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Geographic information — Land Administration Domain Model (LADM)

Information géographique — Modèle du domaine de l'administration des terres

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Contents

Foreword

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ISO 19152 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Introduction

This International Standard (IS) defines the Land Administration Domain Model (LADM). Land administration is a large field; the focus of this standard is on that part of land administration that is interested in rights, responsibilities and restrictions affecting land (or water), and the geometrical (spatial) components thereof. LADM provides a reference model which will serve at least two important goals: (1) to avoid reinventing and re-implementing the same functionality over and over again, but rather to provide an extensible basis for the development and refinement of efficient and effective land administration systems, based on a Model Driven Architecture (MDA), and (2) to enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary (that is, an ontology) implied by the model. The second goal is important for creating standardized information services in an international context, where land administration domain semantics have to be shared between regions, or countries, in order to enable necessary translations. Important considerations during the design of the model were: it should cover the common aspects of land administration all over the world; it should be based on the conceptual framework of Cadastre 2014 of the International Federation of Surveyors (FIG); it should follow ISO standards; and, at the same time, the model should be as simple as possible, in order to be useful in practice.

It should be noted that although this is a land administration domain model, it is not intended to be complete for any particular country. It is likely that additional attributes, operators, associations, and perhaps complete new classes, will be needed for a specific region or country (therefore *code lists* are used which are expandable); see for example the Social Tenure Domain Model (STDM) in Annex B, the country profiles in Annex D, or the integration of LADM with Land Parcel Identification Systems (LPIS) in Annex H. Conversely, it is possible to use only a subset, or profile, of LADM for a specific implementation.

Until now, most countries (or states, or provinces) have developed their own land administration system. One country operates deeds registration, another title registration. Some systems are centralized, and others decentralized. Some systems are based on a general boundaries approach, others on fixed boundaries. Some systems have a fiscal background, others a legal one. However, the separate implementation and maintenance of land administration systems is not cheap, especially if one considers the ever-changing requirements. Also, the different implementations (foundations) of the various land administration systems do not make meaningful communication across borders easy. Looking from a distance, one may observe that the different systems are in principle largely the same: they are all based on the relationships between people and land linked by (ownership) rights, and are in most countries influenced by developments in Information and Communication Technology (ICT). Furthermore, the two main functions of every land administration (including cadastre and/or land registry) are: (1) keeping the contents of these relationships up-to-date (based on legal and related transactions); and (2) providing information from the (national) registers.

Land administration is described as the process of determining, recording and disseminating information on ownership, value and use of land when implementing land management policies. If ownership is understood as the mechanism through which rights to land are held, we may also speak about land tenure. A main characteristic of land tenure is that it reflects a social relationship regarding rights to land, which means that in a certain jurisdiction the relationship between people and land is recognised as a legally valid one (either formal or non-formal). These recognised rights are in principle eligible for registration, with the purpose being to assign a certain legal meaning to the registered right (e.g. a title). Therefore, land administration systems are not just 'handling geographic information', as they represent a lawfully meaningful relationship amongst people, and between people and land. As land administration activity on the one hand deals with huge amounts of data, which moreover are of a very dynamic nature, and on the other hand requires a continuous maintenance process, than the role of ICT is of strategic importance. Without the availability of information systems it will be difficult to guarantee good performance with respect to meeting changing customer demands. Organizations are now increasingly confronted with rapid developments in technology, a technology push (internet, spatial data bases, modelling standards, open systems, GIS), as well with a growing demand for new services, a market pull (e-governance, sustainable development, electronic conveyance, integration of public data and systems). Modelling is a basic tool facilitating appropriate system development and

reengineering and, in addition, it forms the basis for meaningful communication between different (parts of the) systems.

Standardization has become a well-known process in the work of land administrations and land registries. In both paper-based systems and computerized systems, standards are required to identify objects, transactions, relationships between objects (e.g. parcels, more generally spatial units) and persons (e.g. subjects, more generally parties), classification of land use, land value, map representations of objects, and so on. Computerized systems require further standardization, when topology and the identification of single boundaries are introduced. In existing land administrations and land registries, standardization is generally limited to the region, or jurisdiction, where the land administration (including cadastre and/or land registry) is in operation. Open markets, globalization, and effective and efficient development and maintenance of flexible (generic) systems, require further standardization.

Review history

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CD 19152	10-Jul-2009	Comments CD19152.1

Geographic information — Land Administration Domain Model (LADM)

1 Scope

This International Standard:

- defines a reference Land Administration Domain Model (LADM) covering all basic information-related components of Land Administration (including those over water as well as land, and elements above and below the surface of the earth)
- provides an abstract, conceptual schema with five basic packages related to (1) parties (*people and organizations*); (2) rights, responsibilities, and restrictions (*ownership rights*); (3) spatial units (*parcels, buildings and networks*); (4) spatial sources (*surveying*); and (5) spatial descriptions (*geometry and topology*)
- provides a terminology for land administration, based on various national and international systems, that is as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions
- provides a basis for national and regional profiles
- enables the combining of land administration information from different sources in a coherent manner.

The following is outside the scope of this International Standard:

- interference with (national) land administration laws that may have any legal implications
- construction of external databases with party data, address data, valuation data, land use data, land cover data, physical network data, and taxation data. However, LADM provides 'blueprint' stereotype classes for these data sets which indicate what data set elements LADM expects from these external sources, if available.

2 Conformance

Any land administration domain model claiming conformance to this standard shall satisfy the requirements of Annex A.

3 Normative references

The following referenced documents are indispensable for the application of this document.

ISO 4217, *Codes for the representation of currencies and funds*

ISO 13249-3, *SQL/MM Part 3: Spatial*

ISO 19103, *Geographic Information – Conceptual schema language*

ISO 19105, *Geographic Information – Conformance and testing*

ISO 19106, *Geographic Information – Profiles*

ISO 19107, *Geographic Information – Spatial schema*

ISO 19108, *Geographic Information – Temporal schema*

ISO 19109, *Geographic Information – Rules for application schema*

ISO 19111, *Geographic information – Spatial referencing by coordinates*

ISO 19113, *Geographic information – Quality principles*

ISO 19114, *Geographic information – Quality evaluation procedures*

ISO 19115, *Geographic information – Metadata*

ISO 19135, *Geographic Information – Procedures for registration of geographical information items*

ISO 19136, *Geographic information – Geography Markup Language (GML)*

ISO 19138, *Geographic Information – Data quality measures*

ISO/CD 19156, Geographic information – *Observations and measurements*.

4 Terms, definitions, and abbreviations

4.1 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

4.1.1 Administrative source document

document providing formal facts
NOTE. It is the evidence of a party's right to a **launit**.

4.1.2 Building

description of the legal, recorded or informal space of the physical entity

4.1.3 Building unit

component of **building**

4.1.4 Coordinate reference system

set of mathematical rules for specifying how coordinates are to be assigned to points, together with a set of parameters that define the position of the origin, the scale, and the orientation of the coordinate system

4.1.5 Face

2-dimensional topological primitive
NOTE. **Faces** are used for 3D description of **spatial units**

4.1.6 Face string

boundary forming part of the outside of a **spatial unit** described in 2D as GM_MultiCurve
NOTE. This 2D description implies a series of vertical **faces** in 3D space.

4.1.7 Group party

any number of **parties**, considered as an entity
EXAMPLE. Communities, tribes, families, or cooperatives.

4.1.8 Land administration

the process of determining, recording and disseminating information about ownership, value and use of land
NOTE. In many countries land information is determined, recorded and disseminated under the umbrella of cadastre and land registry. Both institutions can be unified in a single (state) organization.

4.1.9 Land administration unit (launit)

administrative entity consisting of zero or more **spatial units** against which (one or more) unique and homogeneous **rights** (e.g. ownership right or land use right), **responsibilities** and **restrictions** are associated to the whole entity, as included in a Land Administration system

NOTE. By unique is meant that a **right**, or **restriction**, or **responsibility** is held by one, or several **parties** (e.g. owners or users) for the whole **launit**. By homogeneous is meant that a **right**, or **restriction**, or **responsibility** (e.g. ownership, use, social tenure, lease, or easement) affects the whole **launit**.

4.1.10 Level

collection of **spatial units** with a geometric and/or thematic coherence
NOTE. The notion of legal independence is the rationale for the level concept. The principle stipulates that **spatial units**, being subject to the same law and underlying a unique adjudication procedure, may be arranged in one individual **level**.

4.1.11 Liminal spatial unit

spatial unit on the threshold between 2D and 3D descriptions

4.1.12 Mortgage

a conditional conveyance of (ownership) right as security for the repayment of a loan

4.1.13 Network

the description of the legal, recorded or informal space of a utility network
NOTE. Not the physical entity is meant.

4.1.14 Parcel

spatial unit with a legal ownership **right** demarcated by its boundaries

4.1.15 Party

person, or group of persons, that compose an identifiable single (legal) entity
NOTE. A **launit** can play the role of **party**.

4.1.16 Party member

member of a **party**

4.1.17 Profile

set of one or more base standards or subsets of base standards, and, where applicable, the identification of chosen clauses, classes, options and parameters of those base standards, that are necessary for accomplishing a particular function
[from ISO 19106]

4.1.18 Register

set of files containing identifiers assigned to items with descriptions of the associated items
[from ISO 19135]

4.1.19 Registration

assignment of a permanent, unique and unambiguous identifier to an item
[from ISO 19135]

4.1.20 Registry

information system on which a register is maintained
[from ISO 19135]

4.1.21 Required relationship

explicit spatial relationship between **spatial units** that might otherwise not be derived from spatial representations, e.g. due to inaccuracies
NOTE. The type of spatial relationship is defined in ISO 13249-3 SQL/MM Part 3: Spatial.

4.1.22 Responsibility

formal or informal obligation to do something

4.1.23 Restriction

formal or informal entitlement to refrain from doing something

4.1.24 Right

formal or informal entitlement to own, or to do something

4.1.25 Source document

document providing facts

4.1.26 Source point

point of a **spatial unit** as observed in the field
NOTE. This can be observed by e.g. terrestrial surveying, photo interpretation, image interpretation, or identification on an existing map.

4.1.27 Spatial source document

source document with the spatial description of a (part of) one or more **spatial units**

4.1.28 Spatial unit

single area (or multiple areas) of land (and/or water) or, more specifically, a single volume of space (or multiple volumes of space) under (one or more) unique and homogeneous **rights**, **restrictions**, or **responsibilities**

4.1.29 Spatial unit set

set of **spatial units**
NOTE. Set means that there are no duplicates of **spatial units**.

4.1.30 Subparcel

subdivision of **spatial unit**
NOTE. The accomplishment of the subdivision should be explained.

4.2 Abbreviations

FIG	International Federation of Surveyors
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
INSPIRE	INfrastructure for SPatial Information in Europe
LA	Land Administration
LADM	Land Administration Domain Model
launit	land administration unit
RRR	Right, Restriction, Responsibility
STDM	Social Tenure Domain Model
UML	Unified Modeling Language

5 Core and packages of LADM

5.1 Core classes of LADM

The core LADM is based on four classes:

1. Class LA_Party. Instances of this class are parties (persons or organizations), or group parties (groups of persons or organizations).
2. Class LA_RRR. Instances of subclasses of LA_RRR are rights, restrictions or responsibilities.

3. Class LA_LAUnit. Instances of this class contain administrative information concerning spatial units with equal rights, restrictions or responsibilities.
4. Class LA_SpatialUnit. Instances of this class are spatial units, parcels, subparcels, buildings or networks.

Figure 1 shows the core LADM as an UML 2.1 class diagram.

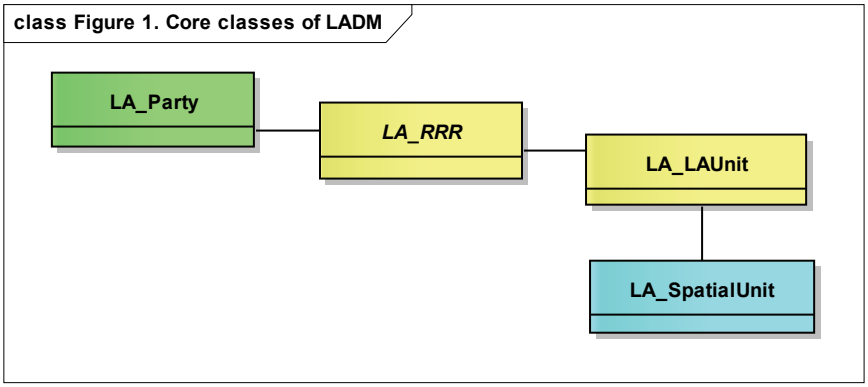

Figure 1. Core classes of LADM

5.2 Packages of LADM

LADM contains five packages. This facilitates the maintenance of different data sets by different organizations. The complete model may be therefore implemented through a distributed set of (geo-) information systems, each supporting data maintenance activities and the provision of elements of the model. The model may also be implemented by one or more maintenance organizations operating at national, regional or local level. This underlines the relevance of the model: different organizations have their own responsibilities in data maintenance and supply, but may communicate on the basis of standardized administrative and technical update processes.

5.2.1 Party Package

The main class in this package is the class LA_Party, with its specialization LA_GroupParty. There is an optional association class LA_PartyMember. See Figure 2.

Class ExtParty is a ‘blueprint’ class for an external registration of parties. A ‘blueprint’ class is a stereotype class that indicates the data set elements LADM expects from an external source, if available (more about external registrations in Section 7.3).

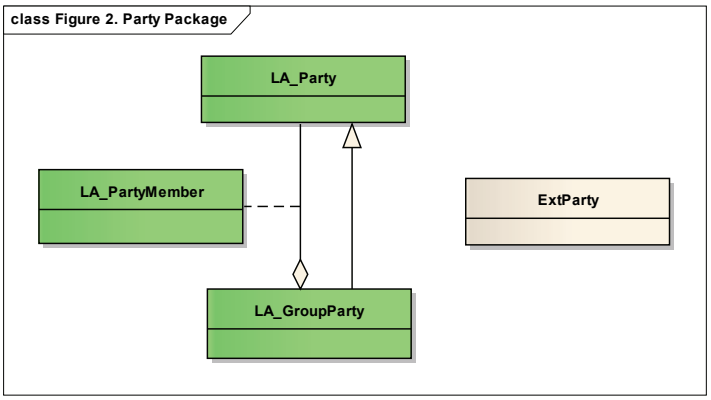

Figure 2. Party Package

5.2.2 Administrative Package

The main class of this package is the abstract class LA_RRR, with its specializations LA_Right (with rights), LA_Restriction (with restrictions) and LA_Responsibility (with responsibilities). In principle, all rights, restrictions and responsibilities are based on an administrative source document (from class LA_Admin-SourceDocument). See Figure 3.

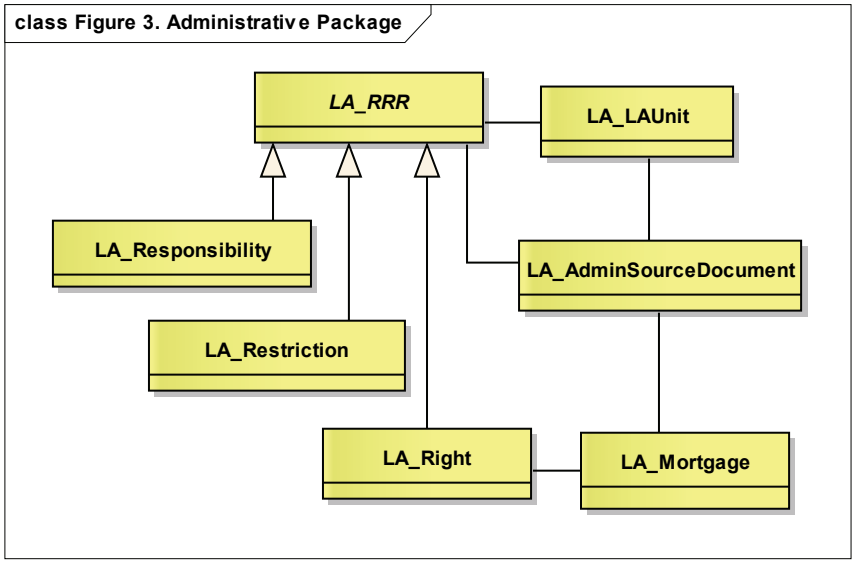

Figure 3. Administrative Package

Each jurisdiction has a different 'land tenure system', reflecting the social relationships regarding rights, restrictions, and responsibilities to land in that area. The variety of rights is quite large within most jurisdictions, and the exact meaning of similar rights may differ considerably between jurisdictions (which can be areas with customary tenures). The aforementioned rights are primarily in the domain of private, or customary law. Usually the rights are created after an agreement between the party obtaining the right and the party (e.g. the land owner) who restricts his or her right by the newly created right. The restrictions usually "run with the land", meaning that they remain valid even when the right to the land is transferred after the right was created (and registered). Ownership rights are generally based on (national) legislation, and code lists in LADM are in support of this. A customary right related to a region, or an informal right may be included.

In addition to those private law restrictions, many countries also have public law restrictions, which are usually enforced by a (local) government body. The holder of the right is a party (either ‘the government’ or ‘society-at-large’). Some of them apply to a specific spatial unit (or right therein), or a group of them, or the duty to pay a certain tax for improvements on a road, or the duty to repair damage, or perform delayed maintenance.

A restriction means that a party allows another party to do something, or that a party shall refrain from doing something itself. Restrictions are both within private law, especially in the form of servitudes, or within public law, through zoning and other planning restrictions, as well as in environmental limitations. A responsibility means that one shall actively do something. Not all formal systems allow such mandated activities as ownership rights, and this will also affect the question whether they shall be (or should be) registered. Their impact may be substantial, and their registration is therefore preferable.

There is always at least one instance of LA_Right in which the type of right represents the strongest (or primary) right, for instance customary or statutory ownership, freehold or leasehold. Connected to this strongest right, certain interests may be added or subtracted from this strongest right. Restrictions can be seen from a ‘positive’ or ‘negative’ side: the fact that a neighbour is allowed to walk over your land is an

additional right (appurtenance, positive-side) to the ownership right of the neighbour, whereas it is a restriction (encumbrance, negative-side) to your ownership. In the present model, both sides are represented, but it is the intention to store only the positive-side, and derive (compute) the negative side, when needed. There is no need to record both the positive and negative side as one side can be derived from the other side by intersecting an instance (of a subclass of LA_RRR) with the other overlapping instances (of a subclass of LA_RRR).

5.2.3 Spatial Unit Package

The main class of this package is class LA_SpatialUnit with 2D or 3D spatial units as instances. Spatial units are refined into three subclasses (see Figure 4):

1. Parcels or subparcels.
2. Buildings or building units.
3. Networks.

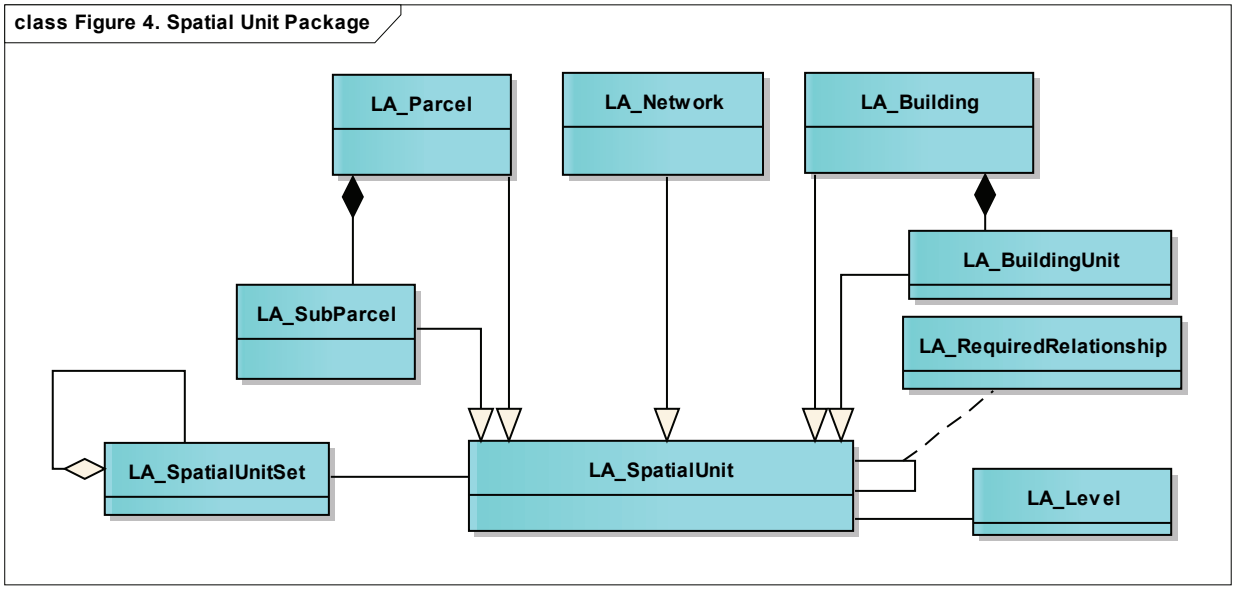

Figure 4. Spatial Unit Package

2D or 3D spatial units may be from different registrations or recordations. The different types of (2D or 3D) spatial units include: text spatial units, point spatial units, line spatial units, polygon spatial units and topological spatial units. A spatial unit may change its description over time, from text spatial unit, into point spatial unit, into line spatial unit, into polygon spatial unit, or into topological spatial unit.

Spatial units may be grouped into spatial unit sets, for example, a municipality, or a planning area. A spatial unit set may be a grouping of other spatial unit sets. In implementations of LADM, this may be related to spatial unit identifiers; when a spatial unit identifier is composed out of hierarchical zones e.g. country id, followed by department id, followed by county id, followed by municipality id, etc.

The different classes of *building* spatial units are LA_Building and LA_BuildingUnit. A building (the description of the legal, recorded or informal space, not the physical entity) is composed out of several building units.

A level is a collection of spatial units with a geometrical/topological or thematic coherence. A level may be organized on the basis of the geometrical/topological structure of the spatial units, and is used for the implementation of the notion of legal independence. For example, a level with rights, a level with restrictions, etc. Another approach is a level structure for urban area, rural area, mining area, etc.

It is possible to establish explicit links between spatial units as instances of class LA_RequiredRelationship. Sometimes there is a need for these links when the geometry of the spatial units is not accurate enough to give reliable results when applying overlap operations (e.g. a building, in reality inside a parcel, is reported to fall outside the parcel).

5.2.4 Surveying Package

The two classes of this package are LA_SourcePoint and LA_SpatialSourceDocument. See Figure 5.

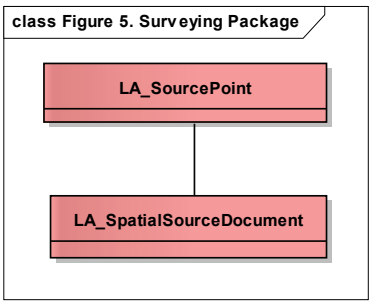

Figure 5. Surveying Package

Data acquisition can be conducted digitally in a field office, or compiled from various sources, for example using forms and field sketches, ortho-images or ortho-photos, or existing topographic maps.

A land administration survey is documented with spatial source documents (from class LA_Spatial-SourceDocument). This may be the final (sometimes formal) documents, or all documents related to a survey. Sometimes, several documents are the result of a single survey. The documents may contain digital signatures. Paper based documents (which may be scanned) should be considered as an integral part of the land administration system. A set of measurements with observations (distances, bearings, etc.) to points is an attribute of LA_SpatialSourceDocument. The individual source points are instances of class LA_SourcePoint, which is associated to LA_SpatialSourceDocument. A spatial source document may be associated to several source points.

If a source point is observed during different surveys, there will be different spatial source documents. However, if a source point is observed from different positions during a survey, there may be only one spatial source document. One of the attributes of class LA_SourcePoint is ‘pointType’, which indicates the type of source point; for example this can be a Geodetic Control Point (GCP). Further, there may be reasons for changing coordinates, for example a map revision, or for moving to a different coordinate reference system, or for a new computation of the existing coordinate reference system. Geodetic control points, including multiple coordinates for source points and supporting multiple reference systems are all supported in LADM.

5.2.5 Spatial Description Package

The two classes of this package are LA_FaceString and LA_Face. 2D and 3D descriptions of spatial units use face strings and faces as key concepts. See Figure 6.

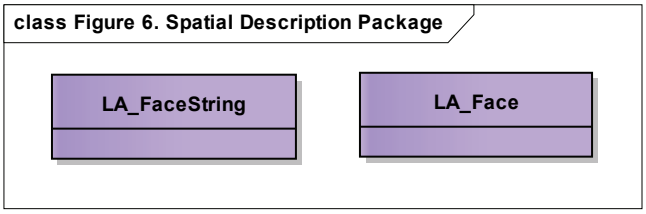

Figure 6. Spatial Description Package

Coordinates themselves are rooted in source points of the Surveying Package. All types of spatail units share the same description structure. Existing 2D data, whether topologically structured or not, or polygons, or unstructured boundaries, or simply point or textual descriptions, can be included. The model supports the increasing use of 3D descriptions of spatial units, without putting additional burden on the existing 2D descriptions. Another important requirement is that there is no mismatch between parts of the domain that are described in 2D and parts of the domain that are described in 3D. Further, LADM is based on accepted and available spatial schema's, such as published in ISO 19107.

6 Classes of LADM

6.1 Introduction

LADM is based on the ISO 19100 series standards and other ISO standards. To differentiate LADM classes from other ISO classes, they are given LA_ as a prefix.

Furthermore, all LADM classes adhere to ISO 19103 stereotype class *FeatureType*. Many LADM classes are subclasses of class *VersionedObject* which is explained in Clause 6.7.1.

This standard presupposes so called 'blueprint' stereotype classes, with a minimal number of attributes, to address the situation where an LADM class refers to external sources for parties, addresses, valuations, taxations, land uses or land covers.

LADM allows user-defined elements to be added. It is likely that additional attributes, operators, associations, or perhaps new classes, will be needed for a specific region or country.Or that parts of LADM are not used at all.

6.2 Classes of Party Package

6.2.1 LA_Party

An instance of class LA_Party is a party. A party (e.g. a person, or group of persons) is associated to zero or more [0..*] instances of a subclass of LA_RRR. LA_Party is also associated to LA_LAUnit, therefore a party can be an launit, which is indicated by the attribute 'type' of LA_Party. See Figure 7.

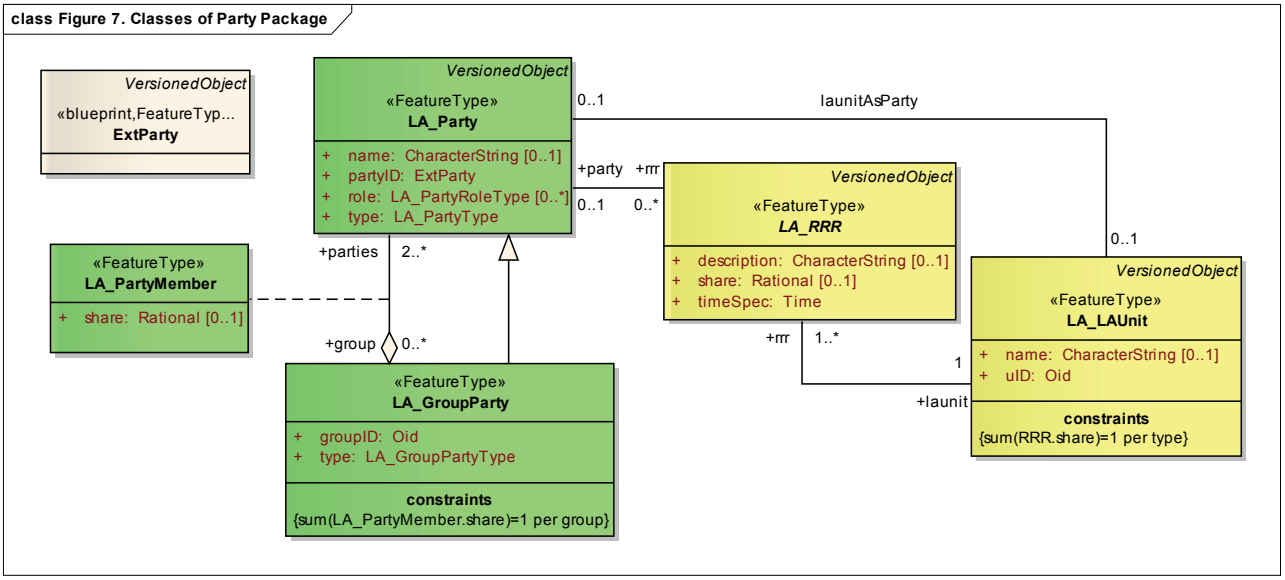

Figure 7. Classes of Party Package (LA_Party, LA_GroupParty, and LA_PartyMember)

The attributes of LA_Party are:

- name: the name of the party
- partyID: the identifier of a party in an external registration ('blueprint' class ExtParty, which includes a reference to an external address)
- role: the role of a party in the data update and maintenance process (e.g. conveyor, notary, writer, surveyor, certified surveyor, bank, money provider, employee, etc.)
- type: the type of a party (e.g. natural person, non natural person, group, launit, etc.).

NOTE. If 'role' has a specific value (e.g. conveyor) than it is possible that no right is associated to the party, hence [0..*] multiplicity.

6.2.2 LA_GroupParty

An instance of class LA_GroupParty is a group party. Class LA_GroupParty is a subclass of LA_Party, because LA_Party has an association to class LA_RRR (and thereby also to class LA_LAUnit).
A group party may consist of two or more [2..*] parties, but also of other group parties (that is to say, a group party of group parties). Conversely, a party is a member of zero or more [0..*] group parties. See Figure 7.

The attributes of LA_GroupParty are:

- groupID: the identifier of a group party
- type: the type of the group party (e.g. a tribe, an association, a family).

There is a constraint stating that the sum of the shares of the group party members is equal to 1.

6.2.3 LA_PartyMember

An instance of class LA_PartyMember is a party member. Class LA_PartyMember is an optional association class between LA_Party and LA_GroupParty.
See Figure 7.

The attribute of LA_PartyMember is:

- share: this is the fraction of the whole.

6.3 Classes of Administrative Package

6.3.1 LA_RRR

Class LA_RRR is an abstract class (it has no instances). An instance of a subclass of LA_RRR is a right (or social tenure relationship), a restriction, or a responsibility. If it is a right or responsibility, than it is associated to exactly one [1] party, and exactly one [1] launit. If it is a restriction, than it is associated to zero or one [0..1] parties, and exactly one [1] launit. The latter allows for the registration of restrictions (e.g right-of-way, right-to-harvest-fruit) to a spatial unit, with, or without an association to LA_Party. See Figure 8.

The attributes of LA_RRR are:

- description: description regarding the right, restriction or responsibility
- share: a share in an instance of a subclass of LA_RRR. There is a constraint that the sum of all shares is equal to 1. For example: two parties each holding a share of ½ in a right of ownership; or one party holding ¼ and another holding ¾ (see NOTE 2 in clause 6.4.5 for a further explanation of the constraint)
- timeSpec: operational use of a right in time sharing. This attribute is capable of handling other temporal descriptions, such as recurring patterns (every week-end, every summer, etc.). This means, for example, that a party can hold a right to use an apartment each year in March, or that a group of pastoralists has the right to cross a field each summer.

NOTE 1. There is a constraint that no overlap is allowed between timeSpec's for same type and same launit.

NOTE 2. The multiplicity [0..1] from LA_RRR to LA_Party expresses that it is possible that a launit is only associated to LA_RRR and not to LA_Party. In this way, land with joint ownership, and other types of common lands, may be modelled.

NOTE 3. The model normally requires exactly one party in the association with LA_RRR. However, for certain types there may be 0 or 1 party involved. This is indicated in the code lists by assigning a postfix _P to these specific types of right, restrictions, or responsibilities.

NOTE 4. For certain types of LA_RRR it is not useful to define the share. This is indicated in the code lists with specific types of rights, restrictions, or responsibilities by assigning a postfix _S. For these types the 'sum(share) = 1 per type' constraint does not apply.

NOTE 5. For types of LA_RRR that both (a) allow 0 or 1 association to a party and (b) have a no use for defining a share, the prefix _B is assigned.

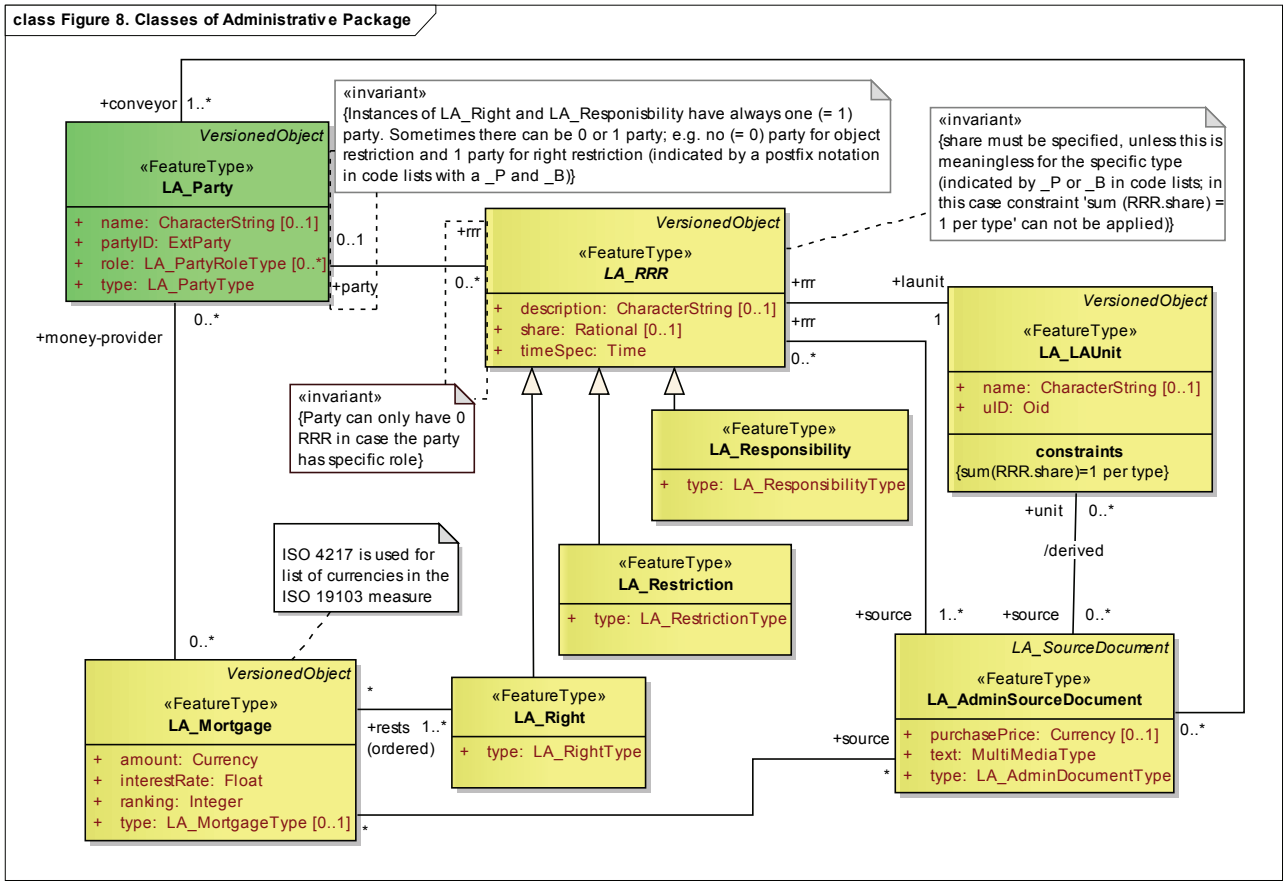

Figure 8. Classes of Administrative Package

6.3.2 LA_Right

An instance of class LA_Right is a right. LA_Right is a subclass of class LA_RRR. See Figure 8.

The attribute of LA_Right is:

- type: the type of a right (e.g. lease, occupation, ownership, water right, grazing right, etc.).

6.3.3 LA_Restriction

An instance of class LA_Restriction is a restriction. LA_Restriction is a subclass of class LA_RRR. See Figure 8.

