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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 mainly connected to land (or water) and property ownership, and the geometrical (spatial) components thereof. The 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 (Kaufmann and Steudler, 1998); 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 in Annex H. Conversely, it is possible to use only a subset, or profile, of the 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 and property, linked by (property) rights, and are in most countries influenced by developments in Information and Communication Technology (ICT). Furthermore, the two main functions of every land administration, 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.

The UN Land Administration Guidelines (UN/ECE, 2006) describe land administration 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, then 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 (see Van Oosterom and Lemmen, 2001). In existing land administrations and land registries, standardization is generally limited to the region, or jurisdiction, where the land administration, 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

Version	*Date*	*Comments*
WD19152.1	01-Feb-2008	Equal with ISO/TC 211 N 2385
WD19152.2	31-Jul-2008	Comments Copenhagen, Denmark, 26-27 May 2008
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WD19152.3	31-Oct-2008	Comments Delft 22-23 September 2008
CD19152.0	25-May-2009	Comments Tsukuba, Japan, 1-2 December 2008

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)
- provides an abstract, conceptual schema with five basic packages related to (1) parties (*people and organizations*); (2) spatial units (*parcels, buildings and networks*); (3) rights, responsibilities, and restrictions (*property rights*); (4) spatial sources (*surveying*); and (5) spatial representations (*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 might have any legal implications
- construction of external databases with party data, address data, valuation data, usage data, and taxation data. However, the LADM provides 'blueprint' stereotype classes which indicate what data LADM expects from these external sources, where it is 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. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4217:2008, *Codes for the representation of currencies and funds*

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 measurement*.

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 document

a document providing formal facts. It is the evidence of a party's right to a recorded object
[equivalent to legal document in UN/ECE, 2004]

4.1.2 Building reserve

the representation of the legal, recorded or informal space of a building (not the physical object)

4.1.3 Building unit

a component of **building reserve**

4.1.4 Coordinate reference system

[from ISO 19111]

4.1.5 Group party

any number of **parties** (members), considered as a unit; for example communities, or cooperatives

4.1.6 Land administration

the process of determining, recording and disseminating information about ownership, value and use of land
[adapted from UN/ECE, 2006]

NOTE. In many countries land information is determined, recorded and disseminated under the umbrella of cadastre and land registers. Both institutions may be unified in a single (state) organization

4.1.7 Layer

a collection of **spatial units** with a geometric and/or thematic coherence

NOTE. The notion of legal independence as mentioned in (Kaufmann and Steudler, 1998) is the rationale for the layer concept

4.1.8 Mortgage

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

4.1.9 Network reserve

the representation of the legal, recorded or informal space of a utility network (not the physical object)

4.1.10 Parcel

a **spatial unit** with a legal ownership right; its boudaries demarcate the right; a collection of **parcels** has the geometric property of a full partition

4.1.11 Party

a person, or group of persons, that compose an identifiable single entity (a **recorded object** may play the role of **party**)

4.1.12 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
[ISO 19106]

4.1.13 Recorded object

administrative information concerning zero or more **spatial units** with one or more **rights,** (and/or **restrictions** and/or **responsibilities),** attached to the whole set, as included in a Land Administration system

4.1.14 Registry

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

4.1.15 Register

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

4.1.16 Registration

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

4.1.17 Right

the formal or informal entitlement to own, or to do something

4.1.18 Responsibility

the formal or informal obligation to do something

4.1.19 Restriction

the formal or informal entitlement to refrain from doing something

4.1.20 Source document

a document providing facts

4.1.21 Source point

an observed point in the field

NOTE. This may be observed by terrestrial surveying, photo interpretation, image interpretation, or identification on an existing map

4.1.22 Spatial source document

a document providing the spatial description of a **spatial unit**

4.1.23 Spatial unit

a single area of land or, more specifically, a volume of space, under a unique and homogeneous (bundle of) **right(s)** (e.g. a property right, a land use right).
[based on UN/ECE, 2004 and WG-CPI, 2006]

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

or mortgage) affects the whole **spatial unit**, with the exception that specific **rights** may affect only part of the **spatial unit** (e.g. an encumbrance)

4.2 Abbreviations

GIS	Geographical Information System
GNSS	Global Navigation Satellite System
INSPIRE	INfrastructure for SPatial Information in Europe
LADM	Land Administration Domain Model
LA_RRR	Right, Restriction, Responsibility
STDM	Social Tenure Domain Model
UML	Unified Modeling Language

5 Land administration domain model (LADM)

5.1 Introduction

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

This standard also provides so called 'blueprint' stereotype classes, with a minimal number of attributes, to address the case where an LADM object class refers to external sources for parties, addresses, valuation, taxation or land usage.

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

5.2 The core LADM

Figure 1 shows the core LADM as an UML 2.1 class diagram (see *www.omg.org* for UML 2.1).

The core LADM is based on four classes:

1. Class LA_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.
2. Class LA_RRR (where RRR stands for Right, Restriction, and Responsibility). An instance of a subclass of LA_RRR is associated to zero or one (0..1) instances of LA_Party, and to exactly one (1) instance of LA_RecordedObject.
3. Class LA_RecordedObject. A recorded object (administrative information concerning spatial units) is associated to one or more (1..*) instances of a subclass of LA_RRR, and to zero or more (0..*) instances of a subclass of LA_SpatialUnit.
4. Class LA_SpatialUnit. An instance of a subclass of LA_SpatialUnit (e.g. parcel, buildin, or network) is associated to zero or more (0..*) instances of LA_RecordedObject.

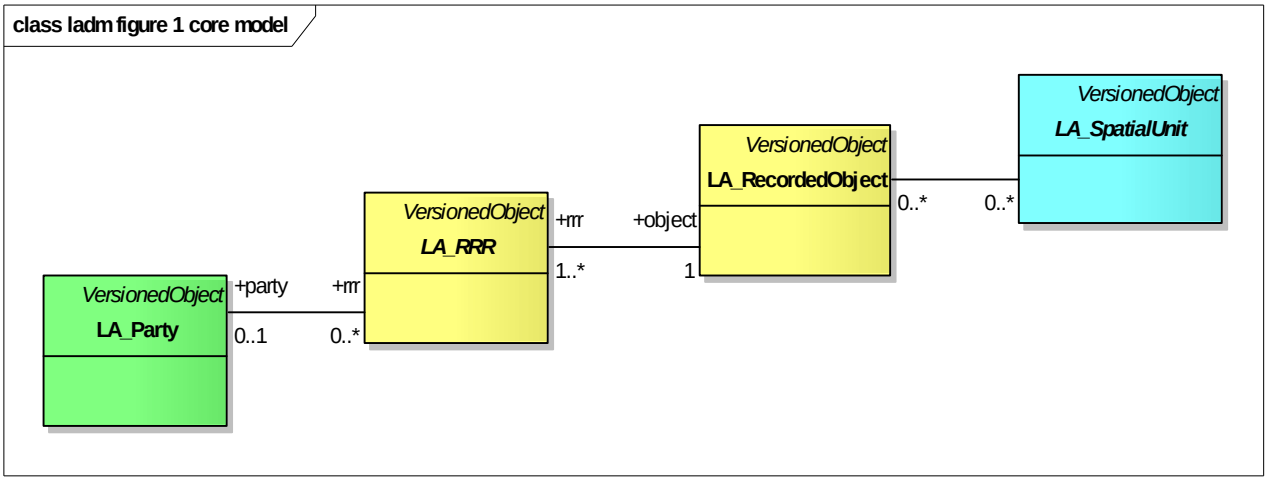

Figure 1. Core classes of the LADM: LA_Party, LA_RRR, LA_RecordedObject, and LA_SpatialUnit

LADM supports temporal aspects of LA_Party, LA_RRR, LA_RecordedObject and LA_SpatialUnit. They all inherit temporal attributes from class VersionedObject.

5.3 The object classes of LADM

5.3.1 Class VersionedObject

This class, re-used from ISO 19108 is introduced into LADM to manage history in the database as shown in Figure 2a.

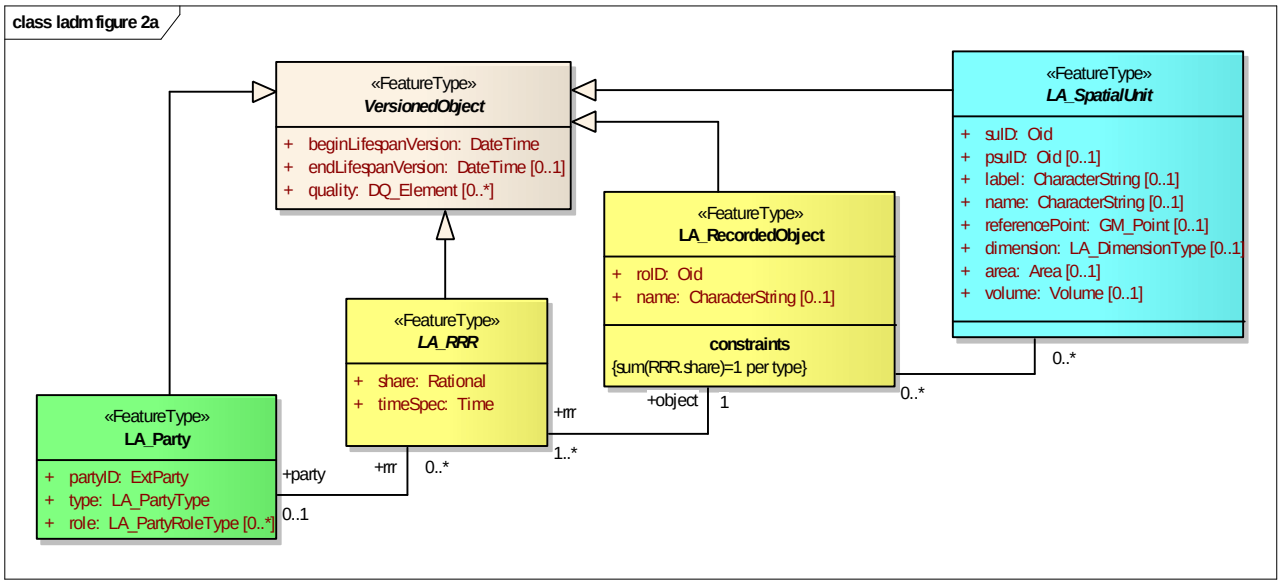

Figure 2a. Class VersionedObject

The attributes of VersionedObject are:

- beginLifespanVersion: the start time of a specific instance version
- endLifespanVersion: the end time of a specific instance version.

