

# Transforming the Land Administration Domain Model (LADM) into an ISO Standard (ISO19152)

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**Key words:** LADM, land administration, modelling, standardization, STDM, INSPIRE, ISO19152

## SUMMARY

In February 2008, FIG submitted the Land Administration Domain Model (LADM) to the International Organization for Standardization (ISO). After three meetings with the LADM/ISO19152 Project Team (in Copenhagen, Denmark, May 2008; in Delft, The Netherlands, September 2008; and in Tsukuba, Japan, December 2008) we are now preparing a Committee Draft (CD), the next stage in the development process of an International Standard.

This paper is an introduction to:

- the background of ISO/TC211, the standards development process, and the issues, which the LADM standard is addressing ([Section 2](#)),
- LADM and its adaptations since FIG Working Week 2008 ([Section 3](#)),
- the relationships with UN-HABITAT's Social Tenure Domain Model (STDM) and INSPIRE's Thematic Working Group (TWG) Cadastral Parcels (CP) ([Section 4](#)), with
- the application of LADM to real world cases, illustrated with UML instance level diagrams ([Section 5](#)).

The development of the Land Administration Domain Model (ISO19152) is as follows:

- New Working Item Proposal (NWIP): was in February 2008
- Working Draft (WD): discussions were in Copenhagen, Delft and Tsukuba
- Committee Draft (CD): will be available in June 2009
- Draft International Standard (DIS): December 2009
- Final Draft International Standard (FDIS): December 2010
- International Standard (IS): June 2011

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## 1. INTRODUCTION

The Land Administration Domain Model (LADM) – earlier named the ‘Core Cadastral Domain Model’ ([Van Oosterom et al., 2006](#)) – aims to support ‘an extensible basis for efficient and effective cadastral system development based on a Model Driven Architecture (MDA)’ and to ‘enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model’. The work on the LADM started within FIG at the congress in Washington, 2002. The first mature version 1.0 was presented at the next FIG congress, in Munich 2006 ([Lemmen and Van Oosterom, 2006](#)) and the last published changes were in version 1.1 as presented at the FIG Working Week 2008, in Stockholm ([Hespanha et al, 2008](#)).

In February 2008, FIG submitted the LADM to the International Organization for Standardization (ISO). After three meetings with the ISO19152 Project Team (in Copenhagen, Denmark, May 2008; in Delft, The Netherlands, September 2008; and in Tsukuba, Japan, December 2008) we are now preparing a Committee Draft (CD), the next stage in the standardization process.

This paper is organised as follows:

- the background of ISO/TC211, the standards development process, and the issues, which the LADM standard is addressing ([Section 2](#)),
- LADM and its adaptations since FIG Working Week 2008 ([Section 3](#)),
- the relationships with UN-HABITAT’s Social Tenure Domain Model (STDM) and INSPIRE’s Thematic Working Group (TWG) Cadastral Parcels (CP) ([Section 4](#)),
- the application of LADM to real world cases, illustrated with UML instance level diagrams ([Section 5](#)), with
- concluding remarks in [Section 6](#).

## 2. THE BACKGROUND OF ISO/TC211 AND THE STANDARDS DEVELOPMENT PROCESS

In this section some background concerning ISO/TC211 is given in Subsection 2.1. Then the ISO standardization process is explained in Subsection 2.2. The cooperation between ISO and the European Committee for Standardisation (CEN) is described in Subsection 2.3. Finally, Subsection 2.4 specifies the scope of the LADM.

## 2.1 The background of ISO/TC211

The Technical Committee 211 (TC211) of ISO (hereafter ISO/TC211) is responsible for the ISO geographic information series of standards ([ISO/TC211, 2009](#)).

Many bodies are actively engaged in the work of ISO/TC211. These include national standardization bodies, the Open Geospatial Consortium (OGC), international professional bodies (such as FIG and ICA), UN agencies (such as the UN Economic Commission for Africa), and sectoral bodies (such as the International Civil Aviation Organization, ICAO).

Since its inception ISO/TC211 has published well over 40 standards, among which is GML, a highly visible OGC specification. ISO/TC211 has participating and observing members from over 60 countries.

## 2.2 The ISO standards development process

There are three main phases in the ISO standards development process:

1. The need for a standard is usually expressed by some community (FIG, in our case), which proposes a new work item (an NWIP) to ISO as a whole. Once the need for an International Standard has been recognized and formally agreed, the first phase involves definition of the technical scope of the future standard (see Subsection 2.4).
2. Once agreement has been reached on which technical aspects are to be covered in the standard, a second phase is entered during which countries negotiate the detailed specifications within the standard. This is the consensus-building phase. In our case three Working Drafts were discussed and a Committee Draft –CD– will be available in June 2009.
3. The final phase comprises the formal approval of the resulting draft International Standard following (DIS) which the agreed text is published as an ISO International Standard. The acceptance criteria stipulate approval by two-thirds of the ISO members that have participated actively in the standards development process, and approval by 75% of all members that vote.

## 2.3 The cooperation with CEN/TC287

There is a close cooperation between ISO/TC211 and (European) CEN/TC287 Geographic Information. Via resolutions adopted by both organization it is now first explained how this cooperation is implemented.

The scope, objectives and strategy of CEN/TC287 activities are formulated in Resolution 40 ([CEN, 2003](#)): ‘The committee will work out structural frameworks of standards and guidelines of methodology which specify methodology of defining, describing and transferring geographical data and appropriate services. *The work will be made in strict co-operation with ISO/TC211.* These standards will support coherent use of geographical

information in Europe in accordance with international use. These standards will also support spatial infrastructure of data at all levels in Europe.’

Applying to ISO standards the Vienna Agreement as expressed in Resolution 52 ([CEN, 2003](#)): ‘The CEN/TC287 Geographic information, considering the Vienna agreement; instructs the secretariat of CEN/TC287 to initiate Unique Acceptance Procedure (UAP) or parallel voting for all deliverables and work items of ISO/TC211 as appropriate.’ The goal is to have equal ISO and EN standards via either submitting the published ISO standard to UAP (completed work) or via parallel and simultaneous voting in the ISO and in the CEN (new/on-going work).

From the side of ISO/TC211 similar resolutions are accepted; first of all Resolution 28 (<http://www.isotc211.org/Resolutions/resolutn.htm>) Cooperation between ISO/TC211 and CEN/TC287, which states: ‘Considering both work programmes together with their schedules and their synchronization, ISO/TC211 agrees with CEN/TC287 that only levels 1 and 2 of cooperation (as defined by the Vienna agreement: exchange of information, mutual representation at meetings) are possible between the two TCs for the time being. With the objective to achieve one harmonized and globally accepted family of standards, ISO/TC211 will use, as far as possible, the CEN/TC287 work as input to the ISO/TC211 work at suitable stages (working draft, CD, DIS). ISO/TC211 welcomes the invitation to comment upon CEN/TC287 draft standards, and encourages its members to provide comments to the CEN/TC287 secretariat.’ Further, Resolution 302, Establishment of focus group on data producer use of geographic information standards, states: ‘ISO/TC211 resolves to establish a focus group to raise the awareness and promote the use of international standards in the area of geographic information by data producers and to collect requirements for development of additional standards in this area. *ISO/TC211 encourages the group to work in close cooperation with CEN/TC287, JRC representing INSPIRE, and other appropriate organizations.* ISO/TC211 accepts the nomination of Mr. Iain Greenway by Ireland to chair this group. The secretariat will, in cooperation with the chair, appoint additional members to the group.’

On 26 February 2009, in the Madrid meeting of CEN/TC287 after voting on the ‘ISO19152 Draft Resolution 153 New Work Item Proposal Geographic Information - Land Administration Domain Model (LADM) - second vote’ (CEN document number N 1304) it was decided to accept also the LADM within CEN TC287. Based on the above resolutions this means that from this moment onwards there will be parallel and simultaneous voting in the ISO and in the CEN on the different stages of the LADM towards an international standard.

## **2.4 The issues LADM is addressing**

The scope of LADM (now also known as *ISO19152*) includes the following:

- it defines a reference model, covering all basic information-related components of Land Administration,
- it provides a abstract, conceptual schema with five basic packages, related to (1) people and organizations (*parties* in LADM terminology), (2) parcels (*spatial units* in LADM

terminology), (3) property rights (*rights, responsibilities, and restrictions* in LADM terminology), (4) surveying, and (5) geometry and topology,

- a terminology for Land Administration, based on various national and international systems, as simple as possible in order to be useful in practice. The terminology allows a shared description of different practices and procedures in various jurisdictions,
- a basis for national and regional profiles, and:
- it enables the combining of land administration information from different sources in a coherent manner.

LADM should be able to accommodate any legal framework. However, legal implications that interfere with (national) land administration laws are outside the scope of the LADM. It supports the reform of existing Land Administration systems at National or other jurisdictional level (e.g. Provincial, like in Canada) through provision of normative and informative annexes which include a number of spatial and legal profiles. These profiles represent specific information arrangements fitting within LADM, offering a variety of modes to organize the geometry and topology of Land Administration spatial units (e.g. text or point based, 2D unstructured, 2D partition, 3D full partition; see Subsection 3.4) or the Legal component (formal real rights, restrictions and responsibilities, including both the private and public originated laws and regulations). The profiles intermediate between the highly generic and widely applicable nature of LADM and the specification of an individual National Land Administration Model, having its own set of classes, obtained from the LADM generic and abstract classes through a mix of profiling and specialization. The ultimate goal of these annexes is thus the support for the implementation of specialized models in existing spatial databases, mainly built around the Object-Relational or the Object-Oriented paradigms. The provision of such a supporting framework is also fundamental in securing a level of interoperability and semantic translation, once different national specialized models are linked through the common ontology provided by LADM.

