ISO Land Administration Domain Model and LandXML in the Development of Digital Survey Plan Lodgement for 3D Cadastre in Australia

Sudarshan KARKI, Rod THOMPSON, Kevin McDOUGALL,
Nevil CUMERFORD, Australia and Peter VAN OOSTEROM, the Netherlands

Key words: 3D Cadastre, Land Administration Domain Model, EARL Project

SUMMARY

The aim of this paper is to explore the implementation issues of 3D Cadastre in Queensland, Australia, which is presently moving towards a full digital lodgement of surveying information, with a focus on validation rules. In Queensland the Electronic Access for Registry Lodgement (EARL) project has already successfully implemented EARL-I, the first of the three phases of the project where surveying information is captured digitally using tools built in-house, called Surveying Information Processing (SIP) tool which is based on LandXML.

EARL-II will establish an electronic service delivery framework, where external surveyors create and lodge digital files, but paper plan still remains the legal document at this stage. EARL-III will be full digital lodgement where the digital files become the legal document.

The ePlan is developed using UML class diagram and implemented using LandXML and its various schemas and protocols. LADM is a standard model from which the ePlan model can be considered a subset. This paper studies the existing methodology and proposed structure of digital lodgement based on LandXML and draws from the questionnaire survey as well as the ISO/TC211 LADM 19152 for identifying and expanding validation rules relevant to the EARL project towards implementation of a 3D cadastre in Queensland. LandXML will continue to support the development of EARL-III but will need to rely on ISO/TC211 LADM 19152 to provide guidelines and requirements for the implementation of a homogenous and comprehensive land administration model in Queensland.

Digital lodgement is a joint effort by all jurisdictions of Australia and New Zealand and is coordinated by the Intergovernmental Committee on Survey and Mapping (ICSM). The third phase (EARL-III) is planned to include, among others, the implementation of electronic capture and visualisation of 3D Cadastre data. Mechanisms for digital capture, validation, storage and visualisation of 2D and some 3D data are already in place in EARL-I.

An outline of the validation rules governing these capture and/or visualisation is already proposed in the department proposal papers. The survey of Australian jurisdictions has assisted in identifying common issues and workarounds independent of the project. This paper explains in detail how the ePlan model is implemented and the 3D validation rules that are proposed; illustrates the support of 3D in LADM and ends with a discussion on the need for the ePlan model to adopt further measures to implement the LADM.

ISO Land Administration Domain Model and LandXML in the Development of Digital Survey Plan Lodgement for 3D Cadastre in Australia

Sudarshan KARKI, Rod THOMPSON, Kevin McDOUGALL, Nevil CUMERFORD, Australia and Peter VAN OOSTEROM, the Netherlands

1. INTRODUCTION

In the past six years, Australia has been moving towards a digital lodgement of cadastral plan. Due to the differences in the methods, terminology, surveying, digital capture and storage etc in each of the cadastral jurisdictions of Australia, a need to coordinate a homogenous approach to e-lodgement was felt.

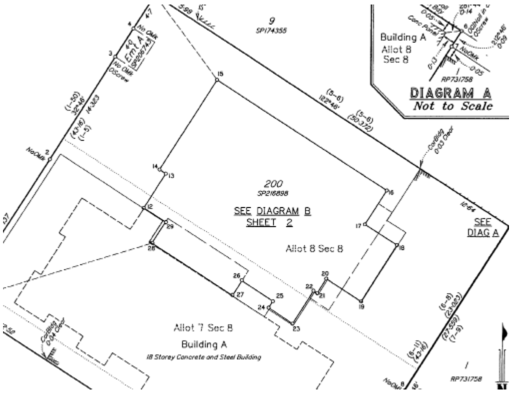
This was coordinated by the Intergovernmental Committee for Surveying and Mapping (ICSM) (www.icsm.gov.au) which is the peak body in Australia and New Zealand for the coordination and development of Standards for Spatial Industry Practice. (Cumerford 2010)

The ICSM drafted the national ePlan, created uniformity in terminology or at least an understanding of what the comparable terms were for each jurisdiction. Class diagrams were created in Unified Modelling Language (UML). LandXML was used to create, store and interchange the cadastral data as described the class diagrams. Schema files were created for LandXML, ePlan Protocol, Enumerated Types, Annotations, Survey Certificates, Administrative Areas and Reference Data and the Australian Government XML Namespace Scheme was used to define the namespace.

The project was done in three stages named as Electronic Access for Registry Lodgement (EARL) I, II and III respectively. In Queensland, EARL-I has been completed successfully with the development of a tool called Survey Surveying Information Processing (SIP) tool which is based on LandXML and is used to electronically capture paper based cadastral plans. EARL-II will establish an electronic service delivery framework, where external surveyors create and lodge digital files, but paper plan still remains the legal document at this stage. EARL-III will be full digital lodgement where the digital files become the legal document. EARL-II is almost ready to be rolled out and EARL-III is the final stage where all plans is expected to be lodged digitally.

Although cadastral plans with 3D objects are captured presently, there is no electronic validation of these plans and need to be done manually. Electronic validation, storage and display of 3D cadastre are to be dealt with in EARL-III. In Queensland, cadastral plans containing 3D data are of two types: Building Format Plans and Volumetric Plans.

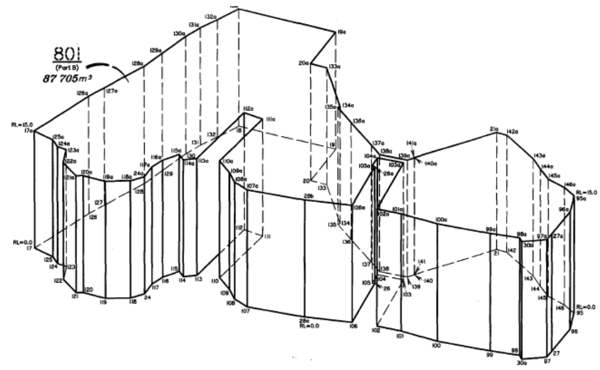
Figure 1 and Figure 2 show an example of what each type of plan looks like and their corresponding LandXML files. A parcel (lot) on a Building Format Plan (also called Stratum Plan in some jurisdictions) may have several parts on different floors in the complex, i.e. a car park, a balcony and the main unit. At present the footprint data is captured as geometrical data and other information like buildings, levels, heights etc are stored as attributes in LandXML.




```
<ns1:Parcel buildingLevelNo="B" useOfParcel="Main" class="Lot" buildingNo="A" parcelFormat="Building" state="
  <ns1:CoordGeom name="CG-47-SP185407" />
</ns1:Parcel>
<ns1:Parcel useOfParcel="Main" class="Lot" parcelFormat="Building" state="created" parcelType="multipart" are
  <ns1:Parcels name="fully allocated">
    <ns1:Parcel pclRef="800cb/SP185407" name="800cb/SP185407" />
    <ns1:Parcel pclRef="800cc/SP185407" name="800cc/SP185407" />
    <ns1:Parcel pclRef="800cd/SP185407" name="800cd/SP185407" />
    <ns1:Parcel pclRef="800ce/SP185407" name="800ce/SP185407" />
    <ns1:Parcel pclRef="800mf/SP185407" name="800mf/SP185407" />
```

