A Domain Standard for Land Administration

Dr.Ir. Christiaan Lemmen,
Prof.Dr.Ir. Peter van Oosterom and Prof.Ir. Paul van der Molen

Abstract

This paper presents the design of a Domain Model for Land Administration (LA). As a result a formal International Standard is available: ISO 19152 Geographic Information – Land Administration Domain Model (LADM) (ISO, 2012).

Domain specific standardisation is needed to capture the semantics of the land administration domain on top of the agreed foundation of basic standards for geometry, temporal aspects, metadata and also observations and measurements from the field. A standard is required for communication between professionals, for system design, system development and system implementation purposes and for purposes of data exchange and quality management of data. Such a standard will enable GIS (Geographic Information System) and DBMS (Data Base Management System) providers and/or open source communities to develop products and applications for Land Administration purposes. And in turn this will enable land registry and cadastral organisations to use the components of the standard to develop, implement and maintain systems in an even more efficient way.

The research objective is to design a Land Administration Domain Model (LADM) for Land Administration System (LAS) development. Such a LADM has to be broadly accepted and it should be adaptable to local situations (Lemmen, 2012). It has to be usable to organise Land Administration data within a Spatial Data Infrastructure (SDI). The design is based on the common pattern of 'people – land' relationships. The model should be as simple as possible, it should cover the basic data related components of Land Administration (legal/administrative, mapping and surveying) and it should satisfy user requirements. The Domain Model in its implementation is can be distributed over different organisations with different tasks and responsibilities.

The research does not focus on the legal, political, economic, institutional or financial aspects of Land Administration and Land Administration organisations; at least as far as those are not related to user requirements for the model. Taxation, valuation and land use are knowledge fields in itself and are not within the focus of research.
In this paper first the motivation and background of the research are presented, followed by the formulation of goals of LADM. Then the model is introduced, followed by an evaluation. Conclusions are presented and attention is given to options for future work.

1. Motivation and background

Main political objectives such as poverty eradication, sustainable housing and agriculture, strengthening the role of vulnerable groups (e.g. indigenous people and women), are in many ways related to access to land, and to land-related opportunities. How governments deal with the land issue, could be defined as land policy, and part of the governmental policy on promoting objectives including environment sustainability, economic development, social justice and equity, and political stability (UN ECE, 1996). Having a policy is one thing, having the instruments to enforce this policy is another. Therefore governments need instruments like regulations concerning land tenure security, land market, land use planning and control, land taxation, and the management of natural resources. It is within this context that the function of LASs can be identified: a supporting tool to facilitate the implementation of a proper land policy in the broadest sense.

Until today most countries (states or provinces) have developed their own LAS. Some countries operate a deed registration, while other operate a title registration. Some systems are centralised, and others decentralised. Some systems are based on a general boundaries approach, others on fixed boundaries approach. Some LASs have a fiscal background, others a legal one (Bogaerts and Zevenbergen, 2001; UN ECE 1996). However, organisational structures with distributed responsibilities and ever-changing system requirements make the separate implementation and maintenance of LASs neither cheap nor efficient. Furthermore, different implementations of LASs do not make meaningful communication very easy, e.g. in an international context such as within Europe or in a national context (for example in a less developed country) where it may happen that different partners in development co-operation design and provide different LASs without co-ordination.

Standardisation is supportive and helpful in design and (further) development of LASs. It is relevant to keep data and process models separated, this means that (inter-organisational) processes can be changed independent from the data sets to be maintained. The data model can be designed in such a way that transparency can be supported: this implies inclusion of source documents and inclusion of the names of persons with roles and responsibilities in the maintenance processes into the data model. The number of attributes should be minimal; during the design of the data model there may be lack of awareness that there is something like a 'multiplier': depending on the number of objects and subjects each attribute can have millions of instances.

Standardisation is a well-known subject since the establishment of LASs. Standardisation concerns identification of parcels, documents, persons, control points and many other issues. It concerns the organisation of tables in the registration and references from those tables to other components, e.g. source documents and maps; this includes efficient access to archives. It concerns coding and use of abbreviations, e.g. for administrative areas. It concerns workflows, etc. It should be observed that all this is valid for both paper based and for digital LASs. During

analogue to digital conversions (many) inconsistencies built up in a paper based system can appear: there can be parcels in the registry which are not on the map and the other way around. Such errors should be *impossible*, because a real right is always related to a person and to a piece of land in reality. The same is valid for the representation of this reality in a register and on a map. This type of inconsistencies should be impossible, but they exist. Measures have to be taken to avoid this in the future after computerisation.

