ISO 19152:2012, Land Administration Domain Model published by ISO

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Key words: Land administration, standards, ISO, cadastral modelling, LADM

SUMMARY

This paper describes the last developments of the Land Administration Domain Model (LADM). The Final Draft International Standard, ISO FDIS 19152, unanimously passed on 1 November 2012 the final vote towards becoming an International Standard (IS). After technical editing by ISO secretariat in Geneve, Switzerland, the first edition has been officially published on 1 December 2012 as International Standard ISO 19152:2012(E) 'Geographic information — Land Administration Domain Model (LADM)' and 'Information géographique — Modèle du domaine de l'administrationdes terres (LADM)'. This after a more than four years standards development process within ISO/TC211 (Geographic Information) and six years of preparation within the FIG, while the original idea for such a standard was launched at the 2002 FIG congress in Washington D.C., US.

This paper presents an overview of the last (and minor technical) modifications from FDIS to IS. The main reason for the modifications was the removal of inconsistencies and in all these cases there was consensus within the project team on the correct interpretation. However, most aspects are mentioned three (or more times) in the standard: in the main clauses, in the figures (UML class diagrams), in some tabular forms, and most often also several times in one or more of the many annexes. Despite the fact that the editors and the editorial committee tried to be extremely careful in processing the comment resolutions (DIS to FDIS), some occurrences were overlooked when processing certain comments that needed adoptions in multiple locations. Annex A, the Abstract Test Suite (ATS), was relatively new and did also contain some sloppy errors which have been removed in the IS. The ATS is of utmost importance when testing a model/profile for LADM conformity.

In this paper we further elaborate on the overall process to arrive at an ISO standard and the lessons, we the authors of this paper and editors, learned during the past years. As the LADM standard is now being used (and read by further eyes) it is inevitable that further issues will arrive. As LADM is a conceptual model, 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 the Open Geospatial Consortium (OGC) to standardize this technical model by participation of FIG in the new OGC Standards Working Group - Land Development (upgrade LandXML and make compatible with LADM).

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1. INTRODUCTION

The Land Administration Domain Model (LADM) moved forward to the IS stage (IS = International Standard): ISO FDIS 19152 and was published on December 1, 2012. This is the last stage after a four years standards development process within ISO/TC211 (Geographic Information www.isotc211.org) and six years of preparation within the FIG, while the original idea for such a standard was launched at the 2002 FIG congress in Washington D.C., US.

This paper reflects on the whole standardization process (Section 2), and starts with an historic overview of the incremental development of the LADM. All the steps in this development have been published in a series of papers. There have been workshops, expert group meetings, scientific reviews, and a number of PhD-theses. In 2008, the FIG did take the initiative to submit the results so far to the TC211 of ISO for standardisation. The proposal was accepted and the LADM was developed and improved on the basis of this proposal. A group of experts from different organisations and international institutions contributed to this development within ISO/TC211. Now LADM has reached the state of an international standard (which is already being implemented in various countries), the issue of conformance is becoming more and more relevant. An overview of conformance testing, as described in Annex A of ISO 19152, is given in Section 3. Next, Section 4 discusses the further maintenance and development of the standard (within FIG, ISO, and OGC). The paper ends with conclusions, last reflections and recommendation in Section 5.

2. REFLECTING ON STANDARDIZATION PROCESS WITHIN ISO/TC211

This section gives an overview of the procedural aspects of the standardization process of LADM during the years 2008 – 2012 (Uitermark, 2012). In this period, the 'editing team' of LADM was constituted (the authors of this paper), this team took the decisions regarding model changes and adjustments, and documented these changes, in two ways, firstly, in the concept text of the standard, and secondly in a 'comment log', because most changes were proposed as official 'comments' by the experts, who were members of the LADM project team. In the subsections below the following items will be discussed: the start of LADM (Subsection 2.1) and the start of the standardization project (Subsection 2.2). Then, the phases of the standardization process are described: the Committee Draft (Subsection 2.3), the Draft International Standard (Subsection 2.4), the Final Draft International Standard (Subsection 2.5), and the International Standard (Subsection 2.6).

