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Land Administration as a Cornerstone in the Global Spatial Information Infrastructure*

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Abstract
This paper shows how standardization activities are progressing and contributing to the fact that Land Administration (LA) is considered more and more *the* cornerstone of the spatial information infrastructure. This is equally valid for regional, national, continental, and global levels, as will be illustrated in this paper. The paper describes the organizations involved and the current status of the LA standardization efforts. The crucial role that LA plays within the spatial information infrastructure is analyzed; including the relationship LA does have with other registrations and themes within the information infrastructure, of which some are non-spatial ones, such as persons. Special attention is given to a number of global aspects related to LA: combating slums (UN-HABITAT), stabilizing post-conflict areas, development of LA based on free/libre/open source software (UN-FAO) and climate change. Finally, the concept of 'land administration levels of maturity' is introduced and four stages of maturity are identified: 1. Standards, 2. Connectivity, 3. Integration, and 4. Network. The LA initiatives described earlier in the paper are assessed in the context of these levels of maturity.

Keywords: land administration, standardization, information infrastructure

1 INTRODUCTION

Spatial data sets are most useful in the support of areas like decision making, management of space, performance of government or business processes, when they are integrated in governmental information infrastructures and architectures. This implies availability of well maintained links between spatial data sets and other 'basic' or 'key' data sets, e.g. on addresses, persons, companies, buildings, or land rights. Integrated inter-organizational value chains and business process management with a reduction in administrative overhead can be realized based on new business models. In general, solving the problems in society requires more information than provided by one single data set. It is evident that this type of data provision is complex in case data is stored at a variety of locations and in data models specific to their applications.

Land administration itself contains both spatial information, e.g. on land parcels, and administrative information, e.g. property rights. In addition, land administration has important relationships with other key registers in the (spatial) information infrastructure, some of which are spatial, e.g. topography, or buildings, while others contain administrative information, like names of persons, addresses, or names of companies. It is therefore important to have unambiguous definitions of the contents of these key registers in order to avoid overlap and to enable reuse of information. Further, due to continuous updating of these independent, but related, key registers care has to be taken to maintain consistency, not only within one database, but also between databases. By reusing basic standards (for geometry, temporal aspects, metadata, observations and measurements from the field), at least the semantics of these fundamental parts of the model are well defined and can be shared. What is needed in addition to this is domain specific standardization to capture the semantics of the cadastral domain on top of this agreed foundation.

International standardization of relevant concepts is a condition for domain specific standardization. The development of the domain specific Land Administration Domain Model (ISO 19152 – a Committee Draft is available since June 2009) will be discussed in Section 2 to demonstrate the relevance of domain standards in relation to international information infrastructures. An effective (spatial) information infrastructure (SII) can be achieved by using ‘authentic registers’ (or 'key registers') to store key data which is available for integration and multiple use. This will be illustrated in Section 3 with an example from The Netherlands, where it became clear that the SII is part of a larger Information Infrastructure (II) with also non-spatial key registers (containing data on persons, companies, etc.). In this contribution we will further extend this approach from a national Information Infrastructure to an international Information Infrastructure. Land administration (LA) is considered to be a cornerstone, that is, an indispensable part of the (S)II, besides foundations such as reference system(s). In Section 3, we also pay attention to the European perspective: INSPIRE cadastral parcels (geometry) and EULIS (administrative/legal), and discuss some important implementation issues e.g. the spatial-administrative integration, and the global access to LA data.

Section 4 then goes further from national or continental to global use of land administration in the context of the spatial infrastructure. Different examples will be given in this context; from UN-HABITAT, UN-FAO, and the US Department of State (about Afghanistan post-war recovery), all institutions with a high interest in the Land Administration Domain Model (LADM). The relation between land use, land use change and forestry with respect to carbon storage and emission reduction is presented, because land tenure and land management have an eminent role in relation to climate change. Section 4 also refers to the evolving voluntary retail market of carbon credits. To promote carbon sequestration and emission reduction, land policy and associated land instruments (like market regulation, land use planning, land taxation and land reform) should include climate proof goals. This requires international information infrastructures including land rights and land holders. The flexibility of the LADM is demonstrated here.

This paper introduces the concept of 'land administration levels of maturity' and illustrates this with examples in Section 5. The following four stages of maturity are identified: 1. Standards, 2. Connectivity, 3. Integration, 4. Network. In the last stage different key-players work together in a networked cross sector approach. It will place the spatial information infrastructure in the context of current relevant social themes; e.g. public safety, environmental issues, or spatial planning. Within these themes many players, with different information sets, and from different sectors must work together to face the social challenges. This will clearly require some 'semantic' translations of information and associated concepts to be suitable for use in the context of these different social themes. It is envisioned that the levels of maturity also apply to other (information) sectors than Land Administration. Finally, in Section 6 the main results and contributions of this paper are summarized together with a list of future work.

2 LAND ADMINISTRATION STANDARDIZATION

This section gives an overview of the Land Administration standardization and implementation activities. A standardized Land Administration Domain Model (LADM) provides an extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA), and enables involved parties to communicate on a shared ontology implied by the model. Despite the fact that it is difficult to agree on the concepts used and their semantics (especially in the land administration where countries often have more than several centuries of different history behind their current systems), this can not be avoided if a meaningful interoperable spatial information infrastructure has to be developed and implemented.

In Subsection 2.1 some background with respect to standardization of the Land Administration Domain Model in the context of ISO TC211 (geo-information) is given. Next the relationships between ISO TC211 and other standardization organizations, such as CEN TC 287 and OGC are described. The last subsection gives an introduction to the current version of the LADM itself (Subsection 3.3).

2.1 ISO TC211 and ISO 19152 LADM

A standardized Land Administration Domain Model (LADM), covering land registration and cadastre in a broad sense (a multipurpose cadastre), serves at least two important goals: (1) to provide a extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA) in order to avoid reinventing and re-implementing the same functionality over and over again, and (2) to enable involved parties, both within one country and between different countries, to communicate based on a 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 get correct translations of terms about similar concepts). But the second goal is also important within one country, in order to combine and exchange information meaningfully from several different key registers in the information infrastructure.

Important conditions during the design of the model were, and still are: it should cover the common aspects of land administrations all over the world, and it should be based on the conceptual framework of Cadastre 2014 (Kaufmann and Steudler, 1998); it should also follow the international ISO and OGC standards, and yet the model should be as simple as possible in order to be useful in practice. The LADM itself heralds an important new wave in geo-information standardization: after the domain independent basic geo-information standards (like the current series of ISO and OGC standards), the new standards based on specific domains will now be developed. Due to historical differences between countries (and regions) similar domains, such as the land administration domain, are modeled differently and therefore a non-trivial harmonization has to be done first. The LADM is a result of this harmonization and one of the first examples of a semantic geo-information domain standard.

A cadastral parcel is single area of land or more particularly a volume of space, under homogeneous real property rights and unique ownership (UNECE 2004 and WG-CPI 2006). By homogeneous property rights is meant that rights of ownership, leases and mortgages affect the whole parcel. By unique ownership is meant that the ownership is held by one or several owners for the whole parcel. This does not apply to specific rights as servitudes, which may only affect part of the parcel. Irrespective of the legal system adopted by a government, the Cadastre is defined as a register under its responsibility. Its use complies with the principles of equality, security and justice. Access to cadastral information is ruled by laws and regulations in order to protect personal information. The classical Cadastre basic unit is the parcel. Parcels can be grouped in register objects. A parcel has a nationwide unique real property identifier. The spatial description of parcels and other cadastral objects should be provided with an adequate degree of accuracy. Descriptive data may include the nature, size, value and legal rights or restrictions associated with each separate land object under or over the surface (adapted from PCC 2003). Cadastral parcels cover a territory (regional or nationwide) and there are no overlaps or gaps between parcels. An exception to this rule may be government land (or public domain) not registered within the Cadastre - though this practice is not recommended.

Besides ownership, cadastral parcels, or to be more general register objects, can be associated with other types of rights, e.g. usufruct (a right to use and derive profit from property belonging to someone else), superficies (a right to own a building erected on land owned by another), long lease, responsibilities or restrictions. The location where a discontinuity in the specific legal situation occurs is the cadastral boundary. Vertices of this boundary may, or may not be marked in the field. In many cases field sketches with survey observations are available as source documents. Field measurements and observations (classical surveying: directions or bearings, angles and distances combined with control points or ‘GPS-based surveying’, resulting in coordinates) are used to determine coordinates in a reference system; these coordinates are adjusted to the cadastral map. Current practice is to express the coordinates in the cadastral map in the National Reference System. In the future this might be changed to the European Terrestrial Reference System (ETRS89), because more and more Global Network Satellite Systems (like GPS, GLONASS and Galileo) surveys will be used to collect data and this will improve data consistency near European country boundaries.

A cadastral boundary does have several attributes of its own. Field sketches (or survey plans) can be used for boundary reconstruction in case of disputes. From a technical point of view the set of related boundaries is sometimes stored as a closed polygon, with a risk for gaps and overlaps between parcels (this is a quality problem in the database). This also implies that every boundary would be stored at least twice (in 'left' and 'right' parcel), which is redundant. Further, the attributes of boundaries have to be attached to a specific instance. A parcel representation based on a topological structure is often used. Mostly, boundaries do not have a meaningful identifier (such as based on an administrative hierarchy), but they could be associated with field sketches (which do have some kind of meaningful identifier).

