

AN INTEGRATED 3D CADASTRE – MALAYSIA AS AN EXAMPLE

M. I. Hassan, M. H. Ahmad-Nasruddin, I. A. Yaakop, and A. Abdul-Rahman

Dept of Geoinformatics, Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia
81310 UTM Skudai, Johor, Malaysia – (imzan, hasif, alias)@fksg.utm.my

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ABSTRACT:

In Malaysia, the cadastre system is controlled by two main agencies, namely, Department of Surveying and Mapping Malaysia (DSMM) and Land Offices (L.O). The DSMM is responsible for the cadastral spatial information i.e. land parcel boundaries. The mission is to enhance quality in surveying and mapping services along with managing the geospatial data. On the other hand, Land Office is responsible for the cadastral attribute information i.e. legal rights that attached to the cadastral objects or plots. The current system only involves with 2D maps and no effort towards 3D registration yet. This paper discusses 3D cadastre in the aspect of property registration i.e. complex building and overlapping properties on different land use. We also discuss the interoperability of the two systems between the two different agencies. This 3D cadastre registration will serve as a first attempt to develop a more complete Integrated Malaysian 3D Cadastre System. A complex system needs a clear and concise method to show the representation of data, and here we utilize Unified Modeling Language (UML) for the data modeling task as it has been considered better technique for such real world data modeling like cadastre data compared to the traditional entity relationship approach. Besides 3D registration, the paper also discusses 3D modeling, 3D geo databasing and 3D visualization. Malaysia could embark on this 3D cadastre system relatively straight forward since it has good 2D cadastre framework. From the research and discussion it can be realized that the hybrid approach certainly would be a good to start with. This approach means preservation of 2D cadastre and the integration of the registration of the situation in 3D by registering 3D situations integrated and being part of the 2D cadastral geographical data set. Nevertheless it is reasonable to believe that there are some irregularities and different information as both systems operates separately. This situation shall trigger a good basis why there is a need for the integration. The challenge is to transform the proposed model into computer means i.e. logical model. The validation of logical model will be then encoded in the spatial database. Spatial DBMS is the foundation for both GIS (presentation, analysis) and CAD (creating models). It offers spatial data type in its data model structure and also in the query language and it can interact with the spatial DBMS. This paper elaborates on an integration of Oracle Spatial and Autodesk Map 3D for an integrated 3D Cadastre. The 3D Cadastre database development especially on the aspect of 3D objects registration form major contributions of the paper towards the development of an integrated 3D Cadastre.

1. INTRODUCTION

Mid of 2006, population of Malaysia increases to 26.64 million and it course the real properties registered increase rapidly. The properties can be divided into two, which are movable and immovable properties. However, the properties considered in this research are only the immovable properties which are land and building registrations that fall in the category of cadastral objects. The Department of Survey and Mapping Malaysia (DSMM) claimed to have a total of 6.4 million cadastral lots (immovable properties) nationwide (Chong 2006).

Traditionally, cadastral registration systems are parcel based systems and it is in 2D nature. 2D cadastre mapping is practiced in Malaysia and at the moment it provides vital land and property information like ownerships of the parcels for most parts of the country. Obviously current cadastral information serves most of the users need for decades. However in very near future this 2D information may not be able to serve for more advanced situations for example in large city centres (see Figure 1) because one way to deal with this situation is by having a more advanced cadastral system like 3D cadastre. This means we need to extend the 2D system into a three-dimensional (3D) (Abdul-Rahman et al. 2005b). The disadvantage of the solutions to register 3D property units in current cadastral registration is that the 3D information is not integrated in the spatial part of the cadastral database. Therefore it is impossible to view the 3D situation interactively. Technical

and institutional aspects have to be considered before the implementations of 3D cadastre system for Malaysia can be embarked.

This paper discusses the integration of 3D cadastre object with the current registration of the 2D cadastre parcel. Section 2



Figure 1: Example of 3D situations in Kuala Lumpur

starts with the current situations in Malaysia where legal and organization aspects are touch. Then, section 3 continues with the solutions towards Malaysian 3D Cadastre based on the cadastral model. Section 4 proceeds with the development of an integrated 3D Cadastre model and finally section 5 remarks the conclusion of the paper.

