THE LADM BASED ON INTERLIS

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ABSTRACT

Both the conceptual schema language INTERLIS and the land administration domain model (LADM) share the same model driven architecture (MDA) principles. In this paper we explore how INTERLIS and LADM complement each other in actual implementation of land administration system based on the LADM using INTERLIS tools. In Switzerland, the requirement for a clearly defined data model that can be adapted in flexible ways resulted in a conceptual schema and object oriented language INTERLIS. The cadastral core data model and many other models (i.e. utility services, urban planning, etc.) have been defined with INTERLIS in Switzerland. The concept of the data description language INTERLIS is compatible with international standards like UML or GML/XML. The language is widely used in the country. Constraints for comprehensive data quality checking can be formulated easily. This is one of the main reasons to keep INTERLIS. INTERLIS tools are available for QGIS, FME and other systems. There is also an INTERLIS aware graphic UML editor, GML can be generated, web services (WMS) are supported, etc. The Land Administration Domain Model (LADM, ISO 19152) has been formulated in INTERLIS now. The result is a layered INTERLIS model description: ISO191xx base model, generic LADM and finally country model specific model expressed in INTERLIS. From this, using INTERLIS tools database schema's (Oracle, PostgreSQL) can be generated and also a foundation for data exchange format (XML) of the specific LADM country profile is available. Specific attention will be paid to expressing the LADM constrains (expressed with pseudo OCL in ISO 19152) into INTERLIS. The paper first introduces the INTERLIS concepts and supporting documentation. Some examples are included. Then the integration of LADM is expressed. Pro's and con's are analyzed (compared to not using INTERLIS and applying just standard UML, OCL, XML). Finally, future work is presented: support of volumetric 3D primitives, more advanced constraints, etc. Briefly stated, INTERLIS brings one more option to implement LADM (with support from Switzerland) in an efficient manner, and supporting a range of actual target platforms (GIS, DBMS, etc.).

Key words: LADM, INTERLIS, MDA, GML/XML, Databases, Constraint Languages

INTRODUCTION

Both the conceptual schema language INTERLIS and the land administration domain model (LADM) share the same model driven architecture (MDA) principles. In this paper we explore how INTERLIS and LADM complement each other in actual implementation of land administration system based on the LADM using INTERLIS and its tools.

This paper now first introduces some INTERLIS concepts in section 2. The concepts are then applied to LADM, as explained in section 3, with special attention to data modelling and constraint formulation. Section 4 compares the LADM/INTERLIS approach with other standards (UML/GML). Finally, future work (section 5) and main conclusions (section 6) are provided.

INTERLIS CONCEPTS

A short history of INTERLIS

The first version of the data modelling language INTERLIS was introduced in Switzerland in the late 1980s (Dorfschmid et al [1]) and has become a Swiss standard in 1998 (SN 612030). The actual version 2.3 of the standard [2] is an object-oriented conceptual schema language (CSL), which is being used to precisely define (spatial) data models in textual form with a rigid computer process able syntax. An important characteristic of the language is that it can easily be understood by application and IT experts, thereby bridging the gap between application and IT domains.

While INTERLIS was originally designed and used mainly for land administration, it is not restricted to land administration data modelling. In fact INTERLIS is a general purpose modelling language. Due to its flexibility it has become part of the Swiss Act on Geoinformation [3] and is currently being used to describe the 160+ data models of the Swiss National Data Infrastructure (NSDI).

INTERLIS Key Features

INTERLIS has a unique set of features which sets it well apart from other modelling standards (i.e. UML or XML-Schema):

- INTERLIS schemas are defined as easy to read text files. The rigid syntax can directly processed by computer programs;
- the language has built-in geometric data types (point, poly-line, polygon), making it especially suitable for models in the geoinformation domain. Note that at the moment there is not yet a data type of a 3D volumetric solid, such as a polyhedron;
- each INTERLIS data model automatically defines a system neutral XML based data exchange format and there are also tools to generate a database schema (SQL DDL);

An interesting aspect of the language is that it is possible to quality check INTERLIS data against INTERLIS data models (including constraints for valid data), thereby enabling fully automated quality control of spatial data.

INTERLIS Tool Chain

- The intense use of INTERLIS in Switzerland would not be possible, if the language would not be supported by a wide range of tools. The following list gives a brief overview by naming the most important tools (free and commercial):
- the INTERLIS compiler checks the syntactical correctness of an INTERLIS data model (free);

- the INTERLIS checker can quality check INTERLIS XML data against INTERLIS data models (free);
- the INTERLIS UML editor is used to create INTERLIS models from UML diagrams or to visualize existing INTERLIS data models as UML diagrams (free);
- data translators can convert data sets from many GIS systems / databases to and from INTERLIS XML (free and commercial);
- schema tools can generate database schemata directly from INTERLIS data models (free and commercial);

More information about the INTERLIS language and its tools is available at the official INTERLIS web site at www.interlis.ch.

INTEGRATION WITH LADM

After the introduction of INTERLIS, it should be obvious that LADM and INTERLIS is a perfect match. By applying the INTERLIS data modelling language to the LADM, ISO 19152:2012 [5, 6] standard, we get computer processable model descriptions, which can be used to initialize databases or transfer LADM data via XML. Using INTERLIS for LADM also means that all free available INTERLIS tools such as compiler, checker, UML editor, etc. can be directly applied to LADM derived country profiles.

Model Descriptions

To test the feasibility of a LADM INTERLIS implementation, the Swiss Land Management foundation (SLM) started to describe the LADM ISO 19152 standard with INTERLIS. The core work was completed in February 2014 and the full model can be downloaded freely from the SLM web site www.swisslm.ch. The following figure shows an example LADM-UML diagram translated to INTERLIS:

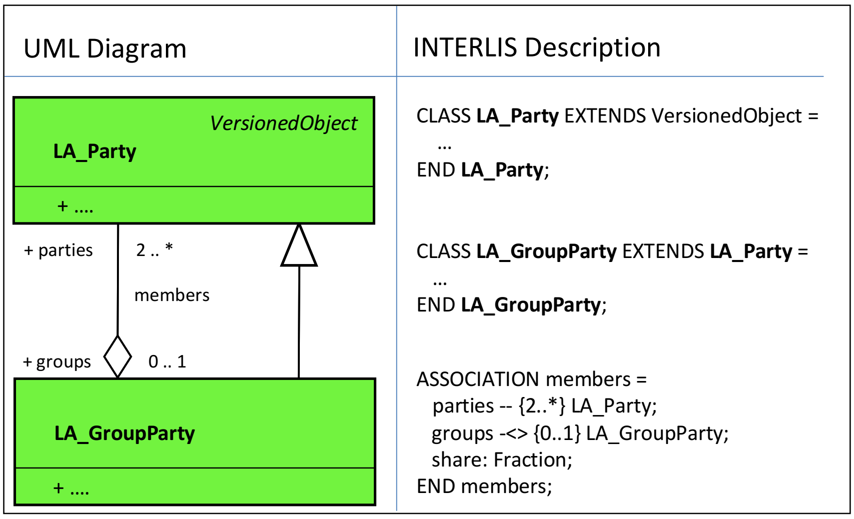

Figure 1: Example of LADM UML diagram translated to INTERLIS (note in the UML Diagram the association class LA_PartyMember is not depicted, but this is included in the INTERLIS description).

Constraints

The INTERLIS standard includes an OCL like constraint language. Constraints can be defined on object level (MANDATORY CONSTRAINT) or class level (SET CONSTRAINT, UNIQUE CONSTRAINT). Some of the constraints / invariants of the LADM model can be directly expressed by the INTERLIS constraint language, as the following example shows (the UML pseudo OCL invariant 'if dimension=2D then volume not specified'):

```
CLASS LA_SpatialUnit EXTENDS VersionedObject =
  area: LIST {0..*} LA_AreaValue;
  dimension: LA_DimensionType;
  extAddressID: LIST {0..*} LADM_Base.External.ExtAddress;
  label: CharacterString;
  referencePoint: GM_Point;
  suID: MANDATORY Oid;
  surfaceRelation: LA_SurfaceRelationType;
  volume: LIST {0..*} OF LA_VolumeValue;
MANDATORY CONSTAINT
  !! if dimension=2D then volume not specified
  NOT (
    dimension == #2D
  )
  AND (
    DEFINED(volume)
  )
END LA_SpatialUnit;
```

The current version of the INTERLIS checker can process such constraints without additional configuration.

COMPARISION WITH OTHER STANDARDS

After the introduction to the INTERLIS language and its application to ISO 19152 LADM the reader might ask him/herself what makes the INTERLIS/LADM approach so special. After all there are other well established standards that could do the same with another set of tools. In this section we try to answer this legitimate question from our point of view.

Reduced Complexity

INTERLIS was designed from the very beginning to model LIS systems and to exchange data between LIS in a system neutral format. The concentration on the two most important tasks, model LIS system and exchange format, in our application domain leads to significant complexity reductions. The INTERLIS 2.3 reference manual consists of only 160 pages, describing the language and also the data exchange format. The reference manual is self-containing making no references to other standards except XML. This reduced complexity makes it much easier for software developers to create powerful tools (compiler, checker, translators, etc.).

Comparison to UML

UML is a standard mainly intended to document all phases of modern software development (design, development, deployment, maintenance). UML provides many diagram types to support those activities including class, state and behavior diagrams. As UML has no direct relation to Land Administration or Land Information System in general, applying UML to LIS is sometimes difficult as concepts for even the most basic geometric types (point, line and polygon) are missing in UML. Note that within ISC TC211 there is a family of standards providing both generic base types (e.g. the geometry primitives in ISO 19107), domain models (e.g. LADM in ISO 19152) and many other aspects in between (e.g. temporal type, reference systems, metadata, quality). INTERLIS uses UML class diagrams for visualization of data model structures. There is even a free tool to support the UML / INTERLIS integration (UML-Editor).

Comparison to GML

While GML was originally designed as a data exchange standard it is used today also as a modelling language. While it is possible to use GML for modelling it is somewhat inconvenient as the resulting XML-Schemas are not easily readable by humans without additional tools. Therefore GML should be used as a flexible and model-driven transfer standard only, but not as a modelling language.

The GML standard supports many geometric primitives, making it difficult for software vendors to implement all those types consistently. The Swiss eCH-0118 specification [4] therefore defines an INTERLIS / GML mapping to use a subset of GML as an alternative INTERLIS transfer mechanism.

FUTURE WORK

Swiss LADM Country Profile

As a next logic step it was decided to implement the Swiss LADM country profile in INTERLIS. This work is sponsored by the Swiss government (swisstopo) and was started in February 2015. The project will also make LADM compatible data from Canton Solothurn available on a public webserver. All provided data will be quality checked (based on more explicit constraints for valid data) by an automatic LADM check service.