All those information aspects are represented in the LADM, which was developed over several years (van Oosterom et al, 2003, 2004, 2006). Many reviews enriched its contents. In practice it was very difficult to keep it simple. After the first version, launched at the XXIII International Conference in Munich, Germany, 2006 (Lemmen and Van Oosterom, 2006) it was decided to “go” for an International Standard: in early 2008 the LADM has been submitted by the International Federation of Surveyors (FIG) as a New Working Item Proposal (NWIP) to the International Organization for Standardization (ISO). This submission has been done by the FIG Standards Network. This initiative has been accepted by ISO Technical Committee 211 on Geographical Information/Geomatics (ISO TC 211). The work of ISO TC 211 amongst others will link LADM to appropriate standards for information technology and data, and provide a framework for the development of sector-specific applications using geographic data.

The Technical Committee 211 (TC211) of ISO (hereafter ISO/TC211) is responsible for the ISO geographic information series of standards (ISO/TC211, 2009a). Many bodies are actively engaged in the work of ISO/TC211. These include national standardization bodies, the Open Geospatial Consortium (OGC), international professional bodies (such as FIG and ICA), UN agencies (such as the UN Economic Commission for Africa), and sector bodies (such as the International Civil Aviation Organization, ICAO). Since its inception ISO/TC211 has published well over 40 standards, among which is the Geographic Markup Language (GML), a highly visible OGC specification. ISO/TC211 has participating and observing members from over 60 countries. There are three main phases in the ISO standards development process:

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

The LADM ISO 19152 Project Team (PT) had three meetings in 2008. First in May in Copenhagen, Denmark. Then in September in Delft, The Netherlands and finally in December in Tsukuba, Japan. The meetings in Europe received most input from PT members from that continent; in Tsukuba the majority of the participants was from outside Europe. The last meeting of the PT was in Molde, Norway, May 2009. The scope of LADM ISO 19152 includes the following:

- it defines a reference model, covering all basic information-related components of Land Administration

- it provides a abstract, conceptual schema with five basic packages, related to (1) people and organizations (*parties* in LADM terminology), (2) parcels (*spatial units* in LADM terminology), (3) property rights (*rights, responsibilities, and restrictions* in LADM terminology), (4) surveying, and (5) geometry and topology
- a terminology for Land Administration, based on various national and international systems, as simple as possible in order to be useful in practice. The terminology allows a shared description of different practices and procedures in various jurisdictions
- a basis for national and regional profiles
- it enables the combining of land administration information from different sources in a coherent manner.

LADM should be able to accommodate any legal framework. However, legal implications that interfere with (national) land administration laws, are outside the scope of the LADM development as an International Standard. The so called Social Tenure Domain Model (STDM) is a specialization of the LADM and can be considered as a pro poor land tool. This specialization of the LADM will be further introduced in Subsection 4.1 of this paper.

2.2 Related organizations (CEN and OGC)

What ISO is to the world, the European Committee for Standardization (CEN) is to Europe. There is a close cooperation between ISO/TC211 and CEN/TC287 Geographic Information. The scope, objectives and strategy of CEN/TC287 activities are formulated in Resolution 40 (CEN/TC287, 2003): 'The committee will work out structural frameworks of standards and guidelines of methodology which specify methodology of defining, describing and transferring geographical data and appropriate services. The work will be made in strict co-operation with ISO/TC211. These standards will support coherent use of geographical information in Europe in accordance with international use. These standards will also support spatial infrastructure of data at all levels in Europe.' Applying to ISO standards the *Vienna Agreement* as expressed in Resolution 52 (CEN/TC287, 2003): 'The CEN/TC287 Geographic information, considering the Vienna agreement; instructs the secretariat of CEN/TC287 to initiate Unique Acceptance Procedure (UAP) or parallel voting for all deliverables and work items of ISO/TC211 as appropriate.' The goal is to have equal ISO and EN standards via either submitting the published ISO standard to UAP (completed work) or via parallel and simultaneous voting in the ISO and in the CEN (new/on-going work). An ISO/CEN Joint Coordination Group, consisting of representatives of both organizations, has been established to monitor and manage the operation of the Vienna Agreement and to deal with any problems that may arise. The Group usually meets annually.

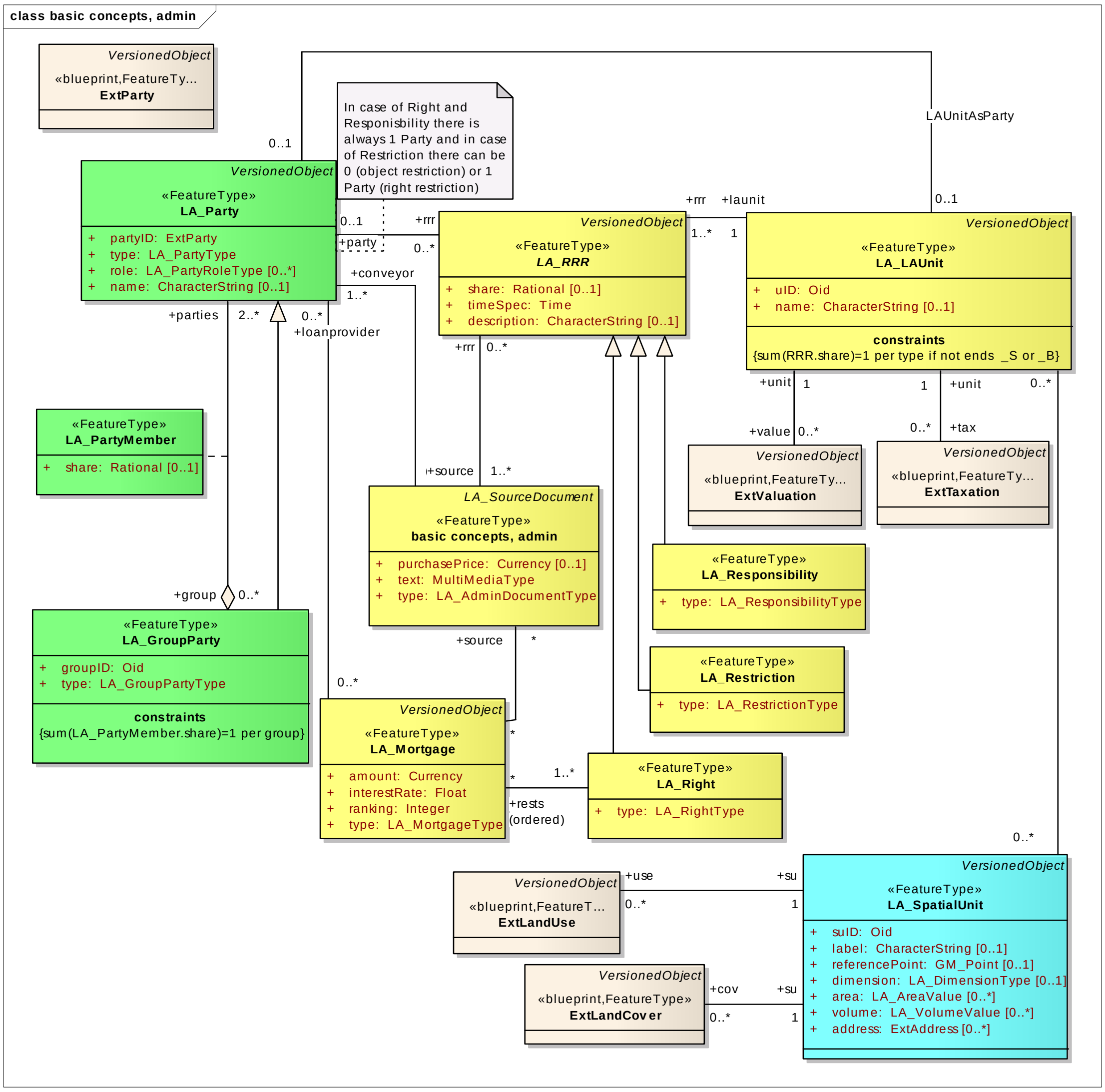
On 26 February 2009, in the Madrid meeting of CEN/TC287 after voting on the 'ISO19152 Draft Resolution 153 New Work Item Proposal Geographic Information - Land Administration Domain Model (LADM) - second vote' (CEN document number N 1304) it was decided to accept also the LADM within CEN TC287. Based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

Similar to ISO and CEN, where desired, ISO and the Open Geospatial Consortium (OGC) coordinate their activities. OGC is an international consortium to develop publicly available "geo-enabled" interface specifications. In 1995, OGC established a Class A Liaison with ISO/TC211 and in 1999 the two organizations signed an agreement that allows both organizations to take full advantage of the contributions of the other. The agreement spells out the intellectual property rights related to documents that fall under the agreement and calls for the alignment of ISO and OGC procedures. The coordination between ISO and OGC is best demonstrated by the fact that many geo-information experts take part in both ISO and OGC activities.