Figure 1. Building Format Plan example and its LandXML representation

This model uses a much broader definition of parcel in that it is a polygon (or volumetric figure) for which a right or obligation can be defined. It includes base cadastral lots as well as easements and secondary interests.




```
</ns1:Parcel>
<ns1:Parcel class="Lot" parcelFormat="Volumetric" state="created" parcelType="multipart" name="80
  <ns1:Parcels name="fully allocated">
    <ns1:Parcel name="801a/SP203415" pclRef="801a/SP203415"/>
    <ns1:Parcel name="801b/SP203415" pclRef="801b/SP203415"/>
    <ns1:Parcel name="801c/SP203415" pclRef="801c/SP203415"/>
    <ns1:Parcel name="801d/SP203415" pclRef="801d/SP203415"/>
    <ns1:Parcel name="801e/SP203415" pclRef="801e/SP203415"/>
    <ns1:Parcel name="801g/SP203415" pclRef="801g/SP203415"/>
```

Figure 2. Volumetric Format Plan (Isometric View) and its LandXML representation

This paper initially provides a brief overview of the status and history of digital lodgement in Queensland, Australia; then examines the ISO TC211 LADM 19152 for similarities with the Australian ePlan Schema, interprets validation rules and then explores the proposed EARL III validation rules with a focus to 3D Cadastre. Finally, it provides a brief discussion on the validations rules based on a questionnaire survey done on 3D Cadastre of all the jurisdictions.

2. STATUS OF DIGITAL LODGEMENT IN AUSTRALIA

All cadastral jurisdictions in Australia plan to implement a full digital lodgement of plans and the project to do this are implemented in stages. The three stages of the project are EARL-I, II and III. EARL-I has been implemented in Queensland since 2006. EARL-II is ready to be implemented by the end of year 2011 or early 2012. EARL-III will involve full digital lodgement by the Surveying industry, is still in its early stages of development and will probably have to go through a major change in process to adopt LADM.

The ePlan is developed using UML class diagram and implemented using LandXML and its various schemas and protocols. LADM is a standard model from which the ePlan model can be considered a subset. The ePlan is being implemented as an ICSM initiative so the overall schema is the same; however, jurisdictions have adapted the ICSM schema to suit the differences in semantics and data models in their jurisdictions. Other jurisdictions are in various stages of implementation of the ePlan. Figure 3 shows a generalised overview of the ePlan Model adopted for the implementation of the project and Figure 4 shows its equivalent in the implementation stage using LandXML. Figure 5 shows the detailed view of the LandXML for the implementation of the ePlan towards creation of a Cadastral Information File (CIF). The following sub-sections explore the various stages of EARL and how it was implemented.

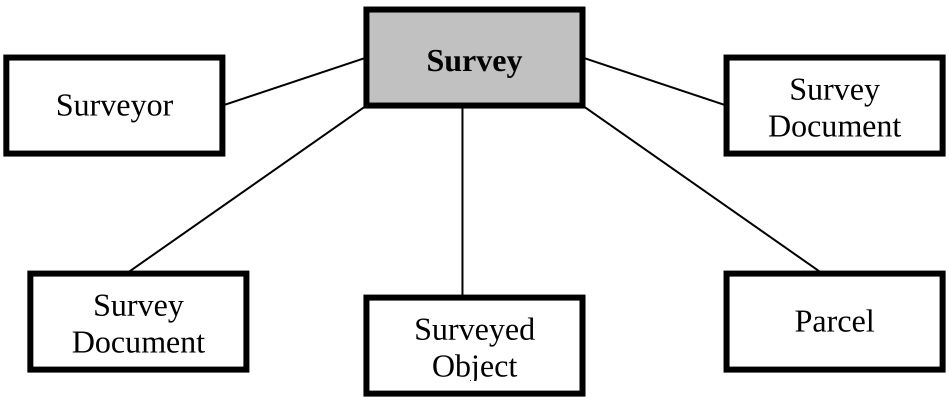


Figure 3. Overview of ePlan Model Diagram (See original at: http://www.icsm.gov.au/icsm/ePlan/Plan-1.2/index.htm)

The ePlan model has been adopted as the model for the CIF and contains all of the information that currently appears on the Plans of Survey submitted to the Department for registration as well as other administrative information. The data model has been agreed upon by the working group and recommended to ICSM as the national model for ePlan.

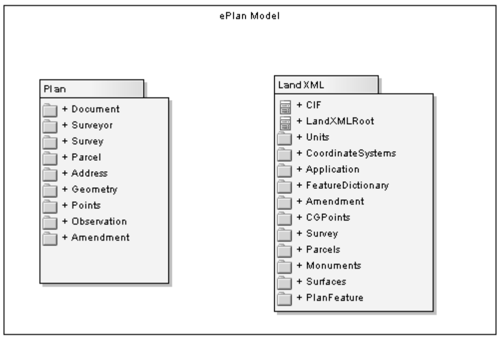


Figure 4. ePLAN logical diagram (http://www.icsm.gov.au/icsm/ePlan/Plan-1.2/index.htm)

The ePlan Model has been developed using UML class diagrams from existing survey plans. The requirement of this model is based on the logical model of a Cadastral Survey. This model inherits the ISO Standards and rules of Harmonised Data Model (HDM), classified into a number of packages.

The UML class diagram consists of Document package and contains those classes, which relate to the Survey Plan as a Legal Document. The Legal Document is based on rights and restrictions. This package deals with the approval of the document and links to the approval schema for the approval parties subjected to conditions etc. This is beyond the LandXML schema and is a function of the document approval process rather than the creation of the survey document.

2.1 LandXML

The "eXtensible Markup Language" (XML) is rapidly becoming the foundation standard for the interchange of data between organisations at the system to system level. An XML instance document carries actual data; an XML schema on the other hand is the formal description of what the instance should look like. XML instance documents will normally reference one or more XML Schema that defines valid content. At runtime, an XML instance is often validated against the schema to ensure accuracy and completeness.