INTERLIS 2.4

The LADM/INTERLIS implementation work has directly inspired some additional work on the actual INTERLIS 2.3 language to even better support the LADM standard (i.e. improved constraint formulation, LIST and BAG with basic types). The upcoming INTERLIS 2.4 standard will be published by mid-2015.

Complete LADM described in INTERLIS

After describing the core of LADM in INTERLIS, the next step is a more complete description covering: all possible spatial representation types (spatial profiles: from text to topology), include 2D, 3D and mixed spatial units, describe all constraints mentioned in ISO19152, all specializations of spatial units (such as LA_LegalSpaceBuildingUnit and LA_LegalsSpaceUtilityNetwork), etc.

3D Support

INTERLIS supports 3D point / line and polygons but there are no special 3D-types (i.e. solids) in the standard at the moment. As 3D cadaster becomes more and more common in urban areas the better integration of 3D data types will be an issue in future versions of the language (INTERLIS 3?). In Lemmen et al 2010 [7] an overview is given of all spatial representation types and the challenges that occur when integrating 2D and 3D spatial units in one environment.

CONCLUSION

By applying INTERLIS to the LADM ISO 19152 standard we get directly computer processable data models. This approach can significantly speed up the implementation of LADM country profiles. As access to all specifications and important tools (compiler, checker, UML-Editor) is free, the LADM/INTERLIS approach can easily implemented with minimal financial investments.

REFERENCES

[1] Swiss Department of Justice (Dorfschmid, S., Kaufmann, J.)(1987). Detailkonzept: Reform der amtlichen Vermessung,
http://www.cadastre.ch/internet/cadastre/de/home/docu/publication/P075.html.

[2] COGIS (2006). INTERLIS 2.3 Reference Manual. Coordination, Geo-Information and Services (COGIS), a division of the Swiss Federal Office of Topgraphy, swisstopo, Switzerland, <http://www.interlis.ch/interlis2/docs23/ili2-refman_2006-04-13_e.pdf>.

[3] Swiss Confederation (2007): Federal Act on Geoinformation.
http://www.admin.ch/opc/en/classified-compilation/20050726/index.html

[4] eCH-0118 (2011): GML Kodierungsregeln für INTERLIS

[5] ISO 19152:2012 (2012). Geographic information - Land Administration Domain Model (LADM), version 1 December 2012.

[6] Lemmen, Christiaan, Van Oosterom, Peter, Bennett, Rohan (2015). The Land Administration Domain Model. Land Use Policy (2015),
http://dx.doi.org/10.1016/j.landusepol.2015.01.014.

[7] Lemmen, Christiaan, Van Oosterom, Peter, Thompson, Rod, Hespanha, João P. and Uitermark, Harry (2010). The Modelling of Spatial Units (Parcels) in the Land Administration Domain Model (LADM). In: Proceedings of the XXIV FIG International Congress 2010, April 2010, Sydney, 28 p.

GERMANY ON THE WAY TO 4D-CADASTRE

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ABSTRACT

In Germany property taxation was the reason for the establishment of the cadaster in the beginning of the 19th century. One hundred years later (1900) the property cadaster was established. In the last decades the cadaster was increasingly used for a lot of other mapping and planning issues - it became a so called multi-purpose cadaster as a geo-basis Land Information System (LIS) and nowadays as a part of the Naional Spatial Data Infrastructure (NSDI). Nowadays economy, science and administration have an increasing demand for official three-dimensional spatial information (3D-geodata) as a base for multiple applications. The surveying and mapping administration in Germany has accepted this demand as a challenge to develop and realize sustainable conceptions for 3D-geodata, focusing on fast and economic solutions. In this context, national and international standards, infrastructures and activities had to be considered. The German AAA® cadaster standard takes into account the international standardization of ISO and OGC to include 3D-geodata. The cadaster in Germany is a parcel-based system, i.e. information is geographically referenced to unique, well-defined units of land. These units are defined by formal boundaries marking the extent of land. Each parcel is given a unique parcel-number. In addition the buildings are collected and updated. Buildings are represented geometrically (2D) and semantically. They are a basic component of the cadaster and basis for tasks of the administration, economy and science. Because of the federalism in Germany, the states and local authorities are responsible for the cadaster. For that reason the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany[1] (AdV) gives recommendations for nationwide cadastral standardization. The AAA® - data model which ensures the interoperability between cadastral and surveying and mapping data is the result of this standardization process. During the last years the information systems of surveying and mapping and cadaster were focusing demands for three-dimensional applications, e.g. environment protection, planning, energy supply and disaster management. The basic request of coverage and actuality was defined for the third dimension. In 2009, the AdV came up with the following decision: "The collection, data modeling and quality management of buildings for the geo-topographical surveying and for the cadaster are main tasks of the official German cadaster. This also includes the third dimension". The fourth dimension (life cycle information) is already an integral component of

[1] Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV), www.adv-online.de

the new German cadastral information system and will be explained later on. This paper will focus on this process and will show benefits and applications.

Key words: DVW2, 4D-cadastre, solar and noise cadaster, CityGML, vertical data integration

THE DEMAND FOR 3D-BUILDING INFORMATION

Energy turnaround

In Germany the government targets at climate and environmental protection currently lead to extensive changes in the energy sector, the so called energy turnaround. This includes the end of the use of nuclear energy by 2020, the reduction of greenhouse gases and other objectives (BlmSchG, 2012). As a result planning processes especially have to take into account the use of photovoltaic technology, geothermal energy, wind energy and the energetic isolation of buildings.

From the process view, data must be available to provide actual information of the environment and all energetically relevant topics. Very often this leads to a data collection or at least to a data processing task. Having the required information, the analysis and the evaluation will give a sustainable picture of the energy balance, including possible savings the use of renewals energies and energetic isolations of buildings.

Photovoltaic map of the city of Dusseldorf

Noise protection

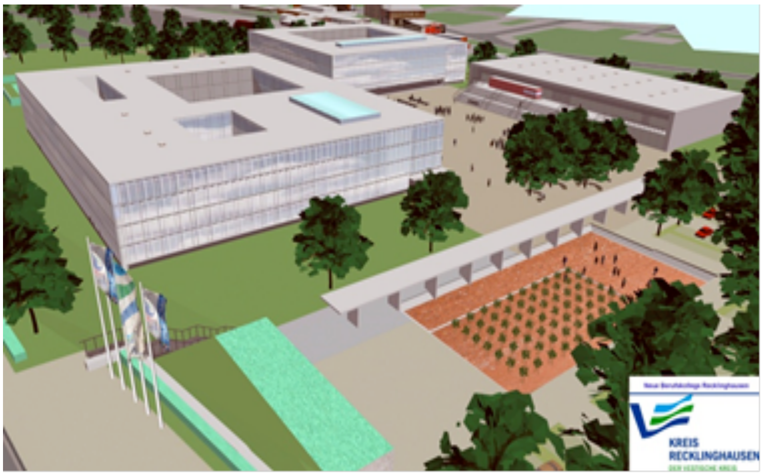
The 3D-geometry and semantics, particularly of buildings, are very important for simulating and mapping of noise expansion. By a European directive every five years the member states of the European Union are obliged to determine and to document noise pollution in cities. In addition the progress of noise-reduction is checked.

[2] German Association of Surveying (DVW), www.dvw.de

Noise map of the city of Dusseldorf (left: during day time, right: at night)

Urban planning

The use of cadastral information for urban planning was always essential in the 2D-world, especially to consider the property distribution. Nowadays 3D-information is a basic demand of the urban planning sector. Demographic effects and other restrictions could be visualized in planning alternatives.



Planned school in the county of Recklinghausen

Disaster management

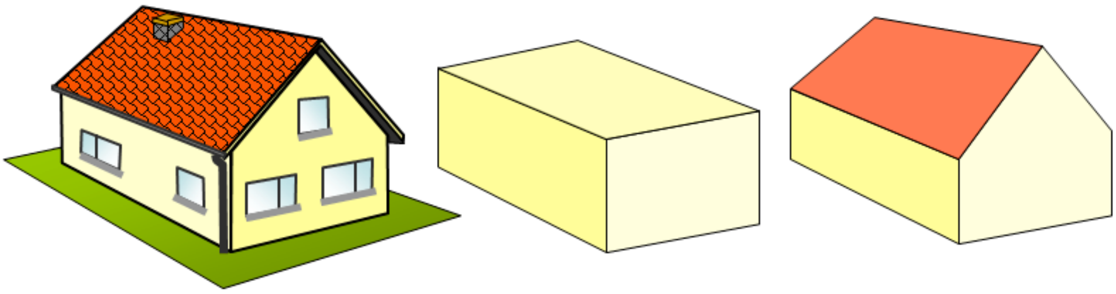
Increasingly 3D-information is used in the simulation of disasters, for example for evacuation and flood scenarios.

Right: Air rescue – county of Recklinghausen

REQUIREMENTS FOR 3D-BUILDING INFORMATION

Level of Detail (LoD) in the cadaster

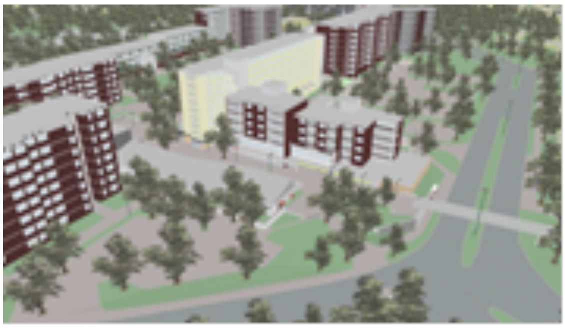
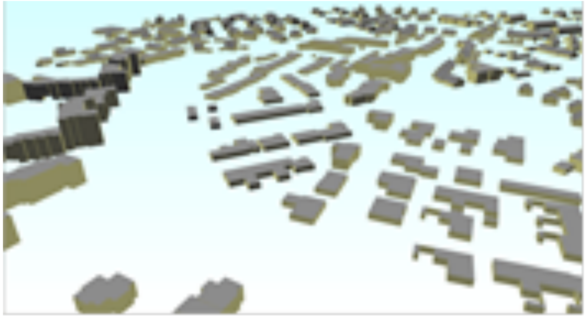
While 3D-building information in the LoD 1 are sufficient for applications like noise mapping (1.2) many other application like the aforementioned photovoltaic map (1.1) at least need a higher LoD 2 resolution (CityGML, 2012). As a consequence so-called “city-models” were built up in many cities in Germany. Their basic goal was to support or even allow a visualization of special application scenarios (examples: 1.3, 1.4). On the other side these models had not special quality or updating mechanisms. Often they used the cadaster as a data source (exact location / 2D building information), but they never became part of the cadaster. To overcome this lack a proposal came up to expand the official cadastral AAA® - data model towards the third dimension.