2.3 The current version of the LADM

In this subsection an overview will be given of the LADM corresponding to the Committee Draft (CD)-version. After the initial submission to ISO TC211, significant comments were received stating that the original model (Hespanha et al, 2008) was too complex. Therefore simplification was one of the most important goals and the motivation to integrate all different types of spatial representations (text parcel, point parcel, spaghetti parcel, or topology parcel) in the single LA_SpatialUnit class. Further, some classes were removed (ServingParcel and NPRegion) and the spatial representation was made more direct via ISO 19107 data types (TP_ and GM_ types) and not via associations to ISO 19107 classes (node, edge, face, solid, in both basic and directed variants). This also resulted in a significant model simplification. Based on the ISO/TC211 convention all class names were given an 'LA_' prefix (ISO/TC211, 2009b),

Figure 1. The basic concepts of the LADM

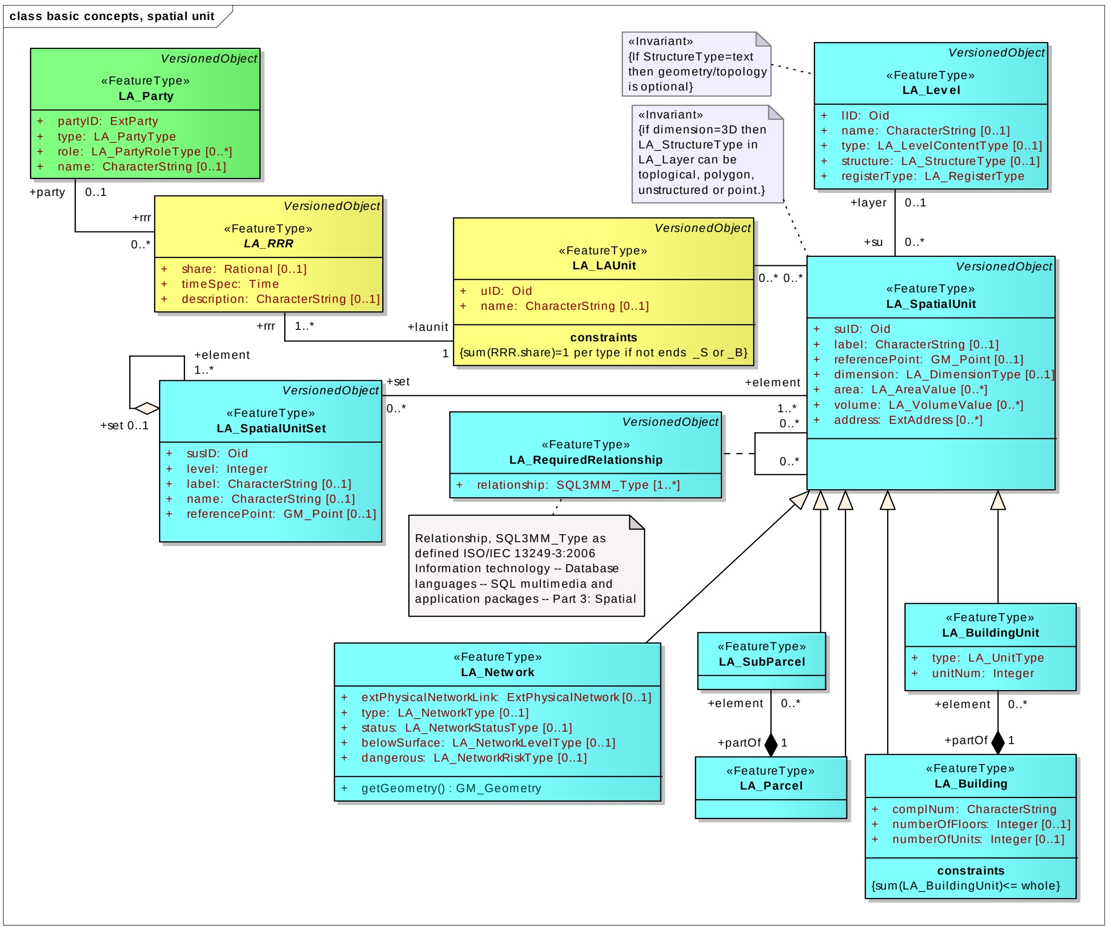


The four central classes in the LADM are LA_Party (persons and groups), LA_RRR (right, restriction, responsibility), LA_LAUnit and LA_SpatialUnit (parcel); see Figure 1. The new class LA_LAUnit is positioned between LA_SpatialUnit and LA_RRR. The LA_LAUnit, a collection of LA_SpatialUnits, is the entity to which the LA_RRR (rights, etc.) are attached. The motivation is the explicit need for modeling in several countries of the so-to-speak ‘real estates’; for example in Spain, Finland and Norway. An instance of LA_LAUnit is associated with zero, or more instances of LA_SpatialUnit; for example, a property consists of several parcels, allowing the possibility of no parcel at all.

Conversely, an instance of LA_SpatialUnit is associated with zero, or more instances of LA_LAUnit. Note that in many other countries the association between LA_LAUnit and LA_SpatialUnit may be one-to-one, which would then result in a single database table in the implementation.

The motivation to associate LA_LAUnit with LA_Party (see Figure 1) is to allow a LA_LAUnit to play the role of a LA_Party; e.g. to be the owner of another LA_LAUnit (parcel). Further, classes which are outside the scope of the LADM (e.g. ExtPersons, ExtAddress, ExtTaxation, Extvaluation, ExtUsage) are represented as blueprint classes. They do not have the 'LA_' prefix, but they do give an exact definition of what the LADM is expecting of these external classes.

Figure 2. The basic concepts of the LADM with LA_SpatialUnit and LA_Level



The class LA_Level has been designed in order to be able to explicitly represent the level concept; see Figure 2. This allows a country for example to model in one level the 'primary' right (or the 'strongest' right), from which other rights and interests can be ‘added’ or ‘subtracted’ (each in their own level). These rights (‘primary’, ‘added’, or ‘subtracted’) can be represented in three different levels. Furthermore, the names of spatial units and the structure type can be defined per level. How to use the levels is up to the country (its profile) and its legislation/regulations.

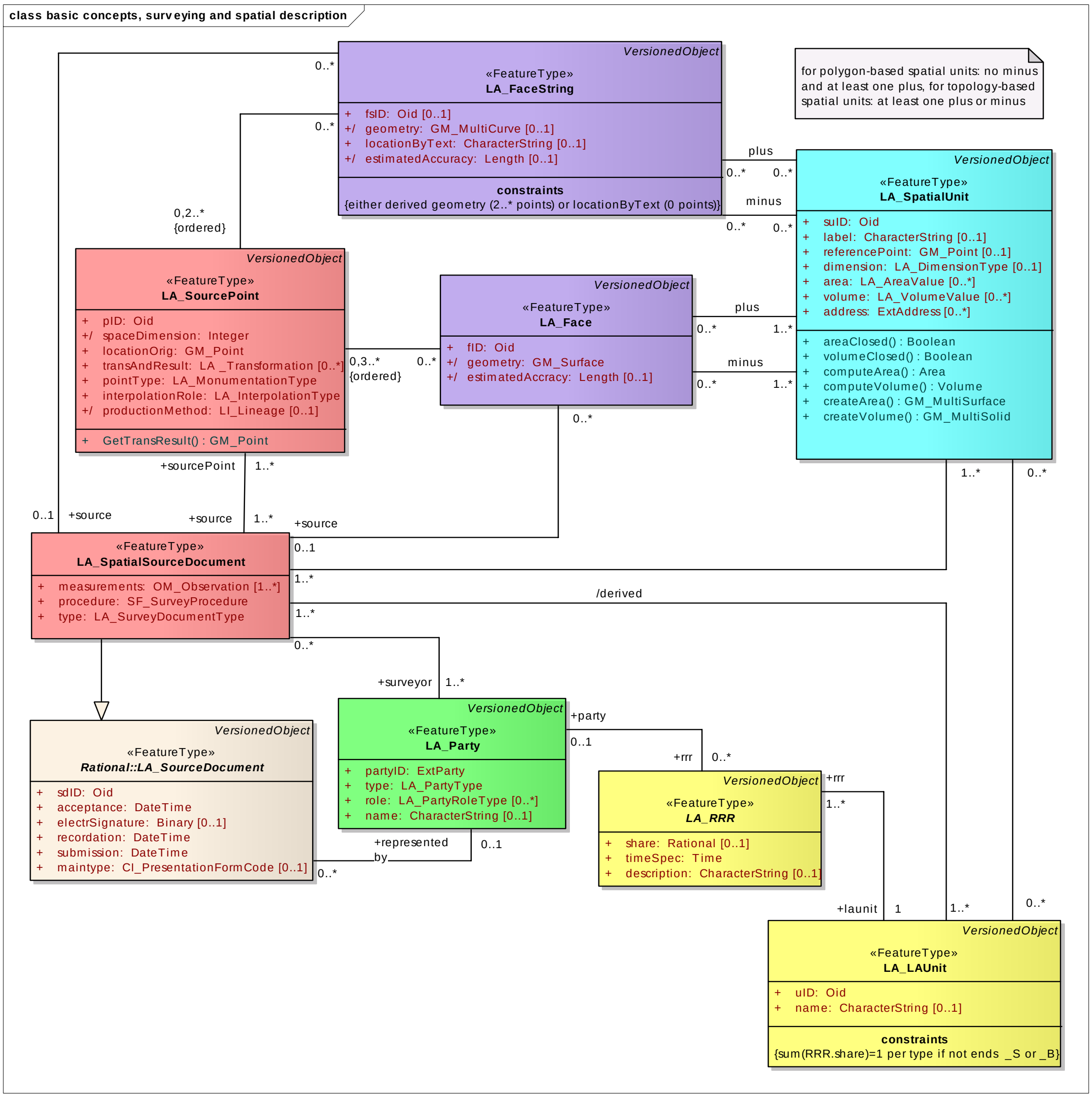
All types of LA_SpatialUnits (2D, 3D parcels, buildings, or utility networks) share the same representation structure. An important requirement is that existing 2D data, whether topologically structured, polygons, unstructured, or simply point or textual descriptions should be easily included. At the same time, the model should also support the increasing use of 3D representations of LA_SpatialUnit, without putting additional burden on the simpler 2D representations. An important requirement is that there should be no mismatch between the parts of the domain that are described in 2D and the parts of the domain that are described in 3D. Further, the LADM must be based as much as possible on the already accepted and available spatial schema as published in ISO 19107. The model described below has been designed using key concepts such as LA_FaceString and LA_Face; see Figure 3 and (Lemmen et al, 2009) for more explanation of the 2D/3D modeling. Coordinates themselves are rooted in instances of LA_SourcePoint (mostly after geo-referencing, depending on the data collection method used).

