A roadmap to accomplish 3D-Cadastres

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Key words: 3D, Cadastre, land, property, roadmap

SUMMARY

Urbanisation is regarded as a significant global trend. This means cities around the world will be accommodating more population. The population demands accommodations as places for living and business activities. Cities have limited land and therefore high-rise structures have become major infrastructures addressing the needs arsing from urbanisation. However, high-rise developments challenge the current land administration systems where methodologies for determining, recording and disseminating people's entitlement in land are predominantly based on 2D methods or simplified 2D representation of 3D complexities. The adoption of the 2D approaches will not stay sustainable. High-rise developments demand a paradigm shift so the complexities they posses in terms of entitlements of people in the 3rd dimension of height can be managed in 3D-Cadsatres. This paradigm shift requires a holistic study on the nature of the high-rise developments including both institutional and technical aspects. This paper presents a roadmap for accomplishing 3D-Cadsatres. For developing the roadmap, the paper uses a case study in Australia where requirements and stakeholders of high-rise developments in relation to 3D-cadsatres area analysed. Technical and institutional issues are presented and a roadmap to achieve 3D-Cadastre is discussed.

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1. SETTING THE SCENE

World urban populations demand apartments and high-rise structures. In 2013, more than 3.5 billion people, about half of the world's population, live in cities. Many complex apartments and structures are being renovated, extended or built to accommodate people and businesses. Between 2006 and 2011, Australia has observed a 15 percent increase in the national average of residential multi-unit and high-rise developments which accommodate more than 3.5 million people (Figure 1). Renovation, extension or construction of these complex structures demand a smarter cross-disciplinary integration in the land development industry including architecture, construction, engineering, surveying and building management disciplines. This includes integration along the supply chain, better documentation and design, the use of technologies and effective communication.

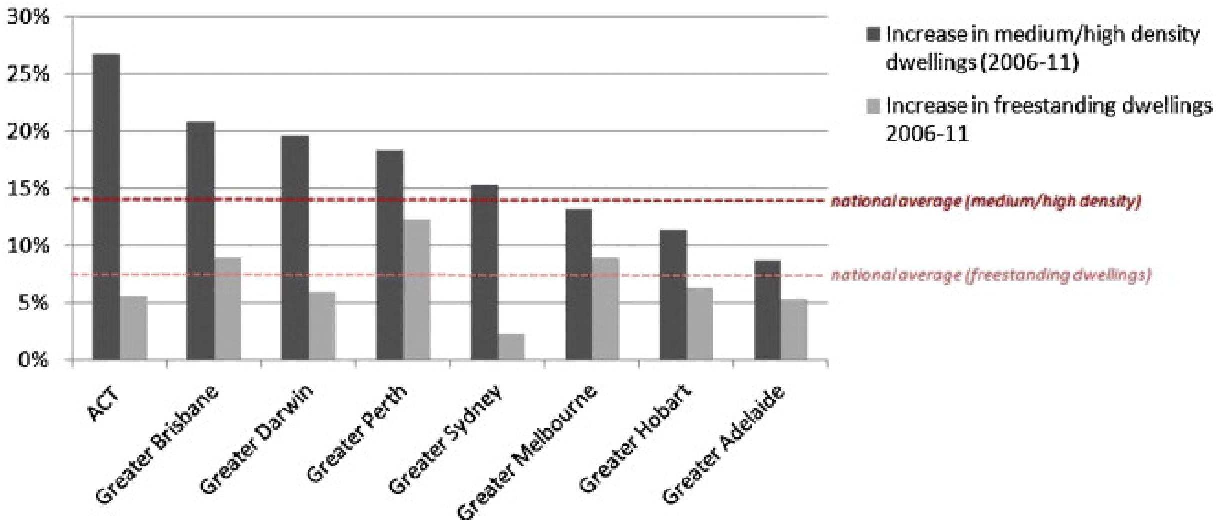

Figure 1: Development density trends for the period 2006 – 2011(Ho et al. 2015)

Addressing these demands creates unique challenges that cannot be met by current practices based on 2D drawings and plans. The challenges involve inter-related property rights, restrictions and responsibilities and complex engineering and architectural features relating to land, interior and exterior of buildings. Incorporating 3D models into the land development industry addresses such challenges by providing data that better describes land and buildings in 3D.

Cadastres play an important role in the land development process. Cadastres define the boundaries of entitlements in land and space. 2D maps and plans are the dominant approaches in the current cadastres. They however fall short in addressing the future needs of the land development and community expectations which are driven by the 3D technologies.