The attribute of LA_Restriction is:

- type: the type of a restriction (e.g. a servitude, a monument, etc.).

6.3.4 LA_Responsibility

An instance of class LA_Responsibility is a responsibility. LA_Responsibility is a subclass of class LA_RRR. See Figure 8.

The attribute of LA_Responsibility is:

- type: the type of a responsibility (e.g. to maintain a monument, or maintain a waterway, etc).

6.3.5 LA_LAUnit

An instance of class LA_LAUnit is an launit, and subject to registration (by law), or recordation (by informal right, or customary right, or another social tenure relationship). LA_LAUnit is associated to class LA_Party (a party may be an launit, indicated by the attribute 'partyType'). Launit is associated to zero or more [0..*] spatial units. See Figure 8.

The attributes of LA_LAUnit are:

- name: the name of an launit
- uID: the identifier of an launit.

NOTE 1. LA_LAUnit allows the association of one right to a combination of spatial units (e.g. an apartment and a parking place).

NOTE 2. A constraint states that, for one launit, the sum of all the shares for the same subclass of class LA_RRR must be equal to 1, unless 'share' is meaningless with regard to the type of right, restriction or responsibility.

NOTE 3. It is possible that no spatial unit exists for a launit. For instance, in the case of a right to fish, where the holder of the fishing right does not (or no longer) hold rights to a spatial unit in the area. This is modelled by the multiplicity [0…*] from LA_LAUnit to LA_SpatialUnit.

6.3.6 LA_Mortgage

An instance of class LA_Mortgage is a mortgage. LA_Mortgage is associated to class LA_Right (the right that is the basis for the mortgage), and class LA_Party (the party that is the money provider). See Figure 8.

The attributes of LA_Mortgage are:

- amount: the amount of money of the mortgage
- interestRate: interest rate of the mortgage (percentage)
- ranking: this is the ranking order if more than one mortgage applies to a right
- type: the type of the mortgage.

NOTE. If one, or several, mortgages are vested on a (set of) right(s), they are not considered as a separate relationship between LA_Party and LA_SpatialUnit. On the other hand, a mortgage is usually vested as collateral for a loan. Therefore, the money provider as a party is connected to the mortgage. See Figure 8.

6.3.7 LA_AdminSourceDocument

An instance of class LA_AdminSourceDocument is an administrative source document. LA_AdminSourceDocument is a subclass of class LA_SourceDocument. See Figure 8.

The attributes of LA_AdminSourceDocument are:

- purchasePrice: purchase price in relation to a transaction (buying, selling, etc.)
- text: the document

- type: type of document (e.g. a deed, title, etc).

6.4 Classes of Spatial Unit Package

6.4.1 LA_SpatialUnit

An instance of class LA_SpatialUnit is a spatial unit. See Figure 9.

The attributes of LA_SpatialUnit are:

- address: the link to external address(es) of the spatial unit
- area: the area value. In this data type each instance has an area size and type (e.g. calculated, official, etc.)
- dimension: the dimension of the spatial unit (e.g. 2D, 3D, liminal, etc.)
- label: short textual description of the spatial unit
- referencePoint: the coordinates of a point inside the spatial unit
- suID: the spatial unit identifier
- volume: (in case of bounded 3D description) the volume value (e.g. calculated, official, etc.).

NOTE. A spatial unit may be associated to several parties (via LA_LAUnit and LA_RRR associations) and, conversely, a party may be related to several spatial units (again, via LA_RRR and LA_LAUnit associations).

6.4.2 LA_SpatialUnitSet

An instance of class LA_SpatialUnitSet is a spatial unit set. LA_SpatialUnitSet is associated to class LA_SpatialUnit. See Figure 9.

The attributes of LA_SpatialUnitSet are:

- label: short textual description of the spatial unit set
- level: the level in the hierarchy of the (administrative or zoning) subdivision
- name: the name of the spatial unit set
- referencePoint: the coordinates of a point within the spatial unit set
- susID: the identifier of the spatial unit set.

6.4.3 LA_Parcel

An instance of class LA_Parcel is a parcel. LA_Parcel is a subclass of class LA_SpatialUnit. See Figure 9.

LA_Parcel has no attributes.

6.4.4 LA_SubParcel

An instance of class LA_SubParcel is a subparcel. LA_SubParcel is a subclass of class LA_SpatialUnit. See Figure 9.

LA_SubParcel has no attributes.

6.4.5 LA_Building

An instance of class LA_Building is a building. LA_Building is a subclass of class LA_SpatialUnit. See Figure 9.

The attributes of LA_Building are:

- complNum: the identifier of the building
- numberOfFloors: the number of floors in the building

- numberOfUnits: the number of units in the building.

There is a constraint stating that, for one building, the sum of volumes of its building units must be less or equal to the building volume.

6.4.6 LA_BuildingUnit

An instance of class LA_BuildingUnit is a building unit. LA_BuildingUnit is a subclass of class LA_SpatialUnit. See Figure 9.

The attributes of LA_BuildingUnit are:

- type: the type of a building unit (e.g. shared, individual, etc.)
- unitNum: the identifier of a building unit.

NOTE. A building unit is intended in the general sense, not only for living purposes, but also for other constructions and purposes, e.g. commercial activities.

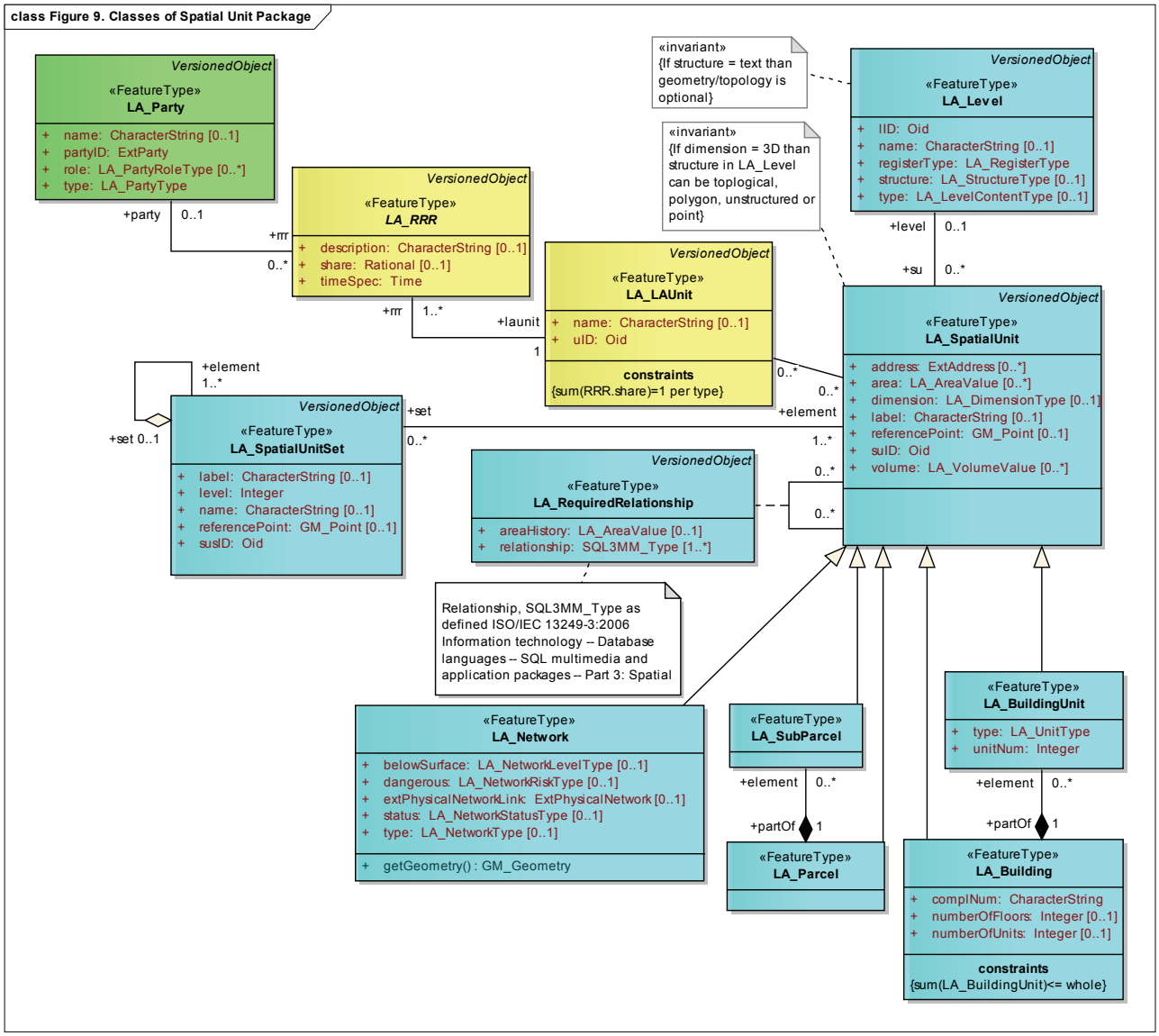

Figure 9. Classes of Spatial Unit Package

6.4.7 LA_Network

An instance of LA_Network is a network. LA_Network is a subclass of class LA_SpatialUnit. See Figure 9.

The attributes of LA_Network are:

- belowSurface: an underground network, or an above-the-ground network, or mixed
- dangerous: an estimation of the risk (e.g. risk type 1, risk type 2, etc.)
- extPhysicalNetworkLink: a reference to the physical (technical) description of the network in an external information source (for instance, the organization responsible for the network)
- status: the status of a network (e.g. in use, planned, etc.)
- type: the type of a network (e.g. chemicals, electricity, etc.).

6.4.8 LA_Level

An instance of class LA_Level is a level. LA_Level is associated to class LA_SpatialUnit. See Figure 9.

The attributes of LA_Level are:

- IID: the identifier of the level
- name: the name of the level
- registerType: the register type of the content of the level (e.g urban, rural, forest, etc.).
- structure: the structure of the level geometry (e.g. full partition, polygons, unstructured, etc.)
- type: the type of the content of the level (e.g. primary right, restriction, building, etc.).

6.4.9 LA_RequiredRelationship

An instance of association class LA_RequiredRelationship is a spatial type from ISO 13249-3, *SQL/MM Part 3: Spatial*. See Figure 9.

The attribute of LA_RequiredRelationship is:

- relationship: an ISO 13249-3 spatial type (e.g. overlaps, contains, etc.).

6.5 Classes of Surveying Package

6.5.1 LA_SourcePoint

An instance of class LA_SourcePoint is a source point. LA_SourcePoint is a subclass of class VersionedObject. See Figure 10.

The attributes of LA_SourcePoint are:

- interpolationRole: the role of source point in the structure of a straight line or curve
- originalLocation: calculated co-ordinates, based on observations
- pID: an source point identifier
- pointType: type of monumentation in the field (e.g. beacon, corner stone, marker, etc.)
- productionMethod: lineage
- spaceDimension (derived): the number of dimensions (2D or 3D)
- transAndResult: transformation and transformed location (ISO 19107).

6.5.2 LA_SpatialSourceDocument

An instance of class LA_SpatialSourceDocument is a spatial source document. See Figure 10.

The attributes of LA_SpatialSourceDocument are:

- measurements: field observations, and measurements, as a basis for mapping, and as a basis for historical reconstruction of the location of (parts of) the spatial unit in the field. The data type is OM_Observation and is re-used from ISO/CD 19156
- procedure: way of surveying
- type: type of the spatial source document (e.g. field sketch, orthophoto, etc.).

6.6 Classes of Spatial Description Package

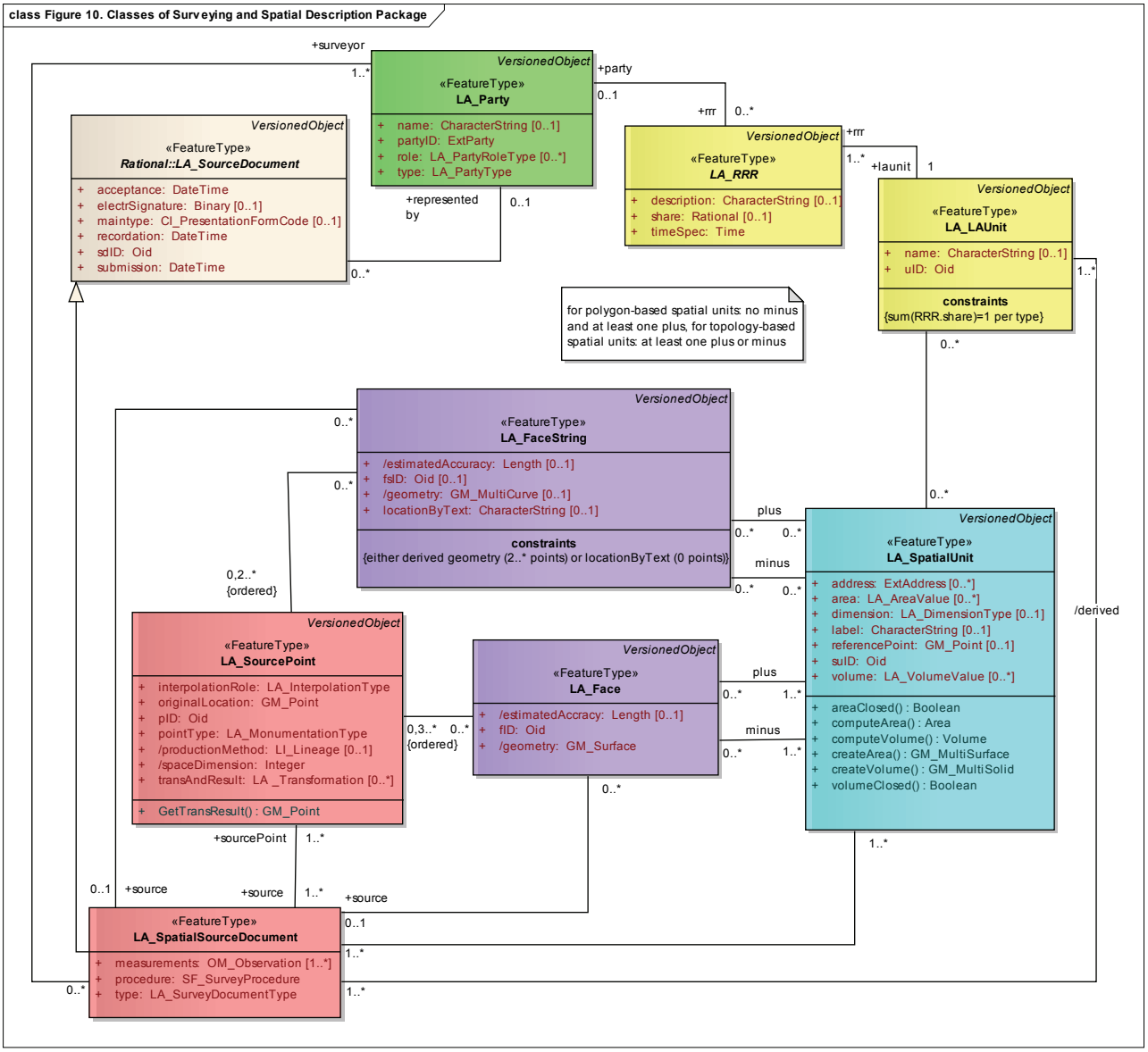

Figure 10. Classes of Surveying and Spatial Description Package

6.6.1 LA_FaceString

An instance of class LA_FaceString is a face string. LA_FaceString is a subclass of class VersionedObject. Face strings are used to describe the boundary of spatial units via linestrings in 2D (which can be projected

vertically up and down to have the 3D interpretation if needed). It has associations with LA_SourcePoint and LA_SpatialSourceDocument to document the source of the geometry. See Figure 10.

The attributes of LA_FaceString are:

- estimatedAccuracy: the estimated accuracy of the boundary description; this can be derived from associated class LA_SourcePoint
- fsID: the face string identifier
- geometry: the boundary described via a curve at ground (or zero height) level; can be derived from the associated class LA_SourcePoint (ISO 19107)
- locationByText: the boundary described via natural text.

6.6.2 LA_Face

An instance of class LA_Face is used to describe the boundary of a spatial unit via a surface in 3D. LA_Face is a subclass of class VersionedObject. It has an association to class LA_SourcePoint to document the origin of the geometry. See Figure 10.

The attributes of LA_Face are:

- estimatedAccuracy: the estimated accuracy of the boundary description; this can normally be derived from associated class LA_SourcePoint
- fID: the face identifier
- geometry: the boundary described via a surface in 3D space; this can normally be derived from associated class LA_SourcePoint (ISO 19107).

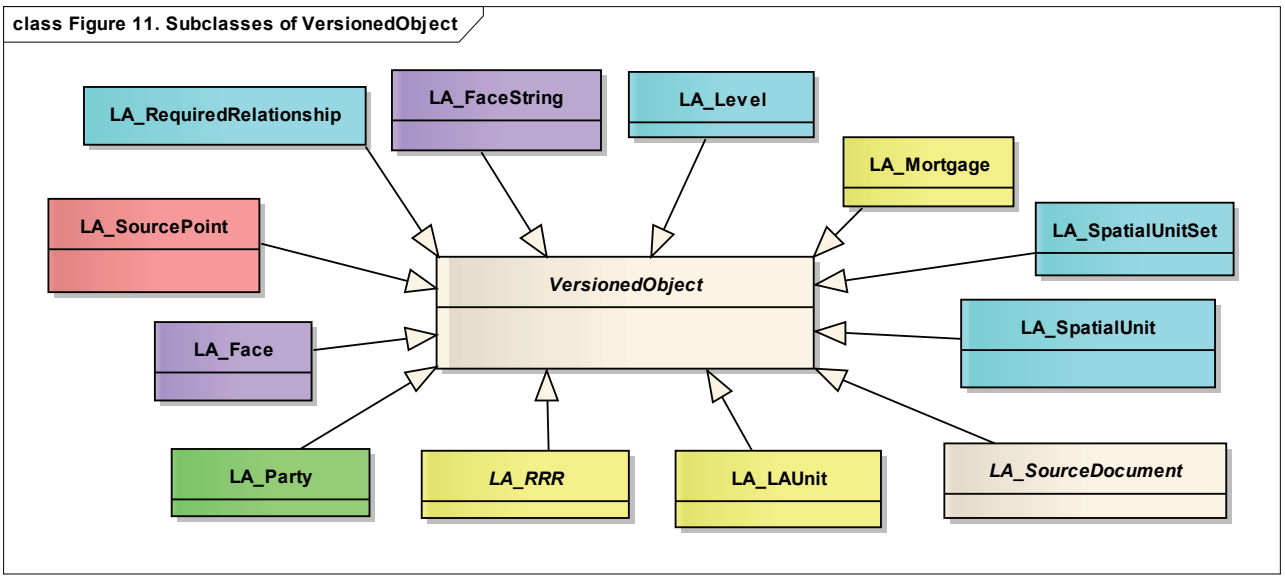

Figure 11. Subclasses of VersionedObject

6.7 Special classes

6.7.1 VersionedObject

This class, re-used from ISO 19108, is introduced in LADM to manage and maintain historical data in the database. This requires that inserted and deleted data are given a time-stamp. In this way, the contents of the database can be reconstructed, as they were at any moment in the past. Classes LA_Party, LA_RRR, LA_LAUnit, LA_SourceDocument, LA_SpatialUnit, LA_SpatialUnitSet, LA_Mortgage, LA_Level, LA_Face-

String, LA_RequiredRelationship, LA_SourcePoint and LA_Face are all subclasses of VersionedObject. See Figure 11.

The attributes of VersionedObject are:

- beginLifespanVersion: start time of a specific instance version
- endLifespanVersion: end time of a specific instance version
- quality: quality of a specific instance version defined as DQ_Element in ISO19108
- source: source (responsible organization) of a specific instance version.

See Figure 12.

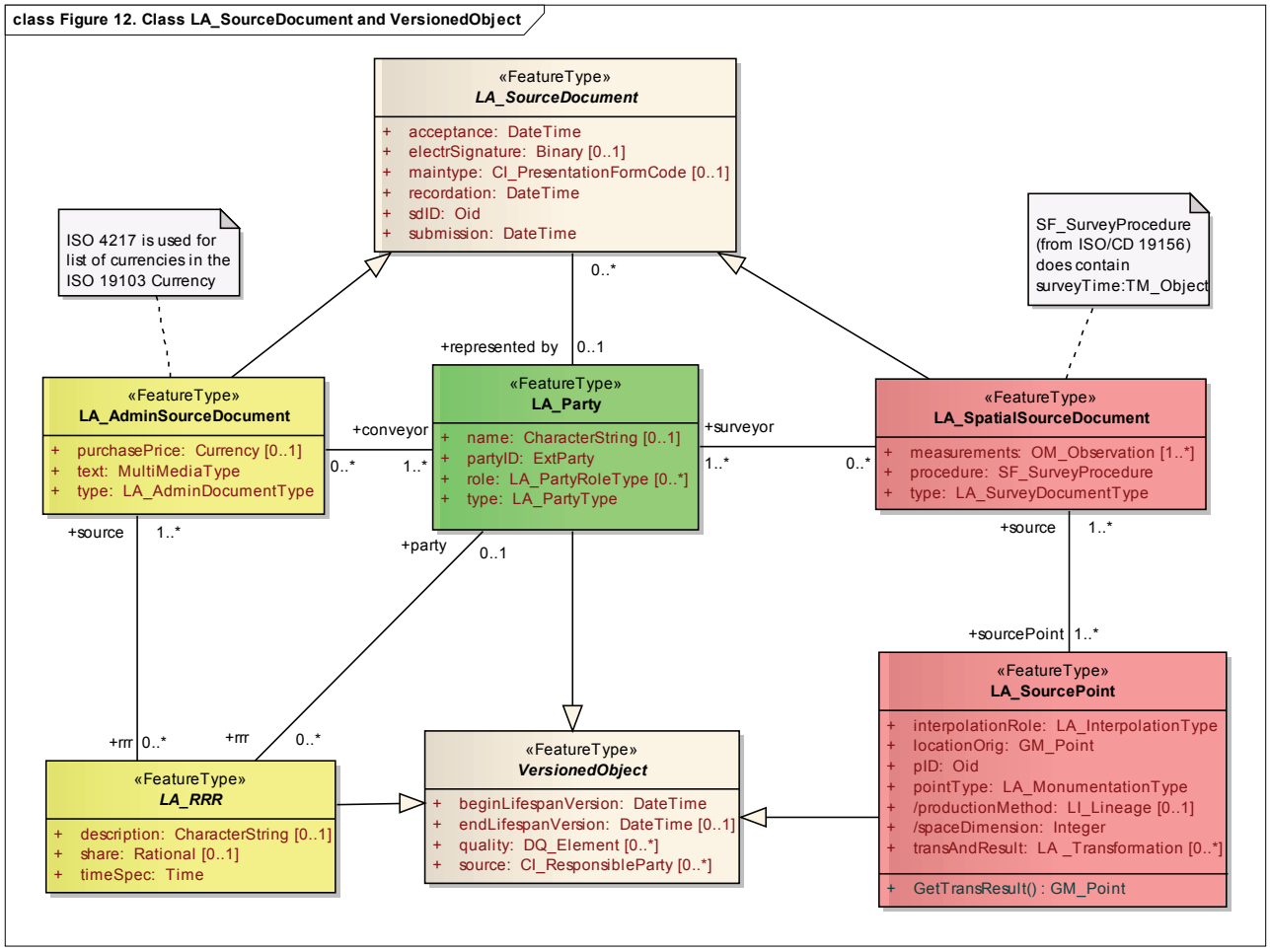

Figure 12. Classes LA_SourceDocument and VersionedObject

6.7.2 LA_SourceDocument

In LADM, source documents are modelled, starting with an abstract class LA_SourceDocument. An instance of a subclass of class LA_SourceDocument is a source document. See Figure 12.

The attributes of LA_SourceDocument are:

- acceptance: date of force of law of the source document by an authority
- electrSignature: data in electronic form which are attached to, or logically associated to other electronic data and which serve as a method of authentication

- maintype: type of document
- recordation: date of registration (recordation) of the source document by registering authority
- sdID: an identifier of the source document
- submission: date of submission of the source document by a party.

NOTE 1. Any kind of document can be added as a source document to LADM according to ISO 19115, section B3.2.

NOTE 2. The fact that all different (public or private law) rights find their base in some kind of transacting document is represented by the association between LA_RRR and LA_AdminSourceDocument. The party responsible for drafting the document is connected to the latter as 'conveyer', 'notary' or 'writer'.
See Figure 12

7 Other aspects of LADM (informative)

7.1 History and dynamic aspects

Two different views are used to model the result of dynamic systems (discrete changes in the state of the system):

(1) Event based modelling. In event based modelling, transactions are modelled as separate entities within the system (with their own identity and set of attributes). When the start state is known, and all events are known, it is possible to reconstruct every state in the past, by reversing the whole chain of events. It is also possible to represent the current state, and not to keep the start state (and go back in time via the 'reversal' of events).

(2) State based modelling. In state based modelling, the states (that is to say, the results) are modelled explicitly: every object is assigned (at least) two dates/times which indicate the time interval during which the object is recorded in the system as actual version. Through the comparison of two successive states it is possible to reconstruct what happened as a result of one specific event. It is straightforward to obtain the state at a given moment in time, by selecting the object based on a time interval (tmin-tmax). The temporal aspect is inherited from class VersionedObject with its attributes beginLifespanVersion and endLifespanVersion. The class LA_RRR has an additional temporal attribute called timeSpec, which is capable of handling other temporal descriptions, such as a recurring pattern (every week-end, every summer, etc.). Note that most objects inherit the temporal attributes via either LA_Party, LA_RRR, LA_LAUnit or LA_SpatialUnit – or directly via VersionedObject.

LADM covers both event based modelling (via class LA_SourceDocument), and state based modelling (via class VersionedObject). In addition to event based and state based modelling, it is also possible for explicit parent-child associations between the spatial units to be modelled (lineage), for example, when a spatial unit is subdivided. However, as these associations can also be derived from a spatio-temporal overlay, LADM has not been made more complex through explicit parent-child relationships.

7.2 Land administration processes

Besides the data modelling aspect of the dynamic processes, LADM provides support for investigating how functions and processes are related to each other. The UML class diagrams should therefore further be completed by state diagrams (use case, sequence, collaboration, state or activity diagrams), covering other aspects. Activity diagrams show how processes are related to the information (data), and how it 'flows' from one into the other. In all the other types of UML diagrams, actors or organizations play an important role, and this can be dependent on (national) arrangements. The introduction of different 'stages' of spatial unit (point, image, surveyed), right (start, landhold, freehold), and party further reflect the dynamic nature of the system.

7.3 External classes

7.3.1 Introduction

The construction of external databases with party data, address data, valuation data, land use data, land cover data, physical network data, and taxation data is outside the scope of LADM. However, LADM provides 'blueprint' stereotype classes for these data sets that indicate what data set elements LADM expects from these external sources, if available.

7.3.2 ExtParty

Class ExtParty is a 'blueprint' class for an external registration of parties. See Figure 13A.

The attributes of ExtParty are:

- addressID: the identifier pointing to an external address
- fingerprint: fingerprint of an external party
- name: the name of the external party
- partyID: the identifier of an external party
- photo: photo of an external party
- signature: signature of an external party.

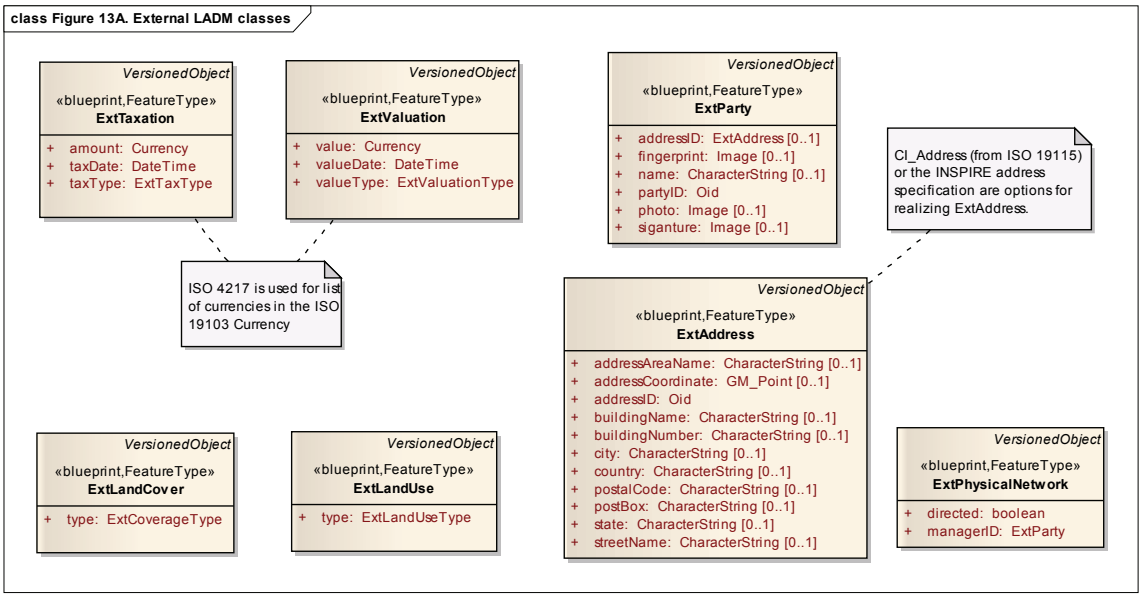

Figure 13A. External LADM classes

7.3.3 ExtAddress

Class ExtAddress is a 'blueprint' class for an external registration of addresses (an address being a direction for finding some location). See Figure 13A.

The attributes of ExtAddress are:

- addressAreaName: address name of an external address
- addressCoordinate: the coordinates of an external address
- addressID: the identifier of an external address
- buildingName: building name of an external address

- buildingNumber: building number of an external address
- city: city of an external address
- country: country of an external address
- postalCode: postal code of an external address
- postBox: post box of an external address
- state: state of an external address
- streetName: street name of an external address.

NOTE. ISO or INSPIRE address specifications may also be used.

7.3.4 ExtTaxation

Class ExtTaxation is a 'blueprint' class for an external registration of taxation data. See Figure 13A.

The attributes of ExtTaxation are:

- amount: the amount of taxation
- taxDate: the date of taxation
- taxType: the tax type.

Class ExtTaxation is associated to class LA_LAUnit. See Figure 13B.

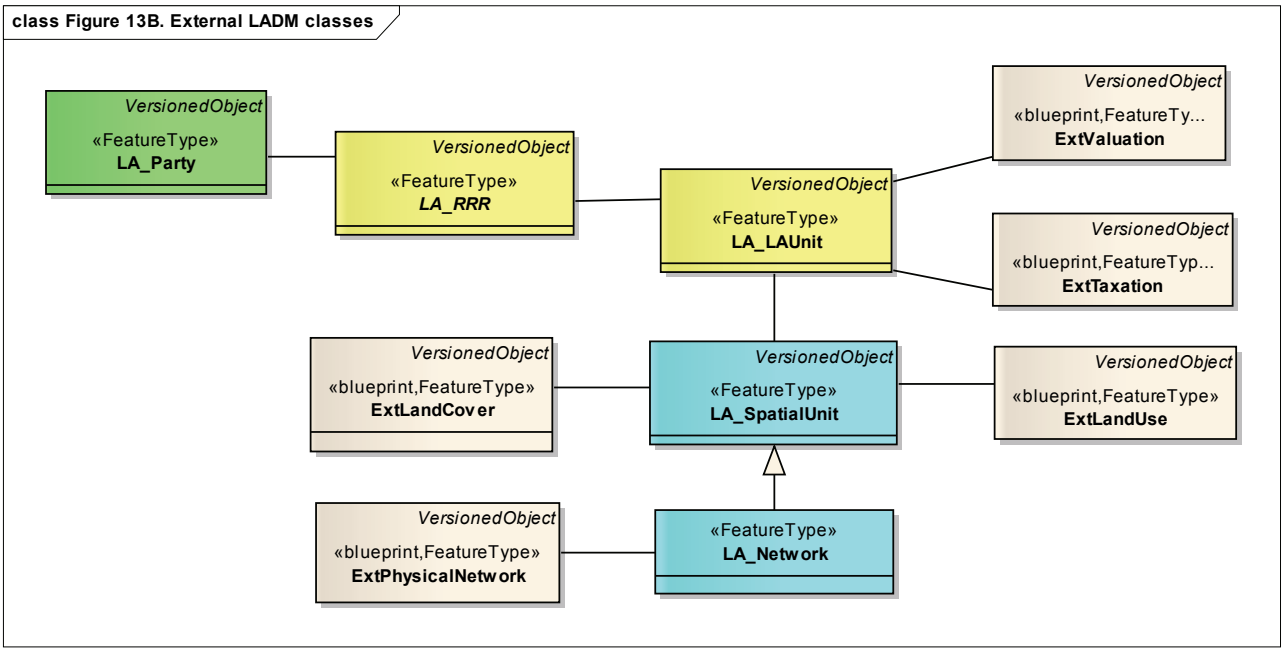

Figure 13B. External LADM classes

7.3.5 ExtLandUse

Class ExtLandUse is a 'blueprint' class for an external registration of land use data; land use is an arrangement, activity or input people undertake in certain land cover type, to produce, change or maintain it. See Figure 13A.

The attribute of ExtLandUse is:

- type: the type of land use.

Class ExtLandUse is associated to class LA_SpatialUnit. See Figure 13B.

7.3.6 ExtLandCover

Class ExtLandCover is a 'blueprint' class for an external registration of land cover data; land cover is the observed (bio)physical cover on the earth's surface. See Figure 13A.

The attribute of ExtLandCover is:

- type: the type of land cover.

Class ExtLandCover is associated to class LA_SpatialUnit. See Figure 13B.

7.3.7 ExtValuation

Class ExtValuation is a 'blueprint' class for an external registration of valuation data. See Figure 13A.

The attributes of ExtValuation are:

- value: the value of a valuation
- valueDate: the date of valuation
- valueType: the valuation type.

Class ExtValuation is associated to class LA_LAUnit. See Figure 13B.

7.3.8 ExtPhysicalNetwork

Class ExtPhysicalNetwork is a 'blueprint' class for an external registration of mapping data of utility networks. See Figure 13A.

The attributes of ExtPhysicalNetwork are:

- directed:
- managerID: the organization responsible for the network.

Class ExtPhysicalNetwork is associated to class LA_Network. See Figure 13B.

7.4 Code lists, data types and enumerations

Code lists are used in LADM for using local, regional, or national terminology. See Figure 14. Also shown are data types and enumerations.

