Towards a Malaysian Multipurpose 3D Cadastre based on the Land Administration Domain Model (LADM) – An Empirical Study

TAN Liat Choon and LOOI Kam Seng, Malaysia

Key words: LADM, Land Administration, Land Information, 3D Cadastre, National Digital Cadastral Database

SUMMARY

One of the important global issues with regard to property is the scarcity of vacant land for development. Many countries, including Malaysia, do not have enough vacant land on the ground surface to cater for rapid development. In the last couple of decades, there has been an increasing demand for property development in urban areas, resulting in the division of property ownership so that different owners can own a delimited space on, above or below ground surface. Under 3D cadastre, the 2D cadastre management of data cannot meet the real land management of the three dimension space aspect and property. It is essential to introduce the 3D cadastre of Three-Dimensional National Digital Cadastral Database (3D-NDCDB) management model. Since the individualisation of property has traditionally been concerned with the subdivision of land using on surface boundaries in the cadastral system, it is appropriate now to consider how three-dimensional situations should be handled from the legal, technical and organisational aspects, and how other countries have addressed similar issues. This paper solely concerned with the theoretical aspects of the study, particularly land, land administration system, land information system and cadastre system. It covers the definitions, history and components of each concept related to properties. It also covers and explains the theory and framework of the Malaysian Cadastre System, good governance involved in land administration and cadastre. The present 2D National Digital Cadastral Database stored information in 2D planimetric. After taking consideration the framework of LADM's core classes and the design concept of it, therefore, choosing a 2D/3D Hybrid Cadastre model since it is suitable for the current situation in Malaysia. In order to achieve the objective, some of these matters must take into consideration, i.e. (a) Method of data collection (b) Adjustment and calculation of observed data (c) The products, and (d) Changes to the format and structure of existing system. It is hoped that this study will provide a better understanding of the nature of 3D-NDCDB, besides adding new information to the available literature in the field. I envisage the main contributions of this study to the present knowledge to be in the cadastral survey and mapping, and land registration practices in the Malaysian Cadastre System from the legislative and technical viewpoints.

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1. INTRODUCTION

This research was carried out in two main stages. The first stage involved the literature review on the characteristics of land administration, cadastre and Land Administration Domain Model worldwide. This was followed by a review of the land administration and cadastre systems in Malaysia, with the conclusion that the Malaysian traditional cadastre is based on the division of land or parcel into flat surfaces with rights of ownership registered on these parcels.

Malaysian land and cadastre registration is served by a transparent and accessible registration of rights to properties. Nevertheless, current cadastre systems that are traditionally parcel-based experience complications in maintaining and providing information on the legal status of properties in three-dimensional situations. A 3D cadastre must cater for not only general, fundamental needs but also country specific needs. General needs address the issue on how to maintain and provide three-dimensional information on properties in land administration and cadastre systems, which are traditionally based on a plane surface cadastral map and registry title.

In second stage, a test project, where a trial implementation for the Three-dimensional Digital Cadastral Database (3D-NDCDB) which allows a mixture of 2D and 3D cadastre was carrying out in State of Negeri Sembilan, Malaysia. This is to provide land with 3D elevation data. This addition information add to the boundary marks in the NDCDB would create a 3D-NDCDB. To achieve this purpose, the matters to be addressed are as (a) Field Data Acquisition (b) Adjustment and Calculation of Observed Data (c) 3D-NDCDB, and (4) Changes of Format and Structure.

2. LITERATURE REVIEW

Historically, there have been four processes or components in land administration, namely land registration, land valuation, land use planning and cadastral survey and mapping. For historical, technical and political reasons, the responsibilities of these four processes or components in many countries are carried by different government departments.

2.1 Land administration system

The term 'land administration', introduced in the 1990's, probably became more widely used after the United Nations Economic Commission for Europe in 1996 formed an ad hoc group of experts known as the 'Meeting of Officials in Land Administration' (United Nations Economic Commission for Europe, 1996). Dale and McLaughlin (1999) add that State land administration functions may be divided into four components, namely juridical component, regulatory component, fiscal component and information management component. Land administration is concerned with three principals and interdependent commodities, viz. ownership, value and use of land. Ownership usually relates to the possession of rights in land; value normally relates to market value; use relates to the rights to use and profit from the land. In short, land administration systems are the basis of conceptualising rights, restrictions and responsibilities related to people, policies and places in support of sustainability as well as land and property.

2.2 Land information system

The declaration by the FIG highlights the importance of the cadastre as a land information system for social and economic development. It offers an international perspective of the cadastre as a land information system for social and economic development. There are three categories of cadastre, namely the juridical cadastre, which serves as a legally recognised record of land tenure as well as a register of ownership of land parcel; the fiscal cadastre, developed primarily for property valuation, is a register of properties recording their value; and the multipurpose cadastre, encompassing both parcel related information, is a register of attributes of parcels of land (Dale, 1976; Dale and McLaughlin, 1988).

A cadastre is required in a wide variety of activities by existing or prospective landowners, lawyers, surveyor, valuator, real estate manager and all levels of government agencies. The cadastre generally pertains to the proprietary land unit that is organised around the cadastral parcel, which is part of an estate and has a separate identity. The principal function of a cadastre is the provision of data concerning proprietary land unit as land ownership, value and use which provides the information component of land registration. The information in a cadastre is collected, stored, referenced and retrieved primarily at the land parcel level while its coordinates may then be added to facilitate data manipulation as well as exchange of information with other systems.

2.3 Cadastre system

Cadastre systems include the interaction between the identification of land parcels, the registration of land rights, the valuation and taxation of land and property, and the present and possible future land use (Enemark, 2005). Therefore, it is noted that even though cadastre systems around the world are clearly different in terms of structure, processes and actors, their design is increasingly influenced by globalisation and technology, moving towards multipurpose cadastres (Molen, 2003). The cadastre system comprises the map, real estate and land register. The map shows the boundaries of real estates and location of the parcels. Real estates and changes are entered into the cadastre. The land register based on the cadastre contains a list of titles for real estate. Today’s cadastre registration not only focuses on property registration but also serves other tasks used by private and public sectors in land development, urban planning, land management and environment monitoring (Federation Internationale de Geometres, 1995; Williamson and Ting, 2001).

Cadastres and cadastral surveys are aspects of land administration. The primary object of a cadastral is to determine for each land parcel, its location, the extent of its boundaries and surface area, and to indicate its separate identity, both graphically on a map or in a record as well as physically on the ground. Its secondary objective is to provide information for a multipurpose cadastre to fulfil the overall information requirements of land administration (Dale, 1976). Cadastral plans can fulfil many of the functions of large-scale topographic maps, not only serving such purposes as boundary control, registration of title and valuation but also forming a basis of planning and development (Dale, 1976).

The objectives of cadastral surveys are to acquire information, process it, coordinate and finally to present the vital information. Cadastral surveying is an expensive process not only in its execution but also in the loss of capital from delays in development and investment which may arise owing to inefficiency. It is mentioned by Rabley and Falk (2004) that cadastral surveys and cadastral maps are fundamental to an efficient and speedy land registration process. They are needed to ensure that rights and restrictions about properties can be quickly identified by referring to the same unique place on the earth. In addition, they all work to define the boundary of real property. In order to speed up and streamline the process of property registration, it is important for cadastral surveys and mapping to emphasize reliable cadastral surveying information, which adds to the security of titles.