The work described in this paper is the first successful attempt to create an accepted international standard (ISO 19152) in this domain.

A standard for the Land Administration Domain serves the following goals:

- *Establishment of a shared ontology implied by the model.* This allows enabling communication between involved persons (information managers, professionals, and researchers) within one country and between different countries. This is relevant in the determination of required attributes and in setting responsibilities on maintenance of data sets in case of implementation of Land Administration in a distributed environment with different organisations involved. This is also in support of the development of LASs as core in SDI (or Geo Information Infrastructures – GII). One more issue is the globalisation; there are already ideas for and approaches to international transactions, e.g. within the European Union. Also in relation to carbon credits registration.
- *Support to the development of the application software for LA.* The data model is the core here. Support in the development of a LAS means provision of an extendable and adaptable fundament for efficient and effective LAS development based on a Model Driven Architecture (MDA). This approach offers automatic conversions from models to implementation, where local details can be added to the conceptual model first.
- *Facilitation of cadastral data exchange with and from a distributed LAS.* Within SDI (GII) combination of LA data with other data sources should be possible. For example legal data related to cadastral objects with data from other sources describing physical objects as roads, buildings or utilities. Exchange can be between cadastres, land registries and municipalities and between countries in a federal state or between countries; etc.
- *Support to data quality management in LA.* Use of standards contributes to the avoidance of inconsistencies between data maintained in different organisations because data duplication can be avoided as much as possible. It should be noted here that a standardised data model, which will be implemented, can be supportive in the detection of existing inconsistencies. Quality labels are important for all attributes.

2. Research objective

In spite of the available basic standards (for modeling the Unified Modelling Language – UML), exchanging structured information (eXtended Markup Language: XML) and ISO generic geo-information standards, there is still one important aspect missing: a standard and accepted base model for the land administration domain.

There is a need for domain specific standardisation to capture the semantics of the land administration domain on top of the agreed foundation of basic standards for geometry, temporal aspects, metadata, and also observations and measurements from the field. This is required for communication between professionals, for system design, system development and system implementation purposes and for purposes of data exchange and data quality management. Such a standard will enable GIS and database providers and/or open source communities to develop products and applications. And in turn this will enable land registry and cadastral organisations to use these components to develop, implement and maintain systems in an even more efficient way.

The research objective is to design a Land Administration Domain Model (LADM). It should be possible to use this model as a basis for LAS development. Such a LADM has to be accepted and it should be adaptable to local situations. It has to be usable to organise LA data within a SDI. The design should be based on the pattern of 'people – land' relationships.

It should be noted that the LADM should be as simple as *possible*, in order to be useful in practice. And it should cover the basic data related components of land administration. This means a start from consolidated knowledge; a re-use of existing, widely recognised and accepted knowledge in order to achieve *generic* results. For the LA domain much attention has been paid to the development of the representation of all possible relationships between people and land, not only *formal* relationships like ownership but also *informal* relationships as proposed in UN-HABITATs (UN-HABITAT is the United Nations Human Settlements Programme) continuum of land rights (UN-HABITAT, 2008). A similar continuum can be applied to the development of a range of parcels (*spatial units*, see also Fourie (1998) and Fourie and Nino-Fluck (2000)), persons and organisations (*parties*), and data acquisition methods, see also FIG (1996). See also the 'axes of variation' in Larsson (1991). Further the concepts of 'Cadastre 2014' of the FIG should be covered; see Kaufmann and Steudler (1998).

Given the research objective, and a design of a LADM, the following questions are formulated:

- What is the common pattern of 'people – land' relationships?
- How can the model be used as a basis for LAS development?
- Is the design usable within a Spatial Data Infrastructure?
- Is the design accepted and supported by LA professionals and governments?

– Is the design adaptable to local situations?
– Is the design implementable and applicable in a real life situation?

3. The LADM

The design of the LADM took place in an incremental approach, resulting in three main versions: A, B and C. For the Versions A and B this concerns input from workshops, personal experience, other expertise and improvements from reviews of publications and for the Version C of the LADM the development process for International Standards. After preparatory works of almost six years the LADM has been submitted to the ISO and parallel to CEN, this is the Comité Européen de Normalisation.