2.1 The start of LADM

The original idea for a land administration standard (LA standard) was launched at the 2002 FIG congress in Washington D.C. (Van Oosterom and Lemmen, 2002a). Since then a LA domain model (LADM) was developed incrementally. Between 2002 and 2008, important mile stones for LADM were:

- in September 2002, version 0.1 was presented at a Technical Committee (TC) meeting of the Open Geospatial Consortium (OGC), organized in Noordwijk, The Netherlands, and in November 2002 at a COST Workshop in Delft, The Netherlands (Van Oosterom and Lemmen, 2002b)
- in March 2003, version 0.2 was presented at a workshop on Cadastral Data Modeling at ITC (Faculty of Geo-Information Science and Earth Observation of the University of Twente) in Enschede, The Netherlands (Van Oosterom and Lemmen, 2003), and in April 2003, during the FIG Working Week, in Paris, France
- in September 2003, version 0.3 was presented during Digital Earth, in Brno, Czech Republic (Lemmen et al, 2003), and at the 2nd Cadastral Congress, held in Krakow, Poland, and in April 2004, at the European Land Information Service (EULIS) Seminar on 'Land Information Systems and the Real Estate Industry', Lund, Sweden
- in December 2004, version 0.4 was presented during the Second Workshop on Standardization of the Cadastral Domain, held at the University of Bamberg, Germany (Van Oosterom et al, 2004)
- in April 2005, version 0.5 was presented at the FIG Working Week in Cairo, Egypt (Lemmen et al, 2005)
- in March 2006, version 0.6 was presented at the UN-HABITAT expert group meeting in Moscow, Russian Federation (Van Oosterom and Lemmen, 2006), and the FIG regional conference in Accra, Ghana, including the third LADM workshop
- finally, in October 2006, version 1.0 was presented at the FIG Congress in Munich, Germany, under the name of 'version 1.0 of the FIG Core Cadastral Domain Model' (Lemmen and Van Oosterom, 2006).

2.2 The start of the standardization project

In 2008 the International Federation of Surveyors (FIG) took the initiative to submit a proposal for standardization of LADM version 1.0. ([1]) The proposal was sent as a New Working Item Proposal (NP) to the Technical Committee for Geographic Information (TC211) of the International Organization for Standardization (ISO). On May 2, 2008, the proposal received a positive vote from the TC211 member countries, and a project team (PT) started to work on the development of the standard. A group of experts from different organizations and international institutions contributed to this development (see Figure 1).

FIG is an international organization representing the interests of surveyors worldwide. It is a federation of the national member associations. FIG was founded in 1878 in Paris and was known as the Fédération Internationale des Géomètres (this has become anglicized to the International Federation of Surveyors). It is a UN-recognized non-government organization

[1] In the years 2006 and 2007, within ISO/TC211, there had been a preliminary discussion about the standardization of LADM, based on the Caïro and Munich papers.

(NGO), representing more than 120 countries throughout the world (www.fig.net). FIG is a *liaison organization* to ISO/TC211.

Figure 1. The Project Team in Molde, Norway, 2009.

ISO/TC211 is one of the more than 200 technical committees of ISO. Its scope is standardization in the field of digital geographic information. TC211 has published over 50 standards. ([2]) TC211 has 34 national standardization organizations as participating members. TC211 works with the support of about 30 liaison organizations, like FIG. The standardization process of ISO is regulated in a directive: *ISO/IEC Directives, Part 1. Procedures for the technical work* (ISO, 2012). According to this directive, FIG as a liaison organization of TC211, is entitled to do a proposal for standardization. This is known, in ISO language, as a New Item Working Proposal (NP). ([3])

LADM as NP: A decision upon an NP is done by *voting* by the members of the Technical Committee, within 3 months after the NP was proposed. An NP is accepted when (1) there is a simple majority of the members of the technical committee voting, and (2) a commitment to

[2] Based on the Vienna Agreement between ISO and CEN (the European Committee for Standardization), many standards are published in parallel with CEN.