Class VersionedObject allows one to manage and maintain historical data in the database. This requires that inserted and deleted data is given a time-stamp in the database. In this way, the contents of the database can be reconstructed, as they were at any moment in the past.

5.3.2 Class LA_Party

An instance of class LA_Party is a party. LA_Party is associated with LA_RecordedObject (a party may be a recorded object, indicated by the attribute type). See Figure 2b.

The attributes of LA_Party are:

- partyID: the identifier of an instance of LA_Party in an external registration ('blueprint' class ExtParty)
- type: the type of an instance of LA_Party (e.g. natural person, non natural person, group, etc.)
- role: the role of an instance of LA_Party in the data update and maintenance process (e.g. conveyor, notary, writer, surveyor, certified surveyor, bank, loan provider, employee, etc.).

NOTE. If role has a value then no right is associated to the party, hence (0..*) multiplicity

5.3.3 Class LA_GroupParty

An instance of class LA_GroupParty is a group party. Class LA_GroupParty is a subclass of LA_Party, because LA_Party may have an association to class LA_RRR (and thereby also to class LA_RecordedObject). Note that an instance of LA_GroupParty may consist of two or more (2..*) instances of LA_Party, but also of other instances of LA_GroupParty (that is to say, a group of group parties, etc.). Conversely, an instance of LA_Party may be a member of zero or more (0..*) instances of LA_GroupParty. See Figure 2b.

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)
- name: the name of the group party

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

5.3.4 Class LA_PartyMember

Class LA_PartyMember is an optional association class between LA_Party and LA_GroupParty. See Figure 2b.

The attribute of LA_PartyMember is:

- share: this is the fraction of the whole.

5.3.5 Class ExtParty

Class ExtParty is a 'blueprint' class for an external registration of parties. See Figure 2b.

The attributes of ExtParty are:

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

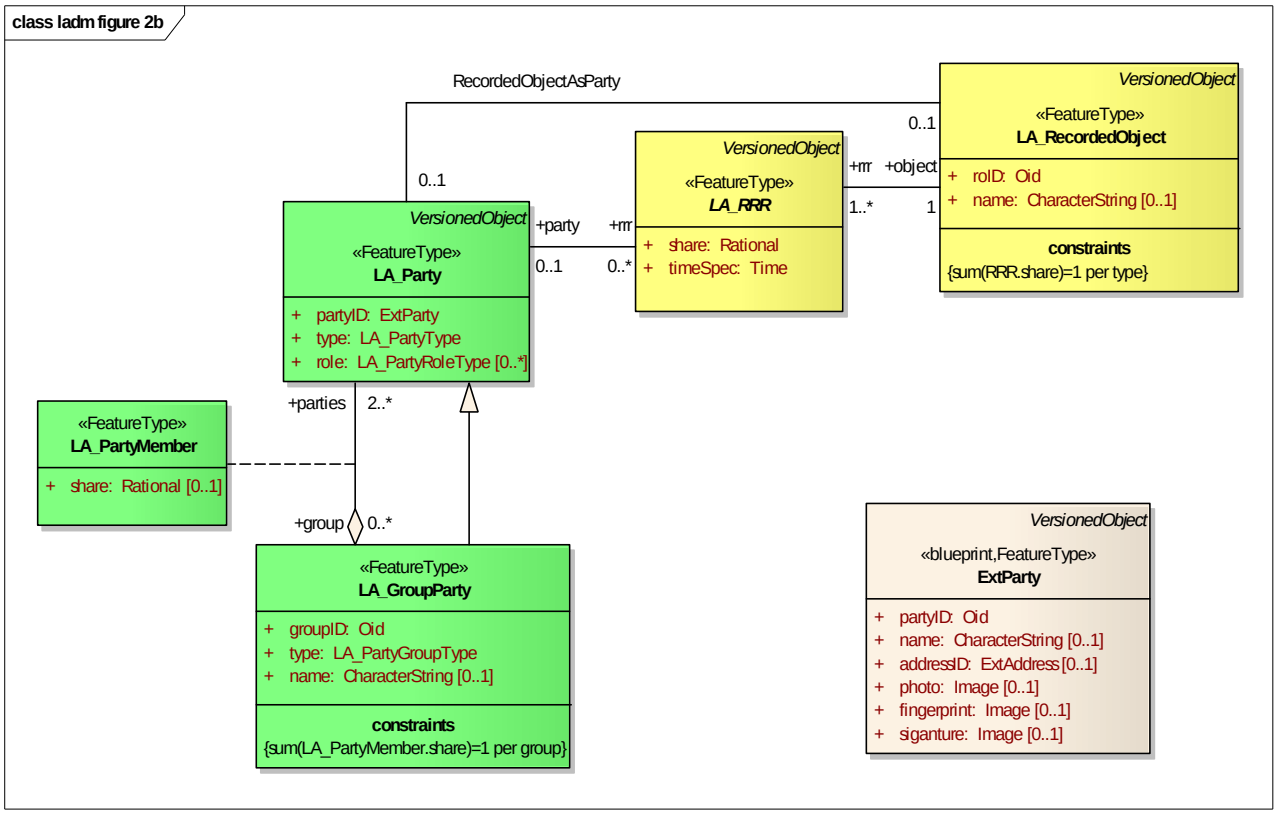

Figure 2b. Classes LA_Party, LA_GroupParty, LA_PartyMember, and ExtParty

5.3.6 Class LA_RRR (Right, Restriction, and Responsibility)

Class LA_RRR is an abstract class (it has no instances). An instance of a subclass of LA_RRR may be a right, a social tenure relationship, a restriction, or a responsibility. If it is a right or responsibility, then it is associated with exactly one (1) instance of LA_Party, and exactly one (1) instance of LA_RecordedObject. If it is a restriction, than it is associated with zero or one (0..1) instances of LA_Party, and exactly one (1) instance of LA_RecordedObject. The latter allows for the registration of restrictions (easements, servitudes, etc.) to a spatial unit, with, or without an association to LA_Party. See Figure 2c

The attributes of LA_RRR are:

- 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
- timeSpec: operational use of a right in time sharing. This attribute is capable of handling other temporal representation, 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.

5.3.7 Class LA_Right

An instance of LA_Right is a right, based on recordation, or registration. Class LA_Right is a subclass of LA_RRR. See Figure 2c.

The attribute of LA_Right is:

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

5.3.8 Class LA_Restriction

An instance of LA_Restriction is a restriction to a (recorded/registered) right. Class LA_Restriction is a subclass of LA_RRR. See Figure 2c.

The attribute of LA_Restriction is:

- type: the type of an instance of LA_Restriction (e.g. a servitude, a monument, etc.).

5.3.9 Class LA_Responsibility

An instance of LA_Responsibility is a responsibility to a (recorded/registered) right. Class LA_Responsibility is a subclass of LA_RRR. See Figure 2c.

The attribute of LA_Responsibility is:

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

5.3.10 Class LA_Mortgage

An instance of LA_Mortgage is a mortgage. LA_Mortgage is associated with LA_Right (the instance of LA_Right that is the basis where the mortgage rest on), and LA_Party (the instance of LA_Party that is the money provider). See Figure 2c.

The attributes of LA_Mortgage are:

- amount: the amount of money of the mortgage, in local currency
- interestRate: interest rate of the mortgage
- ranking: this is, the ranking order if more than one mortgage applies to a right.

5.3.11 Class LA_RecordedObject

An instance of LA_RecordedObject is a recorded object, and subject to registration (by law), or recordation (by informal right, or customary right, or another social tenure relationship). LA_RecordedObject is associated with LA_Party (a party may be a recorded object, indicated by the attribute partyType). LA_RecordedObject may be associated with zero or more spatial units (e.g. a parcel or a building reserve). See Figure 2d.

