – such premises consist of apartment (or other non residential area) itself, share of ownership in common parts of building and share of ownership in the cadastral parcel,
- premises being separately owned estates, when building is connected with cadastral parcel with long-term lease right – such premises consists of apartment (or as above) itself, share of ownership in common parts of building and share of long-term lease right to the cadastral parcel.

The schemas of Polish cadastre objects definitions (parcel, building and premises) are presented in the draft version of new order on ground and building cadastre (The Order (draft version), 2013). They are prepared applying Unified Modelling Language (UML) notation. The source of Cadastral Parcel, Building and Premises UML schemas is the Order of Ministry of Administration and Digitization changing the order on grounds and buildings (draft version from 20th of February 2013) and the translation of Polish names into English is done by the author. The "Cadastral parcel" in UML schema is shown on the picture 4.


**Figure 4.** The cadastral parcel (2D) schema in UML (source: The Order (draft version), 2013)

The object "Building" of Polish cadastre is shown on the picture 5.


**Figure 5.** The Building (2D) schema in UML (source: The Order (draft version), 2013)

The object “Premises” in UML is presented on the picture 6.

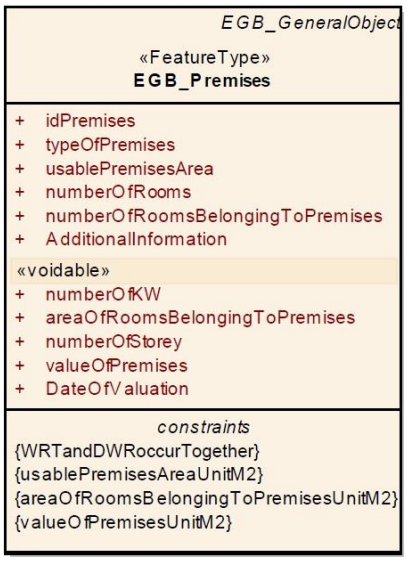


**Figure 6.** The Premises (2D) schema in UML (source: The Order (draft version), 2013)

## 4. Possible options for realization of creating 3D cadastre in Poland

Two possible options of building 3D cadastre in Poland seems likely for realization. The first one is “transferring” existing objects (having two dimensional description presently) of present cadastre, into three dimensional objects. The second choice is creating new cadastral objects. The more acceptable way seems the first option, for it is possible to use already defined objects, which are cadastral parcel, building and premises and then use already existing data from present cadastral databases. Five options for realization of 3D cadastre are known in the literature (www, 2012). They are:

- Minimalistic 3D Cadastre.
- Topographic 3D Cadastre.
- Polyhedral Legal 3D Cadastre.
- Non-polyhedral Legal 3D Cadastre.
- Topological Legal 3D Cadastre.

The Minimalistic 3D Cadastre option for realization may be the simplest way possible, but in author’s opinion in today’s stage of knowledge, it is better to develop more sophisticated and thus having better functionality 3D cadastre. The realization of Topographical 3D cadastre option is not supposed to be an issue, for the topographical and cadastral objects in Poland differ. Apart from that, the premises are not the objects of topographical database in Poland, so they cannot be applied in cadastre deriving from there. The Polyhedral Legal 3D Cadastre seems quite reasonable, when taking into account both, scope of data managed in the polish cadastre, and biding regulations. The Non-polyhedral Legal 3D Cadastre option of realisation seems also not probable, since Polish legal regulations do not usually refer to very sophisticated objects description, for example non-linear. The Topological Legal 3D Cadastre appear also as not possible to implement in Poland, because of its complication and not sufficient present technological solutions.

As it is stated above, according to the author, the Polyhedral Legal 3D Cadastre seems a the only possible option for realization in Poland. However, it seems necessary to supply the Polish legal regulations with new definitions concerning the 3D situations. Some restrictions concerning polyhedrons may be necessary, as well.

### *4.1. Land parcels*

The author suggests the new definition of a cadastral parcel (3D), where polyhedron can be restricted to the right prism. Such parcel being the right prism can be placed overground, underground or possibly both ways. In such definition the parameters $H_o$ (height overground), $H_u$ (height underground) and V (Volume) should be added to the UML definition of parcel. Of course volume can be obtained from $H_o$, $H_u$ and area of the base, but giving such parameter is helpful in better understanding the object attributes. In the transition period when we have

mixed representation of 2D/3D parcels such attributes may be voidable, for some values may be missing. Such an extending of cadastral parcel definition into 3D cadastral parcel should also have some restrictions especially resulting from Geological and Mining Law (The Act, 1994) concerning underground part of parcel and Airspace Law (The Act, 2002) concerning overground parcel part. Therefore some constraints concerning maximum heights of underground and overground parts of parcel are added to the 3D parcel definition. The other constrain, is that the parcel cannot be suspended in space. It is recommended in the first stage of building 3D cadastre objects. Parcels having only subterranean part should not be allowed at first. This situations seems not very complicated, when we have parcels within not built-up areas.