[3] While FIG acted as the principal international body, there was also support and commitment from two other liaison organizations: (1) UN-HABITAT, the United Nations agency for human settlements, and (2) JRC, the Joint Research Centre of the European Commission.

participate actively in the development of the project by at least five members. In Table 1 the result of the voting is summarized. The NP was approved with a majority of 15 over 6, with 10 members willing to participate.

Table 1. The result of voting of LADM as NP.

	Yes	No	Participate?	Comments
Australia (SA)	X		N	
Austria (ON)	X		N	
Canada (SCC)	X		Y	
China (SAC)	X		Y	
Czech Republic (CNI)	X		N	
Denmark (DS)	X		N	
Finland (SFS)		X	N	X
Germany (DIN)		X	Y	X
Italy (UNI)	X		N	
Japan (JISC)		X	N	X
Korea, Rep. of (KATS)	X		N	
Netherlands (NEN)		X	Y	X
New Zealand (SNZ)	X		Y	
Norway (SN)		X	N	X
Russian Fed. (GOST R)	X		N	
South Africa (SABS)	X		N	
Spain (AENOR)	X		Y	X
Sweden (SIS)		X	Y	X
Thailand (TISI)	X		Y	
United Kingdom (BSI)	X		Y	X
USA (ANSI)	X		Y	
Totals (P-members only)	15	6	10	(8)

Negative votes and comments on LADM as NP: According to ISO procedures, members shall provide a statement justifying their positive or negative vote. It is interesting to look at the comments of the negative votes.

Firstly, there is a certain contradiction in saying 'no' to the NP and at the same time saying 'yes' to willing to participate, as was done by three members. E.g. one member justified this behaviour by saying, that when many others are in favour of the NP (in fact, NP's have never been disapproved in TC211), this member is willing to contribute.

Secondly, the justification to vote negative concentrates on the issue whether domain models, that are basically the responsibility of governmental organisations, should be standardized and, if so whether in the end standardization violates national legislation. This last point caused a thorough discussion on the scope of LADM (scope = the subject and the aspects covered, indicating the limits of applicability).

It should be noted that countries bringing negative votes were very positive-critical and constructive during the development process! This resulted in highly valuable improvements.

2.3 From WD to CD: May 2008 – November 2009

The NP was accepted as a (first) Working Draft (WD) for further development, with a total (default) development track of 36 months (three years). See Table 2. In Denmark

(Copenhagen, May 2008), the PT discussed the first WD, resulting in a second WD, that was discussed in The Netherlands (Delft, September 2008), which resulted in a third WD, that was discussed in Japan (Tsukuba, December 2008, Figure 2). Based on the last meeting, a text for a Committee Draft (CD) was discussed in Norway (Molde, May 2009).

Table 2. Default development track LADM.

Document	**Target date for submission:**	**After approval NP**
as a CD:	May 2009	12 months
as a DIS:	November 2009	18 months
as a FDIS:	November 2010	30 months
as an IS:	May 2011	36 months

Consequently, in July 2009 a CD was submitted for approval for registration as a DIS. The decision to circulate a DIS is taken on the basis of the *consensus principle*. The definition of consensus by ISO is: “General agreement, characterized by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments. Consensus need not imply unanimity." The outcome of the submission for approval (October 2009) is summarized in Table 3.

Figure 2. The project team at work in Tsukuba, Japan, 2008.

Table 3. Result of voting CD.

