The 3D Cadastre Aspects in International Standards and Solutions*

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Key words: 3D cadastre, Land Administration Domain Model, ISO 19152, INSPIRE Directive

SUMMARY

There is no single way of transforming 2D cadastre into the 3D one. However, many countries are trying to do so. The different 3D solutions (among them cadastral) appear in international standards and specifications, both in these that are already in power or in those that are just being developed. Two of them seem to be the most important ones. They are the Land Administration Domain Model (LADM), as ISO 19152 and the INSPIRE Directive.
The Land Administration Domain Model gives terminology, reference schemas and solutions for land administration systems modelling. It also provides us with both 2D and 3D reference representations of spatial units and gives solutions for representations of space situated on the threshold between 2D and 3D parcels.
The INSPIRE directive establishes the legal basis for Infrastructure of Spatial Information in Europe, mainly for environmental purposes. Two technical specifications to the directive concerning 3D cadastre seem to be important. They are specification on buildings and specification on cadastral parcels. The specification on cadastral parcels does not directly contain the definitions of 3D parcels, but gives some indications, if we decide to develop it in this direction. The INSPIRE specification on building provides us with several data models that contain various 3D information. This information can be helpful in developing the models of 3D cadastres.
The purpose of this paper is to present ideas on the existing legal and standardization solutions, that may be helpful in developing the 3D cadastre. Some ideas of unification of "Building classes" from Land Administration Domain Model and INSPIRE data specification on buildings are also presented.

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1. INTRODUCTION

The 3D cadastre ideas have been widely presented since the first workshop on 3D cadastre, that took place in Delft, in 2001. According to the later opinions of its organizers, this workshop was premature, if we mean not only the technical and organizational solutions, but popularization of knowledge concerning 3D cadastre in that time. The second workshop on 3D cadastre was held in Delft in 2011, as well. This workshop revived discussion on 3D cadastre around the world. The conferences on 3D cadastre or having 3D cadastre in its scope are organized every year. For example, the 3D cadastral sessions in FIG Working Week in Rome and third workshop on 3D cadastre in Shenzhen have taken place in 2012.
The transformation of 2D cadastre into 3D one is not only an academic, but also a practical issue. There is no single way of performing it. However, many countries are trying to do so. The author thinks that apart from particular country specific regulations, the international standards and solutions should be taken into account when carrying out such a transformation. The different 3D solutions (among them cadastral) appear in the international standards and specifications, both in these, that are already in power or those that are just being developed. Two of them seem to be the most important ones. The Land Administration Domain Model (LADM) – ISO 19152 standard and the INSPIRE Directive.

2. THE LAND ADMINISTRATION DOMAIN MODEL

The Geographic Information - Land Administration Domain Model (LADM, 2012) has been developed by the Technical Committee 211 of International Organization for Standardization and has been finally approved as an ISO standard on the 1st of November this year. The LADM is a descriptive standard and its purpose is to provide formal language to describe existing land administration systems. The Land Administration Domain Model provides a reference model serving two goals. They are providing an extensible basis for the development and refinement of efficient and effective land administration systems, based on a Model Driven Architecture (MDA), and enabling involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary, implied by the model. The Land Administration Domain Model is a conceptual schema, written with Unified Modelling Language (UML) notation. It is performed according to ISO 1900 series standards methodology. The Land Administration Domain Model is based on four basic classes (fig. 1).

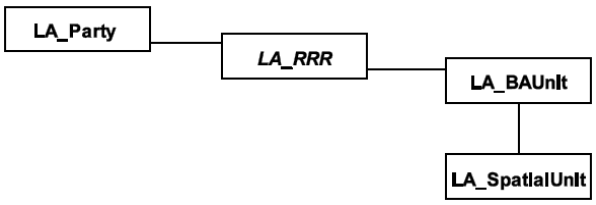

Fig. 1. Basic classes of the LADM (source: (LADM, 2012)).

