TOWARDS 3D-ENABLED URBAN LAND ADMINISTRATION

INVISIBLE CONSTRAINTS AND STRATEGIC CHOICES

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ABSTRACT

In cities around the world, the confluence of myriad factors – including physical constraints of land, affordable housing, the desire for architectural articulation as a status symbol, political platforms that encourage infill development, urbanisation pressures, population growth and sustainability imperatives – serves to stimulate developments with structural and functional designs that produce ever more complex land and property rights, restrictions and responsibilities (RRRs). Of great concern are those RRRs associated with high-rise buildings as they become adopted for residential purposes and are set to be the dominant urban form.

Complex RRRs are often abstract cognitive concepts. The extent of these RRRs exist as invisible volumes of (3D) space whose legal definition relies on paper-based plans using area-based (2D) concepts. The limitations of these current practices are becoming apparent – there is growing recognition, concern and evidence that complex 3D RRRs are not being clearly recorded and represented. Accurate, unambiguous and comprehensible information about land and property RRRs plays a key role in every society, least of which is to underpin well-functioning land markets as a pillar of national and global economies; it is also the foundation of land administration systems.

To provide more proficient land and property systems better able to deal with such complexity, the land registration industry, which produces, registers and manages RRRs, is at a crossroad: how to negotiate change to leverage 3D technological innovations. To date, a tendency to focus on technical developments has left unattended the social and cultural – institutional – issues that are fundamental to successful innovation. Yet throughout the history of innovation, these are the **very** issues consistently found to lie at the heart of progress. As such, no jurisdiction has yet to successfully implement 3D innovations for representing property ownership.

This thesis addresses this knowledge gap. It documents an exploratory study that aims to develop understanding of institutional issues in the context of urban land administration as an important precursor to facilitating the development of strategies to support change. This study uses a multiple case study approach: two interpretive case studies were undertaken as studies into key land administration functions that support urban high-rise development, before findings to the research questions were developed through cross-case analysis and synthesis.

The City of Melbourne provided the context for understanding institutional barriers to change relevant to regulatory subdivision and registration processes, while the city-state of Singapore provided the context for understanding institutional aspects of strategies perceived to be successful in inducing conformity to 3D innovation relevant to regulatory development processes. Data was collected through several channels including interviews, organisational documents and publicly available materials, industry placement programs and participant observation. Institutional theory provided a framework for conceptualising and analysing the range (and basis) of institutional issues around changing longstanding 2D practices in a regulated, multi-stakeholder environment. Thematic analysis of the data supported the emergence of key themes that directly responded to the research objectives.

The research revealed that resistance to change is essentially associated with a limited build up of legitimacy around the need for change, a consequence of history serving to consolidate and deeply-embed current 2D-based practices, conditioning industry, organisations and professions to accept this as 'appropriate' behaviour. This undermines the ability to build the requisite legitimacy to compel and motivate change towards a 3D-based land and property paradigm, a fundamental requirement of institutional change. This is perceived to be immensely difficult to shift.

Yet the research also revealed that it is possible to shift these seemingly intractable institutional issues if the appropriate institutional pressure is exerted. The findings indicate that the characteristics of the land administration industry, such as dependency on the state for regulatory approval and the clear dominance of professions, are likely to be responsive to strategies that exert coercive and normative institutional pressure as a way of inducing conformity to change. Most importantly, the research showed that change was possible in a reasonable timeframe if sufficient legitimacy was cultivated around the reasons for change. However, visible, incisive leadership is then required to direct this into clear actions to make change a reality.

Consequently, one of the key outcomes of the research has been to use the findings derived from cross-case analysis and synthesis to develop a framework of strategic institutional principles that is intended to guide key decision-makers in designing a change path. Cultivation of legitimacy around 3D innovation must necessarily be a first principle in any roadmap designed to support the realisation of 3D-enabled urban land administration.

DECLARATION

This is to certify that:

- The thesis comprises only my original work towards the PhD except where indicated in the Preface.
- Due acknowledgement has been made in the text to all other material used.
- The thesis is fewer than 100 000 words in length, exclusive of tables, maps, bibliographies and appendices.

Serene Shih Lynn Ho

Melbourne, November 2014

PREFACE

1. The following is a list of published works that has been produced as part of this thesis:

i. Journals

- Ho, S., Rajabifard, A. and Kalantari, M. (2015). 'Invisible' constraints on 3D innovation in land administration: A case study on the city of Melbourne. *Land Use Policy, 42*(January 2015), 412-425.

- Ho, S., Rajabifard, A., Stoter, J. and Kalantari, M. (2013). Legal barriers to 3D cadastre implementation: What is the issue? *Land Use Policy, 35*(2013), 379-387.

ii. Peer-reviewed Book Chapters

- Ho, S. and Rajabifard, A. (2012). Delivering 3D land and property management: A consideration of institutional challenges in an Australian context. In P. Van Oosterom, R. Guo, L. Li, S. Ying and S. Angsüsser (eds.), *Proceedings of the 3rd International Workshop on 3D Cadastres* (pp. 219-242), 25-26 October, Shenzhen, China 2012. Copenhagen, Denmark: International Federation of Surveyors.

- Ho, S. and Rajabifard, A. (2012). 3D land and property information system: a multi-level infrastructure for sustainable urbanisation and a spatially enabled society. In D. Coleman and A. Rajabifard (eds.), *Spatially enabling government, industry and citizens: Research and development perspectives*. GSDI.

iii. Conference Proceedings

- Rajabifard, A., Kalantari, M., Marwick, B., Ho, S. and Williamson, I. (2014). Let's talk about land and property information in 3D: What should the future look like? *Proceedings of the 25th FIG International Congress, Engaging the Challenges, Enhancing the Relevance*. Kuala Lumpur, Malaysia, 16-21 June 2014.

2. This thesis has benefitted from voluntary third-party editorial advice. This advice was provided by Ms Fiona Lawry in accordance with Standard D (Language and Illustrations) and Standard E (Completeness and Consistency), as set out by the Melbourne School of Graduate Research, The University of Melbourne.

ACKNOWLEDGEMENTS

For a thesis whose focus centres on making salient the range of institutional influences on behaviour, it seems only appropriate that these first pages highlight how the undertaking of the research has been shaped by my own. These have all in some way or other, provided structures that facilitated opportunity, ability, incentive and support. The thousands of words that constitute the body of this work carry the inflection of many; here, I acknowledge the importance of all their contributions.

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Finally, to my family, Fiona and Reuben, where every hour spent on writing this thesis at home was an hour spent at their expense. But in all truth, this would have been an incredibly insane undertaking but for Fiona's unflagging belief, support, patience, encouragement and love.

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LIST OF ACRONYMS

2D	Two-dimensional
3D	Three-dimensional
ABS	Australian Bureau of Statistics
AEC	Architecture, engineering and construction industry
AHURI	Australian Housing and Urban Research Institute
BCA	Building and Construction Authority, Singapore
BIM	Building Information Model (a product) or Building Information Modelling (a process)
CBD	Central business district
CIFE	Centre for Integrated Facility Engineering
CoM	City of Melbourne
CRC-CI	Co-operative Research Centre on Construction Innovation
DCDB	Digital cadastral database
DTPLI	Department of Transport, Planning and Local Infrastructure (Victoria, Australia)
FIG	International Federation of Surveyors (Fédération Internationale des Géomètres)
ICT	Information and communication technology
ICSM	Intergovernmental Committee on Surveying and Mapping
NSTC	National Science and Technology Council
PDF	Portable Document Format
RRRS	Rights, restrictions and responsibilities

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CHAPTER 1

INTRODUCTION

The increasing complexity of infrastructures and densely built-up areas requires a proper registration of the legal status (private and public), which only can be provided to a limited extent by the existing 2D cadastral registration.

Homepage of the International Federation of Surveyors' Joint Commissions 3 and 7 Working Group on 3D Cadastres

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1.1 THE NEED FOR 3D-ENABLED URBAN LAND ADMINISTRATION

High-rise buildings, tunnels, flyovers, public spaces, rooftop gardens, car parks, underground malls – these are all examples of the types of complex structural developments that have a prolific presence in cities around the world. The physical constraints of space, affordable housing, the desire for architectural articulation as a status symbol, political platforms that encourage infill development, response to urbanisation and population growth, sustainability drivers… the confluence of these myriad factors in the urban context stimulates structural and functional designs that produce increasingly complex land and property rights, restrictions and responsibilities (RRRs).

For these complex urban developments, the boundaries of RRRs, essentially cognitive in nature, are, in reality, layers of invisible, intersecting, interleaving, oddly shaped discrete volumes of space that cross over different physical planes and structural levels. Responsibility for defining, abstracting, recording, representing, examining, registering and managing RRRs is the core function of any land administration system, and as such, the industry comprising surveyors, land registries, local government units, planners and strata managers[1], amongst others, is also often referred to collectively as the land administration industry (adopted in this thesis). Accurate, unambiguous and comprehensible information about the legal extent and ownership of RRRs plays a key role in society, least of which is to underpin well-functioning land markets.

Traditional land administration practices in defining, recording and representing RRRs are proving to be insufficient for these complex urban RRRs. These practices have their origins in area-based, two-dimensional (2D) concepts for organising land and property information. The consequences of using 2D concepts for volumetric spaces that require definition in three-dimensions (3D) have been widely documented in the literature and are detailed in Chapter 2, but can be summarised here as:

- Abstract (plan) version of reality can only be unambiguously clarified by the surveyor who produced the original drawings.
- Representation of complex vertical developments are provided using planar views and cross-sections, which are difficult to understand.
- Adequate representation of the legal extent of all RRRs in complex buildings requires numerous pages of 2D subdivision plans, which are pushing the boundaries of

[1] Strata managers are professionals engaged in the administration of common property in strata developments under the direction of the Owners Corporation (comprising all lot owners in a development) according to

representative and cognitive efficiency.

- Complex 3D RRRs are not adequately visualised in cadastral maps, or not visualised at all.
- Current cadastral systems use a range of technical methods to register 3D RRRs, where technical ambiguities leave open potential threats to security of tenure.
- Lack of adequate processes developed to support the definition of 3D RRRs.

As cities are projected to host 70 per cent of the world's population by 2050, the need to move beyond the current paradigm is becoming more urgent as it is likely that most of this population will be housed in high-rise buildings. This motivates the need to have accurate recording, representation and registration of 3D RRRs to ensure the continued integrity of urban land administration systems; that ownership of such properties remain secure; that the full range of RRRs are understood by the community to facilitate management of private, public and common properties.

1.2 PROBLEMS IN REALISING 3D-ENABLED URBAN LAND ADMINISTRATION

The land administration industry, along with those industries that are key stakeholders in producing and managing information about the built environment, are now engaged with negotiating a paradigm shift from traditional 2D methods towards a 3D environment. It is only now with the maturation and accessibility of 3D technologies that significant effort and resources are being invested to leverage 3D technologies to better represent, and manage, information about the built environment[2]. From 3D city models to specific detailed models about individual buildings, these models appeal at a very primitive logical level: they more accurately reflect the world around us, and therefore can better facilitate our understanding this environment. However, there are several issues that are presenting as obstacles to progress.

Efforts within the land administration industry to move from 2D to 3D have been mainly technical in nature, resulting in significant developments over more than ten years of research: data models that can accommodate 3D information about property rights, restrictions and responsibilities (RRRs) (van Oosterom et al, 2013), data models that integrate legal and structural information (Aien, 2013), and the development of prototypes to prove the technical viability of these data models for land administration purposes (e.g. Stoter et al, 2013; Shojaei et al, 2013).

[2] The definition of the 'built environment' here refers to anything that has been constructed by humans including buildings and infrastructure (adapted from Collins English Dictionary).

In terms of technical realisation, the international land administration industry is yet to be unified behind a single technological approach with various approaches still being investigated. In contrast, the land development industry (differentiated in name but it is technically considered to be another function of land administration) comprising architects, engineers and construction companies, has witnessed 3D innovation crystallising around the use of Building Information Models (BIM) and BIM is gaining widespread adoption and implementation in the operations of the land development industry internationally.

The issues also extend beyond technical limitations to reflect deeper social and cultural issues. For example, even though the limitations of 2D representations of complex building information have been recognised as a significant issue in the land development industry since at least the 1980s (Eastman, 1999), developing new practices that overcome these limitations has not only been a technical exercise, but has also necessitated the confrontation of long-held traditions and practices oriented around 2D ways of thinking and working. Significantly, the ability to successfully exploit 3D technologies throughout the information supply chain demands a more collaborative approach, which is proving difficult especially for the development industry (comprising architects, engineers and construction companies) well known for its 'silo' mentality and culture of fragmentation (e.g. Egan, 1998; Eastman et al, 2011).

Likewise for the land administration industry, these challenges are exacerbated by the fact that land administration processes around tenure and property ownership, such as subdivision and registration, are often governed and defined within legislative frameworks, given the central role that property rights play in generating economic wealth (De Soto, 2000). The ability to successfully negotiate change is therefore predicated on a cultural shift at all levels: personal, organisational, professional and regulatory commitment to change – otherwise known as institutional issues. It is these institutional issues that this thesis pursues in the bid to support the ability of the land administration industry to leverage 3D technologies and develop a change path towards 3D-enabled urban land administration.

1.3 MOTIVATION FOR RESEARCH

The inability to realise 3D-enabled urban land administration has been primarily attributed to the fact that RRR information is governed by legal frameworks (FIG, 2011). These frameworks are contextually variable across different jurisdictions and there is a diversity of practices with regards to the definition of boundaries for multi-storey or 3D properties, and their subsequent rights, restrictions and responsibilities (Fendel, 2002; Banut, 2011). Further, a review on relevant literature by Paulsson and Paasch (2011) demonstrated a clear imbalance in current research efforts, one that has been biased towards technical initiatives to the detriment of progressing the range of non-technical issues pertaining to 3D innovation.

Since van der Molen (2003) first argued the importance of investigating institutional issues more than ten years ago, there has been little research undertaken to develop this aspect of the research agenda. Additionally, although literature relevant to land administration has identified some social and cultural issues, there remains a lack of in-depth understanding as to how these issues work individually, or integrate to pose barriers to innovation. It is also not known whether these issues impact innovation because they reinforce current 2D based practices and processes, or if they create obstacles in terms of conditioned behaviour that limits the identification of strategies that supports innovation.

The importance of addressing institutional issues has been a recurrent theme throughout the history of technical innovation (e.g. Giddens, 1984; Pinch and Bjiker, 1987) since the challenge of innovation is not only in creating new physical products, but also the development of supporting processes, which requires not only a change to existing organisational processes and structure, but also at a more individual level, a change to the cognitive models that relate to the function of the innovative product (Henfridsson et al, 2009). This has led to the increasing use, adoption and application of institutional theories to help explain non-technical barriers to change (e.g. Nelson, 1988; Orlikowski and Robey, 1991; Dosi, 1992; King et al, 1994; Edquist, 1997; Damsgaard and Lyytinen, 2001; Nelson and Nelson, 2002).

Evidence of the importance of understanding these issues can be seen in the growing literature on BIM adoption and implementation where it has been found that success is contingent on transforming deeply embedded, fragmented, 2D-based work processes into collaborative ones (Eastman et al, 2011). This is proving to be far more challenging, leaving the land development industry with a growing recognition that identifying and understanding the social and cultural bases of deeply entrenched behaviour and attitudes will be fundamental to supporting widespread adoption of these innovations (Clark, quoted in NBS, 2013).

1.4 RESEARCH PROBLEM, AIM AND OBJECTIVES

For the land administration industry, moving towards 3D-enabled urban land administration is required to ensure that 3D land and property RRRs can be recorded, represented, registered and managed in the same accurate, authoritative and unambiguous way that current 2D RRRs are, and which arguably, the community expects it to be.

However, the research agenda to date has been dominated by technical investigations and developments, leaving unattended the underlying institutional issues that can impose a range of 'invisible constraints' on innovation – those intangible social and cultural structures that impose a conscious or unconscious influence on behaviour (referred to in this thesis as institutional issues). As such, no jurisdiction has yet successfully implemented 3D innovations for representing property ownership and all its affiliated RRRs (FIG, 2012).

Fundamentally, these institutional issues implicitly supports the continued reliance and use of current 2D-based practices and processes for recording and representing land and property RRRs. This 2D paradigm is highly entrenched, the consequence of longstanding traditions and practices that have led to the development of professional standards for regulating the production and revision of 2D drawings, as well as professional norms in terms of thought and workflow processes that are particular to 2D drawings (Henderson, 1999). These mechanisms serve to continually reinforce the 2D paradigm, which makes creating a sustainable path towards a new 3D paradigm contingent on identifying the range of institutional elements that result in resistance to change.

