Conceptual Modelling of 3D Cadastre and LADM

Nur Amalina ZULKIFLI, Alias ABDUL RAHMAN, Muhammad Imzan HASSAN and TAN Liat Choon

Department of Geoinformation, Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia
amalina.jc@gmail.com and {alias, imzan, tlchoon}@utm.my

Key words: 3D cadastre, LADM and customary rights

SUMMARY

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.

Conceptual Modelling of 3D Cadastre and LADM

Nur Amalina ZULKIFLI, Alias ABDUL RAHMAN, Muhammad Imzan HASSAN and TAN Liat Choon
Department of Geoinformation, Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia
amalina.jc@gmail.com and {alias, imzan, tlchoon}@utm.my

1. 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.

2. 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.

2.1 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.

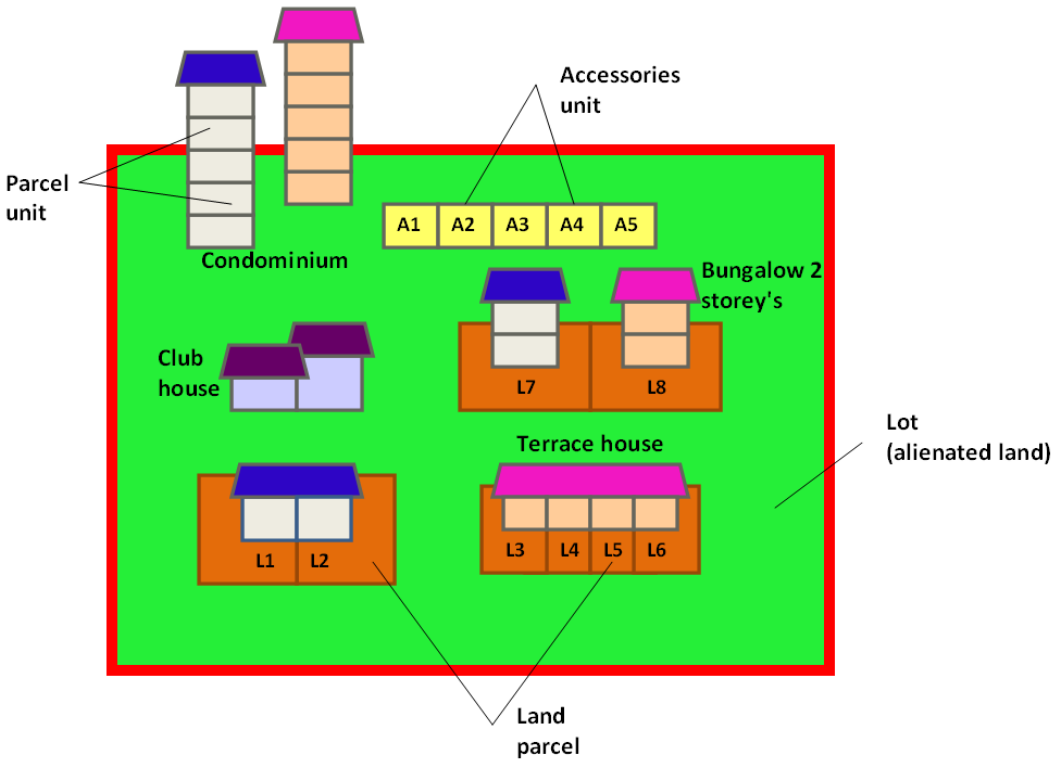

Fig. 1. Various cadastral objects related to strata in context of one lot

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.

2.2 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.

2.3. 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.

3. 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.