The Draft International Standard, published by ISO as ISO 19152, covers basic information related to components of land administration (including water and elements above and below the earth's surface). It includes agreements on data about administrative and spatial units, land rights in a broad sense and source documents (e.g. deeds or surveys). The rights may include real and personal, formal rights as well as indigenous, customary and informal rights. All types of restrictions and responsibilities can be represented. The draft standard can be extended and adapted to local situations; in this way all *people – land relationships* may be represented. The UML class diagram is represented in Figure 1.

The three main packages of the LADM consist of the Party package, the Administrative package and the Spatial Unit package.

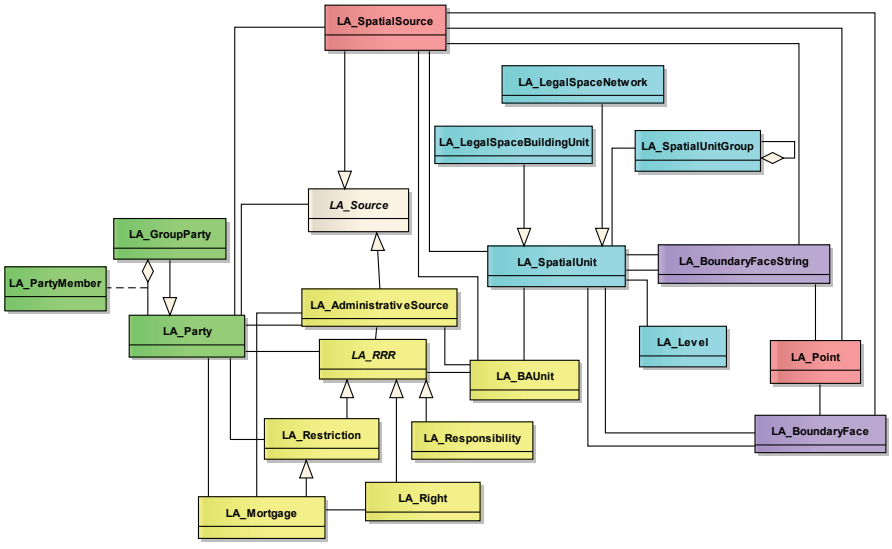

Figure 1. The Land Administration Domain Model.

The main class of the party package of LADM is class LA_Party with its specialisation LA_GroupParty. There is an optional association class LA_Party-Member. A Party is a person or organisation that plays a role in a rights transaction. An organisation can be a company, a municipality, the state, or a church community. A 'group party' is any number of parties, forming together a distinct entity. A 'party member' is a party registered and identified as a constituent of a group party. This allows documentation of information to membership.

The administrative package concerns the abstract class LA_RRR (with its three concrete subclasses LA_Right, LA_Restriction and LA_Responsibility), and class LA_BAUnit (Basic Administrative Unit). A 'right' is an action, activity or class of actions that a system participant may perform on or using an associated resource. Examples are: ownership right, tenancy right, possession, customary right or an informal right. A right can be an (informal) use right. Rights may be overlapping or may be in disagreement. A 'restriction' is a formal or informal entitlement to refrain from doing something; e.g. it is not allowed to build within 200 meters of a fuel station; or a servitude or a mortgage as a restriction to the ownership right. A 'responsibility' is a formal or informal obligation to do something; e.g. the responsibility to clean a ditch, to keep a snow-free pavement or to remove icicles from the roof during winter or to maintain a monument. A 'baunit' (an abbreviation for 'basic administrative unit') is an administrative entity consisting of zero or more spatial units (parcels) against which one or more unique and homogeneous rights (e.g. an ownership right or a land use right), responsibilities or restrictions are associated to the whole entity as included in the Land Administration System. An example of a 'baunit' is a basic property unit with two spatial units (e.g. an apartment or a garage). A 'basic administrative unit' may play the role of a 'party' because it may hold a right of easement over another, usually neighboring, spatial unit.