### 3. LADM AND ITS ADAPTATIONS SINCE FIG WORKING WEEK 2008

In this section an overview will be given of the LADM changes since version 1.1 ([Hespanha et al, 2008](#)), which was also the version submitted to ISO/TC211 as New Work Item Proposal (NWIP) and discussed as Working Draft 1 (WD1) in the first meeting of the ISO19152 Project Team in Copenhagen in May 2008 ([ISO/TC211, 2008](#)). Significant comments were received stating that the model was too complex. Therefore simplification was one of the most important goals of the next working draft (WD2), which was discussed in the Delft, September 2008 meeting of the ISO19152 expert group; see Subsection 3.1. Comments on WD2 were discussed and resulted in some significant model changes in the LADM: introduction of class *RecordedObject* and seamless integration of 2D and 3D representations; see Subsection 3.2. In this version also the LA\_ prefix for the class names (e.g. *LA\_RecordedObject*) was introduced (following ISO/TC211 conventions). However, in the following text we will use the LA\_ prefix in text and figures also before the WD3-version in order to have a more consistent explanation and documentation in this paper. Again comments received on WD3 were discussed in the ISO19152 expert group meeting, in Tsukuba, December 2008 that resulted in some further improvements: the *layer concept* and the reintroduction of a parcel class; see Subsection 3.3. The result will be described in the

ISO19152 Committee Draft (CD) and within the FIG community this LADM-version will be called version 1.2. Finally in Subsection 3.4, there will be specific attention for the integrated 2D and 3D spatial representations.

### 3.1 From NWIP/WD1 to WD2

Simplification: all different types of parcel (text parcel, point parcel, spaghetti parcel, or topology parcel) and other immovables were grouped into a very generic class called *SpatialUnit*. Removal of 3D, *ServingParcel*, and *NPRRegion*. Also some classes got a name more related to social tenure relationships, e.g. *Person* became *Party*). Alignment with the INSPIRE cadastral parcel developments was executed. Finally the spatial representation was made more direct via ISO 19107 data types (TP\_ and GM\_ types) and not via associations to ISO 19107 classes (node, edge, face, solid in both basic and directed variants).

### 3.2 From WD2 to WD3

We have remodeled parts of the LADM, based on comments received from the information community. See [Figure 1](#) and [Figure 2](#) and the explanation hereafter. These are the main adaptations:

- a new class *LA\_RecordedObject* is introduced. *LA\_RecordedObject* is positioned between *LA\_SpatialUnit* and *LA\_RRR*. The motivation is the explicit need for modeling so-to-speak ‘real estates’ (for example in Spain, Finland and Norway). Therefore, an instance of *LA\_RecordedObject* belongs to zero, or more instances of *LA\_SpatialUnit* (for example, a property consists of several parcels, allowing the possibility of no parcel at all). Conversely, an instance of *LA\_SpatialUnit* belongs to zero, or more instances of *LA\_RecordedObject* (that means, ownership of a parcel is not restricted to a single party, and ownership of a parcel might not be recorded)
- an instance of *LA\_RecordedObject* belongs to at least one instance of a subclass of *LA\_RRR*, but an instance of a subclass of *LA\_RRR* belongs to exactly one instance of *LA\_RecordedObject* (the same instance of a subclass of *LA\_RRR* cannot belong to different recorded objects)
- *LA\_RecordedObject* is associated to *LA\_Party*. The motivation is to model instances of subclasses of *LA\_RRR* that belong to spatial units, rather than to other types of parties. For example, where the benefit of a secondary right is held by a parcel rather than by a person
- a new class *LA\_FaceString* is introduced (the label ‘facestring’ is derived from face and line string) in order to model 2D and 3D spatial unit’s uniformly. In addition the class *LA\_Face* is introduced to represent 3D situations where *LA\_FaceString* is not sufficient (see Subsection 3.4), and
- many specializations of *LA\_SpatialUnit* have been removed as separate object classes (for example, *TextSpatialUnit*, *PointSpatialUnit*, *LineBasedSpatialUnit* and *TopologicalSpatialUnit*). However, the modeling of parcels without a geometry (such as *TextSpatialUnit*) is still possible. *LA\_FaceString* has an attribute *locationByText*. In addition *PointSpatialUnit* has been replaced by an attribute *referencePoint* in *LA\_SpatialUnit*. At the same time *TopologicalSpatialUnit* and *LineBasedSpatialUnit* have been replaced by an attribute structure of *LA\_SpatialUnit*, with values for structure *full partition* respectively *unstructured*.

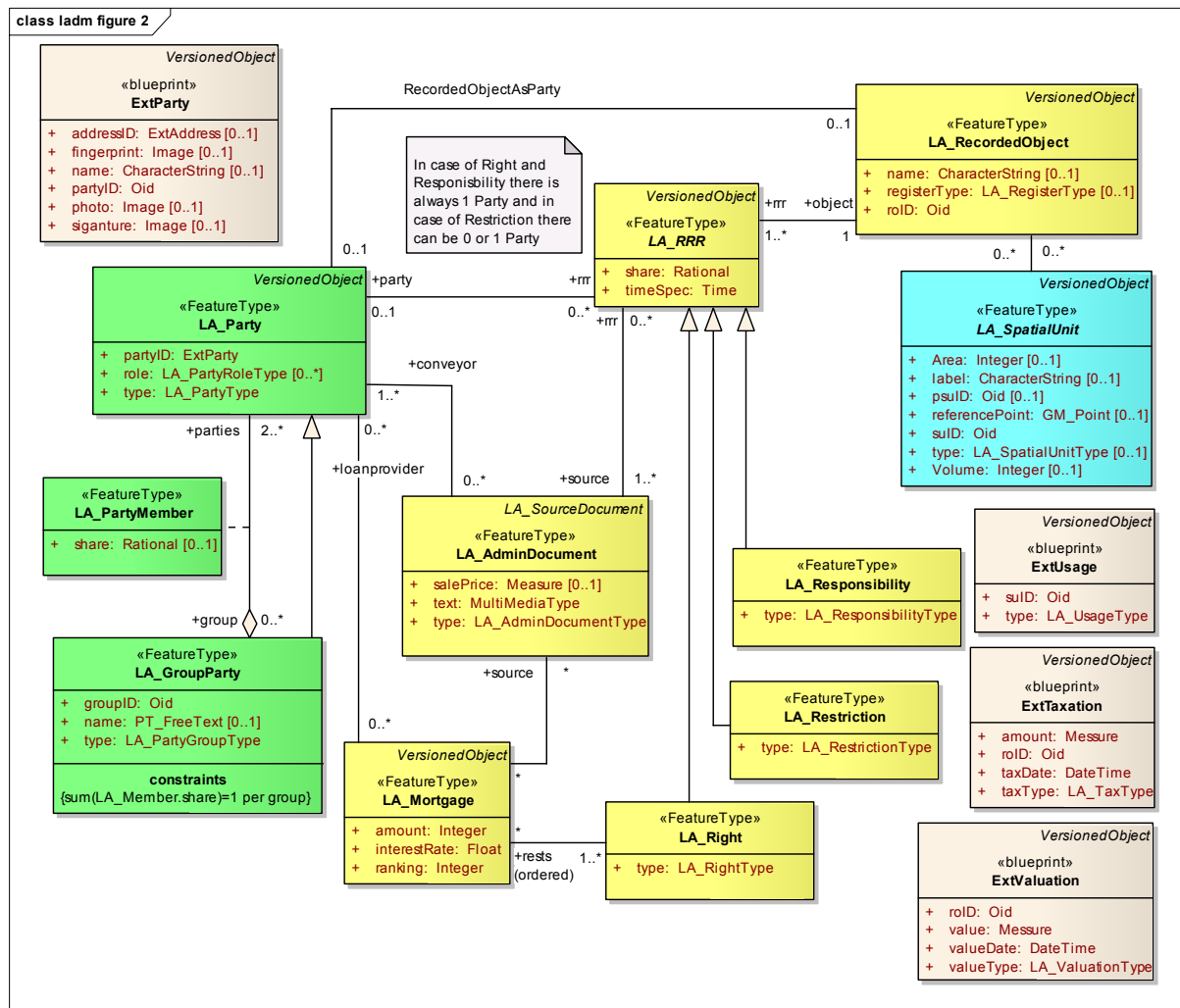


Figure 1. The basic concepts of the LADM (WD3).

We think that these adaptations make the model more simple (to be more precise: the surveyability of the model has been increased). At the same time the model allows the modeling of many complex situations with the necessary flexibility being provided by a suitable combination of attributes.