2. CURRENT SITUATION IN MALAYSIA

Malaysia is a developing country with plenty of cities all over the country e.g. the city of Kuala Lumpur. The high rise buildings have been built in order to optimize the limited space. Hence, more complex buildings were being built to cater the needs of the people e.g. businesses and residential (see Figure 2).



Figure 2: Shopping Mall (with building above road)

Major problems that will be addressed in this paper are associates to the integration of the 2D and 3D cadastre object in a database developed using Oracle Spatial and also the data retrieve with the visualization of the 3D cadastre objects using Map 3D together with the spatial and attribute information.

Cadastre system is being used for some government agencies such as Local Authority and *Lembaga Hasil Dalam Negeri Malaysia (LHDNM)* to support the valuation and taxes system. In Malaysia, there are two organizations responsible on managing and maintaining the cadastre system (Genggatharan 2005). The Department of Survey and Mapping Malaysia (DSMM) deals with the cadastral survey with high accuracy survey determine the location, dimension and size of the properties.

DSMM with *Cadastral Survey System* is responsible for preparing, producing and managing the spatial including the surveying and mapping of the cadastre parcels. The *Land Registration System*, which is non-spatial data is being the responsibility of the Land Office (i.e. the *PTG*). *PTG* deals with the ownership registration, whose owns what (3R; Right, Responsible, Restriction). Both organizations have their own systems called CLRS (Computerised Land Registration System) in *PTG* and CDMS (Cadastral Data Management System) in DSMM. Unfortunately the systems work separately in each organization and is still in 2D in nature (Chong, 2006). As far as Malaysia is concerned the needs for this research output is clearly sought after by the National Mapping Agency (NMA), i.e. DSMM and the Land Office (LO), i.e. The Land and Mines Office (PTG). With the rapid development of technologies and technique, both systems could be integrated to cater the needs of 3D properties registrations.

2.1 The Legal Aspect

The basic concept of land parcel (lot) in Malaysian land law is the infinite ownership space defined as a cone down to the centre of earth, with boundaries on the surface extends vertically upwards and downwards to an extent. Its adjudication consists of two parts, first the ascertaining of the physically surface boundaries by surveyed boundary marks, then the official ascertainment of rights in land via registration and issue of documents of title.

However, it should be noted that existing Malaysian Cadastre deals with properties located not only on the surface, but also above and below the surface level. For all intents and purposes, the rights and responsibilities of the proprietor of the surface parcel shall also apply to the proprietor of the underground land.

There are also provisions to survey and issue title for strata and stratum. The parcel is defined by the bounding floor, walls and ceiling. Individual parcels are then issued with strata title in accordance to a strata registration. On the other hand, the cadastral map or Digital Cadastral Database (DCDB) is only two-dimensional in nature. It contains neither altimetry information nor detailed information of existing objects or structures within the parcel area. The vertical dimensions are only available on the strata and stratum certified plans, as scanned images in the image library.

2.2 The Organization Aspect

The cadastral system comprises a land registration system and a cadastral registration as key components. Land registration is a state government responsibility while cadastral registration is under federal responsibility.

According to Chong (2006), experiences in developed countries have shown that stand-alone or isolated approaches where data and processes were maintained separately are not sustainable. A non-unified land registry system is known to have the following shortcomings:

- Legal administrative and cadastral mapping data integrity is not well maintained.
- Work flow, data updating and data service are less efficient (incomplete DCDB and patches of irregularities of CLRS and DCDB)
- Quality and consistency of information are difficult to maintain due to parallel registration and updating
- Less cost effective (examples include overheads to deal with two separate government departments for one land related transaction – one might be located at the state capital but the other at district, or extra efforts to ensure data integrity during data exchange as both set of records are inter-dependant)

3. SOLUTIONS TOWARDS MALAYSIAN 3D CADASTRE

Solution towards 3D cadastre registration is to study possible solutions in adding 3D component in current registration. Two common 3D Cadastre Models has been study in this research. The models are Core Cadastral Domain Model (CCDM) and Hybrid Cadastre Data Model. These models have been used as a platform to suit with the Malaysian cadastre system.