They are as follows:

- Class LA_Party, where instances of this class are parties.
- Class LA_RRR. Instances of LA_RRR subclasses are rights, restrictions and responsibilities.
- Class LA_BAUnit, where instances are basic administrative units.
- Class LA_SpatialUnit having spatial units as instances.

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, which may be described in text ("from this tree to that river"), or based on a single point, or represented as a set of unstructured lines, or as a surface, or as a 3D volume (see figure 2).

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 3.

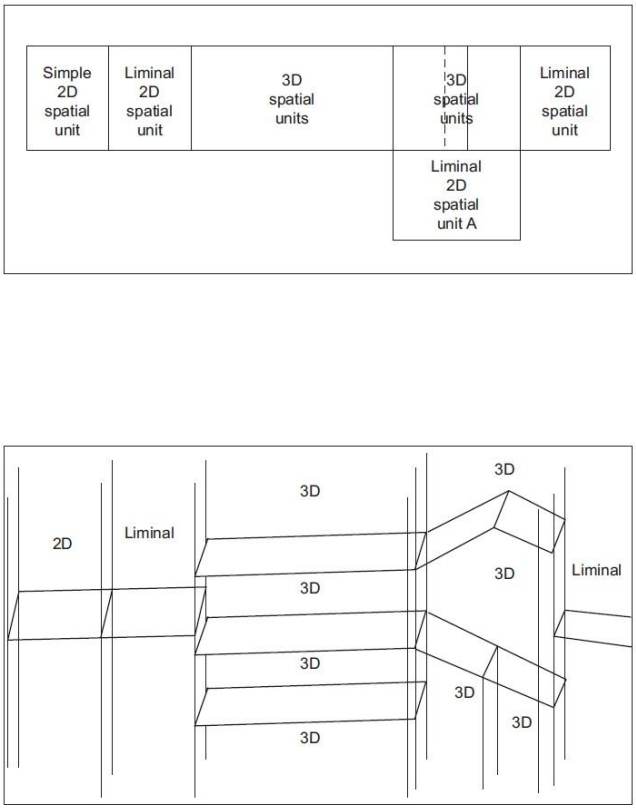

Fig. 2. Top and slide views of mixed 2D and 3D representations (source: (LADM, 2012)).

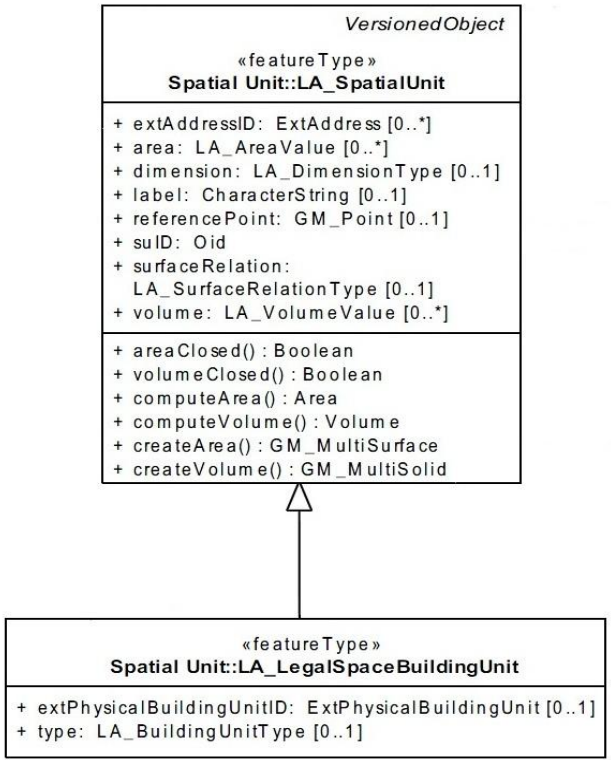

Fig. 3. Classes LA_SpatialUnit and LA_LegalSpaceBuildingUnit with its attributes (source: (LADM, 2012)).

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 4.

