The Land Administration Domain Model Standard

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SUMMARY

LADM is a international standard for the land administration domain. It will stimulate the development of software applications and will accelerate the implementation of proper land administration systems that will support sustainable development. The LADM covers basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth); The standard provides an abstract, conceptual model with three packages related to:

- parties (people and organizations);
- basic administrative units, rights, responsibilities, and restrictions (ownership rights);
- spatial units (parcels, and the legal space of buildings and utility networks); with sub packages for spatial sources (surveying), and spatial representations (geometry and topology).

This paper summarizes the motivation, requirements and goals for developing LADM. Further, the standard itself is described, including the development process and potential future maintenance. Despite being a very young standard, 'born' on 1 December 2012, it is already possible to observe some of the impact of LADM and some examples of this are given in the paper.

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1. INTRODUCTION

This paper presents the design and development of 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.

In this paper the Land Administration Domain Model (LADM) and its design and development is presented. The paper has been prepared on the basis of earlier documents (Lemmen, 2012, Lemmen et al, 2013a, Lemmen et al 2013b) and should be seen as a general introduction of the LADM to the 5th LADM Workshop in Kuala Lumpur, 24 – 25 September 2013.

Motivation, background and goals of LADM are given in section 2 of this paper. The LADM supports Land Administration System (LAS) development. It should be recognised here that LA and LASs are in support to the implementation of Land Policies, see (UN/ECE, 1996). This means that requirements as in Byamugisha (2013), CheeHai (2012), Enemark (2012), FAO (2012), FIG (2010), UN-Habitat (2003, 2004, 2008, 2012) have to be supported in order to align policy requirements and system development based on a LA Standard. In other words: to bridge the gap between policies and information management. Such a LADM has to be broadly accepted and it should be adaptable to local situations (Lemmen, 2012). An overview of LADM requirements is given in section 3. The LADM design, as presented in section 4, 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. LADM development and the future maintenance are in the overview in section 5. A very first overview of LADM impact is in section 6. Conclusions are presented in section 7.

2. LADM MOTIVATION, BACKGROUND AND GOALS

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 in this domain.

What can go wrong if you don't have a standard for the Land Administration Domain? What goes wrong if you don't have standards? Many things went well before standards were introduced. Greenway (2005) gives some examples of standards: the format of telephone and banking cards; the internationally standardised freight container; the number of businesses implementing ISO 90003 (quality management) and ISO 14000 (environmental management); the universal system of measurement known as SI4; ISO codes for country names, currencies and languages; paper sizes and so on. He states that this list points to the ubiquity of standards, but also begins to indicate the economic benefits that they provide. That is the confidence that things will work and will fit together. He quotes key findings from a NASA5 report (NASA, 2005): 'Standards lower transaction costs for sharing geospatial data when semantic agreement can be reached between the parties', and: 'Standards lower transaction costs for sharing geospatial information when interfaces are standardised and can facilitate machine-to-machine exchange'. So, standards are, amongst other things, widely used because of efficiency and because of support in communications based on common terminology. One more issue is the LAS development. As highlighted above many countries are working on this. The data model is the core in those developments.

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.

A specialisation of LADM is the Social Tenure Domain Model (STDM); see (Augustinus et al, 2006, Augustinus, 2010, FIG, 2010). It is developed by UN Habitat, the International Federation of Surveyors and the University of Twente, Faculty ITC. STDM broadens the scope of land administration. It provides a land information management framework that integrates formal, informal and customary land systems. It also integrates administrative and spatial components. Doing so, the model describes relationships between people and land in an unconventional manner: it has the power to tackle land administration needs in communities, such as people in informal settlements and customary areas. The emphasis is on social tenure relationships as embedded in the continuum of the land rights concept promoted by the Global Land Tool Network and by UN-Habitat

3. LADM REQUIREMENTS

Internationally, the wish emerged for a widely accepted standardized domain model, making use of the collective knowledge already existing worldwide. This wish was supported by the International Federation of Surveyors (FIG) and UN-Habitat and also by the Food and Agricultural Organization (FAO) of the UN. The data model should be able to function as the core of any land administration system. The standard should be flexible, widely applicable and function as a gathering point of a state-of-the-art international knowledge base on this theme. After an extensive design and development procedure, starting in 2002 within the FIG and from 2008 within ISO TC211 and involving many stakeholders from all over the world, this standard has now been published.