### 3.3 WD3 to Committee Draft (CD)

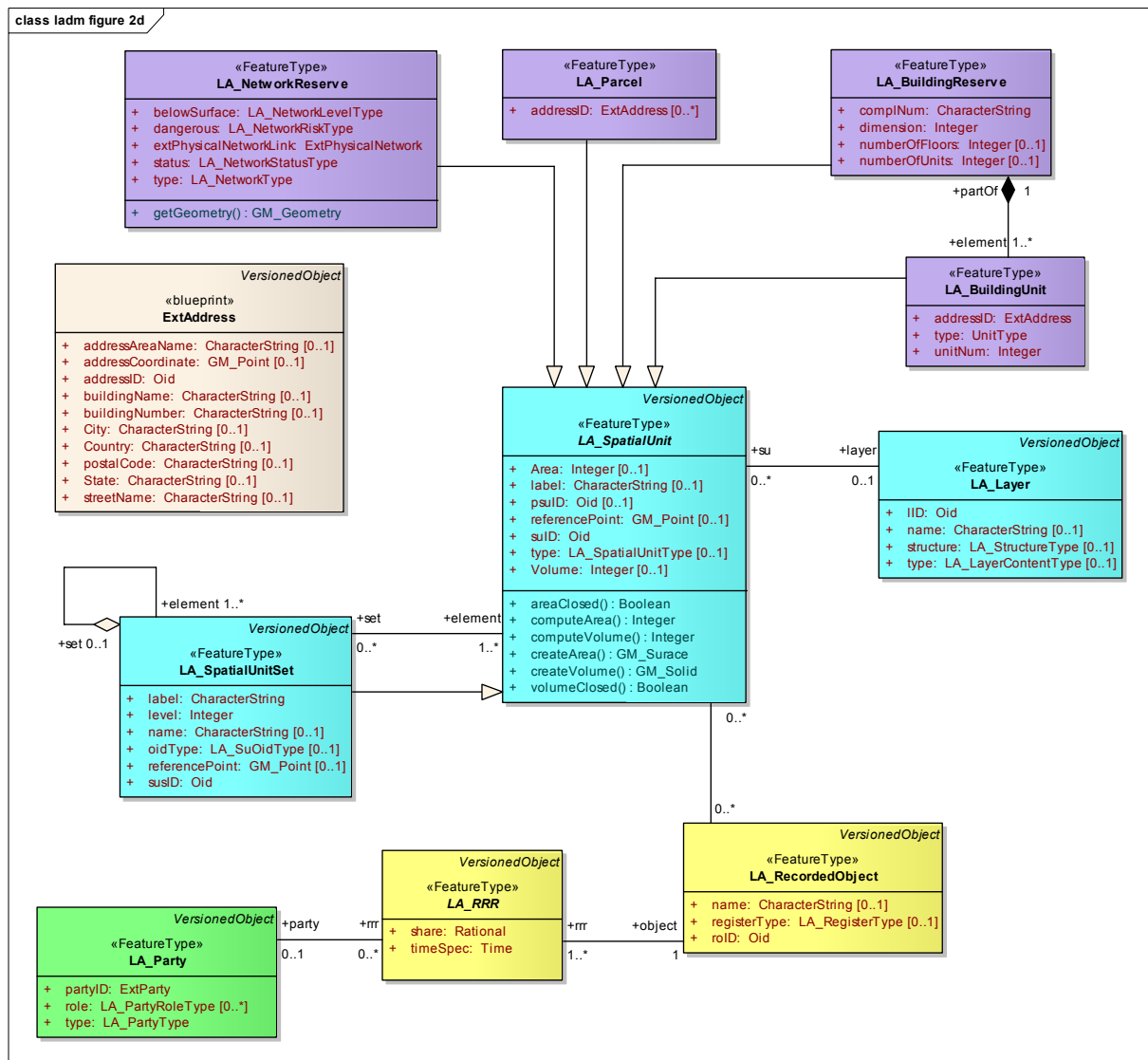
In order to resolve the comments of the LADM, as they were expressed in Tsukuba, Japan, in December 2008, we have further refined parts of the LADM; see Figure 2. These are the main adaptations:

- class LA\_Layer has been added in order to be able to explicitly represent the layer concept as introduced after the Delft meeting (then first as attribute of LA\_SpatialUnit, but now as a separate class). This allows a country for example to model in one layer the 'primary' right (or the 'strongest' right), from which other rights and interests can be 'added' or 'subtracted' (each in their own layer). These rights ('primary', 'added', or 'subtracted')

can be represented in three different layers. Furthermore, the names of spatial units and the structure type can be defined per layer. How to use the layers is up to the country (its profile) and its legislation/regulations,

- class LA\_Parcel has been re-introduced from the NWIP (New Work Item Proposal). It recognizes that, apart from BuildingReserve and NetworkReserve, Parcel as spatial unit is a widely known concept, which should be recognised in an explicit way. As an instance of LA\_Parcel it contains additional attributes in addition to the attributes and associations of its abstract parent class LA\_SpatialUnit (incl. the associations to LA\_Face and LA\_FaceString with spatial representation).

The appendix contains an overview of the different data types and code lists (with sample values, that can be extended) as defined in the LADM. We think that these adaptations make the model more balanced. At the same time the model remains simple, but still allows the clear modeling of many more complex situations.

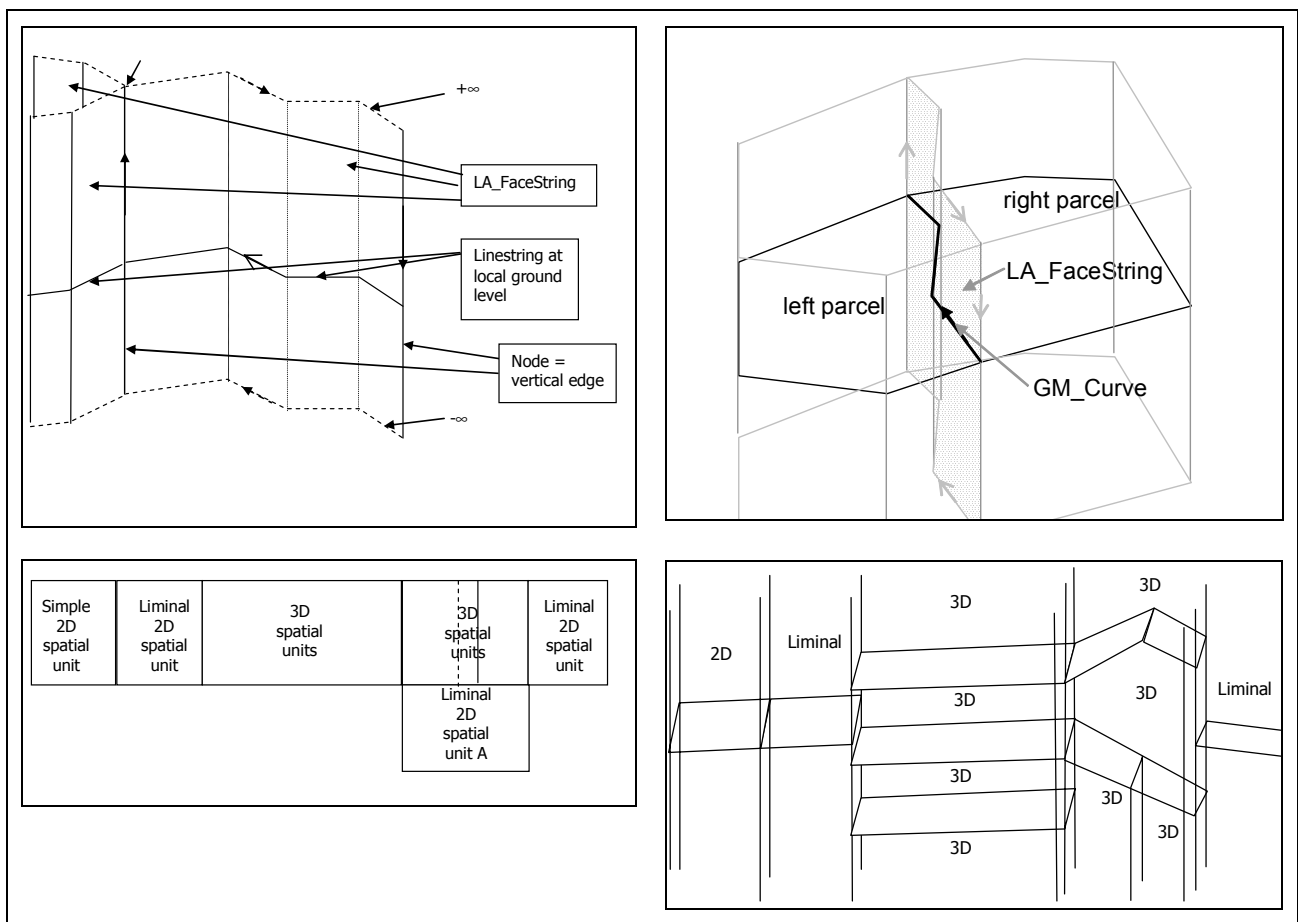


**Figure 2. The basic concepts of the LADM with LA\_Layer and LA\_Parcel.**



### 3.4 Integrated 2D and 3D Spatial Representation

All types of LA\_SpatialUnit (2D, 3D parcels, buildings, or utility networks) share the same representation structure. An important requirement is that existing 2D data, whether topologically structured, polygons, unstructured, or simply point or textual descriptions should be easily included. At the same time, the model should also support the increasing use of 3D representations of LA\_SpatialUnit, without putting additional burden on the simpler 2D representations. An important requirement is that there should be no mismatch between the parts of the domain that are described in 2D and the parts of the domain that are described in 3D. Further, the LADM must be based as much as possible on the already accepted and available spatial schema as published in ISO 19107. The model described below has been designed using key concepts such as LA\_FaceString and LA\_Face. Coordinates themselves are rooted in instances of LA\_SourcePoint (mostly after geo-referencing, depending on the data collection method used).