The attributes of LA_RecordedObject are:

- roID: the identifier of a recorded object
- name: the name of a recorded object
-

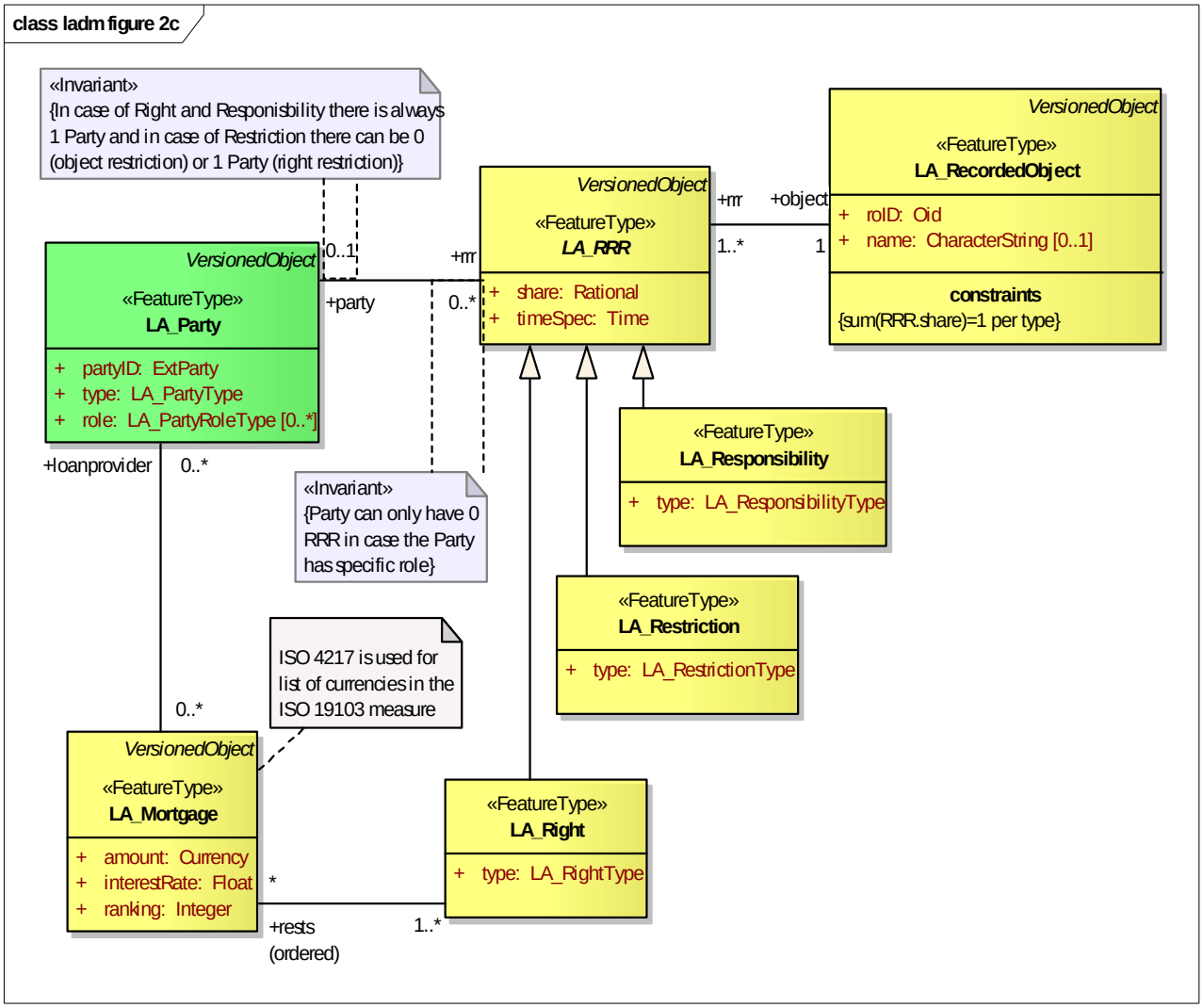

Figure 2c. Classes LA_RRR, LA_Right, LA_Restriction, LA_Responsibility, and LA_Mortgage

5.3.12 Class LA_SpatialUnit

An instance of a subclass of LA_SpatialUnit is a spatial unit. LA_SpatialUnit is a subclass of VersionedObject. LA_SpatialUnit is associated with LA_RecordedObject for administrative information, with LA_Layer for structure information (see Figure 2d), and with LA_FaceString and LA_Face for boundary information, if available (see Figure 2f).

The attributes of LA_SpatialUnit are:

- suID: the spatial unit identifier
- psuID: the preliminary spatial unit identifier. This is an optional temporal identifier, used between data acquisition and final acceptance of the data related to the spatial unit
- label: the label of the spatial unit
- name: the name of the spatial unit
- referencePoint: the coordinates of a point inside the spatial unit
- dimension: the dimension of the spatial unit (e.g. 2D, 3D, liminal, etc.)

- Area: the registered area
- Volume: the registered volume (in case of bounded 3D description)
-

5.3.13 Class LA_SpatialUnitSet

Class LA_SpatialUnitSet is associated with class LA_SpatialUnit and is a subclass of LA_SpatialUnit. Using this class, a link with the administrative subdivision of a region (or country) may be made. See Figure 2d.

The attributes of LA_SpatialUnitSet are:

- susID: the identifier of a spatial unit set
- level: the level in the hierarchy of the (administrative) subdivision
- label: the label of the spatial unit set
- name: the name of the spatial unit set
- referencePoint: a point within the the spatial unit set
- oidType: the type of identifier of the spatial unit set.

5.3.14 Class LA_BuildingReserve

An instance of LA_BuildingReserve is the recorded space or surface around a building. Class LA_BuildingReserve is a subclass of LA_SpatialUnit. See Figure 2d.

The attributes of LA_BuildingReserve are:

- complNum: the identifier of the building
- numberOfFloors: the number of floors in the building
- numberOfUnits: the number of units in the building.

5.3.15 Class LA_BuildingUnit

An instance of LA_BuildingUnit is a building unit. A building unit may be a common (shared) area, or an apartment. Class LA_BuildingUnit is a subclass of LA_SpatialUnit. See Figure 2d.

The attributes of LA_BuildingUnit are:

- addressID: the link to an external address of the building unit
- type: the type of a building unit (e.g. shared, individual, etc.)
- unitNum: the identifier of a building unit.

5.3.16 Class LA_Parcel

An instance of class LA_Parcel is a parcel. Class LA_Parcel is a subclass of LA_SpatialUnit. See Figure 2d.

The attribute of LA_Parcel is:

- addressID: the link to an external address of the parcel.

5.3.17 Class LA_Layer

An instance of class LA_Layer is a layer. Class LA_Layer is associated with class LA_SpatialUnit. See Figure 2d.

The attributes of LA_Layer are:

- lID: the identifier of the layer
- name: the name of the layer

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

5.3.18 Class LA_NetworkReserve

An instance of LA_NetworkReserve represents the area, or space, around a network, which has been registered. Class LA_NetworkReserve is a subclass of LA_SpatialUnit. See Figure 2d.

The attributes of LA_NetworkReserve are:

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

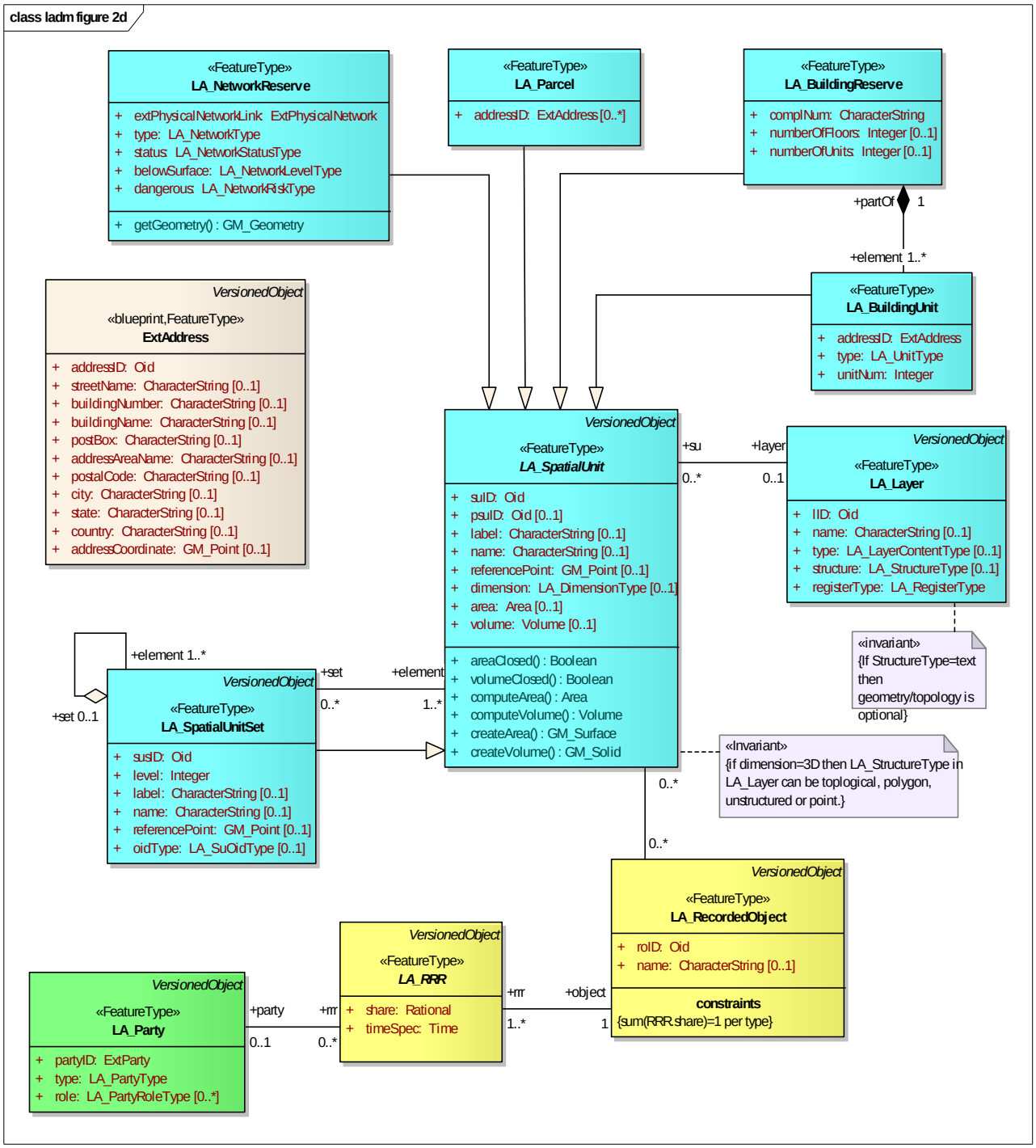

Figure 2d. Classes LA_RecordedObject, LA_SpatialUnit, LA_SpatialUnitSet, LA_NetworkReserve, LA_BuildingReserve, LA_Parcel, LA_BuildingUnit, LA_Layer, and ExtAddress

5.3.19 Class ExtAddress (informative)

Class ExtAddress is a 'blueprint' class for an external registration of addresses. See Figure 2d.