3.1 Core Cadastral Domain Model (CCDM)

Core Cadastral Domain Model (CCDM), (van Oosterom et. al 2006) has been introduced as a model for land registration purposes. The development of this model is designed as a base for various land registration practice in different countries. Two important goals of this model as listed in (van Oosterom et. al 2006) are; (1) avoid reinventing and re-implementing the same functionality over and over again, but provide a extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA), and (2) enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model. The UML class diagram of the CCDM is shown in Figure 3.

3.1.1 Malaysian Cadastre Data Model

CCDM is designed as the base for various land registration system. Therefore, it can also used to describe Malaysia cadastre data model. The definition of these three core classes can be derived from (Chong 2006). Table 1 shows the component of CCDM that follows with the Malaysia Cadastre System. These categories are base from the CCDM classes and reflected in the National Land Code 1965 and Strata Title Act 1985.

Persons (NLC: s.43)	Natural persons (excluding minors less than 18 years old) Corporations, sovereigns, governments or organisations Persons authorised to hold land under the Diplomatic and Consular Privileges Ordinance 1957 Bodies expressly empowered to hold land (e.g. Trade union Ordinance 1957)
RegisterObject	Lot (land parcel) (NLC: s.516) Parcel (building parcel) (STA: s.4) Stratum (underground volume) (NLC: s.92A)
RRR (Right, Restriction and Responsibility)	Rights (e.g. extent of general disposal under NLC: s.44 Responsibilities (duty rent – e.g. survey fees, premium, annual quit rent etc.) Restrictions (e.g. category of land, express and implied condition etc.)

Table 1: Component of CCDM base on Malaysian Cadastre System

3.2 Hybrid Cadastre Registration Model

Hybrid cadastre proposed by Stoter, 2004 is a good start 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

system. There are two approaches to register 3D object namely registration of right-volume and registration of 3D physical object. The 3D representation of each approach is embedded in the CCDM base model.

4. THE DEVELOPMENT OF INTEGRATED 3D CADASTRE MODEL

An integrated 3D Cadastre Model looks on how to add 3D component in the current cadastre data model and make information is interoperable between the two involved organizations. 3D cadastre object e.g. apartment buildings is a real property that being built on the 2D land parcel, which is the responsibility of DSMM. Adapting CCDM, the 3D spatial database being design to make it interoperable with the current land registration database developed by the LO, which is CLRS.

4.1 Integration of the cadastral databases (CLRS with DCDB)

DCDB and CLRS could be integrated electronically. Furthermore the integration of the spatial database of DCDB with the textual database of CLRS is the prerequisite requirement for the formation of a comprehensive land information system. There is currently a research to investigate how best these two standalone databases can be possibly integrated. Genggatharan (2005) proposed a mechanism to integrate these two databases. Nevertheless, there are many hurdles to cross at current stage of practice. Genggatharan (2005) underlines the following issues associated with the proposed integration:

- Organizational - there is no mechanism for exchanging data among organization
- Technological – compatibility of existing hardware and software
- Data - data quality and integrity
- Legal - data custodian and rights
- Different working procedures and practice

Adaptation of CCDM into integrated 3D cadastre model for Malaysia can be seen in Figure 4. In this model, both *LandParcel* and *3DParcel* are registered as an object in current registration system as shown in Figure 5.

The *LandParcel* is represented as a 2D geometry. This object is inherited from the current 2D registration system. Figure 6 shows the data model of land parcel as a registered object. *LandParcel* i.e. cadastral lot consists of boundary lines and boundary marks. The *3DParcel* is considered as 3D physical object based on the hybrid solution by (Stoter, 2004). *3DParcel* is formed with 2D geometry and 3D information. The *3DParcel* is projected with the 3D bounded space with list of coordinate that form flat faces and later form a 3D object which so called 3D cadastre object. The data model of *3DParcel* is illustrated in figure 7.