**Figure 3.** upper left: FaceString concepts, upper right: LA\_SpatialUnits defined by LA\_FaceStrings, lower left: top view of mixed 2D/3D representations, lower right: side view showing the mixed use of LA\_FaceString and LA\_Face to define both bounded and unbounded 3D volumes.

As pointed out by (Stoter, 2004), in many countries a 2D description should be interpreted as a 3D prismatic volume with no upper and lower bound; See Figure 3 (upper left and upper right). Using this interpretation, 2D and 3D representations can be unified. The boundaries in

the 2D descriptions are called LA\_FaceString: they use a normal GM\_Curve (linestring) for storage, but this implies a series of vertical faces. For true 3D descriptions that also have non-vertical faces, the class LA\_Face is introduced. A *liminal spatial unit* has a combination of LA\_FaceString's and vertical LA\_Face's. The vertical LA\_Face's must dissolve into face strings (when common pairs of edges are removed). The faces must be completely defined from  $+\infty$  to  $-\infty$ . This method is used for a 2D spatial unit which is adjacent to a 3D spatial unit, with a split in the shared vertical face. The attribute 'type' in LA\_SpatialUnit indicates if it concerns a 2D, liminal or 3D representation of an LA\_SpatialUnit.

In addition to these principles, there are five levels of spatial description identified (indicated by the 'structure' attribute in LA\_SpatialUnit):

- Point based (point spatial unit),
- Text based (text spatial unit),
- Unstructured (Line) based (line spatial unit),
- Polygon based (polygon spatial unit), and:
- Topological based (topological spatial unit).

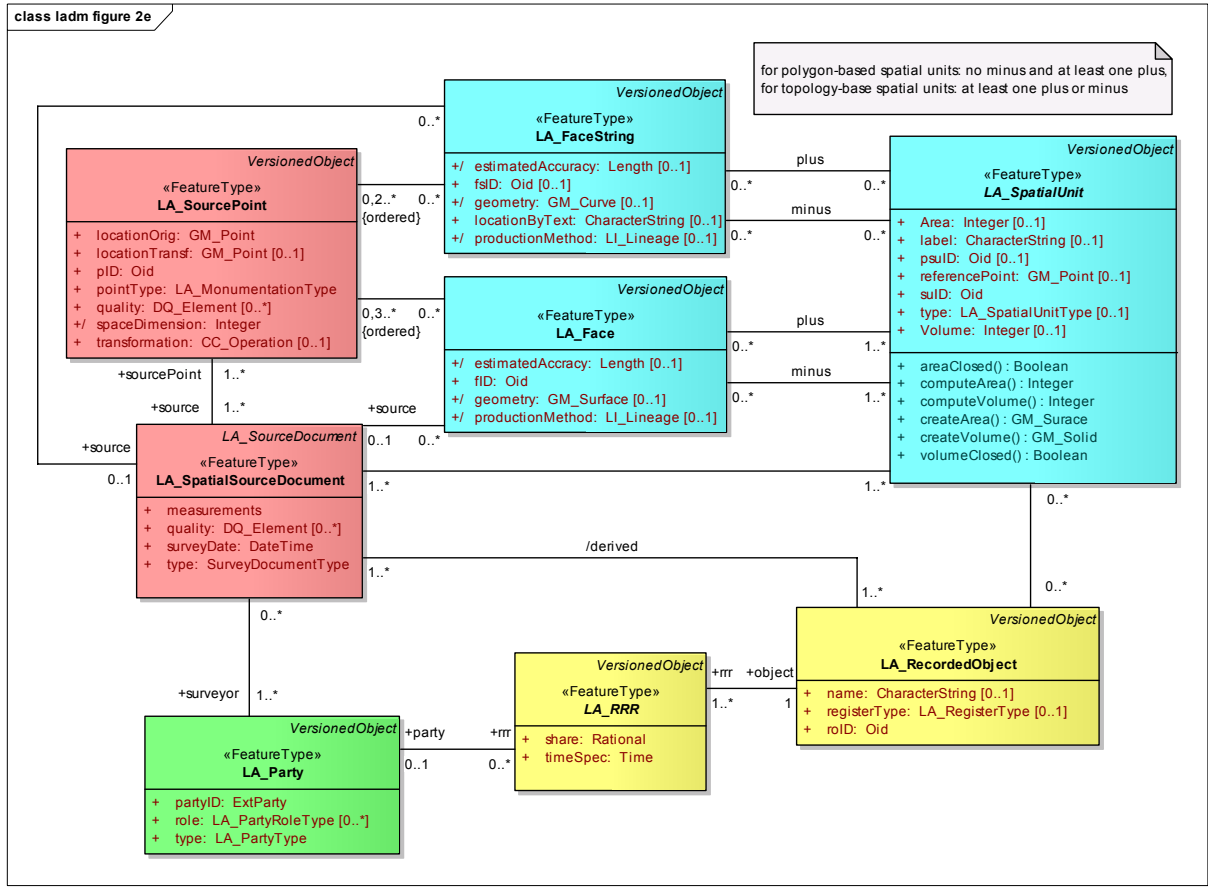


Figure 4. Classes FaceString, Face, LA\_SourcePoint, and LA\_SpatialSourceDocument

The point based LA\_SpatialUnit is used when the only information about location are the coordinates of a single point within its area (or volume). The attribute referencePoint in LA\_SpatialUnit is used to record this location, which may carry a *z value*.

The text based LA\_SpatialUnit is used when the definition of the LA\_SpatialUnit is entirely by descriptive text. LA\_SpatialUnit is accompanied by one or more LA\_FaceString's, each of which carries a block of free text in the locationByText attribute. No geometry is used in this type of face string. The referencePoint is optional, and may be used as a specific labelling point, and could also carry a *z value*.

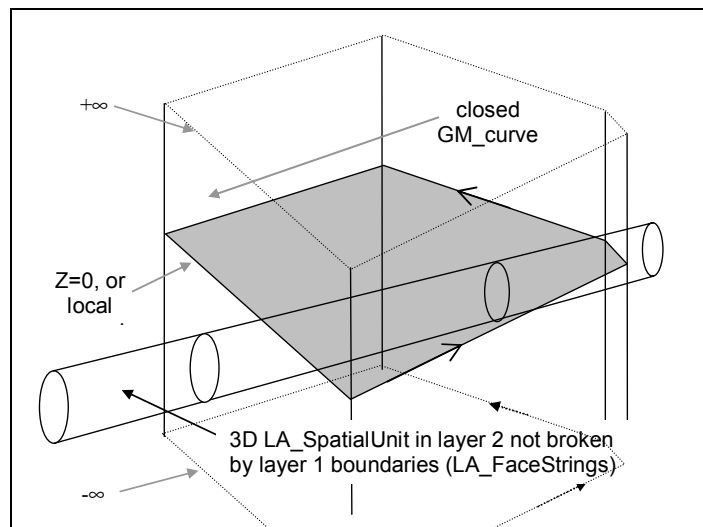
The line based (unstructured or 'spaghetti') LA\_SpatialUnit is used when the description is allowed to have inconsistencies such as hanging lines and incomplete boundaries. For the 2D case, the full length LA\_FaceStrings are stored once only, not broken at the corners of LA\_SpatialUnits, and may participate in the definition of many LA\_SpatialUnits. The LA\_SpatialUnits are linked to the LA\_FaceStrings that define them, but this may not comprise a complete and unambiguous definition. If necessary, the locationByText attribute can be used to supplement the description. For the 3D case, at least one LA\_Face is included (and this may intersect other LA\_FaceStrings and LA\_Faces).

A polygon based LA\_SpatialUnit is used when each LA\_SpatialUnit is recorded as a separate entity. There is no topological connection between neighbour LA\_SpatialUnit's (and no boundaries shared), and so any constraints enforcing a complete coverage must be applied by the sending and receiving software. In the a 2D representation there is exactly one link to a closed LA\_FaceString instance for every ring of the polygon (or set of LA\_FaceString's that form together a closed ring). A polygon based LA\_SpatialUnit used in a 3D representation case has at least one (non-shared) LA\_Face included in the description. Liminal parcels arenot used in this representation.

Topology based LA\_SpatialUnit is used when LA\_SpatialUnits share boundary descriptions. A topological based LA\_SpatialUnit is encoded by reference to its boundaries, with the common boundary between two LA\_SpatialUnit's being stored once only. Thus there is a topological connection between neighbours. In case of a 2D description only, LA\_FaceString's are used forming closed loop(s) and these LA\_FaceString's have left and right references to the LA\_SpatialUnit's. In case of a 3D description, at least one LA\_Face with left/right information is included.

Mixed representations are also possible, because an LA\_FaceString object may be defined either by a geometry, or by a free text block. It is possible for an LA\_SpatialUnit in any form of encoding to be specified by geometry on some faces, but text on others. It is also possible to topologically encode text based LA\_SpatialUnits; for example, part of a boundary may be defined by text 'along the natural shoreline', while the other boundaries could be defined by coordinates. The LA\_FaceString that defines the shoreline can be used in the definition of a water feature on the other side of the boundary, thus ensuring topological correctness without the need for coordinate values. Again, this can occur in both 2D and 3D.