Member body	Approve	Disapprove	Comments
Australia (SA)	X		X
Austria (ON)	X		
Canada (SCC)	X		X
China (SAC)	X		X
Denmark (DS)	X		
Ecuador (INEN)	X		
Finland (SFS)		X	X
France (AFNOR)		X	
Germany (DIN)	X		
Hungary (NSZT)	X		
Japan (JISC)	X		X
Korea, Rep. of (KATS)	X		
Malaysia (DSM)	X		
Morocco (SNIMA)	X		
Netherlands (NEN)	X		
Norway (SN)	X		
Russian Fed. (GOST R)	X		
Saudi Arabia (SASO)	X		
South Africa (SABS)	X		
Spain (AENOR)	X		
Sweden (SIS)	X		X
Switzerland (SNV)		X	
Thailand (TISI)	X		
United Kingdom (BSI)	X		X
USA (ANSI)	X		
Summary Members (25)	22	3	(7)

2.4 From CD to DIS: November 2009 – July 2011

With a comfortable 22 to 3 majority (Table 3) there seemed a 'general agreement' to circulate a DIS, and even with no 'general agreement', a two-thirds majority might be deemed to be sufficient for the CD to be accepted for registration as a DIS. However, every attempt should be made to resolve negative votes. Therefore, with around 300 comments from seven members (see Table 3), it was decided to meet again as an Editing Committee (EC), this time in Canada (Quebec City, November 2009). An *editing committee* meets for the purpose of updating and editing a draft, which is accepted for further processing.

As a result of the Quebec discussions, a new (second) text for DIS was submitted in March 2010, as a final text for approval. Written notifications as to why this text should not enter DIS stage had to be submitted no later than April 2010. And there were a series of comments and observations for extensions, changes and improvements.

In May 2010, ISO/TC211 had their half-yearly plenary meeting in Southampton (UK). Thanks to the Convenor (Antony Cooper, South Africa), it was proposed, in Resolution 500, "to amend ISO/CD19152 in cooperation with the editing committee, to implement the changes required by the comments submitted during the six-week review and make other

editorial changes as required". The resolution was approved.

With the execution of Resolution 500, a new phase started, and a big delay in the development track of LADM. The comments had te be resolved and a new (third) text for DIS had to be prepared. A teleconference with the EC was preferred above a (physical) meeting. All in all, about 50 comments were discussed and a new text for DIS was submitted in January 2011, for a 5-month vote. The outcome of the voting in June 2011 was very favourable. The DIS was approved, with 26 votes in favour (that is 93%; required > 67%) and two negative votes (that is 7%; required < 25%). See Table 4. While the DIS was approved there was also a set of 400 comments.

Table 4. Result of voting DIS.

Country	Approve	Disapprove	Comments
Austria	X		
Canada		X	X
China	X		
Czech Republic	X		
Denmark	X		X
Ecuador	X		
Finland		X	X
France	X		X
Germany	X		X
Hungary	X		
Italy	X		
Japan	X		X
Korea, Republic of	X		X
Malaysia	X		
Morocco	X		
Netherlands	X		
New Zealand	X		
Norway	X		
Poland	X		
Portugal	X		
Russian Federation	X		
Saudi Arabia	X		
Serbia	X		
South Africa	X		X
Spain	X		
Sweden	X		X
Thailand	X		
Turkey	X		
United Kingdom	X		
USA	X		X
Member TOTALS	26	2	(10)

2.5 From DIS to FDIS: July 2011 – October 2012

With this many comments, the editing committee had to be involved again in the processing of the comments. And again, it was agreed not to call a physical meeting, but to work electronically. The editing team prepared draft observations to the comments, distributed

these to the EC members. A limited number of reactions was received back. The text for FDIS was sent to the ISO/TC211 secretariat in November 2011. The text for FDIS had to be remodeled according to *ISO/IEC Directives, Part 2. Rules for the structure and drafting of International Standards* (ISO, 2011). Therefore, it took some time before it was submitted to the ISO secretariat in May 2012.

Table 5. Result of voting FDIS.