Therefore, the **research problem** is defined as:

> The adoption and implementation of 3D technologies in the land administration industry to enable accurate, authoritative and unambiguous recording and representation of 3D land and property RRRs is fundamental to ensuring security, comprehension and ongoing commoditisation of complex vertical tenure arrangements common in urban environments.
>
> **However, efforts to realise 3D-enabled urban land administration are being inhibited by existing institutions that have developed and become entrenched over time, particularly those that continue to support and reinforce the use of 2D-based land administration practices and processes.**

Subsequently, the **main aim** of this research is:

> **To investigate the current environment underpinning urban land administration to identify potential institutional barriers to 3D innovation as well as potential strategies to support change.**

where:
"the current environment" refers to the current practices, processes and associated and/or dependant range of social influencers of the land administration industry including organisational, professional, cultural and regulatory elements;

"urban land administration" refers to the information and processes required to support subdivision, registration and ongoing management of those complex RRRs characteristic of urban areas; and

"3D innovation" refers to technological innovation using 3D digital information and communication technologies.

The aim can be reformulated as two key **research questions**:

1. What are the institutional issues in the current 2D-based land administration environment that are perceived to be inhibiting 3D innovation?
2. What might constitute potential strategies for addressing institutional barriers to 3D innovation for land administration?

To meet the aim of the research and address the research questions, the research is guided by the following **objectives**:

1. **Identify** the strengths and weaknesses of the current 2D paradigm relevant to urban land administration.
2. **Identify** an appropriate theoretical framework that supports investigation and pursuit of the research aim and objectives.
3. Explore the current land administration environment to **identify** those institutional elements that pose as barriers to 3D-enabled urban land administration.
4. Explore an instance of a 3D-enabled urban land administration environment to **identify** the basis of strategies able to produce a positive response to institutional change.

5. Based on the findings, **recommend** potential strategies for responding to institutional barriers in the land administration industry to support change towards realising 3D-enabled urban land administration.

1.5 RESEARCH APPROACH

The research approach in this thesis is framed around the use of interpretive case studies. The literature on 3D-enabled urban land administration to date shows a dominant focus on external phenomena such as technology and processes. This reflects a pervasive positivist approach in research initiatives, which is widely acknowledged to be limited in its ability to produce outcomes that provide sustainable solutions to the challenges of technological innovation (e.g. Davis and Songer, 2002, but further explained in Chapter 4).

A positivist approach tends to also overlook the reality that the relationship between people and technology is constantly shifting in response to environmental pressures (Myers, 1994). In the domain of information systems, the dominance of this research approach has tended to reduce complex organisational landscapes to simplistic causal analysis based on external and observable phenomena only, with little or no consideration is given to the social underpinnings of these phenomena (e.g. Galliers, 1991; Orlikowski and Baroudi, 1991).

Therefore, this research rejects positivism, selecting instead, an interpretive approach since it directly responds to these perceived limitations. This offers the potential to develop other insights to contribute to the current body of knowledge around realising 3D-enabled urban land administration systems. The research and conceptual approach for this thesis is illustrated in Figure 1.1.

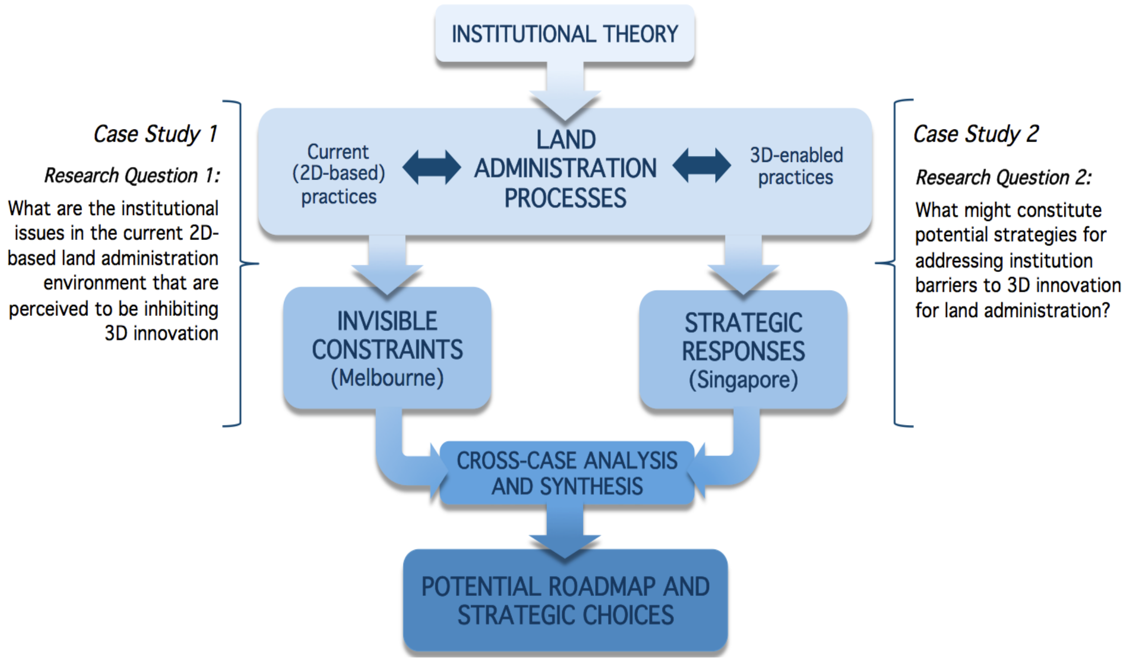

Figure 1.1 Research approach.

Figure 1.1 shows how institutional theory is used to conceptualise and analyse relevant land administration processes in the context of two individual case studies. Each of the case studies is intended to directly respond to one of the key research questions. The outcomes are then subjected to cross-case analysis and the outcomes synthesised to inform the development of a potential roadmap and strategic choices.

In terms of the theoretical framework, institutional theory has been selected to provide the theoretical foundations to facilitate the investigation. The application of institutional theory has proven to be adept at developing understanding of the social characteristics of organisations and to help explain diffusion of new technologies with the domains of information technology and information systems (e.g. Björck, 2004; Mignerat and Rivard, 2009). This will be expanded upon in greater detail in Chapter 3. Specifically, organisational institutionalism, one of the variations of institutional theory, is used to conceptualise the range of social and cultural issues, as well as provide a theoretical framework to support analysis of the data. Organisational institutionalism recognises that organisations are "rationalised" systems but that "models of rationality are themselves cultural systems, constructed to represent appropriate methods for pursuing purposes" (Scott, 2004b: 465). Case studies assist in understanding these models of rationality and socially-constructed systems.

Therefore, to support data collection, a multiple case study approach was used, with the case study sites selected to illustrate contrasting situations. The case study on the City of Melbourne was the primary case study site as it was used to develop in-depth understanding and knowledge around institutional constraints on 3D innovation in land administration (specifically around the land administration function of land tenure). Unstructured interviews with a cross-section of industry stakeholders were used to elucidate perceptions on this issue.

In contrast, the smaller, secondary case study on Singapore was used to explore strategies that stimulated a positive response to 3D innovation in land administration (in this instance around the land administration function of land development). Again, interviews were used to explore the range of strategic activities and perceptions of industry stakeholders regarding those institutional aspects that were successful in supporting change.

In addition to interviews, data was also collected through other methods. A range of public and private documents and data sources were collected for documentary analysis. In the City of Melbourne, industry placements with key organisations in Melbourne also facilitated opportunities for participant observation.

Thematic analysis of the data through an iterative process of data-driven manual coding supported the emergence of key themes relevant to the research objectives. Organisational institutionalism was applied to guide the interpretation of the findings. Cross-case analysis and synthesis of the case study findings was used to extrapolate the findings regarding elements of institutional barriers, and those institutional pressures that are well suited to respond to such constraints.

This supported the development of a framework of key principles to support change. This framework is intended to provide the land administration industry with the basis of an institutional infrastructure to support efforts to realise 3D-enabled urban land administration. The application of the framework to the City of Melbourne demonstrates how it can support the development of a potential industry roadmap and strategic choices to support change.

1.6 THESIS OUTLINE

The narrative of this thesis is constructed through nine chapters, approximating to four different sections within the thesis.

Section 1: Introduction

The first section, consisting of **Chapter 1,** provides an introduction to the research – the background, the motivations, as well as articulating the research problem, aim and objectives. It provides an overview of the research approach including the methodology and methods adopted in the research, as well as an outline of the thesis structure.

Section 2: Research Background

The case for change in moving towards 3D-enabled urban land administration is stated in **Chapter 2**. It provides an overview into the issues facing current 2D-based land administration systems, particularly in the context of servicing complex urban needs. The chapter also reviews the strengths and weaknesses of the current 2D paradigm as a first step towards better understanding of potential bases for resistance to change. An overview of the current initiatives around the development of 3D digital cadastres as the cornerstone of 3D-enabled urban land administration is provided, demonstrating that progress has been mainly technical to date, with little in-road into introducing 3D innovations sustainably into land administration systems.

Chapter 3 introduces the theoretical framework that underpins the way the research is framed and analysed. Institutional theory, specifically organisational theory is central to this thesis and this chapter presents an overview of the theory and its various components as relevant to the research. The chapter concludes by showing how, through considering some of the issues through an institutional lens, it is possible to make a valid argument for a new dimension in the current research agenda.

Chapter 4 provides an overview of the research design. This research adopts an interpretive approach, leading to the use of exploratory case studies for data collection and the use of thematic analysis for its analysis.

Chapter 5 introduces the case study settings of the City of Melbourne and the Republic of Singapore.

Section 3: Case Study Findings

The case study findings are presented in **Chapters 6 and 7**. In both chapters, key themes that emerged are described, followed by an interpretation guided by institutional theory that aims to respond to the main research questions.

Section 4: Discussion and Conclusion

Chapter 8 provides a discussion on the main findings of the case studies and the lessons derived regarding institutional elements that pose invisible constraints, as well as the range of institutional pressures exerted by strategic choices. Through this, the potential for extrapolating the findings is argued, leading to the development of a framework of institutional principles. This framework is intended to support the development of strategic choices for supporting 3D innovation in the land administration industry. An application of the principles to the context of the City of Melbourne shows the applicability this has for supporting the development of a roadmap to support 3D innovation in the land administration industry.

The research aim and objectives are reviewed in **Chapter 9** to demonstrate how these have been met through the main outcomes of the research. The chapter includes a discussion as to the limitations of the work presented, which leads to the identification of potential areas for future research that would build on this piece of work. The chapter concludes with a research reflection and outlook.

1.7 CHAPTER SUMMARY

This chapter presented the background to the research, including a broad overview of motivations behind 3D innovation in general with regards to complex structures, but specifically those pertaining to the current limitations around 2D-based representations of urban ownership information in the land administration industry. This supported the identification of the current gaps in knowledge, which provide the motivations for the research. This was translated into the research problem, aim and objectives central to this thesis. The research approach designed to address the research aim and objectives were then presented, followed by an outline of the chapters to follow in this thesis.

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CHAPTER 2

THE PERSISTENT 2D PARADIGM: SOCIAL AND CULTURAL ISSUES AROUND 3D INNOVATION IN LAND ADMINISTRATION

It will be the cultural and behavioural changes that many will find most difficult, and yet I believe these will prove to be the most important if we are to be successful.

Nigel Clark (referring to efforts to implement 3D building information models for property development) in NBS, 2013

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2.1 INTRODUCTION

Land administration systems around the world are increasingly aware of the limitations that longstanding 2D methods pose for recording and representing complex tenure arrangements, particularly those ownership rights, rights, restrictions and responsibilities (RRRs) associated with urban areas. These complex RRRs are exemplified in high-rise living in cities, borne of the need to combine private, common and public properties often in the same high-rise development.

To adequately represent these RRRs under the current 2D paradigm produces such complexity in plans that it creates comprehension challenges for both specialists as well as the broader community, which potentially threatens the authoritative and accurate nature of information held by land registries. The emphasis on preserving accuracy and authoritativeness of land tenure information, registered and managed through cadastral systems, is vital since this has been acknowledged as being fundamental to the functioning of land markets (De Soto, 2000).

Over the last decade or so, under the stewardship of the International Federation of Surveyors (FIG), there has been significant effort made to leverage 3D technologies to better represent such complex RRRs in cadastral systems. This has been a worldwide effort – from current literature, it appears there are at least 28 different countries undertaking research and development in this area. However, despite significant technological advancements being evident, there remains no land administration or cadastral system that is yet able to introduce 3D innovations sustainably to its everyday operations. This inability has been attributed to limited legal frameworks, but also increasingly, to the gap of knowledge and stagnant state of research pertaining to other non-technical issues (Paulsson and Paasch, 2011).

This chapter aims to review the current state of knowledge around those non-technical issues perceived to be limiting 3D innovation in land administration systems, particularly cadastral systems supporting definition and registration of land tenure and associated RRRs. Due to the limited literature available, the chapter also draws on literature on similar issues around 3D innovation in other aspects of land administration, significantly in land development. There are therefore three main sections to this chapter: the first provides the backdrop to explain why information around high-rise buildings has become such a focal point; the second discusses the current 2D-based paradigm in managing complex high-rise tenure information using the state of Victoria in Australia to provide some real world examples; the third section presents the range of non-technical issues considered to be a barrier in evolving beyond the 2D paradigm.

The chapter concludes with a summary on the significance these issues have for successful 3D innovation, and ultimately, for realising the move towards 3D-enabled urban land administration.

2.2 GROWING IMPORTANCE OF HIGH-RISE BUILDINGS AS A RESIDENTIAL URBAN FORM

Cities are projected to host approximately 70 per cent of the world's population by 2050 (UN-HABITAT, 2010; UN-FPA, 2011) and consequently, there is also a driving need to negotiate the demands of physical development to foster the necessary social and intellectual capital that has made cities the economic engines of countries around the world. These challenges are none more manifest than in the development and management of high-rise buildings.

Developments in structural engineering at the end of the nineteenth century resulted in the construction of the world's first 'high-rise' building. This concept was famously popularised by Le Corbusier as a development response to population growth in his 'Plan Voisin' for Paris in 1925 (Marmot, 1981). High-rise buildings have long been considered a cost-effective development of land in city centres and metropolitan areas, where land values are typically high, leading to the development of a symbiotic relationship between high-rise buildings and cities.

In the urban context of limited land resources, high-rise buildings offer the ability to leverage the vertical dimension to create useable spaces in response to urbanisation, industrialisation and development drivers. These buildings were traditionally used for commercial purposes, where their agglomerating effect improved business productivity and reinforced the status of cities as vital economic engines (e.g. Ciccone and Hall, 1996; Harris and Ioannides, 2000; Ali and Moon, 2007). At the same time, high-rise buildings provided a canvas for novel architectural design traditionally used as representations of status and power (e.g. King, 2004; Adam, 2008, 2012) – leading to the start of the (ongoing) race for cities to claim the mantle of hosting the world's tallest building.

In modern cities, high-rise buildings continue to facilitate economic imperatives. However, sustainability drivers and urbanisation rates have also led to a shift towards using high-rise buildings for mixed-use purposes but more markedly, an increase in its function for residential purposes (Ali and Moon, 2007). This has also been a consequence of policy platforms around the world that encourage infill development in city centres for housing purposes as an urban renewal strategy and to mitigate against urban sprawl (e.g. Farris, 2001; Easthorpe et al, 2008; AHURI, 2011).

In addition, the agglomerating benefits of high-rise buildings demonstrated in the commercial sector have been shown to be transferable to social and environmental settings: more intensive use of public transport, social inclusion, green building technologies are but some of the key benefits (Colin Buchanan and Partners, 2008; Rahman, 2010). Even in countries like Australia where the high-rise model has never really dominated, increasing urbanisation and the need to facilitate sustainable development means that now, more than ten per cent of the population are living in multi-storeyed (strata) properties (Easthorpe et al, 2012).

2.2.1 High-rise Buildings and Urban Land Administration

Increasing structural complexity and a growing trend towards using high-rise buildings for residential or mixed-use purposes (e.g. Safarik and Wood, 2013) has impacted on the design and layout of private and common property RRRs. Bugden (2005) paints a scenario, which although is located in Sydney, is likely to mirror development in any number of cities around the world:

> "This project (King Street Wharf at Darling Harbour in Sydney) is a mixed use staged development comprising nine tower buildings, the majority of which are built over a common basement that houses shared parking, facilities and equipment. Most, but not all the tower buildings are strata subdivided and most, but not all, are under leasehold strata title. One large building is under freehold strata title. Part of the Sydney public road network passes over the basements and a bus interchange facility and large commercial marina facility interfaces with the complex. The uses comprise retail, commercial offices, serviced apartments, residential apartments, restaurants, entertainment venues and charter boat operations" (p. 5).

These are the types of complex high-rise structures that have become the mainstream model in urban environments. Private, common and public ownership RRRs related to these developments are registered and administered by the land administration industry. These RRRs are created during the development phase of the building. These vertically defined and interleaving RRRs are formalised through a form of property ownership known variously around the world as strata title, unit title, copropriété, condominiums or commonhold, where ownership includes both private property and a share of common property (Dredge and Coiacetto, 2011).

Developments in strata legislation are likely to account for some of the momentum in using high-rise buildings for residential purposes. Although instances of such legislation appear to exist from as early as 200 years ago (a condominium law was passed in 1804 in France) (Webster and Le Goix, 2005), modern legislation in this area is attributed to the Australian model of strata titling, introduced in the 1960s (Christudason, 1996). However, the increasing use of strata titling in more developed countries, like Australia, has been driven by a dominant culture of owner occupancy (National Housing Supply Council, 2008).