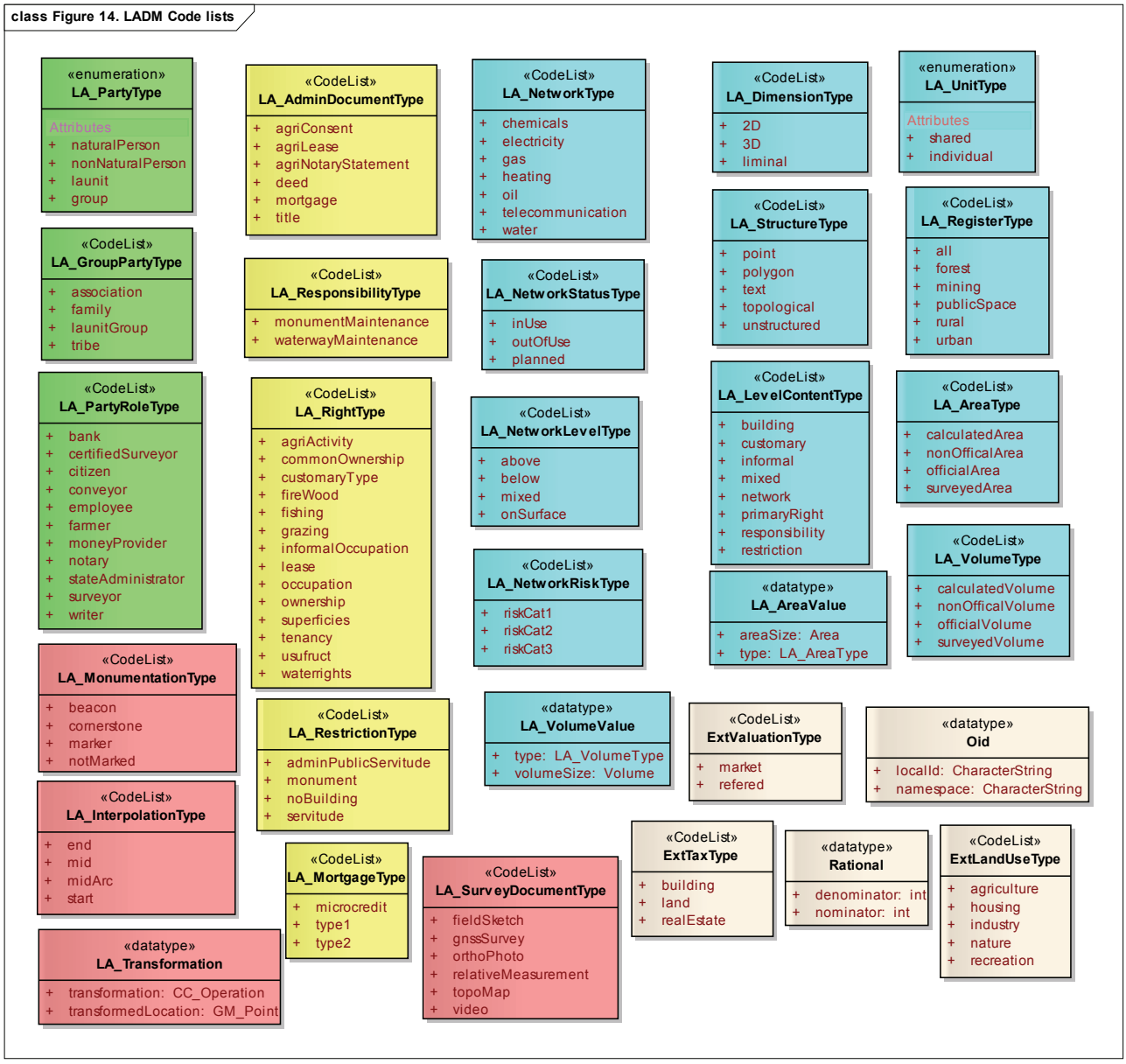

Figure 14. LADM code lists, data types and enumerations

7.5 2D and 3D descriptions of spatial units

2D and 3D descriptions of spatial units use face strings and faces as key concepts. Coordinates themselves are rooted in source points (mostly after geo-referencing, depending on the data collection method used) in the Surveying Package. As pointed out by (Stoter, 2004), in many countries a 2D description may be interpreted as a 3D prismatic volume with no upper and lower bound.

Using this interpretation, 2D and 3D descritions can be unified (Thompson, 2008). The boundaries in the 2D descriptions are called face strings: they use a normal GM_MultiCurve (linestring) for storage, but this implies a series of vertical faces. See Figure 15A.

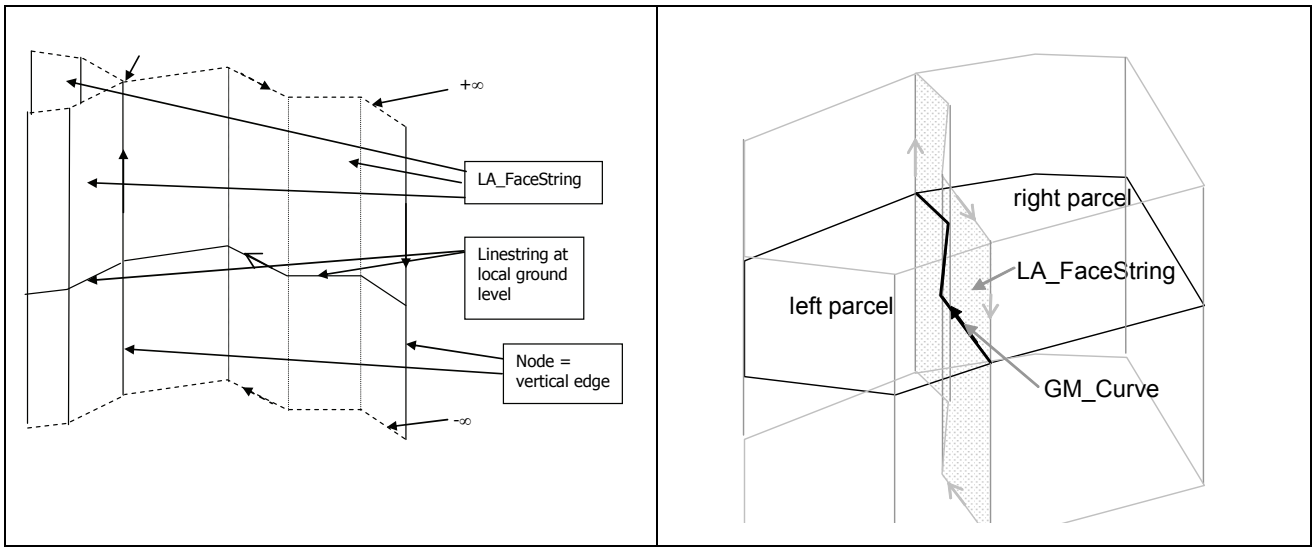

Figure 15A. Face string concepts (*Left*). Spatial units defined by face strings (*Right*)

For true 3D descriptions that also have non-vertical faces, the class LA_Face is introduced. A liminal spatial unit (that is a spatail unit on the treshold of 2D and 3D) has a combination of face strings and vertical faces. The vertical faces shall dissolve into face strings (when common pairs of edges are removed). The faces shall be completely defined from an (undefined) upper bound to an (undefined) lower bound.
See Figure 15B.

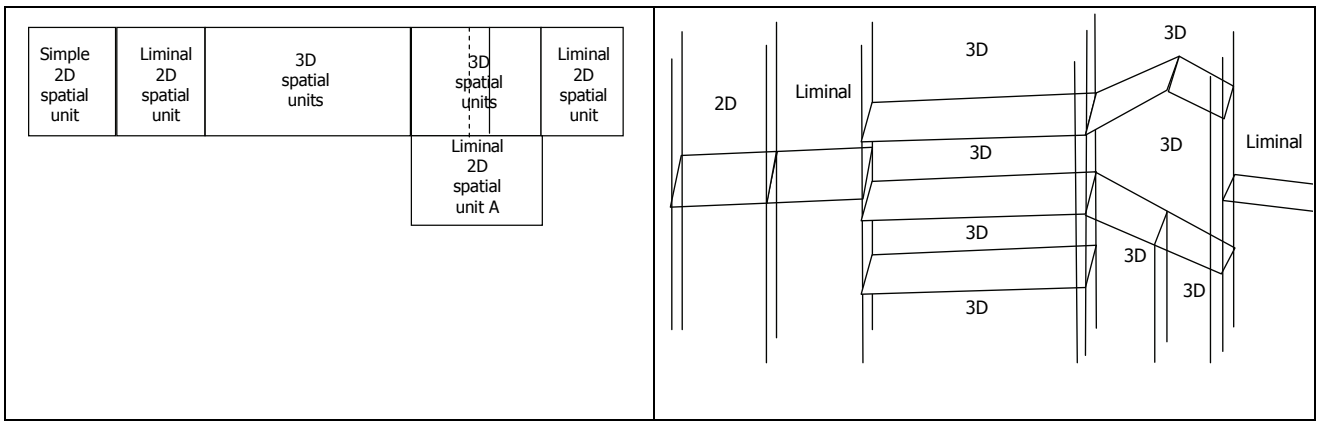

Figure 15B. Top view of mixed 2D/3D descriptions (*Left*). Side view showing the mixed use of face string and face to define both bounded and unbounded 3D volumes (*Right*)

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 ‘dimension’ in LA_SpatialUnit indicates if it concerns a 2D, liminal or 3D description of a spatial unit. E.g. 3D can be applied for a mining cadastre, or it can be applied for individual spatial units.

In addition to these principles, there are five levels of spatial description identified (indicated by the ‘structure’ attribute in LA_Level):

- point based (point spatial unit). A point spatial unit is used when the only information about its location is a pair of 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

- text based (text spatial unit). A text spatial unit is used when its definition is entirely by descriptive text. The spatial unit is accompanied by one or more face strings, each of which carries a block of free text in the 'locationByText' attribute in LA_FaceString. No geometry is used with this type of face string. The 'referencePoint' is optional, and may be used as a specific labelling point, and can also carry a z-value
- unstructured (line) based (line spatial unit). A line spatial unit ('spaghetti') is used when its description is allowed to have inconsistencies such as hanging lines and incomplete boundaries. For the 2D case, the full length face strings are stored once only, not broken at the corners of the spatial units. The spatial units are linked to the face strings that define them. For the 3D case, at least one face is included (and this can intersect other face strings and faces)
- polygon based (polygon spatial unit). A polygon spatial unit is used when every spatial unit is recorded as a separate entity. There is no topological connection between neighbouring spatial units (and no boundaries shared), and so any constraint enforcing a complete coverage shall be applied by the originating and receiving software. In the 2D description there is exactly one link to a closed face string instance for every ring of the polygon (or set of face strings that form together a closed ring). A polygon spatial unit used in a 3D description uses at least one (non-shared) face.
- topological based (topological spatial unit). A topological spatial unit is used when spatial units share boundary descriptions. A topological spatial unit is encoded by reference to its boundaries, with the common boundary between two spatial units being stored once only. Thus there is a topological connection between neighbours. In case of a 2D description, face strings are used forming closed loop(s) and these face strings have left and right references to the spatial units. In case of a 3D description, at least one face with left/right information is included.

Mixed descriptions are also possible, because a face string can be defined either by a geometry, or by a free text block. It is possible for a spatial unit in any form of encoding to be specified by geometry on some faces, while text on others. It is also possible to topologically encode text based spatial units; for example, part of a boundary can be defined by text (e.g. "along the natural shoreline"), while other boundaries can be defined by coordinates. The face string 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 may occur in both 2D and 3D.

It must be stressed that the above applies to any type of spatial unit (including the ones that are used for recorded spaces around buildings and networks, or for servitudes). To organize the instances, there is the concept of a level model. This is especially relevant for the topology based spatial units, but also applies to other types. For example, there may be a base level (Level 1) with ownership spatial units, which are topologically defined and there may be an additional level (Level 2) with polygon based spatial units representing servitudes. The concept of levels may also be used in other situations. For example, Level 1 for present ownership and Level 2 for pre-war ownership. A 3D example would be Level 1 containing ownership (2D, liminal and 3D topological spatial units) and Level 2 would contain ownership of 'legal space' around networks crossing many other spatial units (from which the network space can be subtracted); see Figure 16.

The 2D or 3D (topology) structures shall be valid at every moment in time. With topological spatial units, there are never gaps or overlaps in the partition. However, boundaries belonging to different time spans (defined by versions) may cross. The temporal topology shall also be maintained: that is, no time gaps or overlaps must occur in the descriptions. 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 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. 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).

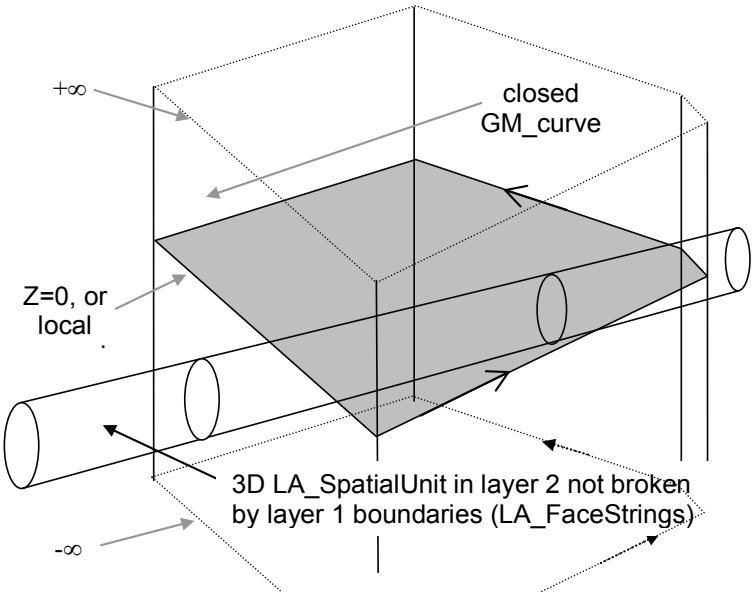

Figure 16. Multiple levels

7.6 Interface classes

There may be interface classes added to LADM to support the generation and management of products and services. These interface classes are considered to be user-defined, and outside the scope of LADM. However, to illustrate the concept of interface class, three interface classes are shown, for parties (see Figure 17A), spatial units (see Figure 17B), and maps with spatial units – e.g. cadastral maps (see Figure 17C).

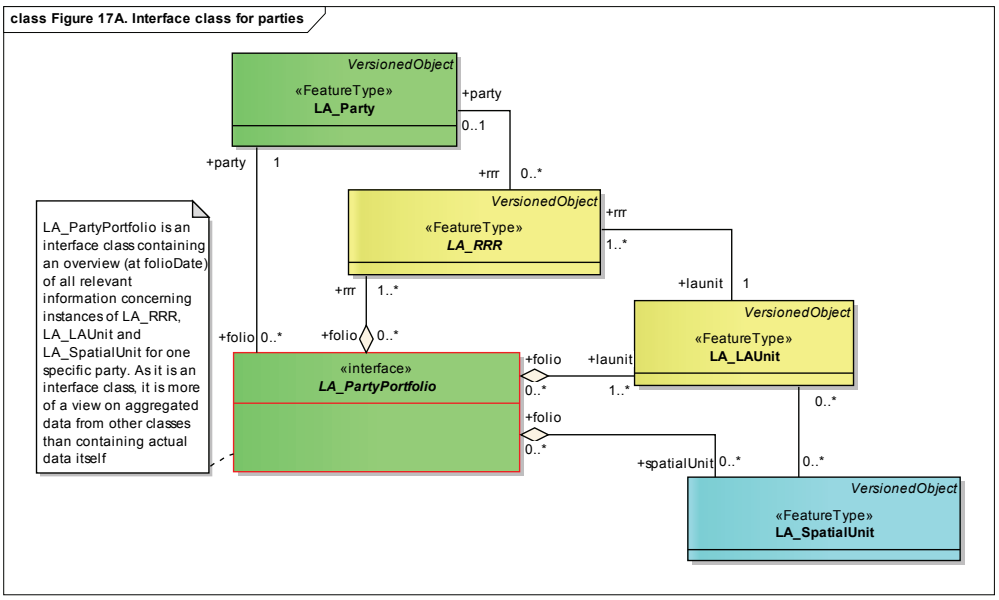

Figure 17A. Interface class for parties

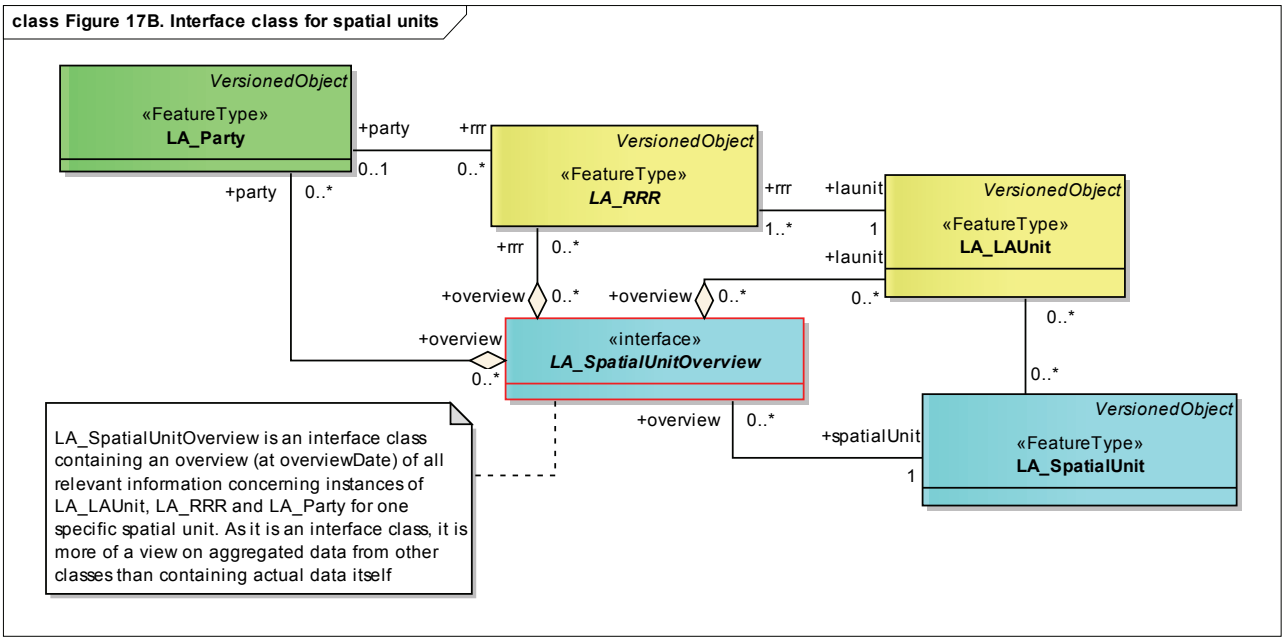

Figure 17B. Interface class for spatial units

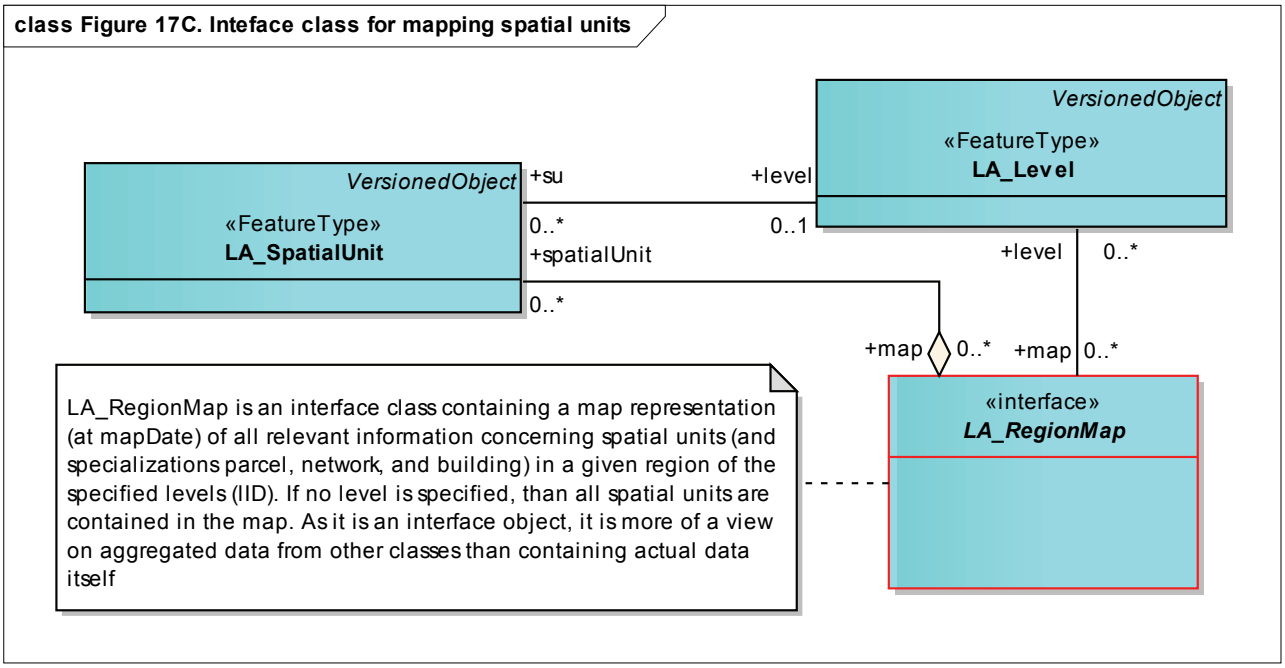

Figure 17C. Interface class for mapping spatial units

7.7 LADM overview

All core classes (clause 5.1), packages (clause 5.2), special classes (clause 6.7), external classes (clause 7.3) and interface classes (clause 7.6) are presented together in Figure 18.

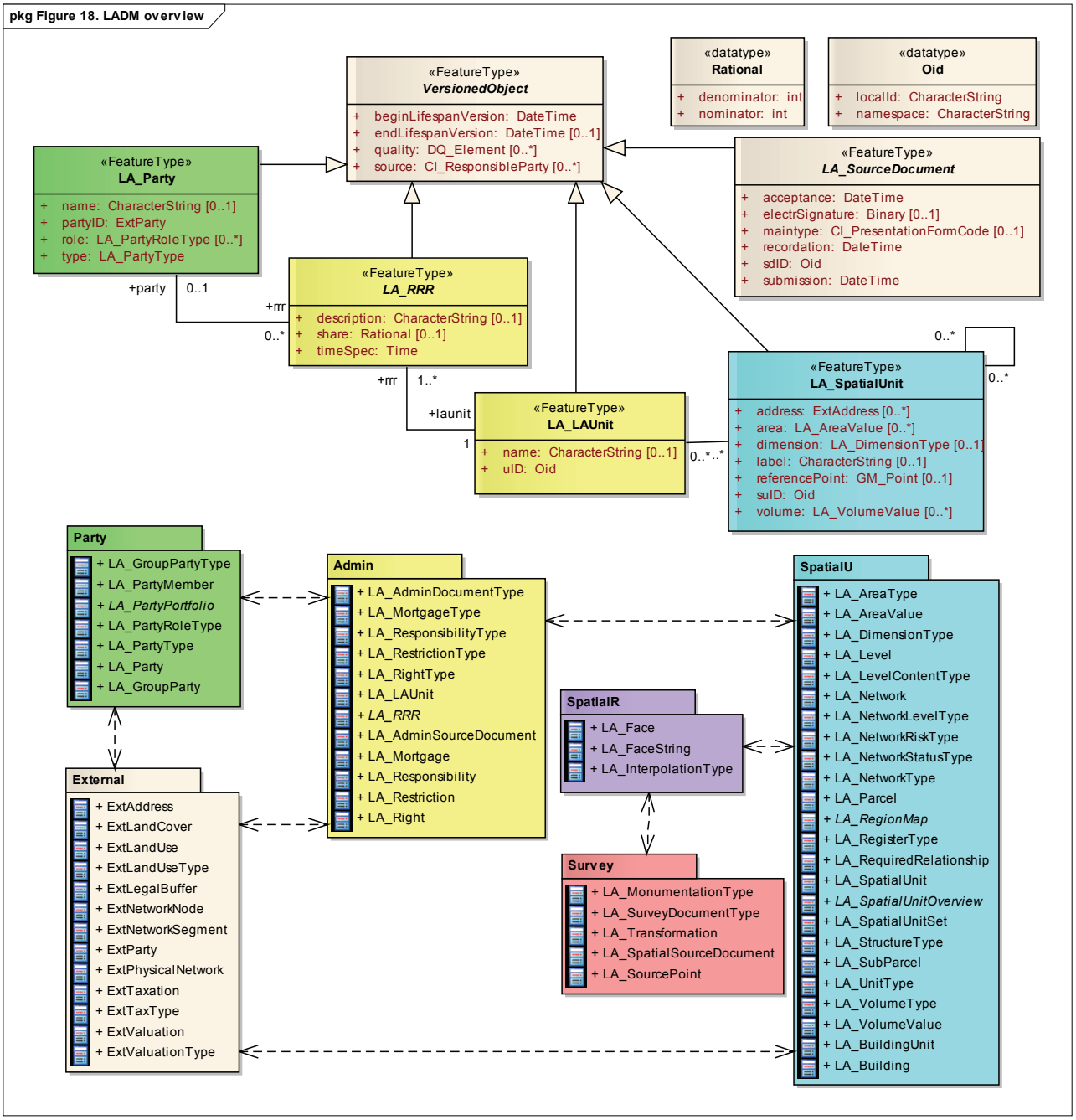

Figure 18. LADM overview

References (informative)

The references in this section have been used in the development of LADM and in the development of the examples in the Annexes. The Cadastre 2014 vision (Kaufmann and Steudler, 1998; see below) was used in the design of LADM; the principle of legal independence is derived from this vision.

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Annex A. Abstract test suite (normative)

Table A1 gives an overview of the mandatory and optional classes per package to check for LADM compliancy. LADM can be implemented per package, but there are interdependencies. The mandatory and optional attributes are given in the class diagrams. The same holds for associations (also in case of interdependencies).

LADM Package name	LADM class name	Optional (O) or Mandatory (M)	Dependencies
Party Package		O	This package can only exist if the Administrative Package is implemented
	LA_Party	M	
	LA_GroupParty	O	
	LA_PartyMember	O	
Administrative Package		O	This package can only exist if the Party Package is implemented
	LA_RRR	M	
	LA_Right	M	
	LA_Restriction	O	
	LA_Responsibility	O	
	LA_LAUnit	M	
	LA_Mortgage	O	
	LA_AdminSourceDocument	O	
Spatial Unit Package		O	
	LA_SpatialUnit	M	
	LA_SpatialUnitSet	O	
	LA_Parcel	O	
	LA_SubParcel	O	
	LA_Building	O	
	LA_BuildingUnit	O	
	LA_Network	O	
	LA_Level	O	
	LA_RequiredRelationship	O	
Surveying Package		O	

	LA_SourcePoint	M	
	LA_SpatialSourceDocument	M	
Spatial Description Package		O	
	LA_FaceString	M	
	LA_Face	O	
Special Classes		M	If two or more LADM packages are implemented this ‘package’ of special classes is mandatory
	Versioned Object	M	
	LA_SourceDocument	O	
External Classes		O	

Table A1. LADM conformance requirements table

Annex B. STDM (informative)

The Social Tenure Domain Model (STDM) is an initiative of UN-HABITAT to support pro-poor land administration (UN-HABITAT, 2009). STDM is meant specifically for developing countries, countries with very little cadastral coverage in urban, or rural areas. It is also meant for post conflict areas, areas with large scale informal settlements, or large scale customary areas. The focus of STDM has been on the relationships between people and land, independently from the level of formalization, or legality of those relationships. It is a search for a model that should support all forms of land rights, social tenure relations, and overlapping claims to land (Van Oosterom et al, 2005; Augustinus, 2006).

LADM class name	*STDM alias*
AdminSourceDocument	SocialTenureInventory
Building	*similar name*
BuildingUnit	Unit
Face	*similar name*
FaceString	*similar name*
GroupParty	*similar name*
LAUnit	*similar name*
Level	*similar name*
Mortgage	Collateral
Network	UtilityNetwork
Parcel	*similar name*
Party	*similar name*
PartyMember	*similar name*
Responsibility	*similar name*
Restriction	*similar name*
RequiredRelationship	*similar name*
Right	STDM_Relationship
RRR	SocialTenureRelationship
SourceDocument	*similar name*
SourcePoint	SurveyPoint
SpatialSourceDocument	SpatialUnitInventory
SpatialUnit	*similar name*
SpatialUnitSet	AdminSpatialUnit
SubParcel	*similar name*
VersionedObject	*similar name*

Table B1. LADM class names with their aliases in STDM

LADM originated from areas with formal cadastre and land registry systems. It should be observed that STDM contains the functionality of LADM, but under different terminology. Formal terminology as used in LADM may not always be applicable because of the informal environment. In STDM the same classes as in LADM are used, but sometimes under different terminology: e.g. class RRR is named class SocialTenureRelationship (see Table B1).

Annex C. Instance level cases (informative)

Note that the content of this Annex is based on:

ISO 19109, *Geographic Information – Rules for Application Schemas*

ISO 19110, *Geographic Information – Methodology for Feature Cataloguing*

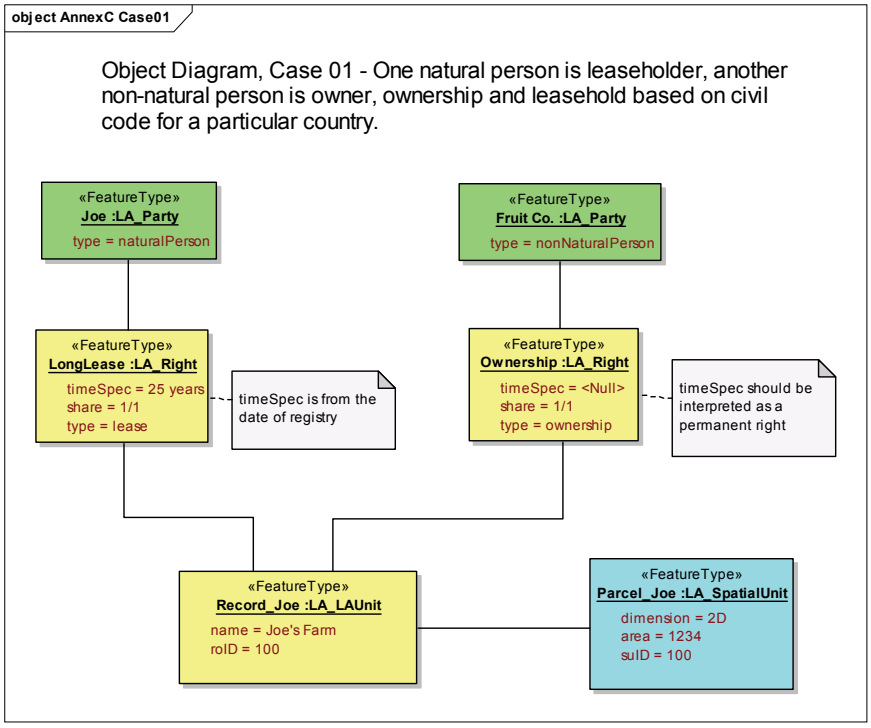
ISO 19126, *Geographic Information – Feature Concept Dictionaries and Registers*

ISO 19131, *Geographic Information – Data Product Specification*

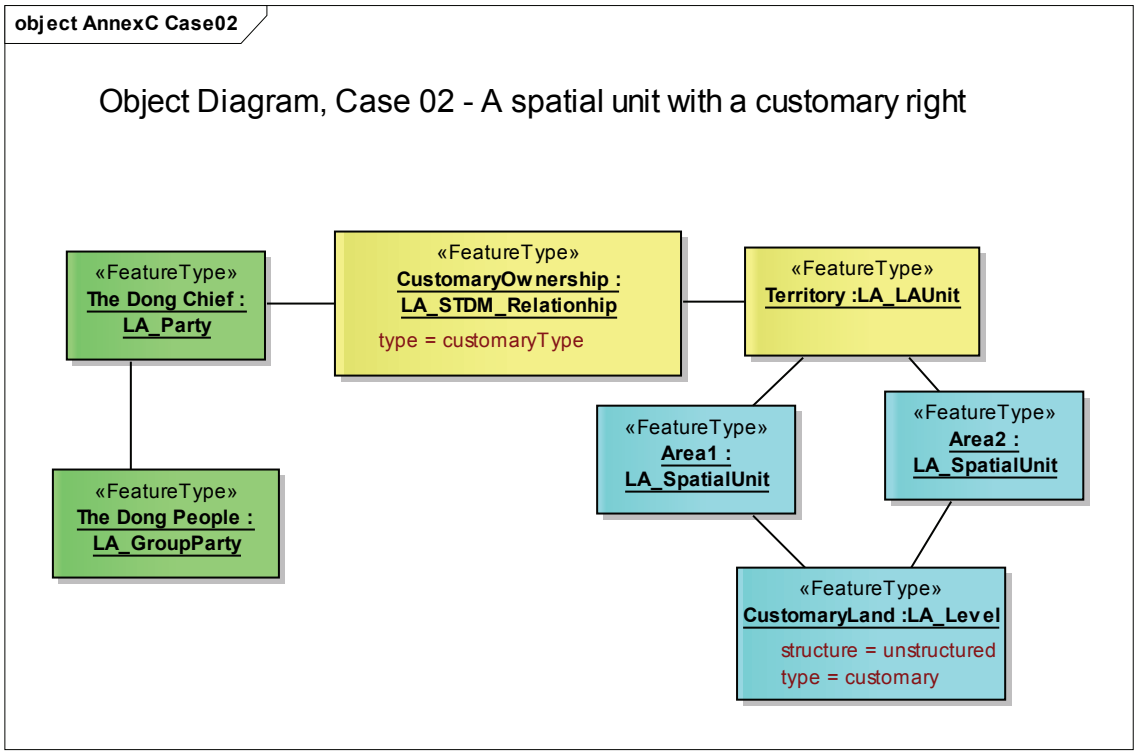
The examples are partly based on the terminology of STDM (Annex B) to illustrate the context of STDM.

1. A natural person is leaseholder, and a non-natural person is owner; ownership and leasehold based on civil code for a particular country (Case C1).
2. A spatial unit with a customary right (Case C2).
3. A serving parcel provides access to four parcels, and the serving parcel is not public, but commonbly owned by four neighbouring parcels (Case C3) .
4. A serving parcel provides access to four parcels, and the serving parcel is not public, but owned by a fifth party. The four neighbouring parcels have right-of-way (Case C4).
5. A group party holds a ownership right on a parcel (Case C5).
6. A building contains individual units (apartments), and a shared unit, with a common threshold (entrance) on ground level (Case C6).
7. A 3D volume spatial unit with one owner (Case C7).
8. A timeshare ownership for the month of February (Case C8).
9. A restriction not to change a building because of its monumental status (Case C9).
10. Mortgage on ownership, bank included as party (Case C10).
11. Mortgage on usufruct of ownership, money provider included as party (Case C11).
12. Informal right by a party (natural person) on a text spatial unit (Case C12).
13. Informal right by a group party on a point spatial unit (Case C13).
14. A conflicting claim on a spatial unit (Case C15).
15. A utility network with one owner and a mortgage (bank included as party) (Case C16).
16. A group party (pastoralists) with an access right for a certain period of time (Case C17).
17. A farmer owning several spatial units in rural area; example Finland (Case C19).
18. Value as basis for taxation valid for five years (Case C20).
19. A milk right to a spatial unit (Case 21).
20. A responsibility to clean the ditches (Case C22).
21. A right to use a road on a property of somebody else (Case C23).
22. A restriction area ("it is not allowed to built within 200 meters of a fuel station") with its own geometry (Case C24).
23. Spatial unit complex with one owner (Case C25).
24. Spatial unit complex with building, one owner (Case 26).