While there are initiatives around the world to enable cadastres with 3D technologies, these initiatives often address specific aspects of the cadastres such as 3D visualisation and 3D data models. There is a knowledge gap as how 3D-Cadastres can be achieved in a comprehensive and holistic approach considering institutional and technical aspects.

The aim of this paper is to present a roadmap that describes the milestones to accomplish 3D-Cadastres. The rest of the paper is organised as follows Section 2 briefly describes the research methodology. Sections 3 and 4 respectively discuss institutional and technical findings. Section 5 presents the roadmap and Section 6 presents the concluding remarks.

2. METHODOLOGY

In developing the roadmap, we undertook an empirical research where we studied both institutional and technical aspects of 3D-Cadastre. To do this, we identified and studied stakeholders involved in the land development process. This includes land developers, architects, engineers, surveyors, building managers, urban planners, local governments and land registries. We undertook surveys and interviews to collect the information required for this study. We selected Victoria as a case study jurisdiction with particular attention to the City of Melbourne which is the mostly populated part of Victoria (Figure 2). We interviewed over 50 experts for the institutional and technical analysis. The study excludes underground utility networks. However, it is focused on the high-rise buildings including underground facilities within the buildings.

Figure 2: Case study area, Victoria, Melbourne

3. INSTITUTIONAL STUDY

The institutional study is based in the framework developed by (Scott 2013) which includes regulatory, normative and cultural aspects. Within this framework, we asked about the stakeholders' experiences with the current methods of dealing with high-rise development, 3D data, barriers and constraints of the current methods, and opportunities to improve the current approaches using 3D technologies (Ho et al. 2015).

Victoria's regulatory framework for land administration allows for the registration of interests in the 3rd dimension of height. In other words, the current legislation accommodates the 3D-Cadastre. However, the regulatory framework does not lay out a detailed specification for collecting and visualising the digital information of complex structures. The stakeholders exploit flexibilities of the current framework to accommodate growing complexities in 3D, but the framework does not specify the requirements for 3D digital data (Ho et al. 2013).

Normative elements were also studied. Current 2D methodology that is normally used within the stakeholders is extended to illustrate 3D complex properties using cross-section. It was evident in the outcomes of the study that the dominant 2D approaches adequately represent the most types of cadastral survey plans. Therefore, the 2D approach has created a norm that the 2D representation of 3D data is much easier to deal with and understand. The stakeholders found the current method satisfactory for the majority of the development but at the same time they argued it will become inefficient in the future.

Cultural elements include the shared set of methods and practices which can be observed in the land administration industry. We studied the current practices of collecting, sharing and data about high-rise and registering 3D interests. There are well established routines within the stakeholders for dealing with these types of developments. An introduction of 3D digital data in the current process will bring along significant changes for the stakeholders.

The result indicates that the current process of dealing with 3D data can become frustrating and complex. It heavily relies on individuals' skills and abilities. Most importantly, it does not meet community expectations. The plans of high-rise buildings are only prepared for the registration purpose and other stakeholders cannot adequately use them. At the same time, the current processes are constraint by legislation and demographics of the stakeholders. Despite this, the current process is identified as satisfactory. The major institutional barrier identified is the absence of a strategic actor to lead the way in accomplishing 3D-Cadastres.

4. TECHNICAL ANALYSIS

To analyse the technical aspects we took a similar approach and conducted a survey of technical requirements of 3D-Cadastre with the stakeholders. This involved required data, methods for sourcing the data, platforms for visualising and analysing the data and user interface of the platforms. We then took a prototyping approach where we developed a 3D-Cadastre tool based on the results of the survey. We then evaluated and validated functionalities of the 3D-Cadastre tool with the stakeholders.

Investigating the technical impediments in implementing 3D-Cadastre, we found that the lack of a clear scope as the major inhibitor. It is not clear as what types of objects should be registered in 3D-Cadastres and what level of details should the objects include. An ambiguous understanding of the 3D-Cadastres provides conflicting expectations (Aien et al. 2013a). The study shows that 3D-Cadastres should include both legal and physical objects represented by the geometry and semantics. The ability to navigate within two hierarchies facilitates selection of appropriate information. In accordance with this requirement, we developed a 3D cadastral data model (Aien et al. 2013b). The 3D cadastral data model identifies and describes above and underground legal and physical objects.