The range of public, private and common property RRRs associated with modern high-rise buildings represent an increasingly complex information challenge for the urban land development process in terms of conceptualising, planning, building and registering, with consequences for its ongoing management. Knowledge about these buildings is essentially contrived using 2D, paper-based representations of information about its physical and legal aspects, which are unlikely to be sustainable given ever-increasing structural and functional complexity. In addition, there are also interoperability and productivity issues associated with traditional 2D-based ways of working, which have been estimated to account for approximately 30 per cent of costs during development (e.g. Gallaher et al, 2004; Brown, 2008; Gralla et al, 2010).

The inefficiency of a 2D-based paradigm for representing information about buildings has been acknowledged as an issue by the land development industry since the 1980s, when digital building models were first developed for use as the basis of representing building design information (Eastman, 1999). However the sheer scale of complexity of modern high-rise buildings has brought this issue to a head and the production and management of information about the built environment now appears to be at a crossroad.

2.2.2 "Brick, Mortar, Data": The Rise of the Smart City

The 2D paradigm, constituted of long-held traditions of paper-based and CAD-based drafting processes, as well as reliance on documents-based (paper or electronic) processes of information transaction and management are being disrupted by the maturation of 3D object-oriented and intelligent approaches to modelling and managing information about buildings and infrastructure. The yield of information and data from complex built environments has outgrown traditional methods and are demanding more efficient approaches to information management and analysis for decision-making.

Against this backdrop, attitudes towards developing and managing buildings are also evolving. For example, IBM now champions a "brick, mortar, data" philosophy that seeks to leverage the digital economy and the proliferation of data about buildings that is a by-product of its development (IBM, 2012). Governments are recognising the need to harness the wealth of information relevant to buildings to facilitate design, construction and management aspects of buildings for sustainable development (National Science and Technology Council, 2008).

Such attitudes are encapsulated in the 'smart city' movement, a concept that has evolved from the notion of the 'intelligent city' (Allwinkle and Cruickshank, 2011). Smart cities, have often been perceived to reflect cities that have become successful in using information and communication technologies – particularly those that offer the ability for citizens to connect, such as mobile devices – in aspects of city management and administration (Allwinkle and Cruickshank, 2011). However, there has been a more recent recognition that smart cities arise to respond to the specific challenges facing a city, and do so by using ICT to connect people with place and data, thereby harnessing both social and physical capital to build intellectual capital and support participatory practices in governance of a city's resources (Holland, 2008; Caragliu et al, 2011).

Driven in part by this increasingly varied and voluminous information landscape and the attribution of low productivity rates in the construction industry to the use of 2D methods for representing and transacting building information, the professions involved in development and management of complex buildings and infrastructures are being compelled to participate in a 3D revolution.

This revolution is a confluence of various factors. For example, the arrival of mature and affordable 3D technologies, the development of geospatial databases, and development of relevant standards have all led to the increased focus on the use of 3D Building Information Models as a key framework for producing and managing information for the duration of a building's lifecycle (Bacharach 2007). More importantly, our drive towards 3D information models for land and property management may come down to one simple, salient point: that it more accurately reflects and represents the world we inhabit.

2.3 CURRENT 2D PARADIGM IN LAND ADMINISTRATION

The term '2D paradigm' is often loosely used and applied in the discourse around 3D innovation for land and property information. To be able to articulate what constitutes this paradigm, its strengths and weaknesses, it is important to first provide a definition.

2.3.1 Definition of a Paradigm

The concept of a paradigm in scientific studies is most notably associated with the work of Thomas Kuhn (1962). In his seminal publication, *The Structure of Scientific Revolutions*, Kuhn argued that the development of science alternates between 'normal' and 'revolutionary, where 'normal' science is a cumulative phenomenon, where ongoing use and practice grows the body of knowledge. In contrast, 'revolutionary' science occurs when those theories, concepts and practices accepted to date as part of 'normal' science is challenged, and where successful, results in a revision to the body of knowledge, thereby progressing the discipline itself (1962, 1996). Consequently, Kuhn argued that since revolutionary science challenges existing concepts and beliefs, one of the outcomes could be that some scientific phenomenon could be left without an explanation at a later time (Kuhn, 1962).

At the heart of this lay Kuhn's concept of a 'paradigm' – the shared system of beliefs, practices and values endemic to a particular scientific community, towards which commitment and ongoing indoctrination was necessary for the development of normal science (Kuhn, 1970). Kuhn's conceptualisation did not simply refer to key theories, but those key theories that have proven its utility in real life applications and real world problem solving (Bird, 2013).

In line with Kuhn's conceptualisation, the dominant paradigm in land administration is comprised of those beliefs and practices that support processes of producing, recording and disseminating information about land tenure, value, use and development. This is currently manifest as 2D-based methods, formats and conceptualisations used for the real-world purpose of capturing and reflecting people's relationship with land. This is the 2D paradigm that is being discussed in this research and can be inferred to align with Kuhn's concept of 'normal' science.

Commitment to this paradigm sets up an inevitable tension between the desire to conserve these values and the requisite break from them that is fundamental for innovation (Kuhn, 1977). As such, this inherent conservativeness means that revolutions tend to be aligned with "extreme circumstances" (Bird, 2013: 4), whose resolution warrant drastic measures – including a re-think of accepted theories and practices.

It is the desire – conscious or unconscious – to conserve this paradigm that this thesis investigates. There is significant value in this paradigm – unfortunately it does not appear to extend to those complex ownership situations associated with building subdivisions that facilitate high-rise living in urban areas.

2.3.2 The Spatial 2D Paradigm

Across different communities and countries, people everywhere share a common cognitive framework that enables us to visualise, orient and understand spatial relationships (Lohman, 1994). These abilities underpin the abstraction and comprehension of the three-dimensional (3D) world into two-dimensional (2D) representations for the practical purposes of deriving, developing and disseminating knowledge about the real world. And in professions such as design, mapping, health sciences, engineering and in the context of this research, surveying, the dependency on higher accuracy representations of 3D objects in 2D perspectives has resulted in the development of specialised work processes (e.g. see Wai et al, 2009), that in turn heightens and reinforces this cognitive framework.

Within the land and property development sector (taken to include planning and design, construction and registration aspects of development), this cognitive framework is embodied in the traditional use of a 2D paradigm for communicating, analysing, coordinating and transacting information. 2D methods for abstracting and representing the real world to produce land and property information can be seen in maps from as early as 1400 BC (Larsson, 1991). This paradigm is self-evident in the history of practices of relevant professions: architects produce both abstract and highly detailed diagrams of the external and internal design; engineers produce technical drawings for physical construction; surveyors produce plans of the metaphysical (albeit sometimes physical) legal boundaries.

Although these methods have become significantly more detailed and sophisticated with technological developments, the fundamental principles of using a planar (bird's eye) view and flat projections persist to this day. For most of these planar or flat drawings, paper provides the medium for facilitating information flow (even when drawings are produced using computer-aided design (CAD) software) – it is the physical artifact that enables information to be analysed, stored, revised and shared. For land administration systems, these 2D methods are persistent not only as an information format, but 2D representation is also intrinsically manifest in its key concept, the land parcel, used as the basic unit of land information (McDougall, 2007).

The 2D paradigm within these professions is highly institutionalised: embedded and taken-for-granted these days as the norm in terms of how these professions think and act, manifest in the information they produce (Eastman et al, 2011). This is largely a consequence of longstanding practices that have led to the development of professional standards for regulating the production and revision of 2D drawings, as well as professional norms in terms of thought and workflow processes that are particular to 2D drawings (Henderson, 1999).

However, within the land and property development and management sector, the 2D paradigm is now under pressure to evolve as it struggles to meet the information demands of complex structures that are becoming commonplace within cities.

2.3.3 Land Administration and Cadastral Systems

To facilitate a discussion on the 2D paradigm in land administration, an overview of land administration and their core cadastral systems is first presented as a background.

Land administration systems are widely recognised as being critical components of national infrastructure (e.g. FIG, 1999; Steudler et al, 2004; Bennett et al, 2013), where land administration is defined as the processes of producing, recording and disseminating information about land tenure, value, use and development (UNECE, 1996). These processes are regarded as the key operational functions that support land management and the commoditisation of land resources. This facilitates transactions in land and property assets, which underpins national economies – a benefit particularly salient in western countries (De Soto, 2000).

By supporting the effective and efficient use and development of land, as well as the formalisation of land markets, these systems are recognised as being critical for delivering a range of benefits including security of tenure, poverty alleviation and improved land planning and management; more recently, there has been broader recognition that land administration systems facilitate sustainable development objectives (Williamson et al, 2010).

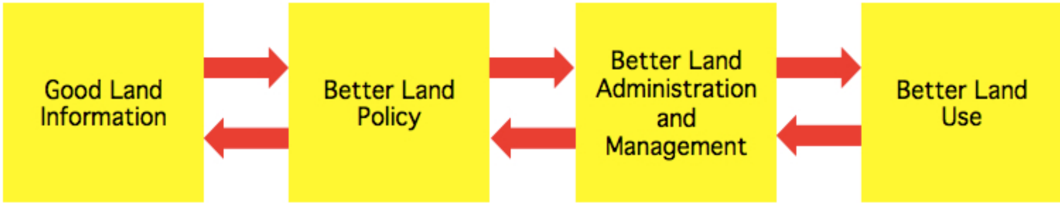

Figure 2.1 Linking good land information to support land management for delivering sustainable development (FIG, 1999: 2).

The important role that land management plays in delivering sustainable development was first formalised in the 1999 Bathurst Declaration jointly made by the United Nations and the International Federation of Surveyors (FIG). The Bathurst Declaration acknowledged that good land management was essentially predicated on having good land information, which in turn is increasingly reliant on information technology for providing the appropriate infrastructure to facilitate access and use of land information to support decision-making. This relationship is illustrated through a simple diagram shown in Figure 2.1.

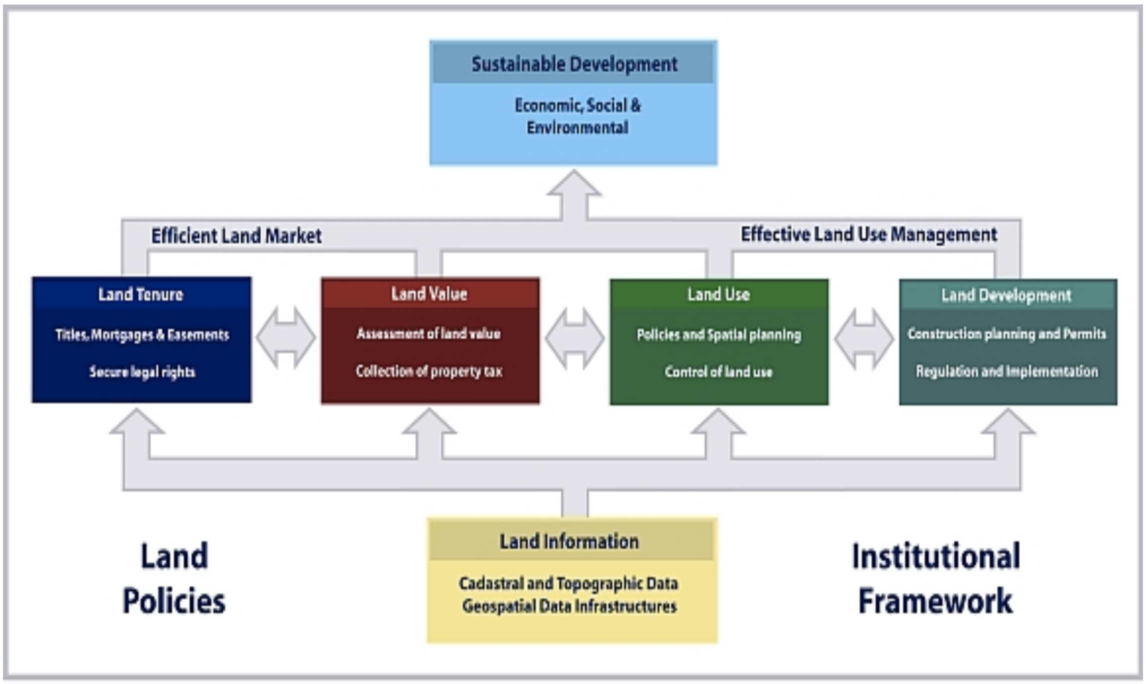

Figure 2.2. Linking land management and land administration systems with sustainable development (FIG, 2005: 8).

More recently, the land management paradigm, shown in Figure 2.2, was developed (FIG, 2005) and established the importance that the various land administration functions have in delivering sustainable development and the key role that cadastral information plays in this. Associated with this perspective, Deininger and Enemark (2010) argued that land administration systems "underpin development and innovation and form the "backbone" in society that supports social justice, economic growth and environmental sustainability (p. xiii).

With land tenure information being key to land administrations systems, the cadastre is acknowledged as the fundamental component of land administration systems (FIG, 1999). Enemark et al (2005: 54) observed that, "The basic building block in any land administration system is the land parcel as identified in the cadastre". In most countries, the cadastre provides the primary source of information about land and property rights (FIG, 1995). Williamson (1995: 115) observed that "no two cadastres are the same" since its design depends on local legal and customary frameworks for land management and registration.

Similarly, Enemark (2005) argued that the cadastre as a concept is difficult to define explicitly since its design can take many forms, depending on its purpose of genesis and country of use. He therefore argued that it may be more appropriate to refer to cadastral systems rather than the cadastre itself, which provide "interaction between the identification of land parcels, the registration of land rights, the valuation and taxation of land and property, and the control of present and possible future use of land" (Enemark, 2005: 3). This is illustrated in Figure 2.3.

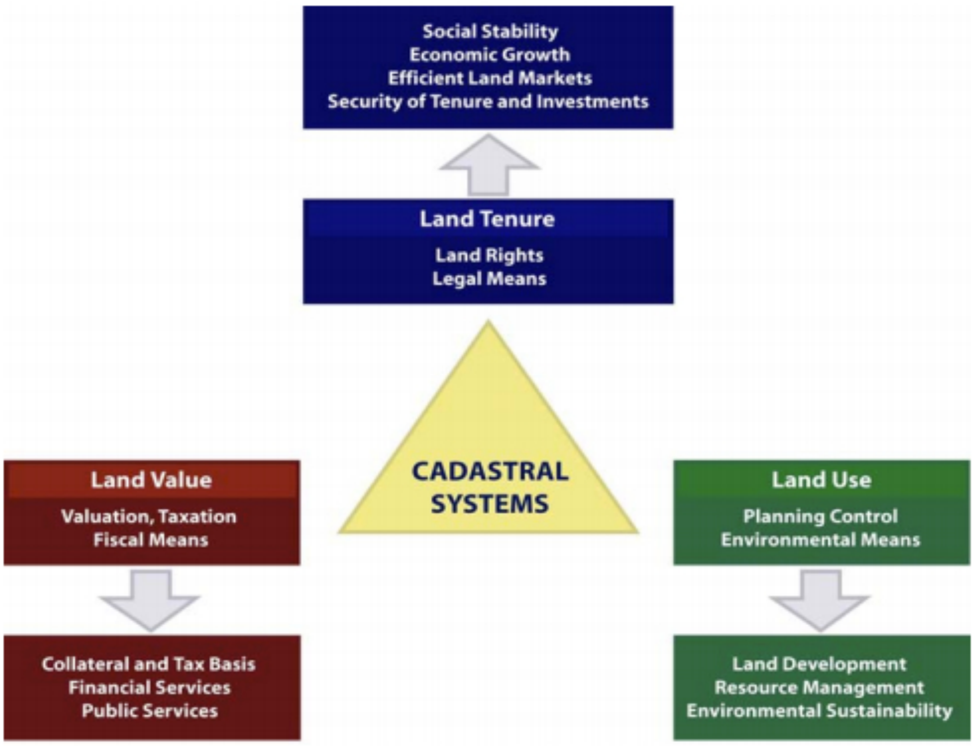

Figure 2.3 Cadastral systems as a the infrastructure to connect land tenure, value, use and development (Enemark, 2005: 3).

Enemark et al (2005) observed that cadastres have evolved from two main historical purposes: a need for land-based information to support fiscal activities such as taxation and valuation, observed in western European cadastres, and cadastres that were primarily intended to facilitate transfer of property ownership such as those cadastres that have adopted the Torrens system of title registration, notably the cadastral systems of Australia.

Stoter (2004) defined the main tasks of modern cadastres be to the registration of the legal status relevant to land and property including all rights, restrictions and responsibilities (RRRs) and the interested parties, as well as information on the land or property itself; subsequently, the cadastre also serves as a source of information on land and property to the community.