Country	Approve	Disapprove	Comments
Australia	X		X
Austria	X		
Canada	X		X
Chile	X		X
China	X		
Czech Republic	X		
Denmark	X		
Ecuador	X		X
Finland	X		
France	X		
Germany	X		
Hungary	X		
Iran	X		
Italy	X		
Japan	X		
Lithuania	X		
Malaysia	X		
Morocco	X		
Netherlands	X		
New Zealand	X		
Norway	X		
Russian Federation	X		
Saudi Arabia	X		
Serbia	X		
South Africa	X		
Spain	X		
Sweden	X		
Thailand	X		
Turkey	X		
United Kingdom	X		
USA	X		
TOTALS	31	0	(4)

The ISO secretariat has distributed the FDIS to all national bodies for a 2 month vote on 30 August 2012. The outcome of the voting on 30 October 2012 was very favourable. The FDIS was approved, with 30 votes of P-members in favour (that is 100%; required > 67%) and no negative votes (that is 0%; required < 25%). See Table 5. While the FDIS was unanimously approved there were still some last comments from some countries. These were all editorial aspects: figure lay-out, minor mistakes (resulting in inconsistencies between text, figures and tables), spelling and grammatical corrections. The parallel FprEN (within CEN) was also approved without no-votes.

2.6 From FDIS to IS: November 2012 – December 2012

As the source document was not anymore within ISO/TC211, but within the central secretariat of ISO (Genève, Switzerland), the editors provided detailed instructions for each of the nearly 60 comments received on the FDIS to the central ISO secretariat. The editors processed all comments to the FDIS. From these comments it became clear that some extremely accurate checking had been conducted and still quite a number of issues were reported despite all efforts to produce a high quality FDIS. As indicated by the commenting countries, the comments were indeed all editorial and most of them need a correction in the document (and some also in the UML model). Besides minor textual and graphical corrections, there were basically 3 types of comments concerning (internal) inconsistency:

1. Inconsistency between text, figure (UML) or table of the same item. This had to be removed, it concerned often very subtle differences and in most cases the editing team agreed with the proposed change (in a few cases the team motivated why an alternative change would be better).
2. The normative wording: in some places the editing team used 'should' with is not firm enough for normative parts of text. One country proposed to use 'must' in a number of places where another proposed to use 'shall'. The terminology must be consistent with other ISO (TC211) standards, and therefore the term ‘shall’ was used throughout the document.
3. Annex A, the ATS, which was relative new text had a number of inconsistencies with the main text of the FDIS, this implied moving a number of items in the key table Table A.1, but also moving some parts of text that follow (and adding one part which was forgotten: a text for two of the classes: LA_level and LA_RequiredRelationshipBAUnit).

These were all processed by the ISO secretariat in an efficient manner and as a result the International Standard ISO 19152 was officially published on 1 December 2012. In addition also the UML model as maintained by ISO/TC211 HMMG (harmonized model maintenance group) was updated accordingly.

3 CONFORMANCE TESTING

A lot of effort has been made to improve conformance testing. Any land administration system claiming conformance with this International Standard has to satisfy the requirements as in Annex A (’Abstract Test Suite’) of the standard. The abstract test suite is in conformance with ISO 19105. The LADM specifies a conceptual schema. Actual use of the LADM requires that an application schema, such as a country profile, is developed. The Annex A to the standard specifies how to test whether a specific application schema is conformant with the LADM in terms of package and level. Testing whether a specific data set is conformant, means checking the data set content against the corresponding conformant LADM application schema.

The test suite in Annex A of the standard specifies the requirements that the implementation under test has to meet in order to be conformant to this International

Standard. For each test the metadata conformity element takes one of the following values:

- Conformant (conformant). The resource is fully conformant with the cited specification
- Not Conformant (notConformant). The resource does not conform to the cited specification, or:
- Not evaluated (notEvaluated). Conformance has not been evaluated.

Table 6 The LADM conformance requirements table (note CI = Conformance level).