The spatial unit package concerns the classes LA_SpatialUnit, LA_SpatialUnitGroup, LA_Level, LA_LegalSpaceNetwork, LA_LegalSpace-BuildingUnit and LA_RequiredRelationshipSpatialUnit. A 'spatial unit' can be represented as a text ("from this tree to that river"), a point (or multi-point), a line (or multi-line), representing a single area (or multiple areas) of land (or water) or, more specifically, a single volume of space (or multiple volumes of space). Single areas are the general case and multiple areas the exception. Spatial units are structured in a way to support the creation and management of basic administrative units. A 'spatial unit group' is a group of spatial units; e.g.: spatial units within an administrative zone (e.g. a section, a canton, a municipality, a department, a province or a country) or within a planning area. A 'level' is a collection of spatial units with a geometric and/or topologic and/or thematic coherence. The Spatial Unit Package has one Surveying and Spatial Representation Sub-package with classes such as LA_SpatialSource, LA_Point, LA_BoundaryFaceString and LA_BoundaryFace. Points can be acquired in the field by classical surveys or with images. A survey is documented with spatial sources. A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of LA_SpatialSource. The individual points are instances of

class LA_Point, which is associated to LA_SpatialSource. 2D and 3D representations of spatial units use *boundary face string* (2D boundaries implying vertical faces forming a part of the outside of a spatial unit) and *boundary faces* (faces used in 3D representation of a boundary of a spatial unit). Co-ordinates themselves either come from points or are captured as linear geometry.

Implementation of the LADM can be performed in a flexible way; the draft standard can be extended and adapted to local situations. External links to other databases (supporting GII type of deployment), e.g. addresses, are included. Legal implications that interfere with (national) land administration laws are outside the scope of the LADM.

The DIS has been developed on the basis of a set of user requirements derived from existing literature (Lemmen, 2012), from experience from practise, both personal and from experts from many different countries and earlier publications on LADM, including earlier versions published within ISO (ISO/TC211, 2008a, ISO/TC211, 2008b, ISO/TC211, 2009).

4. Evaluation

The design of the LADM took place in an incremental approach with a continuous expert reviewing from 2002 till 2006. The final construction took place with Enterprise Architect software. Then the design and development process for International Standards has been followed as a methodology for LADM design from 2008 till 2012. In order to answer the research questions the following methodology is used:

1. What is this common pattern of 'people – land' relationships?
To answer this question a literature review is performed on relevant papers related to this issue – with a lot of attention to informal people to land relationships. Documentation on land conflicts is included. Attention is paid to gender to land (shares in land). Social tenures are worked out in the Social Tenure Domain Model (STDM); this is a specialisation of the LADM. A prototype has been developed to process collected data from the field.

2. How can the model be used as a basis for LAS development?
To answer this question a test has been performed in Honduras. A Model Driven Architecture (MDA) provides a platform independent functionality. Standards, as provided by international standardisation bodies like the Object Management Group and ISO are identified with regard to MDA.

3. Is the design usable within a Spatial Data Infrastructure?
Domain models related to the LA domain do not yet exist. Related (future) domain models are considered to be "external", but can be linked in an information infrastructure. This is a design approach where well defined interfaces are recognised with an update mechanism to keep SDI consistent.

4. Is the design accepted and supported by LA professionals and governments?
In their paper Van Oosterom and Lemmen (2002a) propose to join forces and start working on a standard and accepted cadastral base model. Such a model should be usable in (nearly) every country. The standardised cadastral domain model should be described in UML schemas and accepted by experts in LA modelling, by the proper international organisations and by software suppliers.

An early review was related to the publication of a pre-version of the LADM, called the Core Cadastral Domain Model (Van Oosterom and Lemmen, 2002b). LADM versions were not only discussed with LA professionals. Legal professionals, geodesists, anthropologists, land reformers and ICT professionals were all involved in the discussions and reviews.

In the beginning of 2008, FIG submitted a proposal to develop an International Standard for the Land Administration (LA) domain to the ISO/TC 211 on Geographic Information of the International Organization for Standardization (ISO/TC211, 2008a). The proposal received a positive vote from the TC 211 member countries on May 2, 2008, and a project team started to work on the development of the standard. Within TC 211, many issues and comments have been discussed during several meetings (in respectively May 2008, October 2008, December 2008, May 2009 and November 2009), held with a project team composed of 21 delegates from 17 countries. A significant contribution to the development of the standard has been provided by the research communities of the Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC) and Delft University of Technology, the Netherlands.