Finally, a number of informative annexes have been included to better explain the functionality of the model:

- Social Tenure Domain Model
- Object diagrams, instance level cases
- Spatial profiles
- Legal profile
- National Country profiles (examples)
- LADM and LPIS (agricultural parcels)
- LADM and INSPIRE cadastral parcels.

The annex with LADM country profiles include: Portugal, Queensland (Australia), Indonesia, Japan, Hungary, and The Netherlands. Currently, Spain and Canada are working on a LADM country profile. In the past, country profiles based on earlier versions of the LADM have also been made for Slovak Republic and Iceland. Further for a number of developing countries the developments are based on the STDM specialization of the LADM (see section 4.1).

Figure 3. Classes LA_FaceString, LA_Face, LA_SourcePoint, and LA_SpatialSource-Document



3 LAND ADMINISTRATION WITHIN THE INFORMATION INFRASTRUCTURE

Information and Communication Technology (ICT) offers many opportunities for improving the performance of government and business. Areas which may profit include education, safety, health care, international co-operation, economic efficiency (integrated value chains, business-process management, and reduction in administrative overhead), prevention and detection of fraud, or accident and disaster management. ICT trends such as ubiquitous access, smart objects, open source, increased bandwidth, interoperability and data-exchange standards will result in new business models. New perspectives are opened up by options like increased location independence, high-quality online services based on immediate access to all required data, use of identified objects available for process control, integration within business chains and government organizations, and increased e-shopping.

Groothedde et al (2008) argued that the information content within the (Spatial) Information Infrastructure (SII) consists of several key registers or databases and that it is therefore important to define what contents belong to what register (as an example LADM in Section 2). The different databases within the (S)II are related, i.e. there are references in the content from one database to another. As the databases are maintained by 'independent' organizations care has to be taken when information is updated that related databases are informed (in order to trigger potential related updates elsewhere). The fundamental question is: 'How to maintain consistency between two related distributed systems in case of updates?'. Assume that System A refers to object X in System B (via object id B.X_id), now the data in System B is updated and object 'X_id' is removed. As long as System A is not updated the reference to object X should probably be interpreted as the last version of this object available. Note that the temporal aspect has an important role in and between the systems! The true solution is also updating system A and removing the reference to object X (at least at the 'current' time). How this should be made operational will mainly depend on the actual situation and systems involved. It might help to send 'warning/update messages' between systems, based on a subscription model of the distributed users/systems.

An extremely important aspect of the future (S)II, in which (related) objects can be obtained from another database/organization (instead of copied), is that of 'information assurance'. Though the related objects, e.g. persons in case of a cadastral system, are not the primary purpose of the registration, the whole cadastral 'production process' (both update and delivery of cadastral information) does depend on the availability and quality of the data at the remote server. Some kind of 'information assurance' is needed to make sure that the primary process of the cadastral organization is not harmed by disturbances elsewhere. In addition, remote (or distribute) systems/users might not only be interested in the current state of the objects, but they may need an historic version of these objects; e.g. for taxation or valuation purposes. So even if the organization responsible for the maintenance of the objects is not interested in history, the distributed use may require this (as a kind of 'temporal availability assurance'). It is clear that this can have a serious impact on the data management at the side of registering organization.

Other topics have a strong relationship in the sense that these (physical) objects may result in legal objects ('counterparts') in the land administration. For example, the presence of utility cables or pipelines can also result in a restriction area or space (2D or 3D) in the land administration. However, it is not the cable or pipeline itself that is represented in the cadastral system; it is the legal aspect of this. Though strongly related, these are different aspects compared to a wall, fence or hedge in the field and the 'virtual' parcel boundary. The fact that these 'physical' objects are so closely related to the 'legal' objects within the Cadastre, also implies that it is likely that some form of interoperability is needed. When the cables or pipelines are updated, then both the physical and legal representations should be updated consistently (within a given amount of time). This requires some semantic agreement between the 'shared' concepts, or at least the interfaces and object identifiers. In other words these different but related domain models need to be harmonized. As it is already difficult within one domain (such as the cadastral world) to agree on the concepts used and their semantics, it will be even more difficult when we are dealing with other domains. However, we can not avoid this if a meaningful interoperable geo-information infrastructure has to be developed and implemented. It seems appropriate that also a more neutral organization plays a coordinating role in this harmonization process: OGC, ISO, INSPIRE, FIG (International Federation of Surveyors), CEN (European Committee for Standardization) were already mentioned as possible candidates.

In several countries of the world we see attempts to harmonize a number of domain models within one country; e.g. Australia, USA, Germany, The Netherlands (see Subsection 3.1). But it is not sufficient to harmonize within one country, as the models should also be harmonized internationally as in the case of INSPIRE (see Subsection 3.2), which emphasizes spatial data. Furthermore, in Subsection 3.3 it is shown how the non-spatial components of Land Administration are included in EULIS. In this system users can get access to legal and administrative information related to cadastral parcels in the different partitioning countries. This is quite a heterogeneous network environment as each country operates its own land administration system (land registry and Cadastre).

3.1 The Netherlands

The basic idea behind information infrastructures is that they provide the tools that give easy access to distributed databases to people who need those data for their own decision making processes. Although information infrastructures have a substantial component of information technology, the most fundamental asset is the data itself, because without data there is nothing to have access to, to be shared or to be integrated. In the last decade it was understood that the development of information infrastructures not only provided easy access to distributed databases, but also gave good opportunities for re-thinking the role of information supply for the performance of governments. Based on this starting point, the Program 'Streamlining Key Data' of the Dutch government (Duivenbode and De Vries 2003) took the lead in the development and implementation of a strategy for restructuring government information in such a way that an electronic government will evolve that:

- will only bother the public and the business community with requests for data when this is absolutely necessary
- offers the public and the business community a rapid and good service
- can not be misled
- instills the public and the industrial community with confidence
- is provided at a cost that is not higher than strictly necessary.

Jointly with five other government registers, the property register, cadastral map and topographic map of the Dutch Cadastre, Land Registry and Mapping Agency ('Kadaster') have been formally appointed in 2002 as 'key registers' of the governmental information infrastructure. The key registers will be the core of a system of so-called authentic registers, which might be any register that is maintained by a single government body and used by many others as the authentic source of certain data. If a register is formally designated as an authentic register, all other government organizations are strictly forbidden to collect the same data by themselves. In their budget allocation they will not find any money for data collection at this point. The Program 'Streamlining Key Data' concentrates on two goals:

- The communal use of data: in principle data would be collected on one occasion, and repeatedly used for the implementation of series of laws
- The joint use of data: data from different registrations (organizations) required for the performance of a specific government duty would be combined in one application.
- An authentic register is defined in the Program as 'a high quality database accompanied by explicit guarantees ensuring for its quality assurance that, in view of the entirety of statutory duties, contains essential or frequently-used data pertaining to persons, institutions, issues, activities or occurrences and which is designated by law as the sole officially recognized register of the relevant data to be used by all government agencies and, if possible, by private organizations throughout the entire country, unless important reasons such as the protection of privacy explicitly preclude the use of the register' (Duivenbode and De Vries, 2003).