The attributes of ExtAddress are:

- addressID: the identifier of an instance of ExtAddress
- streetName: street name of an instance of ExtAddress
- buildingNumber: building number of an instance of ExtAddress
- buildingName: building name of an instance of ExtAddress
- postbox: post box address
- addressAreaName: address name
- postalCode: postal code of an instance of ExtAddress
- city: city of an instance of ExtAddress
- state: state of an instance of ExtAddress
- country: country of an instance of ExtAddress
- addressCoordinate: the coordinates of an instance of ExtAddress.

5.3.20 Class ExtValuation (informative)

Class ExtValuation is a 'blueprint' class for an external registration of valuation data. See Figure 2e.

The attributes of ExtValuation are:

- roID: the identifier of an instance of ExtValuation
- valueDate: the date of valuation
- valueType: the valuation type
- value: the value of an instance of ExtValuation.

5.3.21 Class ExtUsage (informative)

Class ExtUsage is a 'blueprint' class for an external registration of usage data. See Figure 2e.

The attributes of ExtUsage are:

- suID: the identifier of an instance of ExtUsage
- type: the type of usage.

5.3.22 Class ExtTaxation (informative)

Class ExtTaxation is a 'blueprint' class for an external registration of taxation data. See Figure 2e.

The attributes of ExtTaxation are:

- roID: the identifier of an instance of ExtTaxation
- taxDate: the date of taxation
- taxType: the tax type
- amount: the amount of taxation.

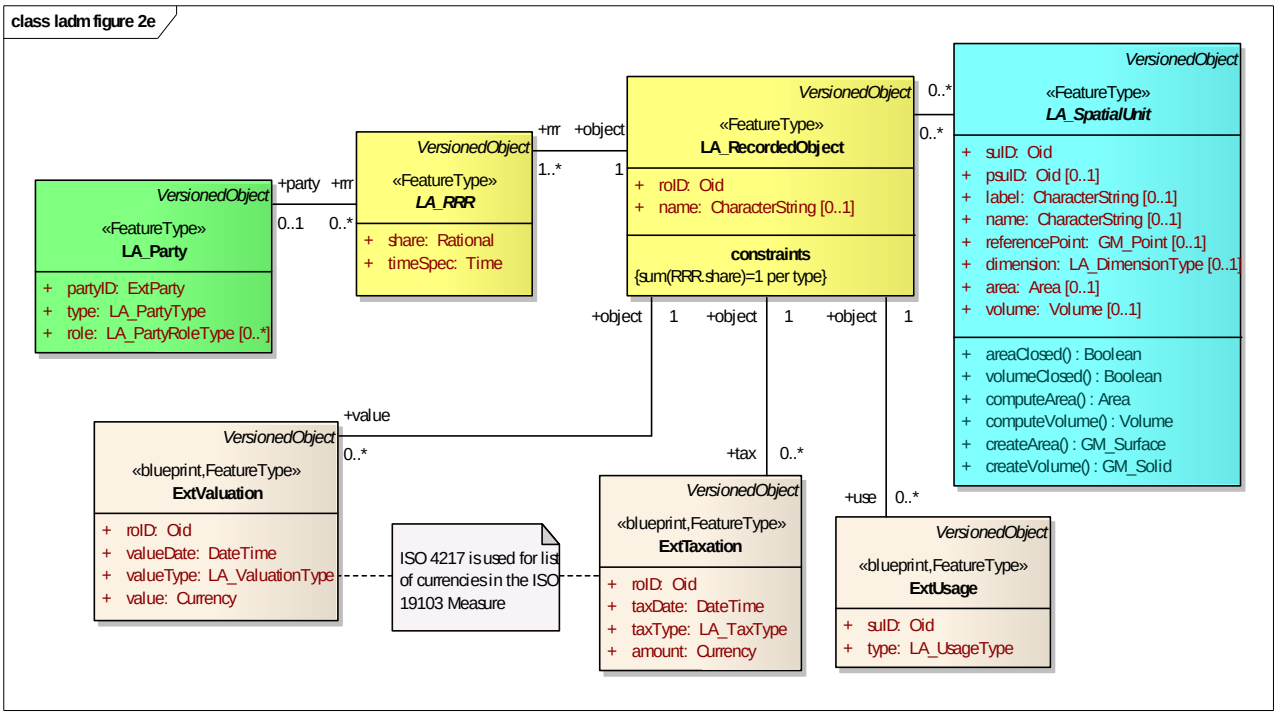

Figure 2e. Classes ExtValuation, ExtTaxation and ExtUsage

5.3.23 Class LA_FaceString

Class LA_FaceString is a subclass of VersionedObject. An instance of LA_FaceString is used to describe the boundary of a spatial unit via a linestring in 2D (which may be projected vertically up and down to have the 3D interpretation if needed; see Section 6.6 for further explanation). It has associations with LA_SourcePoint and LA_SpatialSourceDocument to document the origin of the geometry. See Figure 2f.

The attributes of LA_FaceString are:

- fsID: the LA_FaceString identifier
- geometry: the boundary described via a curve at ground (or zero height) level, can be derived from associated LA_SourcePoint
- locationByText: the boundary described via natural text
- estimatedAccuracy: the estimated accuracy of the boundary description; this can be derived from associated LA_SourcePoint
- productionMethod: the production method of this boundary description; this can be derived from associated LA_SourcePoint.

5.3.24 Class LA_Face

Class LA_Face is a subclass of VersionedObject. An instance of LA_Face is used to describe the boundary of a LA_SpatialUnit via a surface in 3D; see Section 6.6 for more explanations. It has an association with LA_SourcePoint to document the origin of the geometry. See Figure 2f.

The attributes of LA_Face are:

- fID: the LA_Face identifier
- geometry: the boundary described via a surface in 3D space; can this be derived from associated class LA_SourcePoint

- estimatedAccuracy: the estimated accuracy of the boundary description; this can be derived from associated class LA_SourcePoint
- productionMethod: the production method of this boundary description; can this be derived from associated LA_SourcePoint.

5.3.25 Class LA_SourcePoint

An instance of LA_SourcePoint is a point of an instance of LA_SpatialUnit, as observed in the field. See Figure 2f.

The attributes of LA_SourcePoint are:

- pID: an LA_SourcePoint identifier
- spaceDimension (derived): the number of dimensions (2D or 3D)
- locationOrig: calculated co-ordinates, based on observations
- locationTransf: shift in co-ordinates, after a new survey of the same point
- pointType: type of monumentation in the field (e.g. beacon, corner stone, marker, etc.)
- interpolationRole: the role of source point in the structure of a curve
- transformation: transformation used (from calculated co-ordinates in a local reference system to transformed co-ordinates).

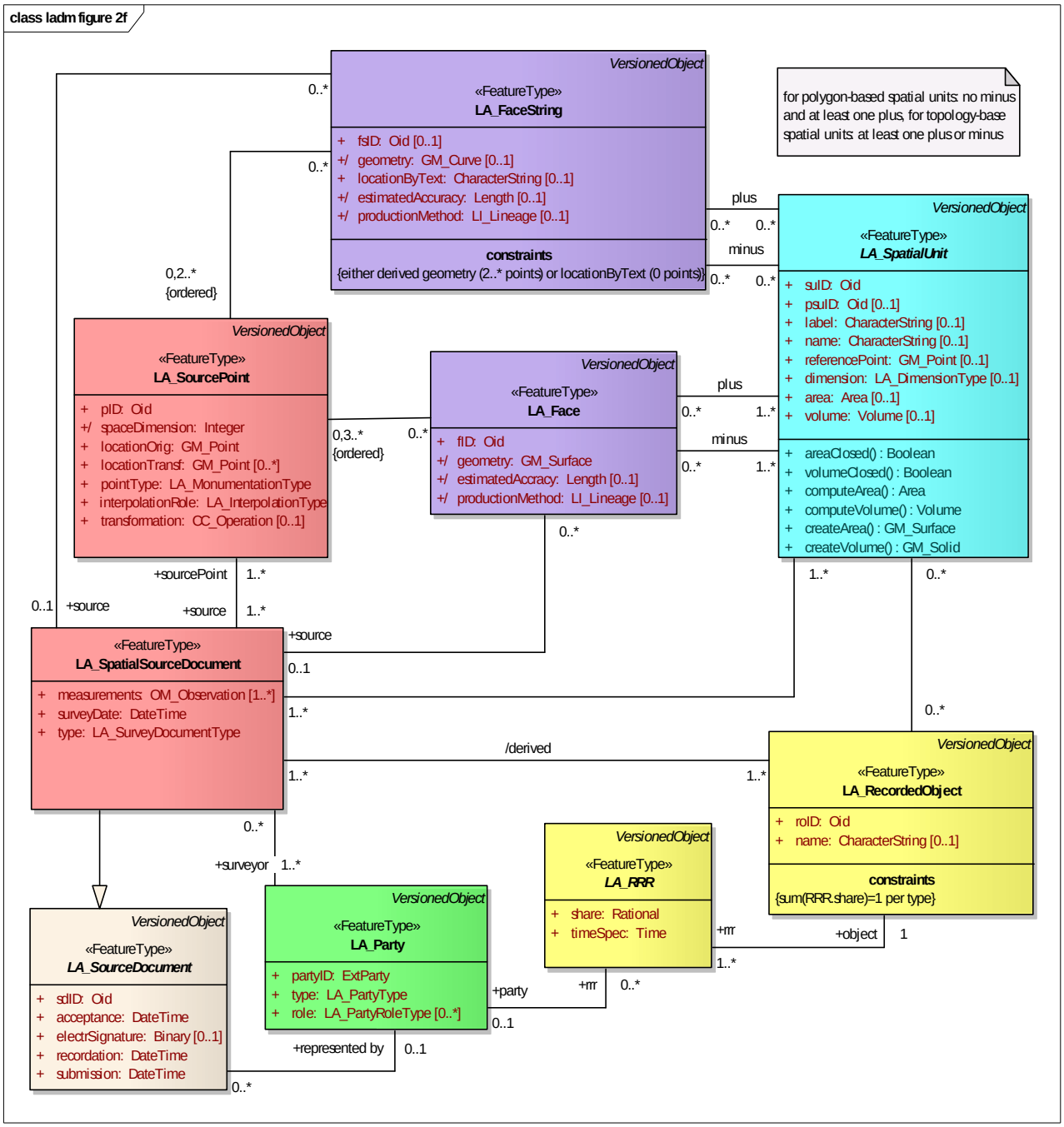

Figure 2f. Classes LA_FaceString, LA_Face, LA_SourcePoint, and LA_SpatialSourceDocument

5.3.26 Class LA_SpatialSourceDocument

An instance of class LA_SpatialSourceDocument is a spatial source document. See Figure 2f.