The development of LADM is based on user needs; comprehensive overview of requirements for the Land Administration Domain is available in (Lemmen, 2012). Open markets and globalisation require a shared ontology allowing enabling communication between involved persons within one country and between different countries. Effective and efficient system development and maintenance of flexible (generic) systems ask for further standardisation.

A standardised land administration domain model should be as simple as possible, in order to be useful in practice. And: it should be adaptable and adoptable to local situations.

The technology adopted should be sufficiently flexible to meet future needs and to permit system growth and change. Detailed LADM requirements are presented in table 1.

Table 1: LADM Requirements

Nr	Requirement	Impact
1	*Continuum of land rights*	The Triple Object (Spatial Unit) – Right (RRR) – Subject (Party) is the common pattern for Land Administration and is the basic structure (Lemmen, 2012). Groupings of objects or subjects should be supported. The flexibility of the model should be based on the recognition that people's land

		relationships appear in many different ways, depending on local tradition, culture, religion and behaviour. It should be possible to merge formal and informal tenure systems in one environment. *Land rights* may be formal ownership, apartment right, usufruct, freehold, leasehold, or state land. It may be social tenure relationships like occupation, tenancy, non-formal and informal rights, customary rights (which can be of many different types with specific names), indigenous rights, religious rights, possession, or: *no land rights (no access to land).* There may be overlapping tenures, claims, disagreement and conflict situations. This is an extensible list to be filled in with local tenancies - flexible and extensible coding of types of rights and restrictions, etc. is needed. People – land relationships can be expressed in terms of *parties having (social) tenure relationships to spatial units*. This is in support to access land for all (UN-Habitat, 2008). It is in support to LA requirements as in (FAO, 2012).
2	*Continuum of land use right claimants (subjects or parties)*	*Parties* can be persons, or groups of persons, or non-natural persons, that compose an identifiable single entity. A non-natural person may be a tribe, a family, a village, a company, a municipality, the state, a farmer's community/co-operation, a slum dwellers group/organisation, a religious community….This list may be extended, and it can be adapted to local situations, based on community needs. It should be noticed that a person can hold a *share* in a right, e.g. in case of marriage, or groups of persons holding rights. Women's access to land can be organised by registration or recordation of shares in rights.
3	*Continuum of spatial units (objects)*	Representation of a broad range of spatial units, with a clear quality indication, should be possible. *Spatial units* are the areas of land (or water – e.g. water rights and the marine environment) where the rights and social tenure relationships apply. Spatial units can be represented as a text ("from this tree to that river"), as a sketch, as a single point, as a set of unstructured lines, as a surface, or as a 3D volume - see for example Fourie (1998) and Fourie and Nino-Fluck (2000)). See also the 'axes of variation' in Larsson (1991).
4	*Basic Administrative Units (or Basic Property Unit)*	In combination to the Triple Object – Right – Subject the constellation of basic property units should be supported. The purpose of a basic administrative unit is the grouping of spatial units, which have the same rights, etc. attached. A basic property unit can have a unique identifier - meaning that all spatial units belonging to this basic property unit have the same identifier). A property unit can play the role of a Party: a property unit may be owned by one or more other property units. To get a generic terminology the BPU should be called 'Basic Administrative Unit'.
5	*A range of data Acquisition methods*	Surveying should be supported; boundary should be included in relation to 'Object' in this Triple. Surveys may concern the identification of boundaries of spatial units on a photograph, an image, or a topographic map. Surveys can be conventional land surveys, based on hand-held GPS. In all cases the representation of 'legal' reality should be distincted from the 'physical'

