ISO/TC 211 N 2385

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ISO/TC 211
Geographic information/Geomatics

Title:	**New Work Item Proposal, Geographic information — Land Administration Domain Model (LADM)**
Source:	International Federation of Surveyors (FIG)
Expected action:	P-members and liaison members are requested to use the ISO committee internal balloting system to cast their vote and submit comments, no later than 2008-05-01
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Type of document:	New Work Item Proposal
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NEW WORK ITEM PROPOSAL	
Date of presentation 2008-02-01	Reference number (to be given by the Secretariat)
Proposer FIG	ISO/TC 211 / SC N 2385
Secretariat SN	

A proposal for a new work item within the scope of an existing committee shall be submitted to the secretariat of that committee with a copy to the Central Secretariat and, in the case of a subcommittee, a copy to the secretariat of the parent technical committee. Proposals not within the scope of an existing committee shall be submitted to the secretariat of the ISO Technical Management Board.

The proposer of a new work item may be a member body of ISO, the secretariat itself, another technical committee or subcommittee, or organization in liaison, the Technical Management Board or one of the advisory groups, or the Secretary-General.

The proposal will be circulated to the P-members of the technical committee or subcommittee for voting, and to the O-members for information.

See overleaf for guidance on when to use this form.

IMPORTANT NOTE: Proposals without adequate justification risk rejection or referral to originator.
Guidelines for proposing and justifying a new work item are given overleaf.

Proposal (to be completed by the proposer)

Title of proposal (in the case of an amendment, revision or a new part of an existing document, show the reference number and current title)

English title: Geographic information — Land Administration Domain Model (LADM)

French title (if available):

Scope of proposed project

This International Standard defines a land administration (cadastral) domain model covering both the 'administrative/legal' component and the 'spatial/surveying' component of Land Administration. The standard provides a conceptual schema with basic packages related to 'persons', 'immovable objects', 'rights/responsibilities/restrictions', 'surveying' and 'geometry/topology'.

The standard model covers the common aspects of cadastral registration in various national and international systems, and is as simple as possible in order to be useful in practice. This allows the harmonisation through a core model of the differing practices and procedures in different jurisdictions, thereby enabling cross-border sharing of cadastral information. The Land Administration Domain Model is designed not to interfere with national land administration laws. It is organised into packages to support its objectives.

Concerns known patented items (see ISO/IEC Directives Part 1 for important guidance)

☐ Yes ☒ No If "Yes", provide full information as annex

Envisaged publication type (indicate one of the following, if possible)

☒ International Standard ☐ Technical Specification ☐ Publicly Available Specification ☐ Technical Report

Purpose and justification (attach a separate page as annex, if necessary)

There are several motivations behind these standardisation efforts, such as meaningful exchange of information between organisations, or efficient component-based system development through applying standardised models.

Cadastral data are initially collected, maintained and disseminated in a distributed environment, which means that data can be maintained by different organisations, such as municipalities or other planning authorities, private surveyors, conveyancers and land registrars depending on the local traditions.

In the future the volume of cross border information exchanges are expected to increase, particularly within the European Union -- see for example the recent agreement within the EU in relation to INSPIRE, where cadastral parcels are included; or the Eulis development. The more remote that the data user is from the data source, the more important it becomes to ensure that the data are well defined -- for the obvious reason that remote users are likely to have much reduced local knowledge to assist them in interpretation - see for example the Glossary as developed in the Eulis project. Trying to make the meaning of the data explicit is therefore an important step in facilitating meaningful exchanges of information across greater distances. The concepts used have to be well defined and structured (that is, related to one other), and this entails development of a cadastral domain ontology. One potential way to express part of this ontology is UML (Unified Modeling Language) class diagrams.

Cadastral data that are accessible in a computerised environment can (significantly) increase the demand for cadastral data. Standardisation contributes to efficient development and renewal of cadastral systems, also in developing countries. Land registry or cadastre organisations are confronted with rapid developments in technology: there is a technology push driven by developments in the Internet, (geo-)databases, modelling standards, open systems, GIS; and a market pull driven by an increasing demand for enhanced user requirements, e-governance, sustainable development, electronic conveyancing, and integration of public data and systems. Standardisation in the cadastral domain would help (geo)ICT vendors, as it would allow them to invest their efforts in the development of a (generic) system, based on the concepts as described in UML class diagrams, instead of focusing on a single cadastral organisation. This would stimulate the availability of generic (object-oriented) standard software from multiple (geo-)ICT vendors from which the cadastral organisations can make a selection. This will provide them with the fundament of new systems, without developing everything from scratch: only local modification and extensions would need to be developed.

Whilst access to data, its collection, maintaining and updating could be facilitated at local level, the overall land information infrastructure could be recognised as belonging to a uniform national service so as to promote sharing within and between countries. A core cadastral domain model in which classes and associations between classes representing objects, attributes and operations are derived from different tenure systems could, definitively contribute to the efficient fulfillment of local cadastral needs.

The land administration domain model will also be useful in comparing cadastral systems.

To summarise: a standardised land administration domain model will serve at least two important goals: it will avoid re-inventing and re-implementing the same functionality over and over again (instead it will provide an extensible basis for efficient and effective cadastral system development), and it will enable stakeholders, both within one country and between different countries, to engage in meaningful communication based on the shared ontology implied by the model. Given that cadastral information is the bedrock of secure land ownership, which is essential to economic development, the creation of a standardised core cadastral domian model is a vital development.

Target date for availability (date by which publication is considered to be necessary)

Proposed development track ☐ 1 (24 months) ☒ 2 (36 months - default) ☐ 3 (48 months)

Relevant documents to be considered

ISO 19115 Metadata

ISO 19113 Quality principles

ISO 19107 Spatial schema

ISO 19108 Temporal schema

ISO 19109 Rules for application schema

ISO 19136 GML

ISO TC211 N1859 Core Cadastral Domain Model discussion paper

OGC Implementation Specification Geography Markup Language (GML 3.0)
OGC Implementation Specification Web Feature Service (WFS)
OGC Implementation Specification Catalog Interface (CAT))

Relationship of project to activities of other international bodies

FIG has been developing the model; and a specialisation of the model is under development in close cooperation with UN-HABITAT

The OGC Property and Land Information Initiative seeks to design, test and operationally validate open architectural (standards based) frameworks for distributed property and land information networks.

INSPIRE, specifically the data specification (related to metadata and data/service sharing) supported by the EU Joint Center (JRC).

Liaison organizations
FIG, OGC, EU JRC (INSPIRE)

Need for coordination with:
☐ IEC ☒ CEN ☐ Other (please specify)

Preparatory work (at a minimum an outline should be included with the proposal)

☒ A draft is attached ☐ An outline is attached. It is possible to supply a draft by

The proposer or the proposer's organization is prepared to undertake the preparatory work required ☒ Yes ☐ No

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Comments of the TC or SC Secretariat

Supplementary information relating to the proposal

☒ This proposal relates to a new ISO document;

☐ This proposal relates to the amendment/revision of an existing ISO document;

☐ This proposal relates to the adoption as an active project of an item currently registered as a Preliminary Work Item;

☐ This proposal relates to the re-establishment of a cancelled project as an active project.

Other:

Voting information

The ballot associated with this proposal comprises a vote on:

☒ Adoption of the proposal as a new project

☐ Adoption of the associated draft as a committee draft (CD) (see ISO Form 5, question 2.3.1)

☐ Adoption of the associated draft for submission for the enquiry vote (DIS or equivalent) (see ISO Form 5, question 2.3.2)

Other:

Annex(es) are included with this proposal (give details)

☒ **Note explaining previous submission of NWIP and action taken**

Date of circulation	Closing date for voting	Signature of the TC or SC Secretary
2008-02-01	2008-05-01	Bjørnhild Sæterøy

Use this form to propose:

a) a new ISO document (including a new part to an existing document), or the amendment/revision of an existing ISO document;

b) the establishment as an active project of a preliminary work item, or the re-establishment of a cancelled project;

c) the change in the type of an existing document, e.g. conversion of a Technical Specification into an International Standard.

This form is not intended for use to propose an action following a systematic review - use ISO Form 21 for that purpose.

Proposals for correction (i.e. proposals for a Technical Corrigendum) should be submitted in writing directly to the secretariat concerned.

Guidelines on the completion of a proposal for a new work item
(see also the ISO/IEC Directives Part 1)

a) Title: Indicate the subject of the proposed new work item.

b) Scope: Give a clear indication of the coverage of the proposed new work item. Indicate, for example, if this is a proposal for a new document, or a proposed change (amendment/revision). It is often helpful to indicate what is not covered (exclusions).

c) Envisaged publication type: Details of the types of ISO deliverable available are given in the ISO/IEC Directives, Part 1 and/or the associated ISO Supplement.

d) Purpose and justification: Give details based on a critical study of the following elements wherever practicable. *Wherever possible reference should be made to information contained in the related TC Business Plan.*

1) The specific aims and reason for the standardization activity, with particular emphasis on the aspects of standardization to be covered, the problems it is expected to solve or the difficulties it is intended to overcome.

2) The main interests that might benefit from or be affected by the activity, such as industry, consumers, trade, governments, distributors.

3) Feasibility of the activity: Are there factors that could hinder the successful establishment or global application of the standard?

4) Timeliness of the standard to be produced: Is the technology reasonably stabilized? If not, how much time is likely to be available before advances in technology may render the proposed standard outdated? Is the proposed standard required as a basis for the future development of the technology in question?

5) Urgency of the activity, considering the needs of other fields or organizations. Indicate target date and, when a series of standards is proposed, suggest priorities.

6) The benefits to be gained by the implementation of the proposed standard; alternatively, the loss or disadvantage(s) if no standard is established within a reasonable time. Data such as product volume or value of trade should be included and quantified.

7) If the standardization activity is, or is likely to be, the subject of regulations or to require the harmonization of existing regulations, this should be indicated.