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

- surveyDate: date of survey in the field
- type: type of the spatial source document (e.g. field sketch, orthophoto, etc.).

5.3.27 Class LA_SourceDocument

An instance of a subclass of class LA_SourceDocument is a source document. In LADM, source documents are modelled, starting with an abstract class LA_SourceDocument. See Figure 2g.

The attributes of LA_SourceDocument are:

- sdID: an identifier of the source document
- acceptance: date of acceptance of the source document by an authority
- electrSignature: data in electronic form which are attached to, or logically associated with, other electronic data and which serve as a method of authentication
- recordation: date of registration (recordation) of the source document by registering authority
- submission: date of submission of the source document by an instance of LA_Party.

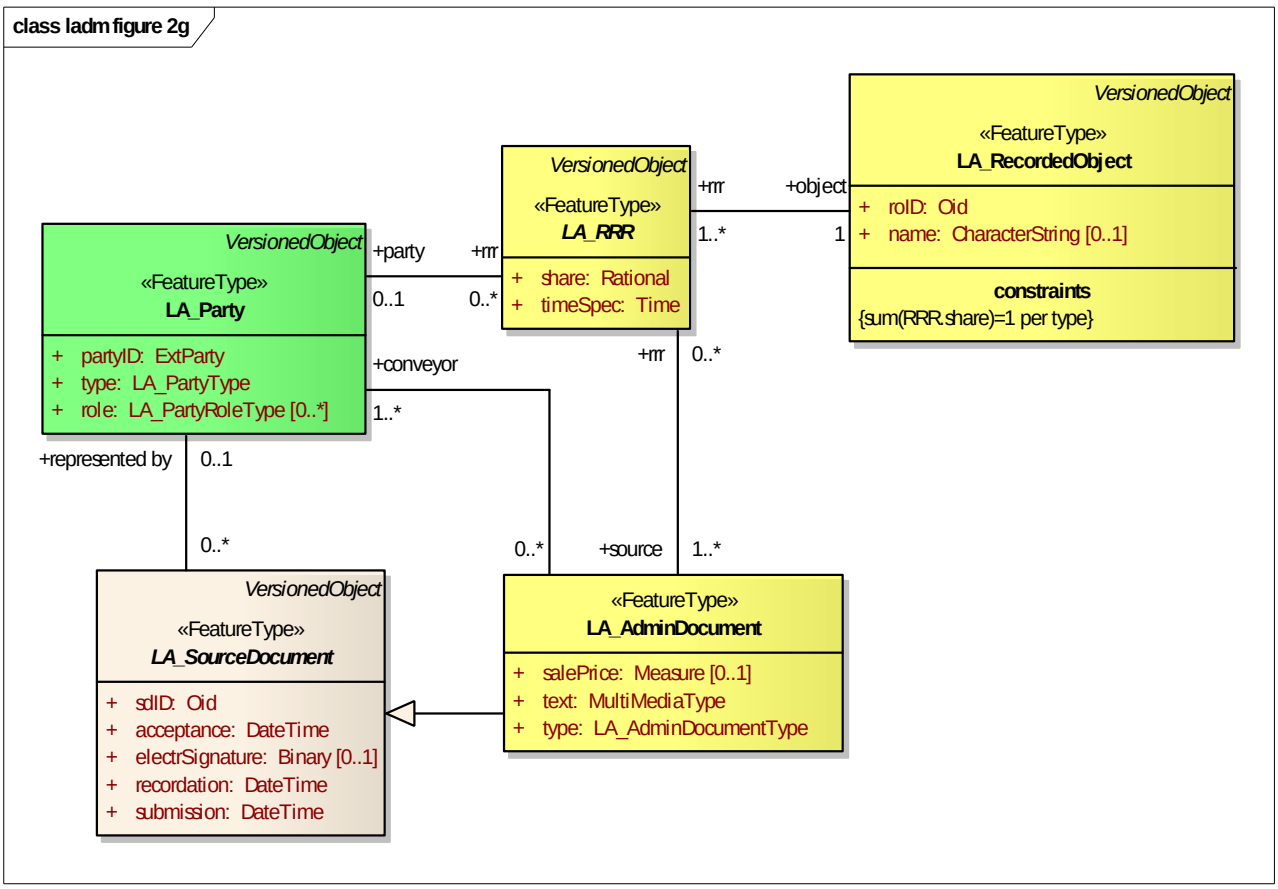

Figure 2g. Classes LA_SourceDocument, and LA_AdminDocument

5.3.28 Class LA_AdminDocument

An instance of class LA_AdminDocument is an administrative document. Class LA_AdminDocument is a subclass of LA_SourceDocument. See Figure 2g.

The attributes of LA_AdminDocument are:

- salePrice: purchase price in relation to a transaction (buying, selling, etc.)
- text: the document
- type: type of document (e.g. a deed, title, etc).

6 Packages of the LADM

6.1 Introduction

The LADM contains several different classes for parties, rights, and spatial units. This facilitates the maintenance of different data 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.

One need not look at the whole model at once, as the coherent parts of the model represent UML packages. The advantages of distinguishing several packages are: to be able to present the LADM in comprehensive parts yet maintain and develop packages independently; and being able to use a package to implement one type of functionality.

6.2 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 3a.

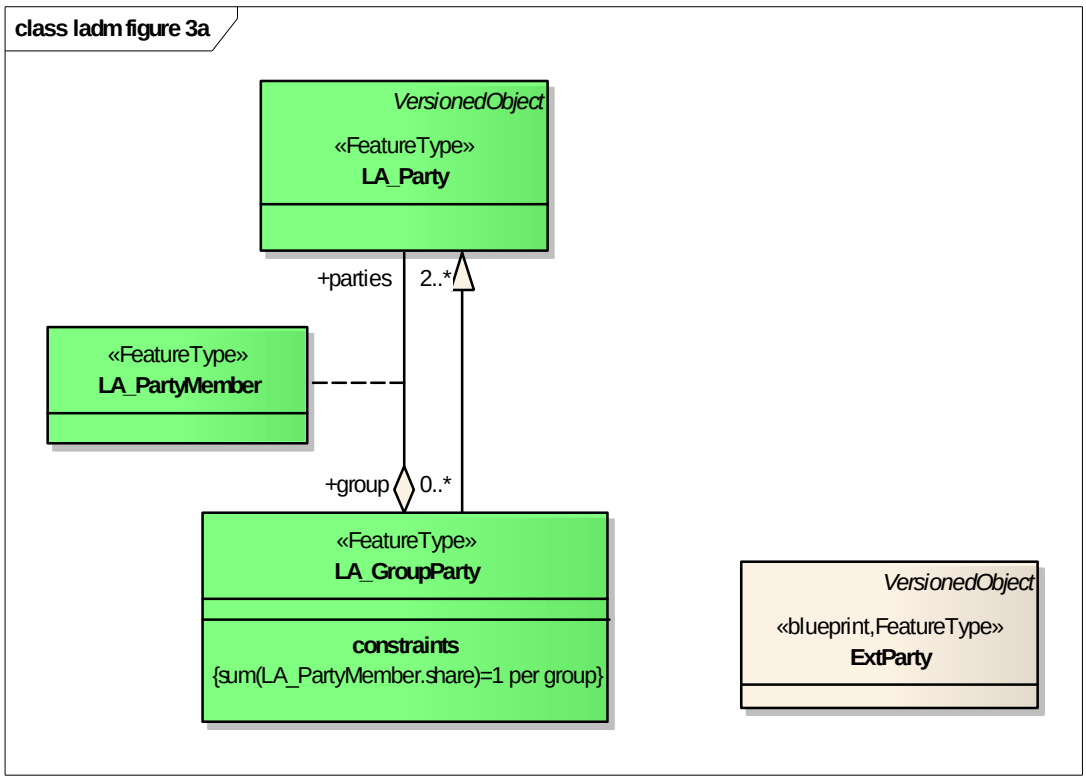

Figure 3a. Party Package

A group party may be a party. This allows for the inclusion of group of groups. A group party may held a share in a right. A party member may hold a share within the group party. If so, then the sum of shares of party members should be equal to 1.

6.3 Spatial unit package

Spatial units are refined into three main categories:

1. Land/marine [2D] or space [3D] spatial units.
2. Buildings.
3. Utility networks.

Land/marine or space spatial units may be from different recordations. See Figure 3b.

The different types of land/marine or space spatial units include: topological spatial units, polygon spatial units, line spatial units, point spatial unit, and text spatial unit.

A collection of topological spatial units have a consistent topological structure (with no gaps nor overlaps or intersections), and include their boundaries, in contrast with a collection of polygon spatial units, where a consistent topological structure is not guaranteed. A line spatial unit is represented by a collection of lines which may be collected from different sources. This collection of lines is not topologically structured, so that area calculation is not possible. A point spatial unit only contains the coordinates of the unit's reference point. A text spatial unit is not represented by coordinates, but has a spatial description in words, e.g. the metes and bounds system (a system of spatial unit description in terms of distance, direction, and landmarks).