Within the literature, there is general acceptance that cadastral systems comprise two main components: a graphical representation of the technical attributes of the land parcel on a plan as well as the authoritative textual description of the rights, restrictions and responsibilities associated with that parcel documented within a register of information (e.g. Dowson and Sheppard, 1956; McLaughlin, 1975; Dale, 1976 in Williamson, 1995). Increasing dependence on technology for managing large-scale information and data (Ting and Williamson, 2000) has led to the cadastre being defined in recent times by the International Federation of Surveyors (FIG) as:

> "…normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection" (FIG, 1995: 1).

This is further illustrated in the 'cadastral concept' (FIG, 1995) shown in Figure 2.4, which shows the reliance on information and communication technologies (ICT) for supporting cadastral systems and cadastral information.

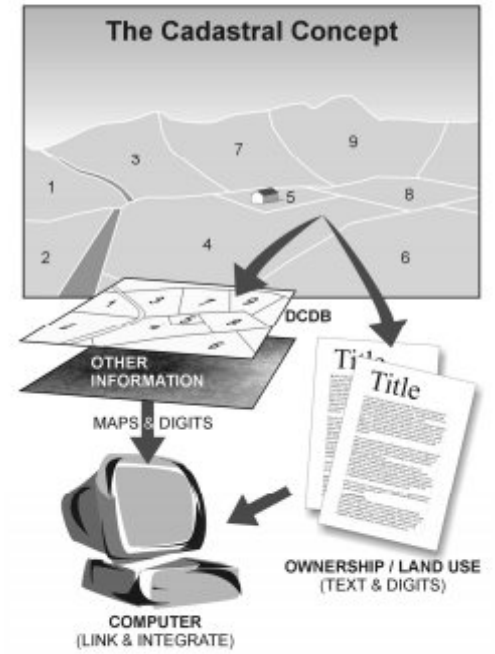

Figure 2.4 The cadastral concept (FIG, 1995).

2.3.4 Key Aspects of the 2D Paradigm

2.3.4.1 Land parcels

A key aspect of the current 2D paradigm that supports land administration processes is the 2D land parcel, regarded as being fundamental to the conceptualisation of cadastral systems. As Williamson (1995) notes:

> "The land parcel is usually the smallest parcel having individual ownership, which may be termed the legal parcel. This parcel is the basic building block of the cadastre. There are some cases, however, when this parcel is not suitable and it must be divided into smaller units. This is usually for valuation, assessment, or rating (fiscal) purposes or for land use classification. In a considerable number of cases the legal parcels must be aggregated to form the larger rateable/land use parcel" (p. 115).

Parcels are defined by (cadastral or land) surveyors to show the legal extent of individual or communal property ownership and should not have overlaps or gaps, enabling each parcel to be uniquely identified. This has provided land administration agencies with an unambiguous way to geo-reference land and property information, which facilitates the registration of land and property ownership (FIG, 1995).

Traditionally, land parcels are produced through the process of 2D subdivision of land (Stoter and Ploeger, 2003b). This has contributed to a widely used and accepted conceptualisation of parcels, and their associated RRRs, as an areal entity. The dominance of this area-based conceptualisation can be seen in a range of international cadastral processes, where formal definition of volume-based RRRs, or 3D RRRs, is not supported. For example, prior to legislative reform, Julstad and Ericsson (2001) observed that in Sweden, a title to a 3D property could only be achieved through the creation of rights for real property that already existed (either individual or shared rights is permitted) or alternatively, in some instances, personal property legislation was also used to facilitate a type of shared ownership of 3D property. Other countries have undergone legislative reform to introduce explicit recognition of 3D RRRs, such as China and Hungary (e.g. Iván, 2011).

Indeed, the land parcel is such an entrenched part of the 2D paradigm that many countries have developed methods to establish 3D properties by using existing juridical boundaries of the base 2D land parcel. This has been practised successfully to a large extent (e.g. The Netherlands and Australia) (e.g. Stoter and Zevenbergen, 2001) or less successfully as in the case of Indonesia (Hendriatiningsih et al, 2012).

2.3.4.2 Digital cadastral databases, survey plans and cadastral maps

The modern definition of cadastres as land information systems infers the need for a database. In terms of the functioning of such a database, the unique land parcel provides the equivalent of a primary key, to which all other land information is referenced, and a cadastral map (underpinned by the digital cadastral database) visualises the spatial extent of all these land parcels (Effenberg, 2001).

In effect, the cadastral map, is a geometric description of all the individual land parcels within a jurisdiction, and serves as a visual and spatial index to all textual and graphical information about land and property that is held by land registries. Depending on how a jurisdiction's cadastral system has developed, cadastral maps may or may not have legal significance (Williamson and Enemark, 1996).

The spatial attributes of a cadastral map are drawn from information provided through survey plans and subdivision plans that set out the spatial extent of all land parcels. These plans are produced in line with legal frameworks that prescribe survey processes, as well as how parcels and associated RRRs are to be represented in plans. These remain mostly oriented to 2D ways of representing such information such as using plan views, cross-sections or isometric illustrations.

As a dynamic representation of the most up-to-date version of the spatial extent of all land parcels within a jurisdiction, modern cadastral maps are now being used as fundamental information inputs for other industries (such as utilities and land management); moreover, they also provide the public with an entry point to land and property information (Hellen, 2012). In this way, they can be considered the tangible, visible and outwardly focused manifestation of the 2D paradigm.

2.3.5 2D Paradigm in Context: Victoria, Australia

The identification of the strengths and weaknesses of the current 2D paradigm, particularly in representing the types of complex 3D RRRs common in urban areas, is undertaken here. It is supported by using practices in Victoria, Australia, to provide examples of how this paradigm manifests in reality.

2.3.5.1 Regulation of 3D property in Victoria

As a former British colony, all land that had been surveyed within Australia was initially registered as land parcels owned by the Crown (government-owned land). Like the other states in Australia, Victoria's cadastral system emerged to support land market processes particularly around transfer and subdivision of land (Williamson and Enemark, 1996).

Another legacy of colonial times is the import of the common law system, and from there, the concept of land and property ownership that is predicated on the concept of 'real property'. This concept of ownership assumes ownership of all the physical structures fixed to the land, and therefore buildings are subsumed under the definition of land. The concept of real property also includes ownership characteristics that can be purely cognitive with no visible physical manifestation, such as right of access over another's land (e.g. vested in easements) (Donnelly, 2012).

Common law generally accepts that land ownership of a parcel theoretically espouses an absolute "heaven-to-hell" paradigm (Hallmann 1994 in Donnelly, 2012) – in effect, inherently 3D as it refers to an infinite volume. However, recent legal challenges and limitations imposed by statutory legislative changes indicates a more pragmatic approach is practiced in reality, where ownership is presumed insofar as use of the property can be controlled in both vertical and horizontal dimensions (Donnelly, 2012).

In terms of regulating ownership of 3D RRRs, predominantly apartment ownership, this has been achieved in Victoria through a range of legislative actions including the *Transfer of Land (Stratum Estate) Act 1960*, *Strata Titles Act 1967*, *Cluster Titles Act 1974*, before the current *Subdivision Act 1988* came into effect. Before specific legislation came into effect, “owning” an apartment was typically conducted through the purchase of shares in a company title (Dredge and Cioacetto, 2011).

2.3.5.2 Representation of 3D property and 3D RRRs

As a result of the concept of ‘real property’, in terms of 3D property and associated RRRs, the Victorian cadastre makes no differentiation between land and buildings. While the cadastre registers information about 3D RRRs, 3D properties derived from building subdivisions are not represented in the cadastral map or DCDB. The cadastre also holds information on roads but not specifically on infrastructure objects (e.g. pipes, cables, tunnels, etc.); information is instead held about easements relevant to infrastructure objects (Donnelly, 2012).

The various pieces of legislation previously mentioned, along with survey-specific legislation, provides the regulatory framework that governs how 3D RRRs are defined and depicted in subdivision plans. The most recent revision to this framework was in the *Subdivision (Registrar's Requirements) Regulations 2011*, which provided detailed clarification on the depiction of 3D boundaries in building subdivisions.

The DCDB serves as the parcel index and base for other land-related information, as well as providing the community with a spatial view of parcels. Most cadastres in Australia and certainly the one in Victoria, currently manages and registers 3D property and associated RRRs but are not able to manage these parcels as digital objects in the DCDB (ICSM, 2011). In Victoria, representation of multi-storey buildings in the DCDB is achieved by depicting only the ground level; information about all other levels can only be accessed through the plans themselves. These developments are recorded under the category of ‘multis’ (or Type 12) in the DCDB. Figure 2.5, which was a response to a national questionnaire, shows that this practice is not isolated to Victoria and is in fact the norm for half of the states and territories in Australia.

BP1	Are building based parcels recorded in the spatial cadastral database?
NZ	No – reference must be made to supporting graphical plans
ACT	Yes – Unit subdivisions (non-stratum) No – Stratum
NSW	No – only referenced to base parcel
NT	No – only referenced to the parent parcel
Qld	No – reference must be made to supporting graphical plans
SA	Yes approximate shape of building extracted from plans and recorded in digital form in the Property (Valuation) Cadastre
Tas	Yes – as part of a strata plan
Vic	Yes – at ground level only. For levels above ground, detail is provided by graphical means on hard-copy plans
WA	No – only referenced to base parcel, no building footprints

Figure 2.5 Response to cadastral system questionnaire regarding building parcels (ICSM 2011: 47).

2.3.5.3 Representing 3D RRR information in current 2D paradigm

In the early days of using company shares to manage strata property (which tended to be land subdivisions, as opposed to building subdivisions), these developments did not require a plan of subdivision; all that was shown on plan was an outline of the lot, shown in Figure 2.6.

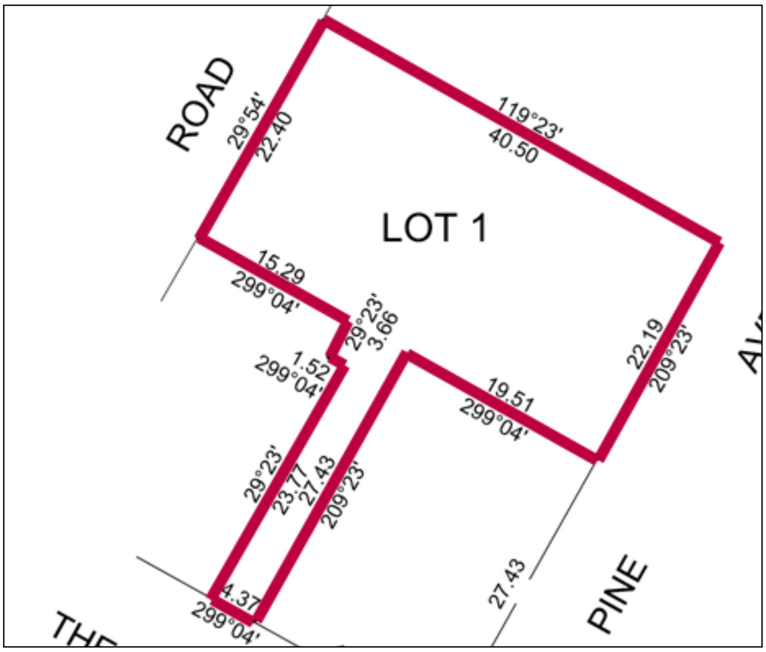

Figure 2.6 Early plan associated with company shares with no further subdivision information (Land Victoria, 2014).

3D properties, often strata properties delimited in height and depth (i.e. land subdivisions), were relatively simple subdivisions and were still adequately represented using 2D methods.

For example, Figures 2.7a and 2.7b shows a stratum plan, which facilitated subdivision into lots and where the vertical boundaries of each lot are shown using a cross section.

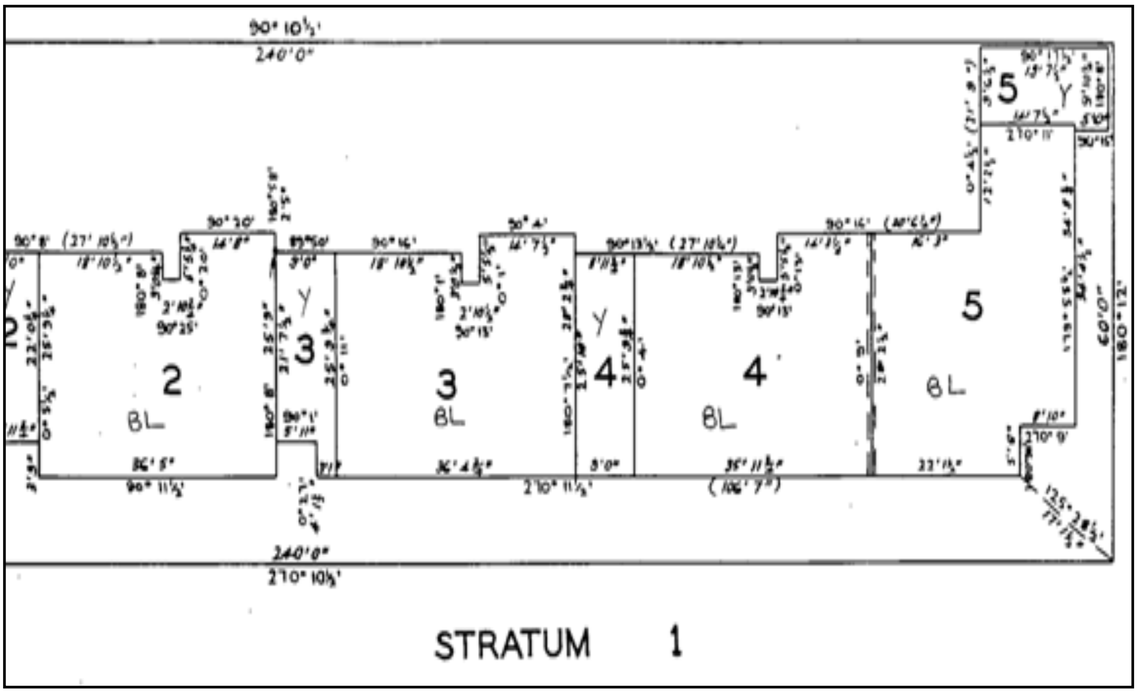

Figure 2.7a Stratum plan showing plan view of lot boundaries (Land Victoria, 2014).

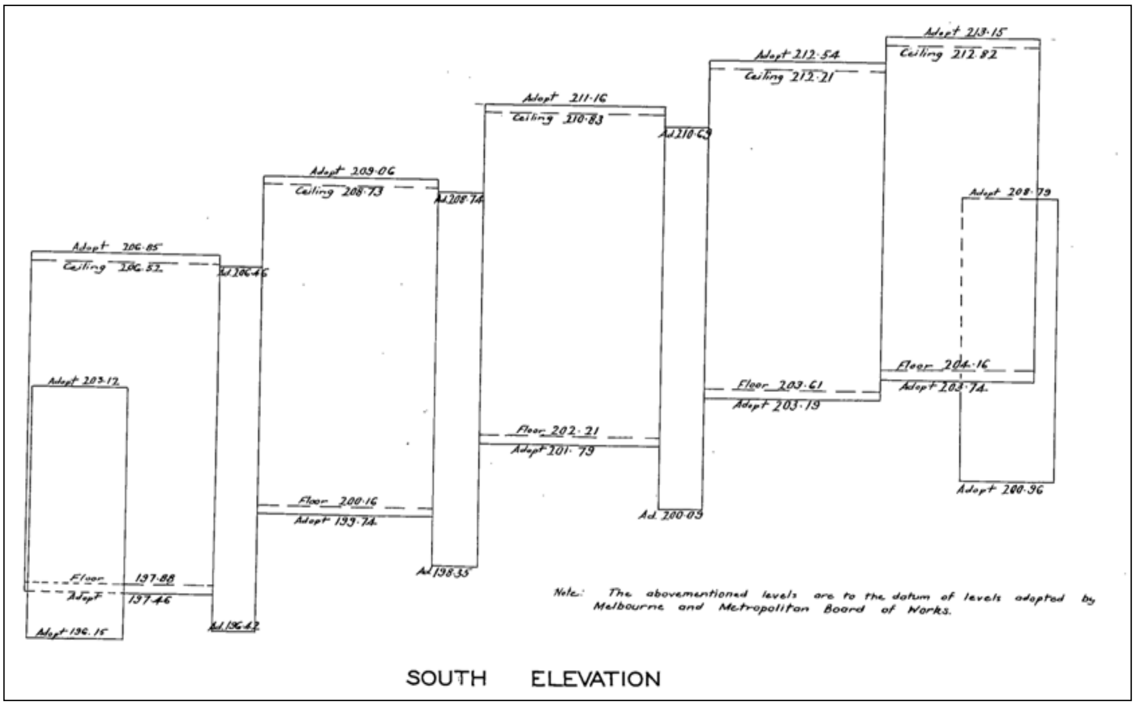

Figure 2.7b Stratum plan showing cross-section of vertical limits (bottom) of a subdivision (Land Victoria, 2014).

This 2D-based approach for representing strata properties, which is using a plan view and a cross-section, has endured till today as shown in the representation of a simple subdivision under the Strata Titles Act (Figure 2.8), and as well, under the Subdivision Act (Figure 2.9 and Figure 2.10). Despite being produced under different pieces of legislation, from the diagrams, it is evident that a 2D representation is still highly effective and relatively easy to comprehend for land subdivisions.