If a series of new work items is proposed having a common purpose and justification, a common proposal may be drafted including all elements to be clarified and enumerating the titles and scopes of each individual item.

e) Relevant documents and their effects on global relevancy : List any known relevant documents (such as standards and regulations), regardless of their source. When the proposer considers that an existing well-established document may be acceptable as a standard (with or without amendment), indicate this with appropriate justification and attach a copy to the proposal.

f) Cooperation and liaison: List relevant organizations or bodies with which cooperation and liaison should exist.

ANNEX TO NEW WORK ITEM PROPOSAL CONCERNING
LAND ADMINISTRATION DOMAIN MODEL (LADM)

A previous version of this NWIP was submitted in late 2006 [N2125], with a number of comments received [N2135]. The comments were considered by the Programme Maintenance Group in May 2007, which concluded:

1. ISO is supportive of this domain-specific work progressing in ISO/TC 211;

2. There has been no notified conflict of the proposal with any other ISO/TCs

3. A draft standard needs to accompany a resubmission of the proposal;

4. It is essential to clarify, in the scope, the relationship of the standard with regard to national land law etc, and what barriers the lack of an International Standard is creating

5. Consideration should be given to whether the standard should be split into parts.

The PMG felt that all other comments submitted could be resolved as part of the normal drafting process.

This resubmission has responded to points 3 and 4 above. Consideration has been given to point 5 but it has not been felt to be necessary.

This amended NWIP is therefore submitted for ISO/TC 211 ballot, with the hope of holding a first Project Team meeting in Copenhagen in May 2008 if the ballot is approved.

ISO TC 211N 2385

Date: 2008-01-25

ISO/WD xxxx

ISO TC 211/SC /WG

Secretariat: SN

Geographic information — Land Administration Domain Model (LADM)

Warning

This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Document type: International Standard
Document subtype:
Document stage: (20) Preparatory
Document language: E

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 191xx was prepared by Technical Committee ISO/TC 211, *Geographic Information/Geomatics*.

Introduction

This International Standard defines the Land Administration Domain Model (LADM). Land administration is a large field; the focus of this standard is on the part of land administration that is mainly connected to real properties, land ownership, and the geometrical (spatial) components thereof. The LADM will serve at least two important goals: (1) avoid reinventing and re-implementing the same functionality over and over again, but provide a extensible basis for an efficient and effective land administration system development based on a Model Driven Architecture (MDA), and (2) enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model. The second goal is very important for creating standardized information services in an international context, where land administration domain semantics have to be shared between countries (in order to enable necessary translations). Important conditions during the design of the model are: it should cover the common aspects of land administration all over the world, should be based on the conceptual framework of Cadastre 2014 (Kaufmann & Steudler, 1998), should follow international ISO standards, and at the same time the model should be as simple as possible in order to be useful in practice.

Annex A contains the abstract test suite in other to establish the conformance of a given model with the LADM. The Social Tenure Domain Model (STDM) is a specialization of the LADM. This model is an illustration of the use of the LADM standard in a specific context. The STDM is presented in the Annex B. The functionality of the STDM is included in the LADM, but the terminology is adapted to the specific needs. For every country something similar has to be done: specialize the model and adapt terminology to the local language. Annex C illustrates using the LADM in a number of specific cases by showing instance level UML object diagrams. Annex D contains an overview of all classes (including their attributes and operations) in the form of a feature catalogue (consistent with clause 5 of the standard).

Until now, most countries (or states or provinces) have developed their own cadastral 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 cadastres have a fiscal background, others a legal one. However, the separate implementation and systems maintenance of cadastral systems are not cheap, especially if one considers the ever-changing requirements. Also, the different implementations (foundations) of the cadastral systems do not make meaningful communication very easy, e.g. in an international context. Looking at it from a little distance one can observe that the systems are in principle mainly the same: they are all based on the relationships between persons and land, via (property) rights and are in most countries influenced by developments in Information and Communication Technology (ICT). The two main functions of every cadastral- and land registry are: (1) keeping the contents of these relationships up-to-date (based on legal transactions), and (2) providing information on this registry.

The UN Land Administration Guidelines (UNECE, 2006) speak about 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 mode in which rights to land are held, we could 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 to assign a certain legal meaning to the registered right (e.g. a title). Therefore land administration systems are not ‘just handling only geographic information’ as they represent a lawfully meaningful relationship amongst people, and between people and land. As the 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, the role of information technology 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. Organisations are now increasingly confronted with rapid developments in the technology, a *technology push*: internet, (geo)-databases, modelling standards, open systems, GIS, as well as a growing demand for new services, a *market pull*: e-governance, sustainable development, electronic conveyance, integration of public data and systems. Cadastral modelling is considered as a basic tool facilitating appropriate system development and re-

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

Standardization has become a well-known subject since the establishment of cadastral- and land registries. In both paper-based systems and computerized systems, standards are required to identify objects, transactions, relations between real estate objects (e.g. parcels) and persons (also called subjects in some countries), classification of land use, land value, map representations of objects, etc. Computerized systems ask for further standardization when topology and identification of single boundaries are introduced (van Oosterom & Lemmen, 2001). In existing cadastral- and land registries, standardization is limited to the region or jurisdiction where the cadastral- and land registry is in operation. Open markets, globalisation, and effective and efficient development and maintenance of flexible (generic) systems require further standardization.

Geographic information — Land Administration Domain Model (LADM)

1 Scope

This International Standard defines a Land Administration Domain Model (LADM) covering both the 'administrative/legal' component and the 'spatial/surveying' component of Land Administration. The standard provides a conceptual schema with five basic packages related to 'persons', 'immovable objects', 'rights/responsibilities/restrictions', 'surveying' and 'geometry/topology'.

The standard model covers the common aspects of cadastral registration in various national and international systems, and is as simple as possible in order to be useful in practice. This allows the harmonisation through a core model of the differing practices and procedures in different jurisdictions, thereby enabling cross-border sharing of cadastral information. The LADM is designed not to interfere with national land administration laws. It is organised into packages to support its objectives.

2 Conformance

An abstract test suite for this International Standard is given in 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 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 19136, *Geographic information -- Geography Markup Language (GML)*

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 Cadastre

A type of land information system that records land parcels as a part of a country's land administration, conveyancing or land registration system. (UN/ECE, 2005).

4.1.2 Registry

Information system on which a register is maintained.

4.1.3 Registration

Assignment of a permanent, unique and unambiguous identifier to an item.

4.2 Abbreviations

EULIS	European Land Information Service
FIG	International Federation of Surveyors
GIS	Geographical Information System
LADM	Land Administration Domain Model
PCC	Permanent Committee on Cadastre in the European Union
STDM	Social Tenure Domain Model
UML	Unified Modeling Language
WPLA	Working Party on Land Administration, operating under the auspices of the United Nations Economic Commission for Europe, Committee on Human Settlements.
WG-CPI	Joint working group of the PCC and EuroGeographics on the Cadastral Parcel in INSPIRE data specification

5 Land Administration Domain Model

5.1 Concept of the LADM

In this section the LADM and related functionality is introduced. The classes, attributes and associations, including the draft (preliminary) definitions are introduced in subsections. The LADM is developed according to the rules for application schema as defined by ISO 19109. 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 even complete new classes will be needed for a specific country or region; see for example the STDM in Annex B. Further it has to be noted that it is possible to use only a subset of the LADM for a specific implementation; there are many options in implementing subsets.

RegisterObject (e.g. Parcel), Person and Right (Restriction and Responsibility) are the three well-known concepts of the LADM. At the class level the model also includes Immovables such as LegalSpaceBuilding and OtherRegisterObject (geometry of an area where a restriction or responsibility is valid, such as a right of way, protected region, LegalNetwork: legal space around utility object, etc.) and the following concepts: SourceDocument such as SurveyDocument or LegalDocument (e.g. deed or title), Responsibilities, Restrictions (defined as Rights by other Person than the one having the ownership Right) and Mortgages. At the attribute level of the model the following aspects are included: salePrice, useCode, taxAmount, interest, ranking, share, measurements, qualityLabel, legalSize, estimatedSize, computedSize, transformationParams, pointCode, and several different date/times.

The core of the model is based on the three classes: (1) RegisterObject (including all types of Immovables and Movables), (2) RRR (Right, Restriction, Responsibility), and (3) Person (including Group). The model supports the temporal aspects of the involved classes: Person, RRR and RegisterObject all inherit from VersionedObjects (with temporal attributes based on ISO 19108:2002), see also section 5.7 below. The model offers several levels of Parcel representation (depending on the data acquisition methods and the use of existing spatial data sources): Parcel (solid, face, edge and nodes based on ISO 19107), SpaghettiParcel (only geometry), PointParcel (single point), and TextParcel (no coordinate, just a description). The geometry and topology (2D and 3D) are based on the ISO/TC 211 standard classes. The model is specified in UML class diagrams and it is indicated how this UML model can be converted into an XML schema, which can then be used for data exchange.

In the model there is no direct relationship between Person and RegisterObject, but only via RRR. The LADM is presented in UML (Booch, Rumbaugh, Jacobsen, 1999). Figure 1 shows the core of the model in a UML class diagram, which also contains the interface object OwnershipFolio; see 5.8 for more details on this.