A spatial unit may change its representation over time, from text spatial unit, to point spatial unit, to line spatial unit, to polygon spatial unit, to topological spatial unit. All these spatial units may have a 3D representation.

Spatial units may be grouped into instances of LA_SpatialUnitSet, for example, a section, a municipality, a planning area. An instance of LA_SpatialUnitSet may be a grouping of other instances of LA_SpatialUnitSet. In implementations of the LADM, this may be related to spatial unit identifiers; when a spatial unit identifier is composed out of e.g. country id/department id/county id/municipality id/etc. Further, it is possible that a recorded object is associated with a group of spatial units.

The different classes of building spatial units are LA_BuildingReserve and LA_BuildingUnit. These specializations of LA_SpatialUnit have associations with zero or more instances of LA_Party via the LA_RecordedObject class. A building reserve (the representation of the legal, recorded or informal space, not the physical object) is composed out of several building units. Note that a building unit is intended in the general sense, not only for living purposes, but also for other purposes, e.g. commercial. Further note that LA_RecordedObject allows the relating of one right to, for instance, a combination of spatial units (e.g. an apartment and a parking place).

A building unit has type as attribute. This may be used to represent shared units, or individual units. In this a way, an apartment could be represented as an individual unit, and the common areas (threshold, stairs, corridors, elevator, roof,…) as a shared unit. For all types there may be separate rights, restrictions or responsibilities.

It is possible that no spatial unit exists for a recorded object. For instance, in the case of a right to fish in a commonly held area, 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_RecordedObject to LA_SpatialUnit.

A layer is a collection of spatial units with a geometric or thematic coherence. A layer may be organized on the basis of the geometric structure of the collection (code list LA_StructureType). In case of a full partition the notion of legal independence from Cadastre 2014 (Kaufmann and Steudler, 1998) will be satisfied. For

example, a layer with rights, a layer with restrictions, etc. Another approach is a layer structure for urban area, rural area, mining area, etc.

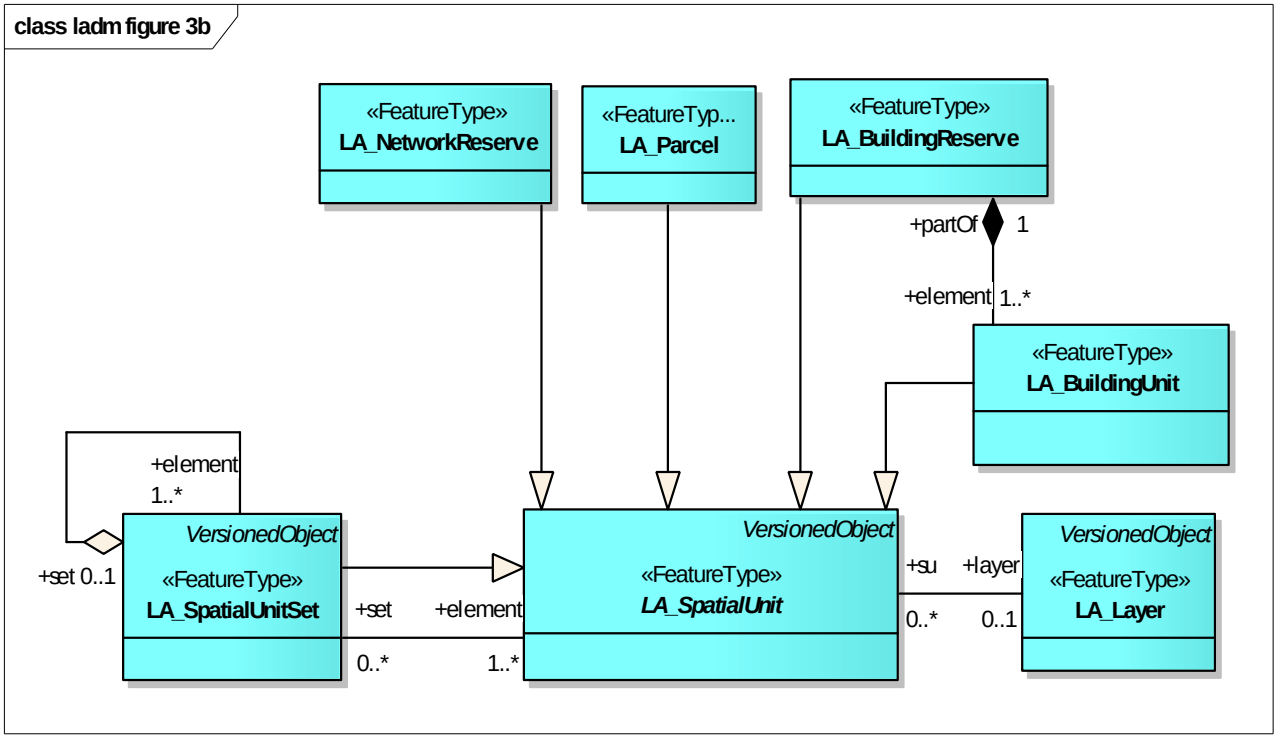

Figure 3b. Spatial unit package

6.4 Administrative package

The main class in this package is the abstract class LA_RRR, with its specializations LA_Right, LA_Restriction, and LA_Responsibility.

In principle, all specializations of LA_RRR are based on an instance of LA_AdminDocument as source. See Figure 3c.The essential data, for example names, or transaction dates, which can be obtained from class LA_AdminDocument, may be represented in the classes LA_RRR, LA_Mortgage, LA_Party, LA_RecordedObject, and LA_SpatialUnit. A single instance of LA_AdminDocument may even create of mix of these types. Conversely, an instance of the specializations of class LA_RRR, or class LA_Mortgage is always associated with exactly one instance of LA_AdminDocument as its source. It is possible to describe more than one mortgage in one administrative document.

It should be noted that 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 could 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 right by the newly created right. The rights and 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). Because property and ownership rights are generally based on (national) legislation, code lists may support this. A Customary Right related to a region, or an Informal Right may be included; from modelling perspective this is straightforward.

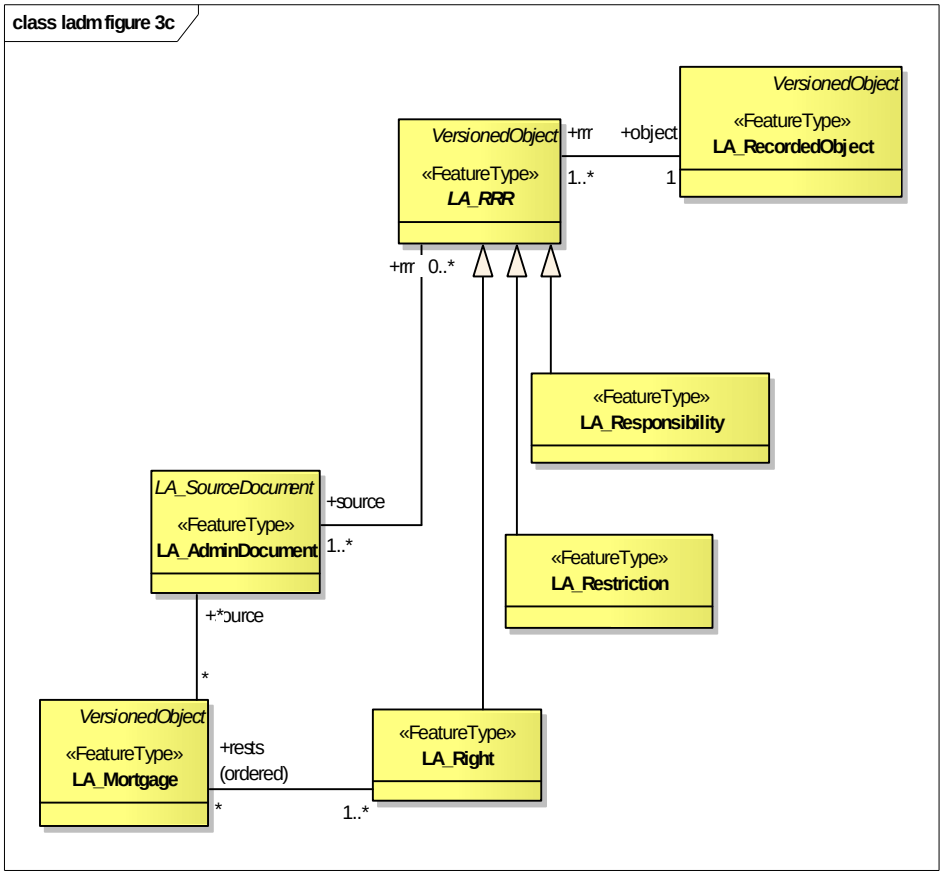

Figure 3c. Administrative package

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 LA_Party (either 'the government' or 'society-at-large') and usually they are primarily seen as restrictions. Some of them apply to a specific spatial unit (or right therein), or a small 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. Each non-ownership right by a third party (be it government, or a private party) creates a restriction.

Class LA_Right (a specialization of the abstract super class LA_RRR) has a compulsory association between LA_SpatialUnit and LA_Party, where this is not compulsory in the case of class LA_Restriction, or class LA_Responsibility (the other specializations of LA_RRR). The class LA_RRR allows for the introduction of shares of rights in cases where more than one instance of LA_Party hold together a complete right (or restriction, or responsibility).

Note that a restriction means that you have to allow someone to do something, or that you have to refrain from doing something yourself. Restrictions may both be 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. Responsibilities mean that one has actively to do something. Not all formal systems allow such mandated activities as property rights, and this will also affect the question whether they may be (or should be) registered. Their impact may be substantial, and their registration is therefore preferable.