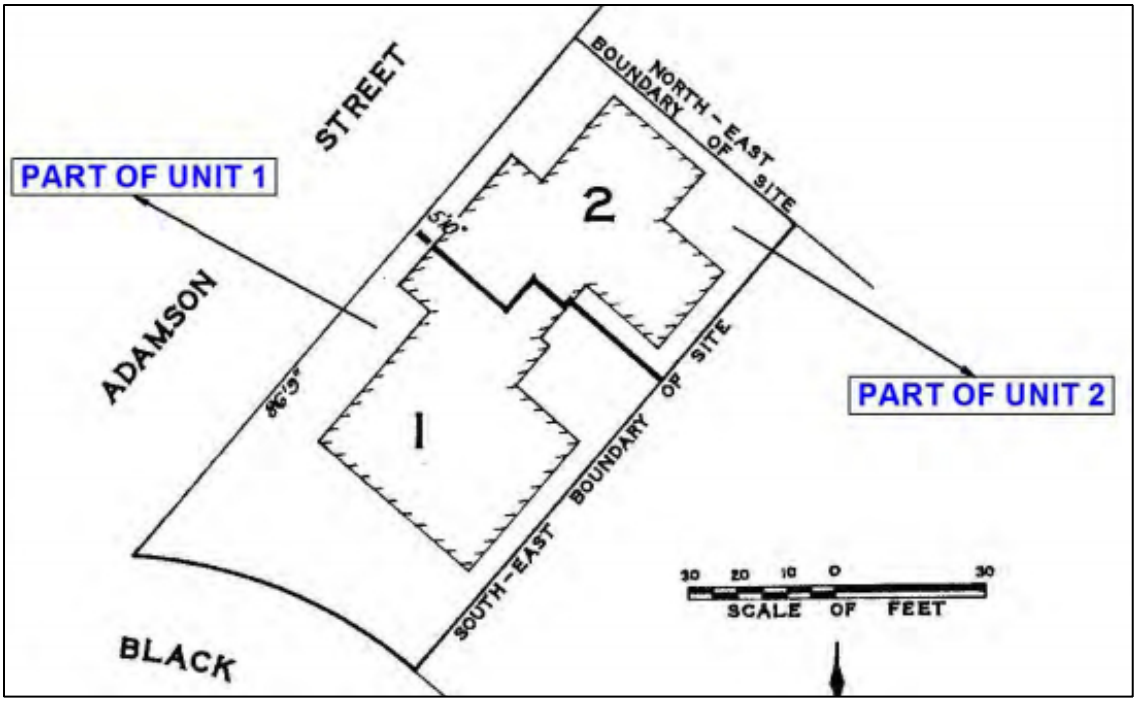

Figure 2.8 Simple subdivision under Strata Titles Act (DTPLI, n.d.: 3).

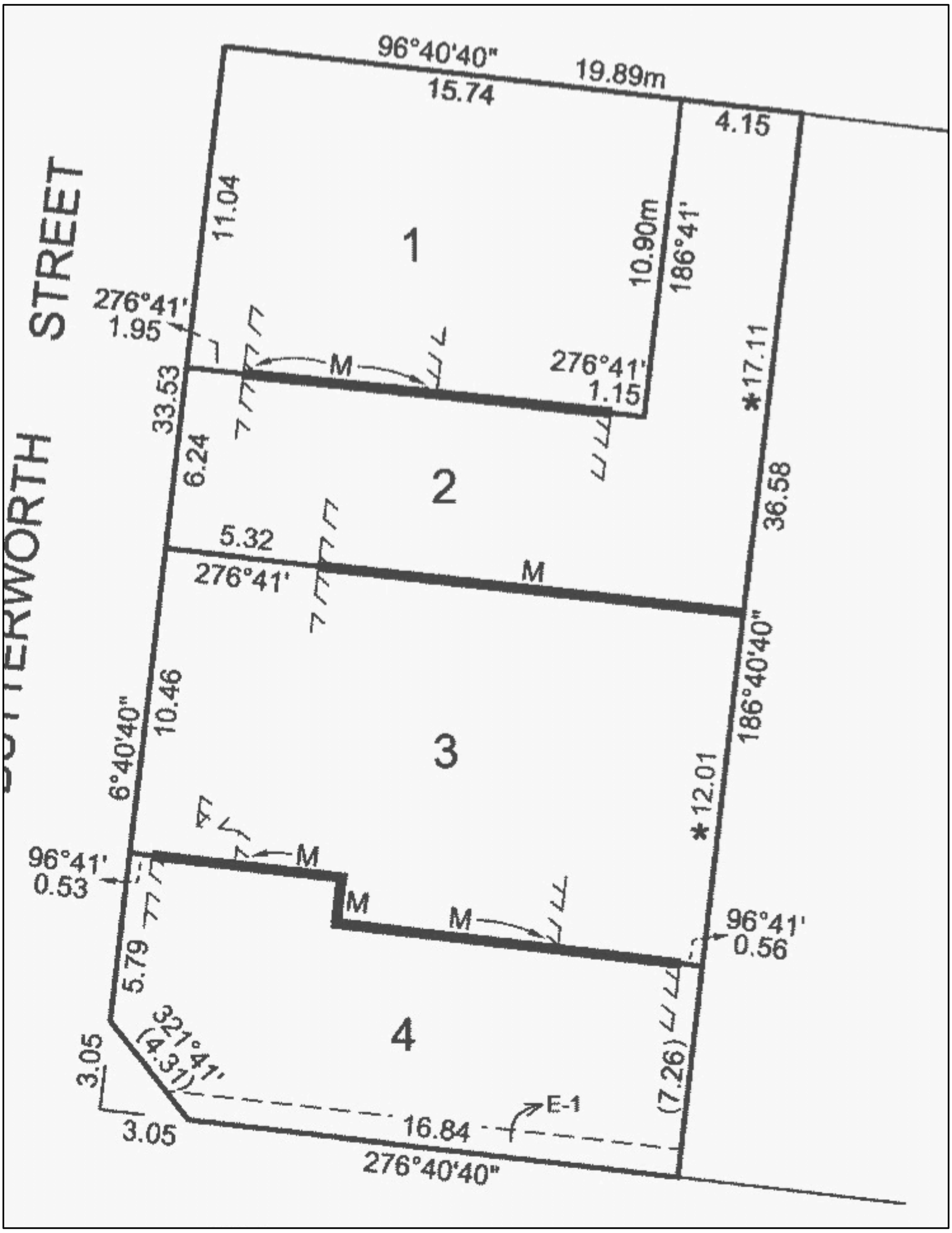

Figure 2.9 Example of simple building subdivision that is unlimited in height and depth under the Subdivision Act (DTPLI, 2013a: 3).

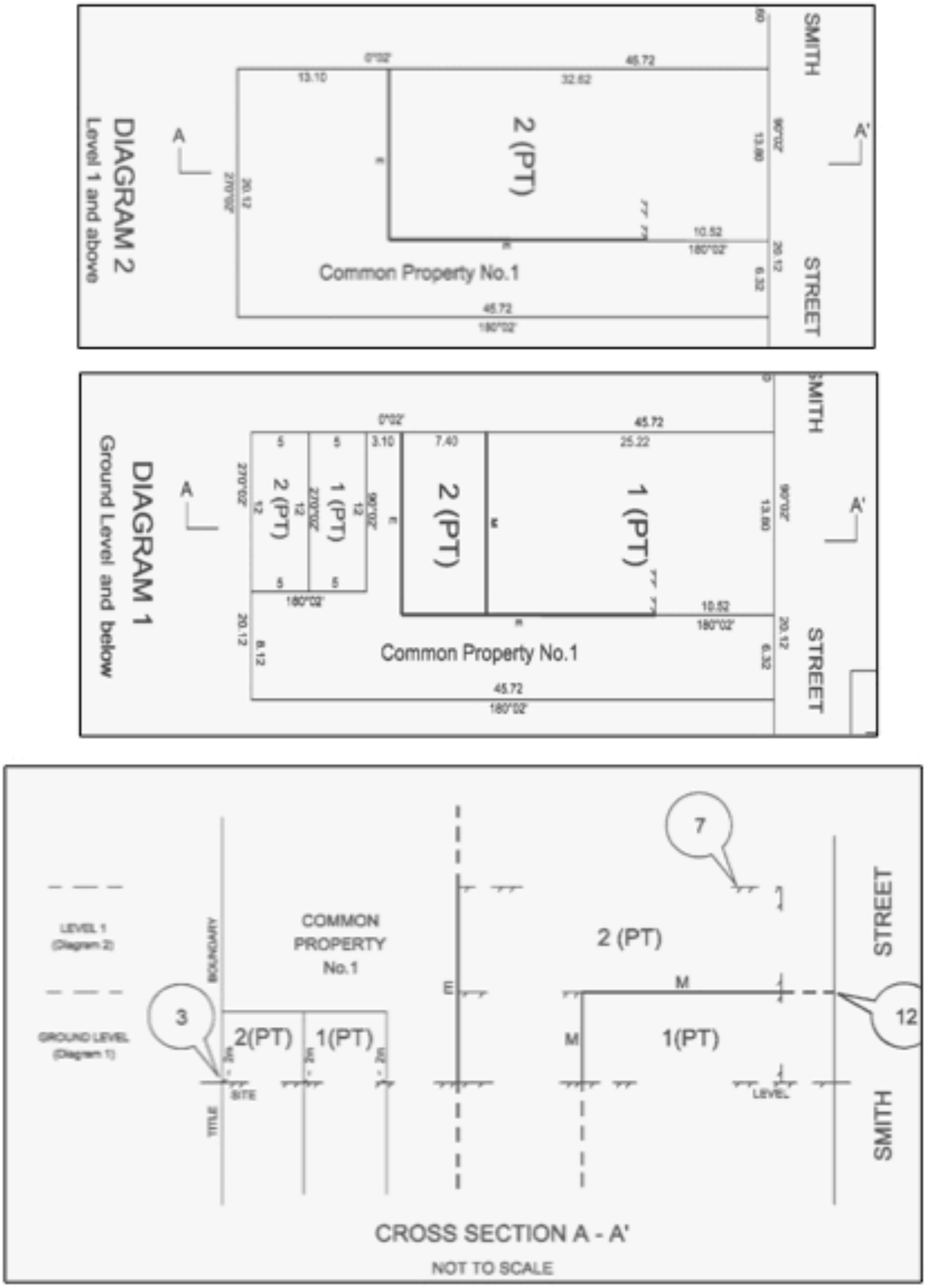

Figure 2.10 Example of simple building subdivision with lots limited in height and depth (DTPLI, 2013b: 3-5).

However, in being used to represent more complex building subdivisions (often multi-storey), the efficacy of the 2D approach is challenged and complicated by several factors. Firstly, the reliance on textual descriptions to define vertical limits, first instantiated under the strata title scheme. Figure 2.11 shows how such textual descriptions can often be quite convoluted and become confusing, but more importantly, carries an inherent assumption that the reader is visualising the property in question in exactly the same way as the surveyor did, or intended it to be.

The lower boundary of each of the Units in the plan is one metre below that part of the site which lies within the vertical or near vertical boundaries of the relevant Unit as shown on the appropriate diagram on the relevant sheet hereof.

The upper boundary of each of Units 1 to 107 (both inclusive) is seven metres above its lower boundary. The upper boundary of each of Units 108 and 437 is eight metres above its lower boundary.

The upper boundary of each of Units 109 to 227 (both inclusive) is four metres above its lower boundary.

Units 109 to 227 (both inclusive) are accessory Units.

The common property is all the land in the parcel except the land contained in Units 1 to 227 (both inclusive) and 437.

Figure 2.11 Description of upper and lower boundaries of lots in strata title plan (Land Victoria, 2014).

Secondly, the 2D approach to representing subdivision information has been affected by subsequent changes to legislation. For example, from the 1960s onwards, the introduction of the Strata Titles Act introduced the concept of a body corporate and common property regimes and associated RRRs, entitlements and liabilities were allocated. When Subdivision Act came into effect, the legislation supported not only an increasing number of public and private RRRs such as lots, roads, reserves and common property, but it also supported a variety of methods for defining lot boundaries. More defined prescriptions for 3D boundary definition has since been established through the Subdivision (Registrar's Requirements) Regulations to ensure consistency in the way boundaries of lots were defined and represented especially those using the building's structure (e.g. median of slab, internal face of wall, etc.).

This leads to the third factor. When the Strata Titles Act permitted the use of the physical structure of the building to determine ownership boundaries, the complexity of legal information about 3D RRRs represented in subdivision plans became highly correlated to a building's physical structure. Physical complexity simply meant that multiple pages of plans were now required to adequately represent information about 3D properties. Figure 2.12 shows a more complex building subdivision under the Strata Titles Act while Figure 2.13 shows a similar complexity continuing under the Subdivision Act.

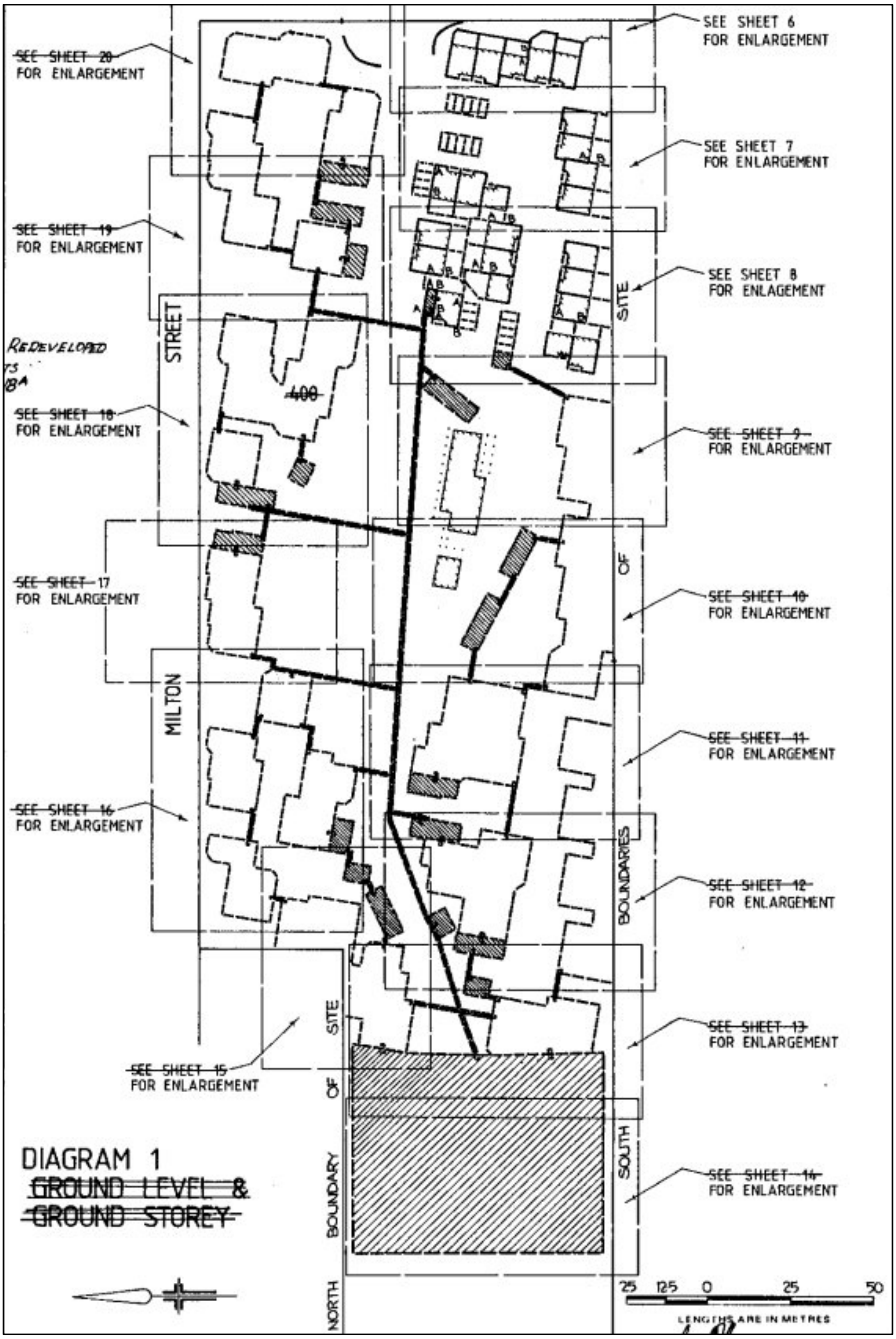

Figure 2.12 Example of complex plan of building subdivision under Strata Titles Act (Land Victoria, 2014).