An XML namespace is a globally unique identifier for a collection of XML elements that are logically related. A namespace is defined in an XML schema and is then declared and used in XML instance documents. An XML namespace uses formal naming schemes to provide both global uniqueness as well as meaningful names. For example, the XML namespace for the first release of the Australian government name & address schema is:
urn:xml-gov-au:final:data:NameAndAddress:1.0 (AGIMO Nov 2006)

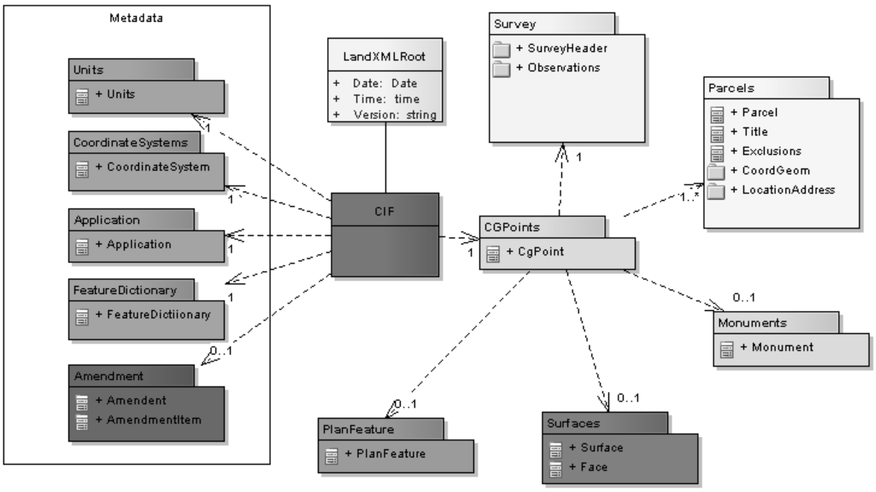


Figure 5. LandXMLRoot logical diagram (http://www.icsm.gov.au/icsm/ePlan/Plan-1.2/index.htm)

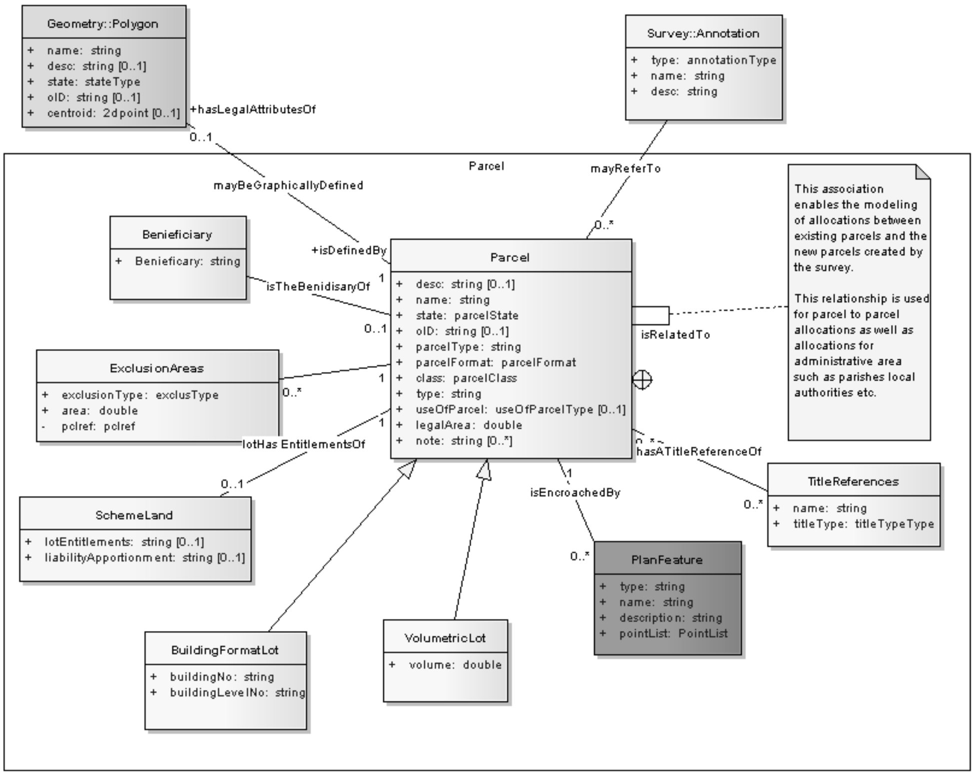


Figure 6. Parcel logical diagram in ePlan Model (http://www.icsm.gov.au/icsm/ePlan/Plan-1.2/index.htm)

Looking into the ePlan model in detail for one component as an example, Figure 6 and Figure 7 shows an UML representation of the class Parcel and its corresponding implementation in LandXML. The Parcel package handles the non-spatial elements of parcel. It relates directly to the HDM: Cadastral: PrivateLawObject and the LandXML: Parcels elements. A parcel is the unit over which a single interest can be created. A parcel may have a specific parcel type for example in Queensland the parcel over which an indefeasible title can be issued is called a lot. A parcel can be made up of a number of sub parcels; each sub parcel must be a closed figure. The total area of a parcel is the sum of the areas of the sub parcels.

This package contains classes, which contain data about the survey. Some of this data is generic in nature and is handled by the LandXML Schema but much of it is jurisdictionally specific and will need to be handled either by extending the LandXML or creating a subschema.

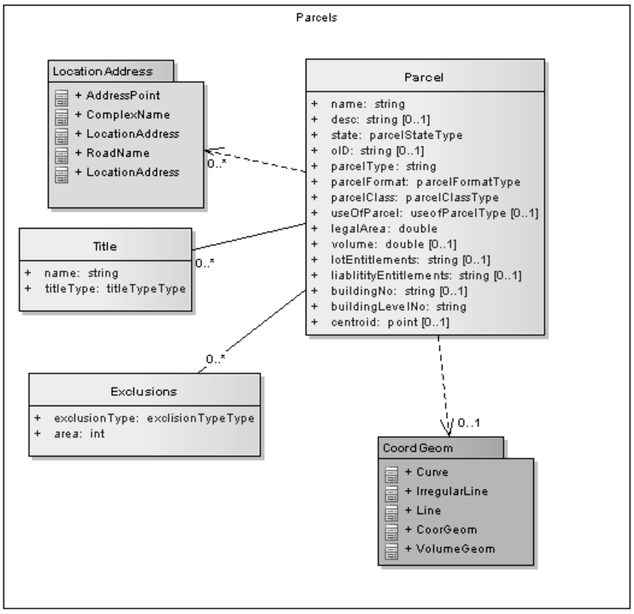


Figure 7. Parcel logical diagram in LandXML (http://www.icsm.gov.au/icsm/ePlan/Plan-1.2/index.htm)

2.2 EARL-I

The first stage of the EARL-I Project developed a data capture tool called the Survey Information Processor (SIP) and a number of web services used to validate and manage the digital data. The digital files created using the SIP tool are called Cadastral Information File (CIF). In both EARL-I and EARL-II 2D data is stored geometrically as CIF, but for plans containing 3D cadastral data, the geometry, apart from the footprint, is not stored in the CIF, rather the attributes are captured in the Areas/Use of Parcel table in SIP which automatically populates the relevant attribute tables in the DCDB. Geometrical capture of 3D data is expected in EARL-III.