It must be stressed that the above applies to any type of LA\_SpatialUnit (including the ones that are used for recorded spaces around buildings and utilities, or for servitudes). To organize the instances, there is the concept of a layer model. This is especially relevant for the topology based LA\_SpatialUnit's (attribute 'layer'), but also applies to the other types. For example, there can be a base layer (1) with ownership LA\_SpatialUnit's, which are topologically defined and there could be an additional layer (2) with polygon based LA\_SpatialUnit's representing servitudes. The concept of layers can also be used in other situations. For example, layer 1 for the current ownership and layer 2 for the pre-war ownership. A 3D example would be layer 1 containing ownership (2D, liminal and 3D topological LA\_SpatialUnit's) and layer 2 would contain ownership of 'legal space' around utilities crossing many other LA\_SpatialUnit's (from which the utility network space could be subtracted); see [Figure 5](#).



**Figure 5.** Multiple layers (note that the ellipses where the layer 1 boundaries meet the 3D LA\_SpatialUnit in layer 2 are there for visualization support and do not subdivide the object in layer 2)

The 2D or 3D (topology) structures must be valid at every moment in time. With topological LA\_SpatialUnit's, there are never gaps nor overlaps in the partition. However, boundaries belonging to different time spans (defined by versions) may cross. The temporal topology must also be maintained: that is, no time gaps nor overlaps can occur in the representations. Therefore, the structure is based on spatio-temporal topology. Current land administration registration systems, based on 2D topological and geometrically described spatial units, have shown limitations in defining the (2D and 3D) location of 3D constructions (e.g. pipelines, tunnels, building complexes) and in the vertical dimension (depth and height) of rights established for 3D constructions ([Stoter, 2004](#)).

In the LADM, 2D and 3D data are treated in a consistent manner throughout the model. It is important to realize that there is a difference between the 3D physical object itself and the legal space related to this object. The LADM only covers the 'legal space'; that is the space that is relevant for the Land Administration (bounding envelope of the object). This is usually larger than the physical extent of the object itself (for example including a safety zone).

## 4. LADM AND ITS RELATIONSHIPS WITH UN-HABITAT AND INSPIRE

In this section a number of modelling activities related to the LADM will be discussed. First in Subsection 4.1 the Social Tenure Domain Model and next in Subsection 4.2 the INSPIRE cadastral parcel model. In both cases the relationship with the LADM will be discussed.

### 4.1 UN-HABITAT and the Social Tenure Domain Model (STDM)

The Social Tenure Domain Model (STDM) is a multi-partner software development initiative to support pro-poor land administration. The initiative is based on open source software development principles. The STDM, as a specialization of the LADM, is integrated in this standardization exercise. The STDM is included as an informative annex in the ISO19152 LADM draft standard. The STDM, as it stands, has the capacity to broaden the scope of land administration by providing a land information management framework that would integrate formal, informal, and customary land systems and integrating administrative and spatial components. The STDM makes this possible through tools that facilitate recording all forms of land rights, all types of rights holders and all kinds land and property objects (spatial units) regardless of the level of formality. Not only in regard to formality, but the idea behind STDM also makes a departure in terms of going beyond some established conventions. Traditional or conventional land administration systems, for example, relate names or addresses of persons to land parcels via rights. An alternative option being provided by STDM, relates personal identifiers such as fingerprints to a coordinate point inside a plot of land through a social tenure relation such as tenancy. The STDM thus provides an *extensible* basis for efficient and effective system of land rights recording.

STDM describes relationships between people and land that it tackles land administration needs in hitherto neglected communities such as people in informal settlements and customary areas. It supports development and maintenance of records in areas where regular or formal registration of land rights is not the rule. It focuses on land and property rights, which are neither registered nor registerable, as well as overlapping claims, that may have to be adjudicated both in terms of the ‘who’, the ‘where’ and the ‘what right’. In other words, the emphasis is on social tenure relationships as embedded in the continuum of land rights concept promoted by Global Land Tool Network (GLTN) and UN-HABITAT. This means informal rights such as occupancy, adverse possession, tenancy, use rights (this can be formal as well), etc or customary rights, indigenous tenure, etc as well as the formal ones are recognized and supported (with regard to information management) in STDM enabled land administration system. Likewise, the STDM accommodates a range of spatial units (‘where’, e.g. a piece of land which can be represented as one point – inside a polygon, a set of lines, as a polygon with low/high accuracy coordinates, as a 3D volume, etc.). Similarly, the STDM records all types of right holders (‘who’, e.g., individuals, couples, groups with defined and non-defined membership, group of groups, company, municipality, government department, etc.). See Figure 6. In regard to evidence, STDM handles the impreciseness and possible ambiguities that may arise in the description of land rights. In a nutshell, the STDM addresses information related components of land administration in an innovative way.

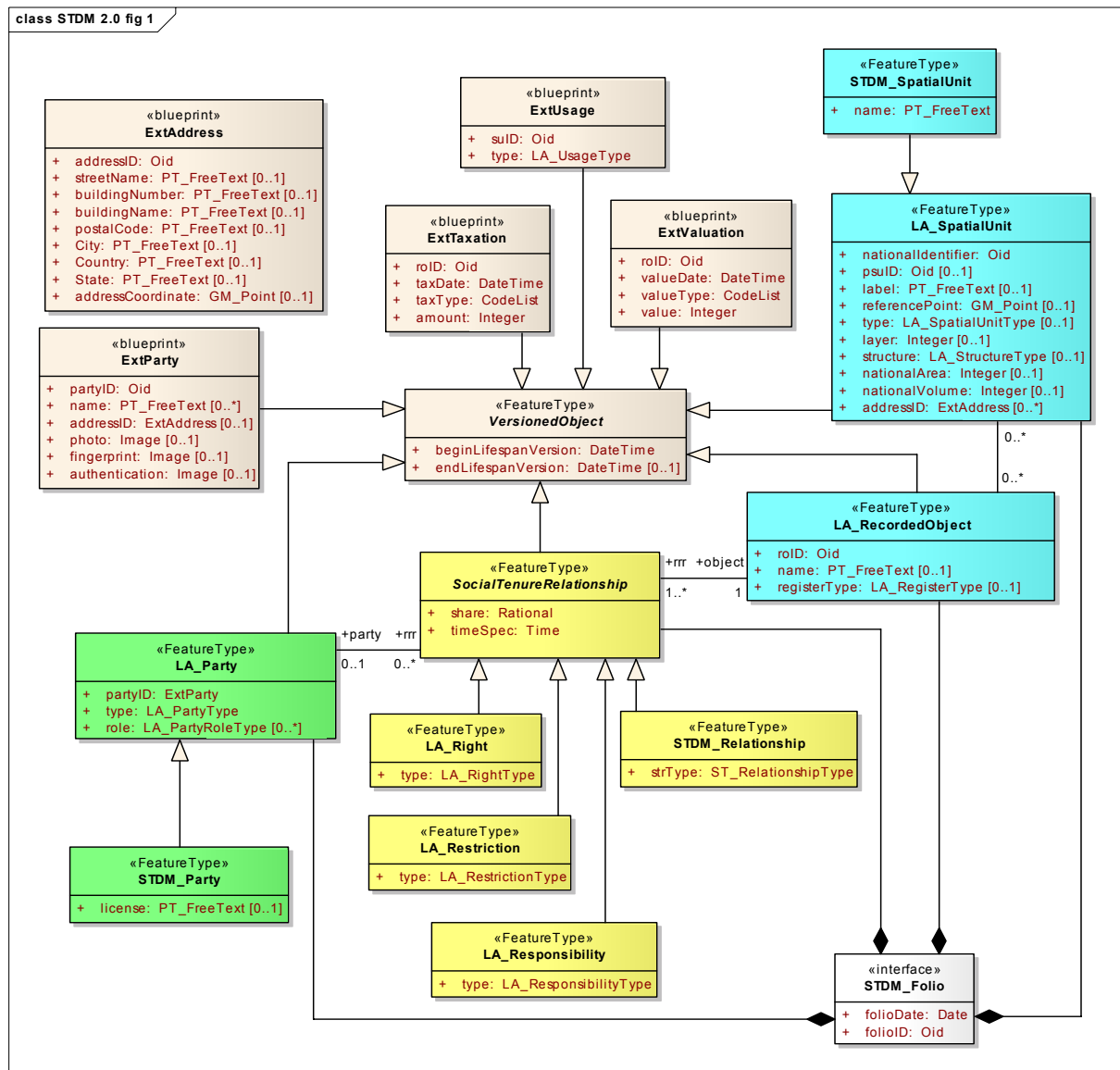


Figure 6. STDM core classes and blueprints for external classes.

In STDM, data coming from diversified sources is supported based on local needs and capabilities. This pertains to both spatial and administrative (non-spatial) data. For example, it may be, in informal settlements, sufficient as a start to relate people-land relationships to a single point. Then attributes such as photographs and fingerprints can be attached to the records. In a central business district (CBD) of a city, a traditional cadastral map/register may be required while in a residential area, land administration needs may entail using a map derived from satellite images and combined with formal descriptions of rights and right holders. The STDM encourages and caters for all these variations.

High resolution satellite image is one of the emerging and a very promising source of spatial data for land administration. A large-scale plot of such an image can be used to identify land over which certain rights are exercised by the people themselves, i.e., in a participatory

manner. As a proof of the concept, World Bank, with GLTN funding, organized and led an exercise in Ethiopia in June 2008 which included doing preliminary test on the feasibility of high resolution satellite images. The results that came out of this experiment were encouraging. Similar initiatives in other countries like Rwanda are also yielding comparable outcomes.