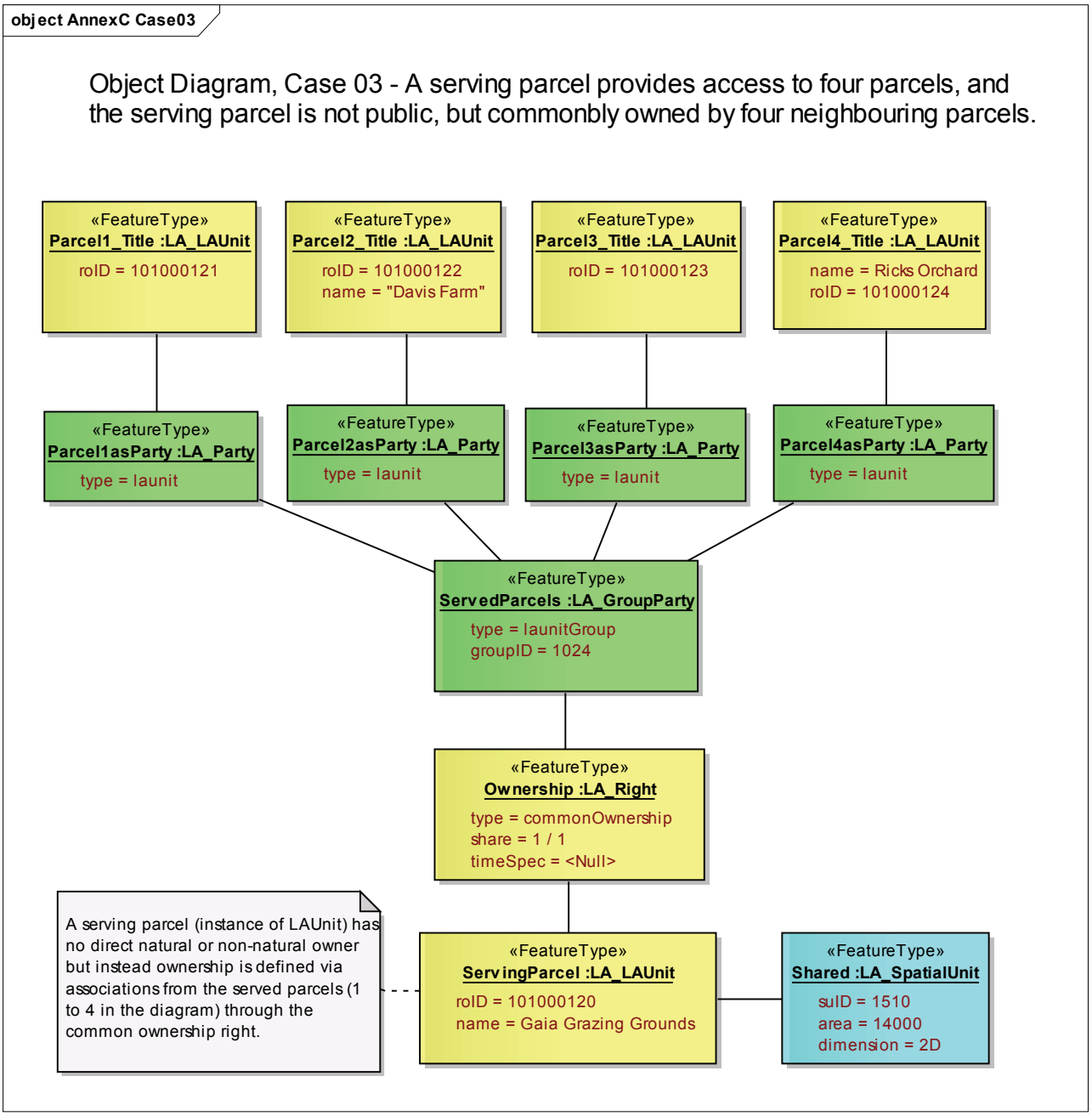
25. Complex of parcels with two owners (Case C27).
26. Spatial unit with micro credit (Case C29).
27. Tax valuations on condominium rights in Spain (Case C30A).
28. A spatial unit with one owner, with a building from a different owner (Case C30B).
29. Marriage and inheritance relationships to property (simple) in Spain (Case C31).
30. Marriage and inheritance relationships to property (complex) in Spain (Case C32).
31. Spanish 'real estate' form of property (Case C33).
32. Norwegian categories of basic properties (Case C34a and Case C34b).
33. Individual and joint property rights in Spain (Case C35).



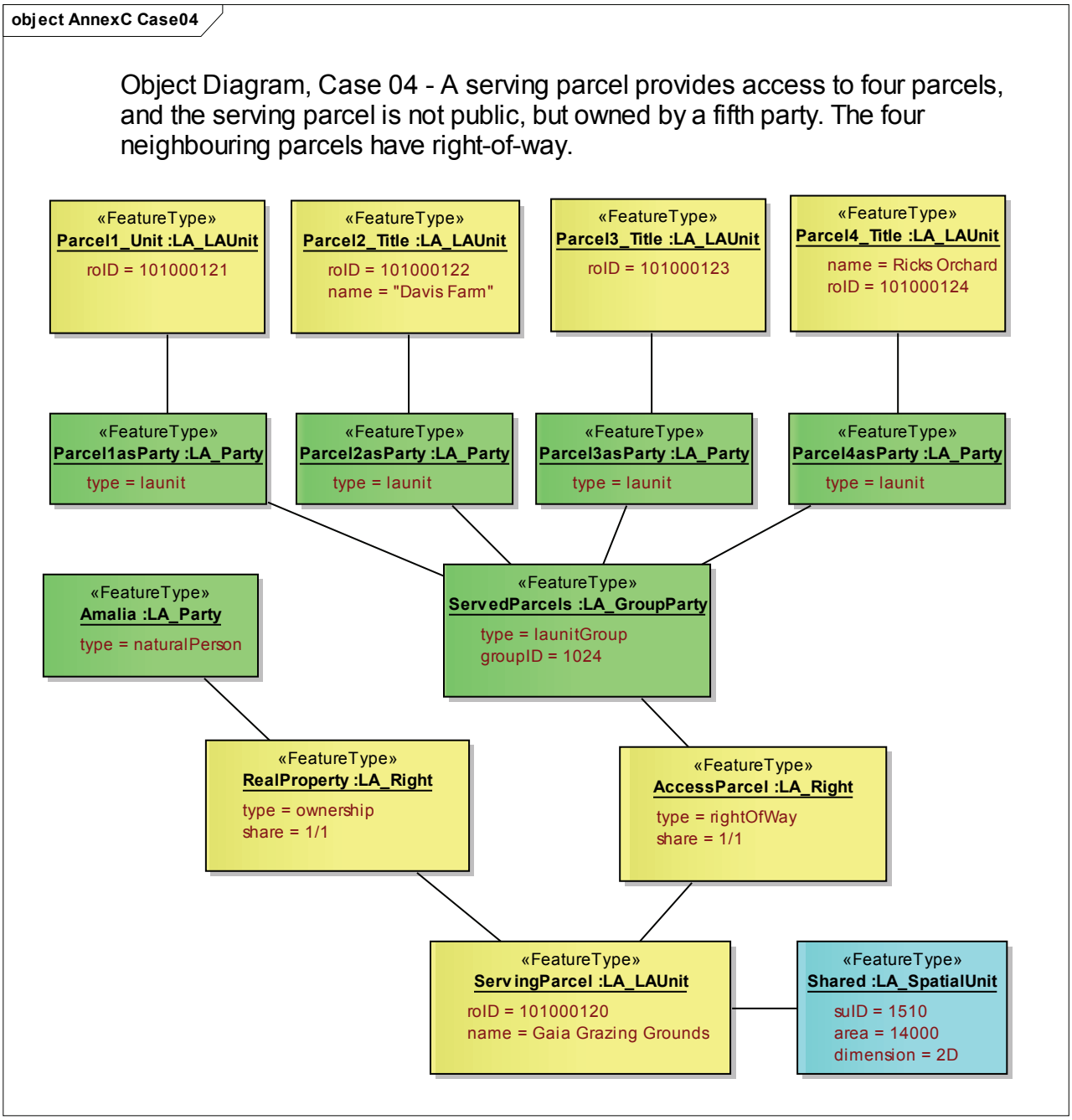
Case C1. A natural person is leaseholder, and a non-natural person is owner; ownership and leasehold based on civil code for a particular country



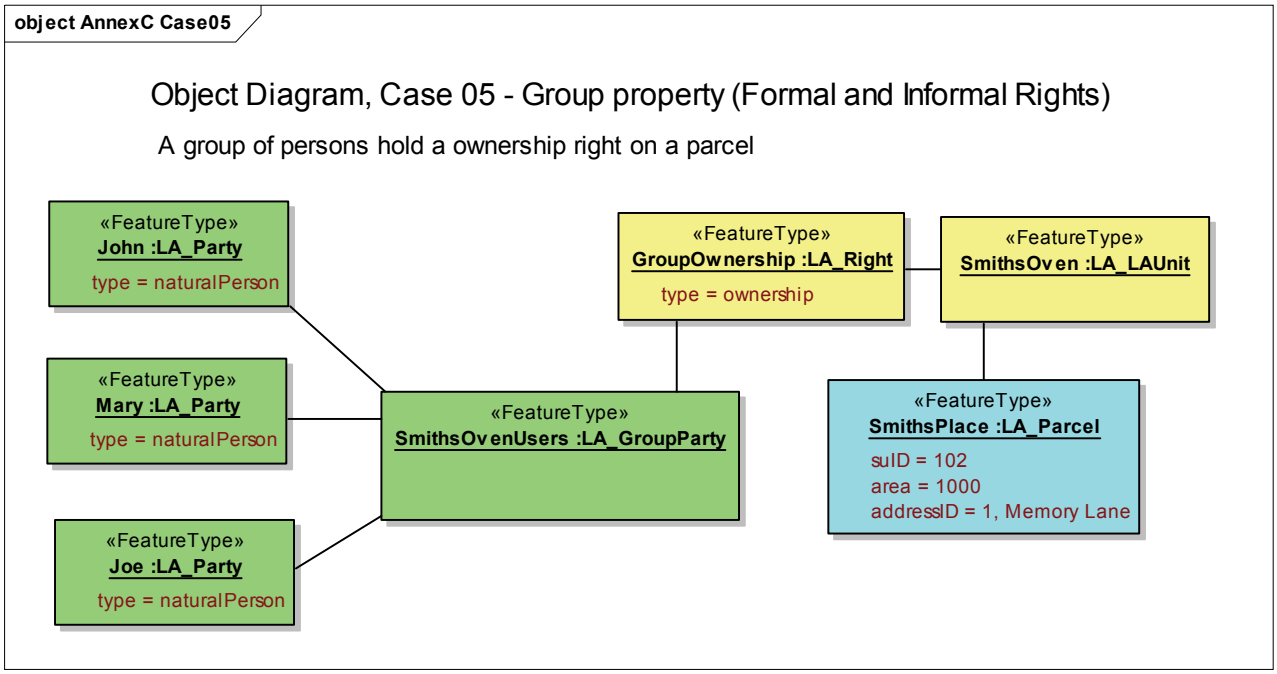
Case C2. A spatial unit with a customary right



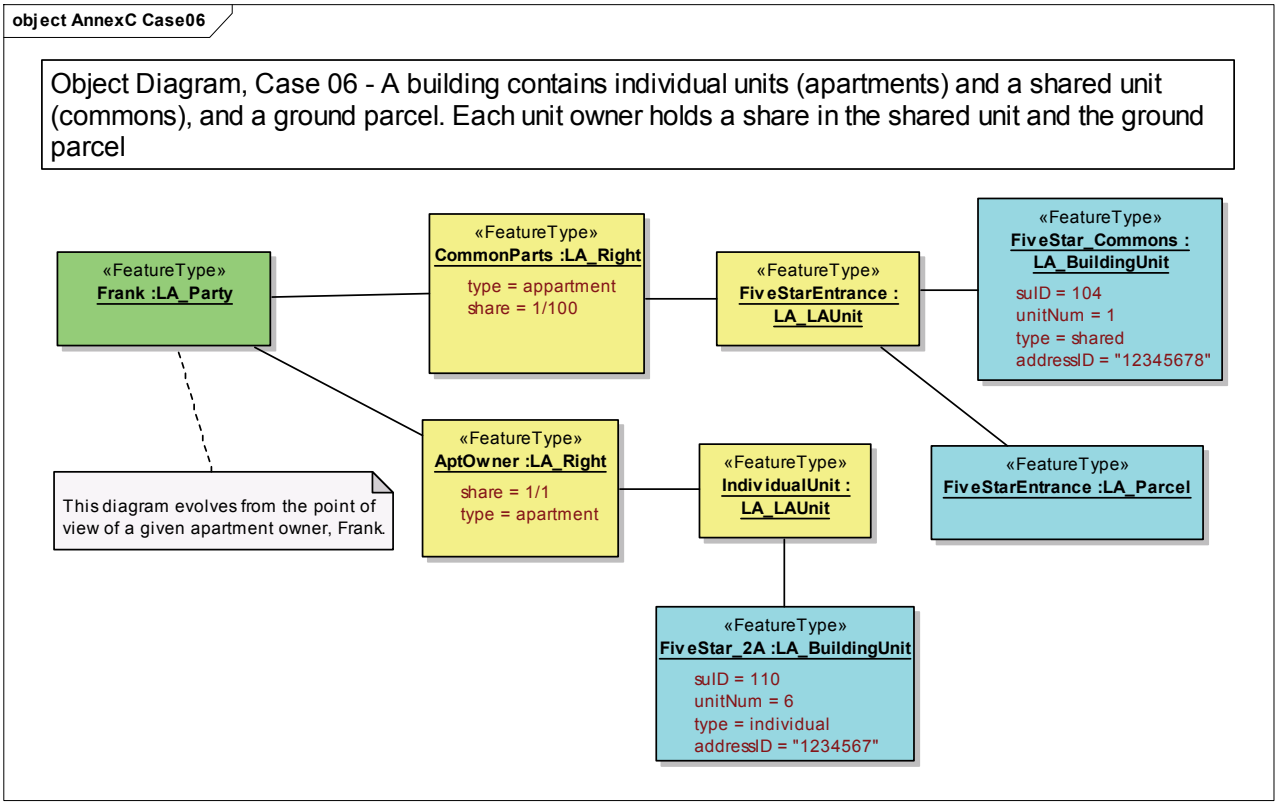
Case C3. A serving parcel provides access to four parcels, and the serving parcel is not public, but commonly owned by four neighbouring parcels



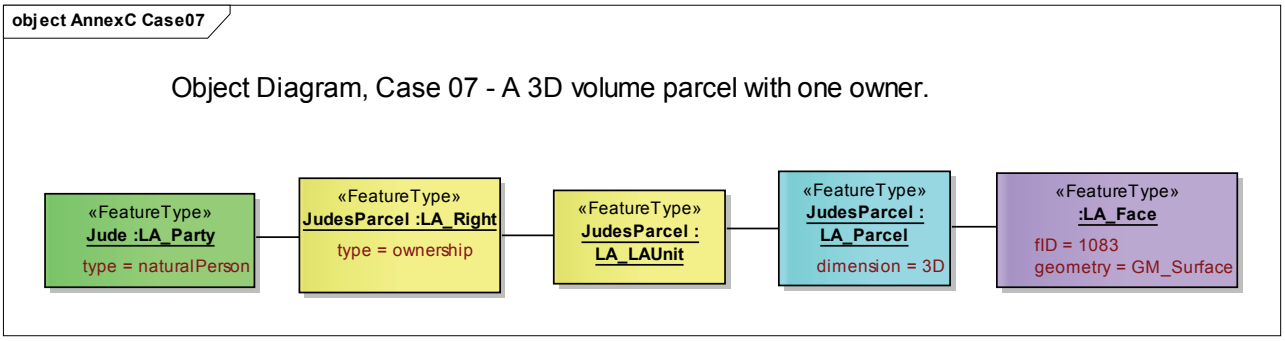
Case C4. A serving parcel provides access to four parcels, and the serving parcel is not public, but owned by a fifth party. The four neighbouring parcels have right-of-way



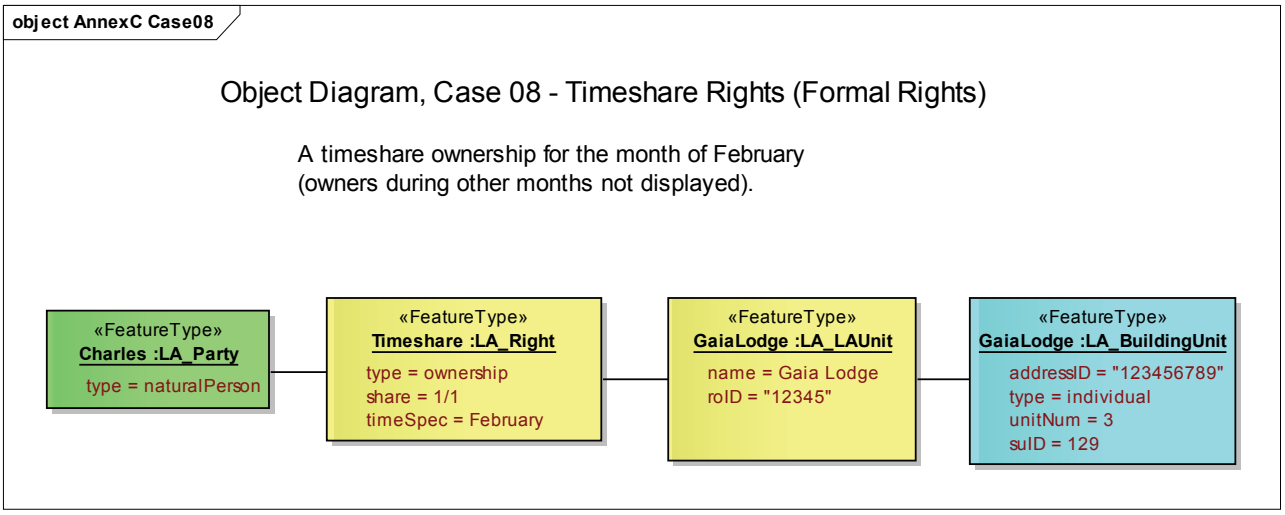
Case C5. A group party holds a ownership right on a parcel



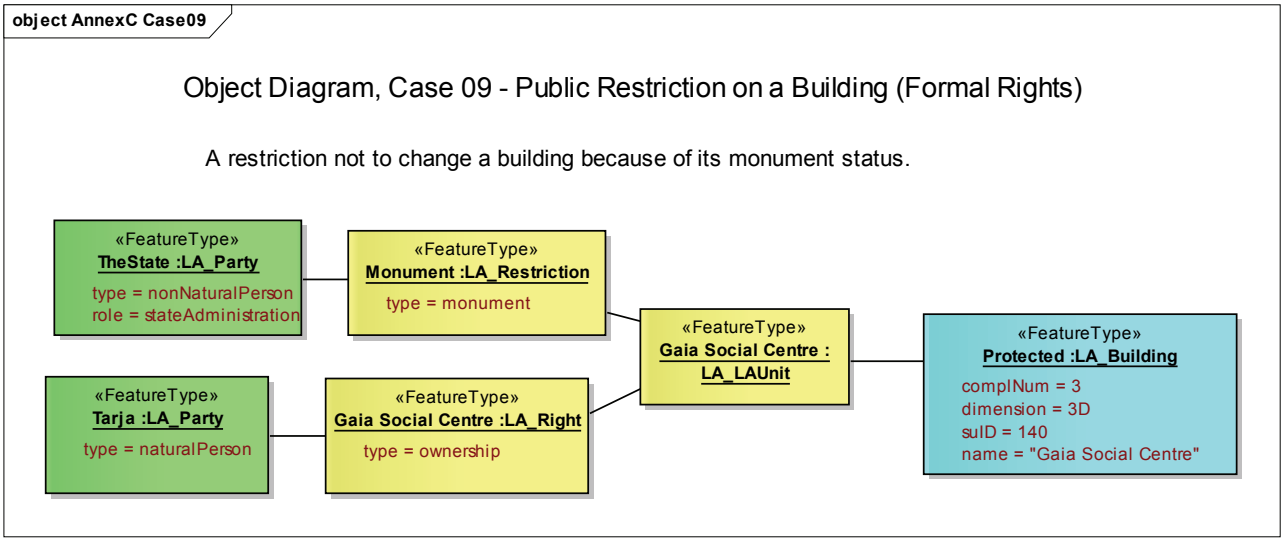
Case C6. A building contains individual units (apartments), and a shared unit, with a common threshold (entrance) on ground level



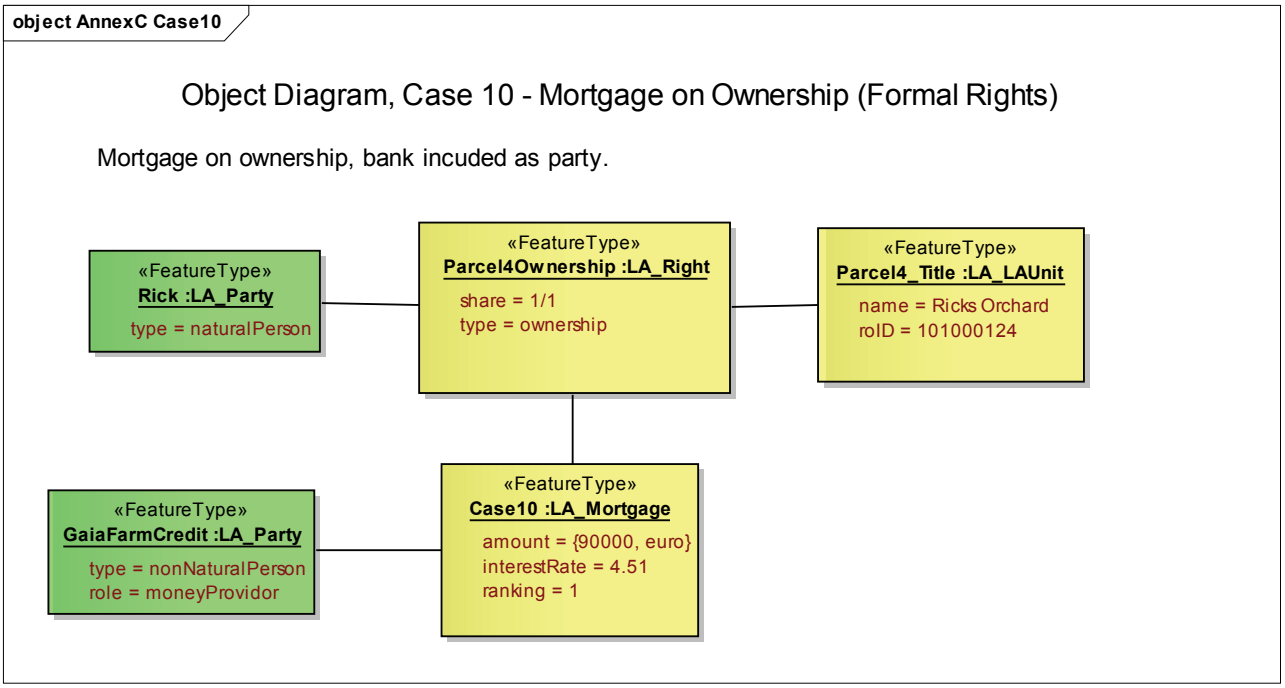
Case C7. A 3D volume spatial unit with one owner



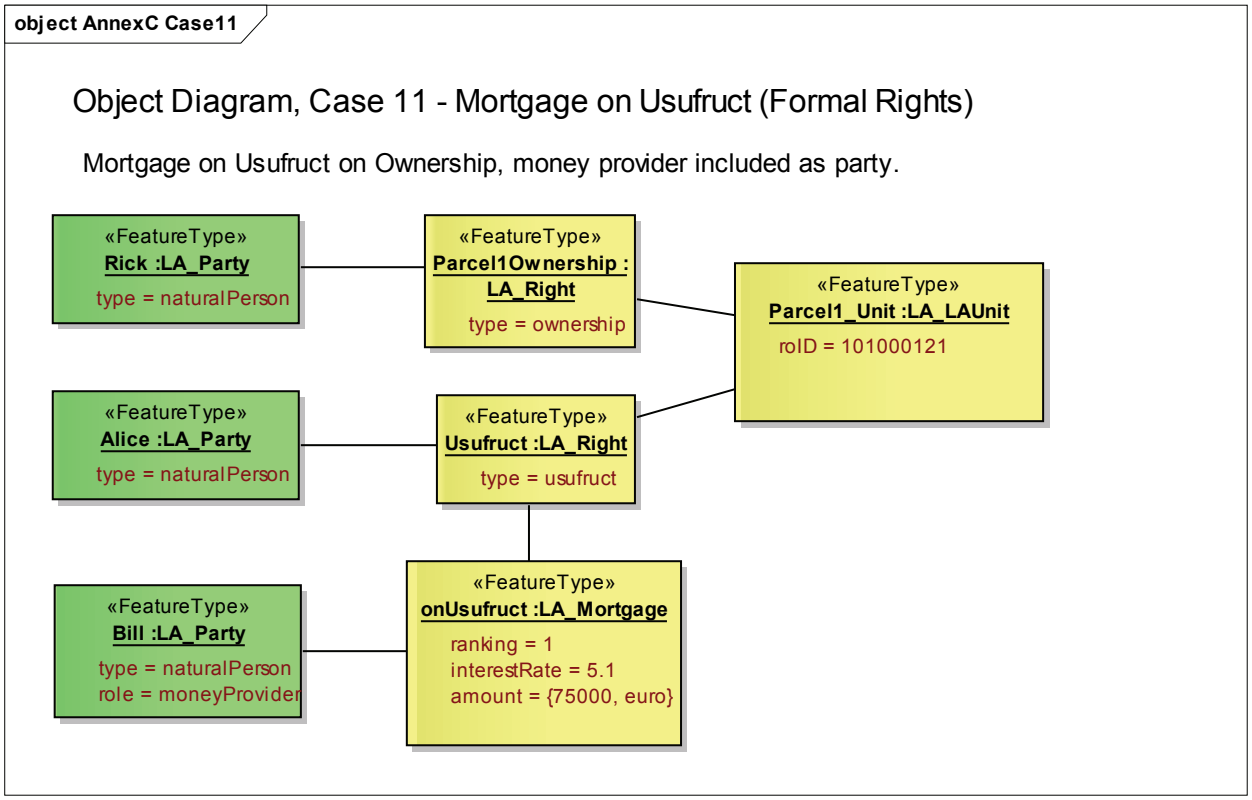
Case C8. A timeshare ownership for the month of February



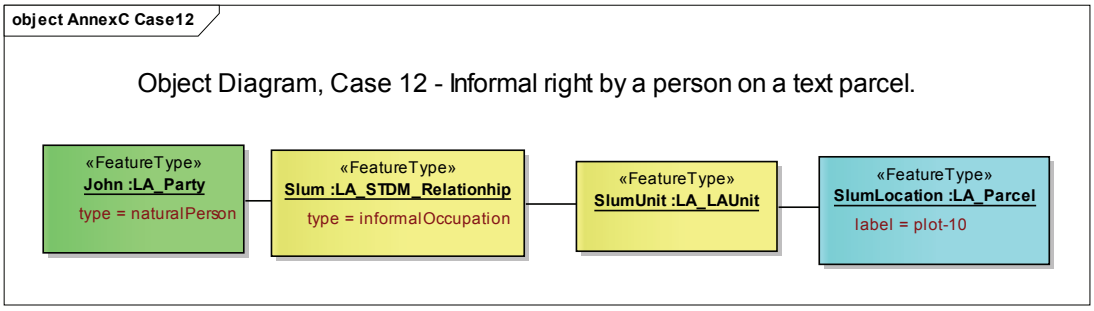
Case C9. A restriction not to change a building because of its monumental status



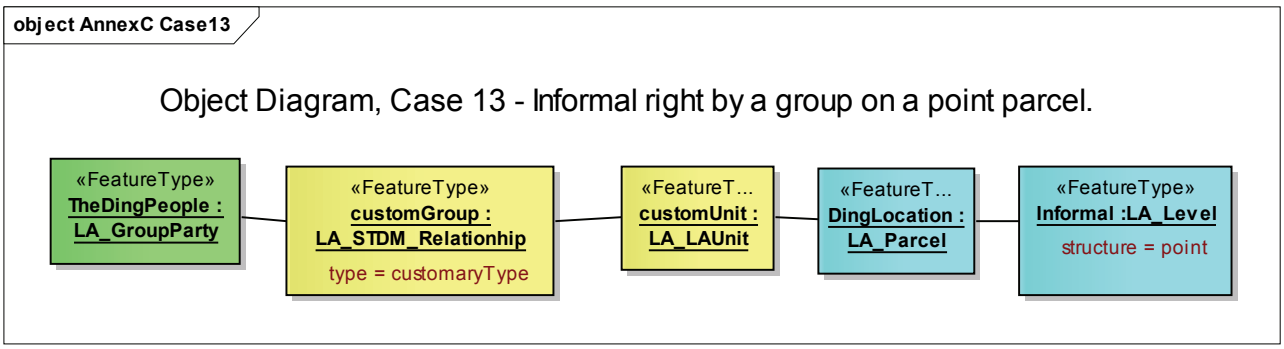
Case C10. Mortgage on ownership, bank included as party



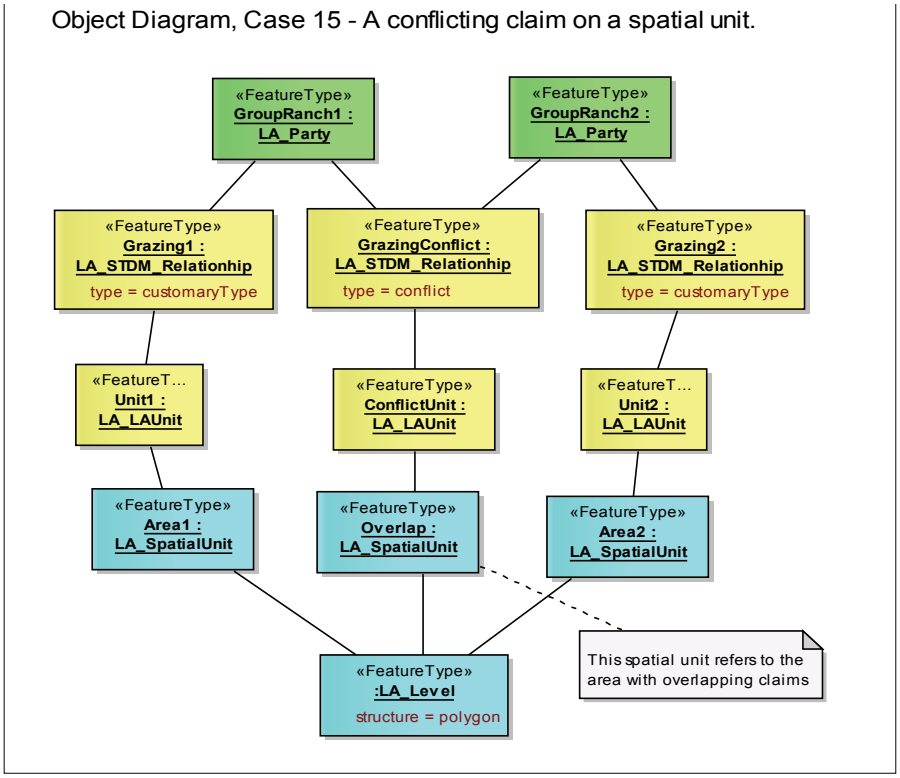
Case C11. Mortgage on usufruct of ownership, money provider included as party



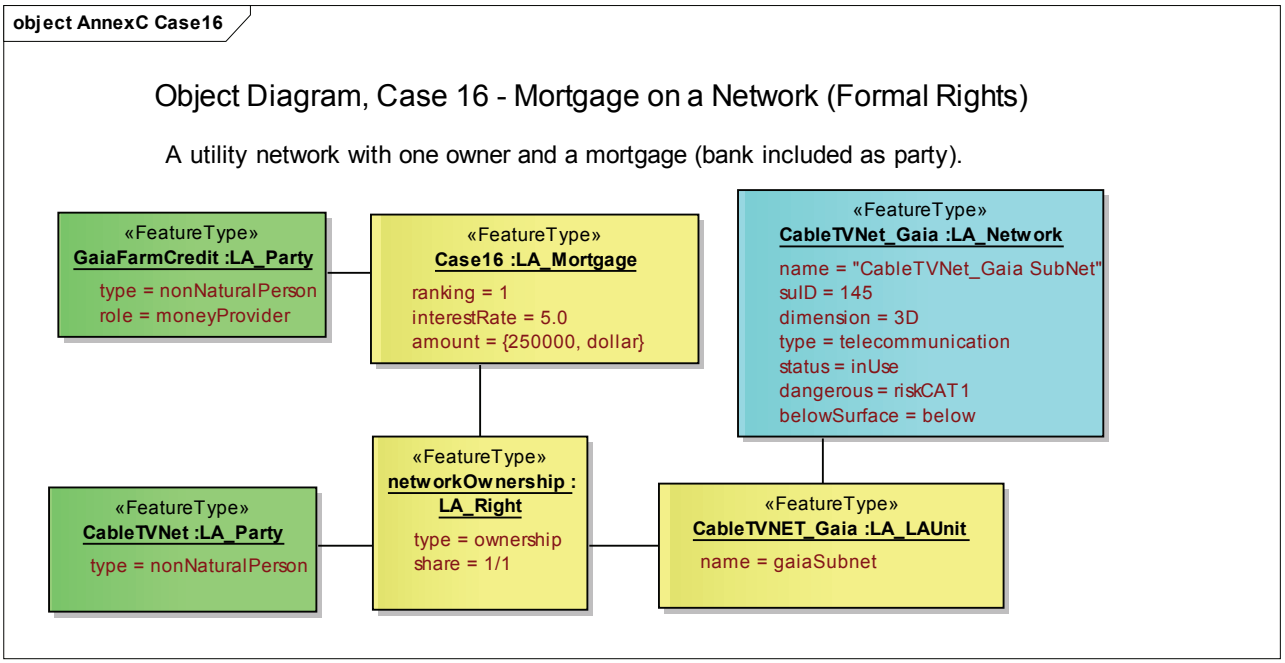
Case C12. Informal right by a party (natural person) on a text spatial unit



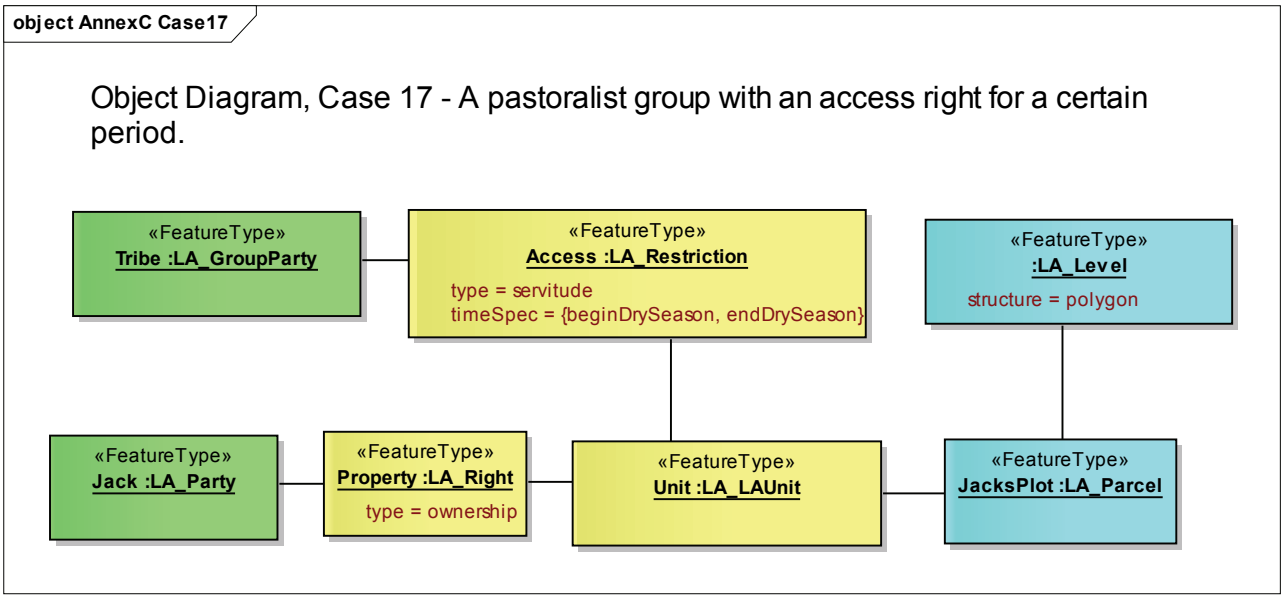
Case C13. Informal right by a group party on a point spatial unit



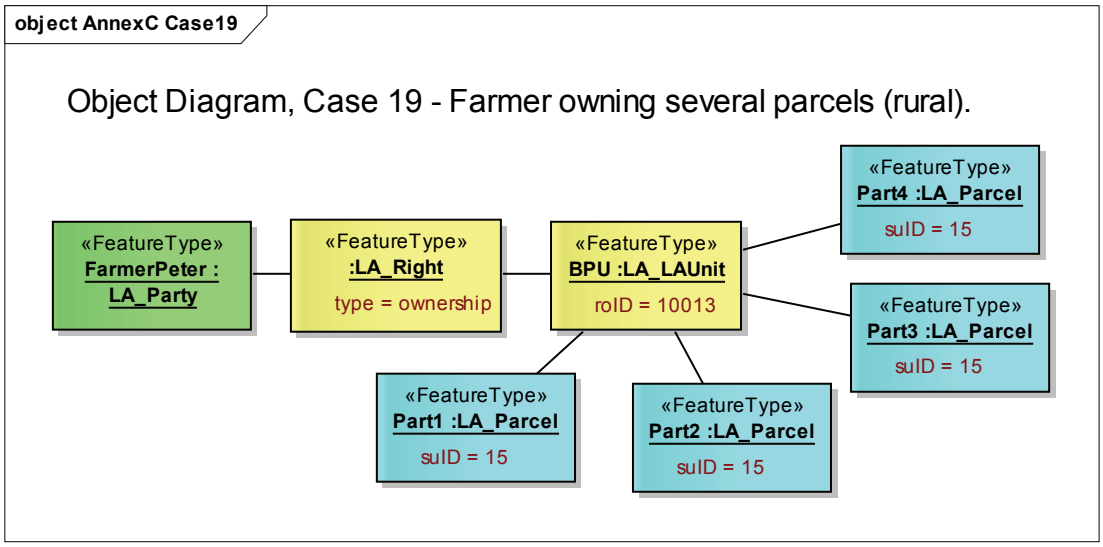
Case C15. A conflicting claim on a spatial unit