The need to indicate boundaries on the ground came long before the practice of title registration, survey, mapping, or conveyancing (Simpson, 1976). In a legal sense, a boundary is a surface which defines where one landowner's property ends and the next begins. Normally, this surface is vertical and intersects the ground along the legal boundary line (United Nations Economic Commission for Europe, 2005). There are three categories of fixed/specific boundaries, namely boundaries that are (i) defined on the ground prior to development and identified; (ii) identified after development; or (iii) defined by surveys to specified standards. There are also three categories of general boundaries, namely (i) the situation where the ownership of the boundary feature is not established, (ii) the indeterminate edge of a natural feature; or (iii) the situation where the boundary is regarded as approximate. The third type of general boundary is suitable in the determination of actual forest or watershed boundaries, or even lot parcels in some countries using aerial photographs or space satellite techniques to define an accurate boundary line that it can be mapped in the register or document of title.

2.4 Land Administration Domain Model (LADM)

Land Administration Domain Model (LADM) is an international standard data model being developed by the International Standardization Organisation (ISO) under Technical Committee 211 (TC211) for Geographic Information/Geomatics and the information provided below are based on this Standard ISO TC211. Groothedde et al. (2008) note that a standardized Land Administration Domain Model (LADM) provides an extensible basis for efficient and effective cadastral system development, however, domain experts from different countries could further develop each package based on LADM (Lemmen et al, 2011b).

According to Tjia and Coetzee (2012b), earlier studies upon which the LADM is based include the Cadastre 2014. The Cadastre 2014 provided that the modern cadastral systems need to move away from the traditional concept of cadastre to a more integrated cadastral modelling and legal land objects. Also, Lemmen et al. (2011a) note that the implementation of LADM can be performed in a flexible way. In other word, the standard can be extended and adapted to local situations which excluded the legal implications that interfere with national land administration laws. Furthermore, external links to other data bases, e.g. addresses, are included.

This international standard of LADM can be used for as a basis for the design of Land Administration Systems. LADM facilitates appropriate system development and, in addition, it forms the basis for communication between different systems in different organisations and the application design can be based on GIS and database technology. When using standards, information can be exchanged in heterogeneous (commercial and open source) and distributed environments (Lemmen et al., 2011a). LADM) also covers land registration and cadastre in a broad sense (Lemmen and van Oosterom, 2011). This is aimed at improving interoperability between cadastral or related information systems, thus improving exchange of land information between local, national and international organisations and information society. (Tjia and Coetzee, 2012a).

In LADM, land administration is defined as the 'process of determining, recording and disseminating information about the relationship between people and land' (ISO/TC211, 2012). Land administration can therefore be broadly described as dealing with information about the relationship between humankind and land, with ownership as one of the most important aspects in this relationship. The manner in which ownership over land is held is referred to as land tenure. Land tenure reflects the social relationship between land and people (Tjia and Coetzee, 2012a). It is available since December 1st 2012 as a formal International Standard, published as ISO 19152:2012 (ISO/TC211, 2012). This paper analyses the impact of the standard with regard to the development of (and information exchange) between Land Administration Systems (Lemmen et al., 2013).

During the development of the LADM, there are three core classes, namely "Person", "Right" and "Parcel" (or "RealEstateObject") (Lemmen et al., 2010). LADM, as a product, is a conceptual schema. Now, LADM is organized into three packages, and one subpackage. Subpackages facilitate the maintenance of different data sets by different organizations, e.g. Land Registry or Cadastre (each with their own responsibilities in data maintenance), operating at national, regional or local level (Lemmen et al., 2011a). The three packages are: Party Package, Administrative Package and Spatial Unit Package. The Surveying and Spatial Representation Subpackage is one subpackage of the Spatial Unit package that integrated and offering source points, lines, and surfaces (Lemmen et al., 2011a).

2.4.1 Land Administration Domain Model packages

The main class of the party package of LADM is class LA_Party with its specialisation LA_GroupParty. A Party is a person or organisation that plays a role in a rights transaction. An organisation can be a company, a municipality, the state, or a church community. A 'group party' is any number of parties, forming together a distinct entity. LA_PartyMember' is documenting the association of a party member with the constituent group party with attributes such as membership share or date of membership in the group (Lemmen et al., 2013).

The administrative package concerns the abstract class LA_RRR (with its three concrete subclasses LA_Right, LA_Restriction and LA_Responsibility), and class LA_BAUnit (Basic Administrative Unit). A 'right' is an action, activity or class of actions that a system participant may perform on or using an associated resource. A 'restriction' is a formal or informal entitlement to refrain from doing something. A 'responsibility' is a formal or informal obligation to do something; e.g. the responsibility to clean a ditch, to keep a snow-free pavement or to remove icicles from the roof during winter or to maintain a monument. A LA_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. (Lemmen et al., 2013).

The spatial unit package concerns the classes LA_SpatialUnit, LA_SpatialUnitGroup, LA_Level, LA_LegalSpaceNetwork, LA_LegalSpaceBuildingUnit and LA_Required-RelationshipSpatialUnit. A 'spatial unit' can be represented as a text ("from this tree to that river"), a point (or multi-point), a line (or multi-line), representing a single area (or multiple areas) of land (or water) or, more specifically, a single volume of space (or multiple volumes of space). Single areas are the general case and multiple areas the exception. Spatial units are structured in a way to support the creation and management of basic administrative units. A 'spatial unit group' is a group of spatial units; e.g.: spatial units within an administrative zone or within a planning area. A 'level' is a collection of spatial units with a geometric and/or topologic and/or thematic coherence (Lemmen et al., 2013).

The Spatial Unit Package has one Surveying and Spatial Representation Subpackage with classes such as LA_SpatialSource, LA_Point, LA_BoundaryFaceString and LA_BoundaryFace. Points can be acquired in the field by classical surveys or with images. A survey is documented with spatial sources. A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of LA_SpatialSource. The individual points are instances of class LA_Point, which is associated to LA_SpatialSource. 2D and 3D representations of spatial units use boundary face string (2D boundaries implying vertical faces forming a part of the outside of a spatial unit) and boundary faces (faces used in 3D representation of a boundary of a spatial unit). Co-ordinates themselves either come from points or are captured as linear geometry (Lemmen et al., 2013).

2.4.2 <u>Spatial Representation and Survey subpackages</u>

LADM is standardised internationally and covers issues which is a best fit for many cadastral jurisdictions. LADM provides good opportunities to further explore 3D implementation issues, as well as modify current 2D models and practices to be more reflective of an international standard (Karki et al., 2011). The Spatial Representation and Survey subpackages of LADM allow a large number of possible representations of spatial units in 2D, 3D, or mixed (integrated 2D and 3D) (Lemmen et al., 2010). A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of LA_SpatialSource. The individual points are instances of class LA_Point, which is associated to LA_SpatialSource. While it is not required that the complete spatial unit is represented, a spatial source may be associated to several points. Geodetic control points, including multiple sets of coordinates for points, and with multiple reference systems, are all supported in LADM (Lemmen et al., 2011a).