Approach

Several investigations have proved that only a few additional information is needed to build up a 3D-spacial data set out of the existing 2D-spacial cadastral data and to keep the information up to date. What is needed are the number of floors, ridge direction, and the building height. Most of this information already exists in the planning process; additional data is collected during the cadastral survey. With this approach and the integration the aforementioned information a future 3D-cadaster could be implemented sustainable.

These days the 3D approach is a “topographic” extension of the cadaster in Germany. The demand for taxation was the reason for the establishment of the cadaster in the beginning of the 19th century. One hundred years later the property cadaster was established. In the last decades the cadaster was increasingly used for other necessary mapping and planning issues - it became a so called multi-purpose cadaster, at that time restricted to 2D. With the AAA® – model modern technologies, XML- descriptions’ suitable software came up (Hawerk 2002) and today the link to CityGML takes place (Gröger et. al. 2011). With this the 3D-ability is included.

City model, Recklinghausen 3D-spatial data, Recklinghausen

The pictures above show the additional contents of a city model compared to 3D-spatial data. While city models often based on visualization, the AAA®-3D-spatial data are focusing on analysis. After the implementation of AAA®-3D-spatial data, city models might be developed automatically as cadastral applications.

STANDARDS

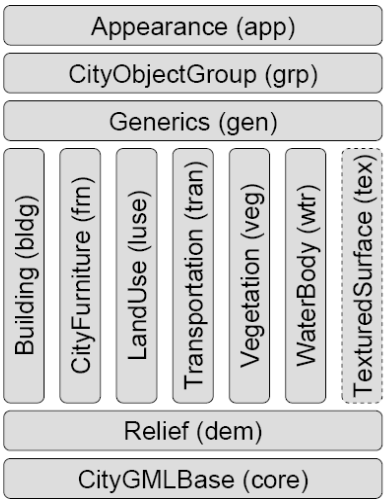
CityGML-Profiles and AAA®-3D-spatial data

The following step by step approach is applied to realize nationwide 3D-geodata set in Germany:

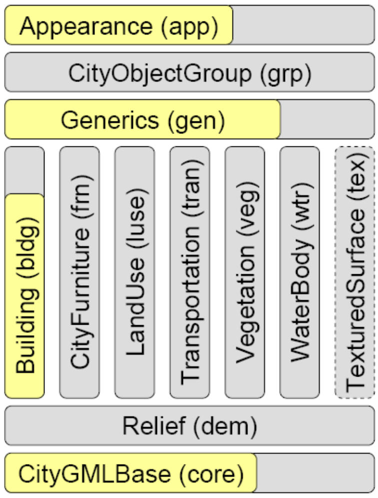
Interim solution CityGML-Profiles

Already today, there is a demand for 3D spatial information. The currently used AAA®-data model (version 6) is not able to store and to provide the expected 3D-information. The expanded AAA® version 7.0 will not be available before 2018 all over Germany.

Therefore the existing OGC standard CityGML (Groeger et al. 2012) for the representation and exchange of 3D- information is used. In March 2012, CityGML 2.0 was published as an international standard by the Open Geospatial Consortium (OGC). To realize the above-mentioned interim solution profiles were created from GML and CityGML taking into account the needs of 3D spatial information of the cadastral and surveying administration. As a result, the classes, attributes and values have been reduced to the maximum extent permitted by the product definition (Gerschwitz et al. 2011).



CityGML Version 1.0

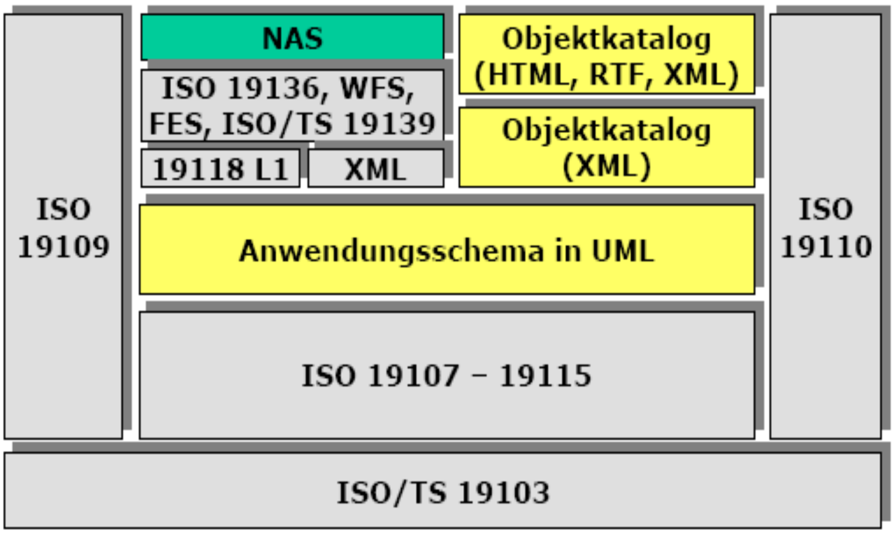


CityGML-Profile of AdV

The diagrams above show that the AdV[1] - profile uses only parts of the CityGML-schema, especially mandatory requirements and quality indicators[2]. The profiles are logical restrictions to CityGML-schema. The updating process of the described interim solution will be done by reprocessing of the existing / original data. An object based actualization does not exist yet.

AAA®-concept

The AAA®- concept is national standard for official spatial information in Germany. It was built up completely by specialization of international standards (AdV 2008). The AAA®-schema is a GML-application schema which represent the national standard for geospatial data of the surveying and cadastral administration in Germany. The model and external schema are completely embedded in existing standards of ISO and OGC

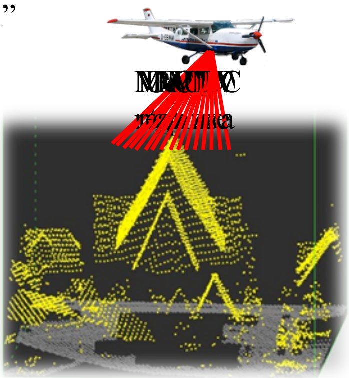


AAA®- embedding existing international standards (AdV 2008)[3]

[3] NAS = exchange interface, Objektkatalog = feature catalogue, Anwendungsschema= application schema

According to size (number of citizens) Recklinghausen is the biggest county district in Germany and therefore comparable to a city like Cologne. In 2011 about 1,600 cadastral surveys took place with respect to buildings. For Recklinghausen, as in general for the German cadaster with over 50 million buildings, it is therefore of fundamental interest to store actual 3D-building information conform to the AAA®- standard and consistent to 2D- and 3D-cadastral object information (in general: 2D-property building layer identical to 3D building footprint) - the so called "vertical integration concept".

This “vertical integration concept” takes into account the source of the data and the production process. The “legal” 2D-property building layer as a major cadastral information is merged with the 3 dimension from laser scan as a topographic source. The result is a “legal” 3D-building model.



It defines the AdV[1] product "3D building model”. As a consequence, the demand, especially of the economy, for official (administrative) 3D-building information could be fulfilled. In addition this data participates in the existing national and international spatial data infrastructure (SDI), for example through simple export to the defined INSPIRE topics.

In contrast to CityGML, which is designed as an external interchange format and for the easy use of 3D-data, the AAA®- concept defines a standard: application schema, feature catalogue and exchange interface[3].

Modeling aspects

<u>Basic schema</u>

The AAA®-schema is logically divided into several packages, essentially into the thematic independent basic schema and the thematic schema, which is based on the basic schema. 3D-classes, which are necessary, are integrated into AAA®-schema in 3 new packages:

- AAA_SpatialSchema 3D,
- AAA_Unabhaengige Geometrie 3D,
- AAA_Praesentationsobjekte 3D

The package “AAA_SpatialSchema 3D” contains additional information of the existing AAA®-schema in accordance with the specifications for 3-dimensional objects of the ISO-norm “191XX”. The package “AAA_Unabhaengige Geometrie 3D” provides all necessary geometric shapes (dot, line and surface) for the AAA®-3D- schema objects with independent geometry. In the package "AAA_Praesentationsobjekte 3D" the modeling of presentation objects is described.

Thematic schema
The AAA®-application schema defines object classes for storing 3D-information: The 2D-classes "AX_Gebaeude" and "AX_Bauteil" as well as the 3D-class "AX_Bauteil3D" have a common upper class "AX_Gebaeude_Kerndaten". The multiface possibilities of occurrence of geometry of 3D-objects in "AU_Geometrie_3D" are limited by constraints.

The storage of quality information is an important part in the German cadaster. Therefore information of quality is modeled conform to ISO-19115 - Metadata. Furthermore the relevant modeling in the INSPIRE[4] -building-topic was considered, which also requires quality information, especially the source of data. As a consequence it will be possible to provide semantics match between the AAA®-model and INSPIRE. This allows the realization of the exchange and conversion of data. The INSPIRE data model, especially the profile extended3D, is one special profile of CityGML, in a similar way to the AAA®-3D-e
"The 3D-building model of the AdV[1] describes buildings in terms of the cadastral view as well as for topographic surveying (LoD 1-3, chapter 2). It does not take into account the modeling of interior rooms (LoD 4), or city topography. The 3D-building is an expansion of the "Hausumringe" (hose foot prints) in the third dimension, accumulated with attributes of associated cadastral 2D-objects. Currently the product standard describes building resolutions conform to LoD 1 and LoD 2 (Gruber, U., 2011).