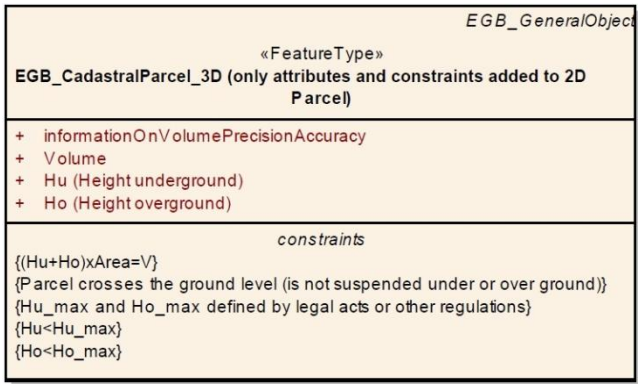


**Figure 7.** The 3D Cadastral Parcel (only additional attributes and constraints) schema in UML (source: own work)

Such a new concept of 3D cadastral parcel may interfere with some present legal regulations in Poland. This new concept of 3D cadastral parcel have influence on definitions of rights, restrictions and responsibilities that may be connected with the parcel. The idea of land parcel definition is certainly open for discussion and some corrections are possible.

### *4.2. Buildings*

In real word buildings are obviously 3D objects. There are generally two types of buildings in Poland if we take the same or differing ownership with land as a criteria. The most typical situation is when the owner of the building and the land is the same. The other case is when land parcel and the building have different owners. It usually happens when the owner of the building has the long term lease (perpetual usufruct) right to the ground.

In the first case the situation is simpler. The more complicated issue is describing it in 3D. Two possibilities appear here. The first is to remain land parcel as 2D object, and create 3D object - building. The second possibility is to create both land parcel and building as 3D objects. The new issue that appears here are relations between 3D land parcel and 3D building.

In the case with different ownership, the solution may be the same, but the parcel will be connected with building with the long term lease right. In the first stage of introducing the 3D cadastre, it is recommended that modelled object is the right prism, like the cadastral parcel. Some constraints are necessary here – the base of 3D building is vertical projection of building contour into the horizontal plane (ground level) and the height overground (Ho) of the object is the distance from the building base (bottom) to the building highest point. The height underground (Hu) is the distance from building base to the building substructure. Such a simplified definition of 3D building may cause interlacing of objects in space. Such problems should be solved in next stages of works on 3D cadastre.

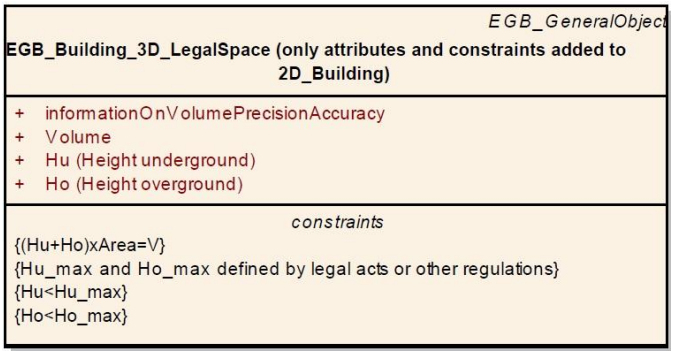


**Figure 8.** The 3D Building (only additional attributes and constraints) schema in UML (source: own work)

### *4.3. Premises*

The real estate *premises* consists of apartment itself, the share in the common part of the building and the share in the ground. It is also a real world object. As it is listed above premises consist of apartment (or other non residential area) itself, share of ownership in common parts of building and share of ownership in the cadastral parcel or share in long-term lease right. The author did not see necessity to suggest the new cadastral object basing on premises. Of course we can consider adding some parameter like heights of rooms or volume of premises and registration of some additional spaces like loggia, balcony and so like, but it can be done in later developments. The main issue concerning premises seems to be their visualization. Obviously, it seems worthy to use other countries experiences. The interesting idea seems the 3D cadastre project pilot, performed in Russia in the city of Nizhny Novgorod, where the very interesting solutions concerning 3D premises registration and visualization were developed (Vandysheva et al, 2012). There are also some other solutions that may be taken account, for example from the Netherlands (Stoter et al, 2012) and Sweden (Paulsson, 2012). Researches from Korea (Jeong et al., 2012) and China (Guo R., 2012) are also worth consideration, taking into account that such countries are much more densely urbanized.

## 5. Recapitulation

Building 3D cadastre seems not an easy task. The author suggest to start this, basing on existing objects of Polish cadastral system which are cadastral parcel, building and premises. We can create new three dimensional objects basing on both cadastral parcel and building, although this is not so simple and needs a lot of further work. It seems not necessary to built the new 3D cadastral abject, basing on premises, but much work must be done for premises proper visualization, where we can benefit from experiences gained from other countries. The new standard ISO 19152 "Land Administration Domain Model" should be taken into account there.

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