Legislation has been created for the designation of the following registers:

- Municipal Personal Records Database - Population Register

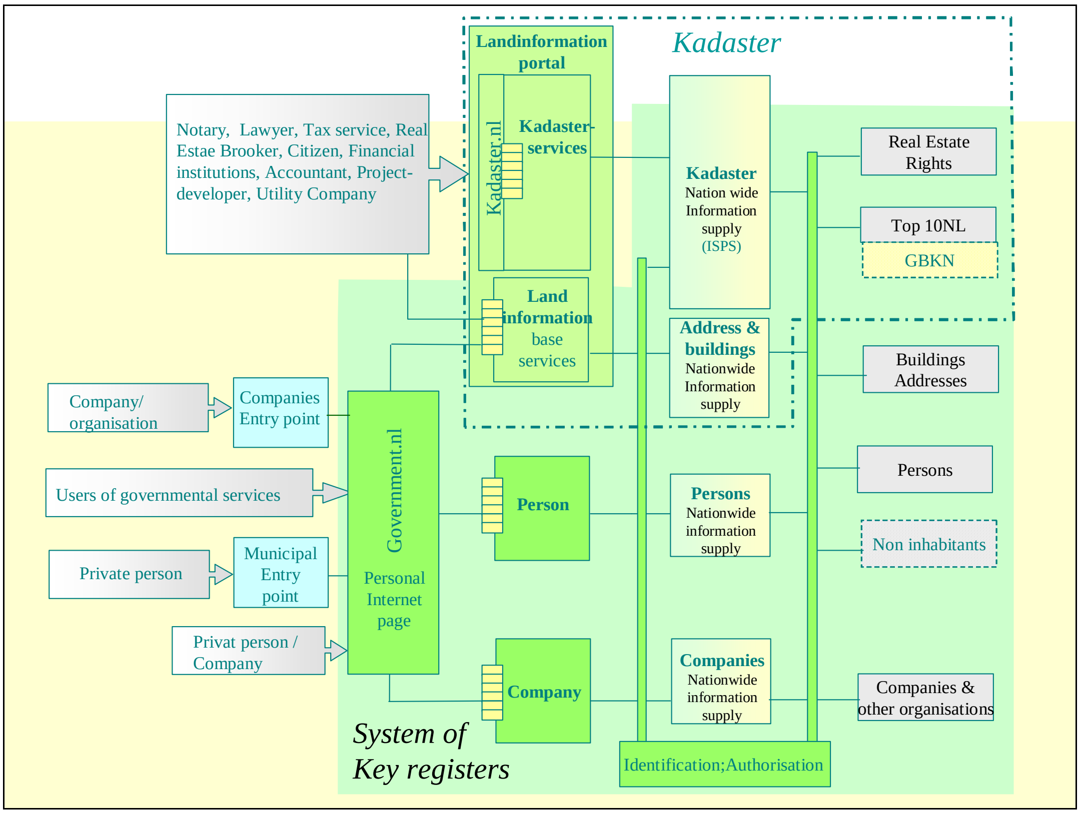
- Cadastre (Parcels and Rights)
- Company Key Register ('New Trade Register')
- Addresses, Buildings, and
- Topography.

In order to provide well harmonized definitions of the content of these registers a common approach has to be applied. In 2005 the ISO/TC211 compliant version of NEN3610 (Basic Model Geo-Information) was accepted (NEN3610, 2005). This generic model provides the concepts, definitions, and relations for objects which are related to the earth surface in The Netherlands and can be shared between the different domains within the context of the SII. Specific domains/sectors can extend NEN3610 by defining their classes as subclasses of the generic NEN3610 classes. The classes inherit all properties, such as attributes, methods and associations, of the NEN3610 and these are then further extended with additional properties. Also the cardinality of inherited attributes and associations may be refined, that is, made more restrictive; e.g. at superclass level an attribute may be optional (multiplicity ‘0..1’) and at subclass level the same attribute can be made mandatory (multiplicity ‘1’). In addition to the more cadastral (IMKAD) and topographic (TOP10NL and IMGEO) models, some other examples of accepted domain models are: water (IMWA), physical planning (IMRO), cables and pipelines (IMKL), soil and subsurface (IMBOD), safety and security (IMOOV), well-being (IMWE) (Geonovum, 2008).

On 8 February 2007 the Dutch Parliament approved the Act on Basic Registration Cadastre and Topography. The implementation start date was 1st of January 2008. The Municipal Personal Records Database has also been accepted as authentic register; the laws where Buildings and Addresses and further the New Trade Register will be appointed as key register are under construction.

Experience acquired with the Municipal Personal Records Database (the population register, which can not yet be consulted on-line) indicates that the Dutch Cadastre could play a role in rendering these addresses and buildings accessible at a national level, even though the municipalities remain the owner of the source information. The Dutch Cadastre’s justification for this approach is based on one of the agency’s competences, i.e. its skills in the management and maintenance of national databases with an extremely high update frequency. It is Dutch Cadastre’s strategy to play a leading role in the system of key registers. Figure 4 provides an overview of the system of key registers.

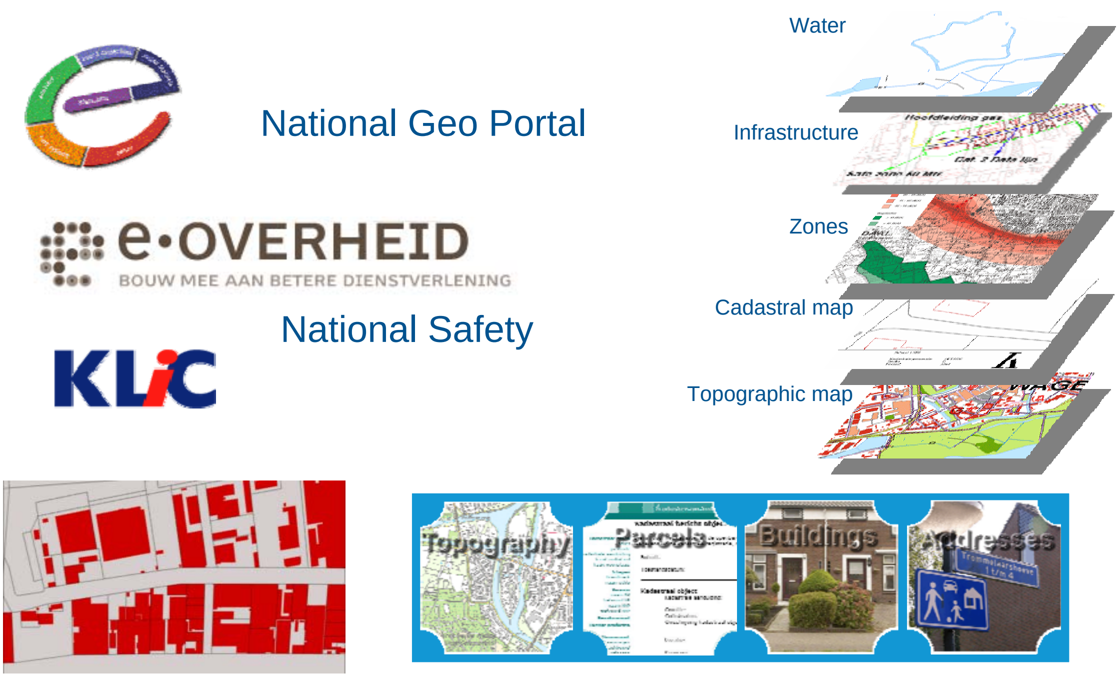
Figure 4: A landscape: the system of key registers and the Dutch Cadastre's land information portal



One may observe that this infrastructure does not only concern spatial data. Dutch Cadastre will review the extent to which supplementary relevant data could be included in the land register. The Kadaster can play a leading directive role in the organization of the provision of this information to the market players, whereby consideration will need to be given to the cooperation with some registers within the context of digital availability and fast accessibility. The Dutch Cadastre can acquire a good position by the provision of a series of topographic and geographic products that possess an internal consistency and are indispensable to third parties within the context of spatial planning, land use, management, and maintenance. For this reason the cadastral map, the Large Scale Topographic Base Map 1:1.000 and Topographic Key Register 1:10.000 (TOP10NL) has to be object-oriented and maintained in a mutually consistent way by means of data set integration using ontologies. Advanced detection of changes, for example using satellite images followed by the processing of the changes in all data sets ('change propagation') will then become a feasible proposition. The 'General Elevation Dataset of The Netherlands', and the

‘National Road Database’, indispensible to dynamic traffic management would be compatible with this. The integration of the National Reference System (named *RD*: x- and y coordinates) and Elevation Datum (named *NAP*: z coordinate) in a 3D reference system will play a pivotal role in the geometric infrastructure.

Figure 5: The implementation of the Dutch Spatial Information Infrastructure



Based on the above, the Dutch Cadastre’s current strategic objectives might be reformulated. It aims for the best possible performance of current public duties and the promotion of innovation and knowledge by adopting a leading role in their evolution in response to societal developments (see Figure 5). Strategic sub-objectives are:

- Investigation of evolution towards more legal evidence of registered data (a positive land-registration system with state guarantee)
- Introduction of a 3D land register
- Ambition to adopt role as centre for a range of key registers
- Provision of more complete in-sight into private and public legal status of registered property
- Achieving a substantial role in organizing information needs of the property market chain

- Provision of appropriately linked set of object-oriented topographic and geographic datasets, mutually consistent with respect to change
- Fulfillment of pivotal role in geometric infrastructure (x, y and z)
- Acceptance of prominent EU partner role in harmonizing registered-property law, land registration, and cadastres
- Development of flexible land-planning instruments suitable for use in realizing a variety of societal spatial objectives.

3.2 Land Administration and INSPIRE

For cross-border access to geo-data, a European metadata profile based on ISO standards has been developed and described via rules of implementation defined by the Infrastructure for Spatial Information in the European Community – INSPIRE (Directive, 2007). For actual data exchange, the INSPIRE implementing rules will further define harmonized data specifications and network services. This is complemented with data access policies and monitoring and reporting on the use of INSPIRE.