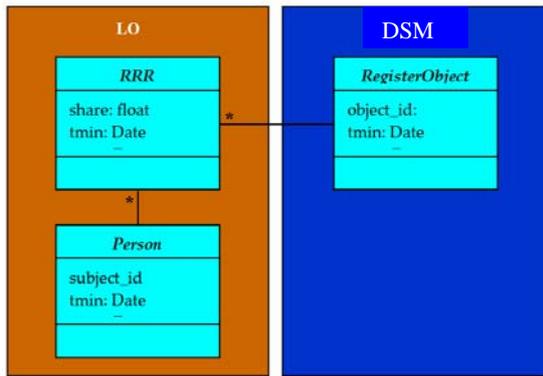


Figure 4: Adaptation of CCDM into Integrated 3D Cadastre Model for Malaysia

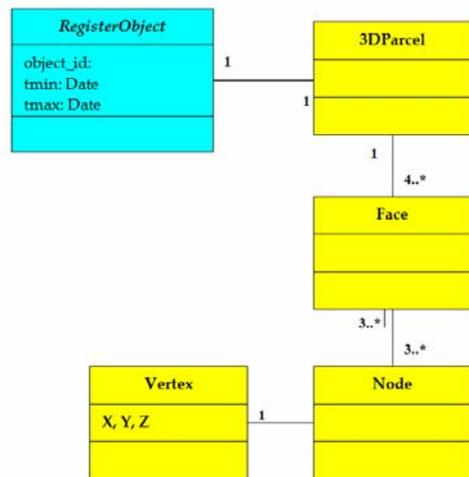


Figure 7: Data Model of 3DParcel in Cadastral Registration

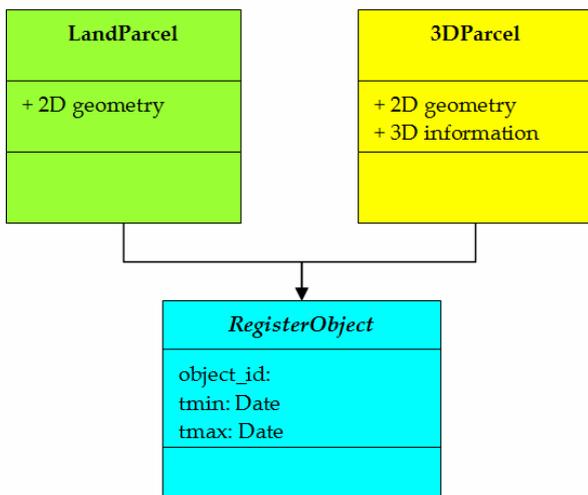


Figure 5: LandParcel and 3DParcel is part of RegisterObject

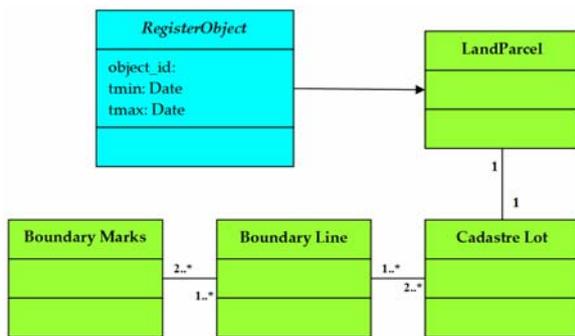


Figure 6: Data Model of LandParcel in Cadastral Registration

4.2 Logical Model for registration of 3D Cadastre object

4.2.1 Spatial Data Model

The spatial data model of *LandParcel* and *3DParcel* are stored in the Oracle DBMS.