		reality. There may be sketch maps drawn up locally. Depending on the local situation, different registrations or recordings of land rights are possible. In rural areas there can be spatial units covering customary areas. Those spatial units can be recorded as ‘text based’ spatial units, where boundaries are described in words. Or as ‘line based’ spatial units, drawn on low accurate satellite images. The tribe may be represented by its chief. Formal property based spatial units can concern formally registered ownership with a related owner and with identified boundaries by accurate field surveys. The (social) tenure relationship to the spatial units may be represented by points collected with (hand-held) GPS instruments – source documents may be printed from websites providing spatial data. Spatial units in urban business districts can be conventional parcels with high accurate boundaries. Spatial units in residential areas can be derived from aerial photographs. Or total stations, radar detection, recording, cyclomedia, pictometry, or other sensors can be used. Digital video or voice recording are also possible; see Barry (2005). Data quality of spatial data may be improved in a later stage of development. Note: Person identification is not a primary responsibility of cadastre and land registry, but might be of relevance in LA processes. It can be observed that biometric approaches are coming more and more available; in passports, in access to countries. Identification documents can be ‘time-line’ disrupted when new documents are provided. It should be possible to link fingerprints to points (co-ordinates).
6	*A range of authentic source documents*	Inclusion of new data and data updates should be documented. This concerns legal administrative data, spatial data and technical data. Updating in one organisation may need updating in another organisation.
7	*Transparency*	The names of persons responsible for transactions are part of the data set (conveyors, surveyors, registrars, etc). All updates should be traceable. This is one reason for management of history and for documentation of all updates.
8	*History*	Distributed systems or users may not only be interested at the current state of objects, but they may need a historic version of these objects. It may be that the organisation responsible for the maintenance of the objects is not interested in history; the distributed use may require this. Deed based systems require maintenance of history, title based systems may require maintenance of history, e.g. in case of distributed systems.
9	*Different organisations*	In FIG (1999) it is highlighted that the *flow* of information relating to land and property between different government agencies and between these agencies and the public must be encouraged. Whilst access to data, its collection, custody and updating should be facilitated at a *local level*, the overall land information infrastructure should be recognised as belonging to a *national* uniform service to promote sharing within and between nations. See also Williamson and Ting (2001). LA data can be maintained by different organisations. And within one

		organisation at many sites. Administrative territories for organisations can be completely different. The LADM is expected to be implemented as a distributed set of (geo-) information systems, each supporting the maintenance processes (transactions in land rights, establishment of rights, restrictions and responsibilities and the information supply of parts of the data set, represented in this model (diagram), thereby using other parts of the model. Note: this implies that it must be possible to use data in data infrastructures – where data are produced by different organisations. There are opportunities for greater cost effectiveness in areas such as subcontracting work to the private sector; increasing cost recovery through higher fees, sales of information, and taxes; and by linking the existing land administration records with a wider range of land information. See also Bogaerts and Zevenbergen (2001) and Fourie (1998). Organisations are becoming more dependent of each other and are in fact forced to openness (of systems) and exchange (of data). Developments such as chain orientation, digitisation and new technologies are leading to the fading of physical product concepts.
10	*Keep data to the source (within SDI)*	Today all data (spatial and thematic) can be stored in a DBMS. Information products are becoming flexible combinations of digital data components and additional facilities and services. This can replace the exchange of copies of data sets between organisations. *Multi source Information products* require avoidance of redundancy and good standardisation protocols.
11	*Existing standards*	Existing ISO and OGC standards should be followed, particularly the ISO 191XX *geographic information* standards. Furthermore, LADM should be based on the conceptual framework of 'Cadastre 2014' (Kaufmann and Steudler, 1998). The layers of the Cadastre 2014 Model map well to GIS layers, each layer has associations with non-spatial tables, the layer set-up has to be flexible, geometry can be based on ISO geometry and ISO topology. A remark related to the Cadastre 2014 principle of legal independence is that it should be possible to include *explicit relations* between different themes, e.g. rights and restrictions. Overlays are not accurate enough in many cases.
12	*Reference system*	Provisions must also be made to accommodate future changes in the network that may occur as a result of technical improvements. These may affect all co-ordinate based systems. If co-ordinates are an essential component of the cadastral system than the survey technique must be capable of producing these. Imagery can be used depending on the user requirements, cost, and timing among other factors. It should be possible to include all documentation on data collected as evidence from the field.
13	*Identifiers*	A key component in LASs is the spatial unit identifier (UN/ECE, 2004), the parcel identifier or the unique parcel reference number. This acts as a link between the parcel itself and all record related to it. It facilitates data input and data exchange. There can be a need to change identifiers during data collection. Identifications should be free of semantics, there is a need for 'identification' providers, e.g. for parcels, areas, names, rights, restrictions, taxation,

		mortgage, land use, survey and document.
14	*Marine Cadastres 3D Cadastres*	In order to ensure sustainable development of territorial oceans claimed under the UN Convention on the Law of the Sea, the UN Nations emphasise the need for claimant countries to develop their capability to support effective marine resource administration through the national SDI. 3D representation of rights should be possible.
15	*Quality*	Users of cadastral information need clarity, simplicity and speed in the registration process. The information must be as complete as possible, reliable (which means ready when required), and rapidly accessible. Consistency between spatial and legal administrative data is important. Topology integrated with geometry and other attributes is relevant. The system must be ready to keep the information up to date. Data quality of spatial data may be improved in a later stage of development of a LAS, this has to be documented. For combined data products from different sources the quality descriptions and meta data related to the original data are relevant in relation to liability and information assurance. Generic versioning and quality labelling for all contents of LADM is needed.