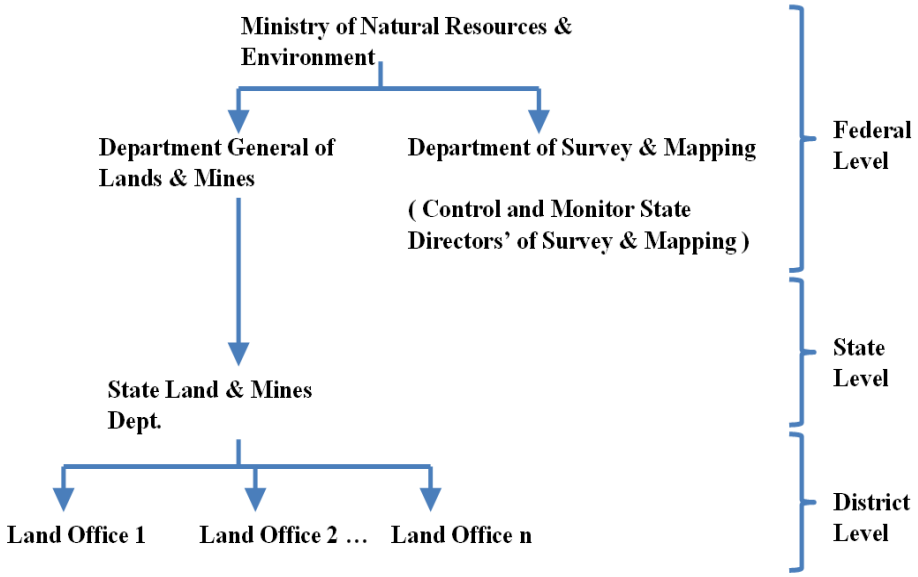

Fig. 2. Organisational structure of land administration in Malaysia

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.

3.1 *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.

3.2 *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.

4. 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.

4.1 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.