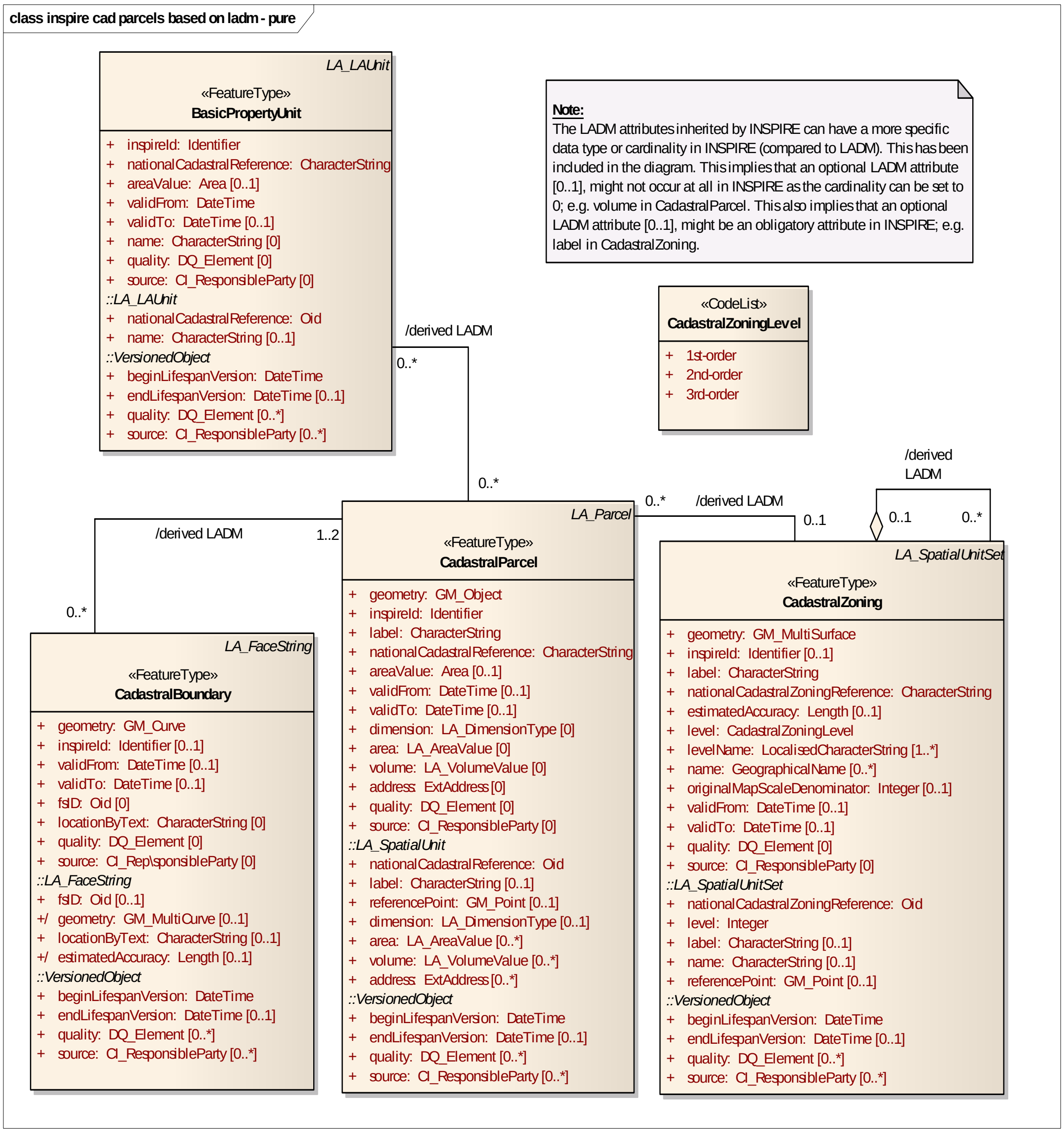
To illustrate the relationships of the cadastral parcel registration (as part of LA) with other registrations within an (S)II, a number of examples from INSPIRE will now be described. Specific boundaries of cadastral parcels are, in many countries, also the boundary of an administrative unit (municipality, province, country); this is an important relationship with theme 4 from Annex I of INSPIRE directive (Directive, 2007). Parcels and boundaries have associations with Buildings (theme 2 from Annex III of INSPIRE directive) - sometimes used as local reference for boundaries, but also used for orientation purposes. Parcels and boundaries have associations with Transport Networks (theme 7 from Annex I of INSPIRE directive) - same orientation purpose, but also roads, railroads, waterways are separate parcels as they are often owned by government. A strong link exists between cadastral parcels and Addresses (theme 5 from Annex I of INSPIRE directive). Further, links exist between cadastral parcels, land use (theme 4 from Annex III of INSPIRE directive) and land cover (theme 2 from Annex II of INSPIRE directive).

Cadastral parcels must have a unique real property identifier to which the legal status is attached. This identifier is often based on a hierarchy of administrative area's (provinces/districts/cantons/..., municipalities/communes/...., sections/polygons/...) and sometimes to the 'mother' parcel (subdivision of parcel ..../..../..../37 means for example ..../..../..../37/1 and ..../..../..../37/2). At a European level, the national identifiers should get a country code prefix to make them unique within Europe. In addition, there could be explicit associations between predecessors and successors. The cadastral information should be maintained continuously in order to reflect the actual legal situation. Of course, in reality and in information provision there might be a slight delay. Due to the legal importance, the history is currently maintained in some countries, but this may be needed in many countries.

The data model for INSPIRE cadastral parcels has been prepared in a way that supports compatibility with the upcoming international standard for the LADM. The INSPIRE model is compatible with LADM and might in the future be extended by the supplementary feature types as included in LADM. Several European countries are represented in the ISO19152 Working Group, which ensures that European cadastral systems are taken into account in this standard. Once adopted, this ISO19152 standard will provide quite interesting Reference Material if Data Specification for Cadastral parcels has to be updated or extended. It may for instance propose harmonization solutions for rights and owners or for 3D cadastral objects (such as building or network reserves).

Included in ISO19152 (as Annex G) is a LADM-based version of INSPIRE cadastral parcels, showing that the INSPIRE development fits within the LADM and that there are no inconsistencies. Figure 6 shows how the INSPIRE cadastral parcels model can be derived from the LADM. In INSPIRE context four classes are relevant: LA_SpatialUnit as basis for CadastralParcel, LA_FaceString as basis for CadastralBoundary, LA_SpatialUnitSet as basis for CadastralZoning, and LA_LAUnit as basis for BasicPropertyUnit. The LADM attributes inherited by INSPIRE can have a more specific data type or cardinality in INSPIRE (compared to LADM). This has been included in the diagram. This implies that an optional LADM attribute [0..1], might not occur at all in INSPIRE as the cardinality can be set to 0; e.g. nationalVolume. This also implies that an optional LADM attribute [0..1], might be an obligatory attribute in INSPIRE; e.g. label. Further, INSPIRE specific attributes are added to the different classes.

Figure 6. The INSPIRE cadastral parcel model derived from ISO LADM via inheritance



3.3 Land Administration and EULIS

European Land Information Service (EULIS) provides since 2005 to subscribed customers (such as banks or estate agents) access to property information in six European countries (England and Wales, Ireland, Lithuania, The Netherlands, Norway and Sweden) and pending for 7 other countries (Austria, Czech Republic, Finland, Iceland, Italy, Northern Ireland and Scotland) (EULIS, 2009). The service was developed by governmental land registration organizations who understand the differences in practices and procedures between different European countries. The EULIS Glossary and reference information assist in understanding the meaning of national terminology. The EULIS Glossary is a service to help customers understand the property registration terminology in their own country and a country in which they are searching. It is an example of an information service that is completely focused on the legal side of Land Administration.

4 GLOBAL IMPACT OF LAND ADMINISTRATION

According to the International Federation of Surveyors (FIG), Land Administration Systems provide the infrastructure for the implementation of land polices and land management strategies in support of sustainable development. The infrastructure includes institutional arrangements, legal frameworks, processes, standards, land information, management and dissemination systems, and technologies required to support allocation, land markets, valuation and control of use and development of interests in land. The way these systems function, their costs, and their governance have enormous implications for the ability of the poor to receive land administration services, to engage in land markets and to use property assets most effectively.

Land Administration Systems are the basis for conceptualizing rights, restrictions and responsibilities (RRR) related to policies, places and people. Rights are normally concerned with ownership and tenure whereas restrictions usually control use and activities on land. Responsibilities relate more to a social, ethical commitment or attitude to environmental sustainability and good husbandry. RRR must be designed to suit individual needs of each country or jurisdiction, and must be balanced between different levels of government, from local to national. This theme will focus on how different jurisdictions are building these systems in ways which are sustainable, well-governed and inclusive and how such systems can best help to achieve the Millennium Development Goals.

In this section we will analyze a number of examples that illustrate the global impact of land administration. First in Subsection 4.1 the role of the LADM as one of the UNO-HABITAT's Pro Poor Land Tools combating slums is discussed. The case of the post-conflict recovery and stabilization in Afghanistan and the importance of land administration is described in Subsection 4.2. The development of land administration systems based on free/libre/open source software (FLOSS) by UN-FAO is next described in Subsection 4.3. Finally, Subsection 4.4 explains the role of land administration in the context of climate change.