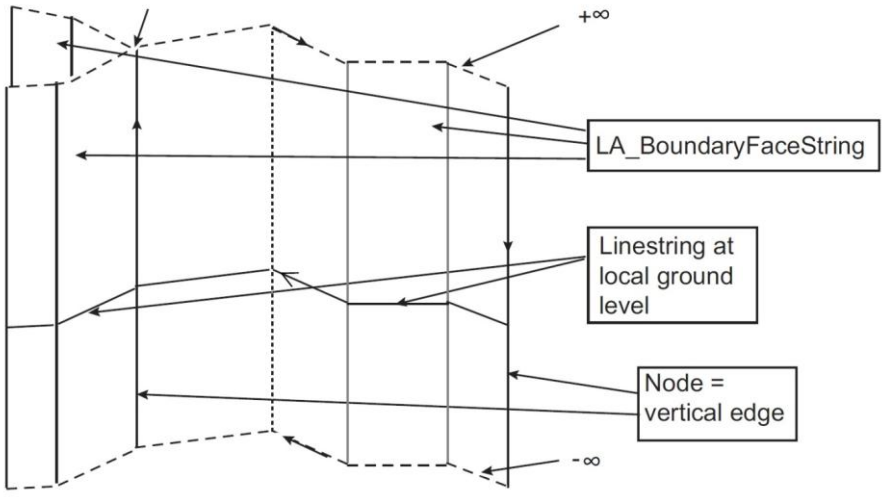

Fig. 4. Boundary face string concepts (source: (LADM, 2012)).

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.

3. THE INSPIRE DIRECTIVE

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.
Under the directive the member states are obliged to prepare and make public Spatial Data Sets listed in annexes to the directive. There are data themes "Cadastral parcels" and "Buildings", among them. The INSPIRE Data Specification on Cadastral Parcels (INSPIRE, 2009) has already been prepared and published. The INSPIRE Data Specification on Buildings (INSPIRE, 2012) is in its draft version and is expected to be ready soon.
The used terms are as follows:
2D data - geometry of features is represented in a two-dimensional space – (X,Y) coordinates.
2.5D data - geometry of features is represented in a three-dimensional space with the constraint that, for each (X,Y) position, there is only one Z.
3D data - geometry of features is represented in a three-dimensional space - the geometry of 2D data is given using (X,Y,Z) coordinates without any constraints.
The INSPIRE Data Specification on Cadastral Parcels has not got the harmonized solutions for 3D cadastral objects. However, some use cases concerning 2.5D or 3D cadastral parcels are listed in so called recapitulative check list of the cadastral parcels data specification. According to this list, there is an interest in 2.5 cadastral parcels and possible requirements for 3D parcels in future. Few countries have 3D parcels, for example Norway has some 2.5D parcels for representing 3D parcels. There is stated in harmonization approach, that Thematic Working Group Cadastral Parcels has restricted parcels to 2D or 2.5D as the INSPIRE directive define parcels as areas, so volumes are excluded. It is also stated that 3D parcels may be useful now for non-environmental or environmental use cases in future. Moreover, some users have expressed the requirement (in future) to combine cadastral parcels with 3D data like DTM or buildings.
The Cadastral Parcels Data Specification does not include 3D cadastral data, but some 3D cadastral data are related to building or to utilities networks. The INSPIRE Directive requires to take existing standards into account (article 7 of the directive). Since, the Land Administration Domain Model has been accepted as the ISO standard, it is possible to extend the INSPIRE Data Specification through the use of LADM, for example on 3D data, if there is requirement and consensus to do so. The INSPIRE class CadastralParcels is presented on the figure 5.

The works on INSPIRE Data Specification on Buildings are still conducted. The author used the last public versions of this specification – Draft Guidelines dated the 9th of July 2012 (INSPIRE, 2012). The data models applied in this specification offer a flexible approach allowing multiple representations of buildings and constructions, through the set of four profiles with different level of details in geometry and semantics.