The project developed processes to:

- Validate the survey data; the first stage of the project implemented about 70 validation rules which could be automatically applied to the survey data which dealt with the survey and administrative data associated with the survey
- Automate update tools for survey related indices for the lodgement of digital data
- Automate update of the survey control data sets from the digital file
- Interface with corporate data storage system
- Automate data entry to the Digital Cadastral Database (DCDB) for management of cadastral boundary data. (Cumerford 2010)

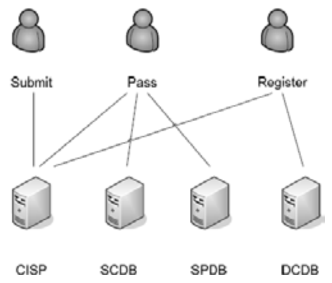


Figure 8. Databases updated at various stages of plan processing (Cooper 2010)

The fundamental outcome of the project was to develop a transfer protocol and procedure to undertake all of the current business practices associated with a paper cadastral plan. This extended beyond the basic vector data currently associated with cadastral mapping and included the use of the data for:

- Development Approvals
- Title creation
- Valuation Splits
- Land Tax processes
- Development Forecasting

It also updated the databases shown in Figure 8 the Digital Cadastral Database (DCDB), Survey Control Database (SCDB), Survey Points Database (SPDB) & Computer Inventory of Survey Plans (CISP) and assisted with:

- Survey Auditing
- Automated updates to plan and survey indices
- Digital Cadastral Update (Cumerford 2010)

In EARL-I the life-cycle of a plan is represented partly by Figure 8 and Figure 9. When a surveyor deposits a paper plan it is captured using SIP tools and survey plan auditing is done. After the pass process Parcel metadata is updated in the CISP database, Permanent marks database is updated in the SCDB and points and marks are updated in the SPDB. After registration by the titles office where ownership, tenure (RRR) data is entered, the DCDB is updated. Several other databases like the valuation, automated titling system and council database are also updated at this stage. Without SIP capture, each stage like Plan Auditing, CISP, SCDB and DCDB update would have to be done manually.

At present all plans that are lodged in the Department of Environment and Resource Management (DERM) are either captured as an electronic file (CIF) using SIP tool or entered into the computer inventory (CISP) as metadata with a supporting paper plan. Cadastral Information files (CIF) and the online Validation Service has been used for Survey Plan Auditing since October 2006 and has been used for updates to the DCDB since June 2009. Currently about 95% of plans annually are captured using the SIP tool. Since production update of the DCDB commenced in June 2009 some 30,000 survey plans have been captured.

2.3 EARL-II

The aim of implementation of EARL-II is to bring the goal of full digital lodgement a step closer. It is the intermediate step and is proposed to be implemented around end of 2011 or early 2012. Figure 9 shows the web enabled survey plan life cycle once EARL-II is implemented. Apart from the continued use of EARL-I with its various improvements, EARL-II aims to achieve the following:

Web Services to

- Extract Digital Survey Search
- Validate CIF (another 90 rules)
- Visualise CIF
- Submit CIF
- Submit Survey Control
- Get a CIF
- Get a Number

The project change management committee also reinforces its relationships and interactions with clients and stakeholders for a smooth transition. These include:

- Survey Auditing, Survey Industry, Survey Software Vendors, Local Governments, Data Brokers and Land Titling Staff

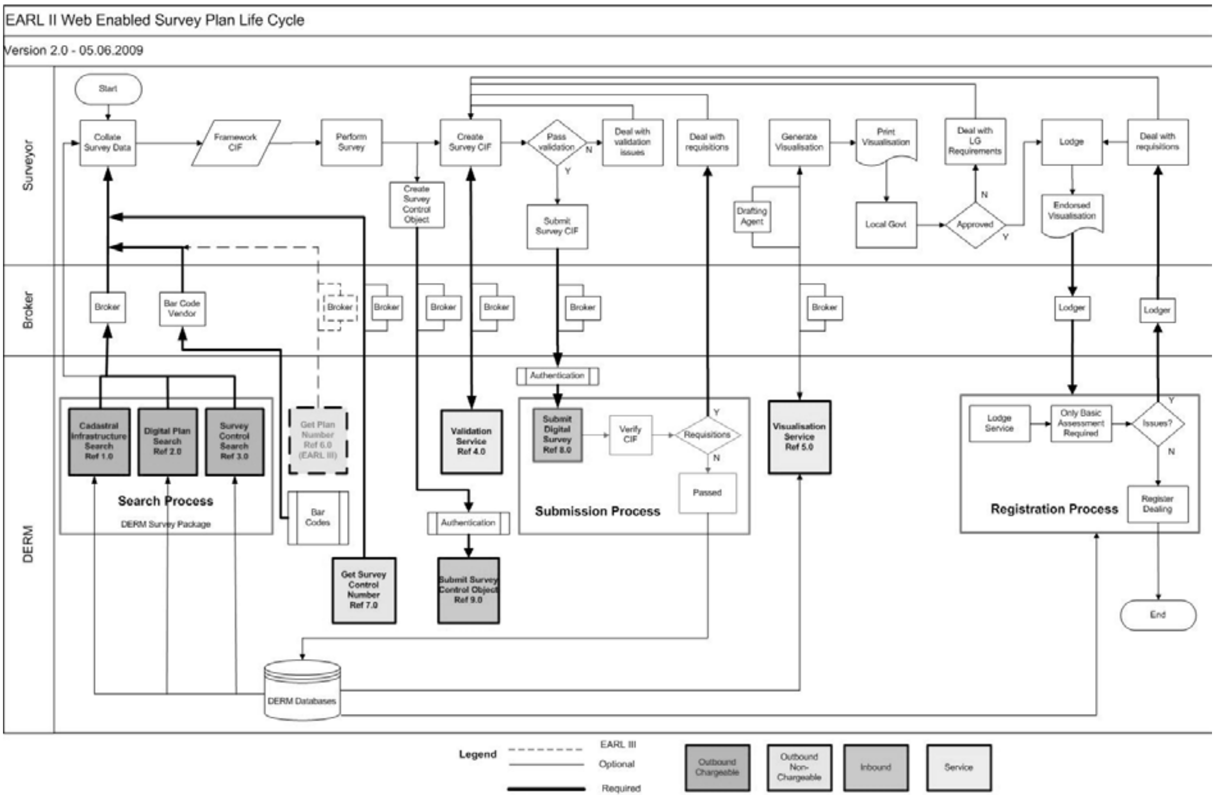


Figure 9. EARL-II Plan Life Cycle (Cooper 2010)

2.4 EARL-III

This is proposed to be the final stage of implementation where a full digital lodgement will be mandatory for the surveying industry. The features of the EARL-III project are:

- Full Digital Lodgement
- Digital Approvals
- Removal of Paper Plan
- Change Management

The tools to be developed for this are:

- Cadastral Searching and Delivery
- Data Verification and Submission
- Data Visualisation

EARL-III will also implement Digital Signatures and Approvals (SmartEDA) for authentication and administrative purposes. This phase is also proposed to include validation rules for 3D Cadastre.