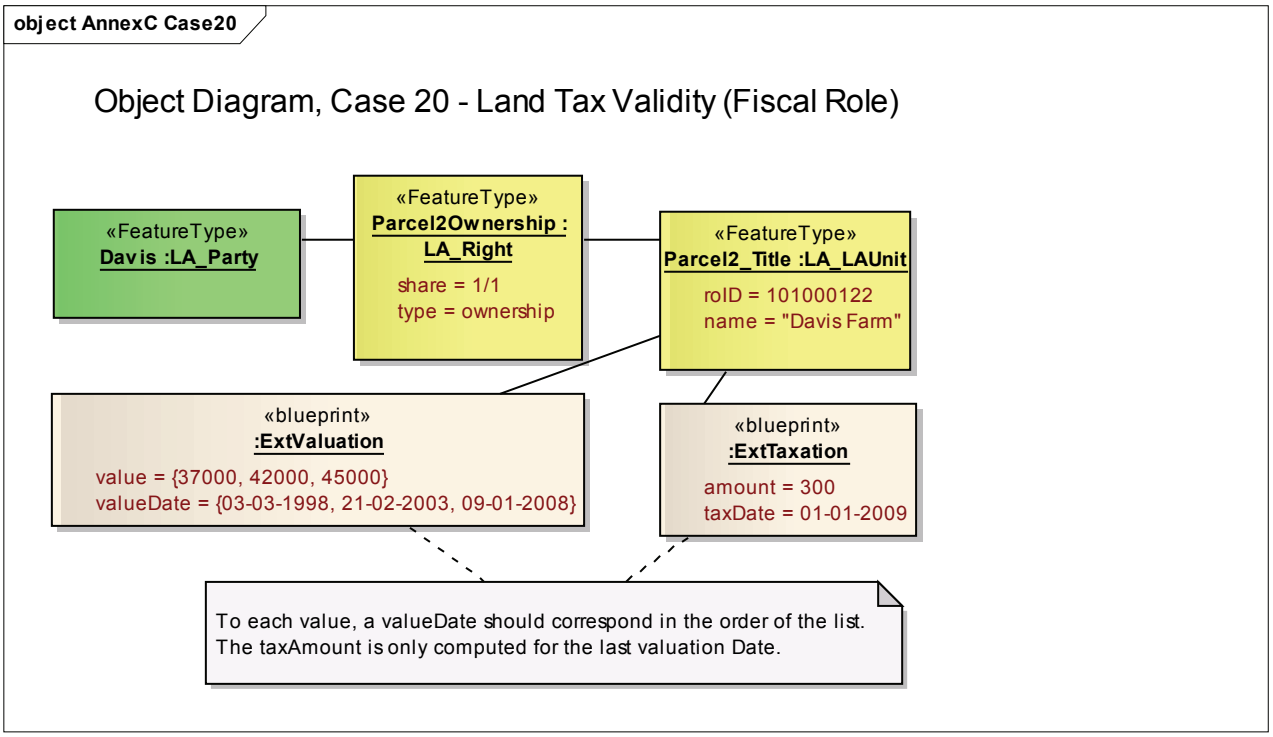
Case C16. A network with one owner and a mortgage (bank included as party)



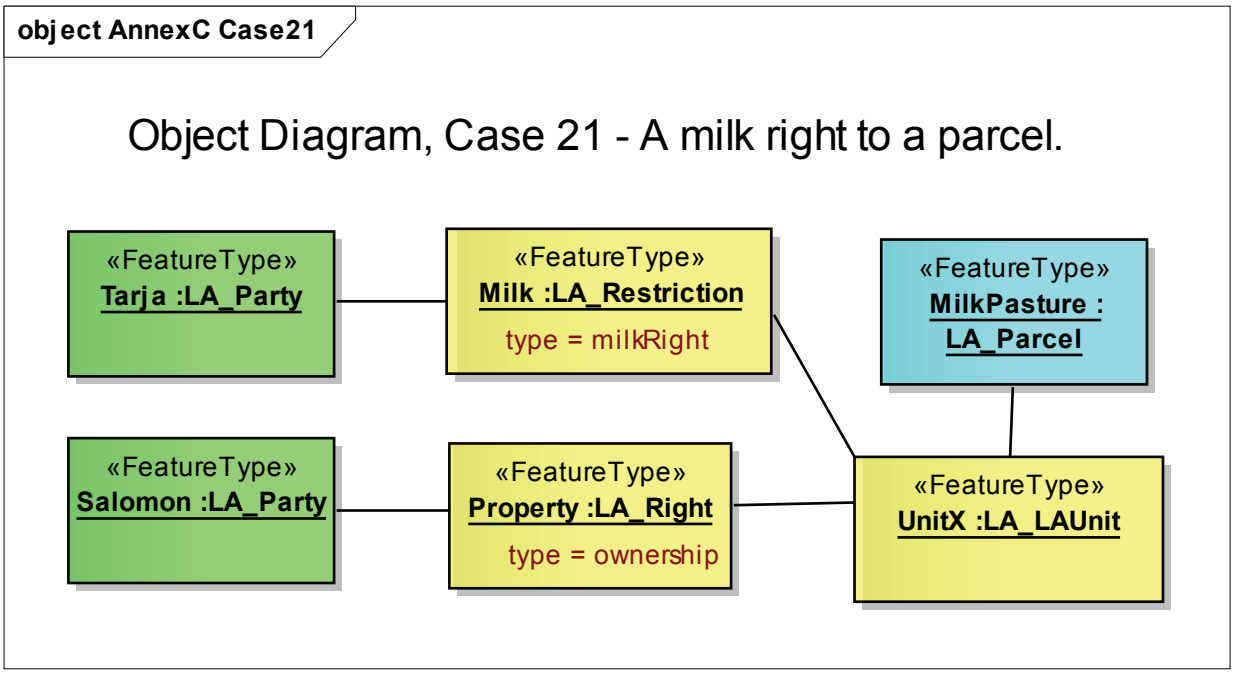
Case C17. A group party (pastoralists) with an access right for a certain period of time



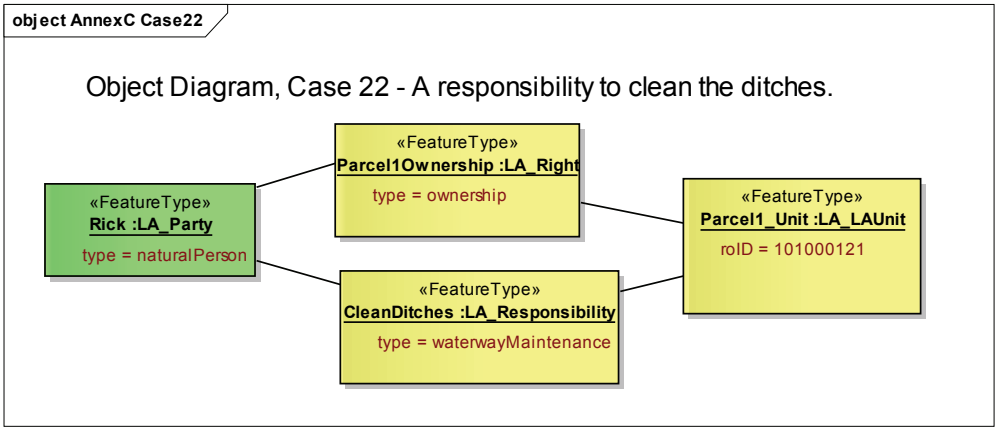
Case C19. A farmer owning several spatial units in rural area; basic property unit = 15; example from Finland



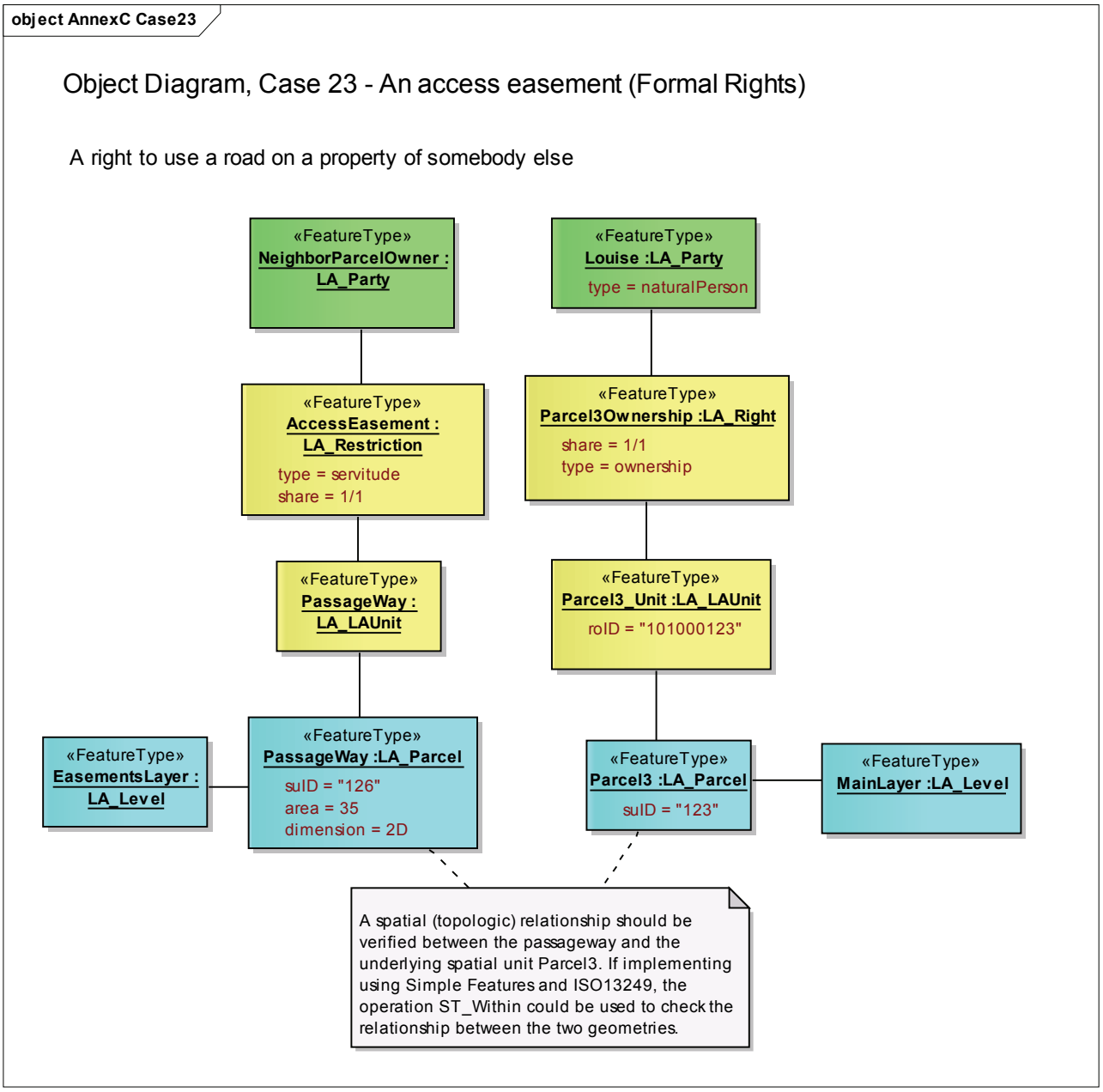
Case C20. Value as basis for taxation valid for five years



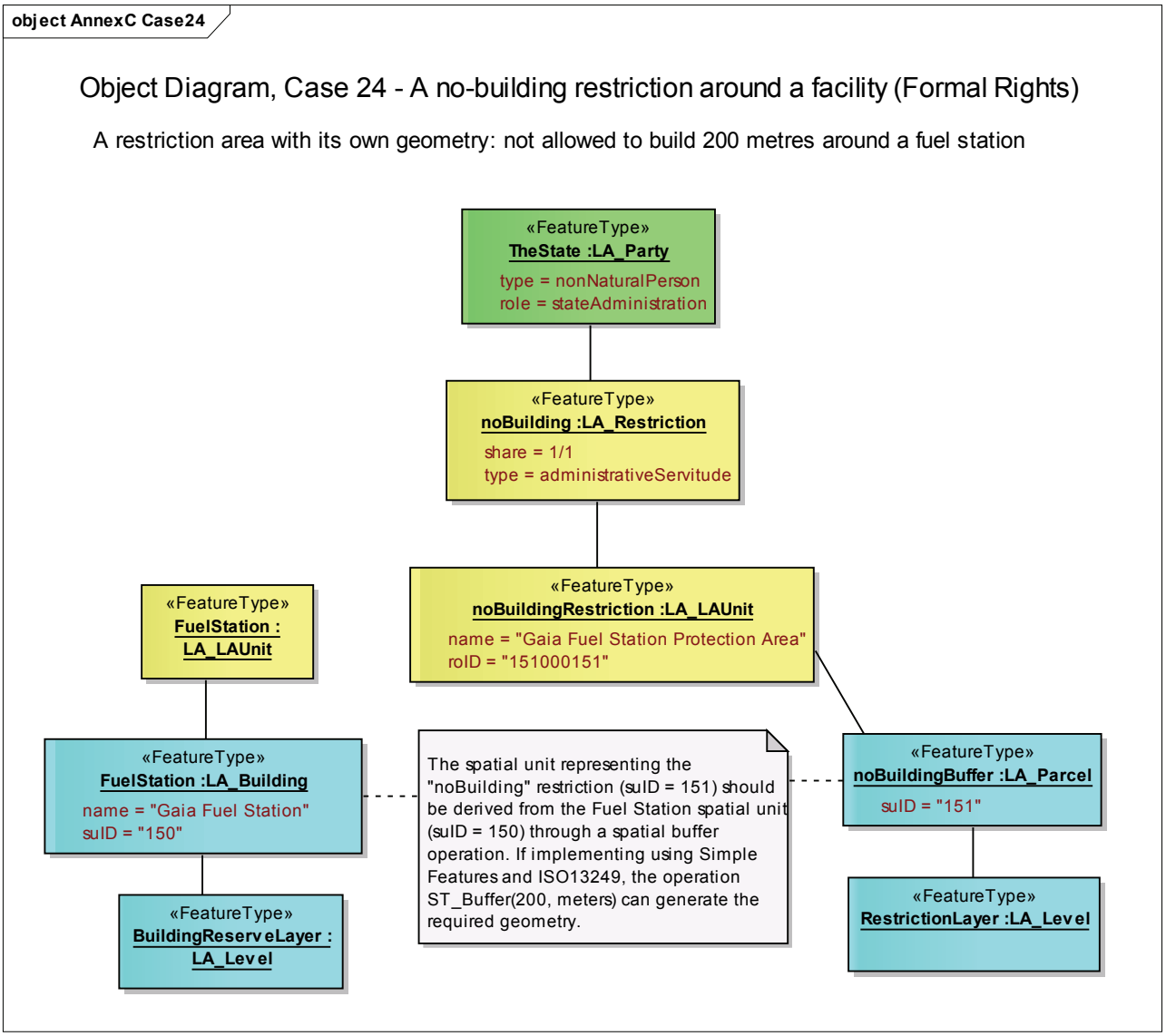
Case C21. A milk right to a spatial unit



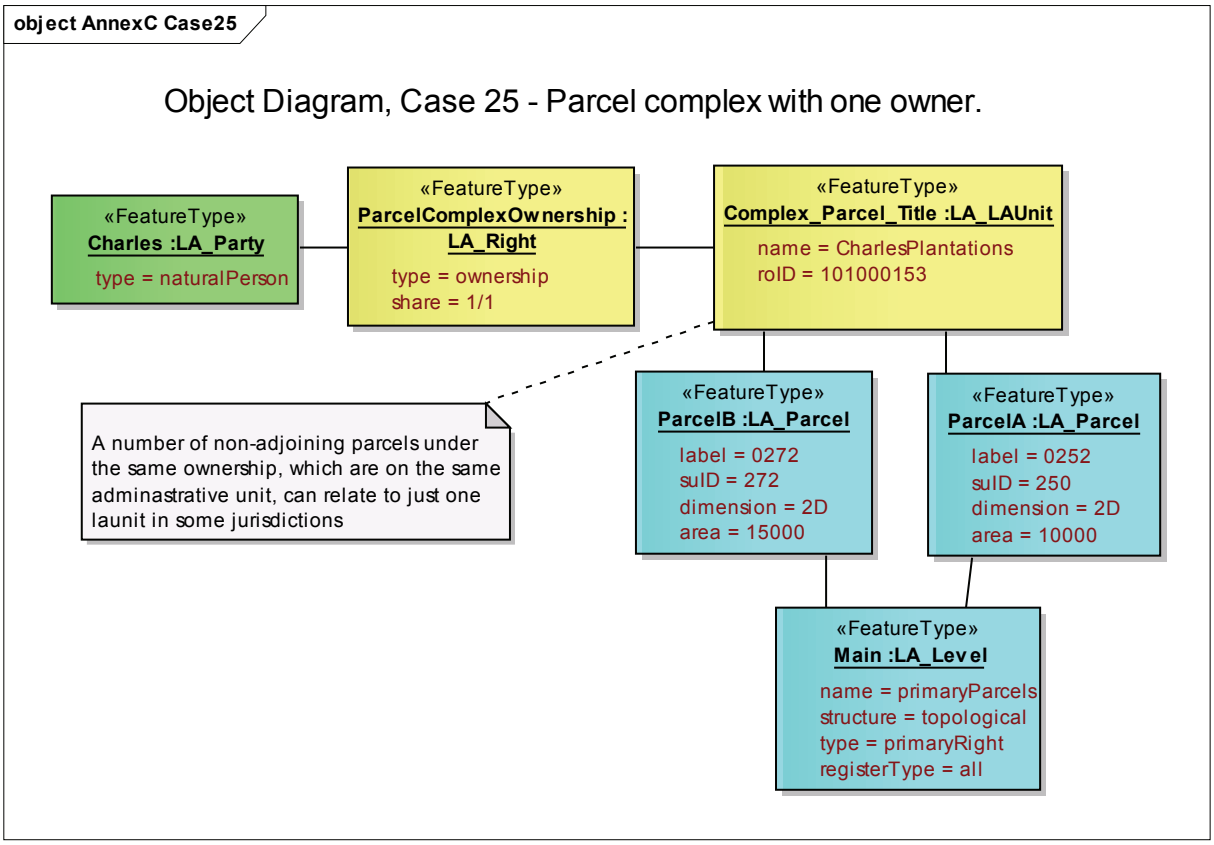
Case C22. A responsibility to clean the ditches)



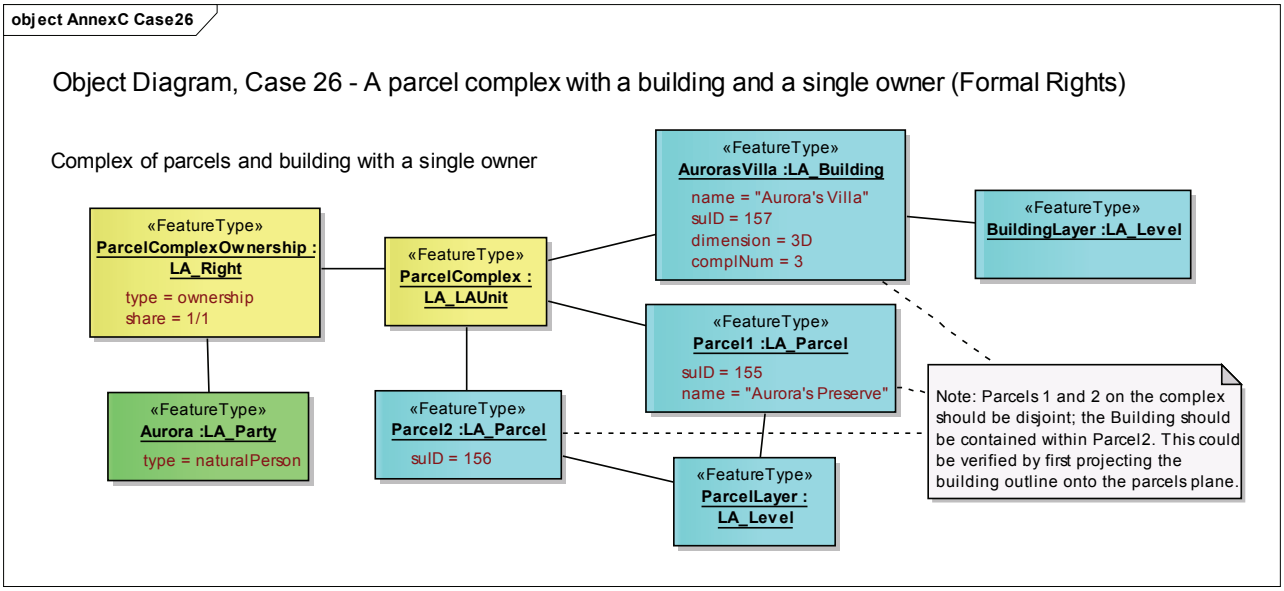
Case C23. A right to use a road on a property of somebody else



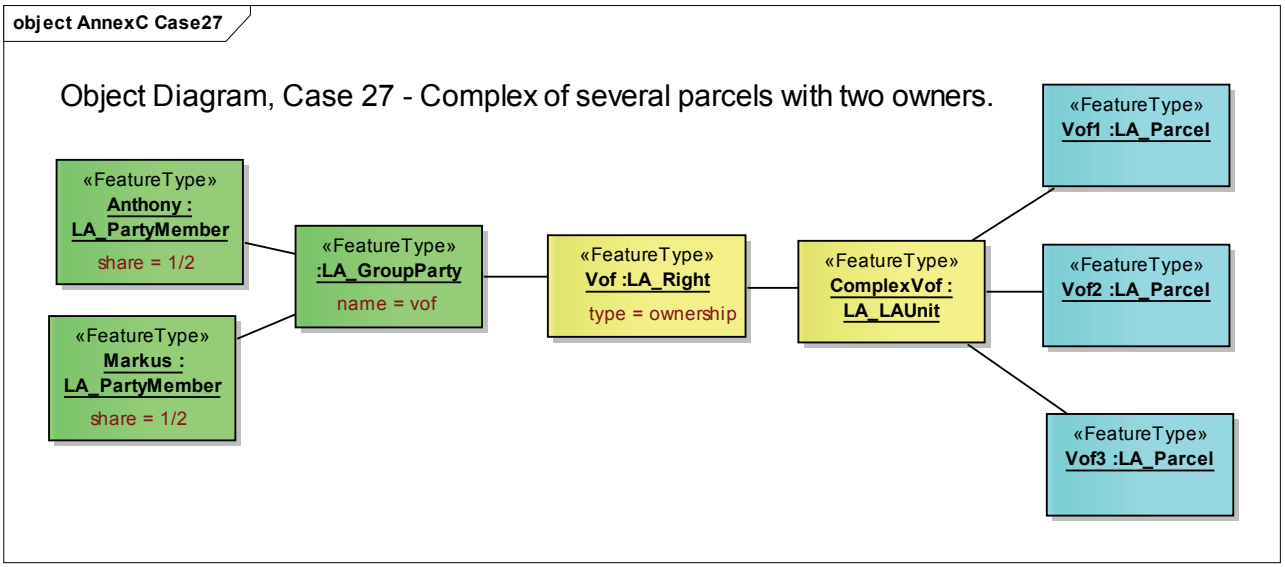
Case C24. A restriction area ("it is not allowed to built within 200 meters of a fuel station") with its own geometry



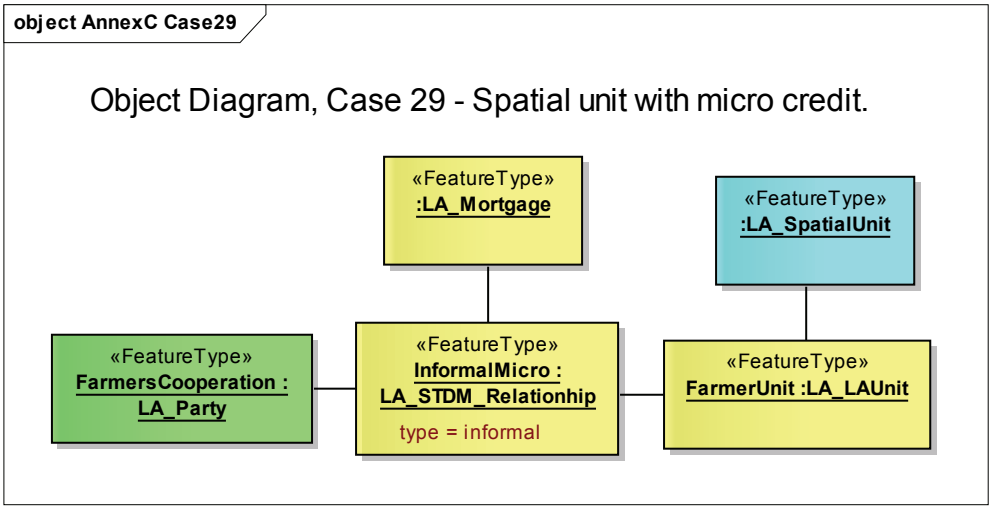
Case C25. Spatial unit complex with one owner



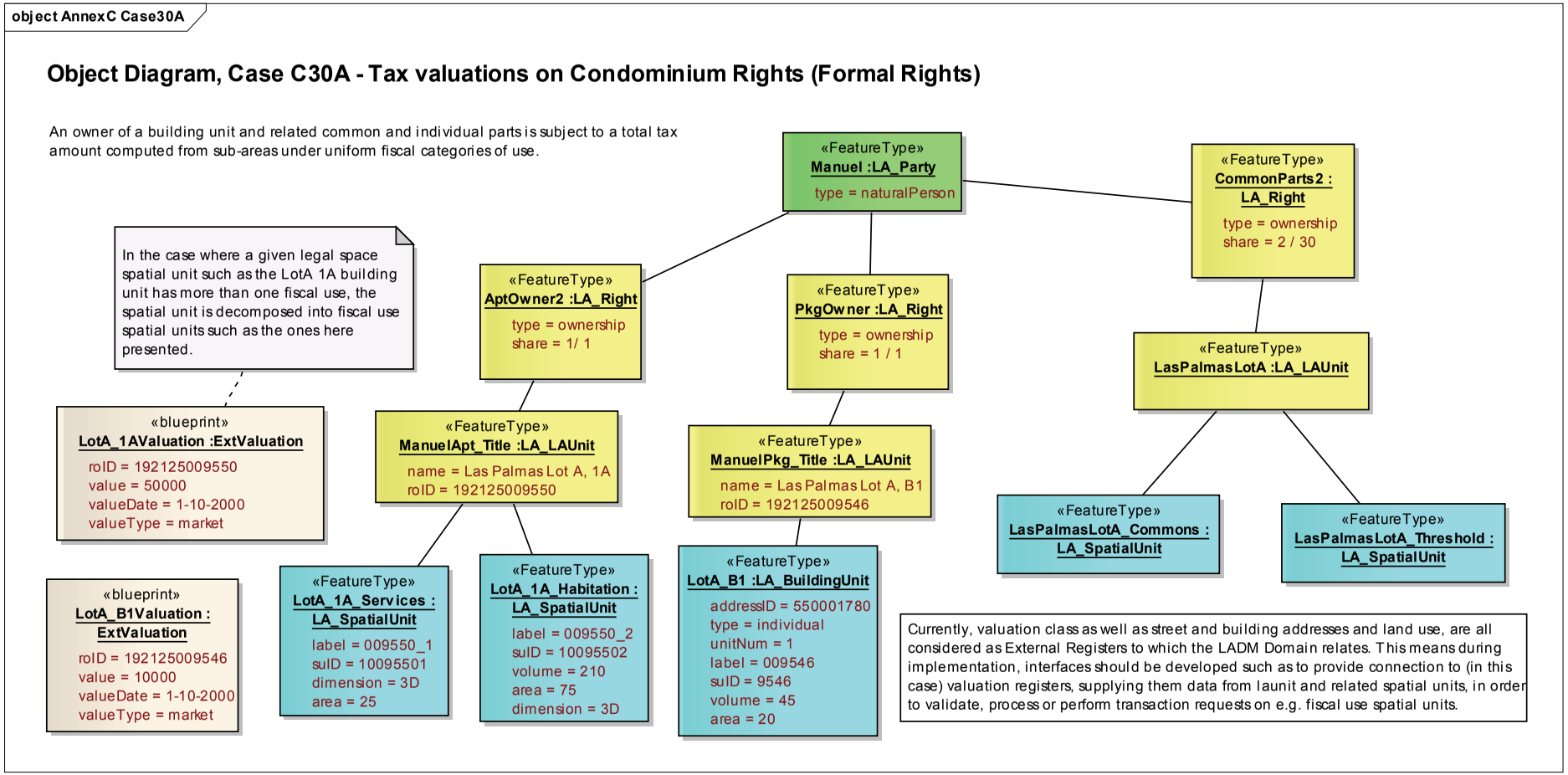
Case C26. Spatial unit complex with building, one owner



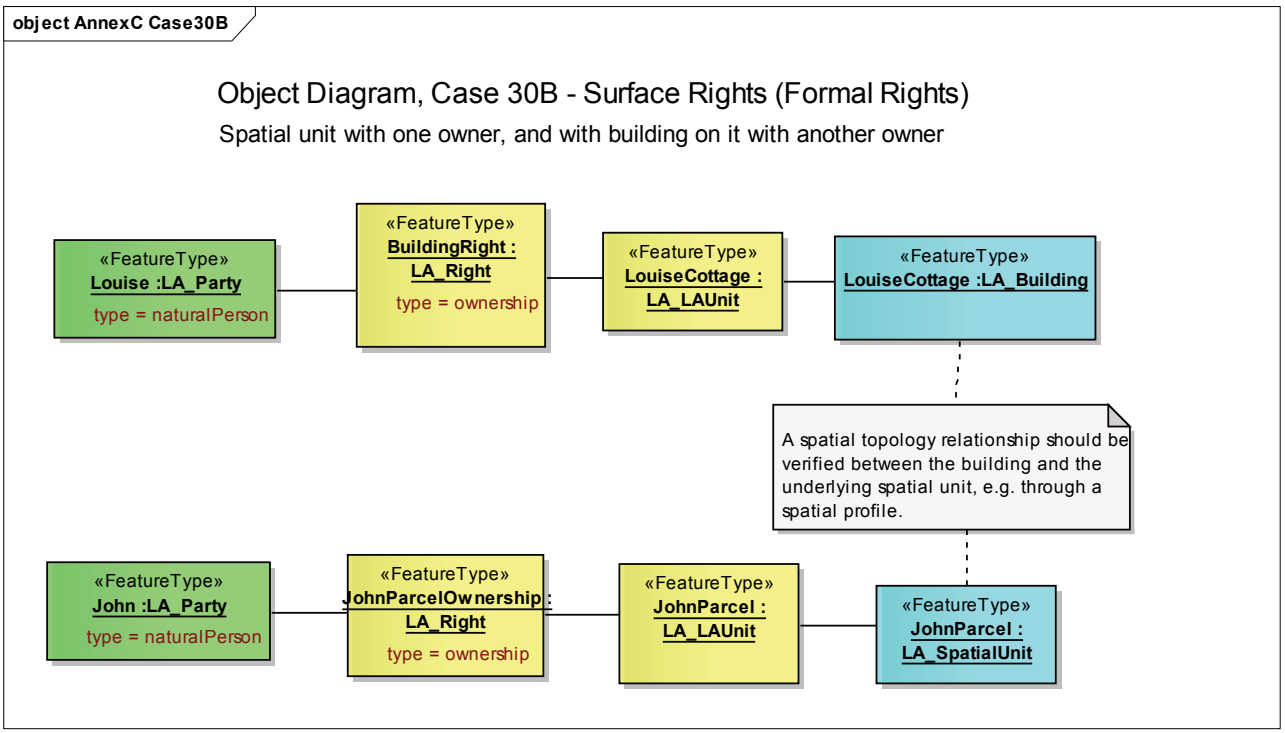
Case C27. Complex of parcels with two owners



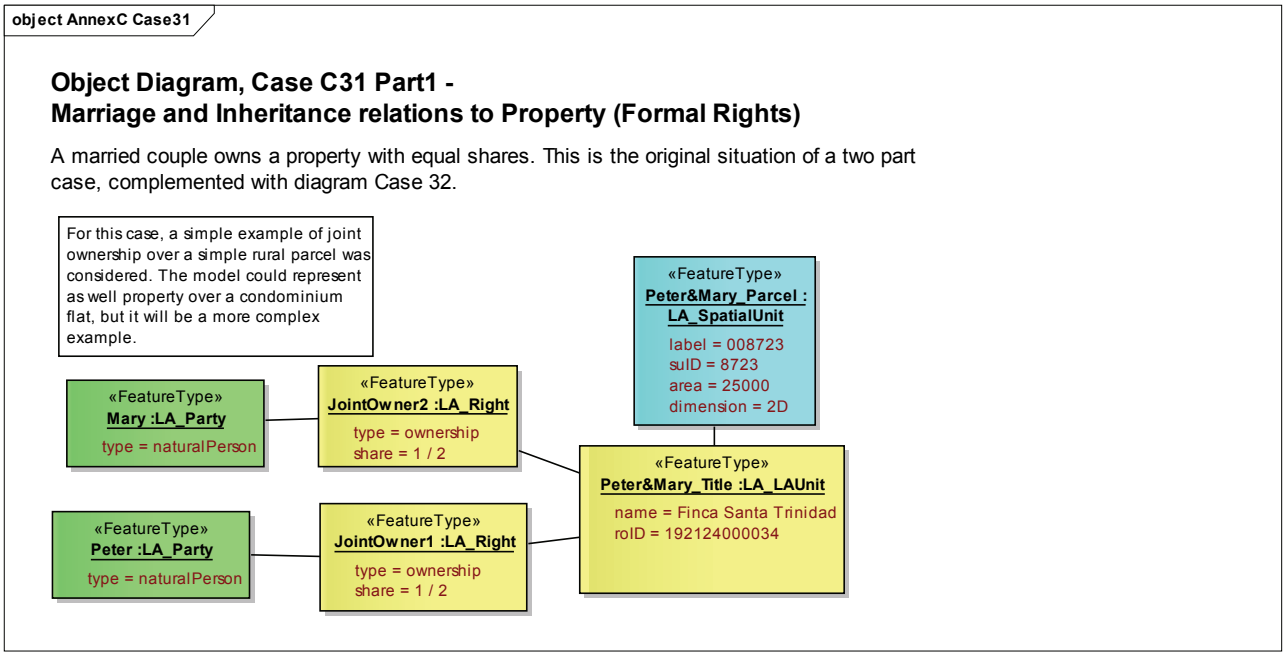
Case C29. Spatial unit with micro credit