2D and 3D representations of spatial units use boundary face strings as instances of class LA_BoundaryFaceString, and boundary faces as instances of class LA_BoundaryFace. Coordinates themselves either come from points, or are captured as linear geometry. LADM supports the increasing use of 3D representations of spatial units, without putting an additional burden on the existing 2D representations. Another feature of the spatial representation within LADM is that there is no mismatch between spatial units that are represented in 2D and spatial units that are represented in 3D (Lemmen et al., 2011a).

According to Lemmen and van Oosterom (2011), data collected from surveys are can be managed by the LADM according to the Surveying and Representation Subpackage. This means that all documentation related to cadastral boundary surveys can be included. It is important to recognise that the original data as collected in the field can be stored and integrated as well as the calculated and adjusted coordinates in the digital cadastral database. Points can be acquired in the field but also in an office by digitizing, or can be compiled from various sources, and later can be used to compose lines (boundaryFaceStrings) (Lemmen and van Oosterom, 2011). Observations made during surveys can be represented in LA_SpatialSource using the OM_Observations attribute. This is about the original observations; e.g. orientation, bearings (azimuths), distances, existing co-ordinates from ground control, digitised points, point series, arc series, parallel to, perpendicular to, collinear to, GPS co-ordinates, units, object identifiers etc. The documents can be represented in LA_Source using CI_Presentation form code attribute.

The original observations as represented in LA_SpatialSource remain unchanged. Now the determination of co-ordinates from the observations can be performed. This implies transformations and also adjustments. Adjustments are needed in case of multiple observations, e.g. observations related to points observed with GPS devices which are also measured using tape or points which are observed with total stations from different positions. Least squares adjustments may be used. This means all observations get corrections in such a way that a mathematical correct model will be available after adjustments. The results of this process are calculated co-ordinates which can be represented in LA_Point under the attribute OriginalLocation. The transformation parameters can be represented under TransAndResult (Lemmen and van Oosterom, 2011).

This means that the mathematical method in co-ordinate determination can be integrated under the LA_Point class and the results of the calculations can be included in the model. This means the transformation parameters are not lost, same for the calculations of co-ordinates and the adjustments to the original observations. (Lemmen and van Oosterom, 2011). Next a process can start to adjust the determined “local” co-ordinates into the boundaries (under class LA_BoundayFaceString). Again transformations (geo-referencing) and adjustments may be needed. In addition, the lines have to be composed from points based on the field observations. Part of field observations is to get a representation of the spatial dimension of real rights or use rights or other rights. The boundaries are discontinuities but in realty a boundary is a boundary between one homogeneous Party/Right situation and another (Lemmen and van Oosterom, 2011).

In conclusion, LADM should integrate important data as party names and rights with source documents as titles, deeds, survey field data, court decisions, decisions made in participatory mapping and other decisions. All crucial data can be related to authentic sources: documents, imagery with evidence from the field, GPS tracks and so on – available ISO standards should re-used to support multi-media archives and measurements and observations as well as spatial representations. A very relevant issue is that field surveys can be included in combination with reconstruct able adjustments to the spatial database. History should maintainable and all attributes may have a set of quality elements. This allows for proper combinations with workflow management (Lemmen et al., 2013).

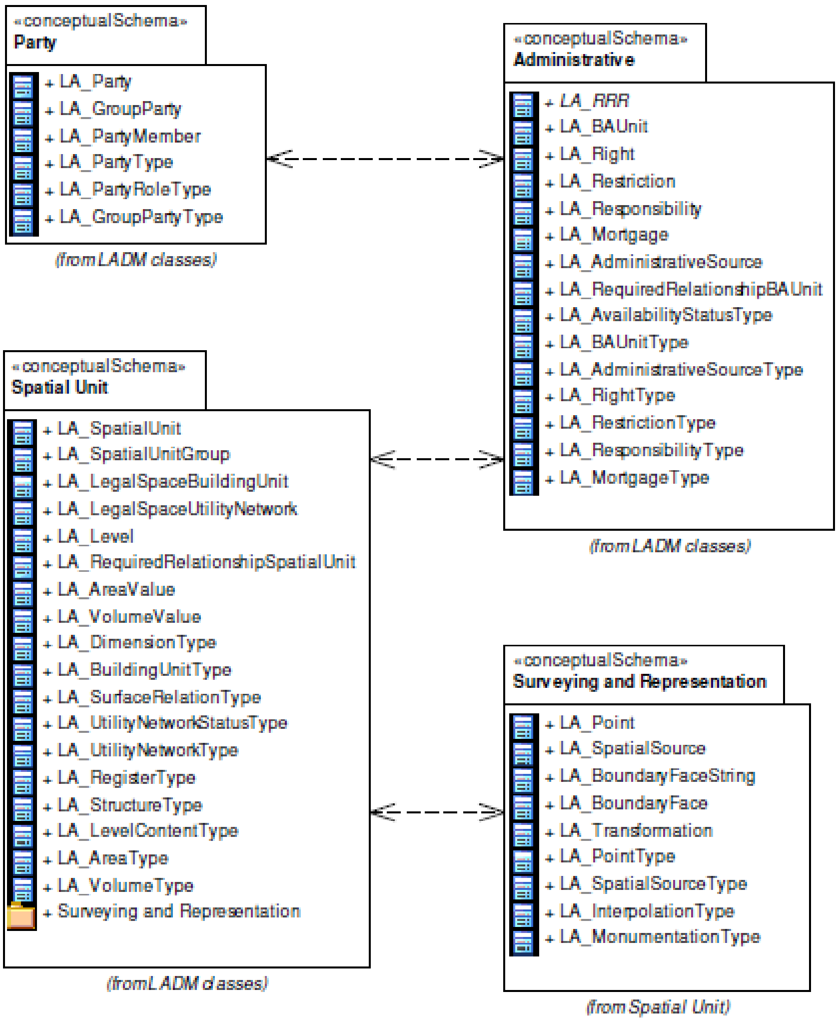

Figure 1. Basic classes of LADM (adapted from Lemmen et al, 2011a)

3. MALAYSIAN SITUATION

Before British rule was established in Penang and Melaka, the customary land tenure followed the same pattern as in Sarawak, Borneo, Burma and parts of India and Ceylon. When the British took over the administration of Penang, it was virtually an uninhabited island with no settled law, much less a recognised land system (Tan, Liat Choon, 2013).

3.1 Land tenure system before and after 1965

Historical records showed that before the arrival of the English traders in 1786, the year that Ruler of Kedah ceded the Penang Island to the East India Company, Malaya was already governed by Islamic Law and Malay Customary Law. The early English Law that was introduced into Penang was known as the Deeds System, which recorded land transactions in the form of deeds or indentures. According to Das (1963), the Deeds System was introduced in Penang properly as early as 1807 and in Singapore in 1819, and later extended to Malacca in 1826.

3.2 Cadastre system

Malaysian land administration is traditionally based on Malaysian land law, while the Malaysian cadastre system has essentially two basic components, namely land registration and the cadastral survey and mapping that have different structures and authorisations. 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 Malaysian land registration system provides for textual and spatial information that is consistent with the two aforementioned components of the system. Although not strictly part of the cadastral survey system, valuation, local government and planning authorities are heavily reliant on the land registration system. They utilise the information provided by the system in conducting their business, and work in close coordination with the institutions supporting the system.

