# Towards “Smart Cadastre” that Supports 3D Parcels

**Victor H.S. KHOO, Singapore**

**Key words**: Cadastre System, 3D Cadastre, Cadastral Survey, 3D Parcels, Singapore

**SUMMARY**

Singapore Land Authority (SLA) is the government agency responsible for the cadastral survey and property title registration in Singapore. We have implemented the SVY21 cadastral survey system which adopted the “Coordinated Cadastre” concept in 2004. In 2005, Electronic Submission of cadastral survey jobs and paperless job processing was introduced. Over the last 18 years, we have embarked on various initiatives to modernise our cadastral survey system. Our challenges in maintaining the cadastral survey system are to be able to stay relevant and progress fast enough to support the needs of the industry and general public. That is why SLA is constantly looking for ways to further improve our system and one of the main thrusts moving forward is 3D cadastre.

Currently, we use a few IT systems to manage the cadastral survey job submission work flow, to maintain the Digital Cadastral Database (DCDB) and to maintain parcels attribute (textual) information. Cadastral plans are submitted in raster format together with final coordinates for each land parcel in ASCII format for the purpose of DCDB. Volumetric parcels such as airspace lots, subterranean lots and strata lots have been implemented in Singapore for more than 15 years. However the airspace and subterranean lots survey plans produced are in planimetric (2D) form and submitted in raster format. Hence, there is a need to consolidate the IT systems and introduce an automated processing system based on digital data submission. Intelligent data in 3D should be submitted and captured in our GIS system.

Going forward, a high level strategic plan of moving towards a “Smart Cadastre” was initiated to set the vision and goals for the improvement and development for a cadastral survey system in the next 4 years. The 3D component will be a major feature in the strategic plan.

This paper describes our idea of “Smart Cadastre” and the approach to achieve the vision. The components identified to develop a cadastre system which is “smart”, that will support and incorporate 3D parcels, will be examined.

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## 1. INTRODUCTION

Singapore is a small island country in South East Asia with an area of about 712 square kilometres. Rapid land development is a result of government’s continuous effort in sustaining high economic growth. Land administration and cadastre system are vital systems to ensure sustainable development.

The Singapore Land Authority (SLA) has 4 major functions:

- the land administration;
- the cadastral survey;
- the titles registration; and
- the management of land / geospatial information.

SLA's new vision statement, "Limited Land • Unlimited Space", aptly captures the evolved mandate of our organisation as we strategise our next lap of progress. The new statement highlights the nation's constraints and SLA's commitment in addressing the issues related to land use and land management. Our mission is to optimise land resources for the economic and social development. This is realised by providing an effective and reliable land management system; including the administration of cadastral survey, the issuance of property titles and management of land information.

In Singapore, cadastre system and cadastral survey information play a significant role towards economic and social development through a stable and reliable property registration system. The system traditionally serves as the foundation for property transactions and securing the legal status of property boundaries. This function will not change and will continue to be significant. However, with the introduction of GIS (Geographical Information System) that allow for capturing of geographic data on a seamless layer containing all property parcels, the cadastral survey information has become the most critical land base information to support development and planning work in government. This cadastral GIS layer data is widely known as the digital cadastral database (DCDB). In Singapore, the DCDB is shared through the NSDI (National Spatial Data Infrastructure) platform and many government agencies heavily depend on this layer for their planning and operation work to serve businesses, communities and individuals.

This paper aims to discuss the cadastre vision of SLA particularly related to cadastral survey information, processes and 3D cadastre. The paper provides a high level framework toward further enhancing cadastral survey processes and cadastral survey information.

## 2. CURRENT CADASTRE SYSTEM

Singapore adopts the Torrens System of conveyancing and title registration. Its cadastre system is made up of the "Register" and the "Map" (Khoo, 2011). The Land Survey Division of SLA is responsible for the cadastral survey information (the "Map") that provides for the base to support the overall cadastre system in Singapore. The overview of the cadastre information system supported by 3 databases is illustrated in Figure 1.

The Cadastral Survey System comprises of 2 databases, the Consolidated GIS System (CGS) which captures the geometry of land parcels (generally known as the Digital Cadastral Database, DCDB) and the Lot Information Management System (LIMS) which is used to capture all cadastral survey attributes i.e. survey plan number, approval date etc. There are generally 3 types of cadastral survey/plan submission for approval: approval of land lot, approval of airspace/subterranean lot and approval of strata lot. The airspace/subterranean and strata lots are 3D in nature. The different types of cadastral survey plans are described in Khoo (2011).