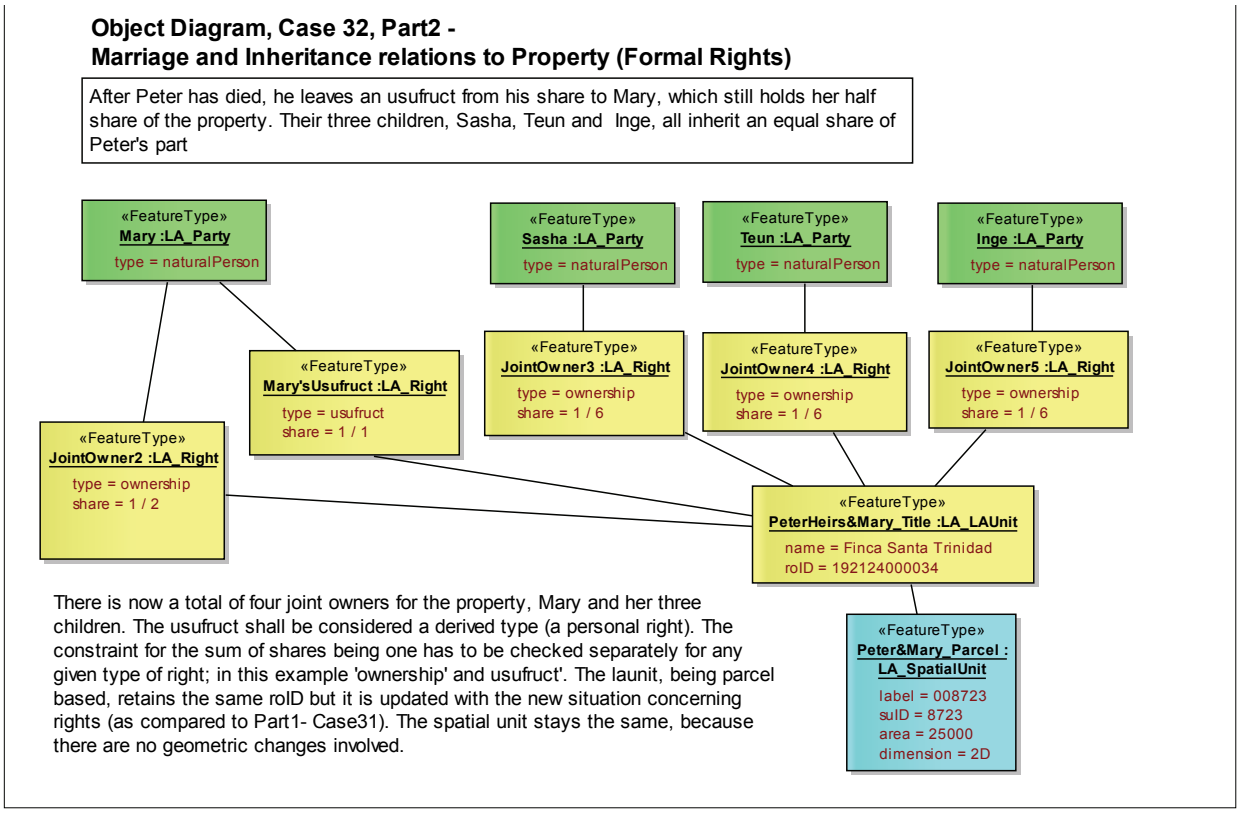
Case C30A. Tax valuations on condominium rights in Spain



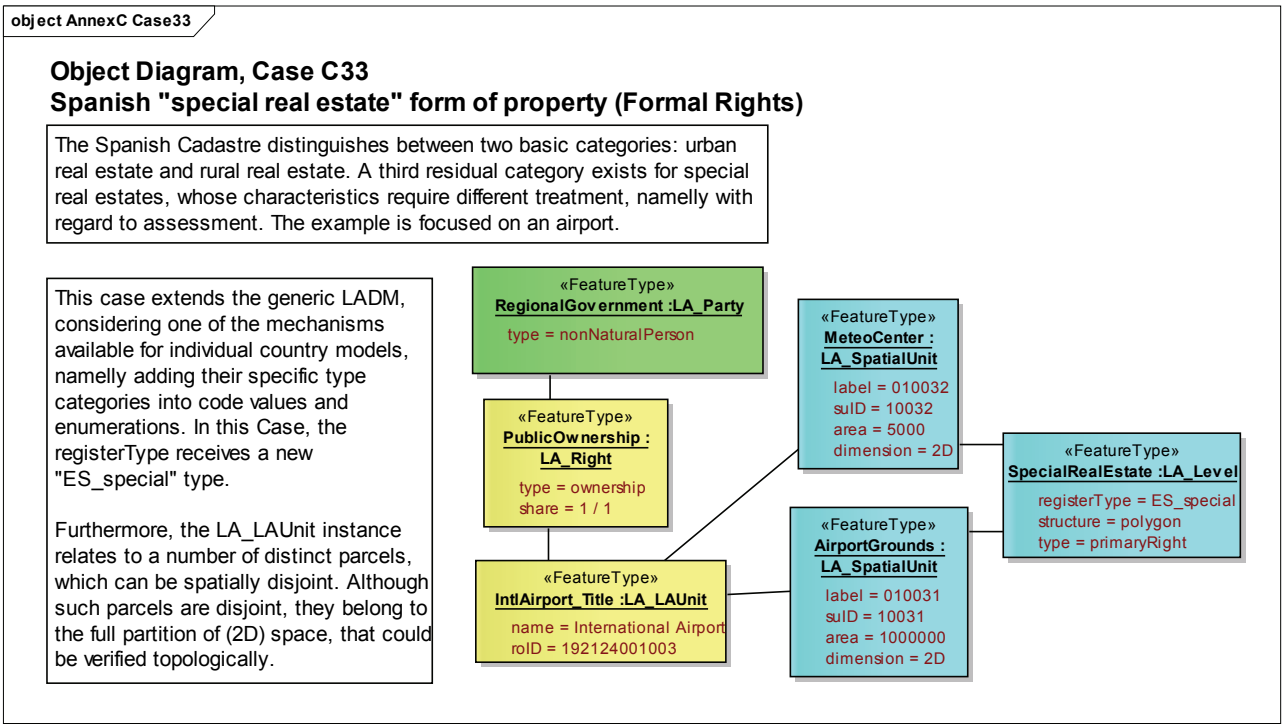
Case C30B. A spatial unit with one owner, with a building from a different owner



Case C31. Marriage and inheritance relationships to property (simple) in Spain



Case C32. Marriage and inheritance relationships to property (complex) in Spain

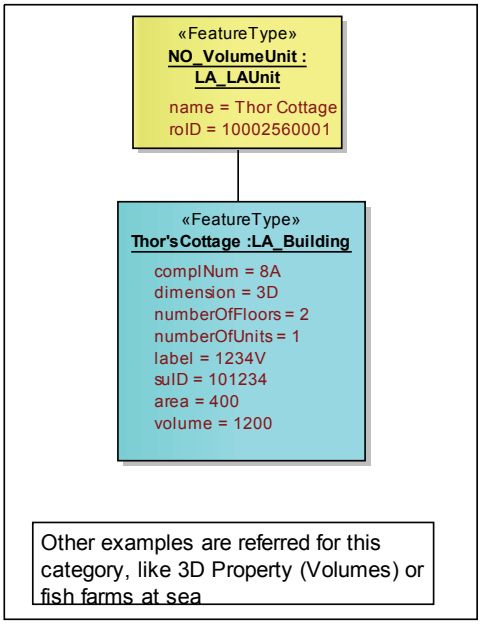


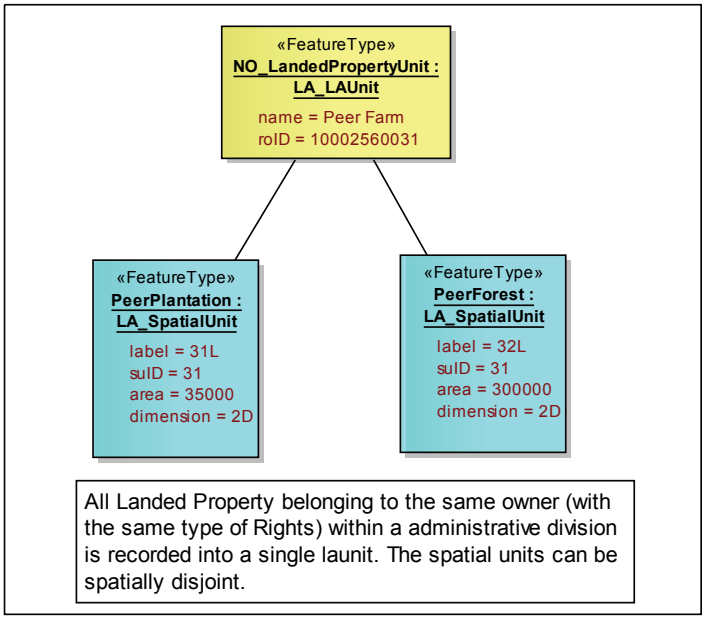
Case C33. Spanish 'real estate' form of property

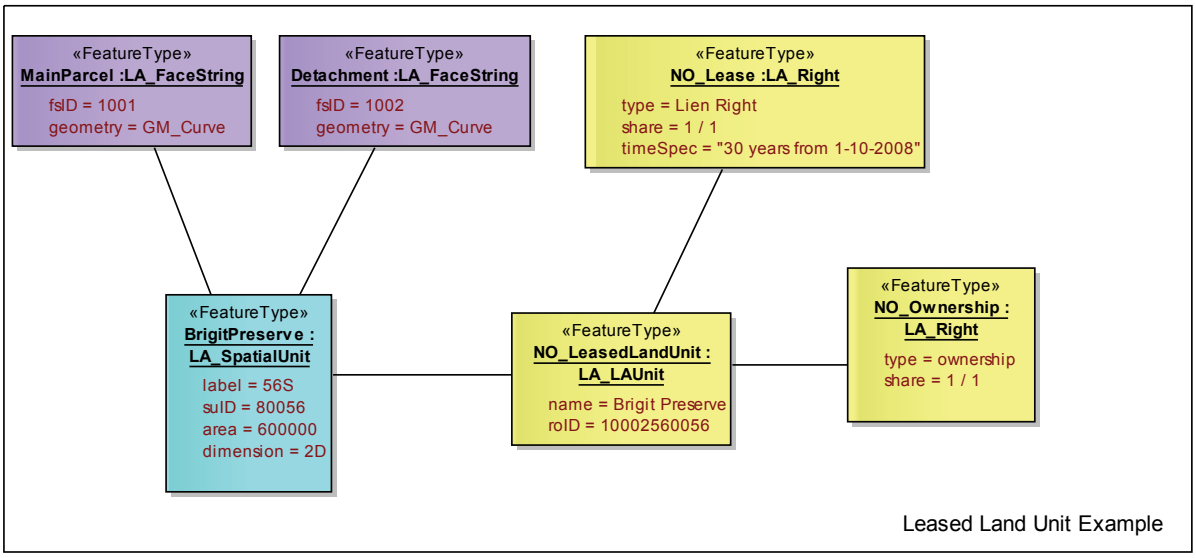
object AnnexC Case34a

Object Diagram, Case C34a - Norway categories of the Basic Property Unit. Examples for Volume Unit, Landed Property and Leased Land Unit.

Each of the five specializations (together with case C34b) of the Norway Basic Property Unit is shown through a specific instance connected to an LADM launit. Association to Rights is shown wherever relevant, but Parties are not shown on these diagrams



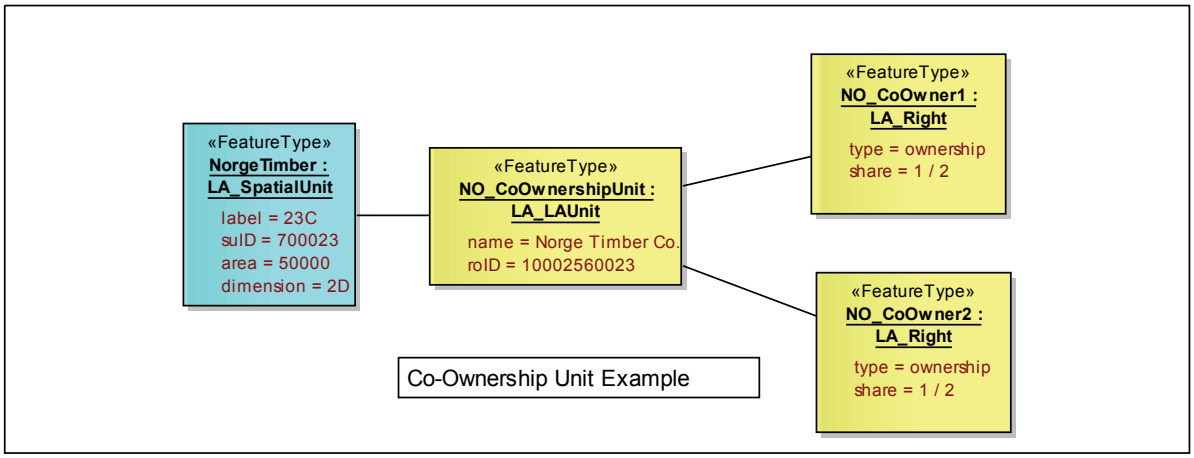


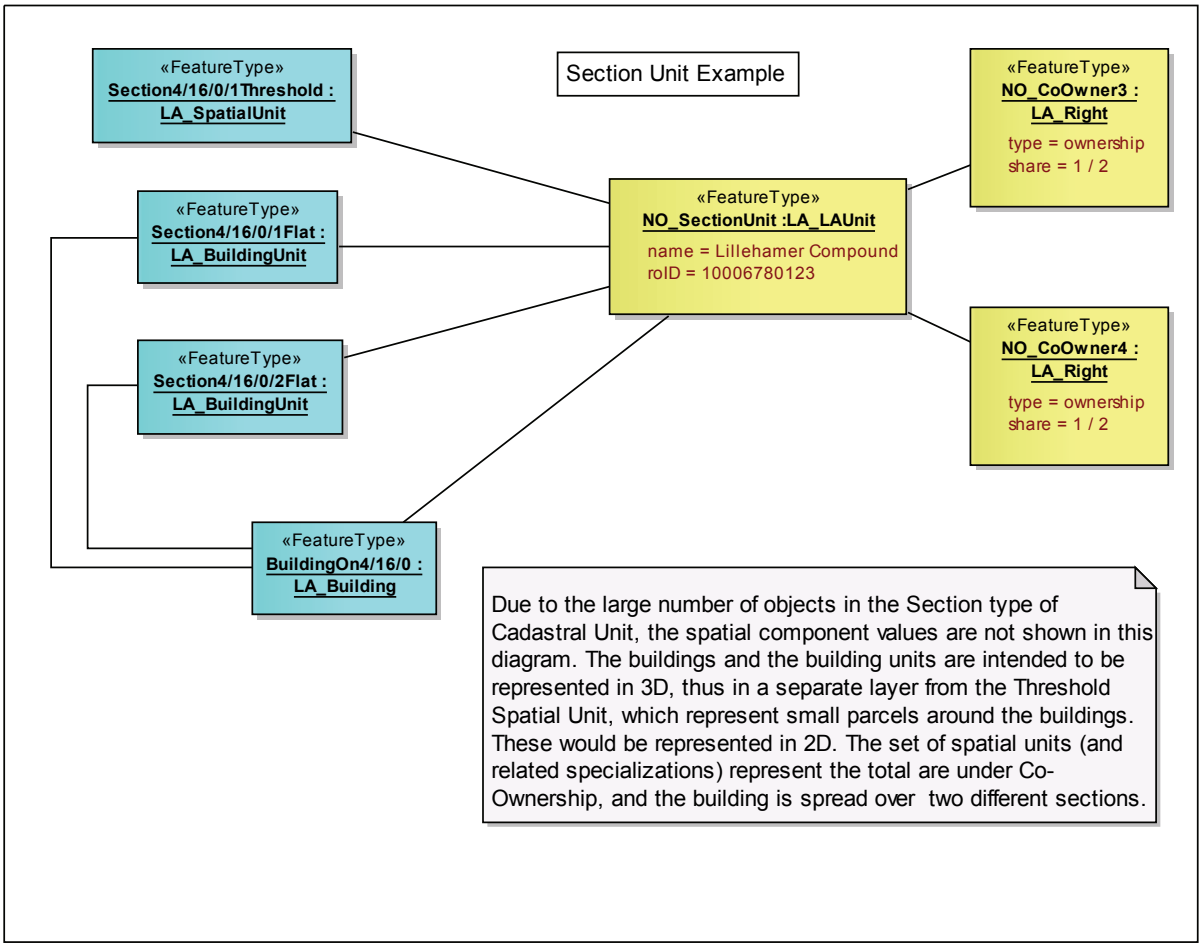


Case C34a. Norwegian categories of basic properties

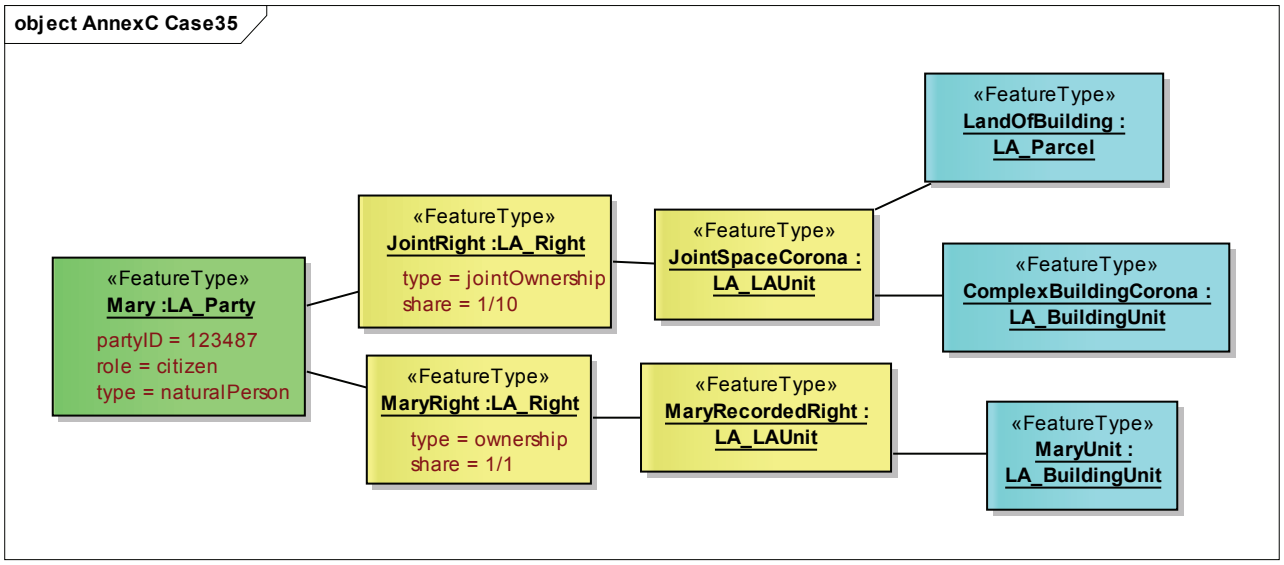
object AnnexC Case34b

Object Diagram, Case C34b - Norway Categories of the Basic Property Unit. Examples for a Co-Ownership Unit and a Section Unit.





Case C34b. Norwegian categories of basic properties



Case C35. Individual and joint property rights in Spain ('Corona' is the building name)

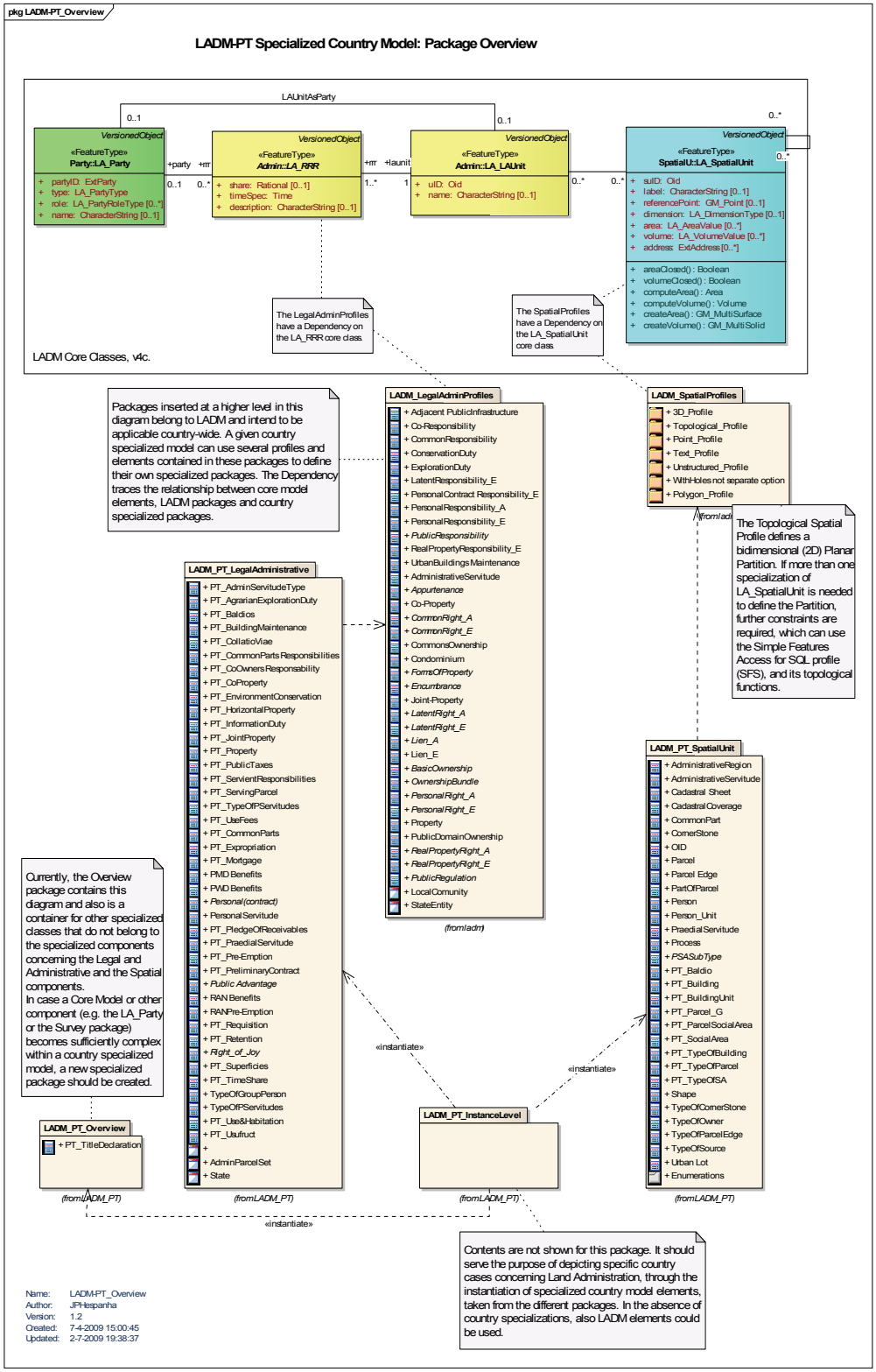
Annex D. Country profiles (informative)

In this annex three country profiles of LADM are mentioned:

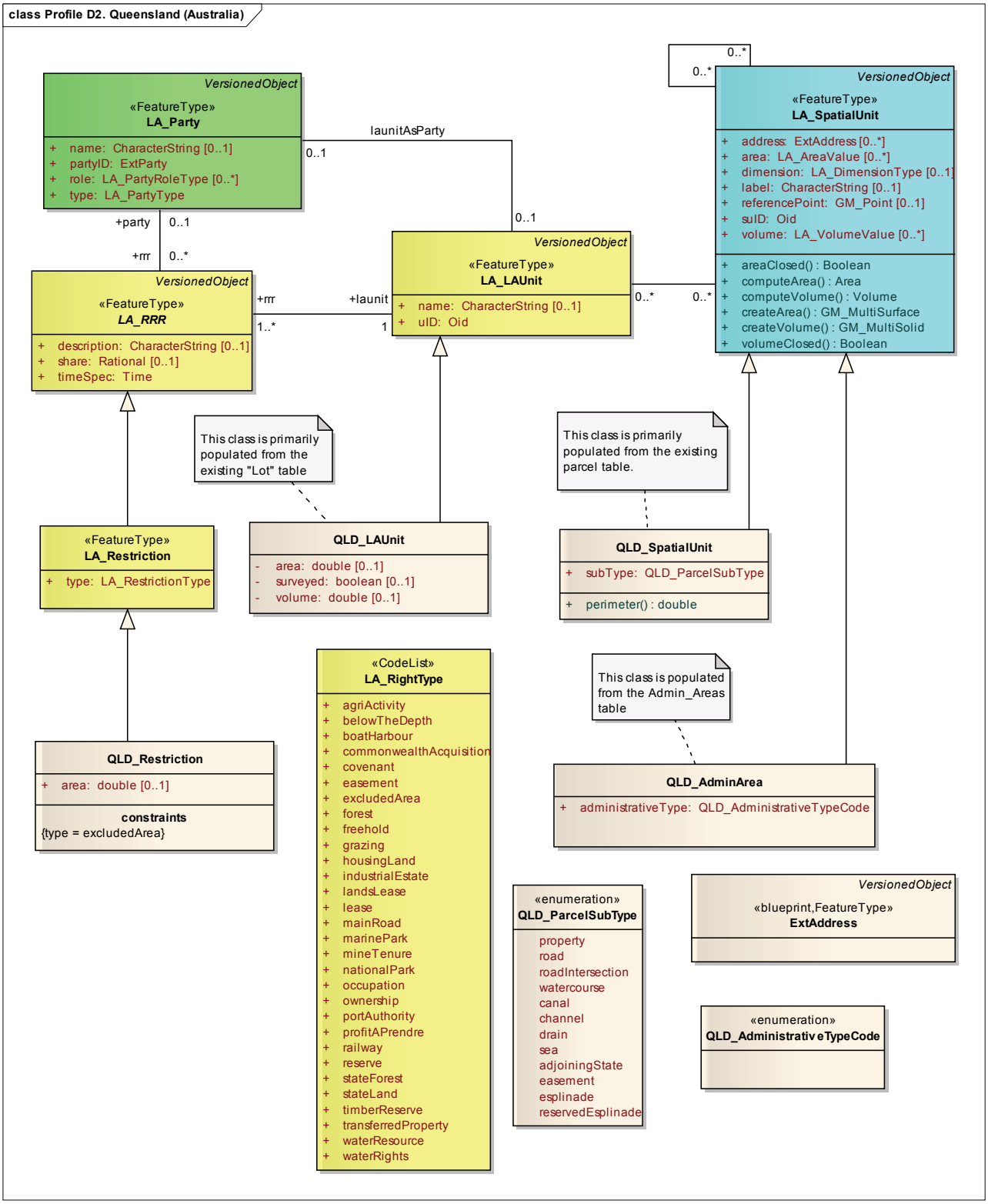
1. Portugal (Profile D1).
2. Queensland, Australia (Profile D2).
3. Indonesia (Profile D3).
4. Japan (Profile D4).
5. Hungary (Profile D5).
6. The Netherlands (Profile D6).

NOTE 1. The *Portuguese Country Profile* is the result of academic research towards a methodology to derive a specialized model from LADM domain model, using state-of-the-art information technologies. Currently, a new Cadastral Data Model complying with a number of ISO standards has been published by the Portuguese Geographic Institute. Work is under way to update this country profile in order to reflect the new specifications.

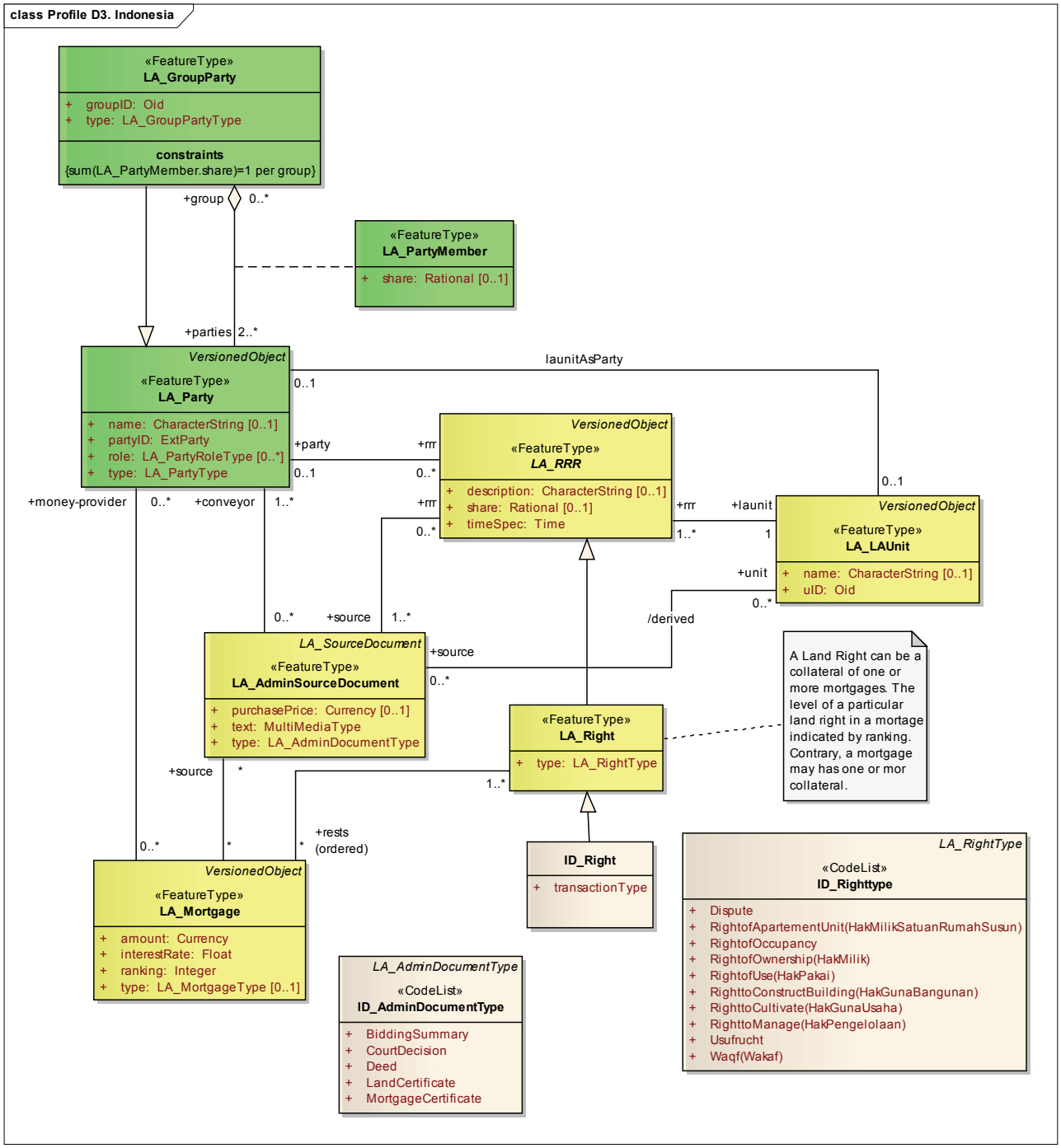
NOTE2. In *Japan*, local municipalities conduct the cadastral resurvey for improving the precision. The registry offices update the cadastres and land registries based on the resurvey results. The data model for data transfer from municipalities to registry offices is summarized in a UML class diagram. The data model of the information system in the registry offices is not open to the public.



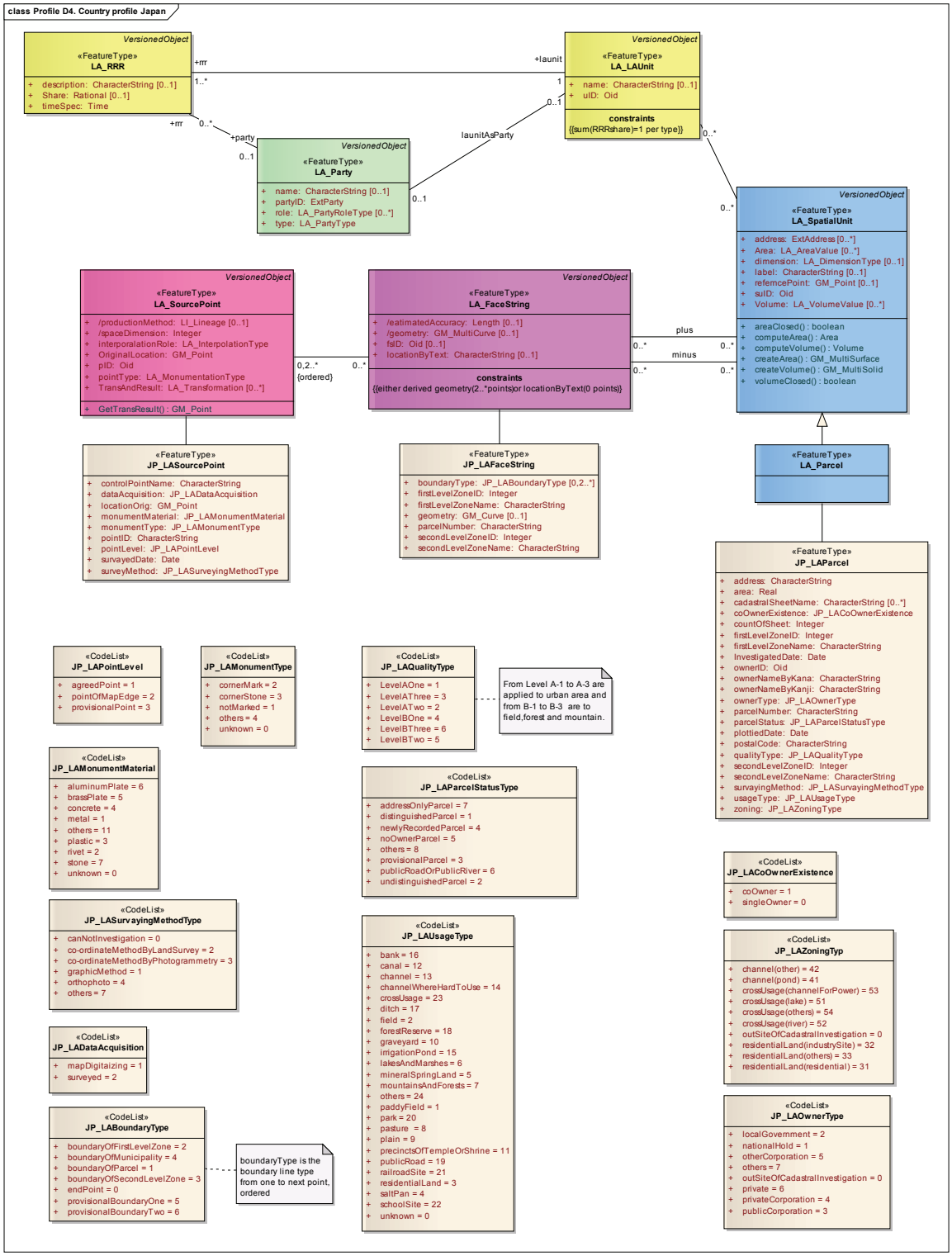
Profile D1. Country profile Portugal (see NOTE 1 on page 64)