The class LA_RRR has associations to both LA_Party and LA_RecordedObject (Zevenbergen, 2004; Paasch, 2005). It is possible that a single spatial unit is associated to several instances of LA_Party (via LA_RecordedObject, and LA_RRR associations) and, conversely, that a single party is related to several spatial units (again, via LA_RRR, and LA_RecordedObject associations). There is always at least one

instance of LA_Right (subclass of LA_RRR) 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. A point of discussion is how to represent the subtractions (restrictions), as they are already implied by a non-primary right of a third party. The fact that a neighbour is allowed to walk over your spatial unit is an additional right (appurtenance, positive-side) to the ownership of his property, whereas it is a restriction (encumbrance, negative-side) to your property. In the present model, both sides are represented (Zevenbergen, 2004).

One or several mortgage(s) are always vested on a (set of) right(s).A mortgage is usually vested as collateral for a loan. Therefore, the loan provider is associated to LA_Mortgage. LA_Mortgage is associated with class LA_Right.

The fact that all the different (public law, or private law) rights find their base in some kind of establishing or transacting document is represented by connecting them to LA_AdminDocument which is a specialization of the abstract class LA_SourceDocument. The party responsible for drafting the document is connected to this as conveyer.

It is possible that a recorded object is only associated with LA_RRR and not with LA_Party. In this way, land with joint ownership, and other types of common lands, may be modelled. This is expressed by the multiplicity [0..1] from LA_RRR to LA_Party.

6.5 Surveying package (see Figure 3d)

Data acquisition may be conducted digitally in a field office, or compiled from various sources using forms and field sketches, orthoimages or orthophotos, or existing topographic maps. In the case of traditional land surveying, a sketch will be used to identify the surveyed points. A further option is data acquisition based on GNSS, or a combined GNSS/images approach. The forms are used to record administrative data about the parties, RRR's (such as social tenure relationships), and spatial units. The orthoimages or orthophotos may be used to create the identifiers of spatial units, possibly with boundaries. The same method can be used for buildings. If no orthoimages or orthophotosare available, a field sketch can be made of the spatial units and buildings, showing the neighbouring relationships. A spatial unit can be incomplete. An alternative field sketch might be a (digital) photograph of a sketch again showing the spatial unit identifiers and neighbouring relationships. Another option is to include a description in words of the spatial units. Finally, it may that no spatial data is referenced at all, except a village name.

A land administration survey is documented on an instance of LA_SpatialSourceDocument, which is a source document. This may be the final (sometimes formal) document, or all documents related to a survey. Spatial source documents may be created in the field, and may be finished in the office. Sometimes, several documents are the result of a single survey. The document may contain digital signatures, where these have legal standing; otherwise, 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 survey points are instances of class LA_SourcePoint, which is associated with LA_SpatialSourceDocument. A SpatialSourceDocument may be associated with several instances of LA_SourcePoint. The survey points form the measured foundation of both the topology-based spatial units, and the non topology-based spatial units.

If a survey point is observed during different surveys, there will be different instances of LA_SpatialSourceDocument. If a survey point is observed from different positions during a survey, there is only one association with an instance of LA_SpatialSourceDocument. One of the attributes of class LA_SourcePoint is the pointType, which indicates the type of survey point; this could for example be a Geodetic Control Point (GCP). Further, there may be reasons for changing coordinates, for example map revision, or moving to a different coordinate reference system, or new computation of the existing coordinate reference system. Geodetic control points, including multiple coordinates for points and supporting multiple reference systems are supported in the LADM.

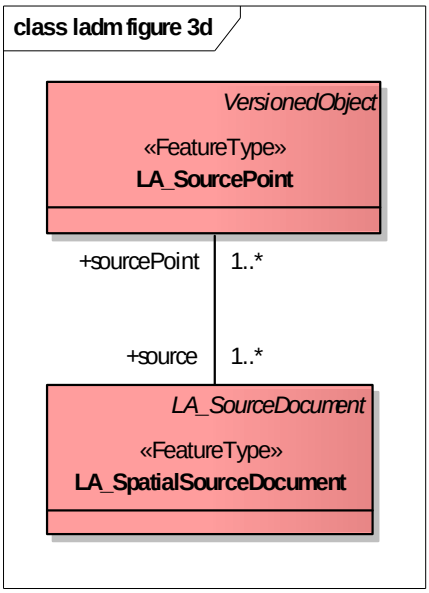

Figure 3d. Surveying package

6.6 Spatial representation package

All types of LA_SpatialUnit (2D parcels, 3D parcels, buildings, utility networks) share the same representation structure. An important requirement is that existing 2D data, whether topologically structured or not, or polygons, or unstructured, or simply point or textual descriptions, should easily be included. At the same time, the model should also support the increasing use of 3D representations of LA_SpatialUnit, without putting additional burden on the existing 2D representations. An important requirement is that there should be no mismatch between the parts of the domain that are described in 2D and the parts of the domain that are described in 3D. Further, the LADM should be based as much as possible on accepted and available spatial schema's, such as published in ISO 19107.

The model described below has been designed using key concepts such as LA_FaceString and LA_Face. See Figure 3e. Coordinates themselves are rooted in instances of LA_SourcePoint (mostly after geo-referencing, depending on the data collection method used).

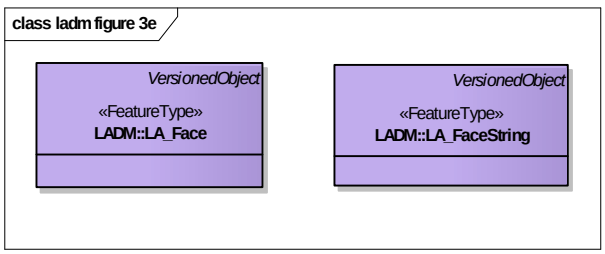

Figure 3e. Spatial representation package

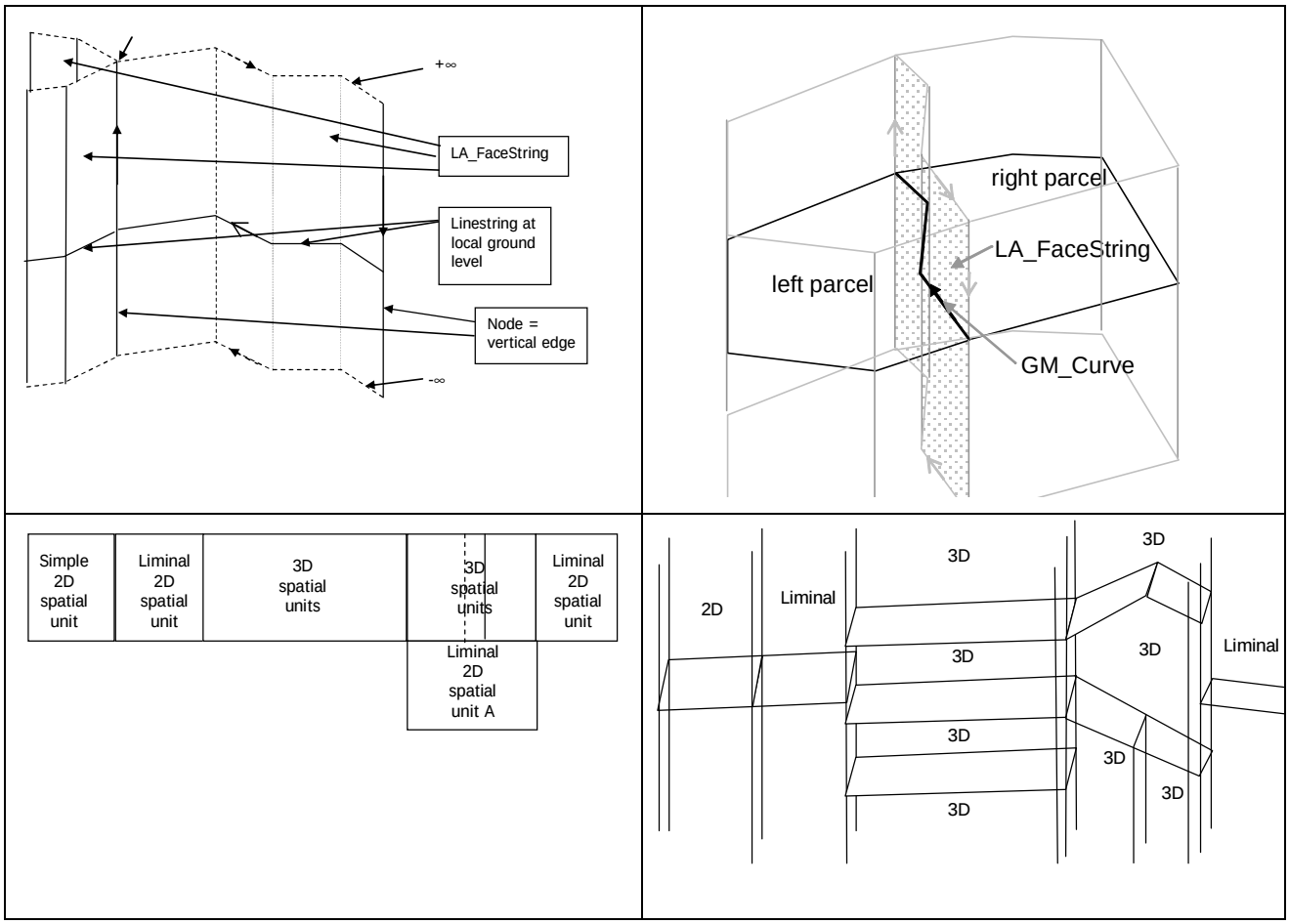

Figure 3f. *Upper left*: Face string concepts. *Upper right*: spatial units defined by face strings. *Lower left*: top view of mixed 2D/3D representations *Lower right*: side view showing the mixed use of face string and face to define both bounded and unbounded 3D volumes (Thompson, 2008)

As pointed out by (Stoter, 2004), in many countries a 2D description should be interpreted as a 3D prismatic volume with no upper and lower bound; see Figure 3f (upper left and upper right). Using this interpretation, 2D and 3D representations may be unified. The boundaries in the 2D descriptions are called face strings: they use a normal GM_Curve (linestring) for storage, but this implies a series of vertical faces. For true 3D descriptions that also have non-vertical faces, the class LA_Face is introduced. A *liminal* spatial unit (that is a spatail unit on the treshold of 2D and 3D) has a combination of face strings and vertical instances of LA_Face. The vertical faces should dissolve into face strings (when common pairs of edges are removed). The faces should be completely defined from an (undefined) upper bound to an (undefined) lower bound. 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 respresentation of an LA_SpatialUnit. E.g. 3D may be applied for a mining cadastre, or it may 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_Layer):

- point based (point spatial unit)
- text based (text spatial unit)
- unstructured (line) based (line spatial unit)

- polygon based (polygon spatial unit), and
- topological based (topological spatial unit).