LADM package	**LADM class**	**Cl**	**Dependencies**
-	*VersionedObject*	1	
	LA_Source	1	Oid, (as a minimum one of the specializations must be implemented [LA_AdministrativeSource or LA_SpatialSource]), LA_AvailabilityStatusType
Party Package			Exist only if Administrative Package is implemented
	LA_Party	1	VersionedObject, Oid, LA_PartyType
	LA_GroupParty	2	Oid, LA_Party, LA_GroupPartyType
	LA_PartyMember	2	VersionedObject, LA_Party, LA_GroupParty
Administra-tive Package			Exist only if Party Package is implemented
	LA_RRR	1	VersionedObject, Oid, LA_Party, LA_BAUnit, LA_Right (as a minimum, this specialization shall be implemented), LA_AdministrativeSource
	LA_Right	1	LA_RRR, LA_RightType
	LA_Restriction	2	LA_RRR, LA_RestrictionType
	LA_Responsibility	3	LA_RRR, LA_ResponsibilityType
	LA_BAUnit	1	VersionedObject, Oid, LA_RRR, LA_BAUnitType
	LA_Mortgage	2	LA_Restriction
	LA_AdministrativeSource	1	LA_Source, LA_Party, LA_AdministrativeSourceType, LA_AvailabilityStatusType
	LA_RequiredRelationshipBAUnit	3	VersionedObject, LA_BAUnit
Spatial Unit Package			
	LA_SpatialUnit	1	VersionedObject, Oid,
	LA_SpatialUnitGroup	2	VersionedObject, Oid, LA_SpatialUnit
	LA_LegalSpaceBuildingUnit	3	LA_SpatialUnit
	LA_LegalSpaceUtilityNetwork	3	LA_SpatialUnit
	LA_Level	2	VersionedObject, Oid
	LA_RequiredRelationshipSpatialUnit	3	VersionededObject, LA_SpatialUnit
Surveying and Repre-sentation Subpackage			
	LA_Point	2	VersionededObject, Oid, LA_SpatialSource, LA_PointType, LA_InterpolationType

	LA_SpatialSource	2	LA_Source, LA_Point, LA_Party, LA_SpatialSourceType
	LA_BoundaryFaceString	2	VersionedObject, Oid, LA_Point (if using geometry)
	LA_BoundaryFace	3	VersionedObject, Oid, LA_Point (if using geometry)

The LADM consists of three packages and one subpackage, and for each of them a conformance test is specified. Three conformance levels are specified per (sub)package: level 1 (low level), level 2 (medium level), and level 3 (high level). A package is level 1 compliant if the classes with level 1 indicators are passing the conformance test. A package is level 2 compliant if the classes with levels 1 or 2 indicators are passing the conformance test. A package is level 3 compliant if the classes with level 1, 2 or 3 indicators are passing the conformance test.

Table 6 gives an overview per package to check for LADM compliancy. Conformance tests on the LADM can be done per package. Conformance tests shall be done on interdependencies between applicable packages when two or more packages are tested. The mandatory and optional attributes are given in the class diagrams. The test method in this Annex is used in all test cases 'to examine the application schema of the implementation under test, including class, attribute(s) and association definitions.' There are a number of different ways to document the positive results of the test method:
1. Show inheritance structure between the LADM and the tested model (elements), or
2. Show mapping of elements between the LADM and the tested model.

In order to realize this conformance test explicitly and completely, knowledge and understanding is required of both the LADM and any specific profile used. The profile should not include different structures or solutions where the LADM has standard provisions.
Conformance testing per right type, responsibility type or restriction type is possible. In the code lists for rights, responsibilities or restrictions, specific (user defined) code list values can be added, indicating a partial responsibility or restriction. Or a right, which is not homogeneous in time. This affects the complete spatial unit with regard to registration (therefore in a sense homogeneous), but in reality only a part of the spatial unit. In addition, a text spatial unit can be defined, describing the location of the part.