4.1 UN HABITAT– Global Land Tool Network: Pro Poor Land Tools

The Global Land Tool Network's (GLTN) main objective is to contribute to poverty alleviation and the Millennium Development Goals through land reform, improved land management and security of tenure. The GLTN originates from requests made by Member States and local communities world-wide to the United Nations Human Settlements Program (UN-HABITAT), who initiated the network in cooperation with the Swedish International Development Cooperation Agency (Sida), the Norwegian Ministry of Foreign Affairs and the World Bank, in 2006.

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

The Social Tenure Domain Model (STDM) describes relationships between people and land in unconventional manner because it tackles land administration needs in hitherto neglected communities such as people in informal settlements and customary areas. It supports development and maintenance of records in areas where regular or formal registration of land rights is not the rule. It focuses on land and property rights, which are neither registered nor registerable, as well as overlapping claims, that may have to be adjudicated both in terms of the 'who', the 'where' and the 'what right'. In other words, the emphasis is on social tenure relationships as embedded in the continuum of land rights concept promoted by GLTN and UN-HABITAT. This means informal rights such as occupancy, adverse possession, tenancy, use rights (this can be formal as well), or customary rights, or indigenous tenure, as well as the formal ones are recognized and supported (with regard to information management) in STDM enabled land administration system. Likewise, the STDM accommodates a range of spatial units ('where', e.g.

a piece of land which can be represented as one point – inside a polygon, a set of lines, as a polygon with low/high accuracy coordinates, as a 3D volume, etc.). Similarly, the STDM records all types of right holders ('who', e.g., individuals, couples, groups with defined and non-defined membership, group of groups, company, municipality, government department, etc.). In regard to evidence, STDM handles the imprecision and possible ambiguities that may arise in the description of land rights. In a nutshell, the STDM addresses information related components of land administration in an innovative way.

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

High resolution satellite image is one of the emerging and a very promising source of spatial data for land administration. A large-scale plot of such images can be used to identify land over which certain rights are exercised by the people themselves, i.e., in a participatory manner. As a proof of the concept, World Bank, with GLTN funding, organized and led an exercise in Ethiopia in June 2008 which included doing preliminary test on the feasibility of high resolution satellite images. The results that came out of this experiment are encouraging. Similar initiatives in other countries like Rwanda are also yielding comparable outcomes. The STDM development activity has thus far generated conceptual, functional and technical designs. The next logical step is the software development, starting with a prototype and testing this through a pilot project in a country which has slums, customary tenure, overlapping claims and non-polygon spatial units, etc. The prototype is under development at the International Institute for Geo-Information Science and Earth Observation (ITC) in close co-operation with Global Land Tool Network / UN-HABITAT and the International Federation of Surveyors (FIG). A World Bank led pre-project (preparatory) activity in Ethiopia is creating opportunities to pilot test the prototype in the context of rural land administration.

4.2 Land Administration in Post Conflict Area's: Afghanistan's recovery

The causes of conflicts and violence are many. For example ethnic envy, nationalistic tendencies, opposing interests, class conflicts, disputed frontiers, acts of expansion or economic interests (FIG, Commission 7, 2004). During such conflicts people are killed or disappear, buildings and physical infrastructure are destroyed, legal frameworks are set aside, public registers are destroyed, markets cease to function, properties are taken and lands occupied. If the conflict ends, peace treaties, UN resolutions or national development plans aim at restoring governance and the rule of law in all its variety (security, health, energy, shelter etc.)

In many cases, a substantial component of the restorative process consists of the (re-introduction) of secure land tenure, mechanisms of resolution of land conflicts, land allocation, restitution, transparent land markets, land use planning, land taxation and the like. This implies both institutional and operational measures. Some form of land registration and Cadastre is needed as a provider of secure property rights, as a facilitator for the land and land-credit market and as an information source for various public tasks like planning, taxation, land reform and the management of natural resources.

In his book ‘Registering the Human Terrain: A Valuation of Cadastre’ the author Doug Batson (Batson, 2008) observes that property rights in volatile countries is an auspicious field of international development for the U.S. to assert its “soft power”. His book is explicitly not about mapping the human terrain, but about *registering the human terrain:* relating a “person” (an individual, a group, or a non-natural person such as an organization) to a geographical place through property records. This book manifests how to answer the “who” question with the same precision the U.S. Intelligence Community answers the “where’’ question. It is observed that also conflicts (overlapping land claims) can be recorded in LADM.

It may be objected that the LADM cannot represent all possible cases for one area of the world, or that the categories it describes for one country may need to change for the next. But this is LADM’s strength, not its weakness. The classes in LADM are expandable. The system is being designed so that additional attributes, operators, associations, and perhaps even complete new classes can be added for a specific country or region. According to Batson (2008) the LADM aspires to be everything that civilian land administrators and civil-military planners want to address regarding land issues of post-conflict societies. It merits close attention by NATO, the U.S. State and Defense Departments, and USAID or other entities tasked with bringing about stabilization because it could be an important breakthrough tool for aiding countries with weak or totally absent land administration.

4.3 Free/Libre/Open Source Software: Land Administration

The initiative for this project came from the Land Tenure Group of the Food and Agricultural Organization (FAO) of the United Nations. Several land administration projects in developing countries sponsored by the FAO in the past have failed, often due to high software licensing costs and inadequate information technology (IT) systems. Despite these failures, IT holds great promise for land administration systems, but only when introduced in a sustainable way. To address this issue a seminar on the use of Free/Libre/Open Source Software (FLOSS) was held on 8th and 9th of May 2008 at the University of Otago, New Zealand (OSCAR, 2008).In parallel to the organization of the seminar, the University has been working on the design of a software shell that includes a data schema for cadastre and land registration. The presentations and discussions in this seminar provide an overview of the software needs and other requirements of land administration projects. The project goals further include:

- To carry out a thorough high level conceptual analysis and design, as well as prepare a preliminary analysis/proposal of FLOSS tools, for the development of a cadastre and land registration shell including at least request management, editorial and maintenance functions for the maintenance of a generic cadastral index map and cadastral record based on the Core Cadastral Domain Model (CCDM, note that this is the previous name of the LADM) and Social Tenure Domain Model (STDM) or similar.
- To prepare a design and main milestones and a tentative budget for a FAO administered support for establishing a sustainable OSS product and community for FLOSS cadastre and land registration.

It was concluded that LADM provides the ontology, the basic concepts for software development. While the model is still abstract and cannot be directly converted to a data structure, it provides the conceptual framework on which to build land administration systems. However, modelling cannot be seen as a goal in itself. After modelling it is necessary to start implementing.

4.4 Land Administration and Climate change

A standardized Land Administration Domain Model (LADM) provides an extensible basis for efficient and effective cadastral system development. Examples on the need for extensibility are provided above in Subsection 4.1 where the social tenure in less developed countries is introduced. Another typical example case is on Carbon Credits (Van der Molen, 2009). Van der Molen concludes that in addition to appropriate registration of land tenure and cadastral geometry, additional information is required about environmental rating of buildings, energy use, current and potential land use related to carbon stock potential and greenhouse gases emissions, clearer definitions of various land types related to the application of various legal regimes (like what is exactly 'idle' land), flood and storm prone areas, salinization rates and transport indicators. This information might not necessarily be recorded in the land registration and cadastre system itself, but at least connected with it, so that a strong link with private and public rights to land remains in existence (within the SII).

In the case of 'unbundled' property rights, with the separation of carbon credit titles, these registers and cadastres should be able to register such rights (registration) and to attach appropriate geometric attributes and to make those titles accessible for trade in the carbon credit market. A study by the Intergovernmental Panel on Climate Change (IPPC) (IPPC, 2003) reveals widespread demand for a well-designed carbon accounting system that provides for the 'transparent, consistent, comparable, complete, accurate, verifiable and efficient recording and reporting of changes in carbon stocks and/or changes in greenhouse gas emissions by resources and removals by sinks from applicable land use, land use change and forestry activities'. Although different approaches are possible, in many cases land surface areas, above-ground and below-ground volumes of biomass, canopy surveys, and geo-information play a role.

Land registers and cadastres also have to fulfill their most vital purpose, namely to provide land tenure security to right holders, with a focus on the poor, the vulnerable and indigenous peoples, in order to safeguard their land rights. For example, in case of demands for land for purposes of large-scale bio fuel production or afforestation for carbon sequestration and to provide information about tenure, value and use of land when governments want to encourage changes in livestock, crop production, conversion from arable land to grazing land, from tillage to no-tillage cropping, reforestation and combating degradation of soils though sound land-use planning and management. These spatial unit related carbon credits can be registered or recorded in the LADM.

When governments want to apply taxation as a measure to achieve such objectives, land registers and cadastres are supposed to provide relevant information about taxable objects, taxable values and taxable persons, including earlier mentioned indicators regarding energy use etc. This would mean inclusion in the LADM of functionality to support taxation. In this moment this is included as external classes.