A point spatial unit is used when the only information about location are the coordinates of a single point within their area (or volume). The attribute ‘referencePoint’ in LA_SpatialUnit is used to record this location, which may carry a z value.

A text spatial unit is used when the 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, may be used as a specific labelling point, and could carry a z value.

A line (‘spaghetti’) spatial unit is used when the 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 unitss. The spatial units are linked to the face strings that define them. For the 3D case, at least one face is included (and this may intersect other face strings and faces).

A polygon spatial unit is used when each 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 should be applied by the originating and receiving software. In the 2D representation 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 representation uses at least one (non-shared) LA_Face.

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 only, 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 representations are also possible, because an face string instance may 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, but text on others. It is also possible to topologically encode text based spatial units; for example, part of a boundary may be defined by text “along the natural shoreline”, while the other boundaries could be defined by coordinates. The face string that defines the shoreline may 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 should be stressed that the above applies to any type of spatial unit (including the ones that are used for recorded spaces around buildings and utilities, or for servitudes). To organize the instances, there is the concept of a layer model. This is especially relevant for the topology based spatial units, but also applies to other types. For example, there may be a base layer (1) with ownership spatial units, which are topologically defined and there could be an additional layer (2) with polygon based spatial units representing servitudes. The concept of layers may also be used in other situations. For example, layer 1 for the current ownership and layer 2 for the pre-war ownership. A 3D example would be layer 1 containing ownership (2D, liminal and 3D topological spatial units) and layer 2 would contain ownership of ‘legal space’ around utilities crossing many other spatial units (from which the utilities space could be subtracted); see Figure 3g.

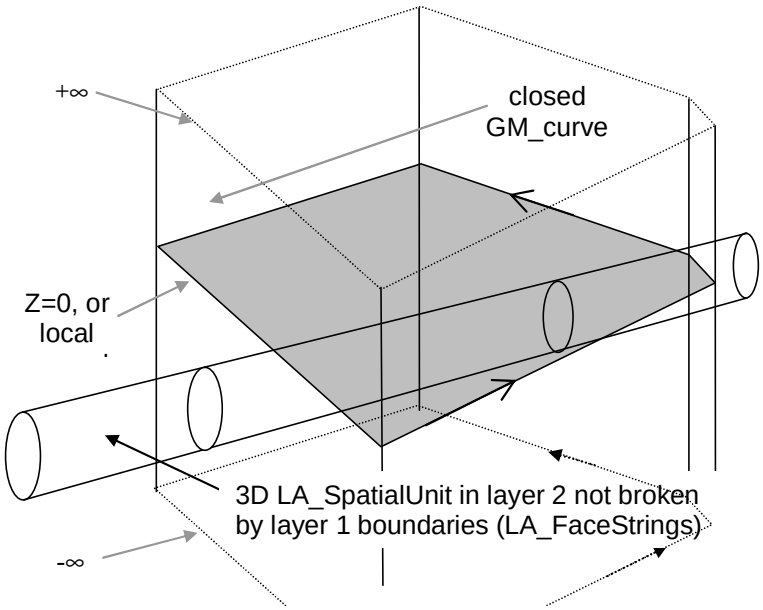

Figure 3g. Multiple layers

The 2D or 3D (topology) structures should 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 should also be maintained: that is, no time gaps or overlaps can occur in the representations. Therefore, the structure is based on spatio-temporal topology. Current land administration registration systems, based on 2D topological and geometrically described spatial units, have shown limitations in defining the (2D and 3D) location of 3D constructions (e.g. pipelines, tunnels, building complexes) and in the vertical dimension (depth and height) of rights established for 3D constructions (Stoter, 2004). In the LADM, 2D and 3D data are treated in a consistent manner throughout the model. It is important to realize that there is a difference between the 3D physical object itself and the legal space related to this object. The LADM only covers the 'legal space'; that is the space that is relevant for the Land Administration (bounding envelope of the object). This is usually larger than the physical extent of the object itself (for example including a safety zone).

7 Other aspects of the 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; and (2) state 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).

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 valid. 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 representations, 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, or LA_RecordedObject – or directly via VersionedObject.

The LADM covers both event based modelling (via class LA_SourceDocument), and state based temporal modelling (via class VersionedObject). In addition to the event and state 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 may also be derived from a spatio-temporal overlay, the model has not been made more complex through the explicit parent-child relationships. Implementation of parent-child relationships is possible in a country profile.

Besides the data modelling aspect of the dynamic processes within the LADM, it provides support for investigating how functions and processes are related to each other? The UML class diagram should further be completed by diagrams covering other aspects, e.g. via state (use case, sequence, collaboration, state or activity) diagrams.

Activity diagrams show how processes are related to the information (data), and how it ‘flows’ from one in to the other. In all the other types of UML diagrams, actors or organizations in this Standard play an important role, and this may be dependent on (national) arrangements. The introduction of different ‘stages’ of a spatial unit (point, image, surveyed), a right (start, landhold, freehold), and a party further reflect the dynamic nature of the system.

7.2 Interface classes

There may be many interface classes 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.

7.3 Code lists

Code lists may be used in the LADM for using local, regional, or national terminology. See Figure 4.

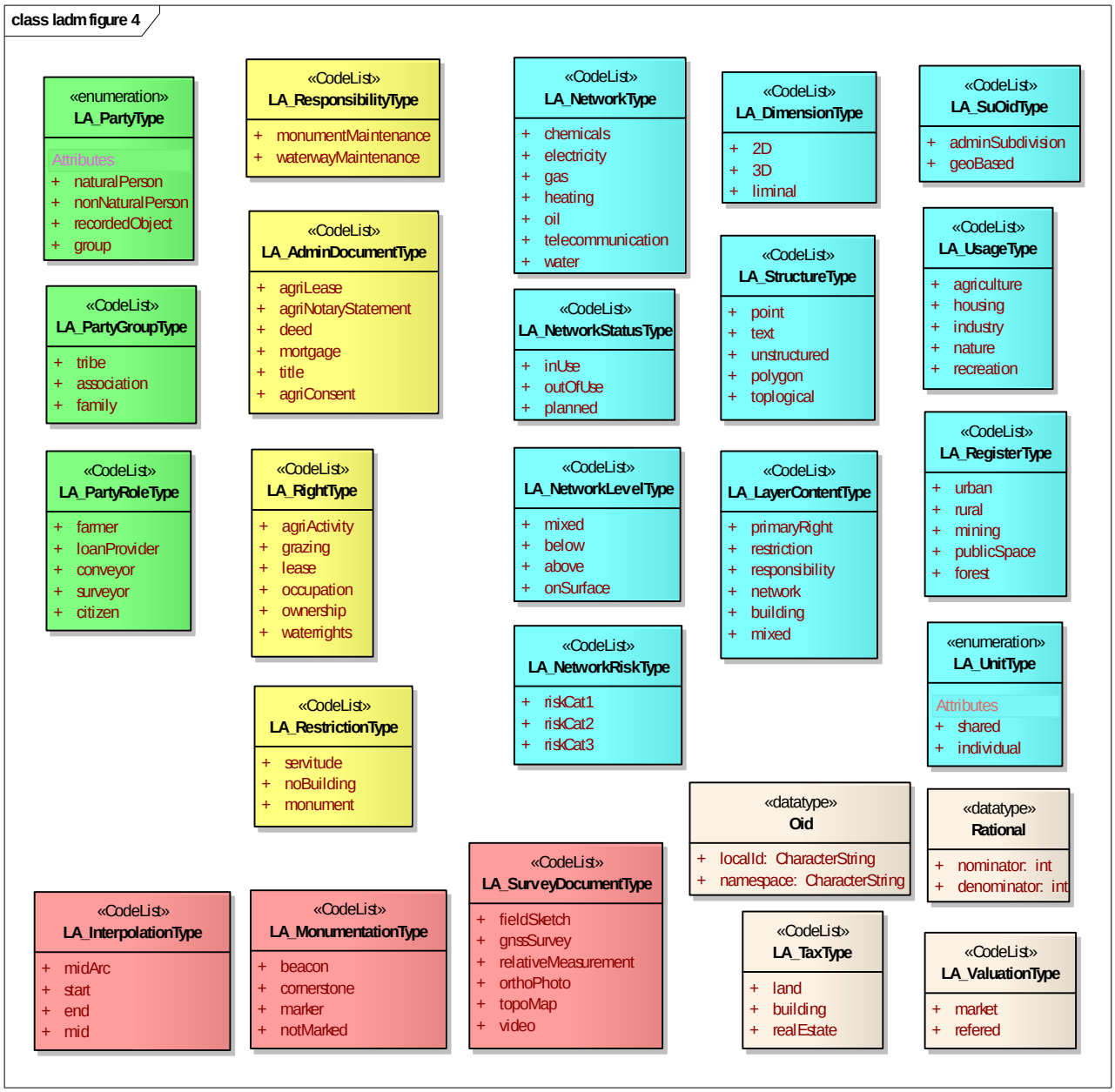

Figure 4 — Types (basic types and code lists)

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