The Malaysian cadastral survey and mapping system is based on the Cassini Solder Coordinate System. Each State has its own origin and reference meridian. Cadastral maps are used primarily for the identification of land parcels for the purpose of land management. All the lots that are surveyed by both government and licensed land surveyors are plotted on the maps. All States currently have cadastral maps in digital form based on a graphical representation of geometric components.

There are two types of boundary in Malaysian statute. First, boundary for land. Land boundaries are identified by boundary marks. Second, boundary for parcel. Parcel boundaries are identified by party wall. Under the Torrens System, the boundaries of each surveyed land parcel are defined by coordinates, bearings and distances. Lots can be defined either by physical demarcation or described mathematically based on a coordinate system. Lots and other information are shown in a cadastral map which provides information for identification of land or building parcels for survey and land administration. The description of parcel boundaries and cadastral survey data are shown as graphical information. It commences with preparation of the survey plan which is then submitted for authentication by the Department of Survey and Mapping Malaysia.

3.3 eCadastre

The primary objective of eCadastre is to expedite the delivery system for land title surveys. This entails the creation of a survey accurate database at the national level suitable for Geographical Information Systems (GIS) users. Various issues related to the generation of a survey accurate database need to be addressed. The vision of Malaysia becoming a developed country by 2020 calls for the realisation of an efficient public delivery system at various levels. Among the issues of national interest are land related matters, which include cadastral surveys. The government approved an eCadastre project under the 9th Malaysian Development Plan (2006-2010) to be implemented by the Department of Survey and Mapping Malaysia (DSMM), in line with the government's aspiration to have a fully digital Malaysia by 2015.

Since 1995, DSMM has embarked on a modernisation program that saw the dramatic computerisation of both its office and field 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 meshwork of parcels will be carried out based on a new geocentric datum concept. The Real Time Kinematic Global Positioning System (RTKGPS) has seen the setting up of permanent stations established to provide precise geocentric positioning to assist the Coordinated Cadastral System implementation. This network is to be implemented to support the eCadastre project.

The current system of cadastral survey is yet unable to capitalise on the advent of satellite based technologies. A complete revamp of the system is required before any improvement to the delivery system could be achieved. The new environment will allow various cadastral survey processes, such as planning, layout design submission, field data capture, completed job submission, quality control and approval, to be carried out remotely via the mobile telecommunication network. Global Positioning System (GPS) will provide real time positioning at centimetre resolution homogenously for 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 will be incorporated into the new database in a move towards a multipurpose cadastre.

There are three main components in eCadastre, namely Coordinated Cadastral System, Virtual Survey System and Cadastral Data Integrity System. The implementation of a Coordinated Cadastral System is a major part of the eCadastre project that includes field and office reengineering to reduce processes and increase the use of digital technology. The Virtual Survey System will equip the field surveyor with ICT, total station, GIS and GPS. The surveyor will be able to interact with the system to extract information that is essential in field operations. Most of the work is automated to reduce tedious computation.

Meanwhile, Cadastral Data Integrity System comprises all the office application related to cadastre, which include pre-survey verification, field survey data computation and verification, digital title plans generation and approval. In order to implement multipurpose 3D cadastre in Malaysia, new requirements are needed to capture the data in three-dimensional (on surface, above surface and below surface) to cater for strata, stratum surface. This process will be performed in the Electronic Strata Module consisting of the Strata Lodgement Module, Electronic Strata Survey Module and Strata Verification Module. The Strata Lodgement Module is developed especially to fulfil the requirement of a spatial database for strata, while the Electronic Strata Survey Module is developed to perform strata job verification on the ground and at same time perform data collection, and the Strata Verification Module is developed mainly to fulfil the needs of spatial usage for data checking from field checks.

3.4 eLand

To realise computerisation of the overall management and administration of land in the country, the Ministry of Natural Resources and Environment (NRE) planned to create an integrated computerised system, known as the Electronic Land Administration System (eLand). ELand is designed to improve the delivery of land administration and management services in Peninsular Malaysia using an integrated ICT infrastructure. Currently, the Ministry of National Resources and Environment has implemented two systems for the administration of land information, namely *Sistem Pungutan Hasil Tanah* (SPHT) and *Sistem Pendaftaran Tanah Berkomputer* (SPTB). Both systems are already being used in all State Land and Mines Office and District Land office in Peninsular Malaysia.

ELand is an integrated and a fully computerised 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 enables the public to make payments online and print the payment receipts, checking details on their own land and so on.

ELand consists of nine main modules with 85 major business processes in accordance to the existing National Land Code 1965 (Act 56). The business processes supported by eLand maximizes the utilisation of the existing ICT infrastructure, taking into account the existing processes and procedures. The new system will be merged and integrated with the existing systems.

The objective of eLand is to develop a comprehensive system in land offices in order to modernise all activities that are related to land and to realise the implementation of electronic government in the public sector. The achievement of an updated, effective, and accurate National Land Administration System via ICT is eLand’s vision. In addition, eLand’s mission is to develop and implement a National Land Administration System via ICT towards enhancing the growth of national development.

The focus of the project will be on major processes that can be implemented without any changes to the existing laws. In fact, one important aspect of the project is that the eLand project does not require any immediate amendment to existing laws during initial implementation. Nevertheless, the modules of eLand are designed to be flexible so that they can address possible changes to the system because of the changes in the existing laws.

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

3.5 Towards multipurpose 3D Cadastre

In recent years, a 3D cadastre registration system is being developed. Researchers have contemplated adding 3D cadastre objects in the current cadastre data model and information, accessible by the Department of Survey and Mapping Malaysia, State Land and Mines Office, and District Land Office. Unfortunately, the two stated databases, viz. the Cadastral Data Management System (CDMS) (eCadastre) and the Computerised Land Registration System (CLRS) (eLand) database work separately under different authorities, still do not support three-dimensional capability. As mentioned previously, the Malaysian Land Administration is based on the Torrens System where the cadastral map and the Document of Title with spatial and textual information are regarded as legal evidence, and are required under the rules and regulations in order to have full institutional coordination. Therefore, a good institution is very important in order to achieve an excellent and reliable cadastre registration system. However, due to historical constraints, it seems quite difficult to realise this unless there is full cooperation from various legal bodies, technical organisations and other land-related government agencies and private sector participants.

A multipurpose 3D cadastre can be defined as an integrated land information system containing legal (e.g. tenure and ownership), planning (e.g. land use zoning), revenue (e.g. land value, assessment and premium) and physical (e.g. cadastre) information. Therefore, the Malaysian multipurpose 3D cadastre should contain all information about administrative records, tenure, value and sale & purchases records, base maps, cadastral and survey boundaries, categories of land use, streets addresses, census utilities etc. It has the potential to support spatial enabled government, private sectors and society by expanding the process of visualisation, organisation and management of useful land information. In brief, there are many advantages for implementing a multipurpose 3D cadastre. It is especially useful for property inventory, project implementation and monitoring, utility management, population estimates, school management, census mapping and urban and rural development.