The STDM development activity has thus far generated conceptual, functional and technical designs. The development of a prototype has started and is under system testing now. This test will be further enhanced through a pilot project in a country which has slums, customary tenure, overlapping claims and non-polygon spatial units. The prototype is under development at the International Institute for Geo-Information Science and Earth Observation (ITC) in close co-operation with GLTN/UN-HABITAT and FIG. A new World Bank led pre-project (preparatory) activity in Ethiopia is creating opportunities to test the prototype in the context of rural land administration.

#### 4.2 INSPIRE (Cadastral Parcels)

For cross-border access of geo-data, a European metadata profile based on ISO standards is under development using rules of implementation defined by the Infrastructure for Spatial Information in the European Community – INSPIRE. For actual data exchange, the INSPIRE implementing rules will further define harmonized data specifications and network services. This is complemented with data access policies and monitoring and reporting on the use of INSPIRE.

To illustrate the relationships of the cadastral parcel registration with other INSPIRE registrations, a number of examples from INSPIRE will now be described. Specific boundaries of cadastral parcels are also the boundary of an administrative unit (municipality, province, or country); this is an important relationship with theme 4 from Annex I of INSPIRE directive ([DIRECTIVE 2007/2/EC](#)). Parcels and boundaries have associations with Buildings (theme 2 from Annex III of INSPIRE directive) - sometimes used as local reference for boundaries, but also used for orientation purposes. Parcels and boundaries have associations with Transport, and as it is already difficult within one domain (such as the cadastral world) to agree on the used concepts and their semantics, it will be even more difficult when we are dealing with other domains. However, we can not avoid this if a meaningful interoperable geo-information infrastructure has to be developed and implemented Networks (theme 7 from Annex I of INSPIRE directive) - same orientation purpose, but also roads, railroads, waterways are separate parcels as they are often owned by government. A strong link exists between cadastral parcels and Addresses (theme 5 from Annex I of INSPIRE directive). Links exist between cadastral parcels, land use (theme 4 from Annex III of INSPIRE directive) and land cover (theme 2 from Annex II of INSPIRE directive).

Cadastral parcels in INSPIRE should serve the purpose of generic information locators, i.e. searching and linking other spatial information ([INSPIRE, 2008](#)). Having included national cadastral identifiers as a property (attribute) of the INSPIRE parcels, the content of a national cadastre or land register can be linked. Using this two-step approach information on the

owners, rights, restrictions etc. may be accessed according to the national legislation on data protection. The data model for INSPIRE cadastral parcels has been prepared in a way that supports compatibility with the upcoming international standard for the LADM.

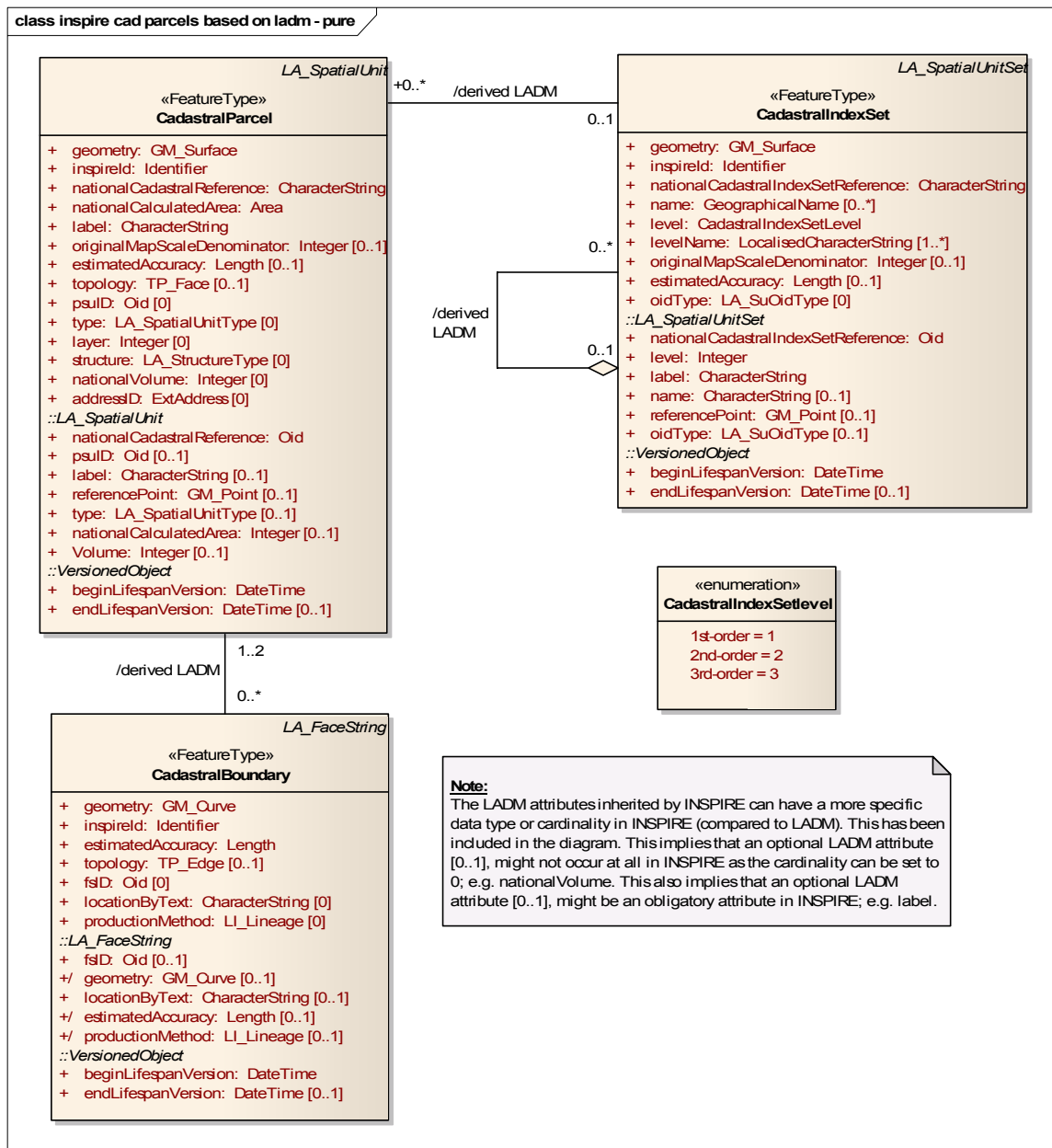


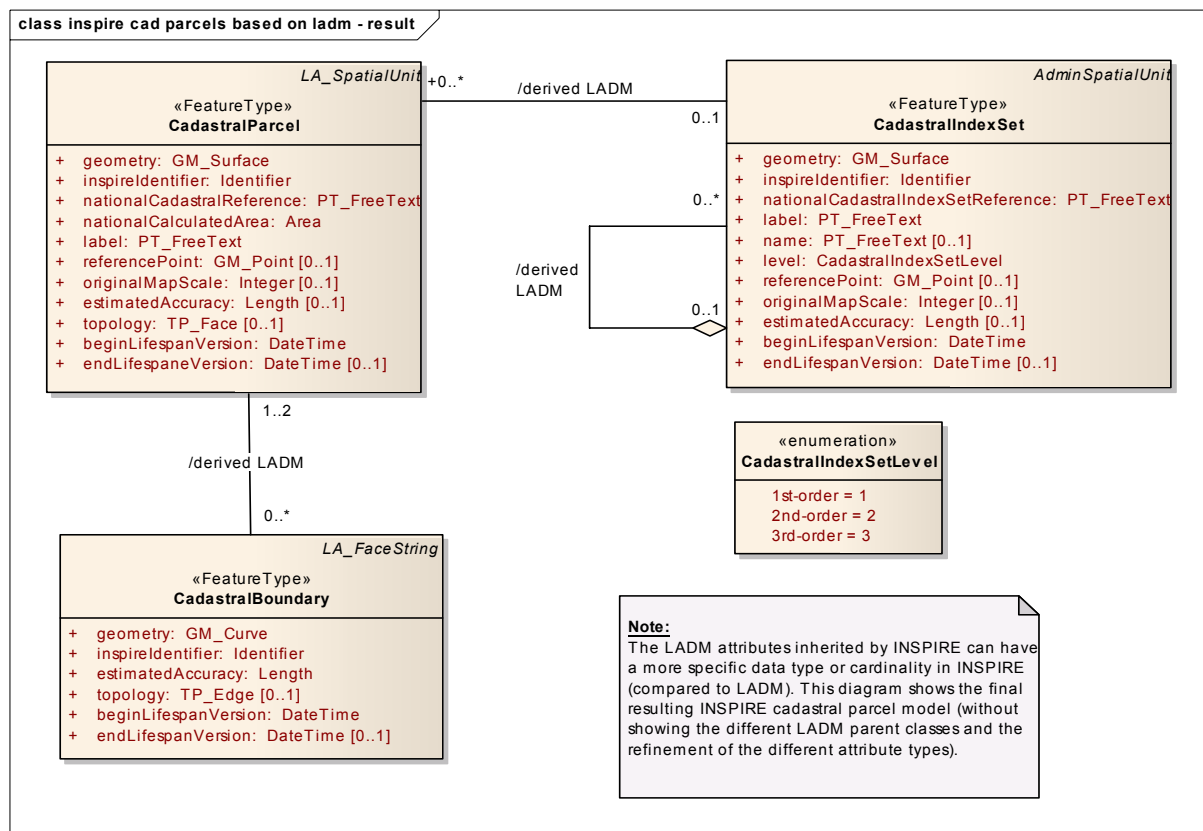
Figure 7. The INSPIRE cadastral parcel model derived from ISO LADM via inheritance.