4. THE LADM

The common denominator, or the pattern that can be observed in land administration systems with legal/administrative data, party/person/organisation data, spatial unit (parcel) /immovable object data, data on surveying or object identification and geometric/topological data (Lemmen, 2012). This has been the basis for LADM design. The design of the LADM took place in an incremental approach. 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.

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 (holding shares in rights).

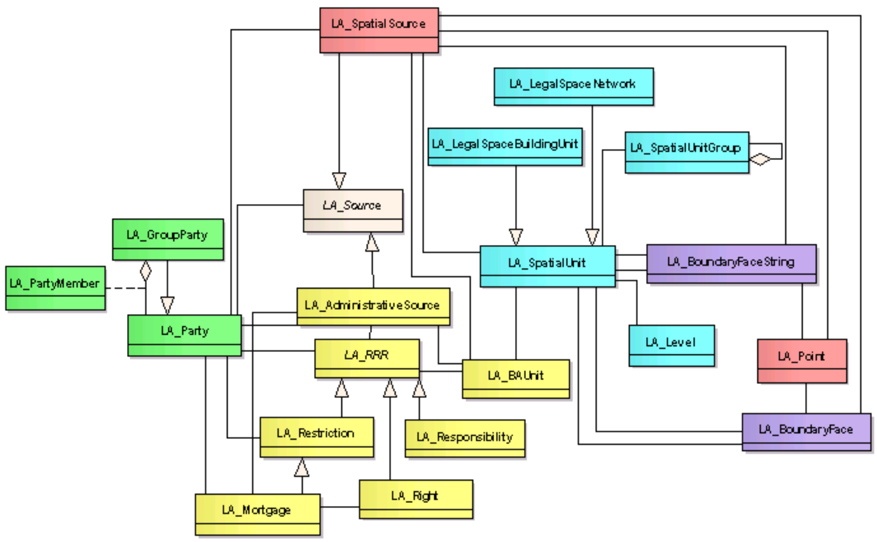

Figure 1: The Land Administration Domain Model

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 neighbouring, 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.

All classes (except LA_Source) inherit from VersionedObject. VersionedObject contains quality labels and attributes for history management. In the LADM, administrative sources and spatial sources are modelled, starting with an abstract class LA_Source. LA_Source has two subclasses: LA_AdministrativeSource, and LA_SpatialSource.

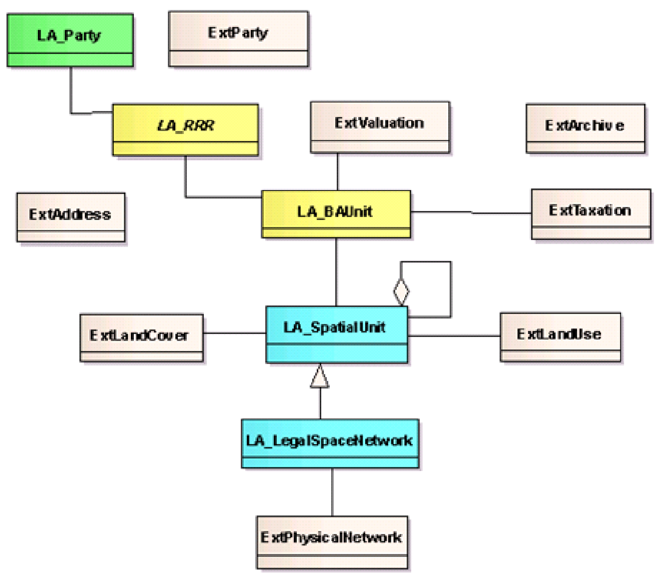

Figure 2: LADM and External classes

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 information infrastructure type of deployment), e.g. addresses, are included. See Figure 2.

Legal implications that interfere with (national) land administration laws are outside the scope of the LADM.

The (Draft) International Standard (ISO, 2011; ISO, 2012) and 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).

All requirements from section 3 are supported in LADM. Code lists for party type, group party type, and party role type allow for flexibility is the representation and extensibility of parties (including parties with responsibilities in transactions. Code lists for right type, restriction type, responsibility type, mortgage type, baunit type, source type allow the flexible implementation of the continuum of land rights (combined with the associations between classes). Similar code lists are available for spatial units and for area management.