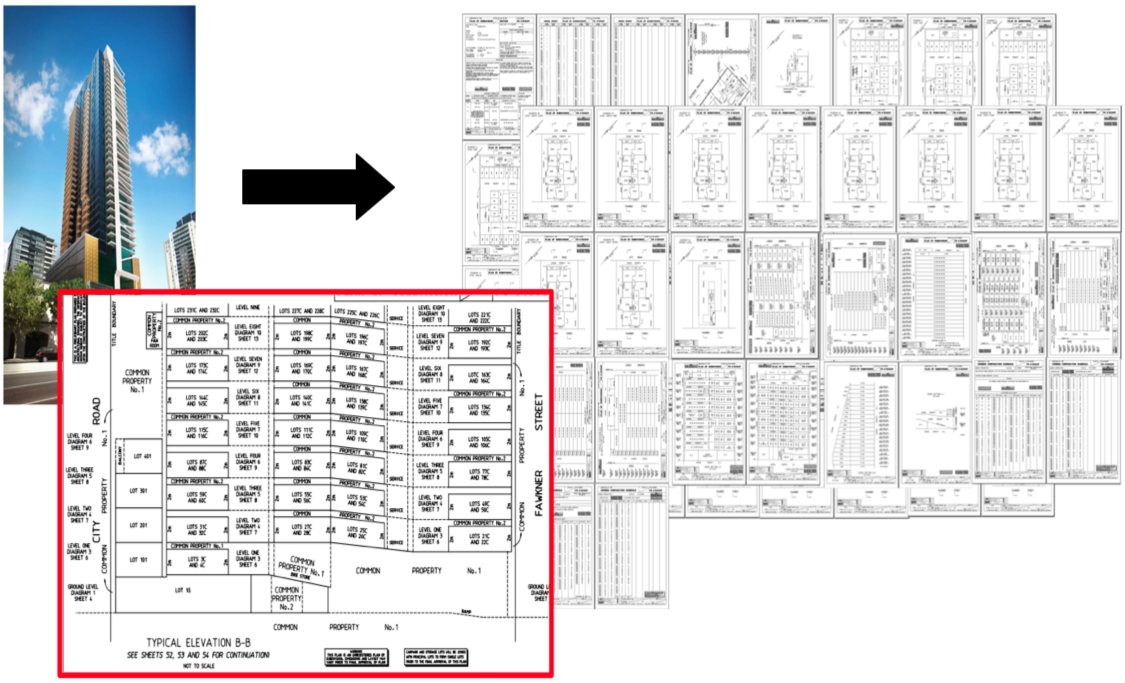

Figure 2.13 Over 50 pages of 2D plan drawings required to represent overall parcel and individual unit (lot) boundaries for a 40-storey apartment building in urban Melbourne with the building's cross section shown highlighted in red (AAM VEKTA, 2012 in Rajabifard et al, 2014: 5).

In both Figure 2.12 and 2.13, the plan still uses the same 2D approach but now relies on multiple sheets to provide enlargements into various areas as a means of coping with complexity of the layout and description of RRRs. These enlargements essentially all have to 'knit' together to provide a cohesive picture. This demonstrates how 2D methods of abstracting and representing subdivision information and associated RRRs can quickly become difficult to understand.

To adequately represent information about complex building subdivisions also requires numerous pages of 2D plans of subdivision, which is challenging in terms of abstraction, representation and comprehension: e.g. the 40 storey building shown in Figure 2.13 required almost 60 pages of plan drawings to represent private and common ownership boundaries and other RRR information (AAM Vekta, 2012 in Rajabifard et al, 2014), which is then used to register the building's individual apartments (lots). Outside of the surveying profession, these plans are difficult for the broader community to understand (Rajabifard et al, 2012). The ability to do this successfully is contingent on one's experiences with reading plans, cognitive perceptions and visualisation abilities.

In line with the physical complexity of urban environments, the Victorian cadastral map, shown in Figure 2.14, shows the difficulty in representing 3D parcels and 3D RRRs using only 2D representation, and the resulting complexity of the visual information presented.

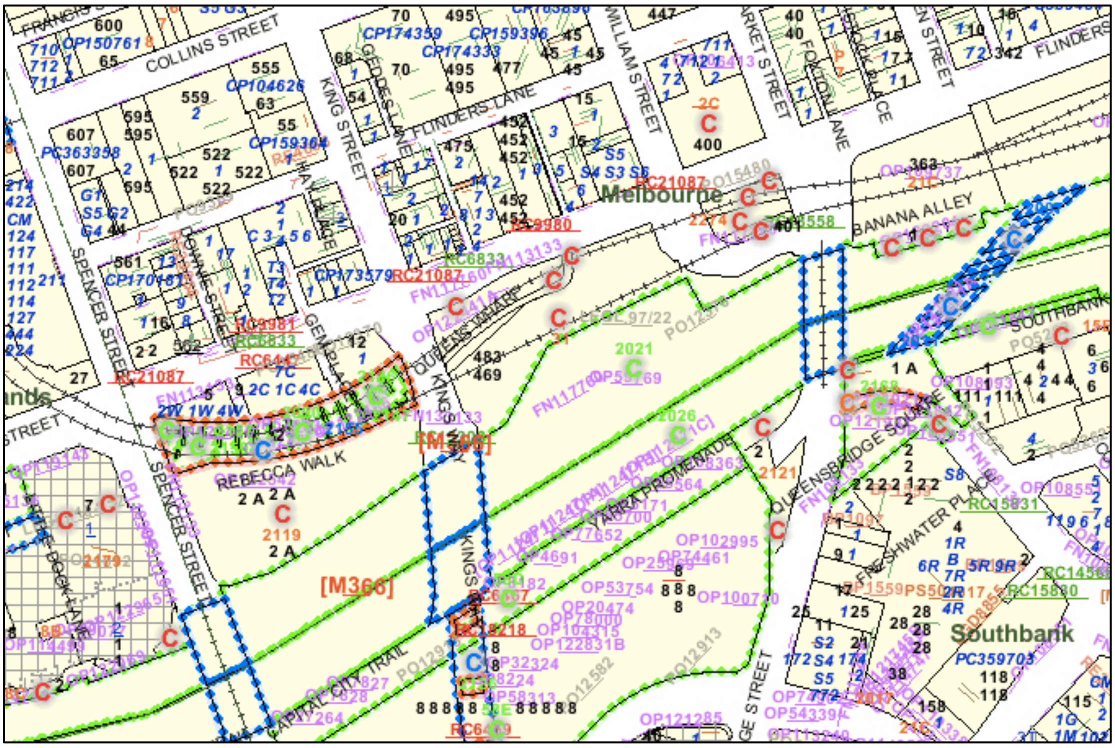

Figure 2.14 Screenshot of Victorian cadastral map showing 3D parcels and 3D RRRs in the Victorian cadastral map.

Figure 2.14 shows the land parcel or base property (in the instance of building subdivisions) outlines clearly marked. These are overlaid with a variety of information but 3D parcels are depicted by using coloured outlines: underground parcels outlined in red, aboveground parcels outlined in blue, and surface parcels that intersect with these 3D parcels are outlined in green.

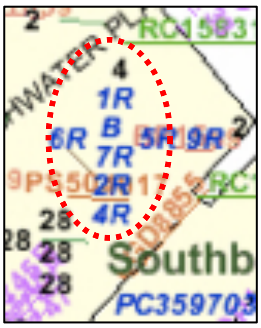

Figure 2.15. Representation of multi-storey lots in building subdivisions in the Victorian cadastral map.

In addition, in developments that are building subdivisions, the subdivided multi-storey lots are represented as constellations of blue numbers (representing the lot numbers inherent to the parcel), with the associated subdivision plan indicated in orange (starting with the letters 'PS', for plan of subdivision under the Subdivision Act), as shown in Figure 2.15.

2.3.5.4 Paper-based formats as part of the 2D paradigm

The format in which the information is held also constitutes part of the 2D paradigm. In Victoria, survey data is required to be submitted in the form of paper-based documents either as hard copy or PDF (ICSM, 2011). Although the legislation has been recently amended to allow for cadastral data to be submitted as e-Plans (digital subdivision plans using a data file as a digital substitute for paper and PDF plans), it nonetheless reflects a widespread cultural norm around paper-based documentation – there simply has been no viable alternative format till recent times.

Even though the Victorian cadastral system is supported by a DCDB, the digital environment is in effect, an electronic one since survey data is not submitted as true digital information, but as imaged data in PDF; consequently, querying of existing survey records are limited to only scanned images of paper documents or PDF images (ICSM, 2011).

2.3.5.5 Summary of Victorian examples

In summary, the Victorian examples show the 2D paradigm manifest in practices and processes in land administration, particularly around the practice of subdivision and recording and representing 3D properties and associated RRRs. The examples show that in land subdivisions and simple 3D building subdivisions, the 2D paradigm remains effective in supporting land administration processes. It however becomes less effective as revisions in legislation have made boundary representation become more prescriptive, but also as building subdivisions in the form of large high-rise buildings become more complex. A reliance on textual data to describe vertical limits is also potentially misleading as it rests on a presumption of agreement between reader and surveyor on what is being represented in the drawings.

The 2D paradigm in Victoria has been a consequence of specific definitive action such as being formalised through legislative prescription of boundary definition and representation. However the paradigm is also a consequence of broader cultural norms, such as paper-based documentation as an information format. Regardless, the paradigm has a longstanding presence, widespread acceptance and is entrenched in processes of abstraction and representation – cumulatively, these indicate a level of embeddedness, likely providing the paradigm with an enduring power.

2.4 LIMITATIONS OF THE 2D PARADIGM FOR URBAN LAND ADMINISTRATION

The limitations demonstrated in the Victorian examples are echoed in other examples around the world. For example, the practice of representing above and underground parcels using overlaid outlines is a familiar one. In The Netherlands, Stoter et al (2013) shows how a complex aboveground structure that sits over multiple land parcels is difficult to represent in the cadastral map using current 2D methods (Figure 2.16). Even though 3D RRRs can currently be registered, limited representation of these RRRs in the cadastral map can give rise to future issues. An example from The Netherlands shows how it is difficult to determine, from the cadastral map, which are surface parcels and which are 3D parcels – a situation that is exacerbated by future transfer and further subdivision of parcels.

(photo by Frans Schouwenburg, Creative Commons-licence).

Figure 2.15 Difficulties in using 2D methods to represent complex structures – example from Netherlands (Stoter et al, 2013: 57).

Although countries like Australia and The Netherlands are able to legally register 3D properties using 2D parcel-based cadastral systems, such practices have ramifications for the cadastre as being authoritative, accurate and unambiguous registers of information. For example, Stoter et al (2012) found that the practice of using numerous 2D parcels to register a 3D property in The Netherlands potentially introduces ambiguity, as well as errors, into the register. They also found that unambiguous interpretation required localised situational knowledge due to the limited representation and information held in the register. This suggests potential legal consequences in the future as it affects the ability of future property owners or other stakeholders to unambiguously interpret the legal extent of a 3D property. This has implications for agreement and respect of property ownership.

Using 2D representations to manage information about such complex structures has also led to a variety of practices for managing information about the third dimension, such as using a 3D tag (Stoter and van Oosterom, 2003; Hendriatiningsih et al, 2012). Alternatively, Stoter and Ploeger (2003b) demonstrated that in complex situations where many parcels are affected by a single development (e.g. underground tunnel), difficulties in establishing and managing new and old rights can result in errors in the system, or even an instance where the spatial extent of the 3D object is not recorded at all, in effect creating a question over the legal status of the development and challenging its ongoing management.

Additionally, the limitations of the current 2D paradigm extend also to fundamental land administration practices. One of the most frequently mentioned limitations is the fact that registering information in the cadastre currently relies on the use of the land parcel, which essentially defines ownership according to terrestrial (surface) boundaries resulting in good registration practices around landed property, but significant variations around registration of properties that are 3D spaces not attached to the land parcel (Stoter and van Oosterom, 2006; Ji, 2007; Hassan et al, 2011).

In turn, this has resulted in a lack of development around surveying practices that support definition of vertical boundaries (Guo et al, 2012). In cities where land use and occupation is necessarily dense and vertically-oriented due to high land prices, the limitations of current 2D practices in clearly identifying, representing and managing 3D RRRs are becoming apparent especially where ambiguous representation of 3D RRRs have the unintended consequence of threatening security of tenure (e.g. Stoter and Zevenbergen, 2001; Hendriatiningsih et al, 2012; Vitikainen and Hiironen, 2012).

The reality is that increasing structural complexity in urban areas is correlated with increasing complexity in associated rights, restrictions and responsibilities that are challenging current 2D-based registration systems, particularly in representing such structures in cadastral maps (Ball, 2013). Current 2D-based cadastral systems appear to still be appropriate and effective insofar as RRRs do not require explicit vertical definition (Stoter and Ploeger, 2003b). In increasingly complex urban environments where the use of space is typically decoupled from the land parcel and there are multiple holders of RRRs associated with a single parcel, there is growing acknowledgement of a need to move beyond the current 2D paradigm in land administration (e.g. Stoter and Ploeger, 2003a, 2003b; FIG, 2012; Rajabifard et al, 2012; Ball, 2013).

There has also been growing recognition and acceptance that current land administration systems, predicated on 2D-based concepts that have fundamentally remain unchanged from their historical origins despite changing times and contexts, are struggling to contend with modern land and property arrangements (FIG, 1999). In addition, there is an argument mounting that traditional land administration systems are not equipped to cope with the types of complex challenges endemic to the urban context as it is viewed to be too linear and often, too disjointed (Palmer et al, 2009). As such, Wallace and Williamson (2006) argued that it is now a matter of urgency that modern land administration systems are able to not only represent height information, but also have the ability to visualise the relationships between these structures for effective management of the built environment.

2.4.1 Broader Limitations of the 2D Paradigm

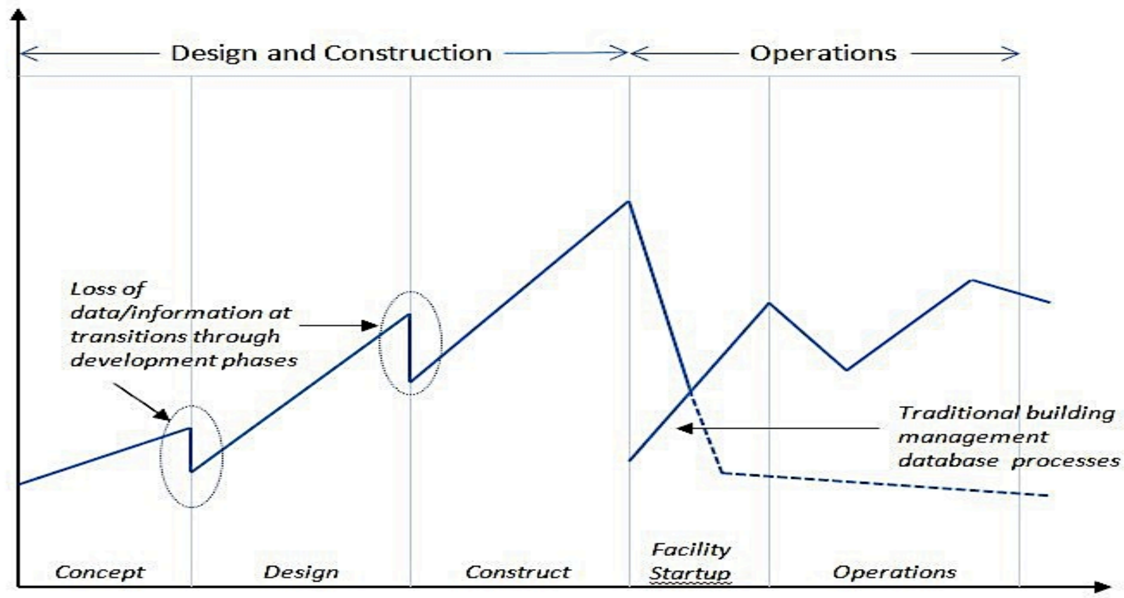

Figure 2.17 Graphical representation of the data issues associated with the traditional 2D paradigm to support information processes of the land development process for high-rise buildings (adapted from Eastman et al, 2008).

In addition to the limitations specific to land administration practices, the same limitations being experienced by other design professions who deal with high-rise buildings ostensibly applies. These have been mainly identified to be lack of data interoperability and loss of data and information, leading to impaired coordination and collaboration among stakeholders (Figure 2.17), both attributed to the non-digital nature of documents (e.g. Eastman, 1999, Eastman et al, 2008).

For these stakeholders – architects, engineers and construction companies, also known as the AEC industry, these issues have gained a level of notoriety because they have significantly impacted on productivity rates, with studies putting cost estimates anywhere between $12 billion to $16 billion annually at a macroeconomic level (Engineers Australia (Queensland Division), 2005; Gallaher et al, 2004). Importantly, since information outputs from the development process are fundamental to the building's ongoing management, poor information coming out of the development phase is likely to exacerbate the costs of management, which is acknowledged to account from anywhere between 85 per cent of a building's total costs over its lifespan (Haviland, 1978), or at least three times its capital costs (Schade, 2007).

2.5 PERSISTENCE OF THE 2D PARADIGM IN LAND ADMINISTRATION

The previous sections have shown that the 2D paradigm is clearly limited in its ability to proficiently support land administration processes and practices where complex, 3D-delimited RRRs are concerned. Yet, despite awareness and recognition of its shortcomings, practices devised to deal with 3D property and 3D RRRs continue to be based on extant 2D-based processes and technologies.