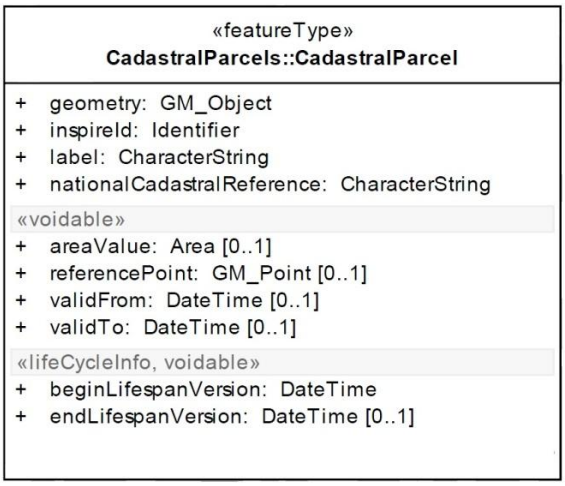

Fig. 5. INSPIRE data specification on CP class CadastralParcels (source: INSPIRE, 2009)

The core profiles contain the requirements to be included in the implementing rule. They contain feature types "Building" and "Building part" and a limited set of attributes mainly related to temporal aspects (construction, renovation and demolition dates), physical information (height, number of floors, elevation) and the classification of buildings according to their physical aspect and current use. The INSPIRE class Building Base is presented applying feature types AbstractConstruction and AbstractBuilding (figure 6). AbstractBuilding is an abstract feature type grouping the common properties of instanciable feature types Building and BuildingPart, that are present in all other application schemas. AbstractConstruction is an abstract feature type grouping the semantic properties of buildings, building parts and of some optional feature types that may be added to core profiles, in order to provide more information about theme Buildings. The optional feature types are described in extended application schemas.
The extended profiles contain the recommendations to provide more detailed information about theme buildings. In addition to building and building part, the main features represented are other constructions, building units, rooms, installations, boundary surfaces and textures.

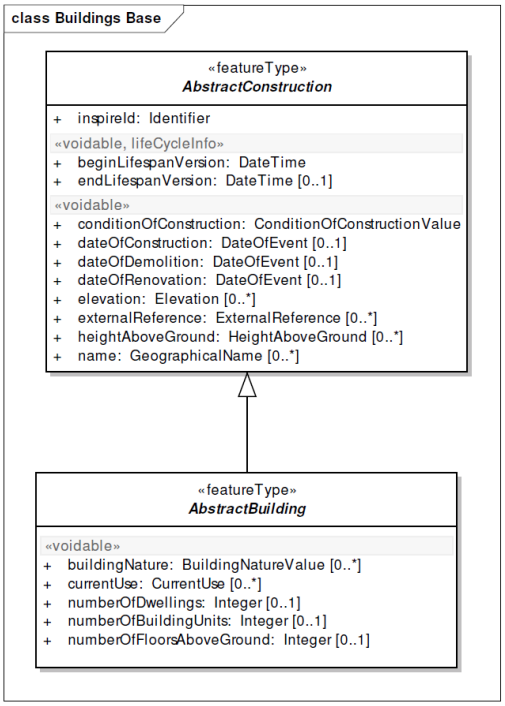

Fig.6. AbstractConstruction and AbstractBuilding future types (source: INSPIRE, 2012)

In the INSPIRE data specification on buildings the buildings and building parts may be represented using any of the four levels of detail (LoD) of City GML:
- in LoD1, a Building (or BuildingPart) is represented in a generalized way as right prism with vertical walls and horizontal 'roofs'. Such a model can be generated by vertically extruding a horizontal base polygon. It is often called "block model",
- in LoD2, a Building or BuildingPart is represented by a generalised way with vertical lateral surfaces and a prototypical roof or cover shape,
- in LoD3 and LoD4, a Building or BuildingPart is represented by its real detailed shape for lateral faces (including protrusions, facade elements, and window recesses) as well as of the roof (including dormers, chimneys).
The level of details general illustration is presented on the figure 7.