The INSPIRE model is compatible with LADM and might in the future be extended by the supplementary feature types as included in LADM. Several European countries are represented in the ISO19152 Working Group, which ensures that European cadastral systems are taken into account in this standard. Once adopted, this ISO19152 standard will provide quite interesting Reference Material if Data Specification for Cadastral parcels has to be



updated or extended. It may for instance propose harmonisation solutions for rights and owners or for 3D cadastral objects (such as building or network reserves).

To be included in future the ISO19152 (as Annex G): a LADM-based version of INSPIRE cadastral parcels, showing that the INSPIRE development fits within the LADM and that there are no inconsistencies. When the implementing rule and guidance material for INSPIRE cadastral parcels are published (target date 15 May 2009), then this annex will be completed. Figure 7 shows how the INSPIRE cadastral parcels model can be derived from the LADM. In INSPIRE context three classes are relevant: LA\_SpatialUnit as basis for CadastralParcel, LA\_FaceString as basis for CadastralBoundary, and LA\_SpatialUnitSet as basis for CadastralIndexSet. The LADM attributes inherited by INSPIRE can have a more specific data type or cardinality in INSPIRE (compared to LADM). This has been included in the diagram. This implies that an optional LADM attribute [0..1], might not occur at all in INSPIRE as the cardinality can be set to 0; e.g. nationalVolume. This also implies that an optional LADM attribute [0..1], might be an obligatory attribute in INSPIRE; e.g. label. Further, INSPIRE specific attributes are added to the different classes. Figure 8 shows the final resulting INSPIRE cadastral parcel model (without showing the different LADM parent classes and the refinement of the different attribute types).



**Figure 8.** The resulting INSPIRE cadastral parcel model derived from ISO LADM via inheritance.

## 5. LADM INSTANCE LEVEL DIAGRAMS

Due to the required high level of abstraction of LADM (in order to offer maximum flexibility in specifying individual Land Administration systems), a clear and easy understanding of the conveyed concepts by both experts and laymen can be a difficult task. To illustrate how LADM can model a variety of tenancy and ownership (including the financial and economical) arrangements, a significant number of concrete cases is depicted as Instance Level or Object Diagrams. The examples included in the CD annex were derived from a number of descriptions covering different jurisdictions (namely the Netherlands, Portugal, Spain and Norway), thus enriching the variety of modelled situations.

### 5.1 Case 1: Ownership and leasehold

One natural person is leaseholder, another non-natural person is owner, ownership and leasehold based on civil code for a particular country.

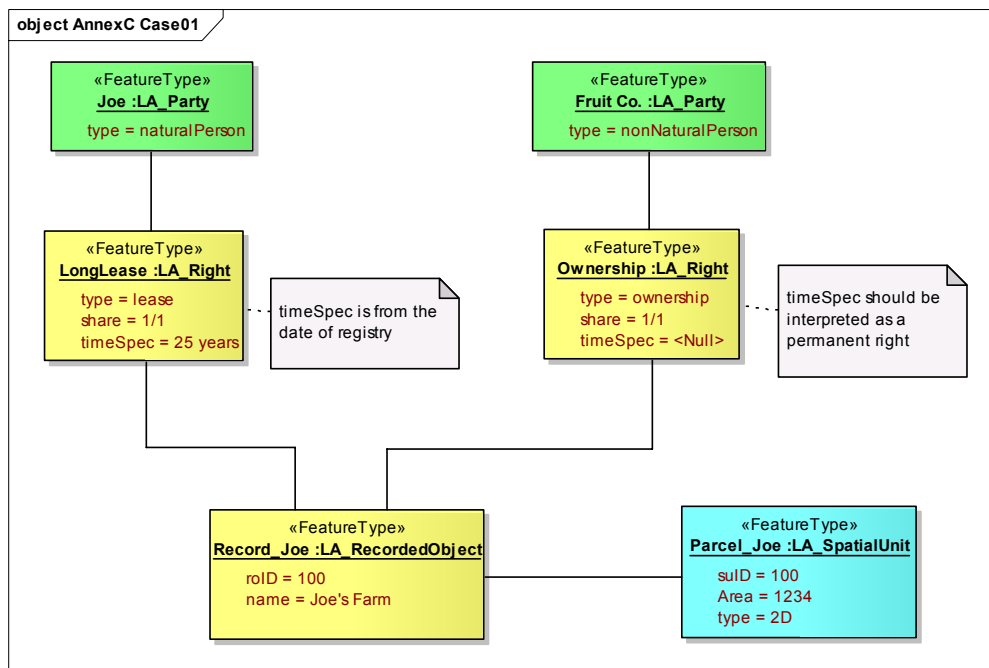


Figure 9. Ownership and leasehold.

## 5.2 Case 2: Parcel complex with one owner

A parcel with a single individual owner. The scenario fits those countries where several non-adjointing parcels can be registered through a single record. This is the situation on Scandinavian countries.

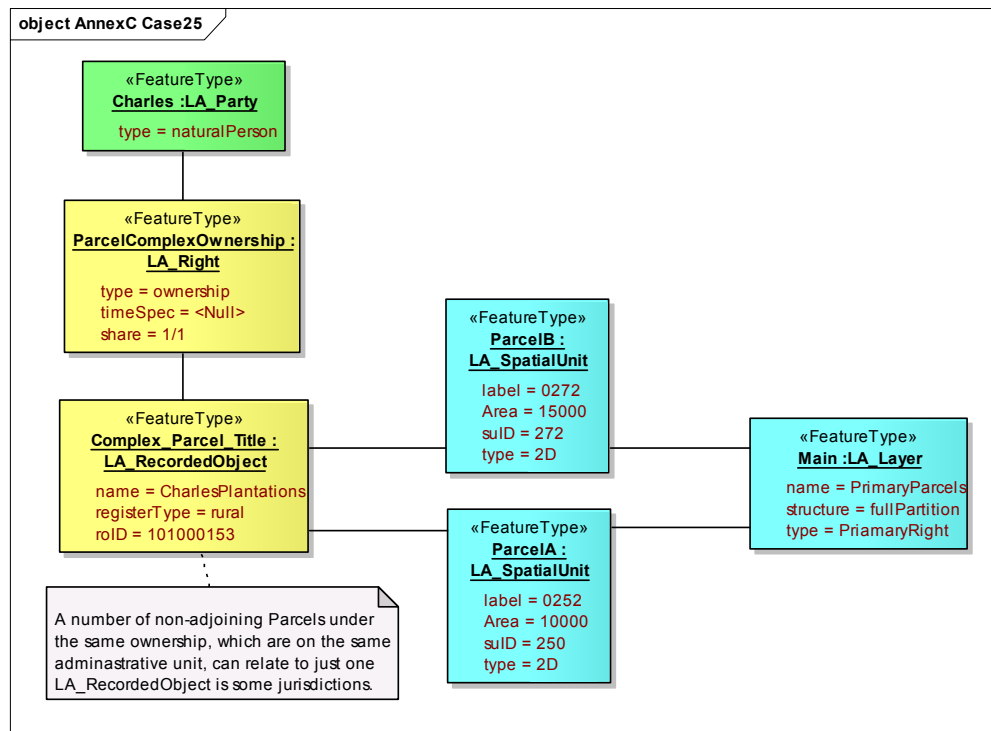


Figure 10. Parcel complex with one owner.

## 5.3 Case 4: Serving Parcel

A Serving Parcel under formal real rights. The parcels itself hold a common ownership over the serving parcel. Spatially, they do not need to be adjacent to each other. In the Diagram, a serving parcel provides access to four parcels, and the serving parcel is not public. Each one of the Parcels (1 to 4) is acting as shareholder on the common Real Property right over the ServingParcel. As thus, they have a direct association with a (Group)Party object, the type of Party being a recordedObject. Each one of the Parcels (1 to 4) has another association with a Party representing a normal ownership (from natural or non-natural person), which is not shown here. The diagram is not showing also the associations from the RecordedObjects to the corresponding SpatialUnits.