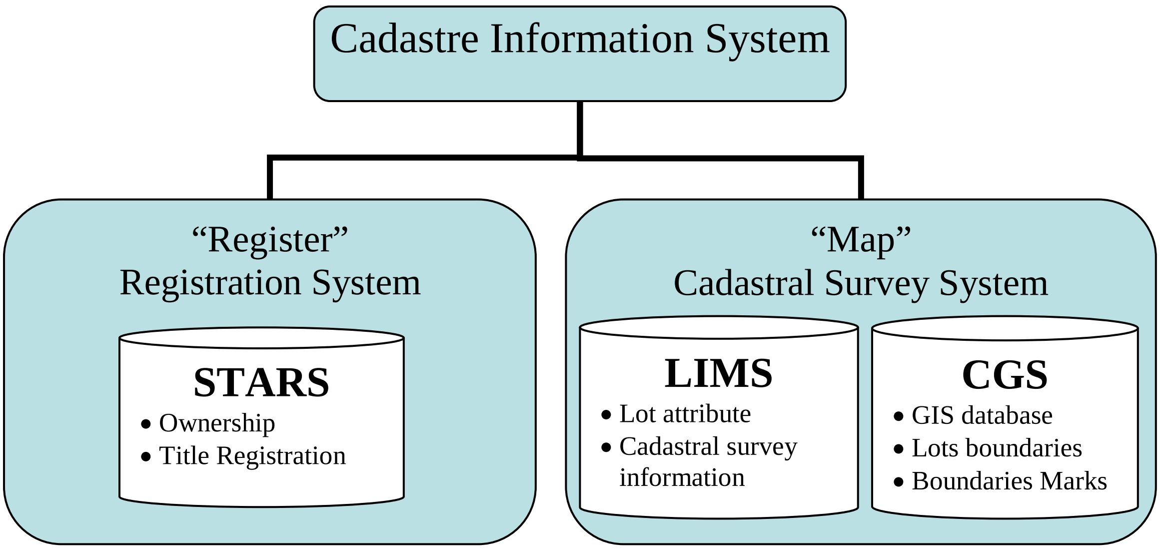


**Figure 1. Overview of the Cadastre Information System in Singapore (Khoo, 2011)**

Since 1992, the SLA has embarked on various initiatives to modernise our cadastral survey system. These improvements are needed for the system to stay relevant (Khoo, 2005 and Andreasson, 2006). Figure 2 lists the various initiatives that were carried out for the modernisation of our cadastral survey system. Further information on Singapore's cadastral survey system is available in the SLA website (http://www.sla.gov.sg).

The most important initiative was the implementation of the Coordinated Cadastre in 2004. This project is key in cadastre modernisation. It enables many other initiatives to improve cadastral information quality and increase productivity.

| GPS Technology / Infrastructure | Co-ordinated Cadastre | Information / GIS Technology | Regulations |
|---|---|---|---|
| • Primary Triangulation with GPS technology (1992)<br>• Secondary control network known as Integrated Survey Network (ISN) (1995)<br>• Establishment of SIMRSN for DGPS applications (1999)<br>• Implementation of SiReNT CORS network (2006) | • New local co-ordinate system, SVY21 (1995)<br>• Coordinated Cadastre pilot study (1996)<br>• Review of the survey directive based on Co-ordinated Cadastre concept (1998)<br>• Cadastre data conversion (1999)<br>• Official implementation of Coordinated Cadastre (2004) | • Electronic Submission via CORENET (2004)<br>• Job Data Storage System (JDS) (2004)<br>• Consolidated GIS System (CGS) (2004)<br>• Lot Information Management System (LIMS) (2011) | • 1998 – Boundaries and Survey Maps Act (BSMS) - Coordinated Cadastre<br>• Use of GPS technology<br>• Electronic submission of cadastral survey<br>• 2000 – LSA amended to include all types of land survey work |

**Figure 2. Initiatives to modernise the cadastral survey system in Singapore**

The cadastral survey workflow based on electronic submission was introduced in 2004. This workflow supports paperless submission via internet (Khoo, 2005). The workflow which is known as the SVY21 system is illustrated in Figure 3.