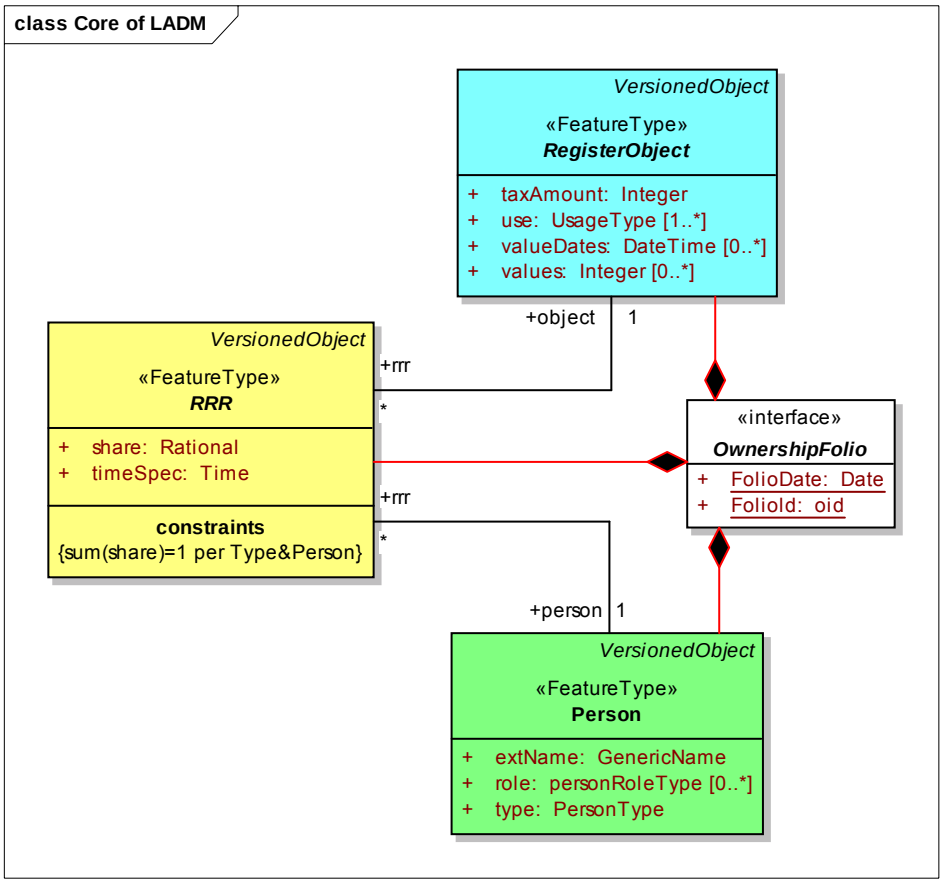

Figure 1 — Core of the LADM: Person, RRR (Right, Restriction, Responsibility) and RegisterObject

The LADM contains legal/administrative object classes such as persons, rights and the geographic description of real estate objects. This means in principle that data could be maintained by different organizations. The model can be implemented in a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model (diagram), thereby using parts of the model. The model can also be implemented for one or more maintenance organization(s) 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 can communicate on the basis of standardized legal, administrative and technical update processes.

One should not look at the whole model at once as the colours represent UML ‘packages’ or coherent parts of the model: immovable object specializations (the “blue package”, see par 5.2), surveying aspects (the “pink

package", see par 5.3), geometric/topological aspects (the "purple package" par 5.4) person aspects (the "green package", see par 5.5) and legal/administrative aspects (the "yellow package", see par 5.6).

The advantages of distinguishing several packages are: being able to present the LADM in comprehensive parts, maintain and develop packages independently, and being able to use a package to implement one type of functionality.

5.1.1 VersionedObject

This class is re-used from ISO 19108 and is introduced into the LADM to manage history in the database. Attributes:

- beginValidityVersion: the start time (DateTime) of a specific object version
- endValidityVersion: the end time (DateTime) of a specific object version

5.1.2 RegisterObject

RegisterObjects are objects which are subject to registration in a (public) registration by law. RegisterObject is a subclass of VersionedObject. RRR (Rights, Restrictions and Responsibilities) is associated with RegisterObject. RegisterObject has as subclasses: Movable and Immovable. RegisterObject has as attributes:

- Use: that is the main use of the RegisterObject, e.g. industry, housing, recreation, agriculture, nature. The value domain type is an enumeration type (code list).
- taxAmount: that is the amount of real estate tax in local currency for the RegisterObject.
- Values: this includes the result of valuation, value domain model is array
- valueDates: the corresponding dates of the value array attribute (array of DateTime)

See Figure 2.

5.1.2.1 Movable

This is a movable object, subclass of RegisterObject.

5.1.2.2 Immovable

An immovable object: land and attached objects. From (WG-CPI, 2006): A single area of land or more particularly a volume of space, under homogeneous real property rights and unique ownership. Remark: By unique ownership is meant that the ownership is held by one or several owners for the whole Immovable. By homogeneous property rights is meant that rights of ownership, leases and mortgages affect the whole Immovable. This does not apply to specific rights, which may only affect part of the Immovable. Immovable is a subclass of RegisterObject.

5.1.3 RightRestrictionResponsibility (RRR)

RRR is the real property right or social tenure relationship between Person and RegisterObject, including restrictions and responsibilities. RRR is a subclass of VersionedObject. RRR is associated with Person, RegisterObject and LegalDocument. Attributes are:

- share, this is a share in a RRR (data type is a fraction, with the constraint that the total of all fractions related to a single RRR is equal to 1)
- timeSpec, operational use of a Right in time sharing; This attribute is capable of handling also other temporal representation such as reoccurring pattern (every week-end, every summer, etc.)

5.1.4 Person

Person is a human being or legal person holding a RRR. Person is a subclass of VersionedObject. It is associated with Mortgage, GroupPerson and RRR. Attributes:

- type, this is the type of person (with a value domain type enumeration: naturalPerson, nonNaturalPerson)
- role, this is the role of a Person in the data maintenance and update process: conveyor, notary, writer, surveyor, certified surveyor, bank, money provider, employee, etc, etc
- exName, this is a reference via the name of this person in an external registry

5.2 Immovable Package

Before the classes are introduced in subsections, an overview on the specializations of Immovable is presented. The Immovable objects are refined into two main categories: land, or in 3D space, objects (the 'parcel' family in 2D and 3D), and the other objects. Parcels may be urban or rural. The different types of land (space) objects include: RegisterParcel, SpaghettiParcel, PointParcel, and TextParcel.

These classes can all have actual instances and these instances in various ways describe a piece of land (2D) or space (3D). The other immovable register objects include: LegalSpaceBuilding, BuildingUnit, NonGeoRealEstate, OtherRegisterObject, and LegalNetwork. All these specializations of Immovable have associations with one or more Persons via the RRR class. There are parts, called ServingParcels in the model, which only have direct associations with two or more RegisterParcels. The characteristic of a ServingParcel is that it serves a number of other RegisterParcels, and that it is held in joint ownership by the owners of those RegisterParcels.

Parcels can be aggregated to AdminParcelSets, e.g. a section, a municipality, a planning area. This class contains a method for area calculation. An AdminParcelSet can be an aggregation of other AdminParcelSets. In implementations of the LADM this can be related to identifications.

In the UML class diagram, RegisterParcel, ServingParcel and NPRegion (Non Partition Region) are specializations of the topologically structured Parcel, which all-together form the partition (subdivision without gaps and overlaps) of the region where land administration applies.

An ImmovableComplex is an (optional) aggregation of Immovables. An ImmovableComplex situation might occur in a system where a set of Immovables (e.g. a BuildingUnit, a LegalSpaceBuilding and a Parcel) has a legal/customary meaning. An ImmovableComplex is in itself an Immovable which can be related to a RRR.

The model also allows parcels to be represented based on a partition of the region and represented via a topological structure (in 2D or in 3D), that is, a set of cells without overlaps and without gaps. A land (or space) Immovable/RegisterObject could (initially) be represented with a textual description (label), a single point or a spaghetti polygon, which is not (yet) adjusted with its neighbours in a topological structure. Spaghetti polygons can overlap each other and can be identified. In this way a land administration region can be covered by two different types of regions:
1. Regions based on parcels with a topological structure, and
2. Regions not (yet) based on parcels with a topological structure.
Together those two different types of regions cover the whole region where the land administration applies.

The object class Parcel is specialized into NonPartitionRegion (NPRegion). A NonPartitionRegion is a region without topologically structured data. Note that the NPRegion itself does not have any associated Person (or RRR), that is, it is not a RegisterObject. On the other hand, the land objects in Immovable class also include the following specializations: TextParcel, PointParcel and SpaghettiParcel. These three 'alternative' non-topology representations of a land object can only exist in NPRegion areas. A parcel may change its presentation over time from TextParcel (e.g. associated to Person or RRR later in time), to PointParcel to SpaghettiParcel to RegisterParcel. However, this does not need to be the case in situation that the TextParcel, PointParcel or SpaghettiParcel fulfils the needs. The text, point and spaghetti representation of a

parcel should be interpreted as a parcel description with a certain fuzziness (all 'fuzzy faces' belonging to the same 'conceptual' partition of the surface).

As mentioned above, the other immovable register objects, the non-land (or space in 3D) subdivision objects, include: LegalSpaceBuilding, BuildingUnit, NonGeoRealEstate, OtherRegisterObject, and LegalNetwork. In the LADM there is no explicit association between LegalSpaceBuilding and a Parcel as this can be derived from the geometry and topology structures. In cases where this is not possible, for example because a TextParcel (without geometry) is involved, an explicit association could be added in that specific country or area. A LegalSpaceBuilding is composed out of several BuildingUnits. Note that a BuildingUnit is intended in the general sense, not only for living purposes, but also for other purposes, e.g. commercial. In other words, all BuildingUnits with legal/registration significance are included here. Further note that ImmovableComplex allows the relating of one right to, for instance, a combination apartment BuildingUnit, parking place and another BuildingUnit in the building.

A BuildingUnit has type as attribute. This can be used to represent shared units or individual units. In this a way an apartment could be represented as an individual unit, the common areas (threshold, stairs, corridors, elevator, roof,…) as a shared unit. For all types there can be separate RRRs and Persons. A BuildingUnit is associated to SurveyPoint via a LegalSpaceBuilding.

In most cadastral systems a restriction is associated to a complete RegisterObject (RegisterParcel) and this is also reflected in the presented model: a Person can have a Restriction (specialization of RRR) on a RegisterObject. Note that OtherRegisterObjects are modelled as closed polygons in 2D or polyhedrons in 3D and there is no explicit topology between OtherRegisterObjects, that is, they are allowed to overlap. Typical examples of OtherRegisterObjects are: geometry of an easement (such as 'right of way'), protected region (as a consequence of sustainable management of national resources or nature preservation), and legal space around a utility object: LegalNetwork.

RegisterObject contains attributes required for valuation purposes: arrays of values attributes with linked dates (of observation) are included.

The class NonGeoRealEstate can be useful in case where a geometric description of the RegisterObject does not (yet) exist. E.g. in case of a right to fish in a commonly held area (itself depicted as a ServingParcel), where the holder of the fishing right does not (or no longer) hold rights to a land parcel in the area.