2.5 Interoperability

The ICSM ePlan CIF Schema is a subset of the LandXML schema. It defines only the elements and attributes required for the ePlan Model and also defines some elements and attributes that are optional in LandXML as being required in ePlan.

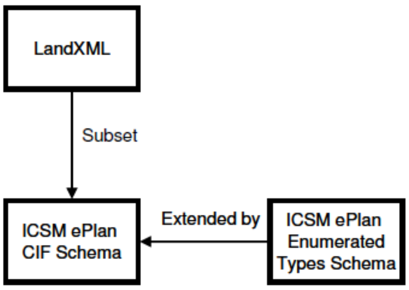


Figure 10. LandXML to ICSM ePlan Schema (ICSM November 2010)

Jurisdictional CIF Schemas are very similar to the ICSM ePlan CIF Schema, the differences are that some optional elements and attributes in the ICSM ePlan CIF Schema may be omitted from a Jurisdictional CIF Schema and others may be made mandatory.

An example of syntactic interoperability is where the definition of the attribute for //Survey/SurveyHeader@desc is:

- Optional in the ICSM ePlan CIF schema
- Omitted from the Victorian schema, and
- Mandatory in the Queensland schema

An element or attribute that is mandatory in the ICSM ePlan CIF schema can't be made optional or omitted from a Jurisdictional CIF Schema, it must remain mandatory. (Cumerford 2010) An example of issues with semantic interoperability would be where the terms Building

Format, Strata and Stratum plans were used to identify a similar plan for a strata unit development all with similar content and rules.

There are numerous other examples of semantic, syntactic and schematic differences but they are beyond the scope of the present paper, however by adopting the ICSM ePlan CIF Schema, all jurisdictions can adapt to their individual needs, yet be able to contribute to each others dataset when necessary.

2.6 Status of other jurisdictions

Apart from the work done in Queensland, significant progress have been achieved by other cadastral jurisdictions.

New South Wales has several projects running to implement the lodgement of ePlan. The most significant being the development of a lodgement portal for the receipt of digital plan. It is utilizing the ESRI suite of products and is developing an interface between the CIF and the ESRI Cadastral Editor product for digital processing and plan auditing. It has codified its business rules and published its jurisdictional schemas. Victoria is currently codifying its business rules and publishing its jurisdictional schemas and designing the interface between the CIF and its "Streamlined Planning through Electronic Applications and Referrals" (SPEAR) lodgement portal. Other states are analysing their business processes and looking at the impacts of digital submission within the framework of modernizing their cadastral records systems. (Cumerford 2010)

3. ISO/TC211 LADM 19152

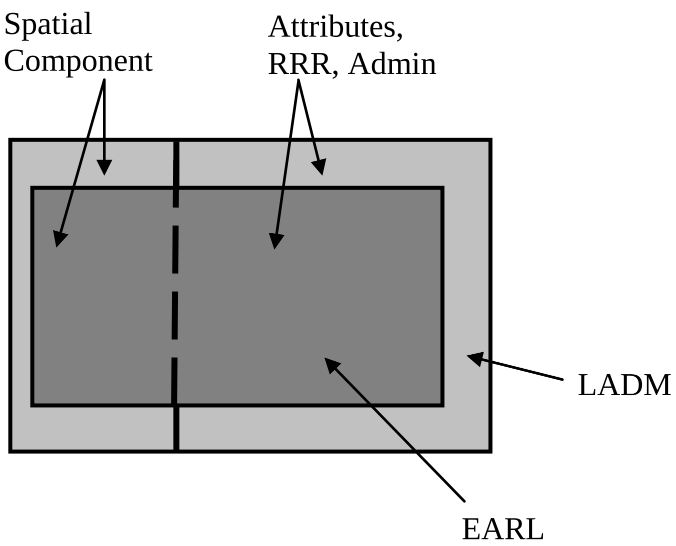


Figure 11. Overview of a relationship between EARL and LADM

When the ePlan was developed the ISO TC211 LADM 19152 was yet to be developed, so the ePlan does not map directly to the LADM. But because the issues dealt with are similar, the ePlan can be considered to be a subset of the LADM. There are similarities in both the models, where each has a spatial component and an ownership, tenures component (Figure 11). LADM is standardised internationally and covers issues which is a best fit for many cadastral jurisdictions. The spatial component covers both 2D and 3D; however the LADM deals and proposes quite extensively in the topic of 3D which has been considered a proposal for EARL-III when it is ready to be implemented much further down the track. In this context, LADM provides good opportunities to further explore 3D implementation issues, as well as modify current 2D models and practices to be more reflective of an international standard.

Figure 12 shows the overall schema of the Land Administration Domain Model (LADM). The inter-relationship between the basic classes LA_Party, LA_RRR, LA_BAUnit and LA_SpatialUnit are as shown with the main focus of this paper being on LA_SpatialUnit.

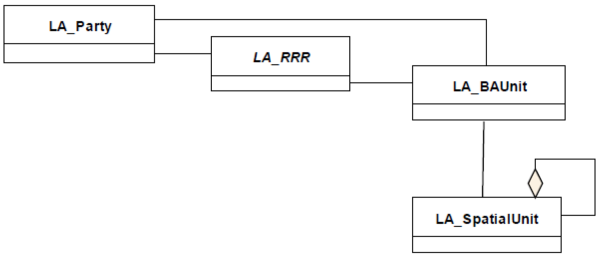


Figure 12. Basic Classes of LADM (ISO-DIS/Ladm19152 2011)

Figure 13 expands the LA_SpatialUnit further, which gives us LA_Parcel which is similar to the definition of parcel used in Figure 6 and Figure 7 of the ePlan Schema and the LandXML model respectively. Other classes like LA_Level, LA_LegalSpaceUtilityNetwork and LA_LegalSpaceBuildingUnit give opportunities for 3D objects to be created and validated. LA_SpatialUnitGroup can be used to create Legal parcels which though not strictly 3D give an opportunity for non-parcel based objects and interests to be created.