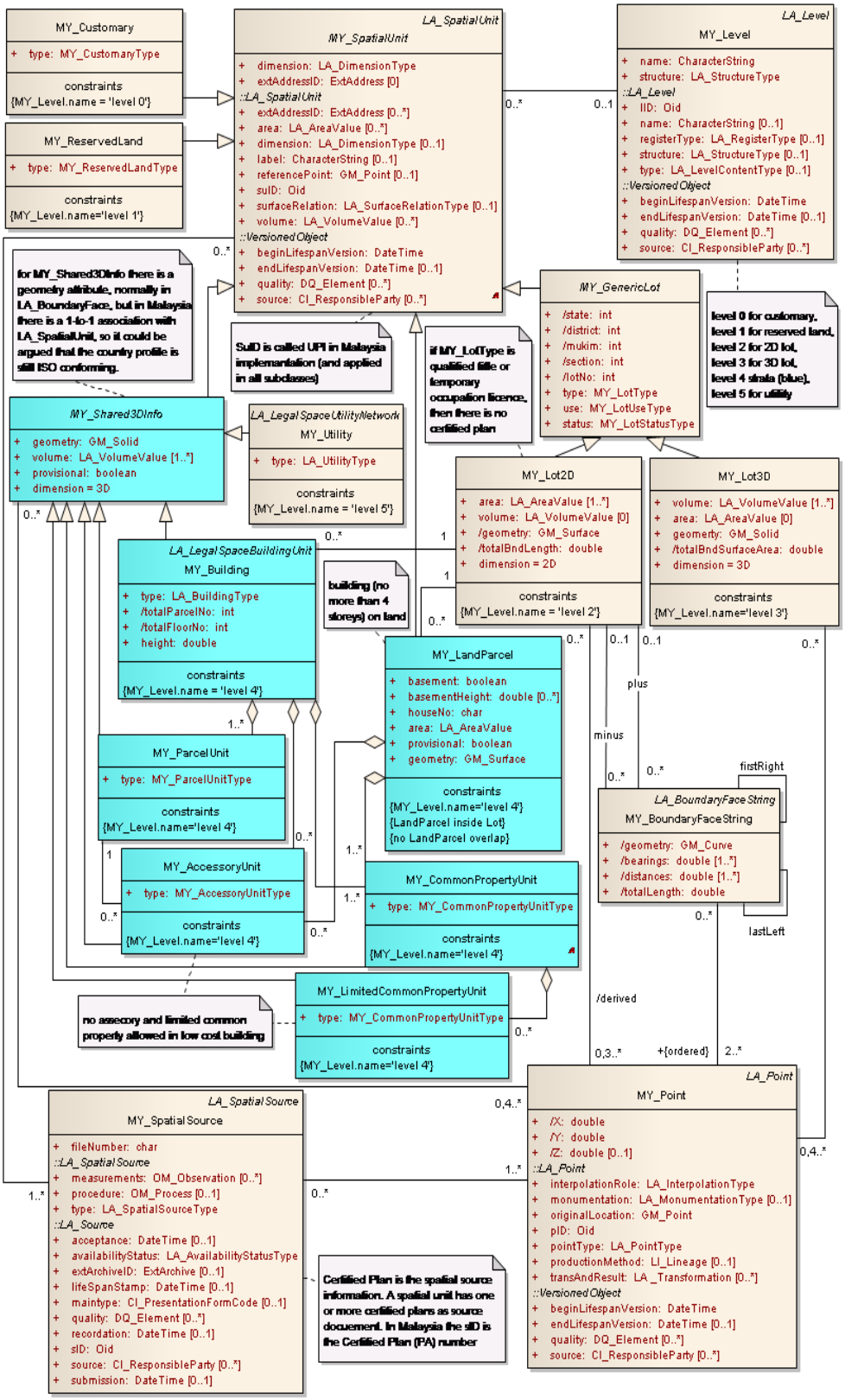

Fig. 3. Details of spatial side of the model

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 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.

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.