5.2.1.1 RegisterParcel

A RegisterParcel is a Parcel subject to registration. This is a subclass of both RegisterObject and Parcel. Attributes are:

- legalSize: The area of the parcel as described in legal (source) documents. This area can have been determined earlier in time and in general this area is not equal to calculated area from the spatial cadastral boundary vertices

- parcelName: this is the geographic name of the parcel as locally known

5.2.1.2 ServingParcel

A ServingParcel serves two or more RegisterParcels and is held in joint ownership by the owners of those RegisterParcels. Is a subclass of Parcel and associated with RegisterParcel.

5.2.1.3 Parcel

A single area of land, or more particularly a volume of space, under homogeneous real property rights (UN/ECE, 2004) or social tenure relationship. Is associated with AdminParcelSet.

Note: Parcel does not inherit from Immovable/RegisterObject and therefore it has to inherit its temporal attributes directly from VersionedObject, so history management is introduced separately here.

Note: the whole domain is subdivided in two types of regions (where it concerns the representation of real objects into the model): regions based on a partition (ServingParcel and RegisterParcel) and regions not based on a partition (NPRegion: Non Partition Region; described within a NPRegion by TextParcel, PointParcel, or SpaghettiParcels). Regions with a partition are completely covered by non overlapping parcels and can be represented in a topological structure (nodes, edges and faces and, depending on the dimension: solids). A Parcel may change its representation over time from TextParcel to PointParcel to SpaghettiParcel to RegisterParcel.

Attributes are:

- urban: is Urban or Rural parcel (in case of Urban and Rural Cadastral system – data type is Boolean)
- computedSize: calculated area based on the co-ordinates of the boundary points. This area is most of the time not exactly equal to the legalSize of RegisterParcel, Data type is real Real; other data types (Area: ha.are.ca or integer: in square metres) as they can be in local use can be derived from this
- dimension: dimension of Parcel, this can be surface or volume (2D or 3D)
- spatialDescription: this is the spatial representation (ISO 19107)

See Figure 3.

5.2.1.4 TextParcel

For a TextParcel the location of the parcel is described in words. TextParcel is a subclass of Immovable and is associated with NPR (Non Partition Region). Attribute is:

- estimatedSize, this is the estimated area of a TextParcel. Data type is real; other data types (Area: ha.are.ca or integer: in square metres) as they can be in local use can be derived from this.

5.2.1.5 PointParcel

For a PointParcel the location of the parcel is described by one single point (inside) the Parcel. PointParcel is a subclass of Immovable and is associated with NPR (Non Partition Region). Attribute is:

- estimatedSize, this is the estimated area of a PointParcel. Data type is real; other data types (Area: ha.are.ca or integer: in square metres) as they can be in local use can be derived from this.

5.2.1.6 SpaghettiParcel

For a SpaghettiParcel the location is defined by a set of boundary lines, which can be incomplete and/or not topologically structured. SpaghettiParcel is a subclass of Immovable and is associated with NPR (Non Partition Region). Attribute is:

- legalSize, this is the estimated Area of a SpaghettiParcel. Data type is real; other data types (Area: ha.are.ca or integer: in square metres) as they can be in local use can be derived from this.

5.2.1.7 NonPartitionRegion (NPR)

A Non Partition Region is a Region, which contains parcels, which are not (completely) topologically described (TextParcel, PointParcel, and SpaghettiParcel). NPR is a subclass of Parcel and is associated with TextParcel, PointParcel, SpaghettiParcel.

5.2.1.8 OtherRegisterObject

This is an object, other then parcel or building, subject for registration. Other RegisterObject is a subclass of Immovable.

5.2.1.9 LegalSpaceBuilding

This is a legal space or on a legal surface around building. LegalSpaceBuilding is a subclass of Immovable and it is a composition of BuildingUnits.

5.2.1.10 BuildingUnit

A BuildingUnit is a subdivision of a LegalSpaceBuilding and can be a common (shared) area in a LegalSpaceBuilding or an individual property (apartment). Is associated with LegalSpaceBuilding. Attributes are:

- extAddressId, this is the Identifier of the postal address (in an external address register) of a BuildingUnit. The value type of address is outside the scope of the LADM.
- unitNum, this is the (cadastral or object) identifier of a BuildingUnit. The value data type depends on the local structure of cadastral identifiers.
- type, this is the type of BuildingUnit, the value domain type is enumeration type (code list: shared or individual).

5.2.1.11 ImmovableComplex

An ImmovableComplex is a set (aggregation) of Immovables. Is associated with and a subclass of Immovable.

5.2.1.12 AdminParcelSet

AdminParcelSet is an association with the next higher AdminParcelSet, of which the current AdminParcelSet is one of the members. This is a class where the link with the administrative subdivision of a region (country) can be made. Attributes are:

- hierachicalLevel, the level in the hierarchy of the administrative subdivision. The data type is a positive Integer.
- name, the name of the aggregated unit. The data type is CharacterString.

5.2.1.13 LegalNetwork

LegalNetwork is the legal area/space around a utility network, which can be registered. Is a subset of OtherRegisterObject. Attributes are:

- belowSurface, is it an underground network or above the ground, data type is Boolean
- dangerous, Boolean: dangerous or not
- exPhysicalNetwork, reference to the physical (technical) description of the utility network in an external information source (of the organization responsible for the network)
- geometricQuality, precision of geometric data
- networkType, value domain is enumeration type (code list)
- status, value domain is enumeration type (code list)

5.3 Surveying Package

A cadastral survey is documented on a SurveyDocument, which is a source document made up in the field – this can be the final (sometimes legal) document or all documents related to a survey. Survey documents may be established in the field, but finished in the office. Sometimes, several documents are the result of a single survey. This document may contain signatures; in a full digital surrounding a field office may be required to support this under the condition that digital signatures have legal support. Otherwise paper based documents (which may be scanned) should be considered as an integral part of the cadastral system. Files with terrestrial observations - distances, bearings, and referred geodetic control- on points are attributes of SurveyDocument: the Measurements. The individual survey points are associated with SurveyDocument. One SurveyDocument can be associated with several SurveyPoints. The SurveyPoints form the measured foundation of both the topology-based objects and the non topology-based objects.

If a SurveyPoint is observed at different surveys there will be different SurveyDocuments. If a SurveyPoint is observed from different positions during a measurement, there is only one association with a SurveyDocument. One of the attributes of a SurveyPoint is the pointType, which indicates the type of SurveyPoint; this could for example be a Geodetic Control Point (GCP). If the 'same point' is resurveyed several times and the location does change significantly there are two options: replace the old SurveyPoint with a new SurveyPoint (with a new id) and all associated classes (LegalSpaceBuilding, but also Parcel TP_node, TP_edge,..) must be updated in order to refer to this new id. This approach is covered in the LADM. An alternative, not yet covered in the LADM, is to make a new version of the old SurveyPoint (keeps same id, but gets different versions by inheriting from VersionedObject). The associated classes do not have to be updated, only the SurveyPoint itself: new version, better coordinate and association to new SurveyDocument. Previous locations of a specific SurveyPoint can be found via its id, which remains the same. In general the second option is preferred in case the location of the SurveyPoint is changed as this offers all the functionality with a relatively small adjustment in the data set. Further, instead of a new survey there could also be other reasons for changing coordinates, for example map improvement or switching to a different coordinate reference system (as defined in ISO 19111), or new calculation of same reference system. Geodetic control points, possible multiple coordinates for points, supporting multiple reference systems are supported in the LADM.

5.3.1 SurveyPoint

A SurveyPoint is an observed point of a RegisterObject in the field. Is associated with LegalSpaceBuilding, PointParcel, SpaghettiParcel, OtherRegisterObject and SurveyDocument. Is a subclass of Immovable. See figure 5 for the spatial representation. Attributes:

- locationOrig: calculated co-ordinates based on observations
- transformation: transformation used (from calculated co-ordinates in a local reference system to transformed co-ordinates)
- dimension: 2D, 3D
- quality; quality label related to survey method
- pointType: type of monumentation in the field, this has as value domain type enumeration (code list)
- locationTranf: shift in co-ordinates after a new survey (with a new SurveyDocument) of the same point

5.3.2 SurveyDocument

This is a document providing the spatial description of the RegisterObject, associated with SurveyPoint and a subclass of SourceDocument (see figure 5 and section 5.6.3). Attributes:

- measurements: observations and measurements as a basis for mapping and as a basis for later reconstruction of the location of (parts of) the RegisterObject in the field. Value data types are: gon, meters, coordinates.

- number: identifier of the SurveyDocument, data type depends on the local approach in document identification
- surveyDate: date of survey in the field
- quality: precision of observation (value type; enumeration (code list))
- type: type of SurveyDocument (value type; enumeration (code list))

5.4 Geometry and Topology Package

The LADM is based on already accepted and available standards *on geometry and topology* published by ISO. *Geometry* itself is based on SurveyPoints (mostly after geo referencing, depending on data collection mode: survey-tape, total station, GPS, etc) and is associated with the classes TP_node (topology node), TP_edge (topology edge) and TP_face (topology face, only in 3D case) to describe intermediate 'shapes' points between nodes, metrically based on SurveyPoints.

Parcels have a 2D or 3D geometric description. In 2D a geometry area is defined by at least three SurveyPoints, which all have to locate in the same horizontal plane (of the earth surface). In 3D a geometry area is defined by at least four non-partition SurveyPoints; this would result in a tetrahedron, the simplest 3D volume object.

Parcels have a 2D or 3D geometric description. The 2D or 3D (ISO) topology structures must be valid at every moment in time. There are never gaps or overlaps in the partition. However, edges belonging to different time spans (defined by versions) may cross without a node. The temporal topology must also be maintained: that is, no time gaps or overlaps in the representations. Therefore the structure is based on spatio-temporal topology. Current cadastral registration systems, based on 2D topological and geometrically described parcels, 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). 2D and 3D are treated in the same manner throughout the model; not only for Parcels but for all types of Immovables. 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 cadastre (bounding envelope of the object), which is usually larger than the physical extent of the object itself (for example including a safety zone).