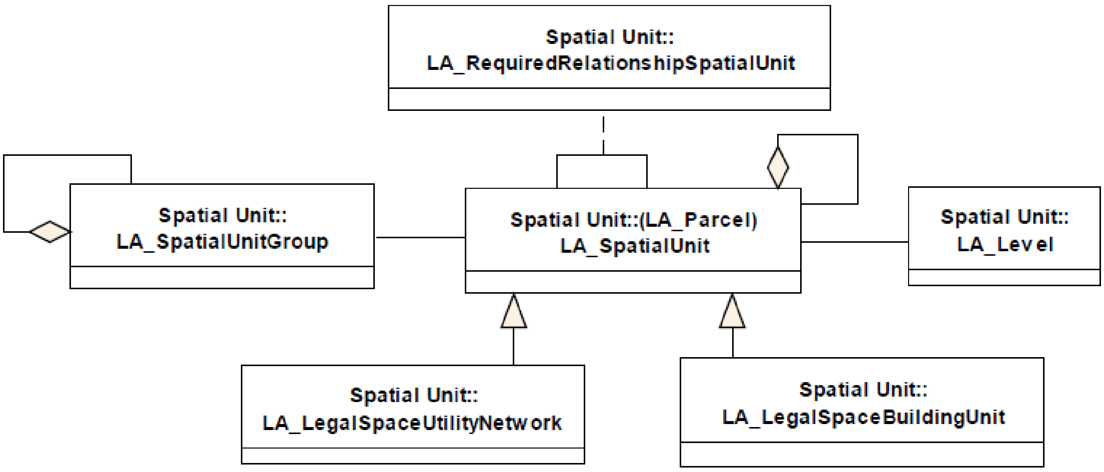


Figure 13. Classes of Spatial Unit Package

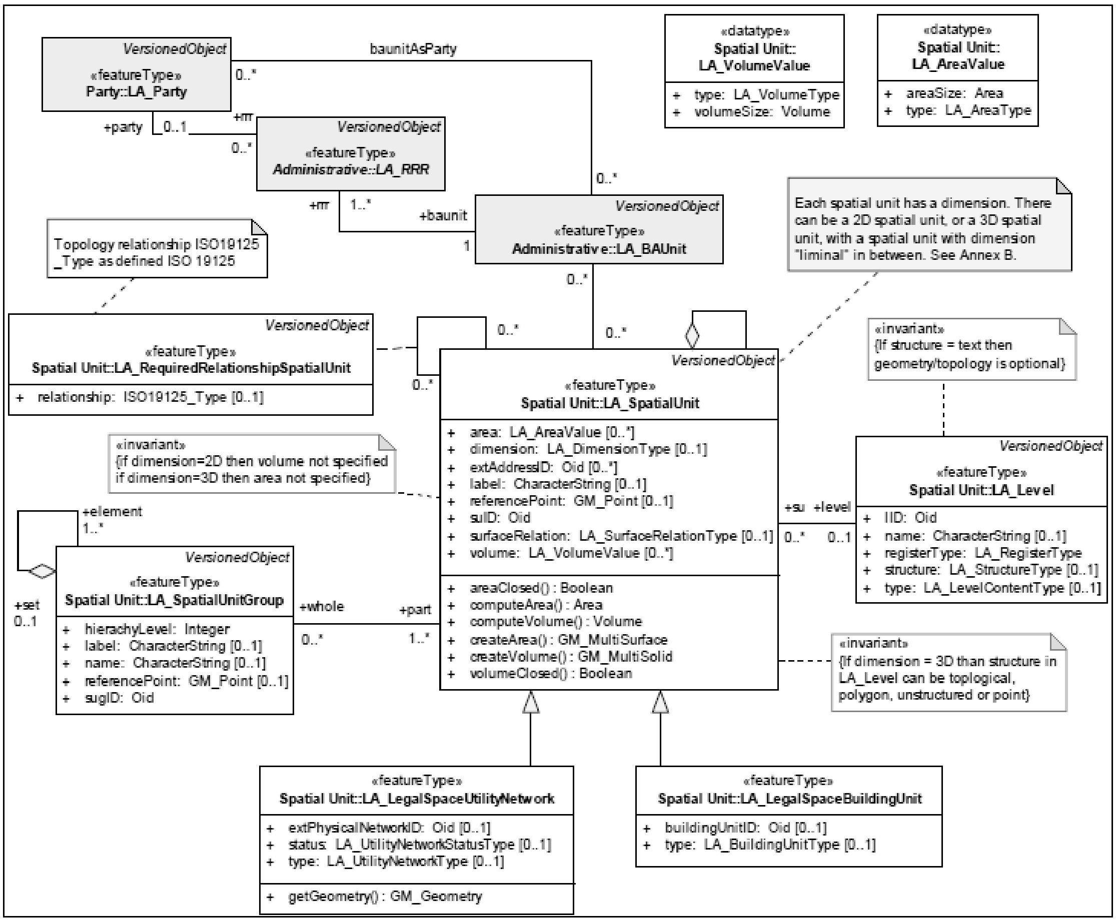


Figure 14. Content of Spatial Unit Package with associations to other basic classes

(Van Oosterom et al, 2011) proves that the LADM is very versatile in adapting to different data needs. LADM provides opportunities for electronic validation and storage of 3D geometrical data. This issue is planned in EARL-III; however it may be quite a distance away before it is implemented. The prospect of using an international standard to solve local issues necessitates the analysis of the LADM for future implementation particularly from a 3D cadastral point of view.

The contents of LA_SpatialUnit as shown in Figure 14 and the Topological description of 3D object in Figure 15 demonstrate that the LADM has plenty of support for integrating 3D Cadastral data. Validation rules can be interpreted from these as below specific to 3D objects, however, they are just the prominent ones, there will be plenty of other validation rules before data can be incorporated into the database.

- validating structure i.e. topological, polygon, unstructured or point
- if topological structure, geometrical construction of the object
  - no liminal representation
  - no overlapping volumes
  - allowing for open-ended volumes
  - constraints on line-directions for construction of boundaries and adjoining objects
- if non-topological, geometry tests optional

– separately defining buildings, volumetric and legal objects
– existence of a volume value depending on the structure of the object

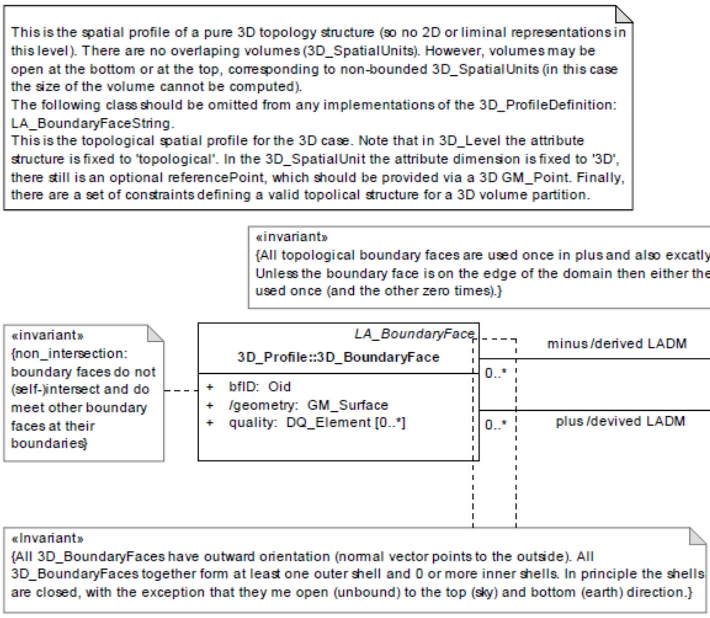


Figure 15. ISO TC 211 LADM 3D topological based

The structure and validation issues described in the LADM is in some instances similar to the EARL definition of 3D Cadastre as discussed in section 4 below. The significant differences are in the construction of a 3D object and its subsequent validation where various types are explicitly defined in the LADM but not so in EARL, the types of plans are well defined in EARL but is not necessary in LADM and geometry can be stored as topological structure in LADM whereas it is not well-defined in EARL.