After positive results of voting on the so-called New Working Item Proposal (NWIP) in May 2008 (ISO/TC211, 2008a) and on the Committee Draft (CD) on October 12, 2009 (ISO/TC211, 2009) the Draft International Standard (DIS) received a positive vote on June 27, 2011 (ISO, 2011); see Table 1. A final voting round resulted in acceptance as International Standard on November, 6th, 2012. Each step in the developments within ISO includes reviews from countries involved in the development process.

Voting	NWIP	CD	DIS	IS
Approve	15	22	26	30
Disapprove	6	3	2	0
Abstain	4	4	4	3
Not Voted	7	3	0	1

Table 1. Voting results at the various stages of ISO 19152.

During the development of the LADM many reviews have been performed resulting in new insights, improvements and proposals for extensions.

Figure 2. ISO 19152 Editorial Committee, Meeting in Molde, Norway, May 2009.

The standard has been developed by experts from all over the world: UN Habitat Land Tenure Section with its comprehensive knowledge on customary tenure systems, EU Joint Research Centre with a broad knowledge base on INSPIRE and LPIS, the United Nations School for Land Administration Studies and experts from Land Administration and Cadastral organisations, universities and normalisation institutes. See Figure 2.

5. Is the design adaptable to local situations?
This is investigated in close co-operation with experts in modelling land administrations from different countries: Cyprus and Honduras. Other cases are INSPIRE Cadastral Parcels and the Land Parcel Identification System (LPIS).

6. Is the design implementable and applicable in a real life situation?
This is tested by the development of a prototype of the STDM.

The development of an International Standard within ISO is a comprehensive, extensive, formal process with a continuous review and a continuous, creative approach to find common denominators in land administration systems, including data sets. Many comments and observations have been processed to bring the LADM to the required quality level needed for international acceptance.

The International Standard, covers basic information related to components of land administration - land administration includes water and elements above and below the earth's surface (ISO, 2012). Those components concern: party related data; data on RRRs and the basic administrative units where RRRs apply to; data on spatial units and on surveying and topology/geometry. The data sets in those components are represented in UML packages and class diagrams in this thesis. All data in a

land administration are supposed to be documented in (authentic) source documents. Those source documents are the basis for building up a trusted and reliable land administration, as basis for transactions and for the establishment of new land rights in a land administration.

Rights may include real and personal, rights as well as indigenous, customary and informal rights. All types of restrictions and responsibilities can be represented. Overlapping claims to land may be included.

The common denominator or the *pattern* that can be observed in land administration systems is with a package of *party/person/organisation* data and *RRR/legal/administrative* data, *spatial unit (parcel)/immovable object* data. This can be derived from the existing work on Land Administration Domain Modelling, see (Lemmen, 2012). During the LADM design it became more and more clear that the Triple 'Subject – Right – Object' is insufficient to cover a group of existing LASs which is not 'parcel or spatial unit based' but 'property based'. In those LASs all spatial units 'belonging' to the same basic property unit are seen as one single object. This implies the core classes Party, RRR and SpatialUnit have to be extended with one more class BAUnit: 'Basic Administrative Unit'.

The innovation is in the availability of the LADM as a basis for structuring and organising of representations of people to land related information in databases in a generic way. Structuring and organising data may be in interaction with data in other databases. Databases can be implemented in a distributed environment in different organisations with different responsibilities in Land Administration. The MDA approach can support in generating database schemas. Exchange formats (XML) between organisations – in case of a distributed environment for implementation – are not illustrated in this thesis. An application schema is needed for software development, but this can only be developed after the local demands are precisely known. The application schema can be built on the generic conceptual schema of the LADM combined with local needs. This is also demonstrated in FAO FLOSS SOLA (FAO, 2011).

Annex A of ISO 19152 provides an abstract test suite to check if a model is LADM compliant.

The LADM is usable within a Spatial Data Infrastructure. This concerns firstly the data exchange between organisations involved in land administration, packages have been introduced in LADM for a proper representation of tasks and responsibilities. Secondly LADM can be a basis for combining data from different LASs; e.g. LASs with datasets on formal and informal People to Land relationships. The Draft International Standard includes informative example cases with People to Land relationships demonstrating the flexibility of the draft standard in its Annex C. The LADM opens options now to bridge gaps between cultures where *People to Land relationships* are concerned, definitively not only in support of globalisation, but

also with a strong attention to bring support in the protection of land rights (tenure certainty) for all. Thirdly, for implementation in SDI the links to external classes in other registrations, are important, see Figure 3.