Building on the data requirements we undertook a comprehensive study as how the data can be sourced. We developed a framework of the requirements for sourcing 3D land and property information. The results highlight methods based on photogrammetry, laser scanning, mobile mapping and Building Information Modelling to source the 3D data (Jazayeri et al. 2014).

Building on the data model requirements, we developed a set of features for interactive 3D cadastral visualisation. The requirements were classified into three categories. This first category includes specific features such as underground, cross section and isometric views. The second category is about general visualisation requirement for 3D data and the last category is about usability and interoperability of the 3D cadastral visualisation system (Shojaei et al. 2013). Building on the requirements we then developed and evaluated a prototype 3D-Cadastre visualisation system (Figure 3) (Shojaei et al. 2014).

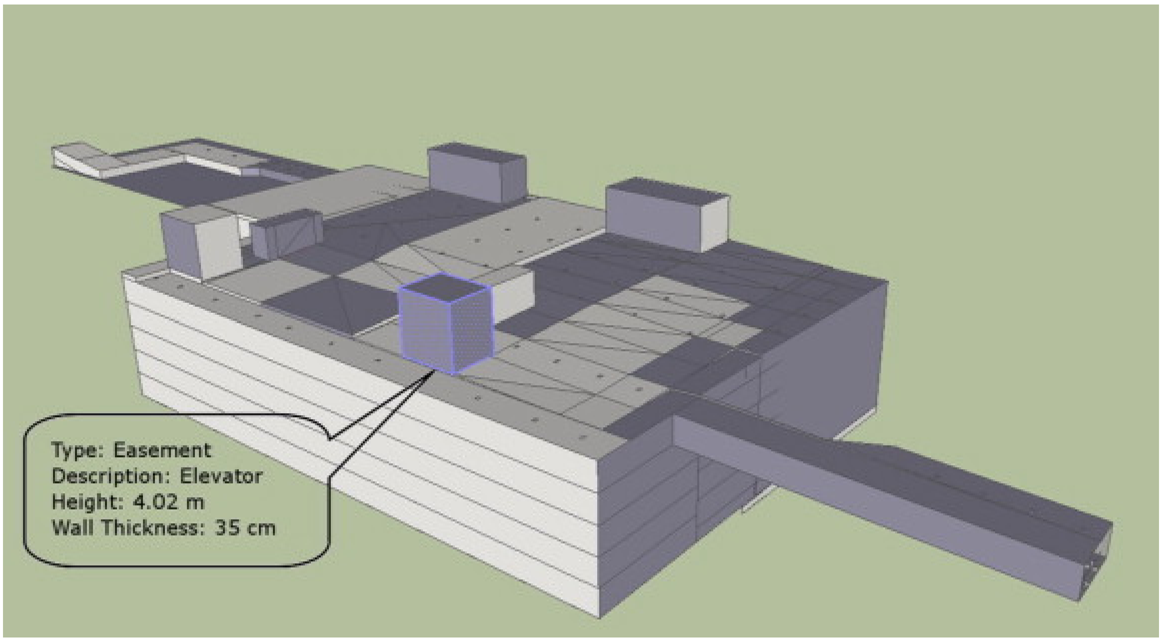

Figure 3: A prototype 3D-Cadastre visualisation system (Shojaei et al. 2014).

5. ROADMAP

Our findings suggest that there already exist an analogue 3D-Cadastre in Victoria where boundaries of entitlements in land and space are described using cross- section, or similar 2D approaches. This means that the legislation is in place and supports the 3D-Cadastre. However, the legislation constraints the way the 3D data is collected, presented and maintained. At the same time, we observed resistance to institutional changes where benefits of cross-disciplinary interaction between the stakeholders of 3D-Cadastre are not realised nor acknowledged. In addition, community expectations in relation to 3D data are not fully understood. We also observed that the required technologies for 3D-Cadastre exist. There are major initiatives related to 3D digital data in Australia that can facilitate accomplishment of 3D-Cadastre. This included ePlan, BIM, laser scanning, and visualisation technologies such as WebGL.