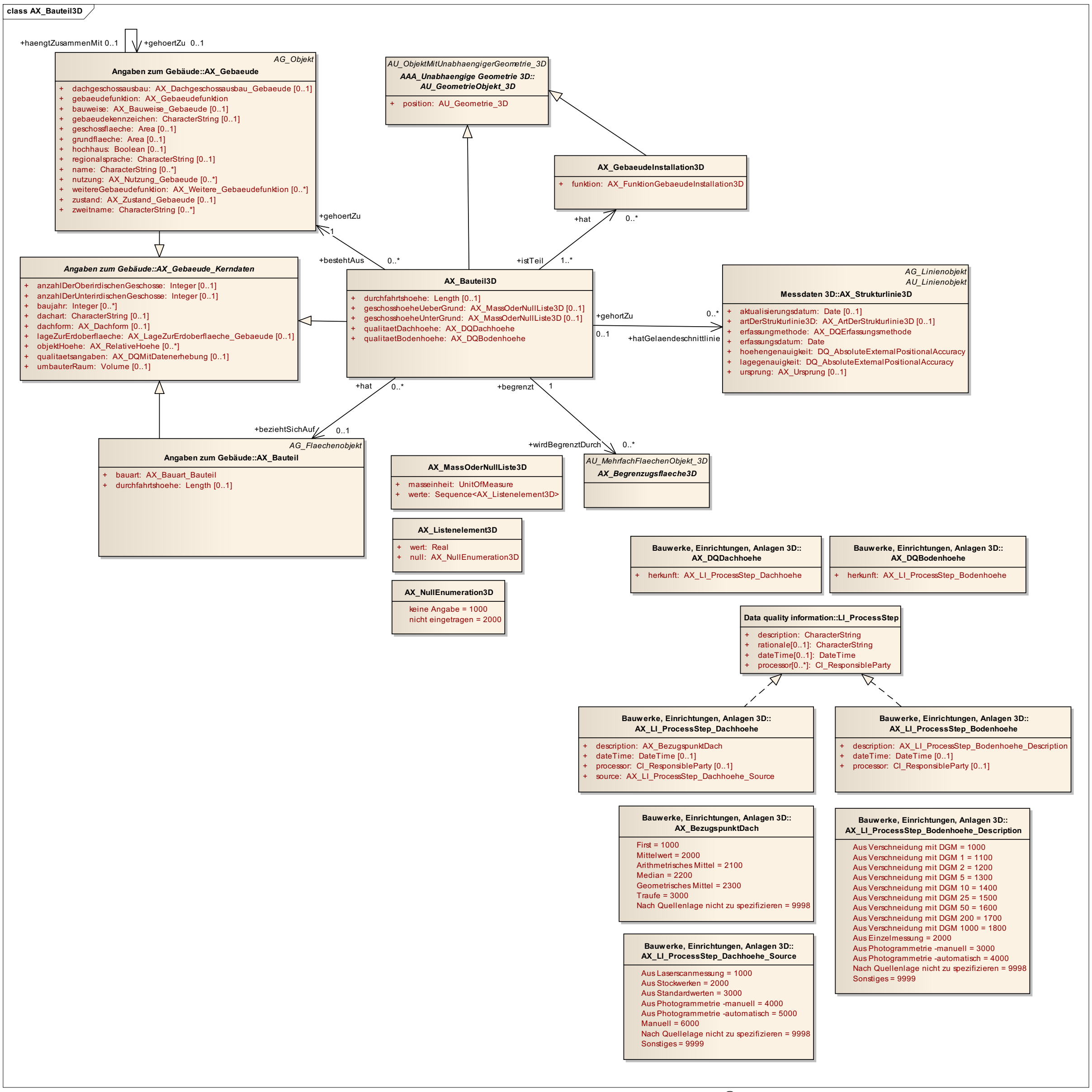
The fourth dimension

Traditionally, in the German cadastre every change of a parcel (e.g. subdivision) is documented by surveying sketches and textual documentations. The development of the cadastral map is continuously monitored and every change over time can be restored in case of cadastral disputed, but usually using non-digital paper documents. Therefore, modern possibilities for inquiries were also a technical requirement for the AAA®- standard. Besides this more internal cadastral use-case there are lots of further requirements for the time-related cadastral information, such as:

- Monitoring the development of cities and villages over time
- Statistic of changes of land use and land cover
- Planning purposes
- Historical archiving
- Monitoring cultural heritage.

xpansion.

[4] Infrastructure for Spatial Information in Europe: A European Directive, see http://inspire.jrc.ec.europa.eu/



„Specification to the building 3D“/AAA® - schema

The AAA®-data model requires for each object a unique identifier together with a designated time stamp for creation and deletion of an object. However, once an object has to be deleted during an updating process the object will not be physically removed from the data base. Only the life cycle of the thematic relevance has ended, but not the existence of the object as an instance. A "deleted" object is then considered the as a historical information which can be easily distinguished from the actual information. Sometimes there are changes of an object which do not require the deletion of the object (e.g. only a name of the person changes). In that case also the different versions of an object can be stored. Within the AAA®-data model this approach is therefore called "versioning concept". Since every object carries life cycle information the storage of historical objects and versions of objects is not limited to any specific object type.

Within the AAA®-data model this approach is used for providing historical information as well as for the incremental updating of secondary used information systems.

CONCLUSIONS

Availability of LoD 1 und LoD 2 in Germany

Due to the constitutional responsibility of surveying and mapping the responsibility for cadastral data is on the state level. As mentioned above the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) defines nationwide cadastral standards. In addition a nationwide access point was established in North Rhine-Westphalia to distribute about 21 million house coordinates (coordinates of buildings with an official address), about 50 million 2D-"Hausumringe" (house foot prints), LoD 1 and LoD 2 - data for Germany (for more information: www.adv-online.de).

4D

Economy, science and administration have an increasing demand for official multi-dimensional spatial information (4D-geodata) as a base for multiple applications. The surveying and mapping administration in Germany has accepted this demand as a challenge to develop and realize sustainable conceptions for 4D-geodata, focusing on quick and economic solutions. In this context, national and international standards, infrastructures and activities had to be considered. The German AAA® cadaster standard takes into account the international standardization of ISO and OGC to include 4D-geodata as an economic solution for guidance and continuation.

Economy, science and administration have an increasing demand for official three-dimensional spatial information (3D-geodata) as a base for multiple applications. The surveying and mapping administration in Germany has accepted this demand as a challenge to develop and realize sustainable conceptions for 3D-geodata, focusing on quick and economic solutions. In this context, national and international standards, infrastructures and activities had to be considered. The German AAA® cadaster standard takes into account the international standardization of ISO and OGC to include 3D-geodata as an economic solution for guidance and continuation. The approach of the vertical integration of 3D-geospatial into the cadastral standard guarantees an interface to the German and European spatial data infrastructure. Especially consistent regulation of modeling, actualization concepts and the quality management are activities which have to be finished in the next years.

REFERENCES

AdV, 2008. Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany: GeoInfoDok (ALKIS®) main document Version 6.0

AdV (2008): Preliminary report "Digital Surface Models, architectural models" of the working groups "Geotopography" and "cadastre" for 120th Committee sessions of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany on 10 to 11 September 2008.

AdV (2009): Final minutes of the 121st Committee sessions of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany of 9 to 10th September 2009.

BImSchG (2012): Law to protect against harmful effects of air pollution, noise, vibration and similar phenomena, as amended by the 03.15.1974 26.9.2002, as last amended by Article 2 of G v. 06/27/2012. (Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge, vom 15.3.1974 i.d.F. vom 26.9.2002, zuletzt geändert durch Art. 2 G v. 27.6.2012)

Gerschwitz, A., Gruber, U., Schlüter, S.: Die dritte Dimension im ALKIS®. In: Kummer, K. & Frankenberger, J. (Hrsg.): Das deutsche Vermessungs- und Geoinformationswesen 2012. Wichmann Verlag, Berlin/Offenbach, 279-310. 2011

Gröger, G., Kolbe, T. H., Nagel, C., Häfele, K.-H. (Hrsg.) 2012, OGC City Geography Markup Language (CityGML), Encoding Standard, Version 2.0, OGC Doc No. 12-019, Open Geospatial Consortium, 2012.

Gruber, U.: Die dritte Dimension im amtlichen Vermessungswesen Deutschlands. In: Löwner, M.-O. Hillen, F. und Wohlfahrt, R. (Hrsg.): Geoinformatics "Mobility and Environment" 2012. Proceedings of "Geoinformation conference 2012" of 28-30.03.2012, Braunschweig, p. 303-309, 2012.

HAWERK, Winfried: Cadastre 2020 – New Trends in Germany's Cadastre ?!, FIG XXII International Congress, Washington, D.C. USA, April 19-26 2002

INSPIRE Thematic Working Group Building, 2012, D2.8.III.2 Data Specification on Building – Draft Guidelines. Version 3.0rc3.

Oestereich, Marco: Das 3D-Gebäudemodelle im Level of Detail 2 des Landes NRW, NÖV 1/2014

Riecken, J., Seifert, M.: Challenges for the multi purpose cadastre, FIG Working Week 2012

SIG 3D (2012), Quality concept: http://www.sig3d.org/index.php?catid=2&themaid=8777960, Last visit at 11.12.2012

CONCEPTUAL MODELLING OF 3D CADASTRE AND LADM

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ABSTRACT

This paper describes cadastre research initiatives in Malaysia particularly at the University of Technology Malaysia (UTM). Two major domains have been investigated, i.e. integrated 3D cadastre (both technical and legal components), and Land Administration Domain Model (LADM). One of the motivations is to establish 3D cadastre system with LADM international standard, thus provide useful tools for the authorities such as the Department of Survey and Mapping Malaysia, Land Office, and other land related agencies in the country. This paper also attempts to incorporate important customary rights within the proposed LADM model. The current legal aspect of the Right, Restrict, and Responsible (RRR) to have the 3D cadastre will be discussed. Conceptual view and model of the profile that include 3D cadastre will be fully described. In the 3D cadastre research, we focus on the aspect of property registration of complex building and overlapping properties on different land use. We also discuss the interoperability mechanism of the two separated systems between the two different agencies. The 3D cadastre registration serves as a first attempt to develop a more complete integrated 3D cadastre system in the country. Modelling tool such as UML is being utilized for such registration of cadastre objects. This paper also describes the other domain, i.e. LADM country profile, where the various aspects land administration has been considered and proposed. This LADM profile comes together with customary rights for indigenous community in the country, especially in the state of Negeri Sembilan, Malacca, Sabah and Sarawak. This paper also highlights the outlook of the cadastre research in Malaysia by developing a prototype of 3D cadastre data model based on LADM international standard.
Key words: 3D cadastre, LADM and customary rights

INTRODUCTION

The cadastral registration system in Malaysia is a parcel based system and it is 2D in nature (Chong, 2006; Hassan and Abdul Rahman, 2010; Abdul Rahman et al., 2011). This system of cadastral information has served most of the users need for decades. However, in the near future, 2D information may no longer be able to serve the community, especially in more complex situations such as buildings above roads in some large cities and towns. Three dimensional (3D) modelling of cadastral objects such as legal spaces of around buildings, utility networks and other spaces is one of the future aspects for the Malaysian cadastral system. The Malaysian 3D cadastral model could be develop within the framework of the LADM where the generation of the UML model that complies with the concept of LADM for the Malaysian cadastral system can be addressed. The purpose of the LADM is not to replace existing systems, but rather to provide a formal language for describing various sub-systems, so that their similarities and differences can be better understood (ISO 19152, 2012).

The LADM covers both the spatial (i.e. LA_SpatialUnit) and administrative (i.e. LA_Party, LA_RRR, and LA_BAUnit) aspects of land administration. The main reason to apply the LADM is to reuse the collective knowledge from many countries in land administration and to have unambiguous definitions of the key concepts (Lemmen, 2012). For the Malaysian country profile, the integrated support for both 2D and 3D parcels is very useful. In the LADM, 2D and 3D data are treated in a consistent manner throughout the model. It is important to realise that there is a difference between the 3D physical object itself and the legal space related to the object. The LADM only covers the 'legal space', that is the relevant space for the land administration (bounding envelope of the object). To be able to register the 2D or 3D parcels in the cadastral registration, all real estate objects must have a survey document (i.e. LA_SpatialSource), which should make clear to what space the real estate object refers to.