There is support from professions, e.g. within FIG (FIG submitted the NWIP to ISO, LADM is 'FIG Proof'), ISO/TC211 (an editorial committee with experts from about ten countries prepared the ISO 1952), UN-HABITAT (the development and implementation of STDM), EU (attention to LADM in relation to LPIS, INSPIRE), FAO (LADM as basis for FLOSS/SOLA) and countries, e.g. Cyprus, Portugal and Honduras, see (Lemmen, 2012). Bahrain, Canada, Indonesia, Montenegro, Uganda, Senegal and South Korea are adopting or interested.

The draft standard can be extended and adapted to local situations; in this way all People to Land relationships may be represented. This can be supportive in the development of software applications built on database technology. LADM describes the data contents of land administration in general. Implementation of the LADM can be performed in a flexible way; the standard can be extended and adapted to local situations.

Applications in real life situations can be concluded from: firstly the prototype based on STDM for processing of field work data for validation purposes. Secondly the case from Cyprus, thirdly the case from Honduras and fourthly the case from Portugal (see for those cases Lemmen, 2012).

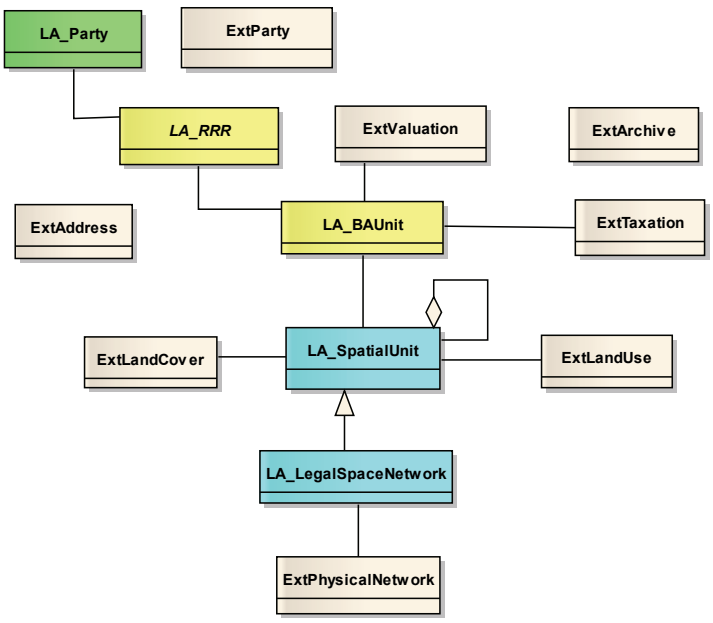

Figure 3. LADM and External classes.

In general it can be observed that standardisation is a comprehensive, extensive, formal process with continuous peer reviews and iterations based on experience of earlier implementations. For LADM this (creative) approach resulted in finding common denominators in land administration. A main effort was in finding agreement between experts from different countries and in provision of balanced reactions to comments and observations made by experts. The standard has been designed in such a way that it can easily be changed depending on local demands. Application of the standard is far away from 'dogmatic implementations' with fixed rules, on the contrary: the approach is as flexible as possible. It is a common language for LA enabling understanding each other. ISO has a standard update cycle for revisions of standards.

5. Conclusion

The objective of this research has been achieved; the research questions have been answered. Validation has been performed. The fact that an international expert group has been involved in the LADM development – with a lot of experience in developments and implementations of LASs – is a solid basis. See Figure 1.

It can be concluded that the common pattern in Land Administration can be represented in four core classes: Party, RRR, BAUnit and SpatialUnit. An application schema can be built on the generic conceptual schema of the LADM for implementation in a distributed environment. The LADM is usable within SDI. Acceptance from within the international professional environment can be observed. LADM can be adapted to local situations.