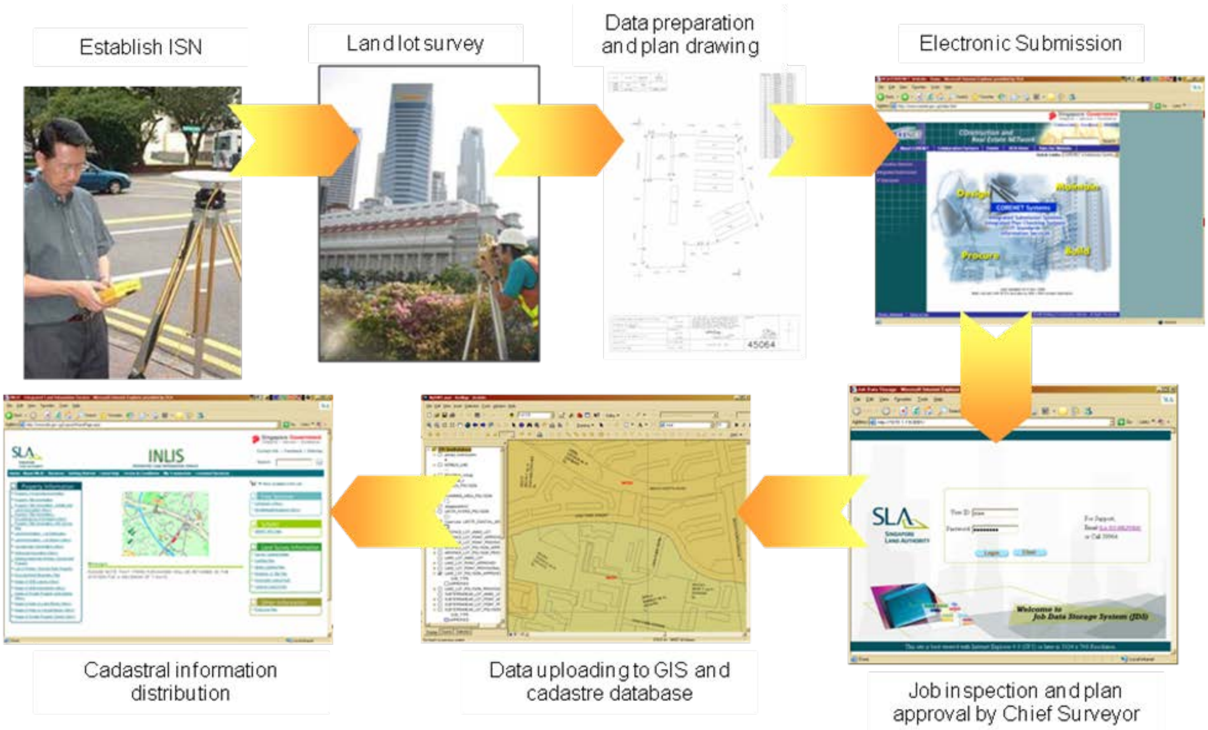


**Figure 3. Cadastral survey workflow - SVY21 system**

## 3. CADASTRE VISION

With the many initiatives and projects implemented, our existing cadastral survey system has incorporated many characteristics of a modern system. Currently, the land, airspace and subterranean parcels are required to be represented and data submitted in 2D digital coordinate format (vector). The airspace and subterranean parcels are represented in 2D and height is required as an attribute. While the strata parcels are still represented in plan format (raster). The cadastre representation of 2D + 1D is sufficient to deal with simple property boundaries. 2D planimetric survey plans are adequate and acceptable by the property owners. With increasingly complex developments above ground and usage of underground space where the structure cannot be seen, this is not the case anymore. The 2D + 1D system cannot adequately satisfy the need for measurements, spatial query, spatial analysis and 3D visualisation for government and private users. The need for 3D representation has become obvious.

Our existing cadastral survey system is supported by GIS database (i.e. CGS) and workflow (i.e. JDS) system designed in early 2004. In supporting external users, cadastral survey data is copied out of CGS system on daily basis because of the software and IT limitations. This has triggered several issues such as data integrity, authoritative and timeliness.

Hence, "business as usual" is not sustainable simply because:

- current cadastral survey system is not fit for future purpose;
- increase in complex 3D development above and underground;
- technology converging – GNSS / GIS / Remote Sensing / Laser Scanning, RFID, Wireless etc.; and
- application converging – Augmented Reality, Mobile devices for information;

So, going forward, a holistic approach is needed for the continuous development of cadastral survey processes, models and systems. As the process of cadastre development cannot be carried out in a short time frame, we have to devise a vision that will systematically improve our current approach.