This paper is organized as follows: Section 2 describes some legal aspects of Malaysian land policy. The current Malaysian cadastral systems such as *eCadastre* and *eLand* are discussed in Section 3. Section 4 presents the development of Malaysian LADM country profile (i.e. spatial and administrative parts). Finally, the conclusion are presented in Section 5.

MALAYSIAN LAND POLICY

Malaysian land registration system requires recording of land rights via the registration of land title. According to the Federal Constitution 1957, land matters are under the jurisdiction of state governments and handled by the respective state registry or district land office, depending on where the document of title is formerly registered and guaranteed by the Federal Constitution 1957 as stated under Article 13 (rights to property).

Land ownerships are governed by the National Land Code 1965 and based on the Torrens System. It is protected by the National Land Code 1965 in Section 340 (Registration to confer indefeasible title or interest, except in certain circumstances). National Land Code 1965 states that land includes; the surface (including air space) of the earth and all substances forming that surface; the earth below the surface and all substances at the surface; all vegetation and other natural products; all things attached to the earth or permanently fastened to anything attached to the earth; and land covered by water.

Strata Rights

The Malaysian strata title registration, was first introduced in 1966 by the National Land Code 1965 under Section 355 to Section 374 that dealt with subsidiary titles to each of the parcels within a building having two or more storeys. In order to simplify and overcome the inadequacies of these provisions in the National Land Code 1965, the National Land Council Review Committee deliberated and decided to recommend that a separate legislation on strata titles be enacted, and the existing National Land Code 1965 for subsidiary titles provisions be repealed and replaced by the Strata Titles Act 1985 (Act 318). This legislation came into force in 1985. Although the provisions of strata titles are now in Act 318, this new act is still to be read and construed together with the provisions and rules of the National Land Code 1965. The amendments under Strata Titles (Amendment) Act 2013 include the introduction of the Electronic Land Administration System of Strata Titles, the designation of limited common property, and the creation of one or more subsidiary management corporations to represent the different interests of parcel proprietors.

In Malaysia, a master lot can be subdivided into smaller lots for the purpose of establishing a strata scheme. Subsequently, the strata scheme lot can be subdivided into parcels and land parcels. Each parcel and land parcel can consist of an individual apartment or house. A land parcel means a unit delineated within the lot in which is comprised a building of not more than four storeys held under a strata title, which may have a shared basement, comprises accessory parcels and common property. A building intended for subdivision into parcels means any building or buildings having two or more storeys in a development area and intended to be subdivided into parcels; and any development area has two or more buildings intended to be subdivided into land parcels.

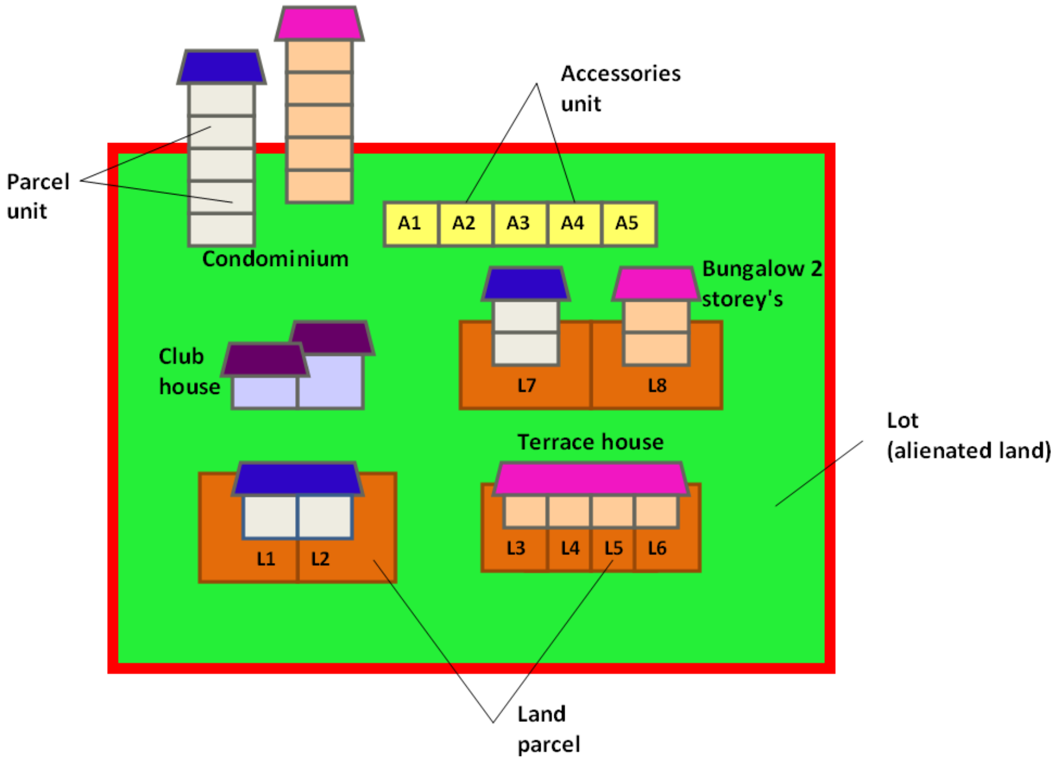

Fig. 1. Various cadastral objects related to strata in context of one lot

Figure 1 illustrates the various types of strata objects in Malaysia. A *parcel* in relation to a subdivided building, means one of the individual units comprised therein (apartment or condominium), which is held under separate strata title. An *accessory unit* means a unit shown in a strata plan, which is used or intended to be used in conjunction with a parcel. A *common property* means so much of the lot as is not comprised in any unit (including any accessory unit). A *limited common property* means common property designated for the exclusive use of the owners of one or more strata lots. A *land parcel* means a unit delineated within the lot (in which is comprised a building of not more than four storeys) which is held under a strata title and which may have shared basement, accessory unit and common property.

Underground Rights

For property deals with dimension below surface, underground land means land that lies below the surface of the earth while stratum means a cubic layer of underground land. Section 44(1)(a) of the National Land Code 1965 states that the extent of the exclusive use and enjoyment of so much of the land below that surface is limited only to such a depth reasonably necessary to the lawful use and enjoyment of the land. According to Section 92B and Section 92E of the National Land Code 1965, the State authority may specify the depth up to which the underground land directly and immediately, below the alienated land may be used, and different depths may specified in respect of different parts of such underground land. Therefore, the National Land Code (Underground Land) (Minimum Depth) Regulations 2006 in National Land Code 1965 was introduced to specify the minimum depth of such underground lands. For agricultural land use, a minimum depth of six metres from the earth's surface has been suggested as the depth for underground land alienation by the committee for the category of agricultural land use. For the category of building and industrial land use, the fixing of minimum depth depends on the depth of piles for building on the earth's surface. Hence, depending on the type of building, the minimum depth of alienation underground land is ten metres from the earth's surface for residential building and, extending to fifteen metres for industrial constructions.

Native (Customary) Rights

This sub-section explains the customary rights in the Malaysian land administration system. The National Land Code 1965 (Act 56) is only valid within Peninsular Malaysia and Federal territories. Both Sabah and Sarawak states have implemented their own Land Ordinance. Malaysian customary rights are not governed by the Federal Constitution of Malaysia but governed by the state authority as customary rights are regarded as state land matters. Prior to the Malaysian Customary Rights, the states that still implemented these rights are namely Melaka, Negeri Sembilan, Sabah and Sarawak, which are Malacca Customary Land, *Tanah Adat Negeri Sembilan*, Native Lands and Native Customary Land for Sabah and Sarawak respectively. Customary rights are acquired by custom and own by the natives. Each of these customary rights differs from one another in terms of land administration systems and land management systems due to the their historical differences.

The majority of the indigenous peoples of Malaysia still live in remote areas, although more and more now live in the periphery of the urban areas. Many survive by hunting and gathering, fishing, farming and by trading forest products. There are 28 indigenous groups making up 71.2% of the population of Sarawak state; 13 native people groups in Peninsular Malaysia numbering around 200,000 people (2010 estimate) or constituting 0.8% of the population of the Peninsular Malaysia. In Sabah, the 39 ethnic groups apparently make up 61.22% of the state's total population.

Various complaints ranging from allegations of encroachment and dispossession of land; land included into forest or park reserves; overlapping claims and slows processing of request for the issuing of native titles or community reserves. A large part of the problem arises from a lack of recognition by the authorities of the concept of customary land of the indigenous peoples, or what constitutes customary land, when much of this land has not been, or is yet to be registered as customary land with the relevant government departments due to ignorance or misunderstanding on the part of the community on the processes involved.

MALAYSIAN CADASTRAL SYSTEM

In Malaysia, there are two organizations responsible for managing and maintaining the cadastral system, they are the Department General of Lands and Mines and the Department of Survey and Mapping Malaysia (DSMM). Both departments are within the Ministry of Natural Resources and Environment as shown in Figure 2. The DSMM deals with the cadastral survey to determine the dimension, size and location of the properties. DSMM is also responsible for preparing Certified Plans (CPs), producing and managing the spatial component including the surveying and mapping of the cadastre parcels. The administrative (legal) data, is the responsibility of the land offices. The land office deals with ownership registration, i.e. who owns the RRRs.

Both organizations have their own information management systems - *eCadastre* within DSMM and *eLand* within the land office (Tan and Looi, 2013). These are two independent systems and in 2D. The Unique Parcel Identifier (UPI) has been introduced to link the land office and DSMM documents where every cadastral object has a unique identity number to differentiate from other cadastral objects.

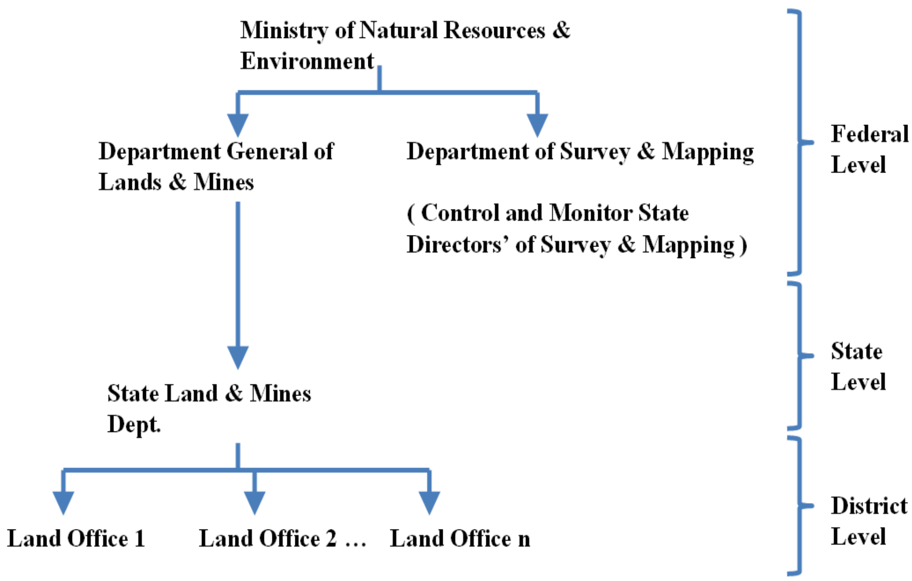

Fig. 2. Organisational structure of land administration in Malaysia

The traditional cadastre system that is practised in Peninsular Malaysia is a parcel bound system and provides essential land and property information of the lots and land parcels. The existing Malaysian cadastral survey and mapping registration system and land registration system deal with properties located not only on the surface level, but also above and below the surface level. Therefore, the rights of the proprietor of the surface parcel shall also apply to the air space above and the space underground as well.