When governments need lands to realize certain land use (water storage, carbon sinks – which are 3D objects), land registers and cadastres should provide information about right holders to be compensated in the land acquisition process, in such a way that people's land rights are respected and the risk of eviction is avoided. When land reform is at stake, land registers and cadastres provide information about the existing land tenure pattern and provide an operational process to change from old to new situations. In summary, land registers and cadastres have a role to play in supporting governments and citizens in their efforts at mitigating global climate change and trying to adapt to its impact.

5 LAND ADMINISTRATION LEVELS OF MATURITY

In this section the concept of 'information sharing levels of maturity' will be explained and illustrated with land administration examples. When moving towards the higher stages, with higher value and efficiency, none of the previous stages can be omitted, as the subsequent stage builds on the previous stage. The step towards the last stage means an important mind shift. It will place the spatial information infrastructure in the context of current relevant social themes; e.g. public safety, environmental issues, spatial planning. Within these themes many different players, information sets, sectors must work together to face the social challenges. It should be noted that the levels of maturity also apply to other (information) sectors than just the land administration.

5.1 Land Administration Levels of Maturity

The practice of Land Administration has many different levels of maturity. Maturity differences between countries are recognized and every country wants to benchmark themselves to relevant institutes. A model is used to specify different levels of maturity. This model can be used for many other purposes, but for now we can use it for measuring Land Administration maturity. Growth in maturity will follow the four levels. The model forms a kind of ladder where every step gives higher value and efficiency. Every level can be met after finishing the previous one. In almost every situation no level can be omitted as the subsequent level builds on the previous one. The model has four stages: Standards, Connectivity, Integration and Network; see Figure 8. Although the names of each level are derived from the technical arena, they hold the entire Land Administration processes and organization:

- Standards. In this stage the necessary standards are created. E.g. Standards in Data modeling, Standards in exchange formats, Standards in Land Administration Systems. Standards are the basic needs in maturity.
- Connectivity. Once standards are clear, different organizations, or countries can start to make a connection. A point to point connection creates possibilities to exchange Land Administration information, both geographic and administrative information.
- Integration. After organizations or countries are connected they start acting as a whole. This will form a kind of Land Administration Information Infrastructure. The spatial information "hang-out" for all related users.

- Network. The ultimate level seems a small step, but means a big mind shift. The focus will shift from the Land Administration or Spatial Information Infrastructure towards higher level social themes. It will place the spatial information infrastructure in the context of current relevant social themes. E.g. public safety, environmental issues, spatial planning, water management, poverty reduction. Within these themes many different players (stakeholders), information sets, sectors must work together to face the social challenges. This will require semantic translations of the information in order to be useful.

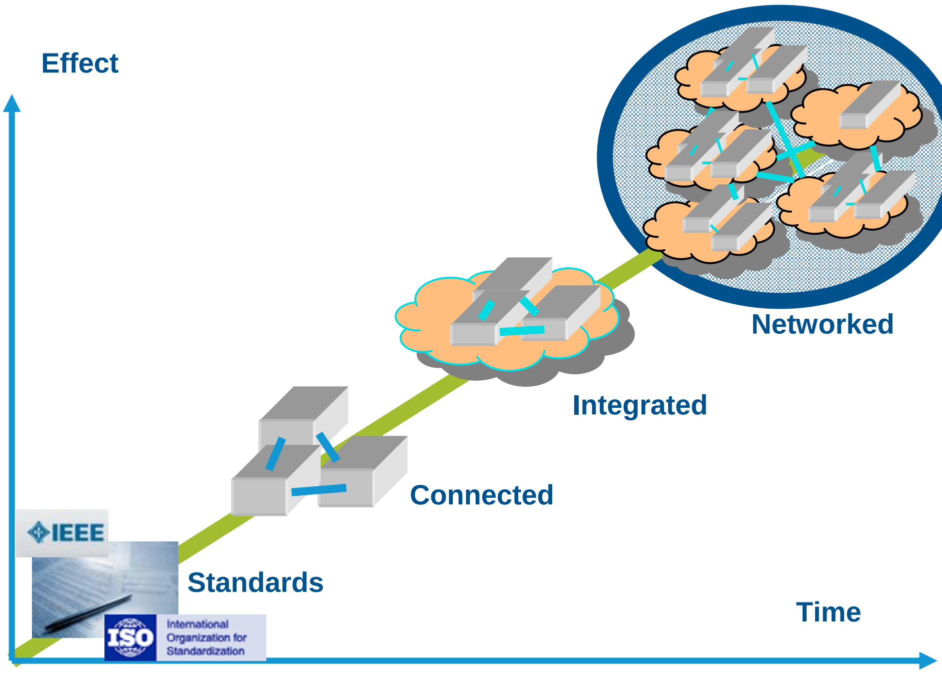


Figure 8. Land Administration Maturity Model

5.2 Current Levels of Land Administration Maturity

At the different scales, world-wide, European, national, the level of maturity can now be assessed as follows:

- World-scale: When we take a look at a global scale, we see the Global Spatial Data Infrastructure (GSDI) efforts resulting in standards. This is the first stage of maturity. An absolute necessity for creating a base level to build on.
- European-scale: In Europe a big step is made with the Inspire initiative. Inspire gives the standardization base for data and exchange of data. The

standardization level of maturity is met in Europe and we see initiatives like EULIS making the step to the next level of Connectivity; Connections between different countries. We also see some cross border initiatives for better Land Administration processes.

- National-scale: The Netherlands is making the next step towards the Connectivity level. Different organizations and sectors work together in a so called National Geo Portal where Public Services are being places on a map. Data is being organized on a national level in so called key registers, a step towards the Integrated level. All spatial data is being structured, where interconnectivity is a prime goal. With this structuring scheme it is secured that data is collected once and used many times by all governmental bodies. Different governmental bodies like Ministries, Provinces, Municipalities do work together.

Only very premature efforts are made to come to this Network level. One example in The Netherlands is the pilot of public safety where a Spatial Information Infrastructure is one of the elements in disaster management. The step towards a nationwide public safety solution will take some years. Experiencing working together with equality, balance, and shared responsibility is easily said and written but very difficult to execute.

5.3 The last step: fact of future?

Worldwide themes like melting ice-caps, the rising of the sea-level, growing world wide poverty, land with rich resources become more scarce every year where spatial planning should help out organizing our earth. These themes for society are where Land Administration and its Spatial Information Infrastructure can play their role. Land Administration is not the center of the solution, but only one necessary brick in the wall. The success will be the balance of power between all relevant organizations or countries. Once one organization or country starts regulating one of these themes and takes a central role, the balance can easily be disturbed. So a Networked approach is needed: a network where everybody is equal and has its own contribution to the solution. It will be a success once everybody starts placing themselves outside the center of the network and accept a cooperative role. The world needs the network approach, the last stage in maturity, where the theme is placed in a central position and not the organization of country. To face the current global themes, our world deserves the network approach. All disciplines should actively and equally work together. Land Administration and Spatial Information Infrastructures is one contribution to handle the challenges in an ever more complex society. It is crucial in such a networked society that the involved stakeholders do understand each other, despite their different background and terminology. An agreed set of concepts (an ontology) is needed and delivered by the LADM.

6 CONCLUSION

Every country (or, federation of countries) in Europe has a Cadastral or Land Administration system operational (although in some countries not yet for the complete territory), often as the responsibility of a national organization, or as the responsibility of a more local government organization. Due to different legal systems and different national tradition, there is a rich variety of cadastral systems around. As this limits interoperability (e.g. in the context of EULIS) and results in high system development and maintenance costs, non-governmental (international) organizations, such as the FIG, developed the Land Administration Domain Model (LADM) and submitted this to ISO/TC211.

Land Administration Systems form an important part of the Spatial Information Infrastructure of the Member States. Cadastral activity is related to creating and updating the land parcel's alphanumerical and graphical information and its aggregation. The Cadastral Organizations in each Member State are those public organizations that have specific legal responsibility in creating and updating the land parcel's alphanumerical and graphical geo-referenced information, or its coordination at national level (IPCC, 2003).

Looking from a 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 the Information and Communication Technology (ICT). The two main functions of every cadastral system are: (1) keeping the contents of these relationships up-to-date (based on legal transactions) in a land administration system and (2) providing information on this registration. In this paper it has been explored which important issues related to a registration in an (S)II have to be confronted (registration content boundaries, keeping related registrations consistent after updates, and harmonized data content). Based on the experience of the Dutch Cadastre, solutions are proposed to solve these issues and this has been illustrated with on-going standardization activities within several international bodies (FIG, CEN/TC287, ISO/TC211, INSPIRE).

Besides important traditional applications of land administration, such as legal security in real estate, taxation, and spatial planning, also less expected crucial societal challenges are benefiting. Examples include combating slum areas (Subsection 4.1), post-war recovering (Subsection 4.2), carbon credits (Subsection 4.4), food security, energy scarcity, natural disasters, urban growth and environmental degradation (FIG, 2009). All these spatial unit related (legal) registrations can be registered or recorded in the proposed LADM.

Some important implementation issues will be discussed in the future: how to manage the different levels of accuracy for LA applications and for small scale topographic data sets, the integration of 3D Cadastres and marine Cadastres, ‘map-matching’ between adjacent countries, a high degree of up-to-date-ness, the integration with surveys (sources), resulting into cadastral index maps.

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