Bennett et al. (2010) discussed about setting a new vision and concept for future cadastres. The factors considered include globalisation, urbanization, good governance, climate-change response, environmental management, 3D visualization, analysis technologies, wireless sensor networks, standardization, and interoperability. His team also outlined the potential characteristics of future cadastres. These characteristics include survey-accuracy, object-oriented design, 3D/4D data model, real-time information, global linkages and organic characteristics. Similarly, to cater for the current and future needs of cadastre information users, a high level strategic vision and plan for Singapore is required. The strategic vision will provide a guide for systems development, data modelling including 3D models, standardisation, technology acquisition, etc.

The first step towards a strategic vision is to identify cadastre information users and understand their usage. This is important as it will serve as a strong rational for the development of a new cadastral survey information system. Figure 4 depicts the various users of cadastre information in Singapore.

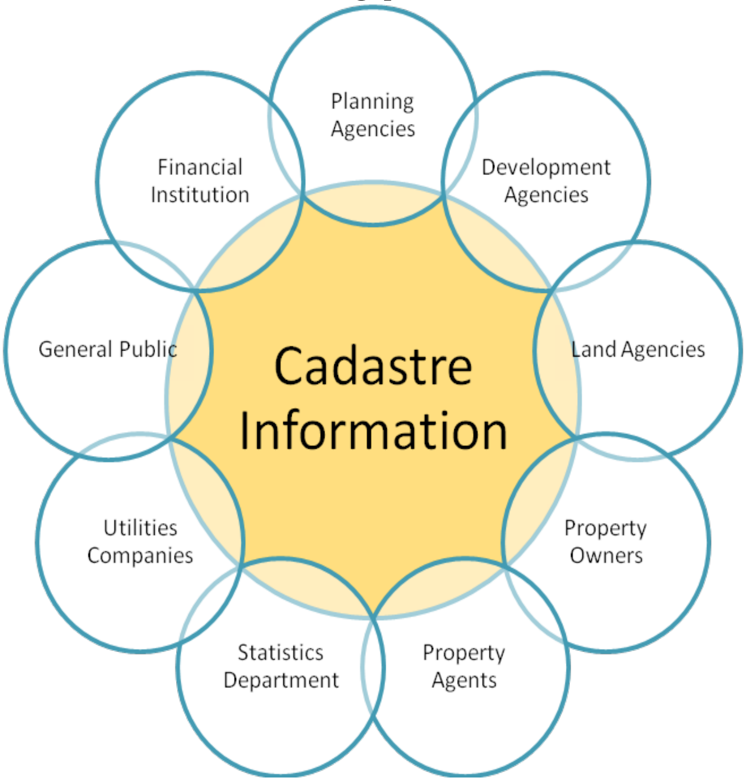


**Figure 4. Users and stakeholders of cadastre information**

Hence, a high level strategic vision of moving towards a "Smart Cadastre" was conceptualised as a guide to steer the improvement and development of the cadastral survey system in the next 4 years. The implementation of 3D parcels in GIS is a major feature in this strategic vision.

The goals set for "Smart Cadastre" are:

- to reduce risk of errors and improve integrity of cadastre information;
- to improve process efficiency and productivity;
- to improve users/customers satisfaction; and
- to support spatial enablement in SLA and the government (i.e. support wide usage of cadastre information, support easy retrieval and analysis of all cadastre related information).

Based on the objectives, the "Smart Cadastre" will be developed with the following characteristics:

- adopt one authoritative source of cadastral survey information;
- adopt open source format for data exchange;
- adopt international standard in data modelling;
- design smart data model that support 3D parcels;
- introduce 4D and 5D into the data model; and
- automate cadastral survey data processing and job approval;

In essence, there will be 3 main trusts in the realisation of “Smart Cadastre” with specific characteristics. First is the establishment of a comprehensive data model to capture all cadastral survey related data. A new data model will be created to ensure smart retrieval of information is possible. We will start by examining the data elements in our system and design a comprehensive data model that support 3D parcels and capture historical data (4D) with various accuracy (5D). Enhanced topology relationship will be implemented to ensure data integrity.