Many countries around the world like Australia, Sweden, The Netherlands and Singapore actually successfully register 3D property ownership (e.g. Williamson 2002; Stoter, 2004; Rajabifard et al, 2012; Stoter et al, 2012; Karki et al, 2013). In these instances, 2D practices are likely to persist because there appears to be little difference made between registrations of 2D versus 3D properties in the legislation (Sandberg, 2001). For example, in Victoria, Australia, and in Sweden, 3D property is registered under legislation initially designed for 2D property (Paulsson, 2012) and 3D properties are simply established by using existing juridical boundaries of the base 2D land parcel (e.g. Stoter and Zevenbergen, 2001). Ambiguity in representing 3D RRRs also appears to be dealt with by not including 3D geometric elements in the mapping of 3D strata rights (the plan drawings for each floor level shows the 2D geometries).

Such examples also indicate why current 2D methods might persist: the current system is essentially not seen to be deficient. The legal mandate for cadastral organisations also means that the onus is on registration; literally, if this can occur and fulfils the organisation's responsibilities under the law, there is arguably no justification for change. Many of the limitations expressed previously are longer-term ramifications that are likely to be experienced by other members of the community, particularly in the growing context of residential high-rise buildings with owners or body corporates that are progressively becoming more complex, and may fall outside the narrow legislated responsibilities of land registries.

The proven utility of current practices and processes, underscored by repetitive and historical uses, can also be a contributing factor in persistence, especially where new practices to facilitate the registration of 3D properties and RRRs do not essentially detract from, or disrupt, current systems and simply build on current practices. This is seen in the use of a 3D tag in Indonesia (Hendriatiningsih et al, 2012) and the use of a range of 2D-based methods in Finland, such as leases, encumbrances and company and shareholding arrangements (Vitikainen and Hiironen, 2012) as a way of dealing with 3D property.

Persistence can also stem from how the law conceives of ownership. For example, in a common law system such as that existing in Australia, the English concept of real property is upheld where ownership of land is key – physical structures on the land are not a consideration and are not recorded in the cadastre for those instances involving multi-level development.

2.6 TOWARDS 3D-ENABLED URBAN LAND ADMINISTRATION

2.6.1 Beyond the 2D Paradigm

The acknowledged limitations of the current 2D paradigm, notably in representation of complex subdivision information, but also in the limitations of the land parcel as the basic unit of information, has stimulated efforts to move beyond this paradigm.

For representation purposes, there are some jurisdictions that have moved beyond the simple planar view to implement the use of isometric views for representing complex subdivision information. An example of this is the practice in Queensland, Australia, where volumetric parcels show lots or leases that are bounded in all dimensions (Department of Natural and Resource Management, 2013). Figure 2.18 shows how these legal spaces are defined in all dimensions on the plan through the use of isometric diagrams.

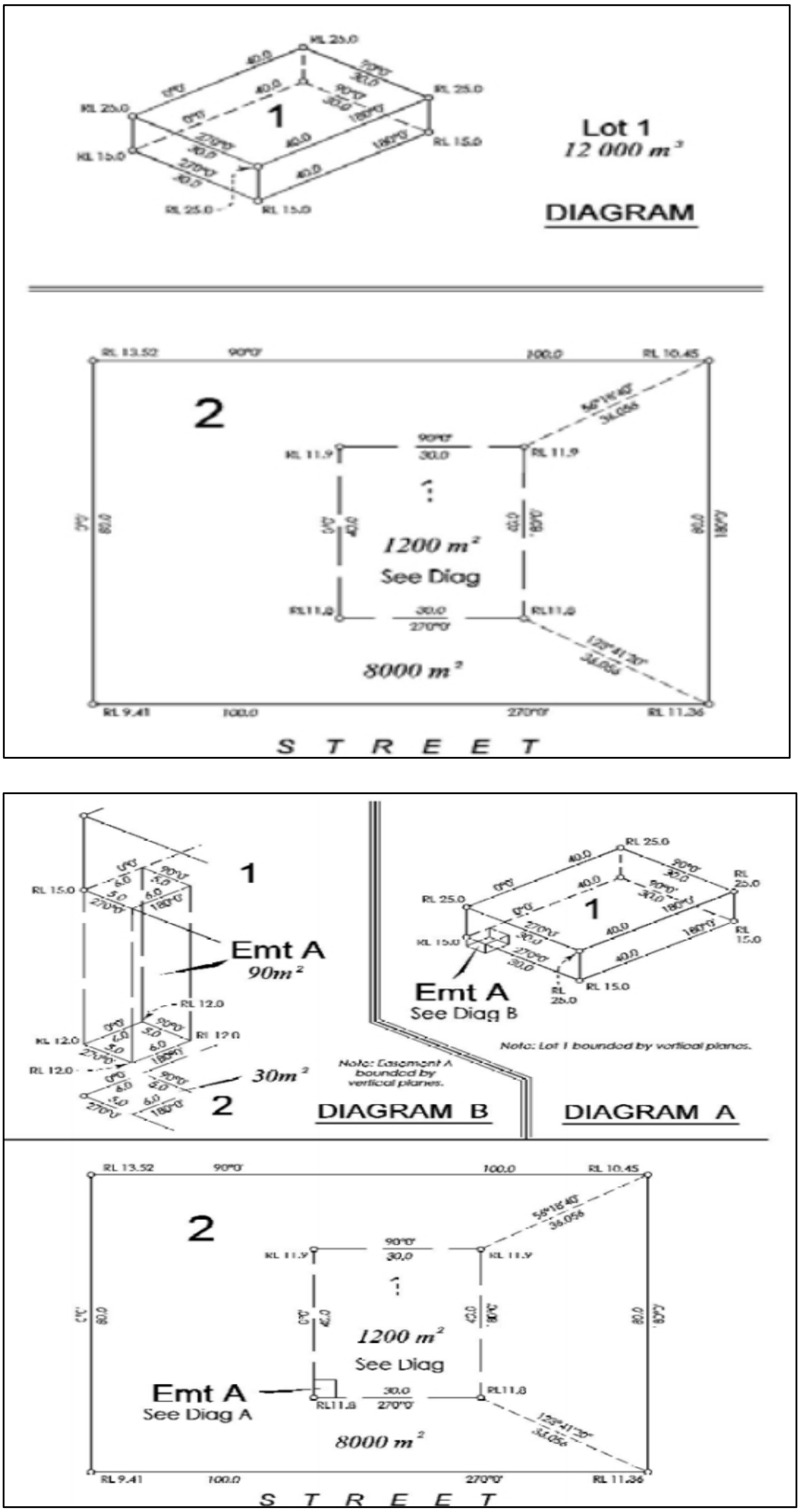

Figure 2.18 Examples of volumetric representation of parcels and easements in Queensland's volumetric plans (Department of Natural and Resource Management, 2013: 69).

While the diagrams shown in Figure 2.18 may still be fairly comprehensible to a lay community of users as it is representing a simple subdivision, one can imagine how complex these diagrams can become when representing complex buildings or infrastructure. It should be noted though that volumetric plans are not used to describe strata lots that are only restricted in one direction (e.g. depth limitation only).

There has also been work undertaken to evolve the concept of the land parcel, mostly by embracing an object-oriented approach. At a broad level, Bennett (2007) argued that land and property RRRs are currently being managed in an inefficient manner, making it difficult for land administration systems to support the realisation of sustainable development objectives. Bennett's case studies revealed that the historical legacy of existing cadastral and registration systems partly account for some of the current deficiencies arising from a tendency to primarily focus on parcel-based land interests, leaving other interests poorly managed or poorly (spatially) integrated despite having significant impact on the individual owner, if not the local community.

Similarly, Kalantari (2008) developed the concept of the legal property object in response to the current lack of flexibility in electronic land administration systems, in which information is organised and managed using land parcel-based data models. Kalantari argued that these data models, although having proven to be relatively successful historically, demonstrate an inflexibility that limits their ability to accommodate new interests in land and property as well as those complex commodities that do not align with land parcels; moreover, these existing data models were also limited in their ability to manage data elements associated with height.

Using a similar object-oriented approach, Stoter (2004) raised the possibility of a hybrid cadastre, based on two objects being held simultaneously: one object representing the legal space (RRRs), and the other, the physical 3D property itself. More recently, Aien (2013) extended Kalantari's work to show how legal property objects could better support integration of physical and legal information for improved urban land administration.

These approaches comprise part of the international research effort aimed at realising a **3D paradigm** that builds on an object-oriented approach, as well as leverages 3D information technologies, to support the management and visualisation of complex RRR information, as shown in Figure 2.19 (Rajabifard et al, 2012).

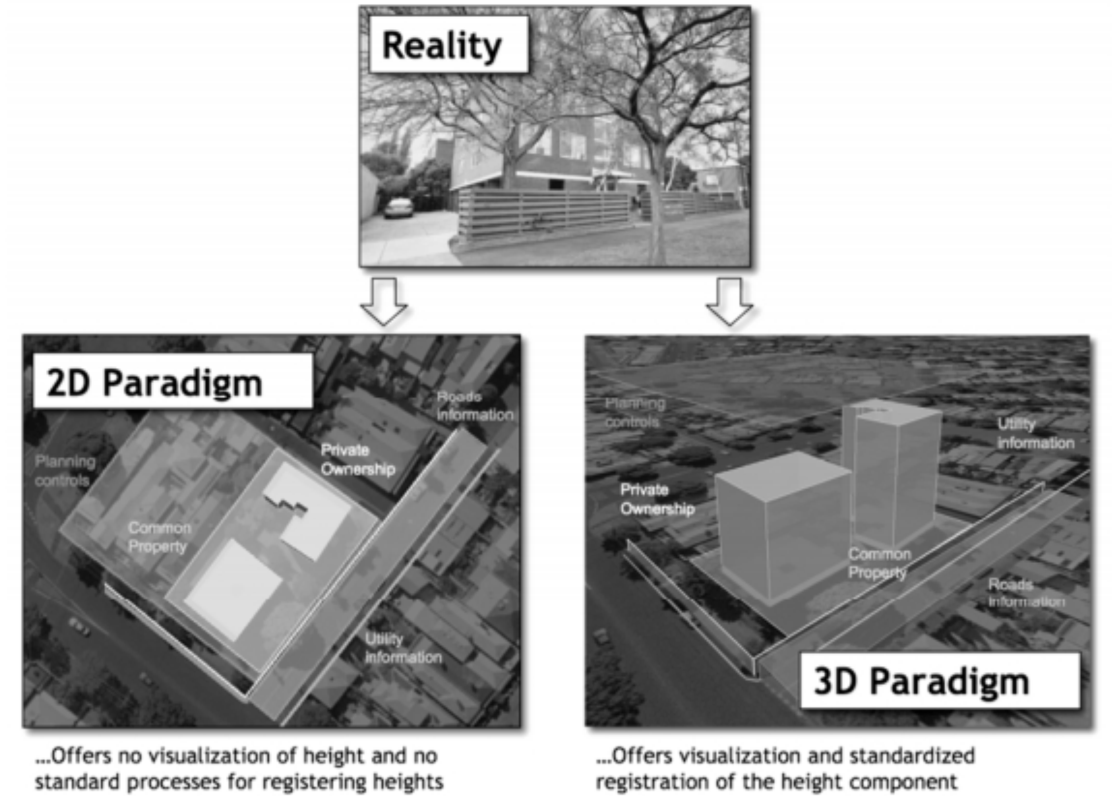

Figure 2.19 Towards a 3D paradigm for land administration (Rajabifard et al, 2012: 4).

2.6.2 3D Cadastres

In response to the limitations of the 2D paradigm, the land administration industry has been moving to leverage opportunities offered by maturing and more readily accessible 3D technologies. These efforts have crystallised around adopting 3D technologies to better represent and manage cadastral information that are defined both horizontally and vertically with corresponding geometric attributes, extending the original cadastral concept to a 3D paradigm (Figure 2.20 below).

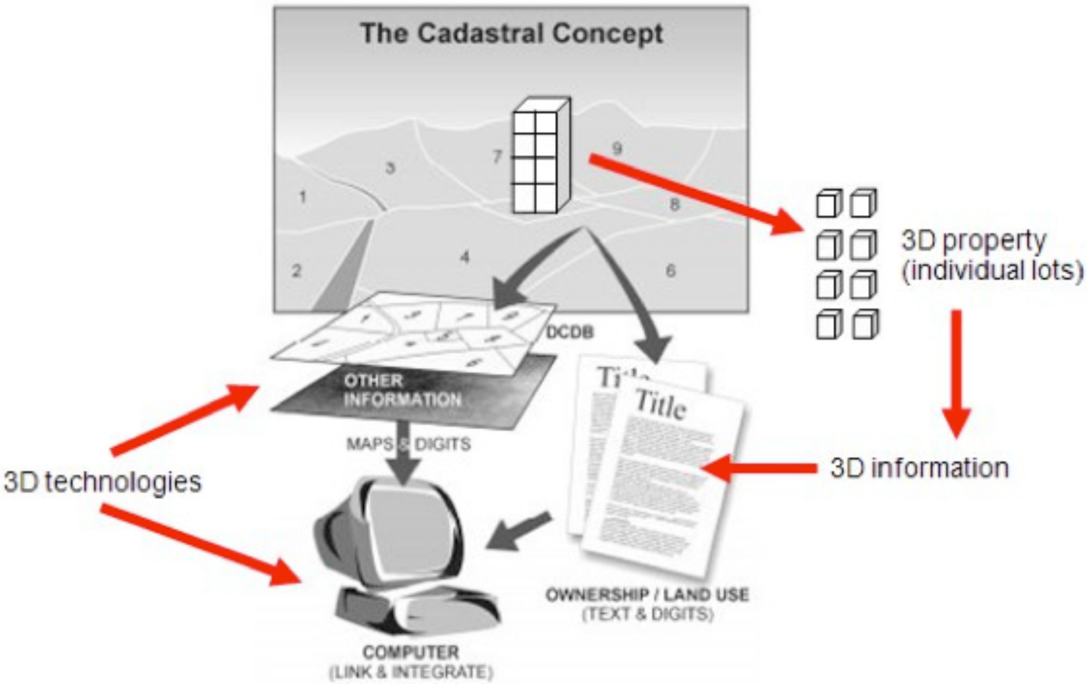

Figure 2.20 Cadastral concept as a 3D paradigm (Ho et al, 2013: 381).

International stewardship around these research efforts have been provided by the International Federation of Surveyors (FIG), mainly through a working group subsumed under the joint portfolios of Commissions Three (Spatial Information Management) and Seven (Cadastre and Land Management), which specifically looks at bringing into fruition a digital 3D cadastre since this is the key instrument for land administration. The aim of the working group, as expressed on the group's website, is "to establish an operational framework for 3D Cadastres" (FIG, 2013). What an "operational framework" entails has shifted as the research has progressed, but has mainly been related to "legal, institutional and technical" aspects (FIG, 2013).

Of these three aspects, technical developments have been the most significant to date with tangible outcomes being realised, particularly over the last five years. There has been the development of prototype 3D cadastral systems, such as those in the Russian and Spanish context (e.g. Olivares García et al, 2011; Vandysheva et al, 2012). There has been the development of data models such as that developed by Aien (2013), which showed the possibility of integrating 3D legal information, such as those managed by land administration, with structural 3D information typically produced by the AEC industry. More notably, the development of the Land Administration Domain Model (van Oosterom et al, 2013), which although not intended for 3D specifically but can accommodate 3D RRR information, is now becoming the dominant data model in 3D research initiatives since being endorsed as an ISO standard in 2012. Initiatives to implement these data models to support land administration practices (e.g. Stoter et al, 2013; Shojaei et al, 2013) suggests the technical realisation of a 3D cadastre is imminent. However, to date, there remains no practical solution yet for realising 3D cadastres (Van Oosterom et al, 2011).

2.6.3 Building Information Models (BIM)

The land development industry's experience of 3D innovation is currently on 'BIM'. This acronym refers to two things simultaneously: Building Information Modelling, a collaborative **process** for producing building information using 3D digital parametric modelling to produce a Building Information Model, a **product**, which is visualised as a 3D model of the building and serves as a unified repository of information about all components of the building that is accessible to stakeholders (NBIMS-US, 2014; Eastman et al, 2011; Smith et al, 2012).

BIM as both product and process innovation has delivered significant improvements in productivity across the land development industry, primarily in planning, coordinating and analysing building design across multiple stakeholders. The value in integrating building design information generated by multiple stakeholders in the development process lies in reducing the costs of design changes and improving project documentation. In modern developments where there can be up to 18 different stakeholders (Rahman, 2010), these costs have been estimated to be up to 30 per cent per project (Brown, 2008).

A graphical representation of the benefits of improved data interoperability and improved coordination has become known as the MacLeamy curve (see Figure 2.21), although arguably, this graph has been based on either Boehm's (1976) or Paulson's (1976) initial graphical representation of costs incurred from inefficient design processes. Nonetheless, the graph shows that resolving design issues prior to construction through the use of technologies such as BIM and associated processes can help limit changes made at the construction stage, which invariably incurs a much more significant cost.