5.5 Person Package

'Person' can be of type natural person or non-natural person like organizations, companies, co-operations and other entities representing social structures. Further there can be a specialization: GroupPerson. The difference between the non-natural person and the GroupPerson is that the first is intended to represent instances such as organizations, companies, government institutes (with no explicit relationships to other Persons), while the second is intended to represent communities, cooperatives and other entities representing social structures. Note that a GroupPerson in itself can consist of all kinds of persons: natural persons, non-natural persons, but also of other GroupPersons. In case of more informal situations the explicit association with the group member Persons is optional. Further, a Person can be a member of 0 or more GroupPersons. The composite association between GroupPerson and Person could be optionally developed into an association class 'Members', in which for each Member certain attributes are maintained; e.g. the share in the group and the start and optionally end date of the membership.

5.5.1 GroupPerson

This can be a community, co-operative and other entities representing social structures. Associated with and subclass of Person.

5.5.2 Member

This is an optional Member of a GroupPerson, associated with Person and GroupPerson. Attributes:

- share, that is a fraction of the whole (with the constraint that the total is 1)

5.6 Legal/Administrative Package

The main class in this package is the abstract class RRR with specializations Rights, Restrictions and Responsibilities. In principle, all RRRs are based on a LegalDocument as source. The essential data of a LegalDocument can be represented in the classes RRR and Mortgage. A single legal document may even create of mix of these types. In the other direction, a RRR or Mortgage is always associated with exactly one LegalDocument as its source. It is possible to describe more the one Mortgage in one LegalDocument.

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 still differs considerably between jurisdictions (which could be areas with customary tenures). The aforementioned rights are primarily in the domain of private law. Usually the rights are created after an agreement between the person obtaining the right and the person (e.g. the land owner) who restricts his right by the newly created right. The rights and restrictions usually ‘run with the land’, which means that they remain valid even when the land is transferred after the right was created (and registered). Because property and ownership rights are based on (national) legislation, ‘lookup tables’ can support in this. ‘Customary Right’ related to a region or ‘Informal Right’ can be included; from modelling perspective this is not an item for discussion. Of course, for the actual implementation in a given country or region, this is very important.

In addition to those private law restrictions, many countries also have public law restrictions, which are usually imposed by a (local) government body. The 'holder' of the right is a Person (either ‘the government’ or ‘society-at-large’) and usually they are primarily seen as restrictions. Some of them apply to a specific RegisterObject (or right therein) or a small group of them, or the duty to pay a certain tax for improvements on the road, or the duty to repair damage or perform belated maintenance. Each non-ownership Right by a third part (be it government or a private Person) causes a Restriction. These Restrictions have their own place in the LADM: they are modelled as views. That is, not intended to be stored in the LADM, but to be derived on demand when needed. Right (a specialization of the abstract super class RRR) is compulsory association between RegisterObject and Person, where this is not compulsory in case of ‘Restriction’ and Responsibility (the other specializations of RRR). The class RRR allows for the introduction of ‘shares of rights’ in case where more than one Person holds an undivided part of a ‘complete’ Right (or Restriction or Responsibility).

A restriction means that you have to allow someone to do something or that you have to refrain from doing something yourself. Restrictions can both be within private law, especially in the form of servitudes, as within public law, through zoning and other planning restrictions as well as environmental limitations. Responsibilities mean that one has actively to do something. Not all legal systems allow such mandated activities as property rights, and this will also effect the question if they can (and have to be) registered. Their impact can be substantial and their registration is therefore preferable.

The class RRR has associations to both Person (exactly one) and RegisterObject (exactly one) as suggested (Zevenbergen 2004 and Paasch 2005). It is still possible that one RegisterObject is related to several Persons (via RRR associations) and reversibly, that one Person is related to several RegisterObjects (again via RRR associations). There is always at least one instance of Right (subclass of 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 can 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 a neighbour is allowed to walk over your Parcel 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, but it is the intention only to store the positive-side and derive (compute) the negative side when needed (compare Zevenbergen 2004).

One or several mortgage(s) is always vested on a (set of) Right(s), and should never be seen as a separate relation between Person and RegisterObject. On the other hand a Mortgage is usually vested as collateral for loan. Therefore the mortgagee is connected to the Mortgage as MoneyProvider; one of the specializations of Person. Mortgage is associated to a Right.

The fact that all the different (public law and private law) RRRs find their base in some kind of establishing or transacting document is represented by connecting them to LegalDocument which is a specialization of the abstract class SourceDocument (as is SurveyDocument). The one responsible for drafting the document is connected to this as Conveyer.

The legal/administrative part of the LADM as just described is based on the notion of one strongest (primary) right, with other limited rights derived from it. This notion can be found in most continental European countries, but it also fits to the different approach found in Anglo-American law. That starts from the concept of property rights as 'estates' held in the land. Ownership in this approach is often seen as a 'bundle of sticks'. Separate 'sticks' of the bundle can be acquired in different ways, can be held by different persons, for different periods. When a person owns all the rights, he is said to own the fee simple title. When he owns only some of the rights, he has a partial interest. This approach is also used in (Paasch 2005). Land administration systems that underpin customary land tenure systems, informally arranged land use or conflicting claims to rights, and whose objects might not be clearly identifiable (fuzzy), not (yet) clearly identified or whose areas overlap are in need of other classes to allow for those type of situations (van Oosterom et al 2005). Often in such countries or jurisdictions both types of situations (strictly legal and formalized and more fuzzy and informal) are to be found in the same area, and should therefore be able to co-exist in the cadastral system, and thus in the LADM.

5.6.1 Right

This is the real property right based on legislation or the social tenure relation ship between RegisterObject and Person. A social tenure relationship can be informal, traditional or customary type of right. Right is a subclass of RRR and is associated to Mortgage. Attributes:

- rightType, this is the type of right or social tenure relationship. Value domain type is enumeration (code list)

5.6.2 Restriction

This is a legal restriction to a (property) right. Restriction is a subclass of RRR. Attribute:

- restrictionType, this is the type of restriction. Value domain type is enumeration (code list)

5.6.3 Responsibility

Responsibility to perform maintenance. Subclass of RRR. Attribute:

- responsibilityType, this has a value domain enumeration (code list)

5.6.4 Mortgage

A Mortgage on a Right. Mortgage is associated to Right, Person and LegalDocument. Attributes are:

- amount, the amount of money of the mortgage in local currency
- interest, interest
- ranking, this is the ranking order in case more the one mortgage applies to a right

5.6.5 SourceDocument

This is a document providing facts. Attributes:

- submission; date of submission of the document by Person
- acceptance; date of acceptance of the document by an authority

- registration; date of registration of the document by registering authority
- electronicSignature: data in electronic form which are attached to or logically associated with other electronic data and which serve as a method of authentication (DIRECTIVE 1999/93/EC)

See figure 5.

5.6.6 LegalDocument

Document providing legal facts: evidence of a Person's rights to land (UN, 2004). Associated with RRR and Mortgage

Note: LegalDocument does not inherit from VersionedObject, so there is no history management of versions here. All temporal attributes are inherited from SourceDocument (acceptance, registration and submission DateTimes).

Attributes:

- number: identifier of the LegalDocument
- text: contents of the LegalDocument
- type: type of LegalDocument, value domain type is enumeration (code list)
- salePrice: Purchase price of the RegisterObject in relation to a transaction (buying, selling etc).

5.7 History and dynamic aspects

There are two different approaches when modelling the result of dynamic systems (discrete changes in the state of the system): event and 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 traversing 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 the results) are modelled explicitly: every object gets (at least) two dates/times, which indicate the time interval during which this object is valid. Via the comparison of two succeeding states it is possible to reconstruct what happened as a result of one specific event. It is very easy to obtain the state at a given moment in time, by selecting the object based on their time interval (tmin-tmax). The temporal aspect is inherited from the VersionedObject with its attributes: beginValidityVersion and endValidityVersion. The class 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 nearly every object inherits the temporal attributes via either RegisterObject, RRR or Person – or directly via VersionedObject (e.g. in the case of Parcel as this is not a subclass of RegisterObject).

The LADM covers both event (via the SourceDocuments) and state based temporal modelling (via VersionedObject). In addition to the event and state modelling, it is also possible that the explicit 'parent/child' associations between the Immovables (RegisterObject) are modelled (lineage); e.g. when a cadastral parcel is subdivided. However, as these associations can also be derived from a spatio-temporal overlay, it was decided to not further complicate the model with the explicit parent-child relationships.

Besides the data modelling aspect of the dynamic processes within the LADM, one could question how are the functions and processes 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 one ‘flows’ from on to the other. In all the other mentioned types of UML diagrams, actors or organizations play an important role and this may be quite dependent on the (national) set-up. The introduction of different ‘stages’ of a parcel (one-point, image, surveyed), a right (start, landhold, freehold) and a person could further reflect the dynamic nature of the system.

5.8 Interface objects

The interface objects CadastralMap and OwnershipFolio support the generation and the management of products and services. Those classes do not contain attributes in itself but they allow the option to relate e.g. customer (identifier), date etc. This can be useful in the link to CRM, WFM and financial systems.