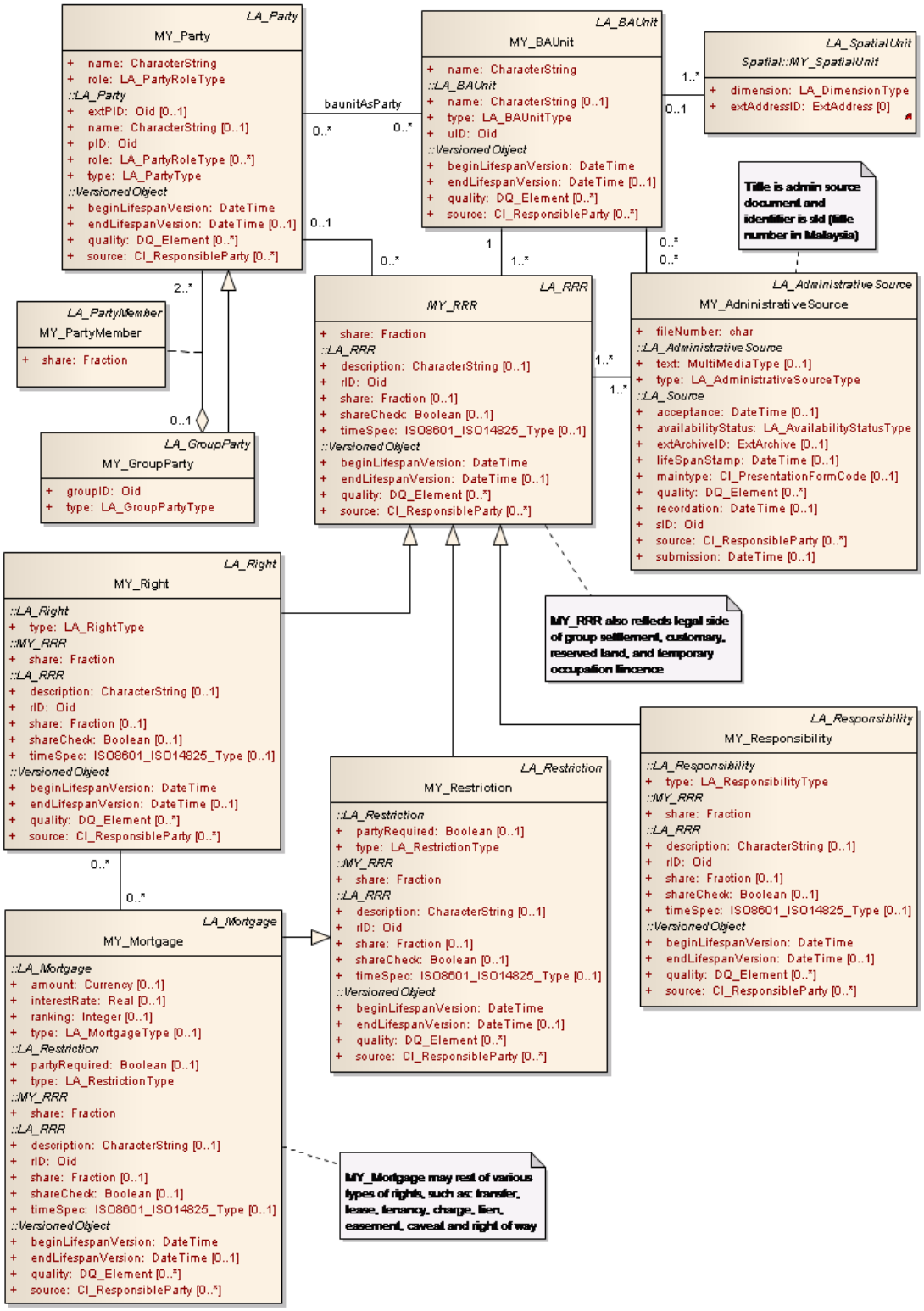

Fig. 4. Details of administrative side of the model

4.3 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.

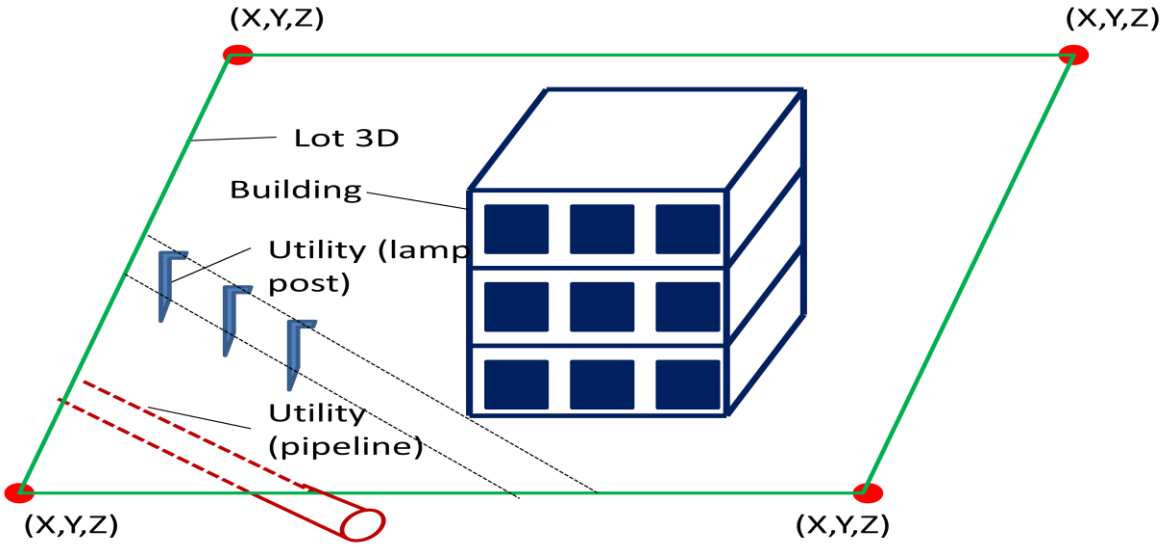

Fig. 5. 3D cadastre components

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)