The authenticated cadastral map for Malaysia is called the Certified Plan (CP). There are three types of certified plans. Firstly, the Certified Plan (land parcel) is prepared in a standard format that permits the presentation of useful technical data such as bearings, distances, areas, lot numbers, boundary marks, abuttal's of adjoining parcels and the coordinates of two extreme boundary marks as well as other relevant information when dealing with strata and stratum alienations. The Certified Plan (strata building/land parcel) contains the parcel information like floor areas, parcel numbers, boundary dimensions where the buildings reside in a strata scheme and additional information on the height of the building, number of floors/levels and the strata parcels. There is no change to the Certified Plan (strata building/land parcel) after the implementation of *eCadastre* in Malaysia. Likewise, the Certified Plan (Stratum) provides additional information on the depth and mean sea level of the underground volumetric parcels.

The Certified Plan then becomes the source document relating to the creation of the parcel boundaries and specific provisions have been made with regard to its role and status in the National Land Code 1965 (Act 56). The said Act gives much significance to the Certified Plan in the sense that land would not be considered to have been surveyed if the plan is not authorised or approved by the DSMM with evidence of the boundaries, boundary marks and areas shown on it.

eCadastre

The vision of the Malaysian government is to become a developed country by the year 2020 which encompasses the realization of an efficient public delivery system at various levels. The *eCadastre* project is under the 9th Malaysian Development Plan (2006-2010). This has been approved to be implemented by the DSMM and aims to achieve a fully digital Malaysia by 2015. The main objective of *eCadastre* is to expedite the delivery system for land title survey. This would entail the creation of a survey accurate database at the national level suitable for Geographical Information Systems (GIS) users. There are three main components in *eCadastre*, namely Coordinated Cadastral System (CCS), Virtual Survey System (VSS) and Cadastral Data Integrity System (CDIS). The implementation of CCS is a major part of the *eCadastre* project that includes field and office reengineering to reduce processes and increase the use of digital technology.

Since 1995, DSMM has embarked on a modernization program that saw the dramatic computerization of both its field and office processes of its cadastral survey division. The digital cadastral database was created by capturing the surveyed accurate information of all land parcels. Under the *eCadastre* project, a comprehensive nationwide readjustment of the mesh-work of the parcels would be carried out based on a new geocentric datum. A dense network model known as the CCS of Real Time Kinematic Global Positioning System (RTKGPS) permanent stations has been established to provide precise geocentric positioning and implemented through the *eCadastre* project.

The current system of cadastral survey is able to capitalize on the advent of satellite based technologies. The new environment allows various cadastral survey processes such as, layout design submission, planning, field data capture, quality control, completed job submission, and approval to be carried out remotely via the mobile telecommunication network. Global Positioning System (GPS) provides real time positioning at centimetre resolution homogeneously to the entire country and coordinates will replace relative measurements as the ultimate proof of boundary mark position. Additional features such as building footprint and space images can be incorporated into the new database in a move towards a multipurpose cadastral.

eLand

Ministry of Natural Resources and Environment (NRE) creates an integrated computerized system, known as the Electronic Land Administration System *(eLand)* to realize the computerization of the overall management and administration of land. *eLand* is designed to improve the delivery of land administration and management services in Malaysia Peninsular using an integrated ICT infrastructure. Currently, the Ministry of NRE has implemented two systems for the administration of land information, which are *'Computerised Land Registration System'* (CLRS) and '*Land Revenue Collection System'* (LRCS). Both systems are already operational in all State Lands and Mines Offices and District Land Offices in Malaysian Peninsular.

The main objective of *eLand* is to develop a comprehensive system in land offices in order to modernize all activities that are related to land and to realize the implementation of electronic government in the public sector. In addition, the mission of *eLand* is to develop and implement a National Land Administration System via ICT towards enhancing the growth of national development. *eLand* is an integrated and a fully computerized system to handle the management and administration of land offices in order to improve the speed and quality of service delivery to the public for all land related transactions. *eLand* also enables the public to make payments online and print the payment receipts, checking details on their own land and so on.

Besides, *eLand* has nine main modules with 85 major business processes in accordance to the existing National Land Code 1965. The business processes are supported by *land* maximizes the utilization of the existing ICT infrastructure, taking into account the existing processes and procedures, and will be integrated with the existing systems (i.e. CLRS and LRCS) accordingly. The focus of the project is on the major processes that can be implemented without any changes on the existing laws. Any required changes to the existing laws will be done later. However, the modules and *eLand* are designed to be flexible to address possible changes to the system because of the changes in the existing laws.

Generally, the design of the module adheres to the best practices in application development. Emphasizes are given to aspects such as ease of use, traceability, expandability, security and flexibility. These fundamental design aspects of the module and *eLand* in general to ensure that the system is able to handle the existing and future requirements on the system.

MALAYSIAN LADM COUNTRY PROFILE

The development of Malaysian country profile is based on the User Requirement Analysis (URA) obtained from DSMM and Land Office officers. The URA of this LADM country profile has been established from workshops and meetings organized by the organization cadastral call group and UTM (together with TU Delft). Many suggestions and views were gathered and discussed during the workshops(i.e. comprehensive, 3D lot, BAUnit, strata objects, 2D topology, intermediate points, spatial source, administrative source, level, abstract class, identifier, code list, constraint in share attribute, indexing, clustering and implicit or explicit encoding of CRS and UoM). All the suggestions were incorporated in the conceptual of the country profile. 'MY_' is the prefix for the Malaysian country profile, covering both the spatial and administrative (legal) data modelling (Zulkifli et al., 2014). All classes in Malaysian model are derived directly or indirectly (via the inheritance hierarchy) from LADM classes. To illustrate the inheritance from the LADM classes, the MY_classes have either in upper right corner the corresponding LA_class name in italics or have the explicit inheritance arrow shown in the diagram.

Spatial Part

In the Malaysian country profile, spatial units can be in 2D or 3D forms. Traditionally, lots (land parcels) are 2D, but the subsurface of lots do already exist with 3D description with volumetric descriptions. The model has introduced an abstract class *MY_GenericLot* holding the attributes of a lot and this class has two specializations *MY_Lot2D* and *MY_Lot3D*, with their own attributes and structure. Currently *MY_Lot2D* is based on 2D topology with references to shared boundaries (*MY_BoundaryFaceString*).

Note that there are several abstract classes in the Malaysian country profile as indicated in Italics: *MY_SpatialUnit*, *MY_Shared3DInfo*, *MY_GenericLot*. These classes are only supporting the modelling process, representing shared attributes and structures, and these abstract classes will not get any instances (and therefore no corresponding table in the database implementation). For *MY_Shared3DInfo* there is a geometry attribute (of type *GM_Solid*). Normally the 3D geometry in LADM is represented in *LA_BoundaryFace*, but given the fact that no 3D topology is used there is 1-to-1 association with the spatial unit (one of the specializations of *MY_Shared3DInfo*). So, it could be argued that the proposed country profile is ISO conforming, despite that absence of the class *LA_BoundaryFace*.

To make the model comprehensive and future proof, a wide range of spatial units is supported including legal spaces for utilities (3D), customary areas, and reserved land (forest, wildlife areas). It should be noted that reserved land (forest, wildlife), are associated with own RRRs, normally have no overlap, but in some cases overlap can happen depending on state and type. The spatial description of reserved land is by text or sketches, but they may also be surveyed (or a combination with the above).

The various types of spatial units are organized in levels. In this model, *MY_Level* class is used to organize the various types of spatial units. For *MY_Level*, there is a type attribute which describes the level type of the spatial unit. The type of spatial unit includes customary, lots (mixed land and road), building (parts, strata) and utilities. The codelist for this attribute can be referred to *MY_LevelContentType*. Basically, *MY_Level* is a collection of spatial units with a geometric or thematic coherence. The following levels are proposed: level 0 for customary, level 1 for reserved land, level 2 for 2D lot, level 3 for 3D lot, level 4 strata, and level 5 for utility. In the involved classes a constraint has been added (third box in class diagram) to make this more explicit. For an example; *MY_Customary* has a constraint: *MY_Level.name* = 'level 0'. In the class diagram (refer Figure 3) the blue classes refer to part of strata objects for a better readability of the model.

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In case of spatial source documents (usually certified plans) there are links with spatial unit and point tables: *MY_SpatialSource* has association with *MY_SpatialUnit* and *MY_Point*. The LADM Malaysian country profile uses suID for spatial unit and sID for spatial source. Basically, suID in Malaysian country profile is based on Unique Parcel Identifier (UPI). sID for spatial source is the certified plan number. A note has been added in the country profile to indicate this.

In Malaysia there is normally 1 to 1 relationship between BAUnit and spatial unit. However, there are some cases where one BAUnit (with same RRRs attached) has multiple Spatial Units: a combination of farmland with residential house (Group Settlement Act). Also, some status values of *MY_Lot* (e.g. 10, which indicates the charting stage) relate to lots that have yet had RRRs attached, to make this possible, the multiplicity of the association between spatial unit and BAUnit is 0..1 (optional) at BAUnit side. In the future, the Malaysian land administration system can consider more grouping of spatial units with the same RRRs attached via a single BAUnit.