5. LADM DEVELOPMENT AND MAINTENANCE

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 2. 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.

Table 2 Voting results at the various stages of ISO 19152

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

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

Figure 3: 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 the Infrastructure for Spatial Information in the European Community – INSPIRE – see (INSPIRE, 2007) and the Land Parcel Identification System – LPIS – see for example Sagris, V. and Devos, W., (2008)), the United Nations School for Land Administration Studies and experts from Land Administration and Cadastral organisations, universities and normalisation institutes. See Figure 3.

LADM is 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.

[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 —*

LADM is a conceptual model and is already is use as such (country profiles, integration in the data specification of cadastral parcels in INSPIRE (INSPIRE, 2009) and the Land Parcel Identification System of the European Union (ISO, 2012), basis for software development initiatives at FAO (FAO, 2011) and UN Habitat (FIG, 2010), etc, (see also 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, 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!

6. IMPACT OF LADM

ISO 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. 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. This means that the LADM is one of the tools (or better: conditions) for the implementation of the continuum of land rights and for FAOs Voluntary Guidelines. The wide range of functionality of LADM is in support to:

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

- 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 modelling 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. This concerns evidence from the field and legal, transactional, and administrative documents,
- land administration development. Software and data base developers are happy: they 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, and:
- 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.

There is support from professionals, e.g. within FIG (FIG submitted the New Working Item Proposal to ISO, LADM is 'FIG Proof'), UN-Habitat (the development and implementation of STDM), EU (attention to LADM in relation to the Land Parcel Information Systems, INSPIRE), FAO (LADM as basis for FLOSS/SOLA) and countries (Cyprus, Portugal and Honduras, Canada, Indonesia, Uganda, Senegal, Vietnam and China and South Korea) are interested. See: http://isoladm.org (this wiki includes LADM documentation).

The standard has been designed in such a way that it can easily be changed depending on local demands. Use 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. A choice for LADM is a strategic choice with its support to the latest insights and global views: the continuum of land rights and the FAO Voluntary Guidelines. ISO guarantees proper maintenance of the standard – future developments in the domain can be included in this way. 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 with many alumni on top positions in land administration organisations in many countries and representatives from Land Administration organisations, universities and normalisation institutes joined forces in this development.

During the development there has been a continuous support by experts from the International Federation of Surveyors with a broad view on land administration and from experts in legislation and Geo ICT. Existing knowledge is integrated.

The standard allows for the implementation of a rich functionality over distributed environment. Some of the offered options still have to be discovered, for example during pilots. A LADM community is developing. So far workshops have been organised in 2003, Enschede, the Netherlands, in 2004, in Bamberg, Germany, in 2009, Quebec City, Canada and in 2012 in Rotterdam, the Netherlands. The LADM 2013 is in September 2013 in Malaysia.

A conformance test is included in Annex A of the standard. Many county profiles and spatial and legal profiles are included, in respectively Annex D, Annex E and Annex F.

This makes the concept of LADM a basis for strategic development in land administration.

Let's built the systems now to achieve the wider goals.

7. **CONCLUSIONS**

LADM, 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. 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, see for example (Uitermark et al, 2010).

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

BIOGRAPHICAL NOTES

Christiaan Lemmen holds an MSc in Geodesy from Delft University of Technology, The Netherlands. He received a PhD from the same University for his thesis 'A Domain Model for Land Administration'. He is sr geodetic advisor at Kadaster International and visting Assistant Professor at Twente University (Faculty ITC), The Netherlands. He is chair of the Working Group 7.1 'Pro Poor Land Management' of FIG Commission 7, and contributing editor of GIM International. He is director of the FIG International Office of Cadastre and Land Records, OICRF. He is one of the co-editors of ISO 19152 (together with Uitermark and Van Oosterom).

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, The Netherlands. In 1990 he received a PhD from Leiden University for his thesis 'Reactive Data Structures for GIS'. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague, The Netherlands as a computer scientist. From 1995 until 2000 he was senior information manager at the Dutch Cadaster, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology (OTB institute) and head of the Section 'GIS Technology'. He is the current chair of the FIG working group on '3D-Cadastres' (Commissions 3 and 7). He is one of the co-editors of ISO 19152 (together with Lemmen and Uitermark).

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