4. PROPOSED 3D CADASTRAL VALIDATION RULES IN EARL III

Validation rules have been identified for EARL-III and will be developed when that stage of the project starts. All jurisdictions define two main types of plans for 3D, namely Volumetric Format and Building Format plans. The validation rules are grouped into four main groups; two each for volumetric format and building format containing identification, administration and geometry issues.

Hundreds of validation rules are defined for EARL-I and EARL-II and there are some rules that have started to be proposed for EARL-III. An example of what a validation rule that is in actual use looks like in EARL-I or can even be used in II or III is as below:

Consistency of plan description (Created Parcels)—VR009
This rule checks that new parcels exist in the plan, rule VR070 (§ 3.1.15.6.1) checks the spatial extent of new parcels. This rule also implements VR011 (§ 3.1.5.1.4).

Rule

Each lot identified in the plan description as being created must have an equivalent parcel in the plan that is being created (i.e. parcel state is "created") except for parcels with a class of road and hydrography.

ePlan element

Description:
Document:SurveyDocument:Survey:surveyDesc
LandXML/Survey/SurveyHeader@desc

Parcels:
Document:SurveyDocument:Survey:Parcel:Parcel:parcelState
LandXML/Parcels/Parcel@state

Reason

"Created parcel '<parcel identifier>' in description is not in plan"

Classification	***Mandatory***	***QLD Specific***	***Error Type***	***Checked By***
Validation	*Y*	*Y*	*Fatal*	—

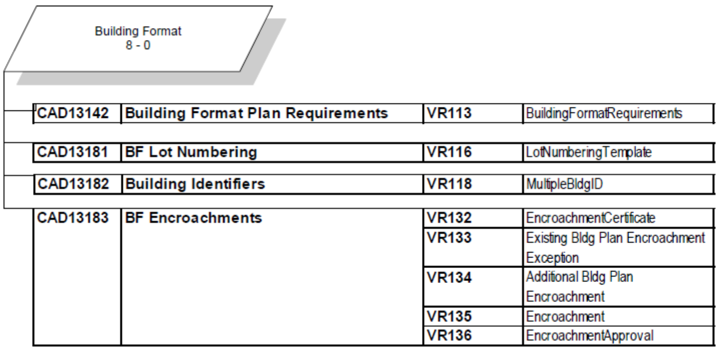


Figure 16. EARL-III Building Format Validation Rules: Identification and Administrative

Figure 16 shows the validation rules for identification and administrative issues for a Building Format plan. These are automated electronic checks after the electronic files are lodged. These are general checks which attempt to validate whether the lodged files follow a pre-determined template or specification. For example, the specification for lot numbering or building identifier convention (single or multiple buildings), encroachments, or plan format requirements etc. all trigger exception reports in validation while submitting the CIF if they do not conform.

Figure 17 deals with validation rules for the geometrical as well as use aspects of a Building Format plan. It deals with validation issues like:

- verifying total area (where the main building or buildings plus the common property add up to the total area of the 2D parcel, and where the total are of the part lots of a building, garage, patio etc. equals the main building)
- verifying voids, it's location and area, voids in common property
- verifying court yards, private yards, if it can be uniquely located and its size
- verifying footprint of single or multiple buildings, their spatial extent and whether they can be located uniquely and encroachments

Building Format EARL III

	Building Format EARL III	VR117	LoNumbering Template Except
		VR119	Building Number Format
		VR120	Validate Total Area
		VR121	Validate Court Yard Area
		VR122	Use of Parcel validation
		VR123	Private Yards
		VR124	Dimensions
		VR125	Void Areas
		VR126	Voids ib Common Property
		VR127	Location of Voids
		VR128	Spatial Extent of Building Fc
		VR129	Location of Footprint
		VR130	Location of Multi Footprints
		VR131	Footprint Encroachment
		VR213	Lot Numbers Across CTS
		VR214	Numbering System Used

Figure 17. EARL-III Building Format Validation Rules: Geometry

Figure 18 deals with the non-geometrical validation rules of a Volumetric Format plan. It deals with:

– Common property: the existence and area common property
– Plan requirements: the geometrical aspects that make it a volumetric plan
– Remainder Lots: the lots remaining after the creation or extinction of a volumetric parcel
– Annotations: the standard format of annotations for identifying, visualising and storage of a volumetric parcel
– Datum and Origin: the origin of the height datum used and the reduced level of the identifying mark, as well as in some cases the relative height
– Restricted easements: depiction on plan, visualisation and storage of restricted volumetric lots or easements

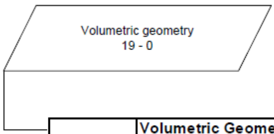
Volumetric
11 - 0

CAD13143	VFP Common Property	VR170	CommonProperty
		VR172	AreaOfCommonProperty
CAD13184	Volumetric Plan Requirements	VR139	VolumetricFormatPlans
CAD13186	VFP Remainer Lots	VR148	StdFormatRemainderLots
		VR149	Multiple Std Format Remainder Lots
CAD13196	VFP Foorprint	VR153	ExtentOfVolumetricLot
		VR154	AreaOfVolumetricLotFootprint
CAD13197	VP Annotaions	VR160	VolumetricAnnotation
		VR169	VolumetricAnnotation
CAD13199	VFP - Datum and Origin	VR164	CoodinatesOrigin
		VR166	CoodinatesDatum
CAD13200	Restricted easements	VR167	Restricted Parcel Lot Or Easement

Figure 18. EARL-III Volumetric Format Validation Rules: Identification and Administrative

Figure 19 deals with the validation rules for the geometrical aspects of a volumetric plan. Brief descriptions of the rules are:

- Geometrical shape: this includes verification of Definition of Bounds, Faces of a Volume, Bounding Surfaces, Vertices, Slope Distances, Bounding edges, Completeness. These assist to define the shape of the volumetric object
- Geometrical volume: this includes verification of Lot volumes, Part Lot Volumes, Total Lot Volumes and Validation of Lot Volumes. These verify the dimensions of the whole or part of a 3D object.
- Geometrical location: these verify the following, Approximate Ground Level, Marking Footprint, Vertical Location, Occupation and Coordinates. These assist in uniquely locating the 3D position of the volumetric object within a 2D parcel.
- Adjoining geometry: these verify the Adjoining Volumes, 3D Topology, Volumetric Footprint Projection and Approximate Ground Level.