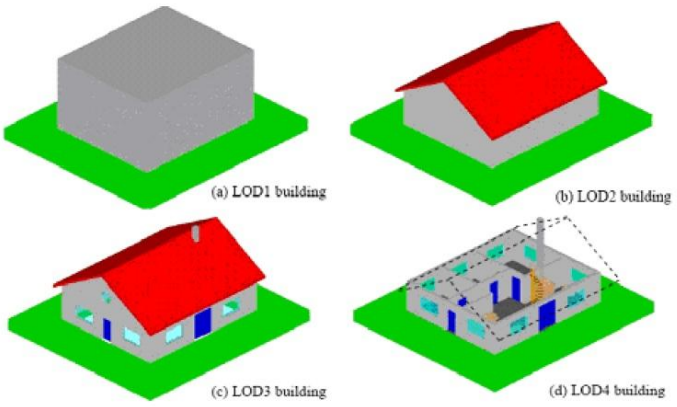

Fig. 7 The four levels of detail of City GML (source: INSPIRE, 2012)

4. DISCUSSION

The two main points concerning 3D cadastre seem to be important if we mean Land Administration Domain Model as a reference model for Cadastre or Land Register and the INSPIRE directive as a basis for building Infrastructure of Spatial Information in Europe. The first one is the liaison between LA_SpatialUnit (alias LA_Parcel) from LADM and CadastralParcel from INSPIRE. The INSPIRE Cadastral Parcel team and LADM development team cooperated during its work, so the LA_Parcel can be basis for CadastralParcel. It seems not to be not complicated in 2D, whereas in 3D, it is not fully possible since as it has been mentioned before, the INSPIRE has serious restrictions on 3D. However, the 2.5D or 3D cadastral parcels are not completely excluded from INSPIRE in future, for it is stated that they may be useful in some ways.
The second point concerns buildings. Both the Land Administration Domain Model and INSPIRE directive indicate buildings as a 3D objects. LA_LegalSpaceBuildingUnit is a subclass of LA_SpatialUnit in Land Administration Domain Model, whereas Building Base class is an separate class in INSPIRE data specification on buildings. As both classes concern buildings, most of data collected in real world for buildings, recorded either using Land Administration Domain Model or INSPIRE data specification are practically the same.
Both INSPIRE and LADM classes have temporal information. It is performed in LADM through versioning, whereas in INSPIRE through attributes like dateOfConstruction or dateOfDemolition. Another attributes of both INSPIRE and LADM classes on buildings concern physical description of building, so they are very often similar or the same. The significant difference between LADM and INSPIRE classes is that LADM describes the legal space of building, whereas INSPIRE specification concerns the physical object himself. This both spaces are often not identical.

5. RECAPITULATION

The Land Administration Domain Model accepted as the ISO 19152 on the 1st of November this year is a reference model for building land administration systems, like cadastres or land registries. It comprises 3D solutions for both cadastral parcels and building spaces. Buildings are rather legal not physical object here.
The INSPIRE Directive, which purpose is to build infrastructure of spatial information in Europe obliges EU member states to implement, inter alia, international standards concerning interoperability and harmonization of spatial data sets and services.
The INSPIRE Directive through its Data specification on Cadastral Parcels (Implementation Guidelines) does not deliver the 3D solutions for parcels, but enables to provide them in future if it is willingness and consensus to do so.
The Data Specification on Buildings (Draft Guidelines) delivers 3D solutions for buildings. Buildings are physical objects here and the scope of mandatory information seems to be much wider than required by Land Administration Model, especially in Level of Details 3 and 4.
For describing buildings with either LADM or INSPIRE we employ the data concerning generally the same physical object, so it would be advisable to collect data on buildings in the way enabling its use for applying for both Land Administration System build with application of LADM and data infrastructure build for INSPIRE purposes.

Author thinks, that it seems worthy to built model connecting both INSPIRE and Land Administration Domain Model building objects.

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BIOGRAPHICAL NOTES

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