3.6 Good governance of land administration

The current Malaysian cadastral survey and mapping system has insufficient three-dimensional objects registration rights for certain overlapping properties. The two-dimensional type of cadastral system, which has been practised in Malaysia for a period of one hundred years, provides essential information about ownerships of lots and land parcels for the country. The eCadastre and eLand, which work separately in each organisation with different legal aspects, are still in a two-dimensional plane surface. Furthermore, there is also insufficient information in three-dimensional objects for taxation and land use to be linked together.

There could be extensive benefits if the eLand, the eCadastre, the taxation data from the Valuation and Property Management Department and land use from the Town Planning and Development Department are linked together. With the integration of attribute data from eLand and spatial data from eCadastre and through identified applications, the efficiency of land administration can be greatly improved. Nordin (2001) stated that the envisaged applications include on-line registration for surveys and preparation of titles, extending the Digital Cadastral Database enquiry module to the land administrators and also linking the Qualified Title information to the Digital Cadastral Database. Although conceptually tenable, the eventual implementation would need substantial negotiation and compromise among land offices and survey department.

With vast changes in ICT, such as GIS, internet and web-based applications, together with the initiative of the Malaysian Geospatial Data Infrastructure (MyGDI) National Spatial Data Infrastructure (NSDI), eLand of Ministry of Natural Resources and Environment (NRE) and eCadastre of DSMM, the eLand and eCadastre databases could be integrated electronically. In order to achieve the goal of a comprehensive Land Information System from the district level up to State level and eventually at the national level, the integration of the spatial eCadastre database with the textual eLand database serves as a preliminary requirement.

4. EMPIRICAL CASE STUDY

At present, the digitalisation has fully implemented in the department and is better known as National Digital Cadastral Database (NDCDB). NDCDB adopted now is a database of two-dimensional (2D) (X, Y), where the information is stored in 2D coordinate planimetric. To produce 3D (X, Y, Z) for each boundaries mark, methods of data collection, calculation and adjustment of traverse survey data need to be changed. The purpose of this paper is to examine the possibility of implementing 3D cadastre system in Malaysia. One of the important principles in the development of cadastral system is the fully 3D information of land surface.

This subsection will discuss a trial implementation for the Three-dimensional Digital Cadastral Database (3D-NDCDB) which allows a mixture of 2D and 3D cadastre. To begging, the aim is to provide land with 3D elevation data. This addition information add to the boundary marks in the NDCDB would create a 3D-NDCDB. To achieve this purpose, the matters to be addressed are as (a) Field Data Acquisition (b) Adjustment and Calculation of Observed Data (c) 3D-NDCDB, and (4) Changes of Format and Structure. For the purpose, a test project was carrying out in State of Negeri Sembilan, Malaysia.

4.1 Field data acquisition

The collection of traverse data in the field in eCadastre environment is fully digitalised. The current method of data collection is using Digital Field Book (BKD) interface. There are two main components of BKD, i.e. observation bearings and distances. Final bearing is produce from the Least Square Adjustment (LSA). Data collection to produce 3D coordinates requires additional information tools, i.e. observation of height of Total Station and prism. With this additional information, existing BKD must be changed to suit those needs. In the existing BKD, the terms of observations is "vertical angle", while the observations recorded are zenith angle values. To implement 3D cadastre, the use of vertical angle observations are more practical, which the surveyor can calculated the high difference in positive or negative value.

4.2 Adjustment and calculation of observed data

Least Square Adjustment (LSA) in the cadastral survey in Malaysia has been fully utilized in eCadastre environment. However, the adjustment only involves 2D data. To produce 3D-NDCDB, an adjustment with 3D data should be doing. For this purpose, the observed data used and exported to an adjustment format are bearings, distances and high differences information. Coordinates (X, Y, Z) reference adopted in the formation of 3D-NDCDB must be compatible with the coordinate system used by eCadastre and MyGEOID. This compatibility is important that the height of product for each traverse boundaries have height information. For this purpose, the start station must have a value of orthometric height to allow the determination of orthometric height of the front station.

4.3 3D-NDCDB

The 3D-NDCDB products will be the basis of fully 3D cadastre implementation. Among the 3D-NDCDB initial products are as follow:

4.3.1 <u>Height information</u>

Height information of each boundary mark (see Figure 2).

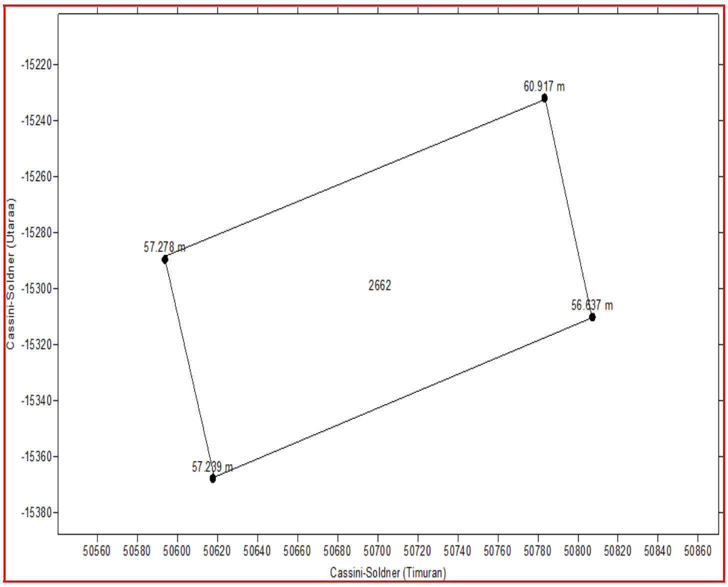

Figure 2. Example of height information

4.3.2 <u>3D Certified Plan (3D-PA)</u>

i) Contour information for each lot (see Figure 3)
ii) 3D plot (see Figure 4)
iii) 3D wireframe plot (see Figure 5)