	Volumetric Geometry	**VR084**	3D Topology
		VR140	Definition of Bounds
		VR141	Faces of a Volume
		VR142	Bounding Surfaces
		VR143	Vertices
		VR144	Slope Distances
		VR145	Bounding Edges
		VR146	Completeness
		VR152	Vol Footprint projection
		VR155	Marking Footprint
		VR156	Lot Volume
		VR157	Part Lot Volumes
		VR158	Total Lot Volumes
		VR159	Validate Lot Volume
		VR161	Aprox Ground Level
		VR162	Vertical Location
		VR163	Occupation
		VR165	Coordinates
		VR168	Approx Ground Level
		VR233	Adjoining Volumes

Figure 19. EARL-III Building Format Validation Rules: Geometry

5. FUTURE DISCUSSIONS FROM QUESTIONNAIRE SURVEY

A questionnaire survey on the status and implementation issues of 3D Cadastre was done in 2010-2011 of all the cadastral jurisdictions of Australia. A similar questionnaire was done by FIG of international jurisdictions (Oosterom *et al* 2011). Issues identified from this questionnaire are used to generate further discussions and proposal to expand or include some more validation rules.

5.1 Issues identified

From the questionnaire, issues that are relevant to 3D would need further exploration for the inclusion of ePlan data into a LADM like data model are identified in this paper. Examples that can be mentioned are like entering geometrical information into the database, allowing and registering different kinds of geometry like utility networks, curved surfaces, consistent dealing of relative elevations for volumetric parcels, support for legal parcels (equivalent to the LA_SpatialUnitGroup of LADM), capture, storage and display of 3D cadastral data in the digital cadastral database, 3D data query and manipulation, 3D topological validation, defining what constitutes a valid 3D object etc.

5.2 Validation rules

Some generalised statements regarding the detailed development of validation rules that can be included in the digital lodgement of cadastral plans in Australia as identified from the questionnaire survey and ISO TC211 LADM are: capture and storage of the construction geometry of 3D cadastral object, topological checks of the object and its adjoining parcel, allowing and verifying open-ended and closed-ended volumes, allowing and checking network objects to exist independent of the 2D base parcel as well as performing neighbourhood queries etc. These provide a basis for discussion and improvement of the proposed project.

5.3 Conclusion

The paper has raised awareness about the various data models and their inter-relationship in digital lodgement in Queensland, Australia. It interprets relevant bits of the LADM and relates it to the ePlan model. Validation rules are discussed and several examples examined. The LADM presents future prospects for digital lodgement of geometrical data in 3D cadastre.

ACKNOWLEDGEMENTS

This research is supported by the Dutch Technology Foundation STW, which is part of the Netherlands Organisation for Scientific Research (NWO) and partly funded by the Ministry of Economic Affairs, Agriculture and Innovation (Project codes: 11300 and 11185).

REFERENCES

AGIMO, Australian Government Information Management Office (Nov 2006). *Recommended* XML Namespace Scheme for Australian Government Organizations <http://icsm-eplan.govspace.gov.au/eplan-protocol/>.

Cooper, K. (2010). Achievements Towards Digital Transfer of Survey Plan Data.

Cumerford, N. (2010). 'The ICSM ePlan Protocol, Its Development, Evolution and Implementation', paper presented to FIG Congress 2010, Sydney Australia, 11-16 April 2010.

ICSM, Intergovernmental Committee on Surveying and Mapping Nov (2010). ePlan Protocol Schema Architecture, <http://icsm-eplan.govspace.gov.au/eplan-protocol/>.

ISO-DIS/LADM19152 2011, Geographic Information - Land Administration Domain Model.

Oosterom, P. van, Stoter, J., Ploeger, H., Thompson, R. and Karki, S. (2011). 'World-Wide Inventory of the Status of 3D Cadastres in 2010 and Expectations for 2014', paper presented to FIG Working Week 2011, Marrakech, Morocco.

BIOGRAPHICAL NOTES

Sudarshan Karki is a Senior Spatial Information Officer, Cadastral & Geodetic Data (Survey Information Processing Unit), in the Data Management & Acquisition, Spatial Information Group of Department of Environment and Resource Management, Queensland Government, Australia. He completed his professional Masters Degree in Geo-informatics from ITC, The Netherlands in 2003 and is currently doing Master of Spatial Science by Research at the University of Southern Queensland.

Rod Thompson has been working in the spatial information field since 1985. He designed and led the implementation of the Queensland Digital Cadastral Data Base, and is now principal advisor in spatial databases. He obtained a PhD at the Delft University of Technology in December 2007.

Kevin McDougall is an Associate Professor and the Head of the Surveying and Spatial Science discipline, Faculty of Engineering and Surveying at the University of Southern Queensland. His research interests are Spatial Data Infrastructure, property and water rights, data sharing. He has over 21 years of experience of teaching at the tertiary level. He obtained a PhD from Melbourne University.

Nevil Cumerford is a Cadastral Surveyor with the Department of Environment and Resource Management in Queensland Australia with the Spatial and Scientific Systems Area of the Spatial Information Group. He has been working in the development of Corporate IT Systems for the Management of Survey Data for over 20 years. He is currently the team leader for the Electronic Access for Registry Lodgment Program for the Department. He is a member of the Surveying and Spatial Science Institute of Australia (SSSI).

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 Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is Professor at the Delft University of Technology and head of the section GIS Technology Section. He is the current chair of the FIG joint commission 3 and 7 working group on ‘3D-Cadastres’ (2010-2014).

CONTACTS

Sudarshan Karki
Queensland Government, Department of Environment and Resource Management
Landcentre, Cnr Main and Vulture Streets,
Woolloongabba, Brisbane, Queensland 4102
AUSTRALIA
Tel.: +61 7 389 63190
E-mail: Sudarshan.Karki@derm.qld.gov.au
Website: http://www.derm.qld.gov.au/

Rod Thompson
Queensland Government, Department of Environment and Resource Management
Landcentre, Cnr Main and Vulture Streets,
Woolloongabba, Brisbane, Queensland 4102
AUSTRALIA
Tel.: +61 7 38963286
E-mail: Rod.Thompson@qld.gov.au
Website: http://www.derm.qld.gov.au/

Associate Professor Kevin McDougall
Head, Surveying and Spatial Science
Faculty of Engineering and Surveying, University of Southern Queensland
West Street, Toowoomba, Queensland 4350
AUSTRALIA
E-mail: mcdougak@usq.edu.au
Webdiyr: www.usq.edu.au/users/mcdougall

Nevil Cumerford
Queensland Government, Department of Environment and Resource Management
Landcentre, Cnr Main & Vulture Streets
Woolloongabba, Brisbane, Queensland 4102
AUSTRALIA
Tel.: +61 7 389 63213
E-mail: Nevil.Cumerford@derm.qld.gov.au
Website: http://www.derm.qld.gov.au/

Peter van Oosterom
Tu Delft, OTB Research Institute for the Built Environment, GIS Technology Section
P.O. Box 5030, 2600 GA Delft
THE NETHERLANDS
Tel.: +31 15 2786950
E-mail: P.J.M.vanOosterom@tudelft.nl
Website http://www.gdmc.nl