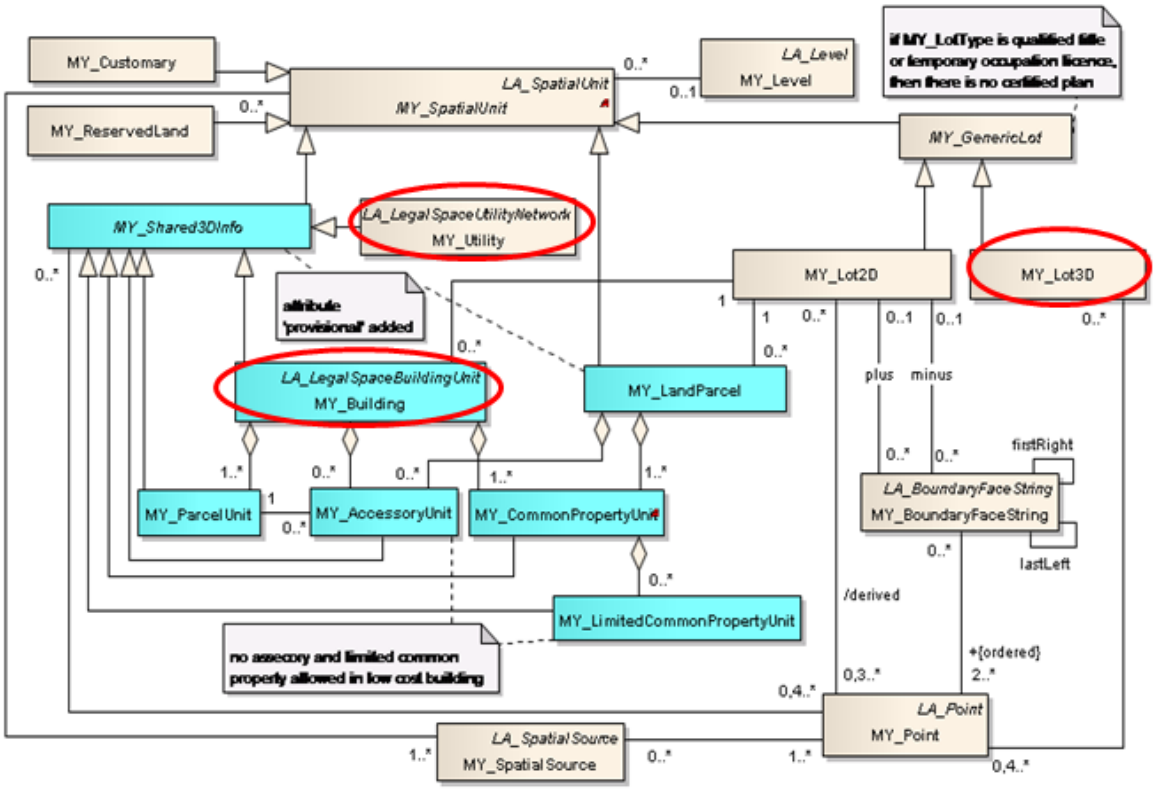

Fig. 6. Overview of spatial unit of the model

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*.

5. 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.

BIOGRAPHICAL NOTES

Nur Amalina Zulkifli is a researcher at the Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia (UTM), Skudai, Johor in Malaysia. She received a degree in Surveying Science and Geomatics from Universiti Teknologi MARA (UITM) in 2008. In 2014, she received her MSc in Geoinformatics from UTM. She is currently working on her PhD research concerning Land Administration Domain Model (LADM) for 2D and 3D cadastral registration.

Alias Abdul Rahman is a professor at the Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia (UTM), Skudai, Johor in Malaysia. He received a degree in Surveying and Mapping Sciences from North East London Polytechnic, England, UK in 1987, Postgrad Diploma in GIS from ITC, Netherlands, and MSc in GIS also from ITC, Netherlands. In 2000 he received his PhD degree from University of Glasgow, Scotland, U.K. He currently leads the 3D GIS research group in the faculty.

Muhammad Imzan Hassan obtained an MSc degree from ITC, Netherlands and a BSc degree in Geoinformatics from Universiti Teknologi Malaysia. He is currently a Faculty staff and PhD researcher with the 3D GIS group of the Faculty of Geoinformation and Real Estate at the Universiti Teknologi Malaysia (UTM) in Malaysia. His current research interests include 3D Cadastres and 3D Modelling.

Tan Liat Choon is a senior lecturer at the Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia (UTM), Skudai, Johor in Malaysia. He received his Certificated in Land Survey from Politeknik Kuching Sarawak, Malaysia, Diploma in Land Survey from University Teknologi Malaysia (UTM), Degree in Land Survey from UTM and Master in Land Administration and Development from UTM. In 2013, he received his PhD from UTM for his thesis on “Towards Developing a Three-dimensional Cadastre for Three-dimensional Property Rights in Malaysia". His research interests focus on 3D property legislation and Land Registration System.