4 FUTURE STANDARD MAINTENACE AND DEVELOPMENT

As the LADM standard is now being used (and read by further eyes) it is inevitable that further issues will arrive. These can range from detecting and correcting simple text error (e.g. on page one it states the standard provides '… model with four packages', while on the same page it is also states 'LADM consists of three packages and one subpackage', which is correct), via omissions (multiplicity in Table 3, row 1 Party GroupParty, not correct) to further extension of the standard (e.g. extension of the legal model conform the proposal of Paasch, 2012). Within the standardization processes there are different methods for handling these issues/requests: the corrigendum for fixing small mistakes, and the 5 annual revision of the standard for significant changes and extensions. In the meantime the LADM Wiki could

function as a collective memory. The Wiki has been extended with an additional subpage ‘standards maintenance’; see Figure 3.

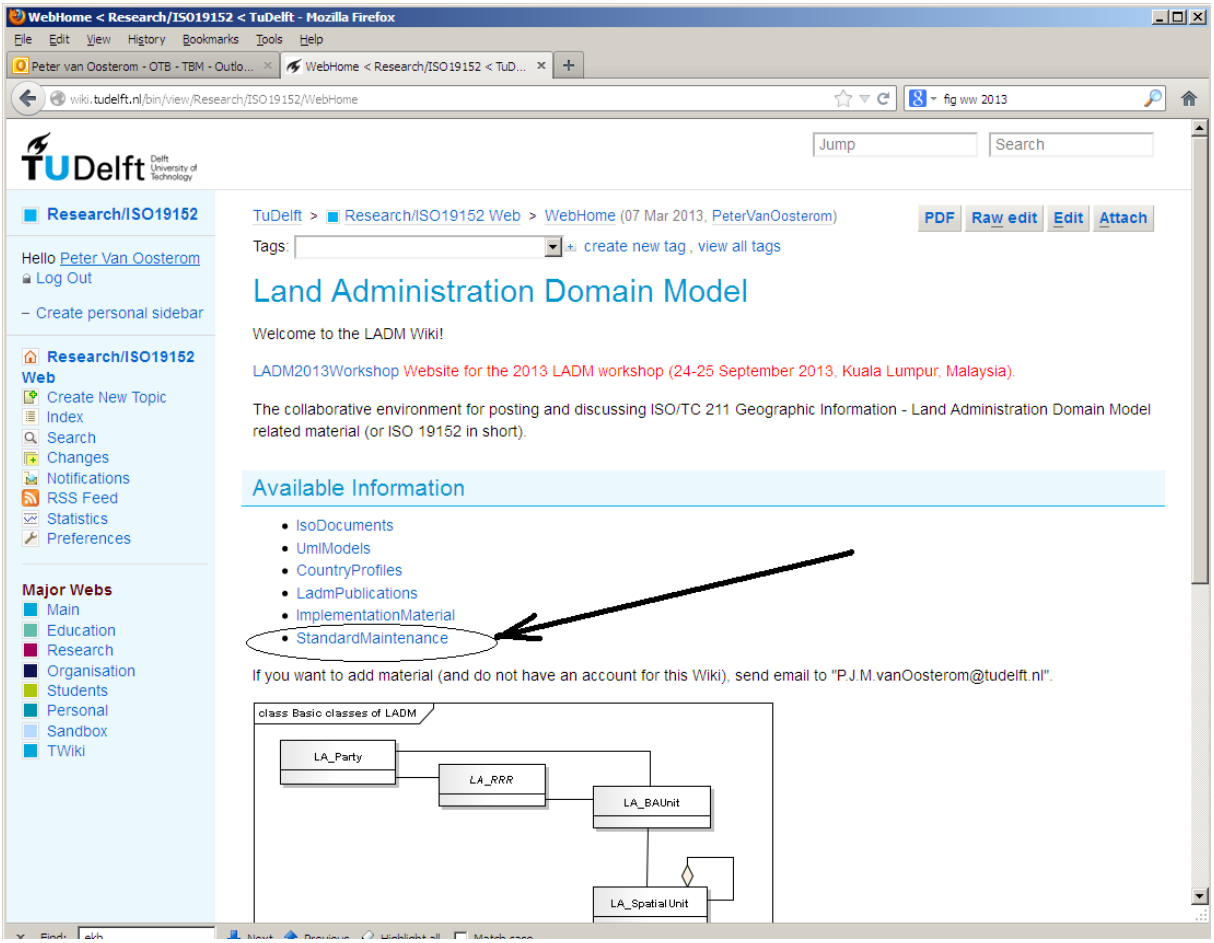

Figure 3. The LADM Wiki with the new ‘standards maintenance’ subpage

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, 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:

1. Develop and register zoning plans

2. Register (public law) restrictions
3. Design new spatial units/objects
4. Acquire appropriate land/space
5. Request and provide (after check) permits
6. Obtain and register financing (mortgage) for future objects
7. Survey and measure spatial units/objects (after construction)
8. Submit associated rights (RR)/parties and their spatial units
9. Validate and check submitted data (and register if accepted)
10. Store and analyze the spatial units
11. Disseminate, visualize and use the spatial units.

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. Very relevant 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!

5 CONCLUSIONS

The Land Administration Domain Model provides a comprehensive set of functionality, based on Model Driven Architectures. The LADM can be supportive in business process reengineering, with normalised data models to avoid data duplication (also in relation to external databases). The LADM includes all documents, this means building a complete and full digital cadastre. A major advantage in adopting LADM is the classification and structuring of RRR, where classifications in categories are possible, see (Elia, et al, 2011). 3D Cadastres are treated in such a way that these integrate seamlessly with existing 2D registrations; see Annex B of the LADM (ISO, 2011).

After positive results of voting on the so-called New Working Item Proposal (NWIP) in May 2008, on the Committee Draft (CD) on October 12, 2009, on the Draft International Standard (DIS) on June 27, 2011, the Final Draft International Standard (FDIS) received a positive vote on October 30, 2012; see Table 7. The International Standard (IS) was finally published on December 1, 2012. Each step in the developments within ISO includes reviews from countries involved in the development process.

Table 7 Voting results at the various stages of ISO 19152

Voting	**NWIP**	**CD**	**DIS**	**IS**
Approve	15	22	26	31
Disapprove	6	3	2	0
Abstain	4	4	4	5
Not Voted	7	3	0	2

It can be concluded that there is support for the LADM from FIG, ISO/TC211, UN-HABITAT, EU, FAO, several countries and many professionals. FIG may be involved in the development of other domain standards in the future, those standards make SDI working. During the development of the LADM many reviews have been performed resulting in new insights, improvements and proposals for extensions. All together the development took place from 2002-2012. Already existing ideas written in papers or books which could be used as possible input or requirements for the development of the LADM came available during this period. Not all of the existing materials were known at the start of the development. Apart from the versions published during the development of the international standard within (and published by) ISO/TC211 there are publications in scientific journals related to the LADM (and its predecessor the CCDM) and even three PhD-theses in 2012: Lemmen, 2012, Hespanha, 2012 and Paasch, 2012.

The standardization process started after a six year period of preparation (2002-2008). The starting document, LADM version 1.0, as a New Working Item Proposal (NP) got a simple majority in May 2008, and with a development track of 36 months. With 36 months, there could have been an International Standard (IS) in May 2011. Why is did it take until December 2012 before the IS was finally published? Firstly, the editing team were absolute beginners in the field of ISO standardization. This meant that we did not know the procedures, nor that we knew the rules for the structuring of ISO documents. As an example, simple rules like "annexes shall appear in the order they are referenced in the document" were not applied, which caused extra work and time for the ISO/TC211 secretariat (Bjørnhild Sæterøy, thanks!). Secondly, we did every attempt to resolve negative votes, with the danger that we "tried to please everybody", with potential "hazardous" effects, because resolving a comment for one country might result in a next iteration by a "not amused" other country. It is remarkable how the number of comments grew along the development track: from 295 comments for the CD (of which 92% was accepted) to 398 comments for the DIS (of which 86% was accepted). Of course, many comments were relevant, but part of the "booming" of comments was the redundancy of information in text, figures and UML-model. All in all we had to deal with about 900 comments, which was, from an editorial point of view, quite cumbersome.

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