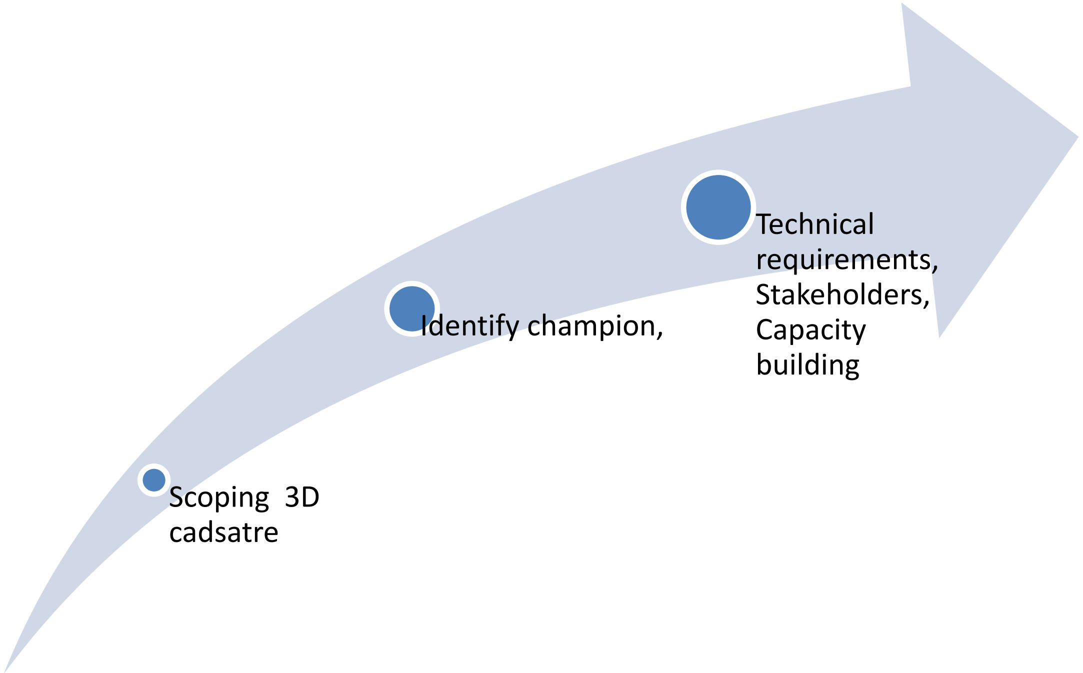

Figure 4: The roadmap to 3D-Cadastre

Based on our finding we have identified three key milestones for the Roadmap. The first milestone is about the scope of the 3D-Cadastre. In establishing 3D-Cadastre, the scope should be limited to complex urban and multi-storey built environments. We identified 3D-Cadastre will not be cost effective, nor it will be efficient for other environments such as low level built environments or rural areas. To reach the second milestone, there is a need for a body or organisation to take the lead in the development of the 3D-Cadastre. The leadership should place emphasis on extending the role of the surveying industry in the architecture, engineering and construction and investing in understanding of the community expectations. The last milestone includes fulfilling technical requirements; this involves extending 3D capabilities of ePlan with BIM and engaging in the international initiatives such as InfraGML. Capacity building in both industry and higher education in the areas of 3D digital data such as ePlan and BIM is essential in this milestone.

In the end, we also identified areas for future research. This includes research and development in the technical infrastructures e.g. visualisation services, 3D databases, data delivery mechanisms and data validation.

6. CONCLUSIONS

Current 2D approaches in land administration are not adequate for the growing number of high-rise and complex infrastructures. There are technical and institutional impediments. The exiting regulatory frameworks have not been designed for managing the requirements of complex buildings. In addition, 2D approaches have become norms and are dominant in the current practices. While 2D methods are perfectly valid and efficient for non complex and low-rise development, high-rise developments require a paradigm shift in the current Cadastres. Technical requirements as what data to be collected, how to be collected and the level of details to be visualised are not very well specified. On top of this, there is the absence of a champion in leading the realisation of 3D-Cadastres which is evident in the research.

Considering these issues the paper presented a roadmap to accomplish 3D-Cadastres. The roadmap sets three millstones; 1. To limit the scope of the 3D-cadsatre to only high-rise and complex buildings, 2. To identify the champion to lead the way towards the 3D-Cadastre and, 3. To consider technical requirements and capacity building in accordance with needs of stakeholders.

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BIOGRAPHICAL NOTES

Mohsen Kalantari is a lecturer in Geomatics at the Department of Infrastructure Engineering and Associate Director at the CSDILA. Dr. Kalantari teaches Land Administration Systems (LAS) and his area of research involves the use of technologies in LAS and SDI. He has also worked as a technical manager at the Department of Sustainability and Environment (DSE), Victoria, Australia.

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