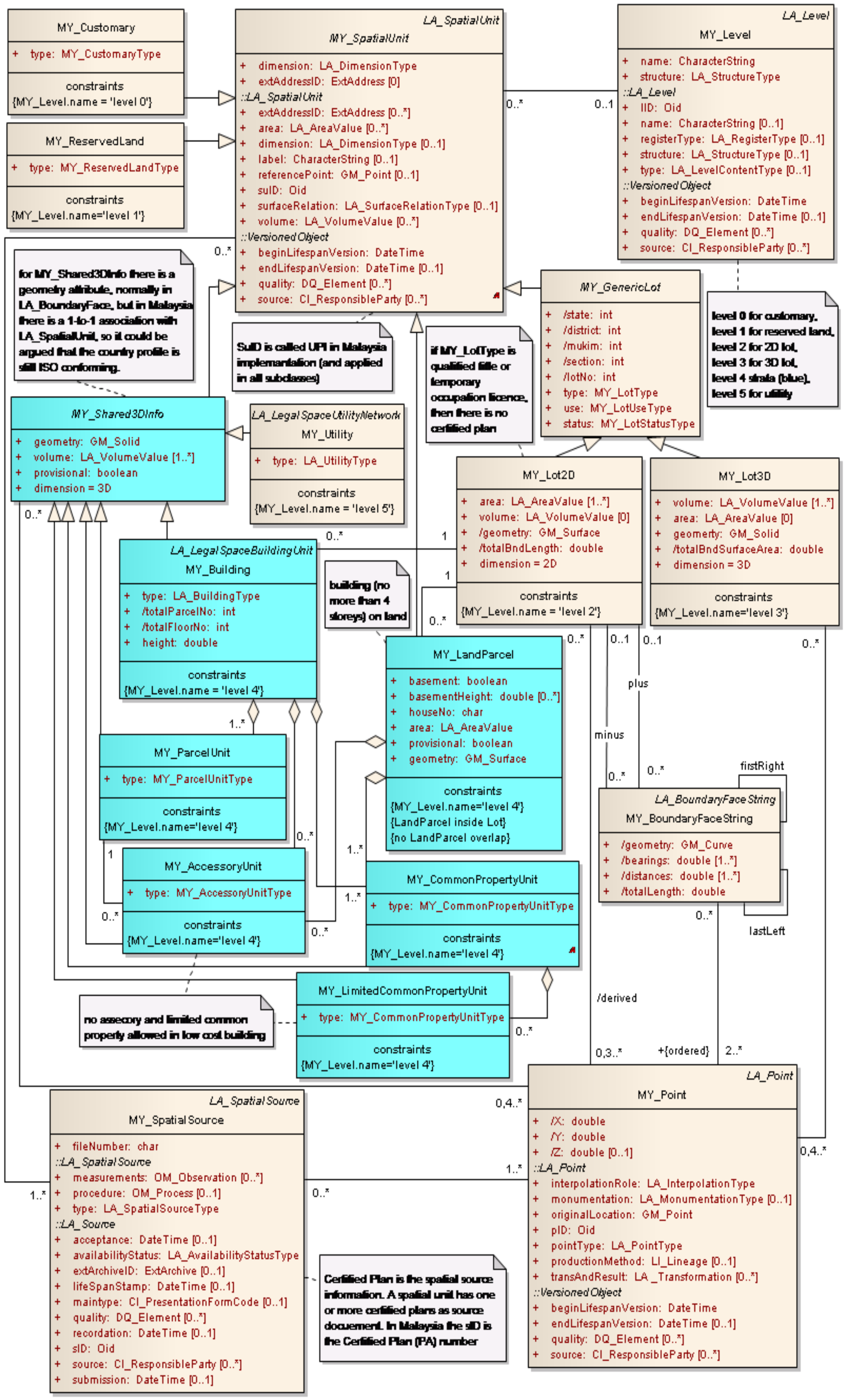

Fig. 3. Details of spatial side of the model

4.2 Administrative Part

The legal part of the Malaysian LADM country profile contains Party and Administrative package. The main class of the party package is a *MY_Party* class with its specialisation *MY_GroupParty*. There is an optional association class called *MY_PartyMember*. Basically, a party is a person or organisation that plays a role in a rights transaction. The organisation can be a company, a municipality or a state. 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 the documentation of information to a membership (holding shares in right).

The administrative package concerns the abstract class *MY_RRR* (with its three concrete subclasses *MY_Right*, *MY_Restriction* and *MY_Responsibility*), *MY_Mortgage*, *MY_BAUnit* and *MY_AdministrativeSource*. A *right* is an action or activity that a system participant may perform on or using an associated resource such as ownership, customary, easement and tenancy rights. The rights may be overlapping or may be in disagreement. A *restriction* is a formal or informal entitlement to refrain from doing something. For example, it is not allowed to build a house on a piece of land or not allowed to transfer the title to other parties within some period time. A *responsibility* is a formal or informal obligation to do something such as the responsibility to maintain a monument or a building. The instance of class *MY_Mortgage* is a mortgage. *MY_Mortgage* is a subclass of *MY_Restriction*. *MY_Mortgage* is also associated with *MY_Right* class. The mortgage can be associated to zero or more rights.

A BAUnit is an administrative entity consisting of zero or more spatial units (parcels) against which one or more unique and homogeneous rights, 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 with same RRRs attached (e.g. Federal Land Development Authority - FELDA). A settler can have two spatial unit (i.e. residential and farm land) with same RRRs attached. A BAUnit may play the role of a 'party' because it may hold a right of easement over another, usually neighbouring, and spatial unit.
One of the important foundations of LADM is the fact that all information in the system should originate from source documents and that the association to the source document is explicitly included. In case of administrative source documents (usually titles) there are associations with right, restriction (including mortgage) and responsibility (RRR) and basic administrative unit. *MY_AdministrativeSource* associates with *MY_RRR* and *MY_BAUnit*. The LADM Malaysian country profile uses sID for administrative source. Basically, sID for administrative source is title number.

Except source documents, all classes in LADM (and therefore also all derived classes in Malaysian country profile), are a subclass of VersionedObject and inherit all the VersionedObject attributes (refer Figure 4). The class VersionedObject is introduced in the LADM to manage and maintain historical data. As source documents cannot change, only new source documents can arrive, they are not versioned. The current land administration system in Malaysia does not yet support full history management, so this is a significant change. It is not only an important change for the land administration system itself, but it is also crucial for the future Malaysian information infrastructure, as others might need the functionality to refer to historic versions of land administration objects.

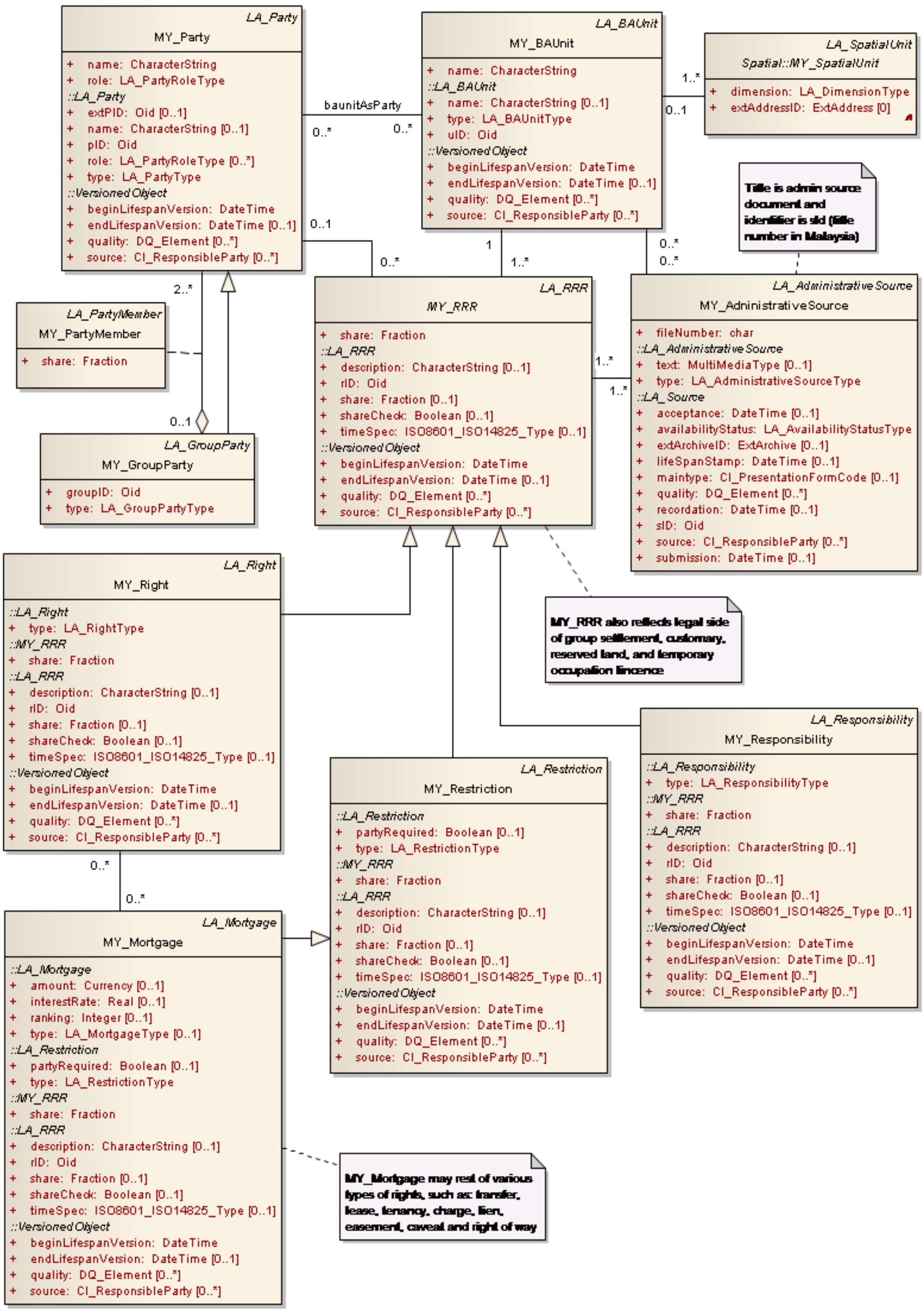

Fig. 4. Details of administrative side of the model

The 3D Cadastre Modelling within LADM

In 3D cadastre, 3D space is subdivided into volumes partitioning the 3D space. A legal basis, real estate transaction and the cadastral registration should support the establishment and conveyance of 3D right. Hybrid cadastre proposed by (Stoter, 2004) is an initial step towards implementation of 3D cadastre in Malaysia. The concept of hybrid cadastre is to preserve the current 2D registration and add the 3D component in the registration situation. Figure 5 illustrates examples of 3D objects in the cadastral system.

Traditionally, cadastral registration systems are parcel based and it is 2D in nature. However, in the very near future, this 2D cadastral system may not be able to serve more advanced situations and need to be extended to 3D cadastral system as reported by the following researchers (Griffith-Charles & Sutherland, 2013; Guo et al., 2013; Karki et al., 2013; Pouliot et al., 2013; Stoter et al., 2013; Vandysheva et al., 2012; Wang et al., 2012). The LADM therefore supports 3D cadastral registration as shown the Figure 6 below.