The table recording 3DParcel include the following items:

- Owner_no: the ownership number of the particular building
- Area: the floor area of the building parcel
- Geometry: the list of coordinates which form the 3D spatial objects

The table recording the *LandParcel* includes the following items:

- No_lot: Lot number of the mother parcel for buildings registered
- Area: the area of the main parcel for the buildings
- Geometry: List of coordinates that form the 2D Parcel

4.2.2 Administrative Data Model

The administrative component is created to show the attributes for registered 3D cadastre object. The attributes shows the information as follows:

Entity Name	Geometry Type	Field Name	Description	Data Type	Width	Key
Owner		Owner_No	Ownership no.	Varchar	25	PK
		Name	Name of land proprinter	Varchar	25	
		IC_No	IC no	Varchar	15	
		State	Name of state	Varchar	10	
		Mukim	Name of mukim	Varchar	10	
		District	Name of district	Varchar	10	
3DParcel	Polygon	Type_owner	Type of ownership	Varchar	10	
		Owner_No	Ownership no.	Varchar	25	PK
		Area	Area of parcel	Number	10	
		Geometry	Column of geometry	Mdsys.sdo.geometry		
LandParcel	Polygon	LotNo.	Lot number	Varchar	10	FK
		LotNo.	Lot number	Varchar	10	PK
		Area	Area of parcel	Number	10	
		Geometry	Column of geometry	Mdsys.sdo.geometry		

Table 2: Physical Development of 3D Cadastre Registration Database

The table recording table Owner include with the following items:

- Owner_No: the ownership number of particular registered object
- Name: the name of the person who hold rights on the registered parcel
- IC_No.: the identification number of the land owner.
- State: description name of the state for the registered objects
- Mukim: the name of the mukim of the registered objects
- District: the name of district of the registered objects
- Type_owner: type of ownership referring to registered object

4.3 Association of the Components Elements in DBMS

Table 2 show the physical development of the registration for 3D cadastre object. There are three main entities that are owner, 3DParcel and LandParcel.

The 3D cadastre registration system is developed to show registration of 3D spatial objects and combine with the land attributes. The linkage of these tables is base on owner_no (field name) that being set as primary key (PK). The 3D Parcel is located in the primary land of 2D parcel. Therefore, the linkage between these tables is based on the lot no.

4.4 The Linkage of DBMS and CAD

The sample data of building as shown in Figure 8 has been chosen for the experimental purposes. In the experiment, we have chosen Autodesk Map 3D and Oracle database to visualize the spatial objects. The interoperability of Map 3D and Oracle is developed based on the schema that helps to connect the software. The specification of the schema need to be fulfilled before the connection can be done.

The visualization of 3D cadastre object is conducted via the Map 3D schema administration. Here, the Map 3D requires user to login the Oracle database login name, password and the service name. Later, the interested table in the Oracle database will be selected to visualize in the Map 3D.

The visualization of the 3D cadastre objects are shown in Figure 9. The registered coordinates in the Oracle DBMS can be listed base on the primary key of the table.



Figure 8: Sample building for the experiment purposes

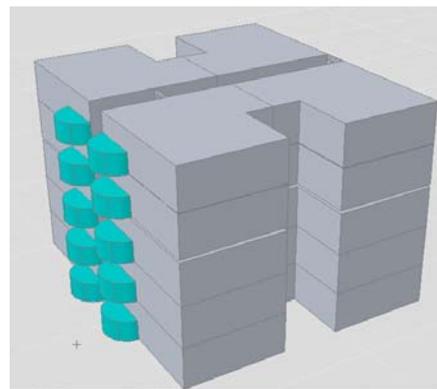


Figure 9: Visualization of 3DParcel in CAD

The query for the administrative purposes can be done via the interface develop by creating a linkage to Oracle database. In the interface, several functions have been setup to perform some operations such as add, save, delete and update data. The example of the query can be seen in figure 10 where the query is based on owner_no. Figure 11 shows result of the query together with the attributes of the registered 3D parcel object.