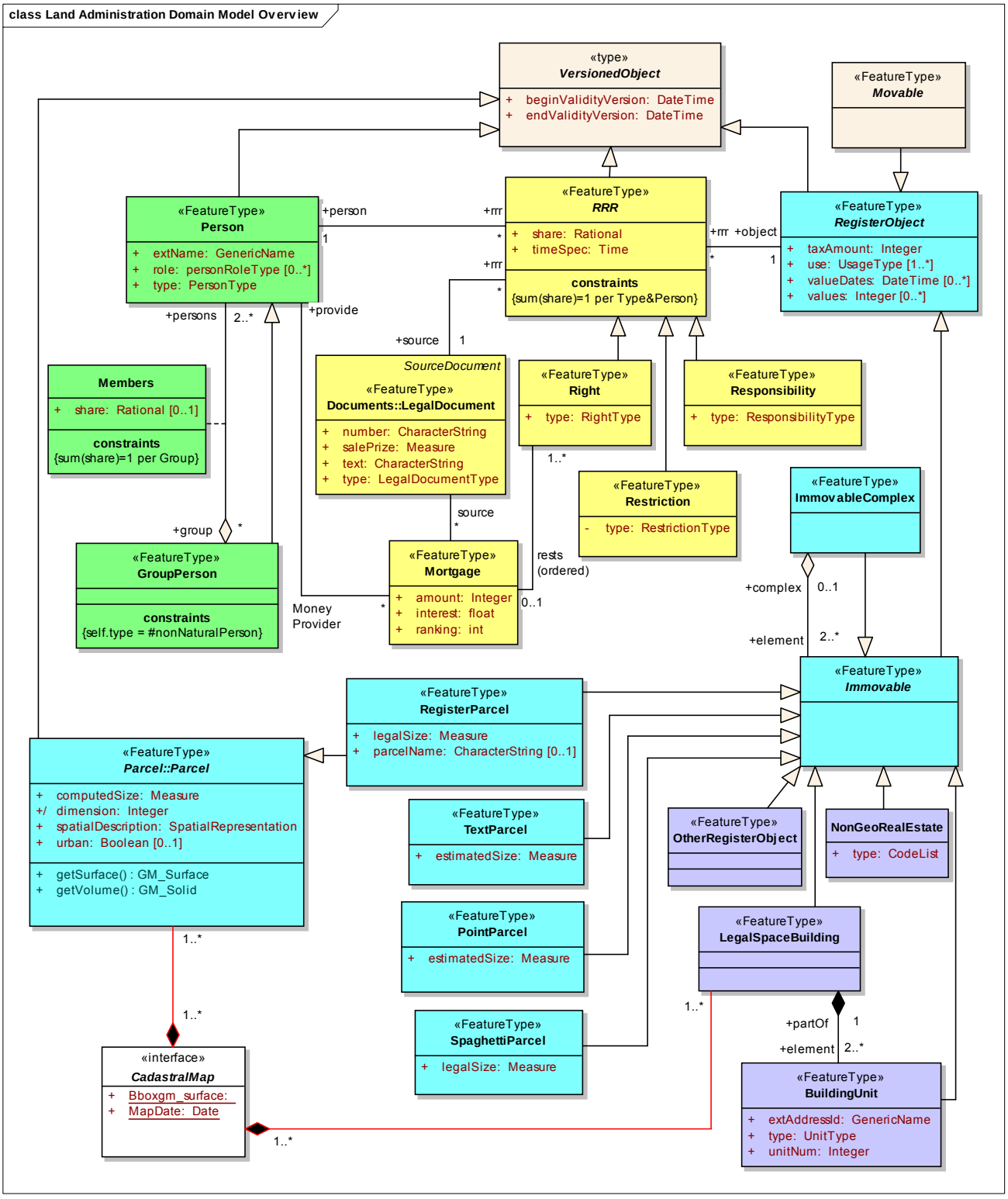

Figure 2 — Registered objects

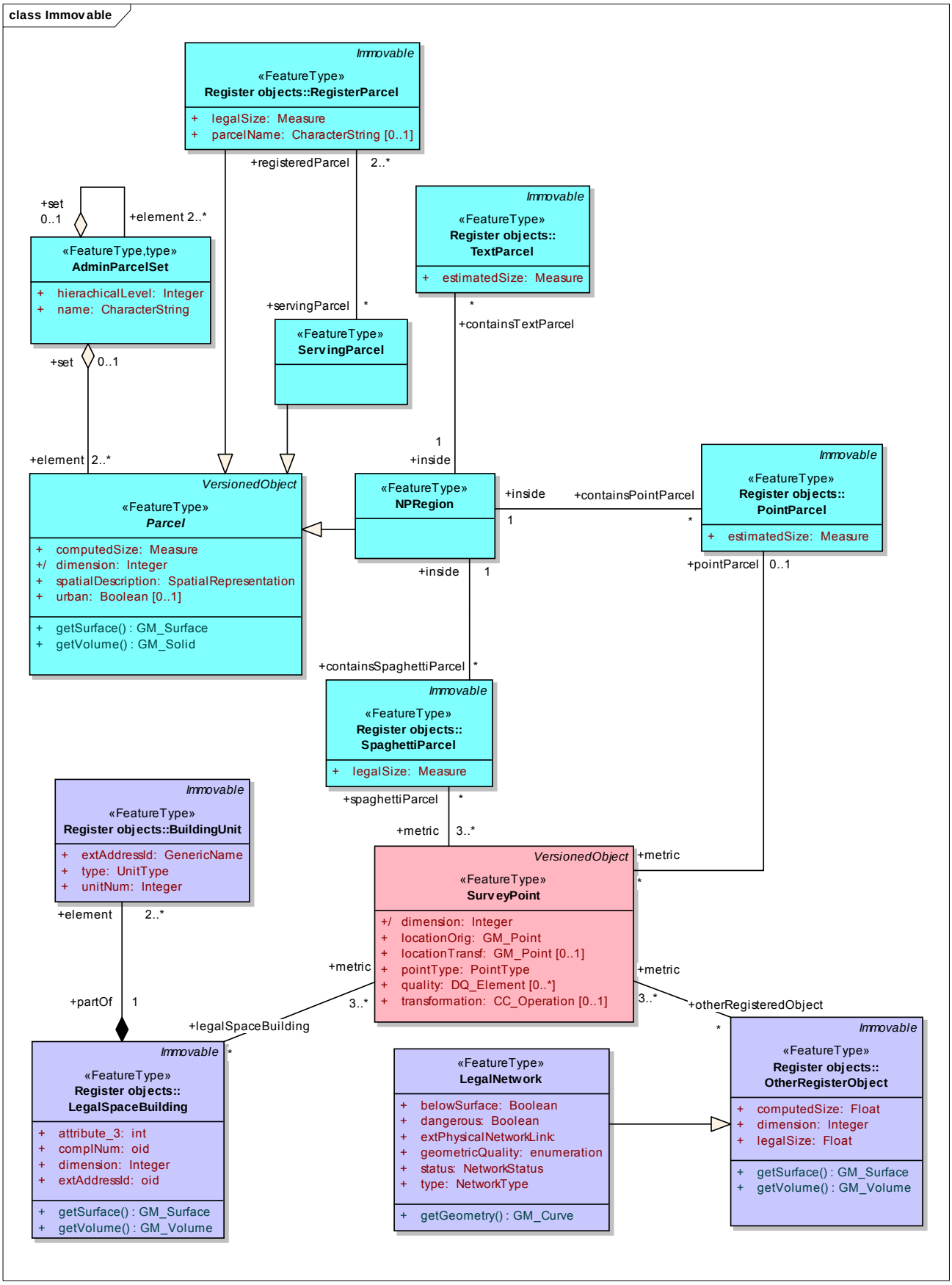

Figure 3 — Parcels

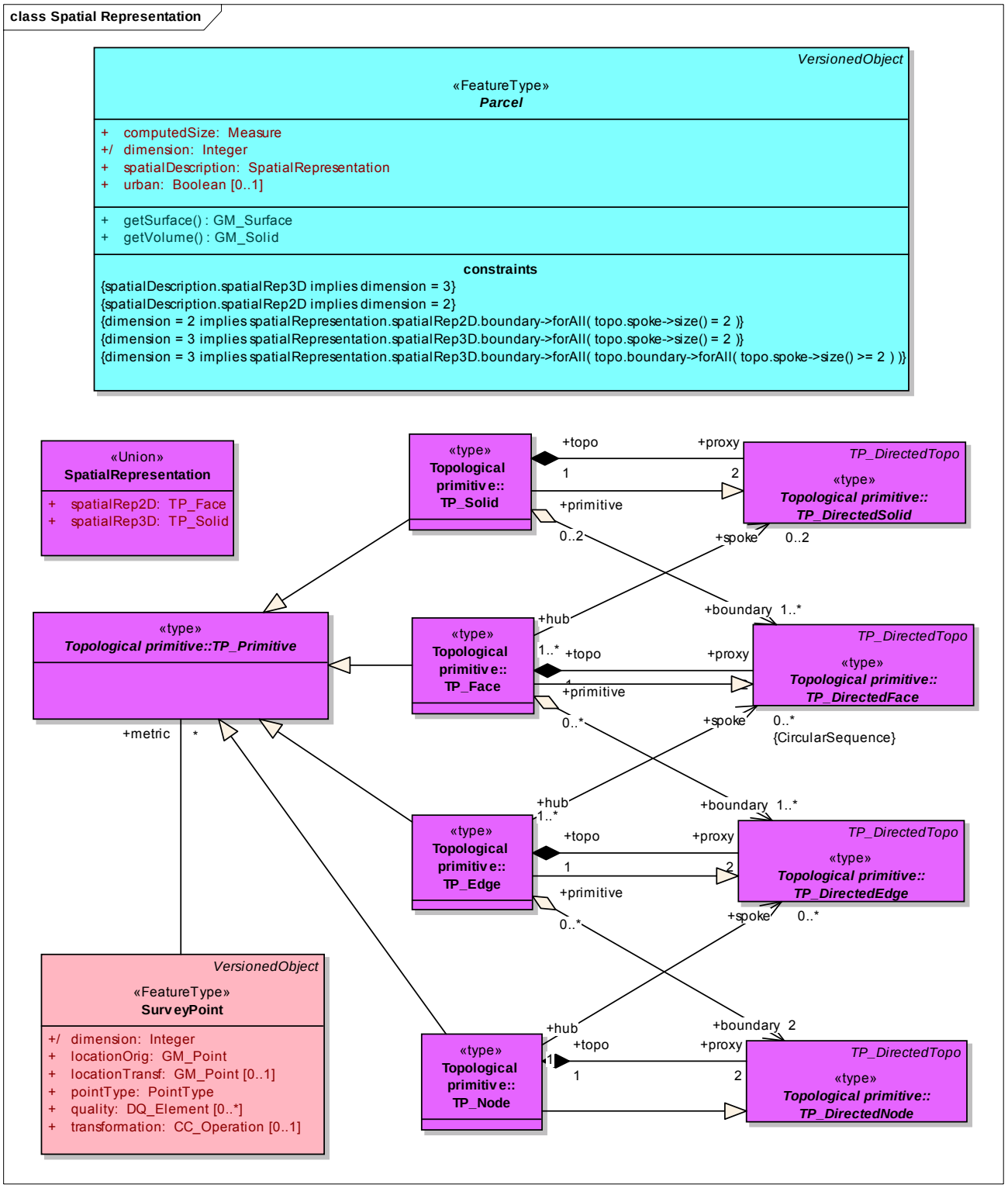

Figure 4 — Spatial representation of parcels and survey points

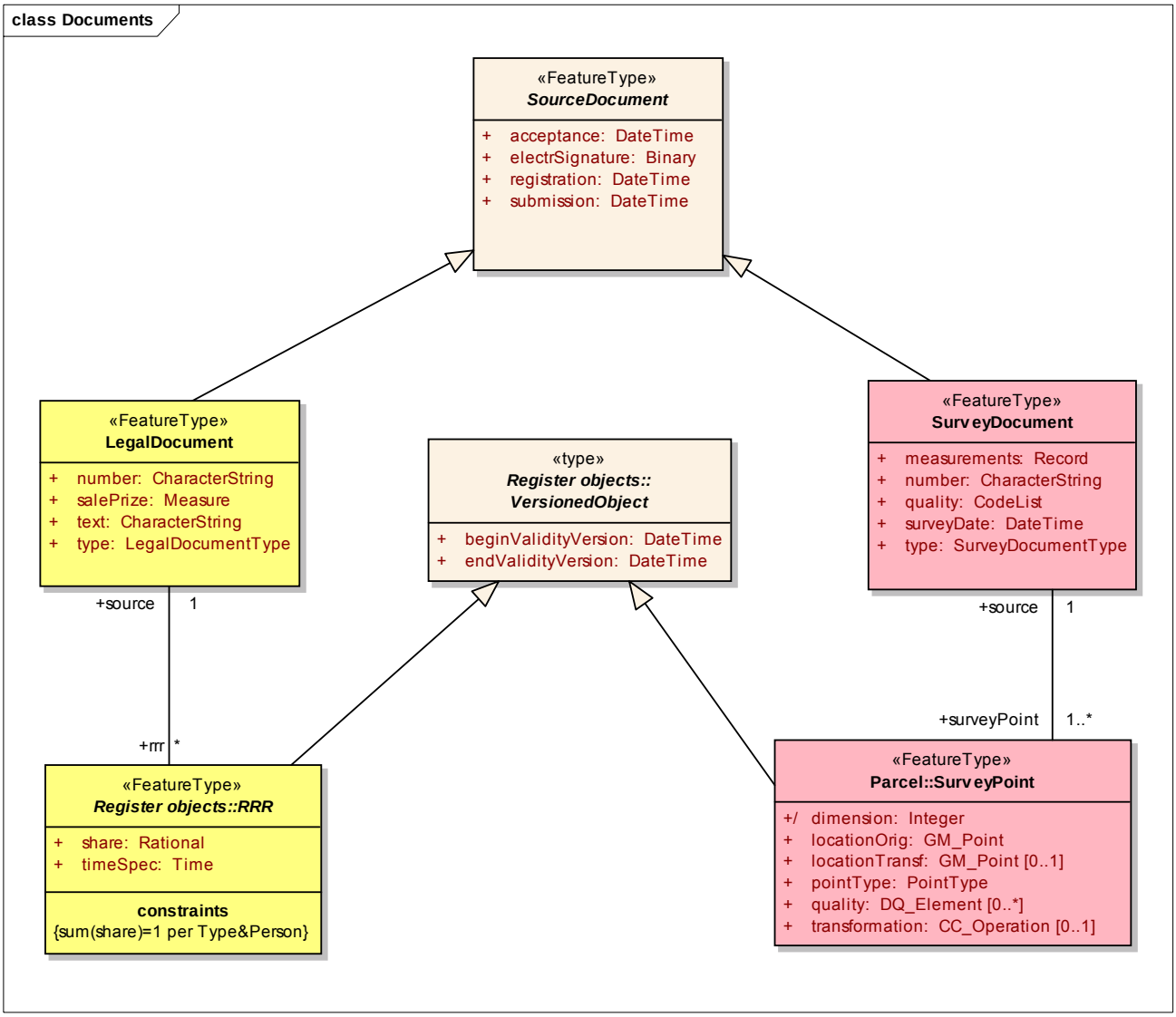

Figure 5 — Documents

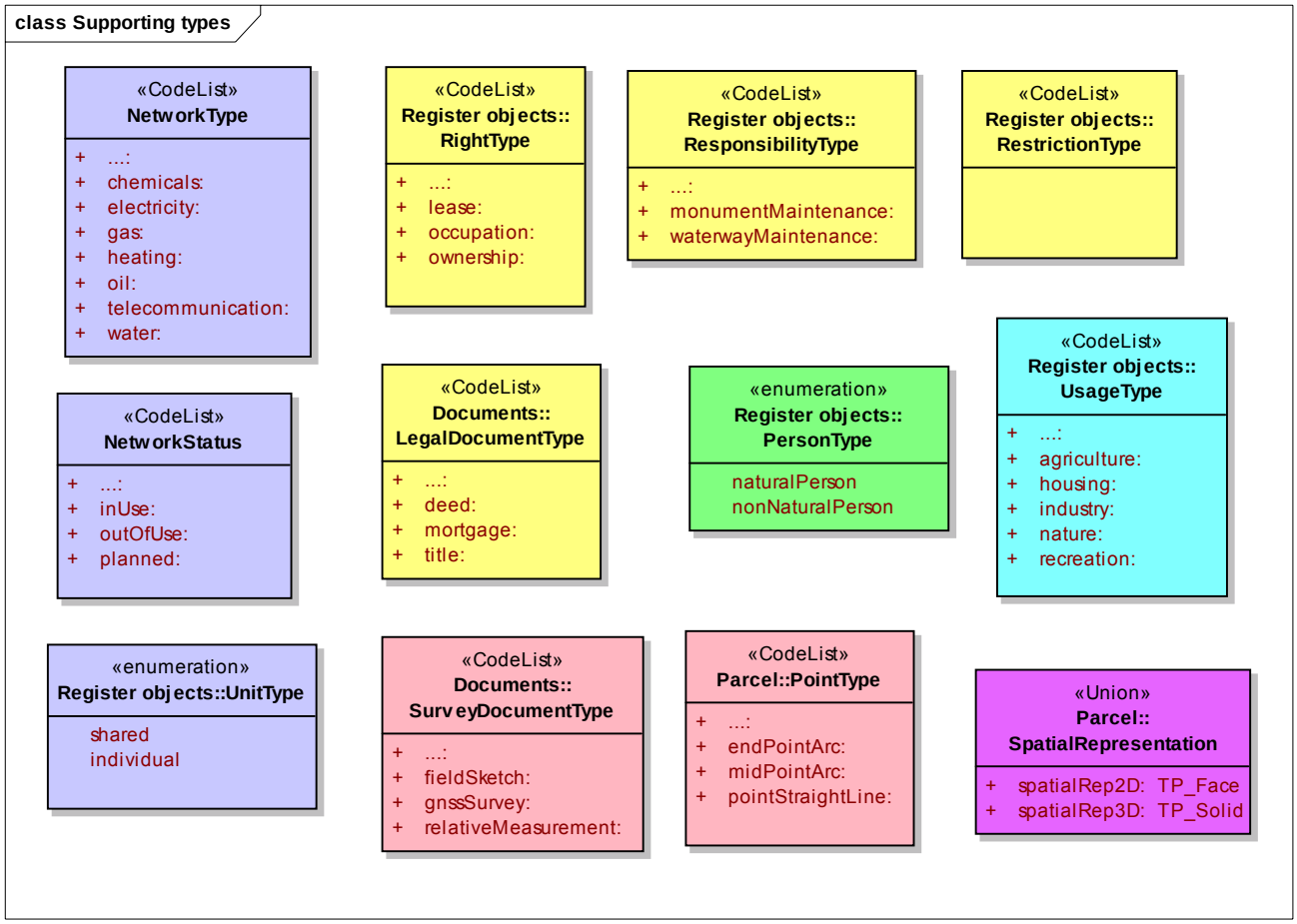

Figure 6 — Types (basic types and code lists)

6 The Social Tenure Domain Model (STDM)

The STDM is a specialization of the LADM. The LADM is considered to be designed for areas with formal cadastre and land registry systems. It should be observed that the LADM contains the functionality for the STDM, but under incorrect terminology, (Augustinus, 2006). Many countries have an incomplete or absent land administration. Formal terminology as used in the LADM such as Parcel, Right, LegalDocument, Restriction, RegisterObject etc can not be applied because of the informal environment. For this reason the STDM has been developed. In the STDM the same classes as in LADM are used, but under different terminology: e.g. a RegisterObject is named SpatialUnit, an RRR is called SocialTenureRelation. More detail on the SDTM is provided in Annex B.

This has an impact that PointParcel is called PointBasedSpatialUnit, etc. It should be recognised that standardisation of the LADM includes the STDM and is most relevant for practitioners in developing countries.