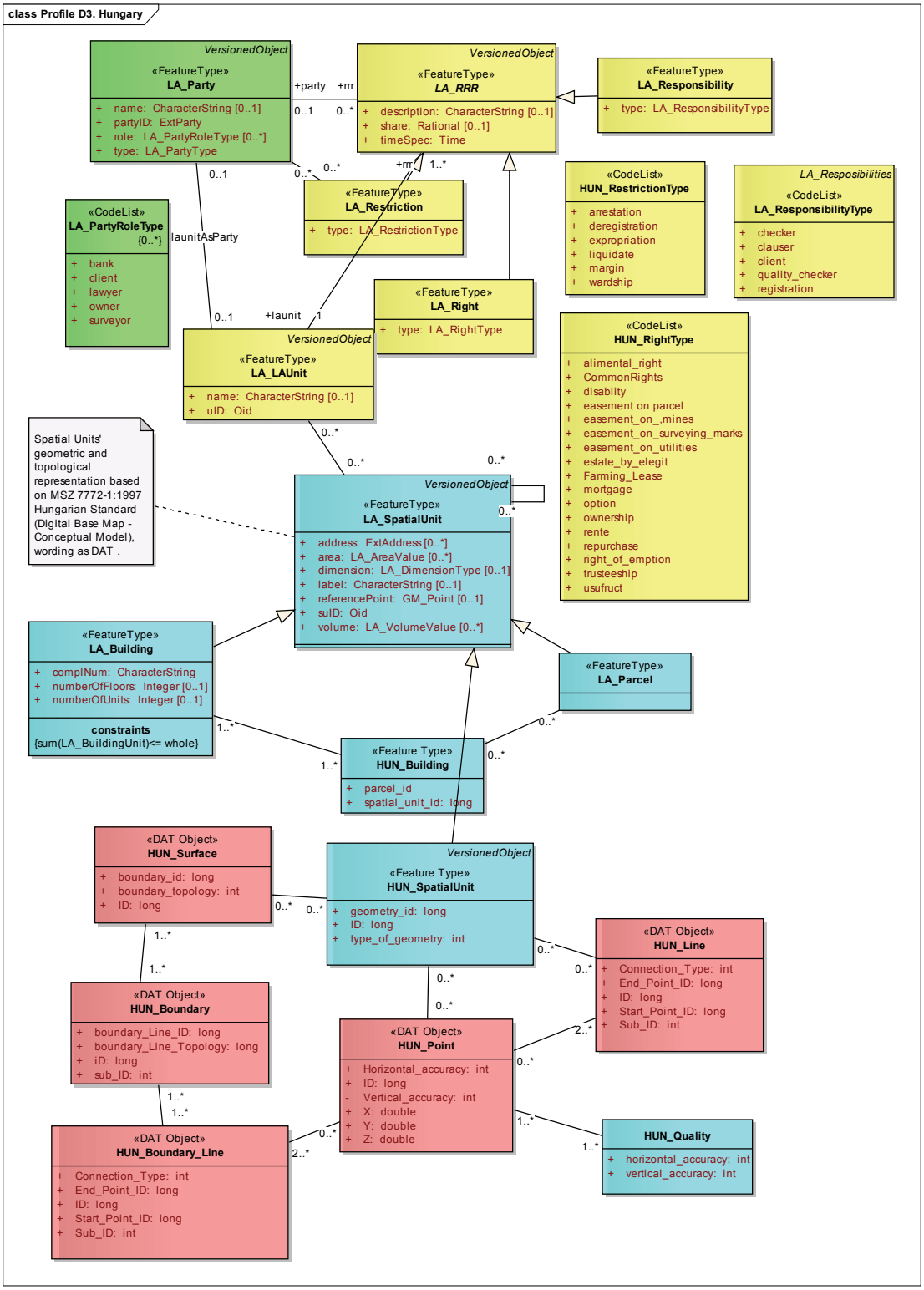
Profile D2. Country profile Queensland (Australia)



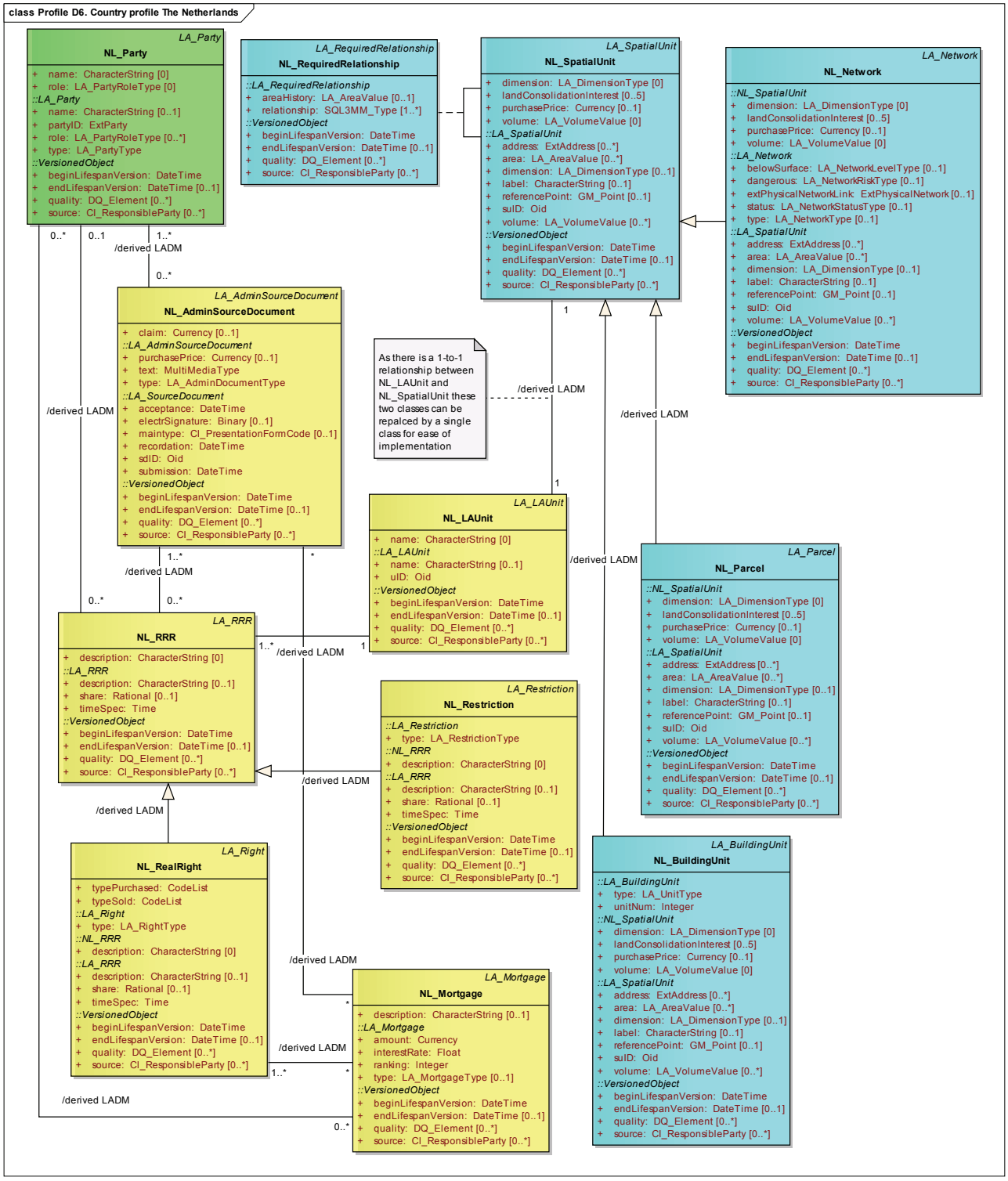
Profile D3. Country profile Indonesia



Profile D4. Country profile Japan (see NOTE 2 on page 64)



Profile D5. Country profile Hungary

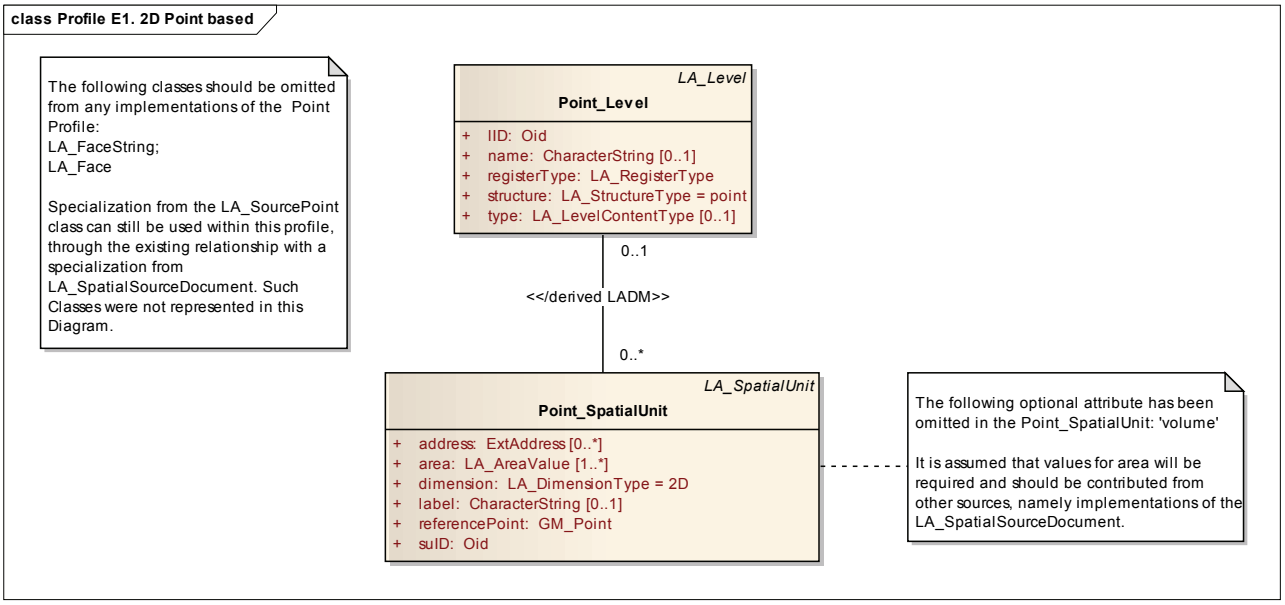


Profile D6. Country profile The Netherlands

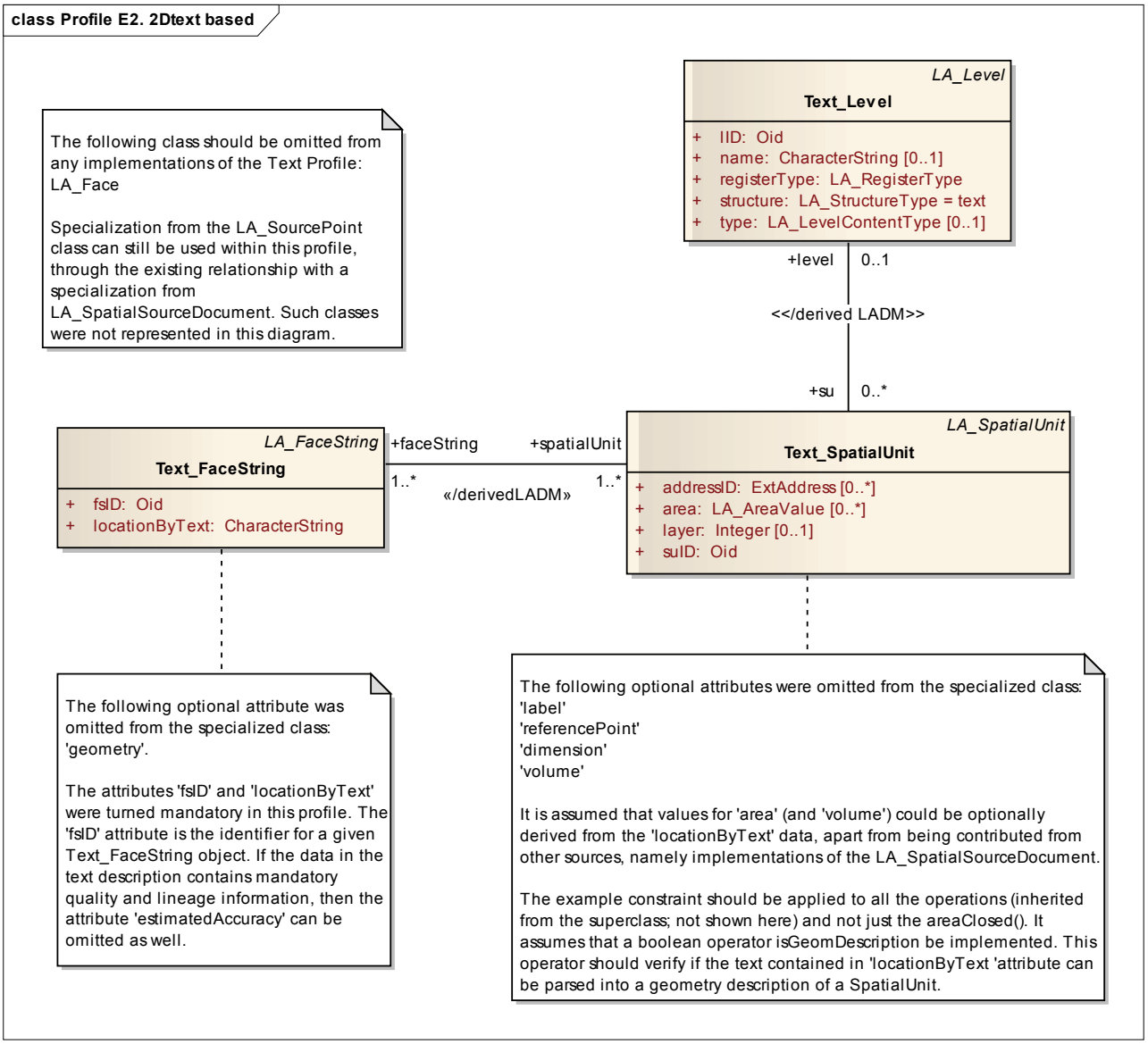
Annex E. Spatial profiles (informative)

The spatial description package of LADM (Section 5.2.5) allows a large number of possible descriptions of spatial units in 2D, 3D, or mixed (2D and 3D). For one specific type of spatial description, there are often just a limited number of classes and attributes needed. This annex shows per spatial profile the needed classes and attributes. The 3D cases also cover mixed 2D and 3D configurations. Further, in a specific country profile it is possible to combine several spatial profiles; e.g. parcels with 2D topology based spatial units and buildings with 2D polygons.

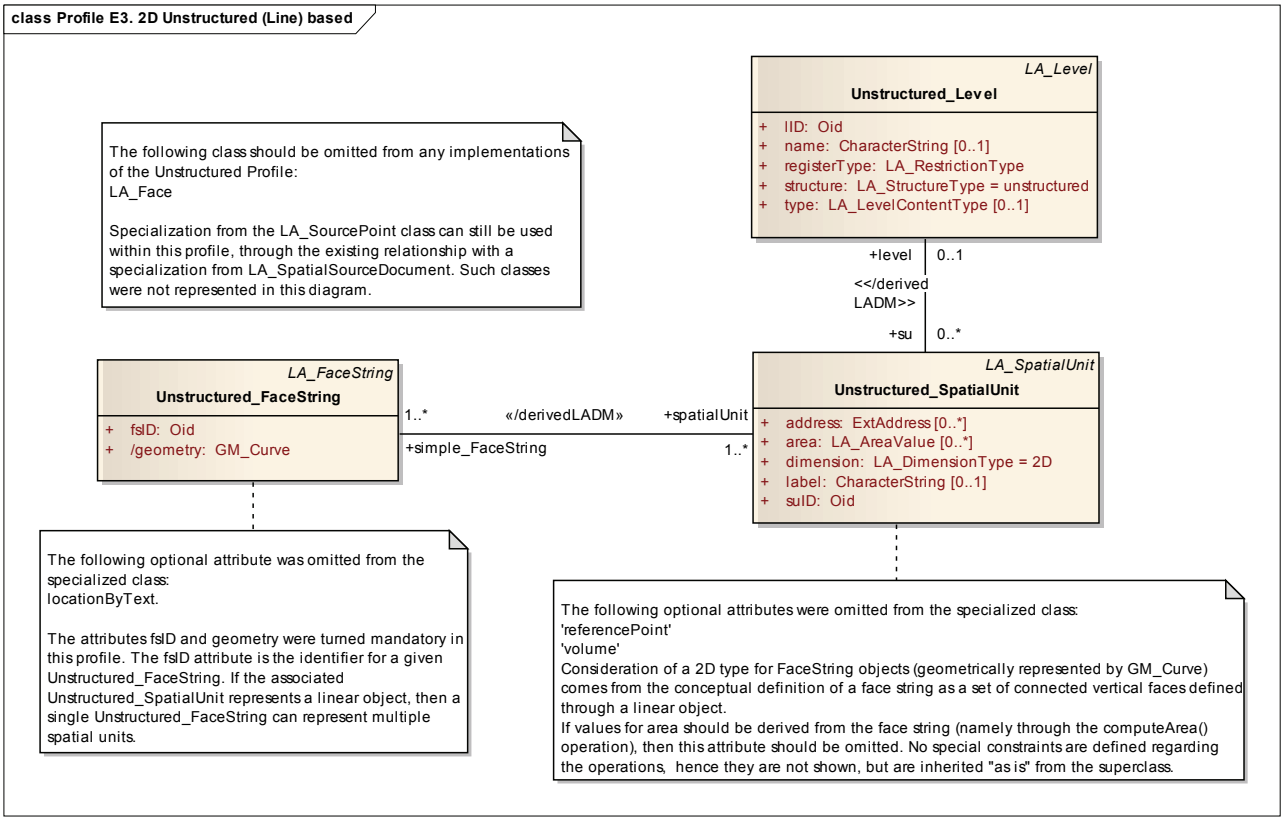
- 2D Point based (Profile E1)
- 2D Text based (Profile E2)
- 2D Unstructured (Line) based (Profile E3)
- 2D Polygon based (Profile E4)
- 2D Topological based (Profile E5)
- 3D Topological based (Profile E6)



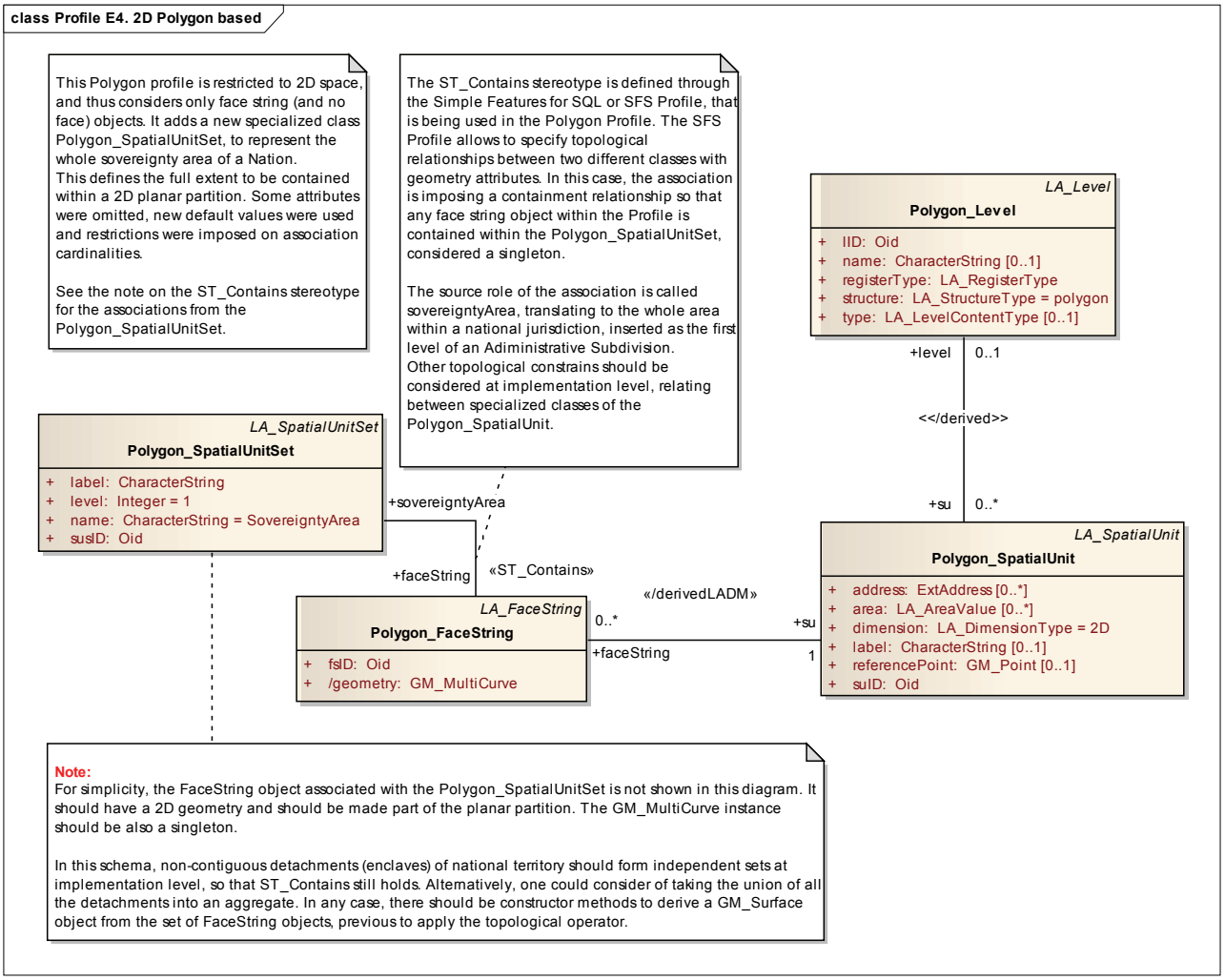
Profile E1. 2D Point based



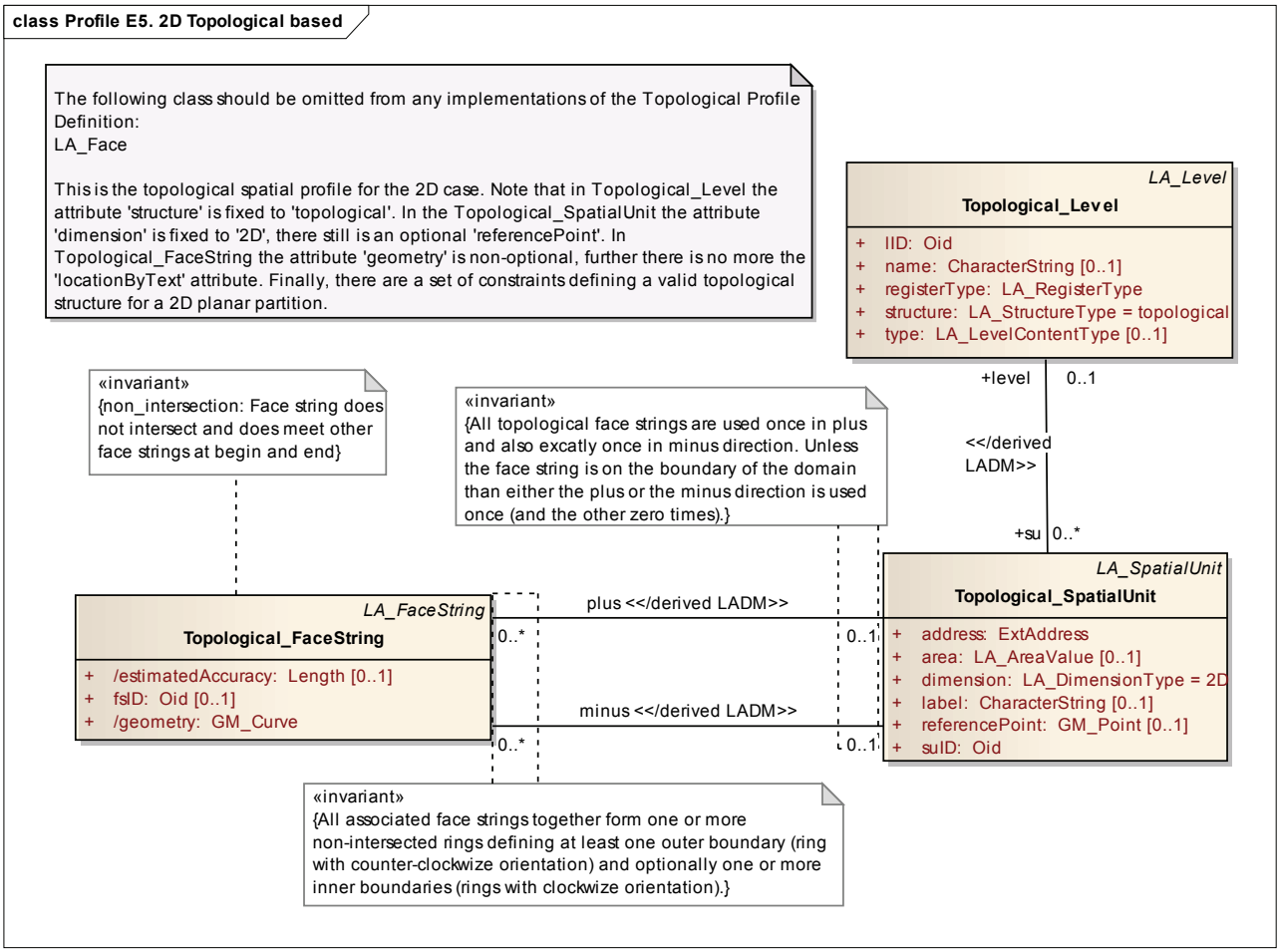
Profile E2. 2D Text based



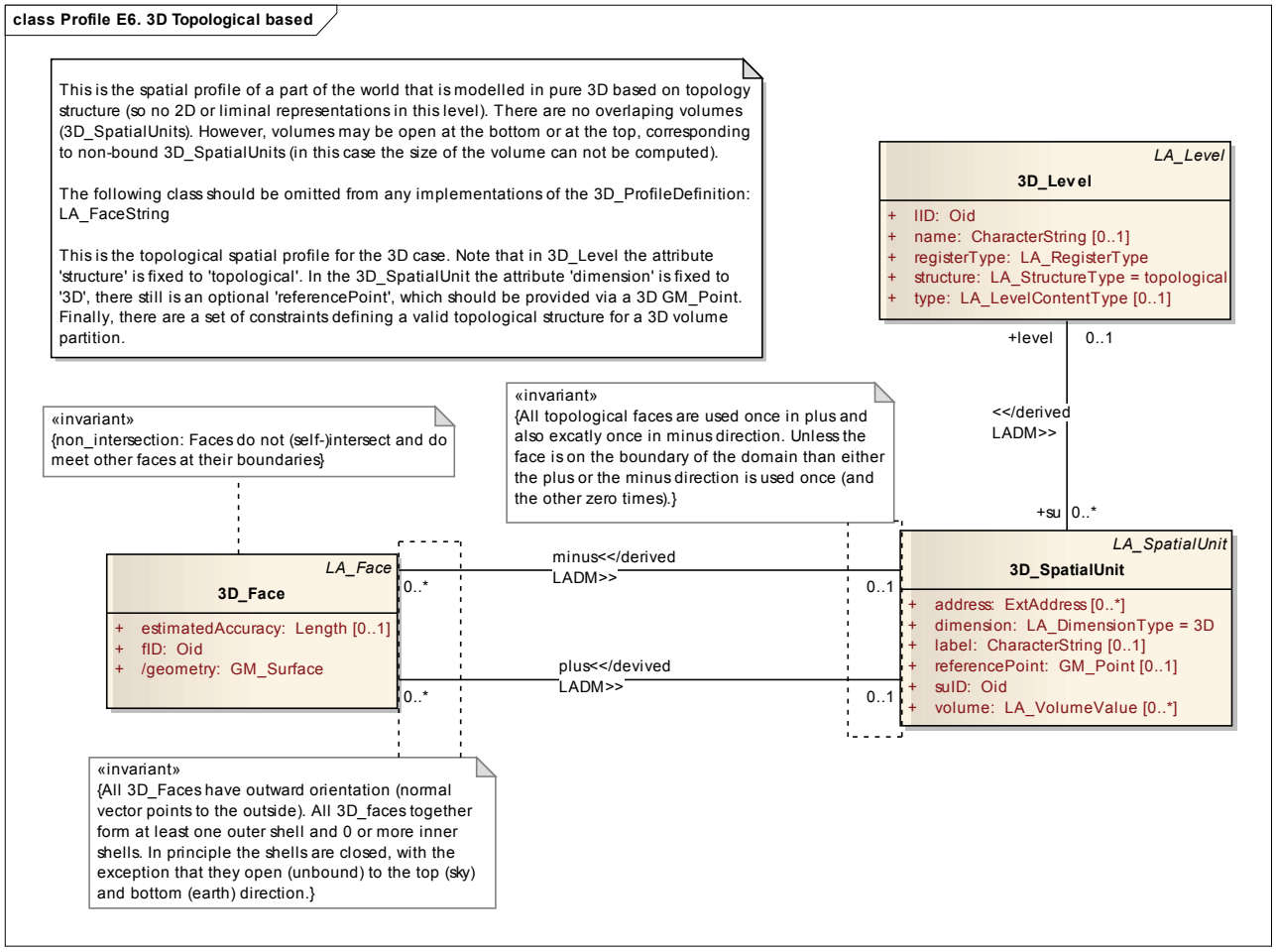
Profile E3. 2D Unstructured (Line) based



Profile E4. 2D Polygon based



Profile E5. 2D Topological based

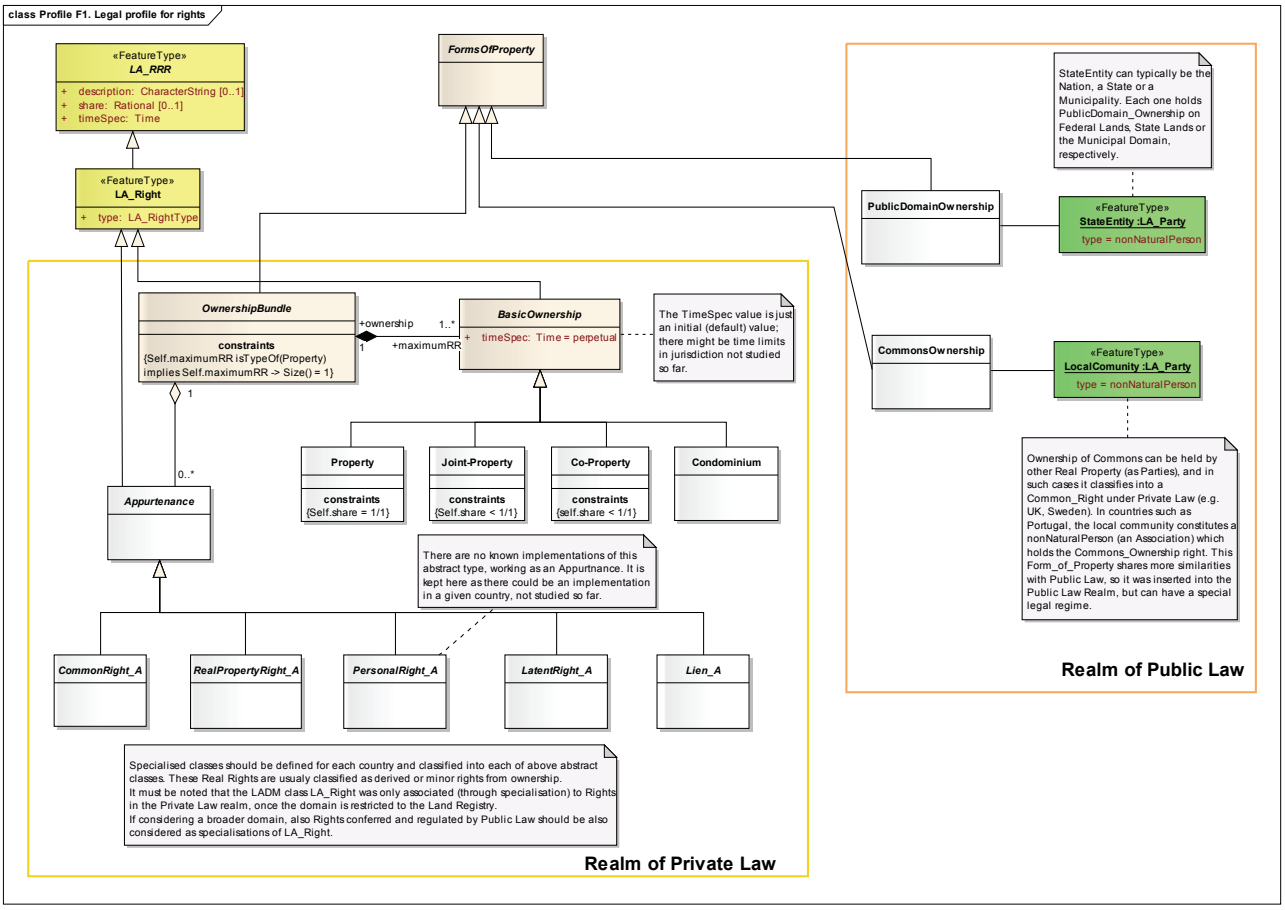


Profile E6. 3D Topological based

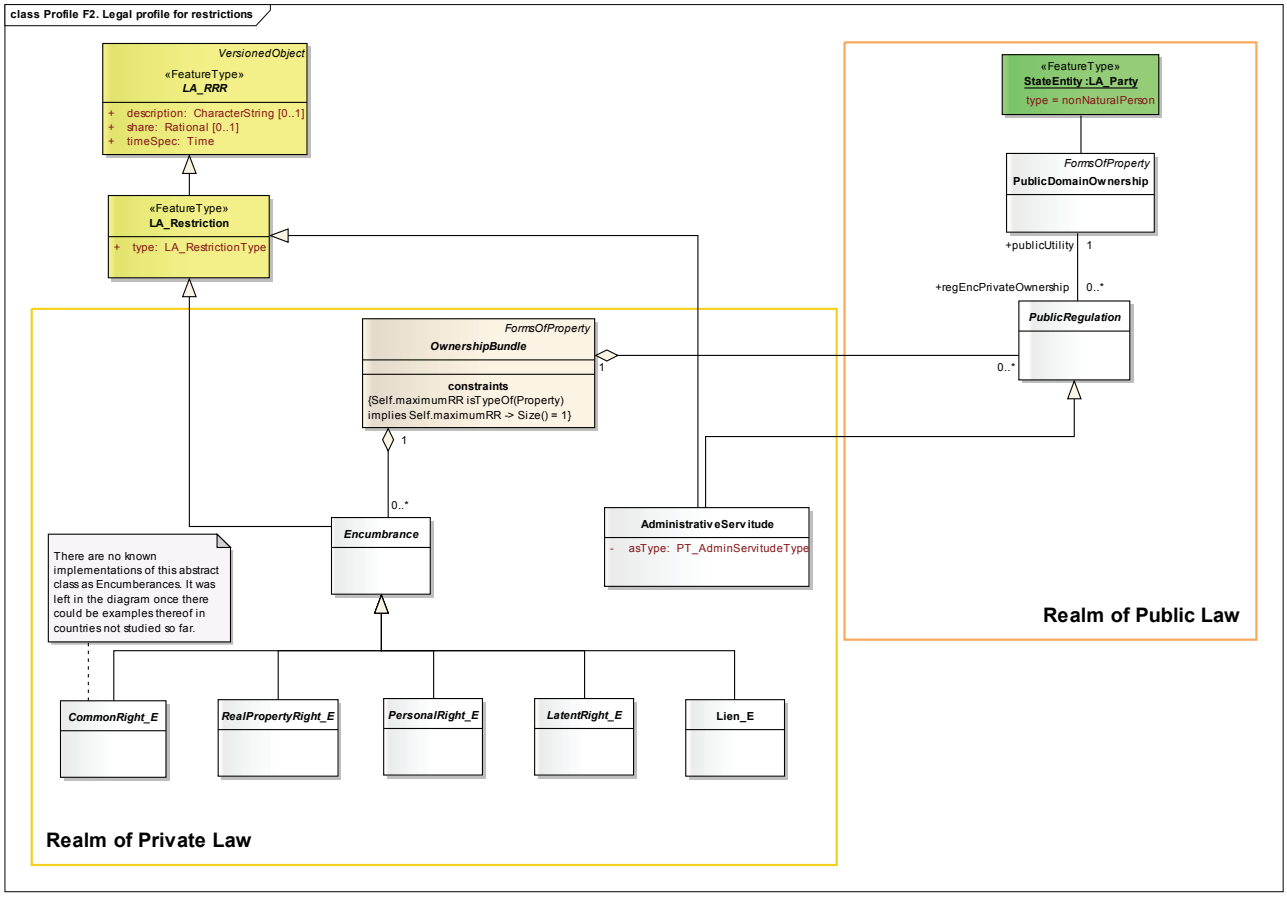
Annex F. Legal profiles (informative)

In this Annex three legal profiles are shown:

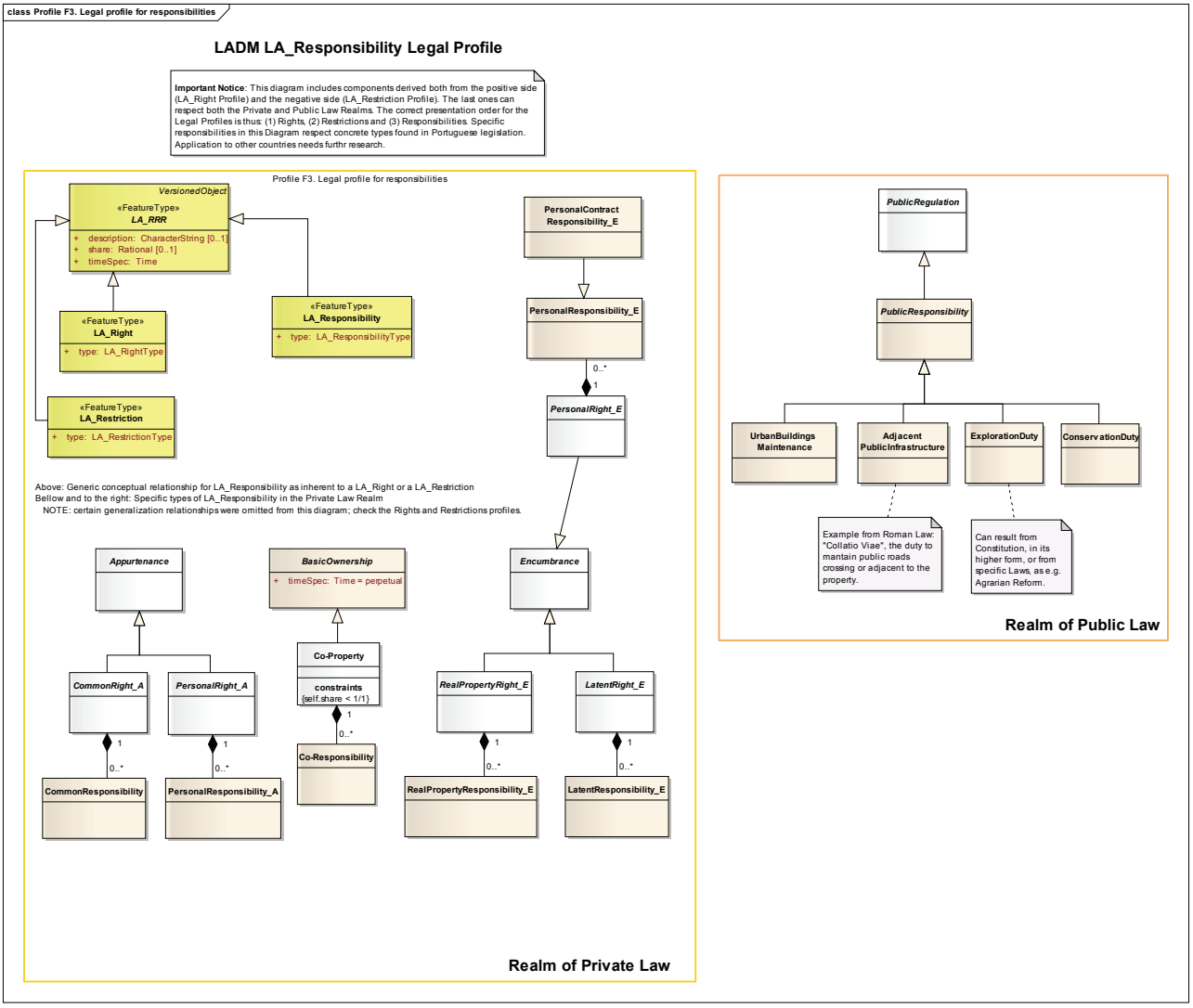
- a legal profile for rights (Profile F1)
- a legal profile for restrictions (Profile F2)
- a legal profile for responsibilities (Profile F3).