The wide range of functionality of LADM is in support to:

- the continuum of land rights (management of different tenures in one environment), the continuum of approaches, the continuum of recordation, the continuum of spatial units and subjects. The LADM opens options now to bridge gaps between cultures where People to Land relationships are concerned, definitively not only in support of globalisation, but also with a strong attention to bring support in the protection of land rights (tenure certainty) for all,
- land administration system design and development with coverage of all tenure types. Those systems can operate in formal and informal environment ("self made land administration"). LADM describes the data contents of land administration in general. Implementation of the LADM can be performed in a flexible way; the standard can be extended and adapted to local situations. Alignment with ICT developments is possible (the LADM is available in a well known modeling language, model driven architectures can be developed on the basis of the standard,
- the quality upgrading of existing (not proper maintained) datasets (consistency building and validation),

– the management of a wide range of documentation options. This concerns evidence from the field and legal, transactional, and administrative documents,
– land administration development. Software and data base developers like stable (but extensible) standards as a starting point for developments. Both industrial software developers and open source software communities are enthusiastic. LADM allows a flexible, step by step approach in the development of a Land Administration based on the needs, priorities and requirements of users and society. This can be combined in a natural way with organizational development with a proper alignment to ICT development,
– the linking to workflow management. Processes are not integrated in LADM, linking is possible by role types, versioning, quality labels and exchange of data between involved organisations,
– structuring and organising data in interaction with data in other databases. Databases can be implemented in a distributed environment in different organisations with different responsibilities in Land Administration and population registration. The LADM is usable within a Spatial Data Infrastructure. This concerns the data exchange between organisations involved in land administration. The LADM "packages" have been introduced for a proper representation of tasks and responsibilities (which can be in different organisations). LADM can be a basis for combining data from different LASs; e.g. LASs with datasets on formal and informal People to Land relationships. The International Standard includes informative example cases with People to Land relationships demonstrating the flexibility of the standard. For implementation in SDI the links to external classes in other registrations are important.

LADM will be maintained by ISO/TC211. Relevant existing international standards[1] have been re-used in LADM. Those data standards are accepted in the world of the Geographical Information Systems and Data Base Management Systems – and maintained by ISO TC211. LADM is a conceptual model and is already is use as such (country profiles, integration in INSPIRE and the Land Parcel Identification System of the European Union, basis for software development initiatives at FAO and UN Habitat, etc, see Lemmen (2012), the next steps include elaborating (via a country profile) and realizing a technical model suitable for implementation: database schema (SQL DDL), exchange format (XML/GML), and user interface for edit and dissemination. A good option for this is the collaboration between FIG and OGC to standardize this technical model (with options such as CityGML or LandXML). When considering the complete development life cycle of rural and,

1. For example: ISO/IEC 13240:2001, *Information technology – Document description and processing languages – Interchange Standard for Multimedia Interactive Documents (ISMID)*; ISO 19107:2003, *Geographic Information – Spatial schema*; ISO 19108:2002, *Geographic Information – Temporal schema*; ISO 19111:2007, *Geographic Information – Spatial referencing by coordinate*; ISO 19115:2003, Geographic information – Metadata; ISO 19125-2:2004, Geographic information – Simple feature access – Part 2: SQL option; ISO 19156:2011, Geographic information – Observations and measurements.

in particular, urban areas, many related activities should often also support 3D representations (and not just the cadastral registration of the 3D spatial units associated with the correct RRRs and parties). The exact naming of these activities differs from country to country, and their order of execution may differ. However, in some form or another, the following steps performed by various public and private actors, which are all somehow related to cadastral registration, are recognized: develop and register zoning plans, design new spatial units/objects; acquire appropriate land/space; request and provide (after check) permits. Etc.

Several of the activities and their information flows need to be structurally upgraded from 2D to 3D representations. Because this chain of activities requires good information flows between the various actors, it is crucial that the meaning of this information is well defined – an important role for standardization. Important are ISO 19152 (LADM) and ISO 19156 (Observations and Measurements), and very related and partially overlapping is the scope of the new OGC's Land Development – Standards Working Group (LD-SWG), with more of a focus on civil engineering information, e.g., the planned revision of LandXML (to be aligned with LADM). This phenomenon is especially true for 3D cadastre registration because it is being tested and practiced in an increasing number of countries. For example, for buildings (above/below/on the surface or constructions such as tunnels and bridges), and (utility) networks, this overlap is clear. LADM is focusing on the spatial/legal side, which could be complemented by civil engineering physical (model) extensions. It is important to reuse existing standards as a foundation and to continue from that point to ensure interoperability in the domain in our developing environment!