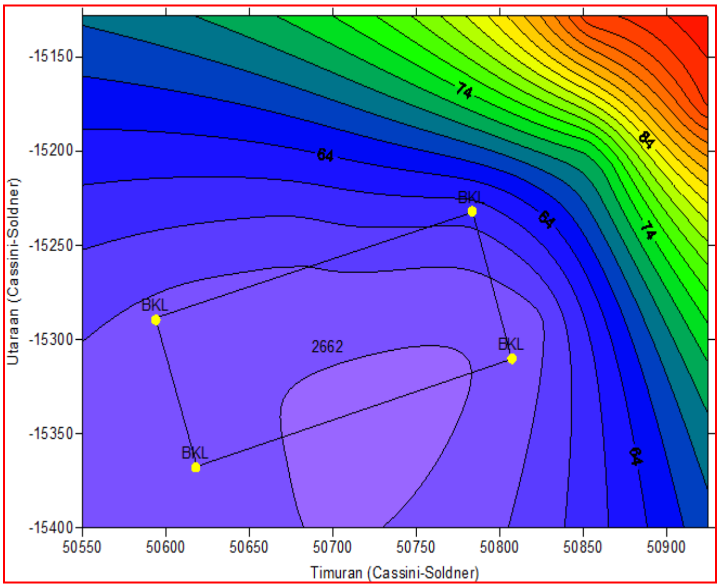

Figure 3. PA with contour lines

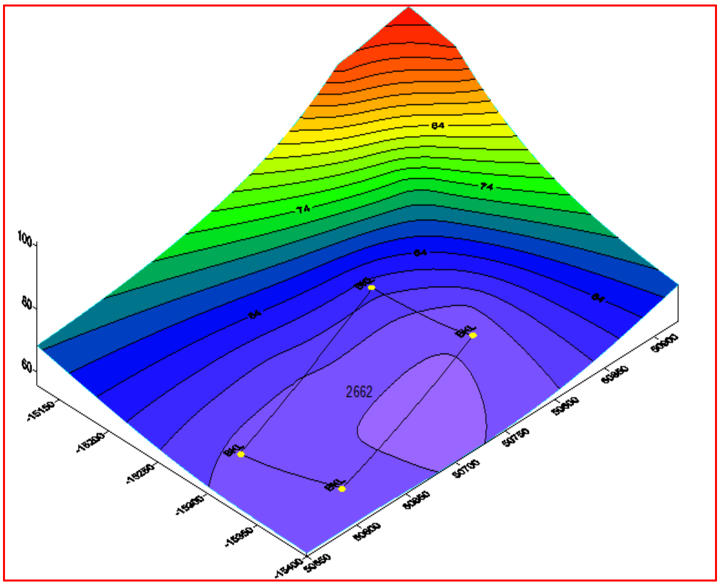

Figure 4. PA with 3D plot

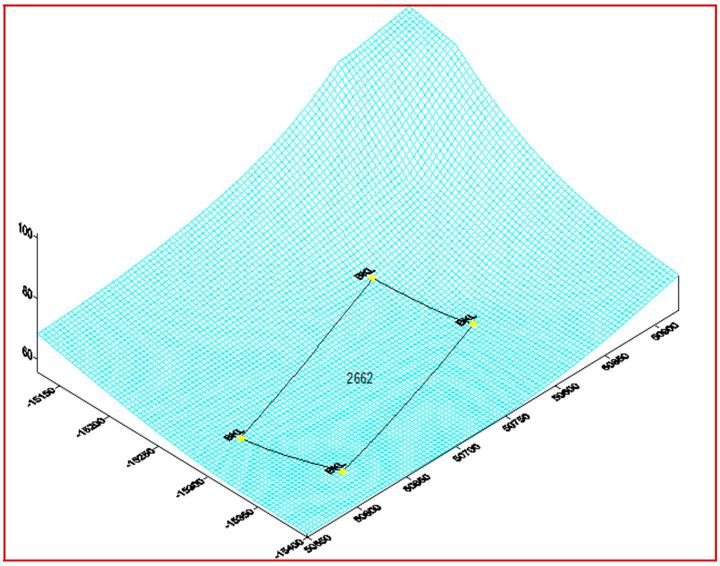

Figure 5. PA with 3D wireframe plot

4.3.3 Certified Plan (PA) with satellite image

Overlay plot with satellite imagery for surface analysis for landslide studies and consolidation of information from LIDAR or IFSAR grid (see Figure 6).

Figure 6. PA with satellite images

4.3.4 Digital Terrain Model (DTM)

Produce Digital Terrain Model (DTM), which is more accurate for use in the field of geodesy (see Figure 7).

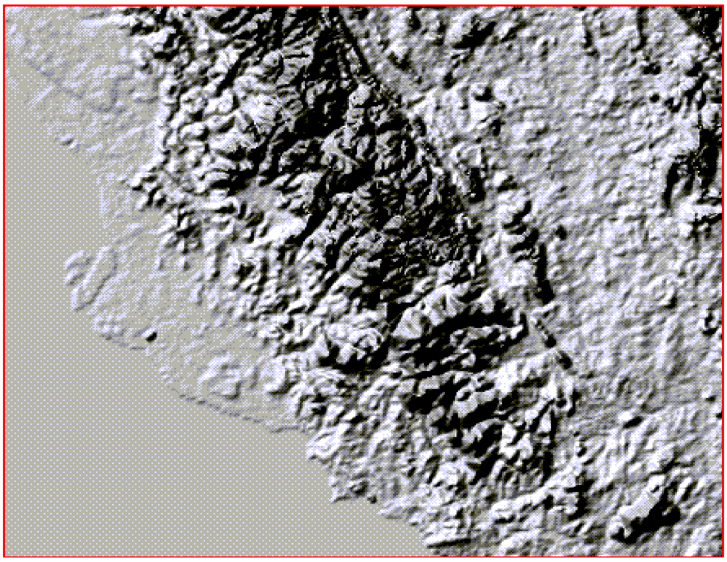

Figure 7. Improvement DTM

4.4 Changes of format and structure

Owing to the additional information collected, format and structure of the existing system should be changed and make available to meet these needs. Later, the amendments should emphasize on (a) Procedures in Survey and Mapping Director General Secular, (b) Output structure of the data collection, (c) Adjustment methodology and data processing, (d) Existing NDCDB Structure , and (e) Existing eCadastre application.

5. A SUITABLE MALAYSIAN LAND ADMINISTRATION DOMAIN MODEL

As point out by Lemmen et al. (2013), if coordinates are an essential component of the cadastral system than the survey technique must be capable of producing these. The Malaysian cadastral survey and mapping system is based on the Cassini Solder Coordinate System. Each State has its own origin and reference meridian. Cadastral maps are used primarily for the identification of land parcels for the purpose of land management. All the lots that are surveyed by both government and licensed land surveyors are plotted on the maps. All States currently have cadastral maps in digital form based on a graphical representation of geometric components, through the implementation of the Cadastral Data Management System project, which was completed in 2002.

Duncan and Abdul Rahman (2013) points out that the data model for 2D cadastre is polygonal in shape, this consists of nodes, edges and the surface (land), the data is usually in vector format with spatial information such as the x, y coordinates, distances and bearings between the nodes, or the survey beacon. The 3D data model is obtained by the inclusion of height (z) to the 2D data model. Experience has shown that the move towards 3D cadastre is widespread throughout the world, and does not wait for the existence of a 3D cadastral database (Stoter and Van Oosterom, 2006).

5.1 Proposed Malaysian Land Administration Domain Model

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.

Under the Torrens System, the boundaries of each surveyed land parcel are defined by coordinates, bearings and distances. Lots can be defined either by physical demarcation or described mathematically based on a coordinate system. Lots and other information are shown in a cadastral map which provides information for identification of land or building parcels for survey and land administration. The description of parcel boundaries and cadastral survey data are shown as graphical information. It commences with preparation of the survey plan which is then submitted for authentication by the Department of Survey and Mapping Malaysia. However, the cadastral map or Digital Cadastral Database (DCDB) is only two-dimensional in nature.

According to Abdul Rahman et al. (2011), the State Land Offices and Department of Survey and Mapping Malaysia may follow ISO TC211 models of Land Administration Domain Model (LADM). These models have been used as a platform to suit with the Malaysian cadastre system. This approach means preservation of 2D cadastre and the integration of the 3D registration by registering 3D situations, integrated and being part of the 2D cadastral geospatial data.

The 2D/3D hybrid cadastre (Stoter, 2004) can be used for the 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. An integrated 3D cadastre model looks on how to add 3D component in the current cadastre data model (3D cadastre objects on the 2D land parcel), which is the responsibility of Department of Survey and Mapping Malaysia (DSMM). Adapting LADM, the 3D spatial database being design to make it interoperable with the current land registration database (Abdul Rahman et al., 2011).