Figure 10: Interface for query the registered 3D Cadastre object

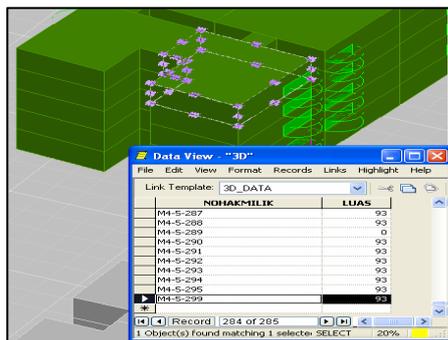


Figure 11: Result from the query with the attribute information

5. CONCLUDING REMARKS

From the foregoing discussions it shows that the Integrated 3D Cadastre Model introduced in this paper which is basically expanded from the CCDM model can be realized on the big scale of 3D cadastre object registration for Malaysia. Three main classes in CCDM namely RegisterObject, Person and RRR have been transformed to suit with Malaysian cadastre system. In the proposed registration model, new class namely 3D parcel has been derived from RegisterObject to hold 3D objects. The 3D parcel spatial is bound within 2D geometry and 3D information. The registration of 3D objects is validated in the geo-DBMS. Oracle Spatial was used to store the cadastre dataset. The 3D object registered in the Oracle Spatial DBMS then queried using the simple interface and the both spatial and attribute information were displayed using Map 3D software. Beside that, simple data updating function has been developed (query tool). Even though this paper does not discuss the integration issues between two involved departments as mentioned in the previous section, but it shows the opportunity for an integrated Malaysian 3D Cadastre.

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REFERENCES

- Abdul-Rahman, A. and Stoter, J. E. (2005a). *3D Cadaster in Malaysia – how to realize it?* 7th. Surveyors Congress, Petaling Jaya, Selangor, Malaysia.
- Abdul-Rahman, A. and J. E. Stoter, A.F. Nordin (2005b). *Towards 3D Cadaster in Malaysia*. International Symposium and Exhibition on Geoinformation (ISG 2005). Penang, Malaysia.
- Chong, C. S. (2006). *Toward a 3D Cadastre in Malaysia - An Implementation Evaluation*. Delft, Delft University of Technology: 110
- FIG (1995). *The FIG Statement on the Cadastre. Technical Report Publication 11*, Federation International des Geom'etres, Commission 7, 1995.
- Genggatharan, M. (2005). *Conceptual Model for Integration of Cadastral Data Management System (CDMS) and Computer Land Registration System (CLRS)*. MSc. Thesis, Universiti Teknologi Malaysia. (In Malay)
- Imzan Hassan, M., A. A. Rahman, et al. (2006). "Developing Malaysian 3D cadastre system : preliminary findings." In: *Innovations in 3D geo information systems : selected papers from the 1st international workshop on 3D geoinformation science and engineering*, 7-8 August 2006, Kuala Lumpur, Malaysia / ed. by A.A. Rahman, S. Zlatanova, V. Coors. Berlin : Springer, 2006. ISBN 3-540-36997-X. pp. 519-533
- JUPEM, *Manual Pengguna Sistem Pengurusan Pangkalan Data Kadaster*. Department of Survey and Mapping Malaysia. (In Malay)
- KPTG (1997). *Manual Sistem Pendaftaran Tanah Berkomputer: Latihan kepada Pendaftar*. Department of Director General of Lands and Mines. (In Malay)
- KPTG, *Manual Sistem Pendaftaran Tanah Berkomputer: Bidang Liputan SPTB*. Department of Director General of Lands and Mines. (In Malay)
- National Land Code (1965).
- Nordin, A. F. (2001). *Institutional Issues In The Implementation Of The Coordinated Cadastral System For Peninsular Malaysia: A Study On The Legal And Organisation Aspects*. Geomatic. Skudai, Universiti Teknologi Malaysia.
- Omar, A.H. (2003). *The development of Coordinated cadastral System for Peninsular Malaysia*. MSc. Thesis, Universiti Teknologi Malaysia.
- Stoter, J.E., M.A. Salzmann, P.J.M. van Oosterom and P. van der Molen (2002), *Towards a 3D Cadastre*, FIG XXII/ACSM-ASPRS, 19 - 26 April, 2002, Washington, USA.
- Stoter, J.E (2004), *3D Cadastre*, PhD Thesis, International Institute for Geo-Information Science and Earth Observation (ITC), the Netherlands.