Profile F1. Legal profile for rights



Profile F2. Legal profile for restrictions



Profile F3. Legal profile for responsibilities

Annex G. LADM and INSPIRE (informative)

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 (INSPIRE, 2008). 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. Cadastral parcels is one of the harmonized data sets. Cadastral parcels in INSPIRE should serve the purpose of generic information locators for environmental applications, i.e. searching and linking other spatial information.

The INSPIRE Directive requires to take existing standards into account (article 7 of the directive). Once adopted, the ISO/CEN 19152 standard should be taken into account if there are requirements and consensus to extend Data Specification for Cadastral Parcels. In case of ISO/CEN LADM, there was an excellent opportunity as both INSPIRE CP and ISO/CEN LADM where under development at the same time. Through joint work between the INSPIRE TWG CP and the LADM Project Team this has been achieved. This ensured consistency between INSPIRE and LADM and resulted in a matching of concepts and compatible definitions of common concepts. Of course it must be remembered that there are differences in scope and targeted application areas; e.g. INSPIRE has strong focus on environmental users, while LADM has a multi-purpose character (also supporting legal security, taxation, valuation, planning, etc.) and LADM is supporting both data producers and data users in these various application areas. Also, LADM has harmonization solutions for rights and owners of 3D cadastral objects (such as building or network reserves), which are currently also outside the scope of INSPIRE CP. However, trough the intensive cooperation, it is now made possible that a European country may be compliant both with INSPIRE and with LADM. Further, it is made possible through the use of LADM to extend INSPIRE specifications in future, if there are requirements and consensus to do so.

In order to ‘proof’ the compatibility, Figure G1 shows the LADM-based version of INSPIRE cadastral parcels, explicitly indicating how the INSPIRE development fits within the LADM and that there are not inconsistencies. In selecting relevant classes from LADM, using inheritance and adding attributes and constraints it has been possible to express the INSPIRE cadastral parcels data set consistent with LADM. In INSPIRE context four classes are relevant:

- LA_Parcel as basis for CadastralParcel
- LA_LAUnit as basis for BasicPropertyUnit
- LA_FaceString as basis for CadastralBoundary
- LA_SpatialUnitSet as basis for CadastralZoning.

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 G1 looks a bit more complicated as the normal INSPIRE CP UML class diagram, because it is showing the different LADM parent classes and the refinement of the different attribute types (but the resulting model is the same).Within the European Community geo-information is harmonized according the INSPIRE legislation. Cadastral parcels is one of the harmonized data sets. The data product specification of the INSPIRE cadastral parcels is currently under construction. According to the Directive the original planning is that this shall be included in an implementing rule not later that 15 may 2009. However, there is a slight delay and the implementing rule for data specification is now expected in the fall of 2009.

In selecting relevant classes from LADM, using inheritance and adding attributes and constraints it has been possible to express the INSPIRE cadastral parcels data set consistent with LADM. Once the implementing rules will be adopted and the INSPIRE cadastral parcels data specification is final, this annex will contain

two UML class diagrams: one showing how the INSPIRE cadastral parcels can be derived from the corresponding LADM classes and one diagram showing the result (without the inheritance relationships).

It should be noted that the current scope of the INSPIRE cadastral parcels is more limited than LADM; e.g. it does not include rights, restrictions and responsibilities.

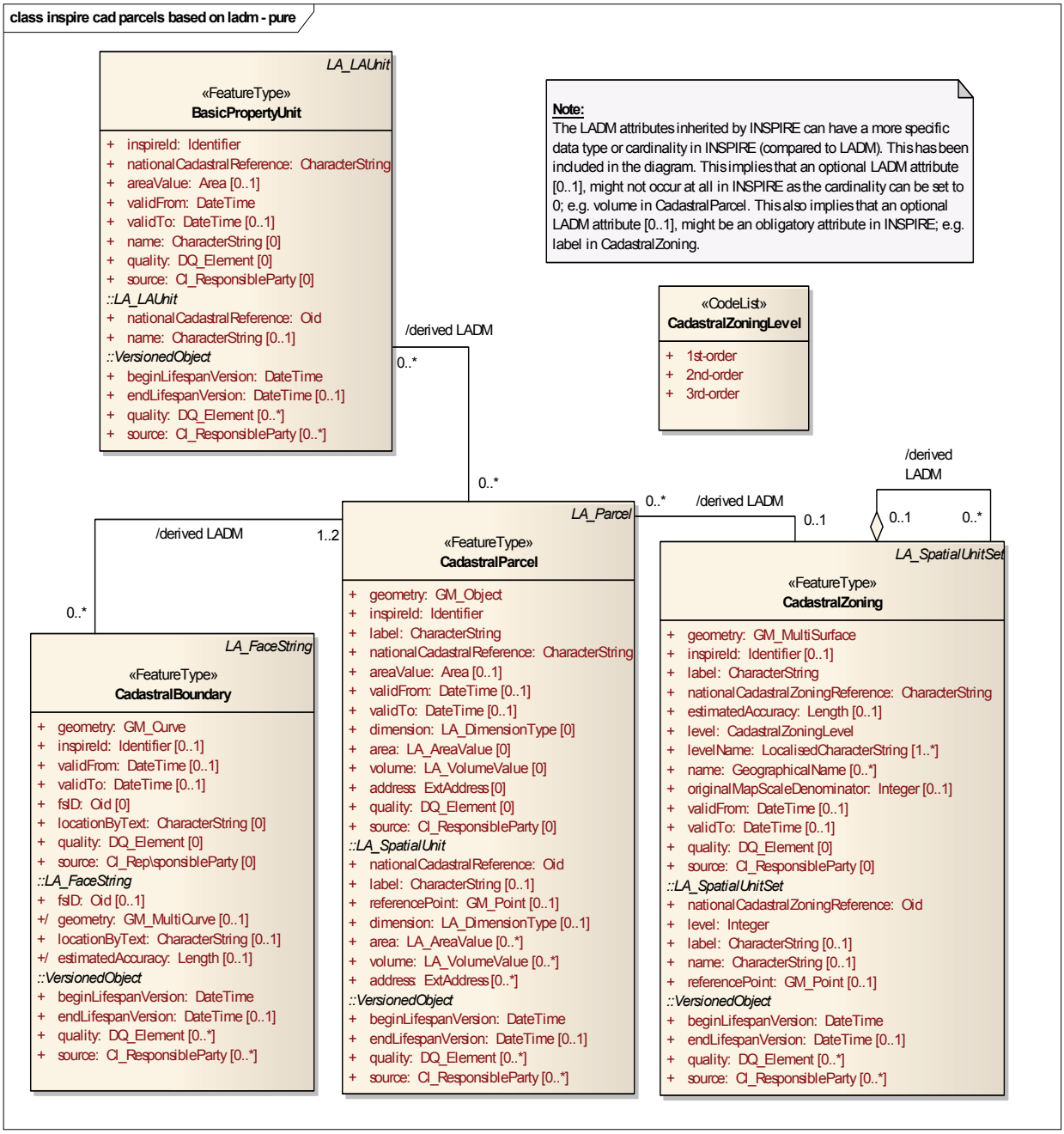


Figure G1. The INSPIRE cadastral parcel model derived from ISO LADM via inheritance

Annex H. LADM and LPIS (informative)

1. The integration of LADM with Land Parcel Identification Systems (LPIS)

One of the aspects of the Common Agricultural Policy (CAP) of the European Union is to focus on the management of subsidies to the farmers. For this purpose, member states have established Integrated Administration and Control Systems (IACS), including Land Parcel Identification Systems (LPIS) as the spatial component. The LPIS as a concept was developed already in 1992, when the need for identification of the agriculture parcels to support IACS emerged. At that time, the data model was purely alphanumerical without any geospatial reference. It was in the Council Reg. No 1593 (2000) that the spatial LPIS based on Geographic Information System (GIS) was promoted. Five years have been given to the member states to establish LPIS in digital and geo-referenced format. Thus, the first year of operational GIS-based LPIS was 2005. Although the regulatory requirements were unique across the sector, the particular implementations were a subject of the member states. In fact, during the development stages of different LPISs in different member states, the use of Land Administration (LA, or Cadastre) data, as well as large scale topography data, were on the agenda for a considerable while (UN/ECE,2004). In the following example a data model is designed that implies the collaboration or integration of LADM and LPIS. The standardization initiative in the area of LPIS (Sagris and Devos, 2008) by the Joint Research Centre (JRC) of the European Commission is used in this example in order to represent potentials for integration/collaboration between LADM and LPIS.

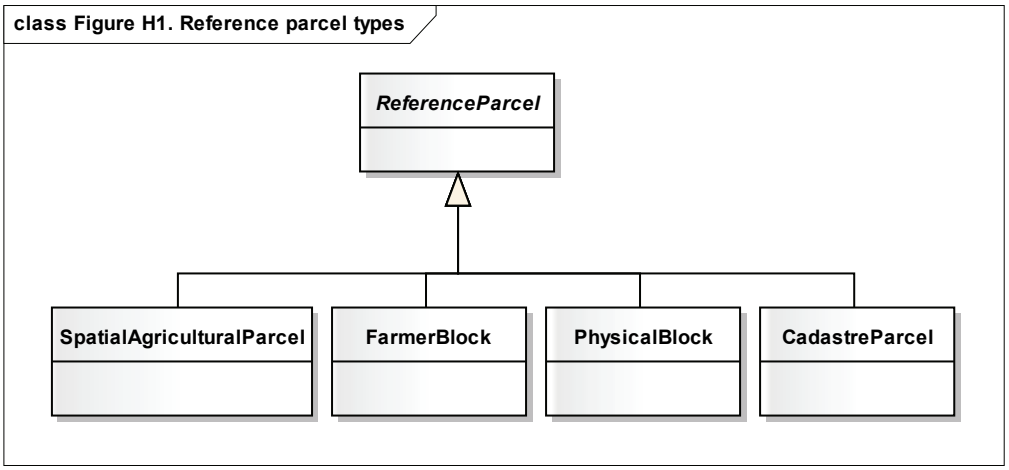


Figure H1. Reference parcel types

A declared agricultural parcel is a key concept applied in relation to area-based payments, which determines the subject of the aid application, geographic location and extent (area) of agricultural activity. The declared agricultural parcel is a subject of the payment calculation as well as for administrative control. Due to the dynamic nature of agricultural activities, declared agricultural parcel can be unstable over time and space (crop rotation, out of use, aggregation or subdivision of fields, different extent of use, conditions for eligibility for payments etc.). Therefore, the reference parcel (RP) is used as basic unit of LPIS for purpose of identification of the declared agricultural parcels where one RP can contain one or many (1..*) declared agricultural parcels. The EU regulations specify that reference parcel can be either cadastral parcel or production block (see Figure H1). In the end some member states decided to build their systems as close to declared agricultural practice as it possible and use reference unit which contains only one spatial agricultural parcel.

The main difficulties of Cadastral parcel as reference for subsidies' application are that (i) it contains non-agricultural land, so area eligible for payment can not directly determined, and (ii) that boundaries of

agricultural activity are out of LA scope and their maintenance via cadastral update cycle is very complicated. Therefore in Section 2 the concept of SubParcel is introduced, which plays the role of a reference parcel (and as glue between LADM and IACS/LPIS).

2. A data model for the integration of LADM and LPIS

In the UML class diagrams, current LADM classes are used with or without small changes in their attributes or they are extended with new classes, and IACS/LPIS classes are shown in a single colour (grey).

2.1 Basics of LPIS Core Model (LCM)

LPIS Core Model (LCM) has been developed by the Agriculture unit of the EC Joint Research Center (JRC). The intention with this model is extracting general classes from functional LPIS system and test them for conformance with the EU Regulations; therefore model does not cover every aspect of the LPIS. MS experts could extend the boundaries of the LCM to fit for particular needs of national implementations. Figure H2 represents the logical business model of the main concepts of the LCM. All basic concepts are represented as classes.

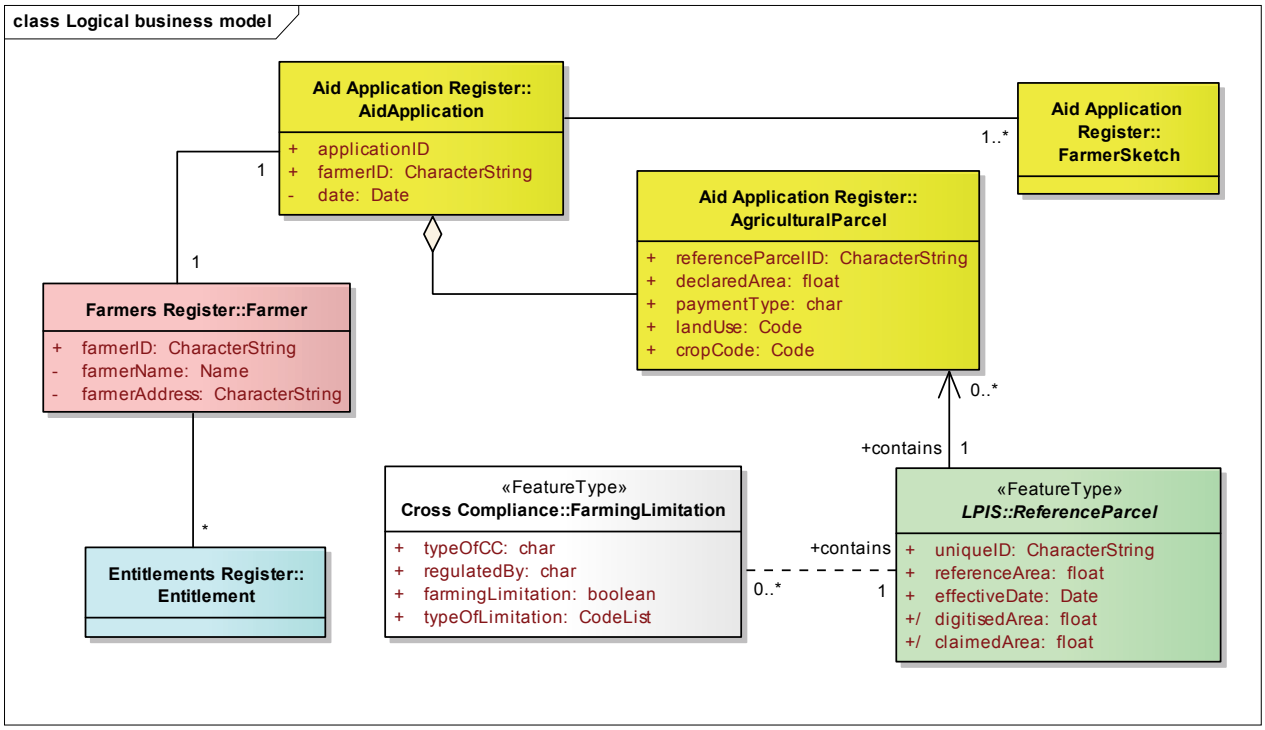


Figure H2. The core (classes) of the LCM

2.2 Integration of LCM and LADM Basic Classes

2.2.1 Spatial classes

The class LA_SpatialUnit is one of the core classes of LADM. LADM also provides the functionality of administrative grouping the LA_SpatialUnits with the class LA_LAUnit through which the legal facts (right, restrictions, responsibilities in LA_RRR) are attached. The specialized class LA_Parcel is inside the scope and the other specialized classes of LA_SpatialUnit are outside of the scope of the LADM and LPIS integration (LA_Building, LA_BuildingUnit, LA_Network) as is the hierarchical grouping in LA_SpatialUnitSets (sections, municipalities, etc.); see Figure H3. For a meaningful, comparable and standardized classification of land, at least for the case of cadastral parcels as agricultural reference parcel, SubParcel class is designed as a part of cadastral parcels in the model. SubParcel has composition

association to LA_Parcel. In the SubParcel class, the attribute typeSubParcel is designed to store different types of SubParcel. These are defined in the code list SubParcelType (Figure H3). One important consideration is that the boundaries of the defined classes should be stable over time. Otherwise, the update and maintenance procedures will definitely be a burden.

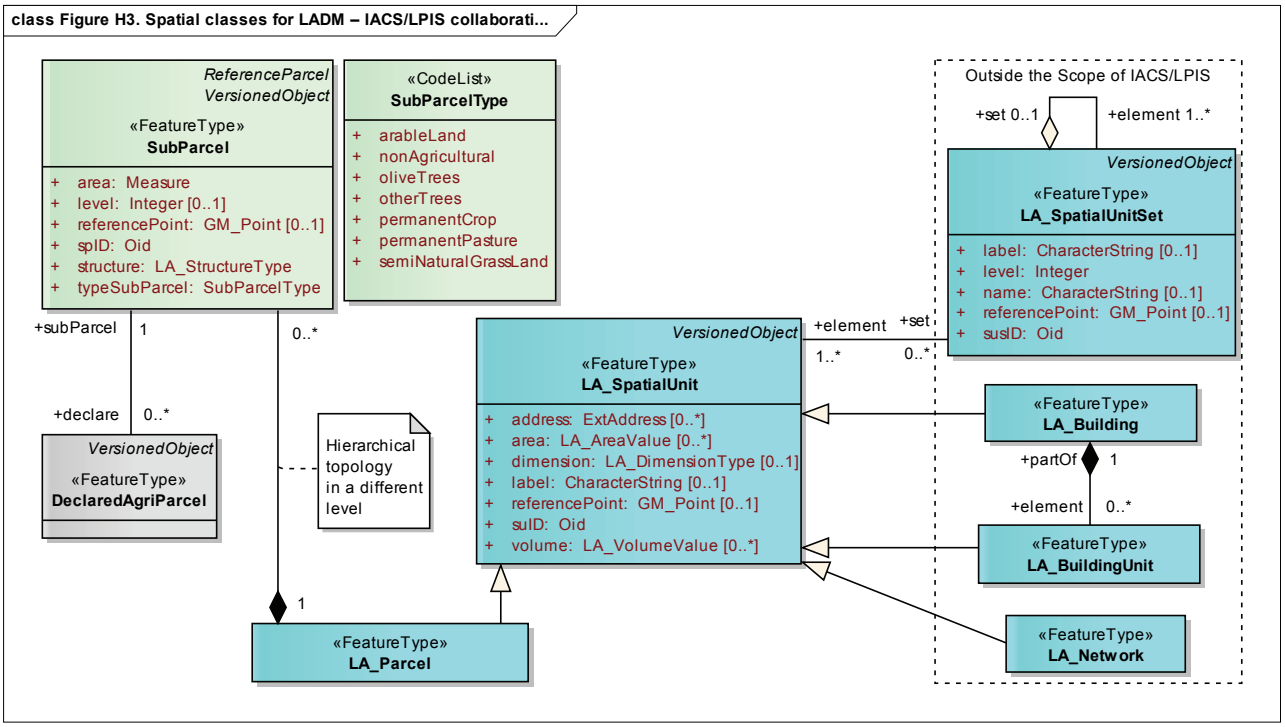


Figure H3. Spatial classes for LADM – IACS/LPIS collaboration

2.2.2 Administrative classes

LA_Party (person), Farmer, Right/Restriction/Responsibility (LA_RRR), YearlyAidApplication, YearlyFarmerSketch, DeclaredAgriParcel are the basic classes designed to manage administrative data in the model (Figure H4). LA_Party and LA_RRR are two core classes coming from LADM. Other classes are designed for the description of LPIS administrative data.

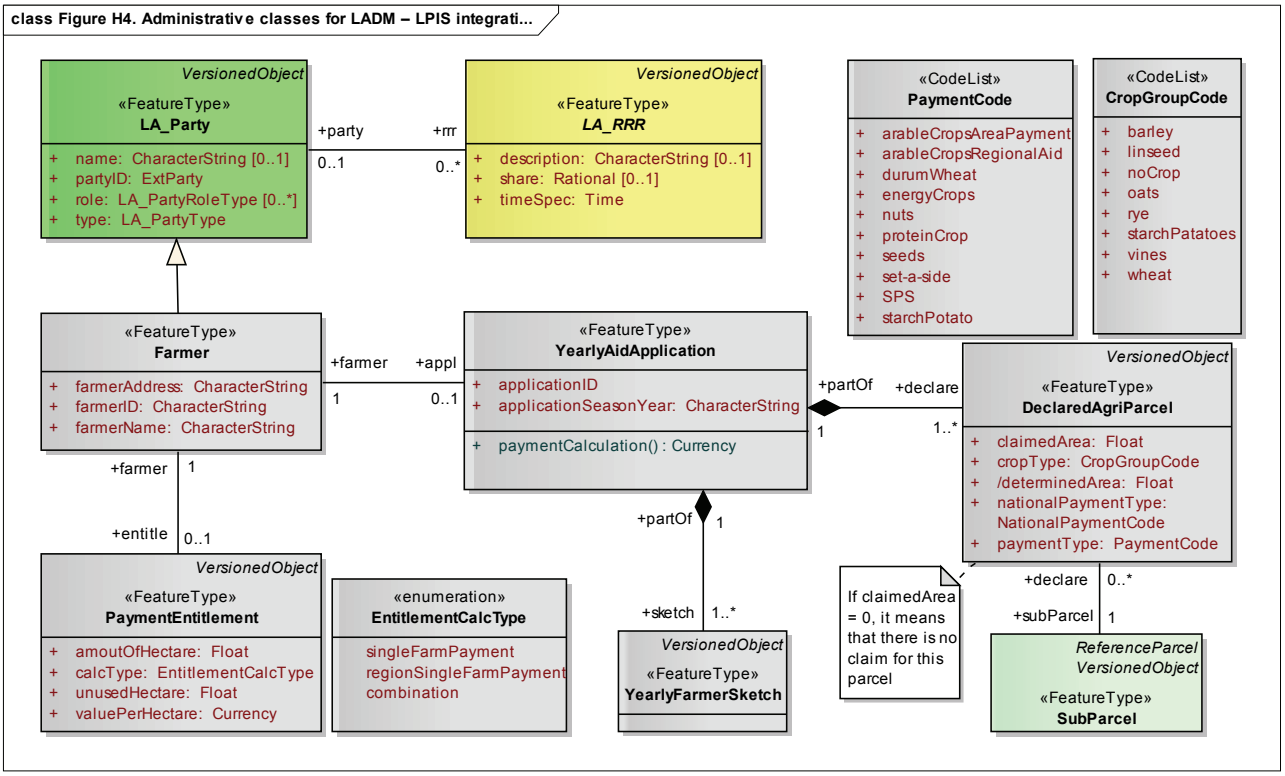


Figure H4. Administrative classes for LADM – LPIS integration

Farmer class is designed as a specialization of LA_Party class in order to handle the attributes specific to farmers. Farmers may apply for agricultural subsidies every year. To handle the application information of farmers, YearlyAidApplication class is designed. Aid applications submitted by farmers must be accompanied by farmer declarations which describe each piece of land used by farmer for agricultural activities and farmers' sketch. Therefore there are two corresponding classes (DeclaredArgiParcel and YearlyFarmerSketch) composing the YearlyAidApplication (a LA_SourceDocument) in the model. To represent their entitlement rights, PaymentEntitlement class is introduced in the model. In the skech which farmers must provide together with their applications, they indicate the boundaries of their agricultural parcels. They may use one single agricultural parcel or many of them. They may draw the boundaries of their land in separate sketches for each piece of land. Some grouping is also possible depending on their location and the scale of the sketch. Aid applications submitted by farmers must be accompanied by farmer declarations which describe each piece of land used by farmer for agricultural activities. These declarations are subject to agricultural subsidies after some control processes are carried out. Farmer declarations are represented by DeclaredAgriParcel in the model. It is designed as a part of YearlyAidApplication class because this class can not be without any aid application.

3. Special issues for the integration of LADM and LPIS

Farmer is defined in article two of the Regulation EC No 1782/2003 as a natural or legal person or a group of natural or legal persons. This definition of person can be represented by LA_Party classes designed for LADM. In Figure H5, the classes in green are LADM person classes. LA_Party is the main class which represents natural person and non natural person, and also groups of natural and non natural persons via LA_GroupParty class. So, LADM person classes have the functionality of representing farmers as all kinds of persons. However, a new class Farmer is designed to represent the attributes which are specific only to farmers. Currently in the model, only two specific attributes. One is farmerID which indicates that the person is a farmer. The other is farmerAddress which includes up-to-date address information.

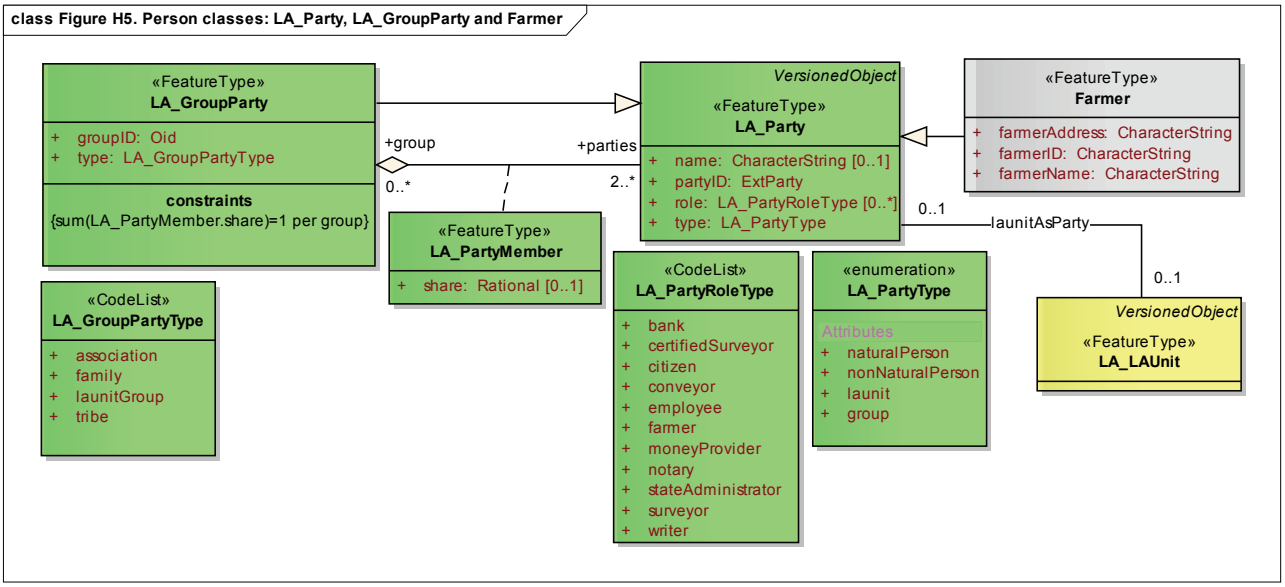


Figure H5. Person classes: LA_Party, LA_GroupParty and Farmer

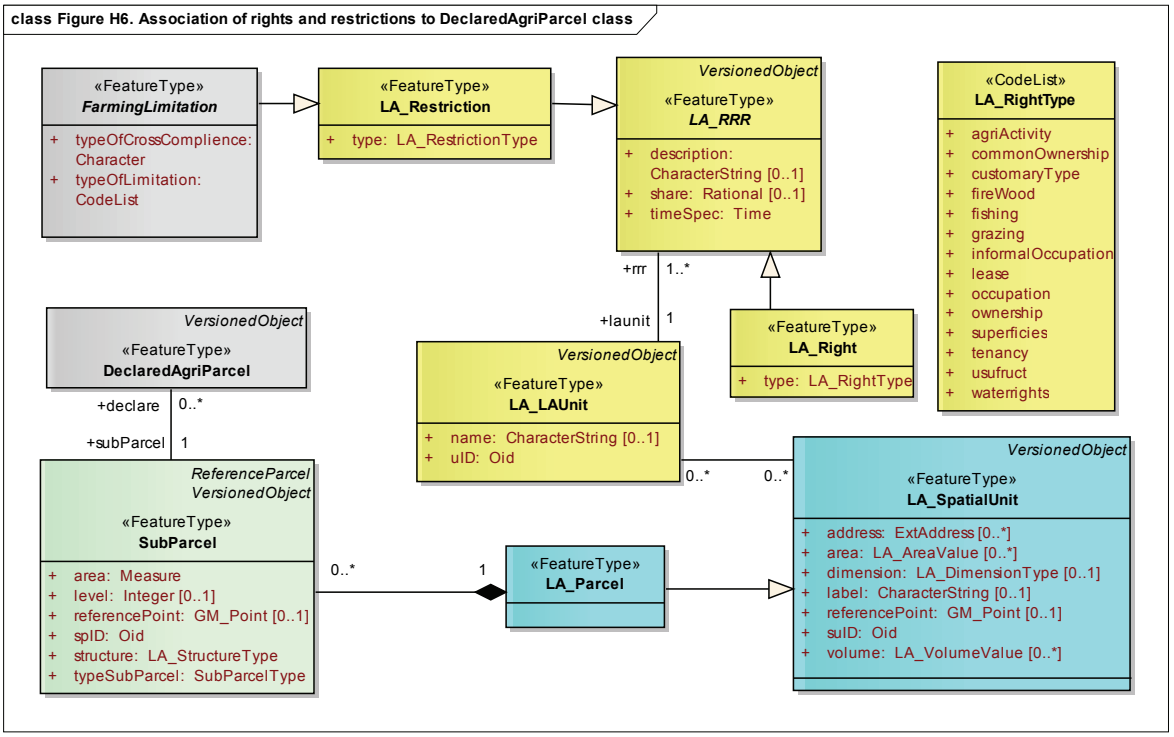


Figure H6. Association of rights and restrictions to DeclaredAgriParcel class

In LADM, LA_RRR class has three main types of specialization classes – LA_Right, LA_Restriction, and LA_Responsibility. In the collaboration model for LPIS integration, farming rights are represented by LA_Right class and some of farming limitations are represented by FarmingLimitation class as a specialization of LA_Restriction class (Figure H6). The only right IACS/LIPS is about is right to be paid (entitlement). It is associated with Farmer and via YearlyAidApplication and DecalredAgriParcel to SubParcel. It is not related directly to the whole LA_Parcel.

4. Discussion

This Annex shows that several aspects of LADM can be used in the integration of different LPIS set-ups in different member states of the European Union. Several other important aspects are not mentioned here but can be found in (Inan et al, 2008).

There has been a common understanding that the LPIS deals with farmers (users of land) and the Cadastre (or the LAS) deals with owners and they may not be the same person. Unlike such kind of common understanding, LASs, by definition, deal with a wide range of information related to land including ownership, land use rights (right holders of registered properties), farming rights, restrictions, responsibilities etc. We can also call such kind of a LAS as multi purpose cadastre. However, it is a fact that conventional LASs as legacy systems are currently not always capable of administering all kinds of land related rights. This is why LASs are generally underestimated by third parties. Therefore, registration of farmers and farming rights in a LAS has been regarded as an obstacle when compared with LPIS. In fact, a farmer is a person who does some kind of agricultural activity on some piece of land. Farmers may own some land for their activities. They may lease and/or get some kind of consent from others for another piece of land.

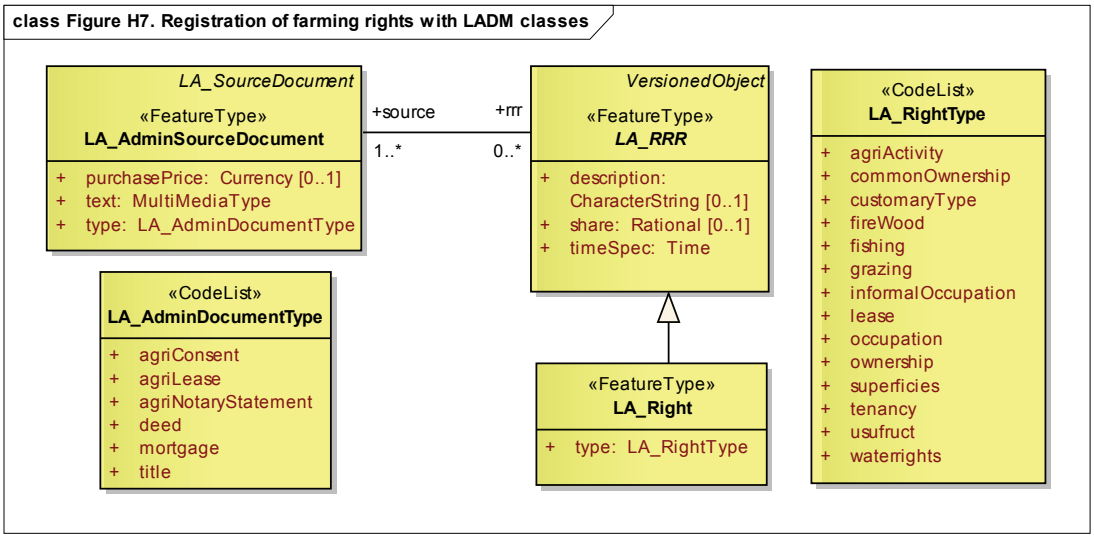


Figure H7. Registration of farming rights with LADM classes

In this example, farming rights are designed as part of LAS with a few extensions in code lists (LA_RightType and LA_AdminSourceDocumentType) with attribute values for attributes of some LADM classes (see Figure H7). The idea is that this will enable the application of an integrated solution for the management of land use rights both for LAS and LPIS applications.

In order to try to design and test properly the model presented above, a modeling of the use cases (from the business and system point of view) should be elaborated, including Activity diagrams of the processes and workflows.