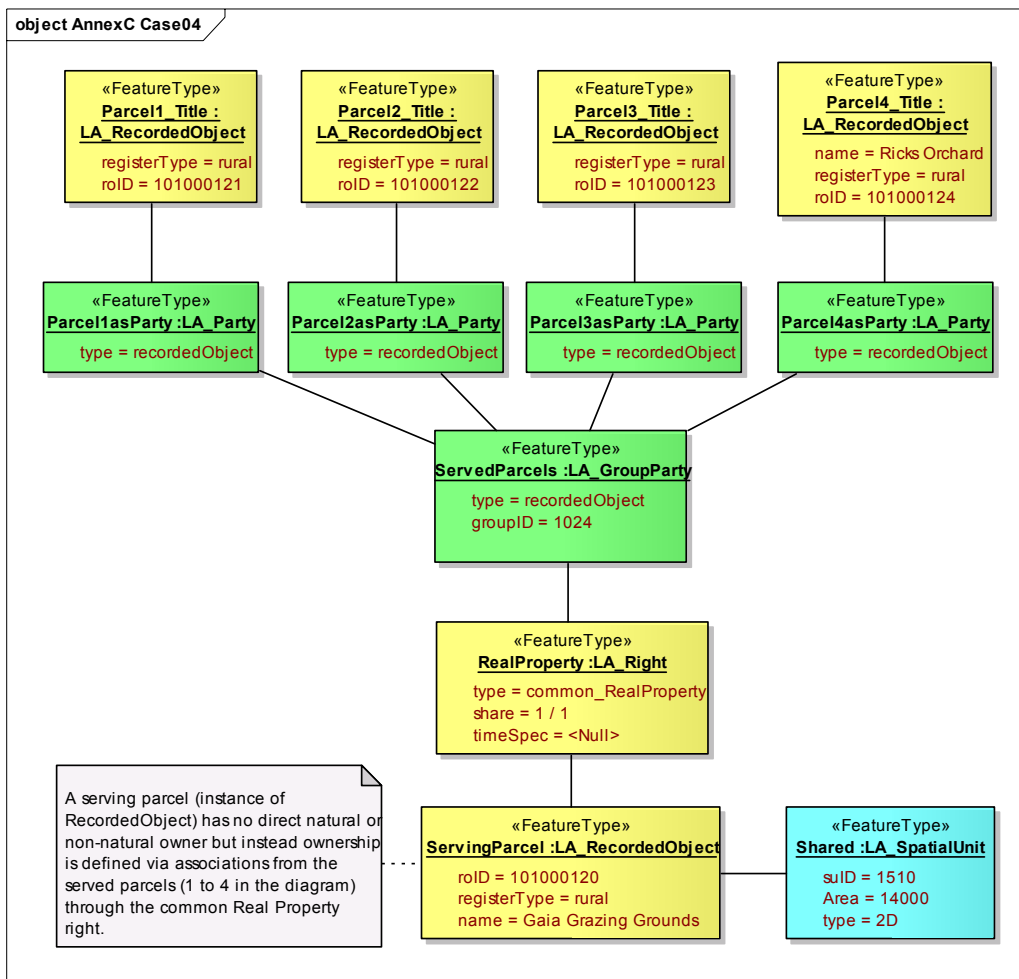


Figure 11. Serving parcel situation formal rights.

## 6. CONCLUDING REMARKS

The development of the Land Administration Domain Model (ISO19152) is as follows:

- New Working Item Proposal (NWIP): was in February 2008
- Working Draft (WD): discussions were in Copenhagen, Delft and Tsukuba
- Committee Draft (CD): will be in June 2009
- Draft International Standard (DIS): December 2009
- Final Draft International Standard (FDIS): December 2010
- International Standard (IS): June 2011

The LADM has been accepted by CEN for development as a European Standard. Progress is made towards the development of country profiles for Portugal, Australia, The Netherlands, Japan, and Hungary. The Social Tenure Domain Model is a specialisation of the LADM, with a prototype under development in close co-operation with UN HABITAT. INSPIRE Cadastral Parcel model also fits to the LADM. The LADM provides a wider context for the INSPIRE

Cadastral parcels as the LADM includes additional information on rights (bound to national legislation) and owners, which are outside the direct scope of INSPIRE. Efforts are made to develop the LADM with support of large communities (FIG, CEN, OGC, and ISO) and user groups, which means that it can be implemented by the GIS industry. In this way the inclusion of Land Administration into Spatial Data Infrastructures (SDI) can be better supported ([Grootchedde et al, 2008](#)).

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## REFERENCES

CEN/TC287 ‘Geographic Information’ doc.nr. N 1015, Resolutions 39 - 54 taken by CEN/TC287 meeting November 10/11, 2003.

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

Grootchedde, A., Lemmen, C.H.J., Van der Molen, P. and Van Oosterom, P.J.M. (2008) A standardized land administration domain model as part of the spatial information infrastructure. In: *Creating spatial information infrastructures : towards the spatial semantic web.* / ed by P.J.M. van Oosterom and S. Zlatanova. Boca Raton : CRC, 2008. ISBN: 978-1-42007-068-2.

Hespanha, Joao, Jan van Bennekom-Minnema, Peter van Oosterom and Christiaan Lemmen, 2008. *The Model Driven Architecture Approach Applied to the Land Administration Domain Model Version 1.1 - with Focus on Constraints Specified in the Object Constraint Language*, FIG Working Week 2008, Integrating Generations, June 2008, Stockholm, 19 pp.

INSPIRE, 2008. *Infrastructure for Spatial Information in Europe. D2.8.I.6 INSPIRE Data Specification on Cadastral Parcels, Draft Guidelines (version 2)*.

ISO/TC211, 2008. *Geographic information/Geomatics, New Work Item Proposal, Geographic information — Land Administration Domain Model (LADM), ISO/TC211 N 2385, 2008-02-01*.

ISO/TC211, 2009. [www.isotc211.org](http://www.isotc211.org)

Lemmen, C.H.J. and P.J.M. van Oosterom (2006). *Version 1.0 of the FIG Core Cadastral Domain Model*. XXIII FIG Congress. Munich, Germany, FIG.

Stoter, J.E., 2004, *3D cadastre*, PhD thesis, 327 pp, TU Delft, the Netherlands.

Van Oosterom, P.; Lemmen, C.; Ingvarsson, T.; Molen, P.; Ploeger, H.; Quak, W.; Stoter, J. & Zevenbergen, J., 2006. *The Core Cadastral Domain Model*. Computers, Environment and Urban Systems, 30, 627-629.

## APPENDIX: DATA TYPES AND CODE LISTS

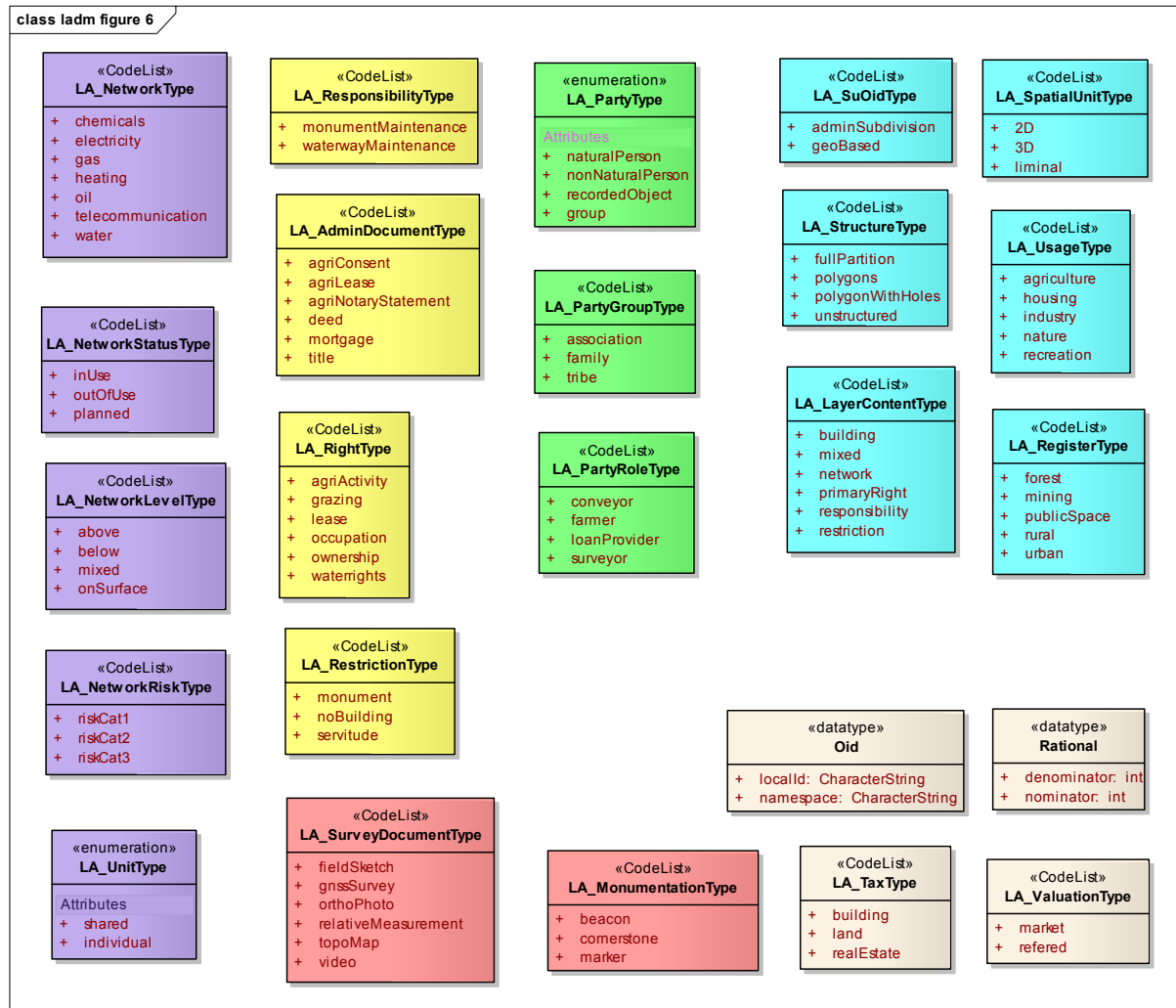


Figure 12. Overview of the different data types and code lists (with sample values, that can be extended) as defined in the LADM.

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