With the official status of the LADM as an International Standard approaching, the question arises: what's next? The answer is of course *more implementation and use of the model in practice*. Already several country profiles have been designed and other model usage is being conducted.

Future requirements concern (Uitermark et al, 2010): formalisation of current constraints, standardisation of processes, new RRRs, mature information infrastructures to serve society; 3D, 4D that is, space and time integrated in Land Administration; applications of augmented reality; spatial design applications; semantic web technologies; monitoring applications; and user dominance (this is a dynamic process model with acquisition/updating/participation by actors and community driven cadastral mapping – crowdsourcing). LADM is a requirement here from a modelling perspective.

Future maintenance within ISO TC211 includes (amongst others): further detailling of the legal/administrative package, maintenance of code tables and the link to LandXML. This has to be organised in close co-operation with FIG and the Open GeoSpatial Consortium.

References

Bogaerts, T. and Zevenbergen, J.A., (2001). "Cadastral systems - alternatives." Computers, Environment and Urban Systems 25 (4-5): pp. 325 - 337.

FAO, (2011). FAO FLOSS SOLA Data Dictionary for the SOLA Desktop Development Snap shot, version 1.0. Prepared by Elton Manoku, Matthew Boafo and Neil Pullar. Version 1.0, August 24, 2011.

FIG, (1996). The Bogor declaration for cadastral reform. Inter-Regional Meeting of Experts on Cadastre, Bogor, Indonesia.

Fourie, C., (1998). An integrated geo-information system with emphasis on cadastre and land information systems for decision makers in Africa, working document for the expert group meeting held at United Nations Economic Commission for Africa, Addis Ababa, Ethiopia, 23 - 26 November 1998.

Fourie, C., and Nino-Fluck, O., (2000). Cadastre and Land Information Systems for Decision Makers in the Developing World, paper presented at the UN-FIG Conference on Land Tenure and Cadastral Infrastructures for Sustainable Development, Melbourne, Australia, October 25-27, 1999. Paper published in Geomatica, 54 (2000): pp. 335 - 342.

ISO, (2011). ISO 19152, Draft International Standard (DIS), Geographic information - Land administration domain model (LADM). Lysaker, Norway: ISO: 118 p.

ISO, (2012). ISO 19152:2012, Geographic Information – Land Administration Domain Model. Edition 1, 118 p. Geneva, Switzerland.

ISO/TC 211, (2008a). ISO 19152 New work item proposal (NWIP), Geographic information – Land administration domain model (LADM). Lysaker, Norway.

ISO/TC 211, (2008b). ISO 19152 Working Draft 3 (WD3), Geographic information – Land Administration Domain Model (LADM). Lysaker, Norway.

ISO/TC 211, (2009). ISO 19152. Committee Draft (CD), Geographic information – Land Administration Domain Model (LADM). Lysaker, Norway.

Kaufmann, J. and Steudler, D., (1998). Cadastre 2014. A vision for a future cadastral system. FIG XXI International Congress. Brighton, United Kingdom.

Larsson, G., (1991). Land regsitration and cadastral systems. Tools for land information and management. Longman Scientific and Technical.

Lemmen, C.H.J., (2012). A Domain Model for Land Administration. Publications on Geodesy 72. Netherlands Geodetic Commission. Delft, 2012. 244 p. ISBN: 978 90 6132 336 5.

Uitermark, H.T., Van Oosterom, P.J.M., Zevenbergen, J.A. and Lemmen, C.H.J., (2010). From LADM/STDM to a spatially enabled society: a vision for 2025. The World Bank Annual Bank Conference on Land Policy and Administration. Washington D.C.

UN-HABITAT, (2008). Secure land rights for all. Nairobi, Kenya, United Nations Human Settlements Programme: 40 p.

UN ECE, (1996). Land administration guidelines. With special reference to countries in transition. Geneva, Switzerland, United Nations/Economic Commission for Europe: 112 p.

Van Oosterom, P.J.M. and Lemmen, C.H.J., (2002a). Impact analysis of recent Geo-ICT developments on cadastral systems. FIG XXII International Congress, Washington, D.C. USA, FIG.

Van Oosterom, P.J.M. and Lemmen, C.H.J., (2002b). Towards a standard for the cadastral domain: proposal to establish a core cadastral model. COST Action G9 workshop, Delft, the Netherlands.

There is a LADM wiki available: http://isoladm.org