The STDM contains both ‘administrative’ object classes such as Persons, SocialTenureRelations and the ‘geographic’ class SpatialUnit. The model could be implemented as a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model (diagram), thereby using the services provided by the systems supporting other parts of the model. The fact that they are based on the same standards makes sure that the content of these systems is interoperable. Decentralised approaches are also very possible if based on standards.

Conventional basic concepts of land administration are affected in three ways:

- the Person: group with non-defined membership (note: a person can be a Natural Person, a Company, a Municipality, Co-operation, a Married couple, a Group, a Group of groups, a Ministry, etc)

- the rights: the recognition of types of non-formal and informal rights (possibility to include: Ownership, ApartmentRight (can be formal or informal for Shared Units and Individual Units), Informal Tenures, Customary Types, Indigenous Rights, Co-operations, Tenancy, Flexible Tenure, Possession, Use Rights, Leases (alternative: primary, demarcated and register able Leases), Long Leases, Islamic Rights: Miri, Milk, Waqf; Restriction Types; State Property; (Certificate of) Comfort, Conflict situations (Disagreement, Overlap), Occupation, Uncontrolled Privatisation

- the object: units other than accurate and established units. Apart from Parcel, Apartment, Building, we have shown that it is possible to represent Spatial Units as One Point (Geocoding), a set of Lines, a Polygon (low-high accuracy), topologically structured Parcels or a 3D Volume. Quality labels have to be included for this purpose.