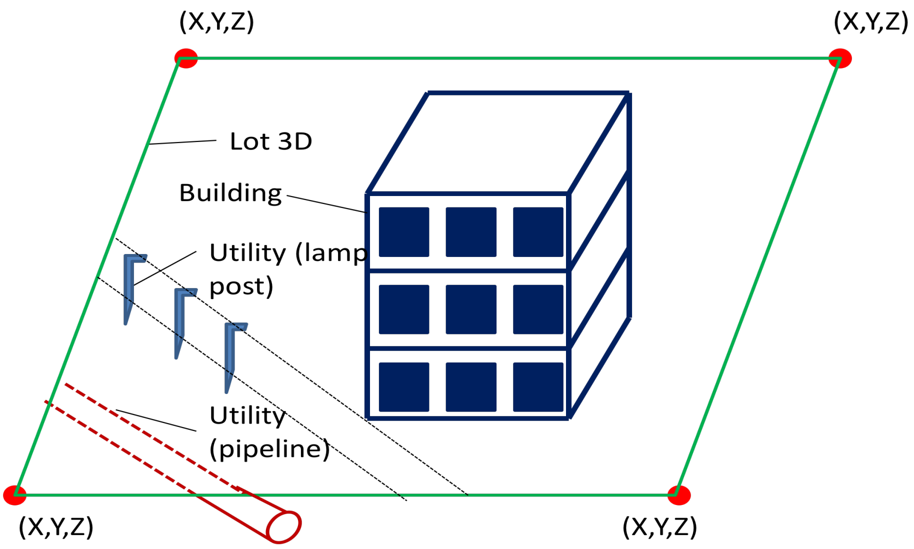

Fig. 5. 3D cadastre components

In the Malaysian LADM country profile, there are several classes represent 3D spatial unit (i.e. *MY_Building*, *MY_Utility* and *MY_Lot3D*). Both *MY_Building* and *MY_Utility* are subclasses of *MY_Shared3DInfo*, containing attributes such as a *GM_Solid* geometry, volume and Boolean attributes. Boolean attribute is used to indicate whether the object is provisional or not. Meanwhile, *MY_Lot3D* is a subclass of *MY_GenericLot*. *MY_GenericLot* has another subclass called *MY_Lot2D*. Both *MY_Shared3DInfo* and *MY_GenericLot* are abstract classes and do not have any instances. Figure 6 illustrates the overview of associated classes for spatial components (with the 3D spatial unit as indicated by the circles)

In the 3D spatial unit, topology is not available for lot (*MY_Lot3D*), utility (*MY_Utility*) or for strata objects. In the model, one strata object type remains to be represented in 2D, *MY_LandParcel* (with building no more than four storeys). The other strata objects are all proposed to be 3D and therefore inherit from an abstract class *MY_Shared3DInfo*, with strata specializations (i.e. *MY_BuildingUnit*, *MY_ParcelUnit*, *MY_AccessoryUnit*, *MY_CommonPropertyUnit* and *MY_LimitedCommonPropertyUnit*. As there can be several limited common property's in one common property, this is modelled as a part of relationship to *MY_CommonProperty*.

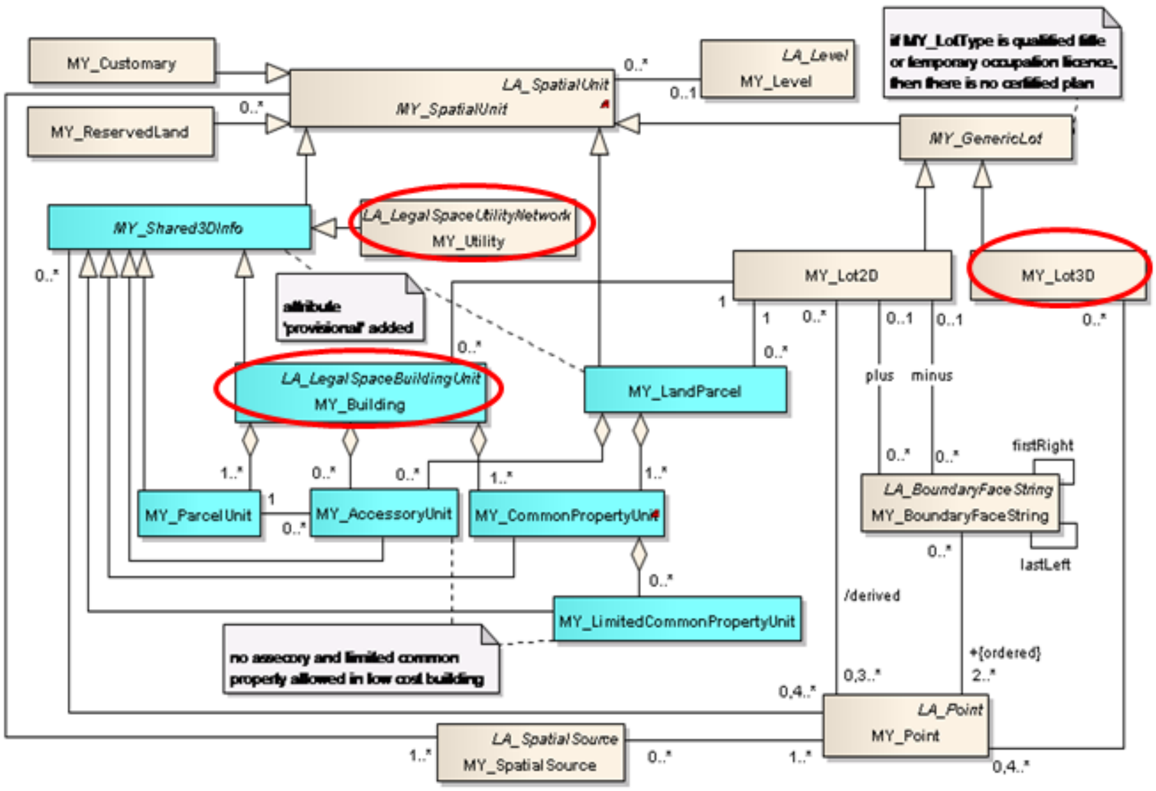

Fig. 6. Overview of spatial unit of the model

CONCLUSION

A concept of 3D modelling for 3D cadastre has been initiated and introduced in the Malaysian LADM country profile. The UML details of the model comply with the concept of the LADM has been presented. The presentation of country profile based on the standard is to understand the structure within the individual country land administration system and to show examples of structures that can be useful in building profile for other countries. However, the country profile only proposed 2D topology model and do not include 3D topology model for spatial unit. The potential usage of the 3D topology per building needs further investigation to represent the various units within the building that share faces. In the near future, the Malaysian LADM country profile should be extended to develop a 3D cadastre prototype that would support and maintain the topology with other geometric elements.

REFERENCES

Abdul Rahman, A., Teng, Chee Hua and Van Oosterom, P.J.M. (2011). *Embedding 3D Into Multipurpose cadastre*. In: FIG Working Week 2011- Bridging the Gap between Cultures. 18-22 May 2011. Marrakech, Morocco.

Chong, S. C. (2006). *Towards a 3D Cadastre in Malaysia-an Implementation Evaluation*. M.Sc. Thesis. Delft University of Technology, Delft, the Netherlands.

Griffith-Charles, Ch., & Sutherland, M. (2013). *Analysing the costs and benefits of 3D Cadastres with reference to Trinidad and Tobago*. Computers, Environment and Urban Systems, 39(2).
Guo, R., Li, L., Ying, S., Luo, P., He, B., & Jiang, R. (2013). *Developing a 3D cadastre for the administration of urban land use: A case study of Shenzhen, China*. Computers, Environment and Urban Systems, 39(2).
Hassan, M.I. and Abdul Rahman, A. (2010). An integrated Malaysian cadastral system. FIG Congress 2010. Sydney. Australia.
ISO 19152 (2012). *Geographic information - Land Administration Domain Model (LADM)*, version 1 December 2012
Karki, S., Thompson, R. J., & McDougall, K. (2013). *Development of validation rules to support digital lodgement of 3D Cadastral plans*. Computers, Environment and Urban Systems, 39(2).
Lemmen, C. (2012). *A Domain Model for Land Administration.* PhD Thesis. DelftUniversity of Technology, Delft, the Netherlands.
National Land Code 1965 (2010). *National Land Code (Act 56 of 1965) & Regulations*.
Pouliot, J., Vasseur, M., & Boubehrezh, A. (2013). *How the ISO 19152 land administration domain model performs in the comparison of cadastral systems: A case study of condominium/co-ownership in Quebec (Canada) and Alsace Moselle (France).* Computers, Environment and Urban Systems, 39(2).
Survey and Mapping Director General Secular (2003). *Survey and Mapping Director General Secular (PKPUP), Ref.3, Garis Panduan Amalan Kerja Ukur Kadaster Sehubungan dengan Pelaksanaan Peraturan Ukur Kadaster 2002*. As at 22 October 2003. Kuala Lumpur, Malaysia: Department of Survey and Mapping Malaysia.
Survey and Mapping Director General Secular (2006). *Survey and Mapping Director General Secular (PKPUP), Ref.3, Peraturan dan Garis Panduan Ukur bagi Pecah Bahagi Bangunan untuk Pengeluaran Hakmilik Strata*. As at 29 August 2006. Kuala Lumpur, Malaysia: Department of Survey and Mapping Malaysia.
Strata Titles Act 1985 (2010). *Strata Titles Act 1985 (Act 318) & Rules and Order*.
Stoter, J.E. (2004). *3D Cadastre*. Ph.D. Thesis. Delft University of Technology, Delft, the Netherlands.
Stoter, J., Ploeger, H., & van Oosterom, P. (2013). *3D Cadastre in the Netherlands: Developments and international applicability*. Computers, Environment and Urban Systems, 39(2).
Tan, L.C. and Looi, K.S. (2013). *Towards a Malaysian Multipurpose 3D Cadastre based on the Land Administration Domain Model (LADM) – An Empirical Study*. In proceedings of the 5th FIG Land Administration Domain Model Workshop, 24-25 September 2013, KualaLumpur, Malaysia, p. 109-131.
Vandysheva, N., Sapelnikov, S., van Oosterom, P., de Vries, M., Spiering, B., Wouters, R., et al. (2012). *The 3D cadastre prototype and pilot in the Russian Federation*. In Proceedings of the FIG working week 2012, May 2012, Rome.
Wang, C., Pouliot, J., & Hubert, F. (2012). *Visualization principles in 3D cadastre: A first assessment of visual variables*. In Proceedings 3rd international workshop on 3D cadastres (pp. 309–324), Shenzhen.
Zulkifli, N.A., Abdul Rahman, A., Jamil, H., Teng C.H., Tan L.C., Looi K.S., Chan K.L., and van Oosterom, P. (2014). *Towards Malaysian LADM Country Profile for 2D and 3D Cadastral Registration System*. In proceedings of the FIG Congress 2014, Kuala Lumpur, Malaysia, 16 – 21 June 2014.