Adaptation of LADM into integrated 3D cadastre model for Malaysia as illustrated in Figure 8. It is clearly defined that the LA_Party (owner) and the LA_RRR (right, restriction, responsibility) are under responsibility of the State Land Office while the LA_SpatialUnit (spatial data) are under responsibility of DSMM. The integration between these two databases is made on the linkage of LA_SpatialUnit and the LA_RRR in the integrated 3D Cadastre model for Malaysia. In this model, both LandParcel and 3DParcel are registered as an object in current registration system (Abdul Rahman et al., 2011).

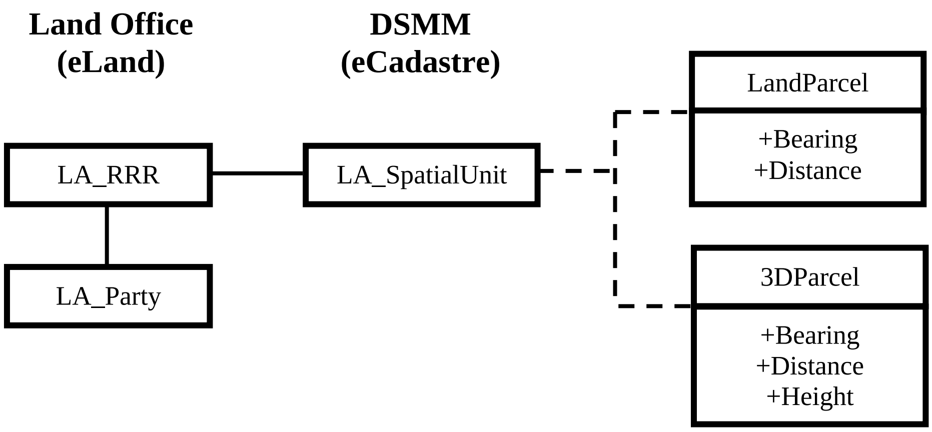

Figure 8. Adaption of LADM into 3D Cadastre Model for Malaysian LandParcel and 3DParcel (partly adapted from Abdul Rahman et al, 2011)

The LandParcel is represented as a 2D geometry (bearing and distance). This object is inherited from the current 2D registration system. Figure 9 shows the data model of land parcel as a registered object. LandParcel i.e. cadastral lot consists of boundary lines and boundary marks. 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 (Abdul Rahman et al., 2011).

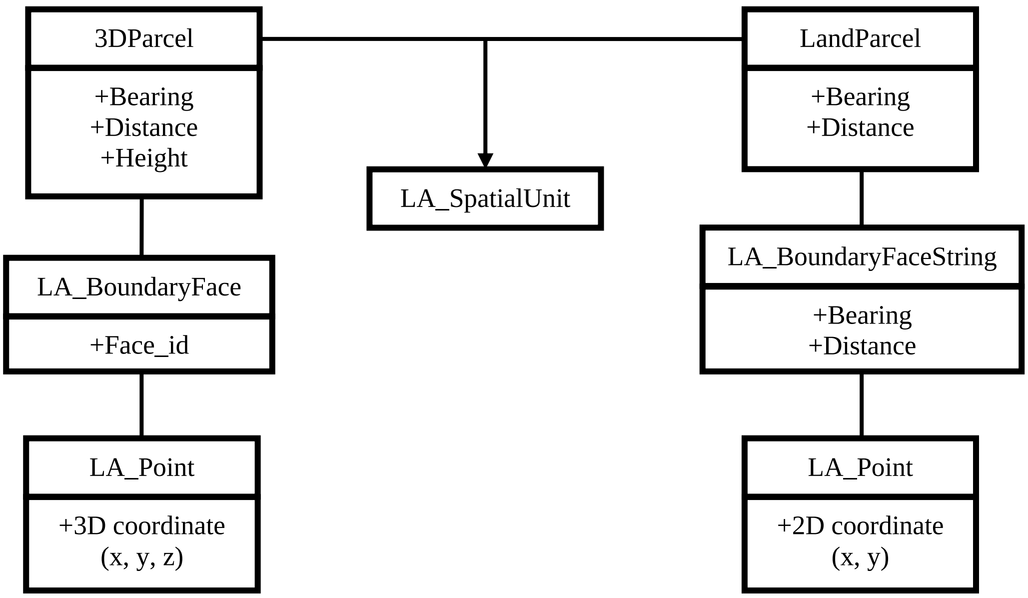

Figure 9: The data model for LandParcel and 3DParcel as LA_SpatialUnit (partly adapted from Abdul Rahman et al, 2011)

6. CONCLUDING REMARKS

The purpose of this paper is to give a brief understanding and an overview of land administration in general, land tenure and cadastre systems in Malaysia. We also look into the proposed Malaysian Land Administration Domain Model (LADM) by Malaysian researches. The empirical study proposed a suitable solution, where possibility of embedding Three-dimensional National Digital Cadastral Database (3D-NDCDB) into the existing National Digital Cadastral Database management model, i.e. introduce height value for each cadastral boundary mark. The foundation of the proposal is the LADM of the ISO TC211, which offers integrated support of 2D and 3D parcels. A Malaysian LADM profile has been highlighted for this purpose.

According to Tan, Liat Choon (2013), the development of a multipurpose cadastre information system requires the contribution of many different departments to execute the fundamental components of the system. Both the governmental and private institutions have to be involved concurrently to integrate all items of the new system. The implementation of each component is carried out by specific institutions at national, regional, and local level. The new system could aim for support land planning, land administration, land taxation, and cadastre. For dissemination purposes, even hyperlinks from the cadastre or its spatial indexes to the data files of land-use planning authorities may be sufficient. However, the multiplicity of organisational and legal relations stresses the importance of structure information and in making information more widely accessible. Efficient data exchange must be focussed on data modelling, standardisation and an appropriate use of the common spatial reference framework.

In addition, there could be wide-ranging benefits if the data information in the Certified Plan from Department of Survey & Mapping Malaysia (DSMM), Registry Title and Land Office Title from State Land & Mines Office (PTG) and District Land Office (PTD), taxation from Valuation & Property Management Department, and category of land use from Town Planning & Development Department are linked together. Furthermore, the integration of the spatial database with the textual database is the prerequisite requirement for the creation of an inclusive land information system, ranging from the town level till the national level. Therefore, with the integration of these data information from various departments and agencies which are responsible for the cadastral survey, title registration, taxation and land use and through the unique parcel identifier that is assigned, the effectiveness of land administration system, land registration system, land information system and cadastre system can be significantly improved.

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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.

Dale, P. F. (1976). *Cadastral Surveys within the Commonwealth*. (1st ed.). London: Her Majesty's Stationery Office (HMSO).

Dale, P. F. and McLaughlin, J. D. (1988). *Land Information Management*. (1st ed.). Clarendon Press, Oxford: Oxford University Press New York.

Dale, P. F. and McLaughlin, J. D. (1999). *Land Administration Systems*. (1st ed.). Clarendon Press, Oxford: Oxford University Press New York.