Secondly, we will establish the 3D GIS and 3D plan requirements for 3D parcel submission. The survey methodology and submission requirements will be implemented for the 3D modelling of 3D parcels.

Thirdly, we will implement a comprehensive IT system for workflow and GIS based on the data model and 3D GIS requirements. In order to enable automation in cadastral job processing, LandXML that support 3D parcels will be used as the exchange format for cadastral job submission (Soon, 2012).

## 4. CONCLUDING REMARKS

Singapore’s legislation allows for creation of 3D parcels such as strata parcels and airspace/subterranean parcels since 1967 and 1994 respectively. The descriptions and characteristics of the 3D parcels are defined in Khoo (2011). However, the current cadastral survey processes are only required for submission of 2D plans and 2D GIS data. Professionals involved in civil and construction work such as architects and engineers have started to use 3D design tools in their work. They have adopted building information models (BIM) to increase productivity and improve capability in 3D design. 3D land developments put enormous pressure on the cadastres not being able to effectively accommodate 3D information (Aien et al., 2011). The existing 2D + 1D cadastral survey system is inadequate to support the rapid and dense development in our city state (Khoo, 2011). Furthermore, the key driver for cadastre system innovation and development is technologies and applications convergence. Thus, it is impossible not to move forward with system development that adopts 3D GIS in Singapore.

A holistic approach is needed to implement a full 3D cadastre that captures 3D parcels in 3D geometry/GIS. Essentially, the “Smart Cadastre” vision will transform the current system based on 2D + 1D to a full 3D system. The “Smart Cadastre” will be a critical mechanism to support the drive for optimisation of land use in Singapore. The “Smart Cadastre” vision sets out the characteristics for a future cadastral survey system. It helps us in our work plan for the next 4 years. However, this is not the end point. “Smart Cadastre” will serve as a base and facilitate further development of our cadastre system towards “Ubiquitous Cadastre” that support advance data mining and analysis as illustrated in Figure 5.

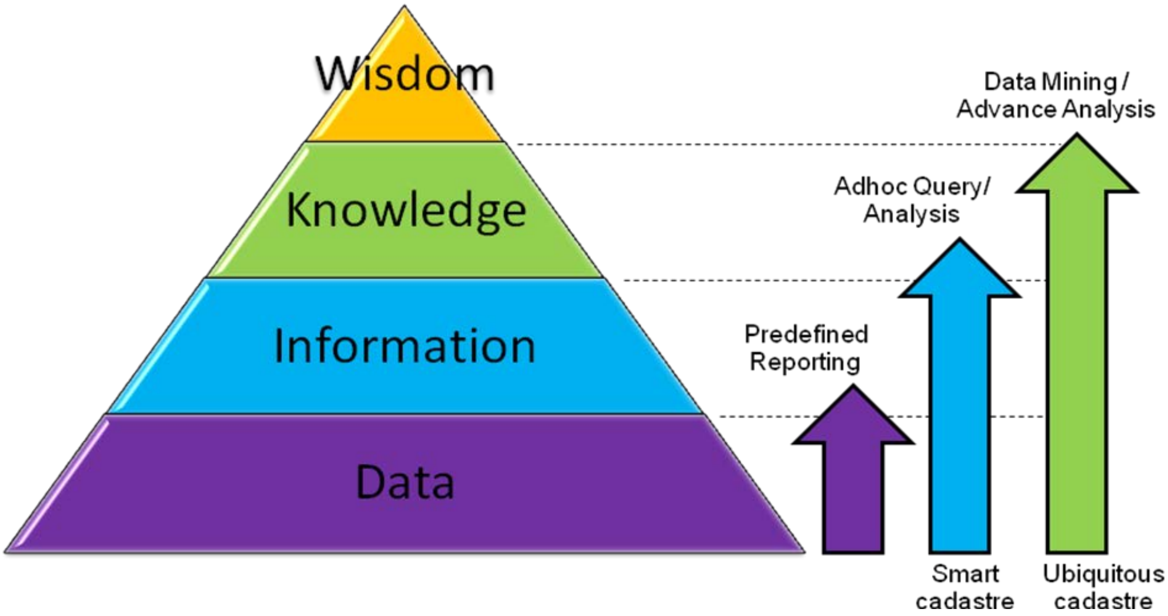


**Figure 5. The data-information-knowledge-wisdom hierarchy**

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## BIOGRAPHICAL NOTES

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