A person (natural, non natural), a group of persons or a group of groups can have a one or more types of rights or SocialTenureRelations associated, where each right concerns one or more SpatialUnits; SpatialUnits can overlap (in certain explicit cases) and can always be identified with a label. A right or SocialTenureRelation is always in between Persons and SpatialUnits. A right can be undocumented, in that case the source document is 'no document'.

Annex A
(normative)

Abstract Test Suite

To be included.

Annex B
(normative)

Social Tenure Domain Model

B.1 Introduction to the Social Tenure Domain Model

The Social Tenure Domain Model (STDM) is developed as a specialisation of the Land Administration Domain Model, specifically for developing countries, countries with very little cadastral coverage in urban and/or rural areas, for post conflict areas, countries with large scale informal settlement and/or large scale customary areas.

Developing the STDM has been focussed on modelling the relations between people and land; independent from the level of formalisation and/or legality of those relationships. It is a search for a domain model that can be used as a basis for the development of a land administration system that can support all forms of land rights, social tenure relations and overlapping claims to land (e.g. in post conflict areas). In the development of the LADM efforts were made to include customary and informal tenures (van Oosterom et al, 2005). In (Augustinus et al, 2005) it was stated that not all the requirements could in fact be addressed by the LADM and that additional domain requirements could be included to achieve this.

There is growing concern about slums, as clearly stated in the year 2000 in the United Nations Millennium Declaration (Augustinus, 2005). In light of the increasing numbers of urban slum dwellers, governments have recently adopted a specific target on slums. It is contained in the Millennium Development Goal 7, Target 11, which aims to significantly improve the lives of at least 100 million slum dwellers by the year 2020. Because land is literally at the base of slum formation, addressing the slum challenge means taking the land issue seriously. Given that experience has shown that it takes 15-25 years to change a country's land administration system, we cannot afford to wait if we wish to improve the lives of slum dwellers now and to meet the Millennium Development Goals.

Land titling is important and necessary, but it is not enough on its own to deliver security of tenure to the majority of citizens in most developing counties. Customary tenure and informal settlement tenure has a very strong influence. Individual land titling often works against the needs and aspirations of ordinary people, also because of its cost. There is an urgent need to have a land information system that works very differently from the conventional land information system (Augustinus, 2005). Land tenure types which are not based on the cadastral parcel and are not registered require new forms of land administration systems, including land information management systems.

B.2 STDM is a specialization of the LADM

The STDM is a specialization of the LADM, the LADM is considered to be designed for areas with formal cadastre and land registry systems. The LADM contains the functionality for the STDM, but under incorrect terminology.

The STDM contains both ‘administrative’ object classes like Persons, SocialTenureRelations and the ‘geographic’ class SpatialUnit. The model could be implemented as a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model (diagram), thereby using the services provided by the systems supporting other parts of the model. The fact that they are based on the same standards makes sure that the content of these systems is interoperable. Decentralised approaches are very possible if based on standards.

Conventional basic concepts of land administration are affected in three ways:

- the Person: group with non-defined membership (note: a person can be a Natural Person, a Company, a Municipality, Co-operation, a Married couple, a Group, a Group of groups, a Ministry, etc)

- the rights: the recognition of types of non-formal and informal rights (possibility to include: Ownership, ApartmentRight (can be formal or informal for Shared Units and Individual Units), Informal Tenures, Customary Types, Indigenous Rights, Co-operations, Tenancy, Flexible Tenure, Possession, Use Rights, Leases (alternative: primary, demarcated and registerable Leases), Long Leases, Islamic Rights: Miri, Milk, Waqf; Restriction Types; State Property; (Certificate of) Comfort, Conflict situations (Disagreement, Overlap) Occupation, Uncontrolled Privatisation

- the object: units other than accurate and established units. Apart from Parcel, Apartment, Building, we have shown that it is possible to represent Spatial Unit's as One Point (Geocoding), a set of Lines, a Polygon (low-high accuracy), topologically structured Parcels or a 3D Volume. Quality labels have to be included for this purpose.

A person (natural, non natural), a group of persons or a group of groups can have a one or more types of rights or SocialTenureRelations associated, where each right concerns one or more SpatialUnits; SpatialUnits can overlap (in certain explicit cases) and can always be identified with a label. A right or SocialTenureRelation is always in between Persons and SpatialUnits. A right can be undocumented, in that case the source document is 'no document'.

B.2.1 Person classes

It should be noticed that a person can hold a *share* in a SocialTenureRelation. Further there can be GroupPerson. A GroupPerson is intended to represent communities, tribes, cooperation's and other entities representing social structures (both legal and non legal).

A GroupPerson should have 2 or more members. Further, a Person can be a member of 0 or more GroupPersons. The aggregate association between GroupPerson and Person could be further described into an association class 'Members', in which for each Member certain attributes are maintained; e.g. the share in the group and the start and optionally end date of the membership.

Persons with a specific role in the data collection process are SpatialDataCollector (could be a Surveyor) and Conveyor.

B.2.2 SocialTenureRelation

Each jurisdiction has a different 'land tenure systems', reflecting the social relationships regarding rights (and restrictions) and claims to land and/or building in that area. The variety of rights, social tenure relations and claims can be quite large within an area where the STDM will be applied:

Ownership
Apartment Right
Informal Type
Customary Type
Co-operation, this is a form of group rights
Social housing/cooperatives
Tenancy/simple lease
Possession, e.g. in case of squatter invasions
Primary, demarcated and registerable leases
Miri
Milk
Waqf (religious land)
Restriction Types
State Property
Disagreement
Conflict
Occupation
Unconventional Privatisation
Claims against property registered to others –either in occupation of property or not in occupation –post conflict

A Social Tenure Relation can be recognised as a collateral for a Person with role money provider. E.g. a micro credit provided by a co-operative or community. This in addition to mortgages provided by banks.

B.2.3 Spatial Units

The SpatialUnits are refined into several groups: the 'Parcel Family' (in 2D and 3D, including DescriptiveSpatialUnit, PointBasedSpatialUnit, IncompleteSpatialUnit, SketchPhotoSpatialUnit), the 'Building Family' (including Building, IndividualUnit, SharedUnit), SpatialUnitComplex and OtherRegisterObjects. Further there can be Fishing/hunting/thatching grass/right of way rights without specific territory. The 'Parcel Family' has been introduced and described in (see: Lemmen, van Oosterom, 2006).

The idea is that it should be possible to represent parcels not only as faces of a planar (or spatial) partition (that is, a set of areas without 'overlaps' and without 'gaps'), but also in alternative ways. Such alternative Spatial Units could (initially) be represented as a text describing the SpatialUnit (DescriptiveSpatialUnit), as a single point (PointBasedSpatialUnit) or a spaghetti polygon, which is not adjusted with it neighbours in a topological structure (IncompleteSpatialUnit – can have spatial data from different sources and can be topological incomplete) or with the accommodation of graphical (pictorial) data with any spatial reference is missing (SketchPhotoSpatialUnit). This means an area represented in the STDM 'Parcel Family' is subdivided into two types of regions:

1. regions based on a planar partition (type PlanarPartitionRegion - PPR), only well defined Parcels can exist in such a region and they have a topological structure; and
2. regions not based on a planar partition (type NonPlanarPartitionRegion - NPPR), in this type of regions other types of parcels can exist: DescriptiveSpatialUnit, PointBasedSpatialUnit, IncompleteSpatialUnit or SketchPhotoSpatialUnit.

In principle PPR and NPPR do not overlap. However, in case of conflict there can be explicit OverlappingSpatialUnits (not part of the normal 'Parcel Family' in the UML diagram).

The other Spatial Units (blue) include: Building, Unit and OtherRegisterObject (e.g. overlapping claims or utility networks). All these specialisations of Spatial Unit have associations with one or more Persons via the Social Tenure Relationship class.

A Building is composed out of several Units. A Unit can be used for living purposes, commercial or other. There are IndividualUnits and SharedUnits. The latter correspond to common areas and facilities.

SpatialUnitComplex allows the relating of one right to e.g. a combination apartment Unit, parking place and another Unit in the building.

Annex C
(informative)

Cadastral cases, instance level UML object diagrams

Remark: the contents of this Annex are based on:
EN ISO 19109, Geographic Information – Rules for Application Schemas
EN 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 the STDM.

- 1 natural person is leaseholder another non-natural person is owner, ownership and lease hold based on civil code for one country
- 1 spatial unit with a customary right
- 2 persons hold a share in a right (e.g. one person a share 1/2 and the other person a share 1/2 , or 2/3 and 1/3)
- A serving parcel provides access to 4 parcels, and the serving parcel is not public
- A group person holds property right on a spaghetti parcel
- A legal space building contains individual units (apartments) and a shared unit, with one common threshold on 1 ground parcel
- A 3D volume parcel with 1 owner
- A timeshare ownership for the month of February
- A restriction not to change a building because of its monumental status
- Mortgage on ownership, bank included as person
- Mortgage on usufruct on ownership, money provider included as person
- Informal right by a person on a text parcel
- Informal right by a group on a point parcel
- Informal right on a spatial unit
- A conflicting claim on a spatial unit
- A utility network with 1 owner and a mortgage (bank included as person)
- A pastoralist group with an access right for a certain period
- Parcel with 1 owner, building on it with other owner
- Farmer owning several parcels (rural)
- Value as basis for taxation valid for 5 years
- A milk right to a parcel
- A responsibility to clean the ditches
- A right of use a road on a property of somebody else
- A restriction area with its own geometry: not allowed to built 200 meters around a fuel station
- Parcel complex with one owner
- Complex of parcels and building with one owner
- Complex of several parcels with two owners
- Spatial unit in conflict
- Spatial unit with micro credit

Annex D
(informative)

Feature catalogue

summary of section 5 and presented in form similar to INSPIRE D2.6, annex C

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