Das, S. K. (1963). *The Torrens System in Malaya*. (1st ed.). Singapore: Malayan Law Journal Ltd.

Duncan, E. E. and Abdul Rahman, A (2013). A Unified 3D Cadastre Data Model-A Geometric Approach. *In: GIS Ostrava 2013-Geoinformatics for City Transformation*. 21-23 January 2013. Ostrava, Czech Republic.

Enemark, S. (2005). *The Land Management Paradigm for Sustainable Development*. In: Williamsom, I. P., Enemark, S., and Wallace, J. (Eds.). *In Proceedings of the Expect Group Meeting on Incorporating Sustainable Development Objectives into ICT Enable Land Administration Systems.* (pp. 17-29). Melbourne, Australia: Department of Geomatics, University of Melbourne.

Federation Internationale de Geometres (1995). *FIG Statement on the Cadastre*. FIG Technical Report Publication 11, Federation Internationale des Geometres, Commission 7 (Cadastre and Land Management). Canberra, Australia: FIG.

Groothedde, A., Lemmen, C. H. J., Molen, P. V. D. and Van Oosterom, P. J. M. (2008). *A Standardized Land Administration Domain Model as part of the (Spatial) Information Infrastructure. Towards the Spatial Semantic Map*. Van Oosterom, P. J. M. and Zlatanova, S. Boca Rotan, Florida, CRC Press. Taylor & Francis Group: 129-150.

ISO/TC211 (2012). ISO/TC211 Geographic Information-Land Administration Domain Model (LADM), ISO/FDIS 19152.

Karki, S., Thompson, R., McDougall, K., Cumerford, N. and Van Oosterom, P. J. M. (2011). ISO land Administration Domain Model and LandXML in the Development of Gigital Survey Plan Lodgement for 3D Cadastre in Australia. *In: 2nd International Workshop on 3D Cadastres*. 16-18 November 2011. Delft, the Netherlands.

Lemmen, C., Van Oosterom, P. J M., Thompson, R., Hespanha, J. and Uitermark, H. (2010). The Modelling of Spatial Units (Parcels) in the Land Administration Domain Model (LADM). *In: TS 4K-Land Administration Domain Model. FIG Congress 2010-Facing the Challenges-Building the Capacity*. 11-16 April 2010. Sydney, Australia.

Lemmen, C., Uitermark, H., Van Oosterom, P. J. M., Zevenbergen, J., and Greenway, I. (2011a). The Road to a Standard Land Administration Domain Model, and Beyond. *In: TS 7G-Innovation and Pro-poor land Records and Information System. FIG Working Week 2011-Bridging the Gap between Cultures*. 18-22 May 2011. Marrakech, Morocco.

Lemmen, C., Van Oosterom, P. J. M., Uitermark, H., Zevenbergen, J. and Cooper, A. K. (2011b). *Interoperable Domain Models: The ISO land Administration Domain Model LADM and its External Classes*. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXVIII-4/C21.

Lemmen, C., Van Oosterom, P. J. M., Uitermark, H. and Zeeuw, K. D. (2013). Land Administration Domain Model is an ISO Standard Now. *In: Annual Work Bank Conference on Land and Poverty 2013*. 8-11 April 2013. Washington DC, United States.

Lemmen, C. and Van Oosterom, P. J. M. (2011). ISO 19152-The Land Administration Domain Model. *In: 11th South East Asian Survey Congress (SEASC 2011)*. 22-24 June 2011. Kuala Lumpur, Malaysia.

Nordin, A. F. (2001). *Institutional Issues in The Implementation of a Coordinated Cadastral System for Peninsular Malaysia: A Study on The Legal and Organisational Aspect*. M.Sc. Thesis. Universiti Teknologi Malaysia, Skudai, Johor, Malaysia.

Molen, P. V. D. (2003). The Future Cadastres-Cadastres after 2014. *In: PS1-Cadastre, FIG Working Week 2003*. 13-17 April 2003. Paris, France.

Rabley, P. and Falk, T. (2004). *An ILS White Paper on Integrated Registry and Cadastral Systems*. International Land Systems (ILS). USA.

Simpson, S. R. (1976). *Land Law and Registration*. (1st ed.). Cambridge, London: Cambridge University Press.

Stoter, J. E. (2004). *3D Cadastre*. Ph.D. Thesis. Delft University of Technology, Delft, the Netherlands.

Stoter, J. E. and Van Oosterom, P. J. M. (2006). *3D Cadastre in an International Context*. Boca Raton, FL. USA, Taylor & Francis.

Tan, Liat Choon.. (2013). *Towards Developing a Three-dimensional Cadastre for Three-dimensional Property Rights in Malaysia*. Ph.D. Thesis. Universiti Teknologi Malaysia, Skudai, Johor, Malaysia.

Tjia, D. E. and Coetzee, S. (2012a). Towards a Profile of the Land Administration Domain Model (LADM) for South Africa. *In: Global Geospatial Conference 2012-Spatial Enabling Government, Industry and Citizens*. 14-17 may 2012. Quebec City, Canada.

Tjia, D. E. and Coetzee, S. (2012b). *Land Administration Domain Model: Application to the City of Johannesburg Land Information System, South Africa*. GISSA Ukubuzana 2012. Academic paper.

Williamson, I. P. and Ting, L. (2001). *Land Administration and Cadastral Trend-A Framework for Re-Engineering*. Department of Geomatics. The University of Melbourne , Parkville, Victoria, Australia.

United Nations Economic Commission for Europe (1996). *Land Administration Guidelines*. Meeting of Officials on Land Administration, United Nations Economic Commission of Europe. ECE/HBP/96.

United Nations Economic Commission for Europe (2005). *Land Administration in The UNECE Region: Development Trends and Main Principles*. United Nations Economic Commission for Europe. ECE/HBP/140.

BIOGRAPHICAL NOTES

Tan Liat Choon is an Assistant Director of Survey at Department of Survey and Mapping Malaysia (JUPEM) since 16 July 2003. He first attach as Assistant Director with Malaysian Centre for Geospatial Data Infrastructure (MaCGDI). He is now with Database Section, JUPEM. He has studied on “Towards Developing a Three-dimensional Cadastre for Three-dimensional Property Rights in Malaysia" as his PhD thesis. His research interests are 3D property legislation in Cadastral Survey and Mapping Registration System and Land Registration System. He holds MSc. Degree in Land Administration and Development (2002), a BSc. Degree in Land Survey (1998), and a Diploma in Land Survey (1996) all from Universiti Teknologi Malaysia (UTM), and also Certificated in Land Survey (1993) from Politeknik Kuching Sarawak, Malaysia.

Looi Kam Seng is a Principle Assistant Director of Survey at Department of Survey and Mapping Malaysia (JUPEM) since 2 May 1992. He first attach as Assistant Director with Department of Survey and Mapping, Penang. He holds a BSc. Degree in Land Survey (1991) from Universiti Teknologi Malaysia (UTM).

CONTACT

Tan Liat Choon
Sr Looi Kam Seng
Department of Survey and Mapping Malaysia
Wisma JUPEM, Jalan Semarak
50578, Kuala Lumpur
MALAYSIA
Phone: +603-26170800
Fax: +603-26170714
Website: http://www.jupem.gov.my