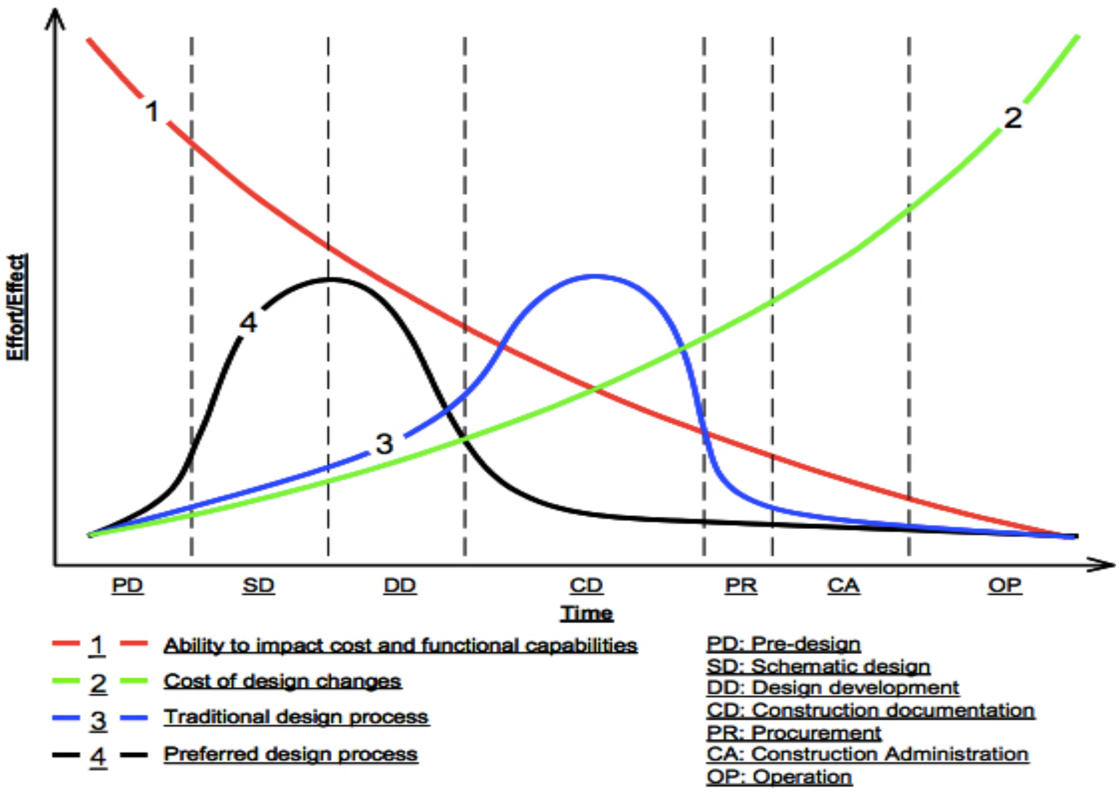

Figure 2.21 The MacLeamy Curve (Construction Users Roundtable, 2004: 4).

In a study on the potential of BIM for improving productivity in Australia, the Allen Consulting Group (2010) found that BIM could improve productivity by up to nine percent. A more sustained adoption of BIM over a building's lifecycle to involve management aspects as well could potentially add $5 billion to Australia's Gross Domestic Product (GDP). Other evidence estimates that for every dollar saved on design by using BIM returns 20 dollars to the client during construction to the client, and up to 60 dollars in the operation phase of the building (Hamil, 2012). Further, the Co-operative Research Centre for Construction Innovation (CRC-CI) noted that improving design and project documentation can save up to 17 per cent in constructions costs; in turn, a ten per cent improvement in efficiency in the construction industry could boost GDP by up to 2.5 per cent over the next five years (CRC-CI in Engineers Australia (Queensland Division), 2005).

Similar trends are being experienced and documented internationally (e.g. McGraw-Hill, 2012). Such potential has been recognised and widely appreciated, culminating in a range of countries now mandating the use of BIM for a variety of purposes associated with construction and management of structurally complex buildings (Davis Langdon, 2012). This has also been facilitated through activities conducted by an industry alliance of relevant and interested organisations, 'buildingSMART', which now has chapters in many different countries and who aims to support the use of BIM within the land development and facilities management (FM) industries.

The growing momentum around the use of Building Information Models (BIM) by most of the stakeholders involved in the development, and increasingly management, of high-rise buildings, is now stimulating an exploration of how BIM might facilitate 3D representation of cadastral information. Shojaei's (2014) work on visualising 3D cadastral information stored using the Industry Foundation Class (IFC) format, which is used by BIM, goes some way to demonstrating the viability of BIM for cadastral purposes. Rajabifard et al (2014) argued that there are now considerable factors motivating greater consideration of the use of BIM for land administration purpose, including the growing incidence of mandatory use of BIM, the availability of detailed building information, and the use of BIM throughout a building's lifecycle.

2.7 SOCIAL AND CULTURAL ISSUES AROUND 3D INNOVATION

2.7.1 Social and Cultural Issues around 3D Innovation in Land Administration

Although it is becoming increasingly evident that realising 3D cadastres is now, technically, only a matter of time, there has been little progress made to introduce the new technologies into land administration operations. This has been attributed to the fact that research to date has been disproportionately biased towards technical developments, and has ignored the non-technical aspects of innovation. This is despite recognition that the legal aspect of 3D cadastre development should be of paramount importance since an appropriate legislative framework is necessary to create RRRs around 3D property, and without this, there would be no reason for having a 3D cadastre (Banut, 2011). In their review of the literature associated with 3D cadastres, Paulsson and Paassch (2011) found that research on legal and organisational issues were the lowest among four categories of research foci (Paulsson and Paasch, 2011).

For the land administration industry, to date, research on social and cultural issues around 3D innovation has been limited. Van der Molen (2003) provided early arguments for the need to adopt a sociologically oriented approach to support the introduction of 3D innovations, where understanding the basis for behaviour would support the identification of incentives to support change. This early work, which was framed in the context of institutional theory, followed North's definition of institutions as "rules of the game" (North, 1990: 3), has arguably helped to reinforce the land administration industry's focus on regulatory barriers to change. However, there has been little work undertaken to build on this position.

The literature so far has placed significant emphasis on legal issues as the primary obstruction in the bid to realise 3D-enabled urban land administration. The range of ways in which legislation can affect how 3D property is defined was identified as part of this research. This is represented graphically in Figure 2.22.

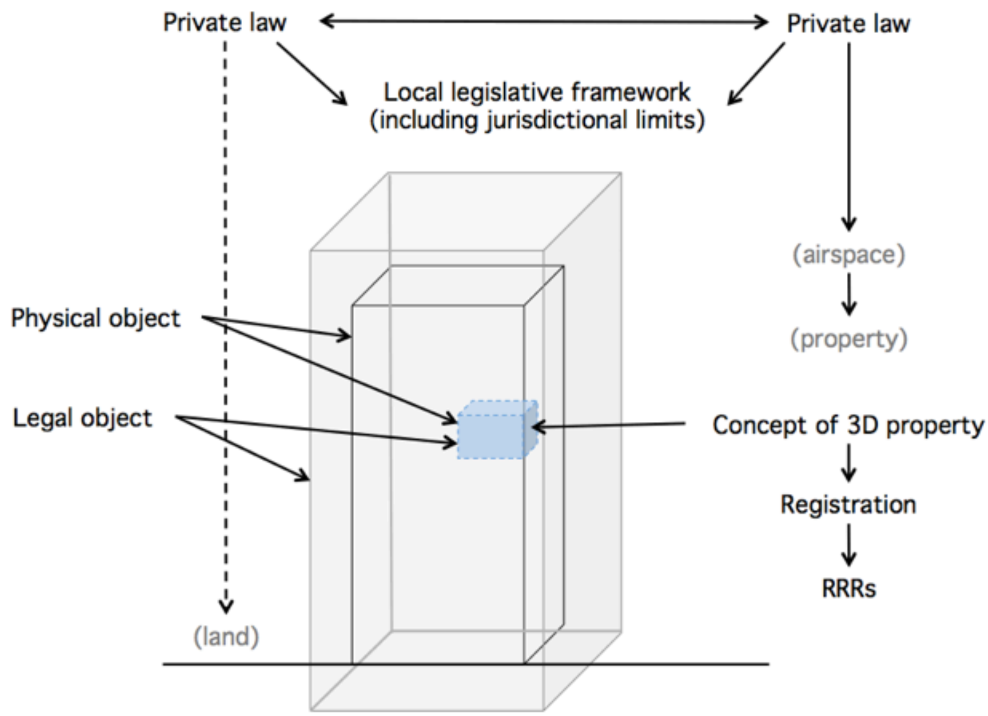

Figure 2.22 Range of legal issues relevant to defining 3D property (Ho et al 2013: 381).

It was found that these issues tend to fall along a public/private law binary and affects how 3D property is conceived legally. A classification of these issues through a literature review is presented in Table 2.1. In considering the impact of these issues in the context of current practice of registering 3D property and associated RRRs, it was found that many jurisdictions were already reacting by developing alternate solutions, which at times, were no more legitimate, but were a necessity given the constant and immediate day-to-day need for registration to support the continued functioning of land markets. These solutions have been mentioned earlier in this chapter and include the use of a 3D tag in Indonesia, as well as the use of a range of 2D-based methods in Finland, such as leases, encumbrances and company and shareholding arrangements as a way of dealing with 3D property.

ISSUES REGARDING 3D PROPERTY	SOURCES OF RELEVANT LITERATURE
Concept of a 3D property, its legal status and classification of associated rights	Stoter and Zevenbergen, 2001; Fendel, 2002; Stoter, 2004; Paulsson, 2007; Paulsson, 2008; Karki et al, 2010
Components of legislative framework required to support autonomous registration of 3D property	Stoter and Zevenbergen, 2001; Huml, 2001
Legislative limits and considerations	Huml, 2001; Sandberg, 2001; Stoter and Ploeger, 2003a; Papaefthymiou et al, 2004; Aien et al, 2011; Tan and Hussin, 2012
Registration of real property vs. physical objects	Ossko, 2001
Effect of public law on private rights	Navratil, 2012
Common property regimes	Paulson, 2012

Table 2.1 Overview of legal issues regarding 3D property (Ho et al, 2013: 380).

Additionally, such alternative solutions are still based on the dominant 2D paradigm, even though there is increasing evidence that this potentially, can have a negative impact on tenure security with regards to 3D RRRs. This challenged the dominant assumption within the 3D cadastre research domain that has attributed the lack of progress towards implementation as resting mainly on legal limitations. Instead, it raises an argument that a range of sociologically based issues such as culture, norms and cognition (of which legislation is a part of) that underpins current cadastral and land administration systems is of greater significance.

However, the technologically dominant response to 3D innovation observed in land administration literature is not unique. In light of the limited literature on non-technical aspects of innovation in the land administration domain, insight is drawn from the Architecture, Engineering and Construction (AEC) industry's experience of 3D innovation – in their case, the diffusion of Building Information Models (BIM), and the lessons this can provide on the significant barriers that social and cultural issues present to 3D innovation.

2.7.2 Social and Cultural Issues in BIM Adoption for Land Development

BIM is noted for its potential for delivering significant savings, yet its diffusion has not been commensurate with this potential. Although digital models for managing building information has been strongly suggested as the basic practice for the AEC industry since the 1990s, and the specific use of building models since the 2000s (Eastman et al, 2008), momentum in the BIM movement has really only picked up since the mid-2000s. This has mainly been attributed to a range of social and cultural issues considered characteristic of the development sector that are widely recognised as impeding the sector's ability to innovate. These social and cultural issues related to a range of inherent issues that create resistance to innovation in general, but which has also been particularly obstructive due to the nature of changes that BIM demands.

Inherent issues include an adversarial environment (Davis Langdon AECOM, 2013) and a culture of fragmentation (Egan, 1998) – both likely due to the number of stakeholders involved in construction of buildings where friction is exacerbated by a highly competitive environment (Eastman et al, 2008). In addition, the construction industry is renowned for a deep resistance to changing the way of "doing things" within the construction industry (Kajewski et al, 2001) and some segments of the industry specifically do not tend to receive ICT (information and communication technologies) innovations well (e.g. Walker and Peansupap, 2004). Within Australia, a recent report by the federal government found that the construction sector is the least innovative sector across all industries, demonstrating not only historical, but ongoing low levels of innovation: only 40 per cent of the sector reports innovative activity – of these, only 15 per cent had introduced organisational innovation, and only 11 per cent had introduced process innovation (Department of Industry, 2010).

In general, specific to the AEC industry, there is a significant body of work that supports the importance of understanding social and cultural issues in the context of technological change (e.g. Todd, 1996; Cleveland, 1999; Mitropolous and Tatum, 2000; O'Brien, 2000). One of the earliest insights suggested that because the AEC industry is highly invested in the forms of technology it uses, any introduction of new technologies is a socially disruptive experience (Barley, 1986; Bechky, 2003). Early work by Renkema and Berghout (1997) also found that poor perceptions regarding return on investments were a key reason behind the lack of ICT innovation for productivity purposes, particularly in networked environments such as that of the AEC industry. However, when the sector does decide to adopt new technologies, Davis and Songer (2002) found that there is a tendency to focus on technology to drive change, which ignores the impact this has on the people upon whom successful diffusion is dependent on. This led to research that focused on capacity for change at the level of the individual.

The AEC sector certainly appears more adroit in recognising the importance and pursuing research on the sociological aspects of 3D innovation, with the literature showing a growing recognition of the impact these issues have on innovation, especially in the current wave of 3D innovation (e.g. Davis and Songer, 2002; Dossick et al, 2009).

Compounding the ongoing issues that the industry generally experiences has been the fact that exploiting the benefits of BIM is contingent on transforming deeply embedded fragmented work processes into collaborative ones (Eastman et al, 2011). This is proving to be far more challenging, leaving the industry with a growing awareness that identifying and understanding the social and cultural bases of deeply entrenched behaviour and attitudes will be fundamental to supporting widespread adoption of these innovations (Clark, quoted in NBS, 2013).

In the context of BIM and its demands for higher levels of collaboration, Beamish and Biggart (2006, cited in Dossick et al, 2009) found that successful collaboration in networks associated with building development was contingent on the existence of shared cognitive frameworks such as professional standards, regulatory frameworks and industry norms since these networks comprised multiple stakeholders. Aligned with this, Dossick et al (2009) found that in the context of BIM adoption, the fragmented business model in the sector and traditional workflows between disciplines create entrenched organisational and cultural characteristics that are proving immune to the economic promise of BIM.

Brewer and Gajendran (2012) further argued that such economic arguments are also often based on assumptions of rationality, which is in contrast to a reality where decisions are often made in a state that where complete information is not available. In such instances, decision-making tends to be driven by prior experiences and decisions are guided more by emotions rather than economic rational logic.

Finally, in their investigation into inter-organisational practices pertaining to BIM use, Dossick and Neff (2010) found that using BIM to exchange information was more efficient for those tasks where explicit knowledge was exchanged. They found that the structured nature of these communications reduced the opportunity to exchange tacit knowledge on a range of non-specific issues that actually played a role in supporting innovation and collaboration in an inter-organisational context.

2.8 CHAPTER SUMMARY

The confluence of demands and challenges arising from increasingly complex urban environments, the limitations of 2D concepts and formats for accurately and unambiguously representing land administration information, and the maturation and availability of 3D information technologies has generated momentum in leveraging 3D technologies to more effectively and efficiently represent land and property information, particularly in an urban context. The traditional 2D paradigm is under pressure to evolve to meet this requirement. For the land administration industry, 3D technologies have the potential to more accurately and unambiguously represent the legal extent and geometric attributes of the complex arrangements of property rights, restrictions and responsibilities (RRRs) that characterise urban spaces that are vertically delimited.

This chapter started by providing a backdrop to show why information around high-rise buildings has become such a focal point and the challenges it presents for urban land administration. It then provided a review of the current 2D-based paradigm that supports land administration processes, using real life examples from the state of Victoria in Australia to illustrate the current advantages and disadvantages of the paradigm in recording and representing information about 3D properties and associated RRRs. The chapter shows that the limitations in Victoria are not idiosyncratic but are experienced in similar ways to other land administration and cadastral systems around the world and identified efforts to move beyond the current 2D paradigm.

The final part of the chapter reviewed the range of non-technical issues considered to be a barrier in evolving the 2D paradigm. Specifically, it reviewed the key barrier emphasised in land administration literature – the role of legislation, and found that this was less significant than previously thought since land registries were adapting and finding alternate paths forward to enable registration of 3D properties. Due to a dearth of relevant literature, the chapter drew on literature regarding similar issues around 3D innovation in the AEC industry, which underscores the significance these issues have for facilitating 3D innovation and the pressing need for the land administration industry to develop a more mature research agenda on the sociological aspects of change.

The aim to develop this research agenda leads to the selection of institutional theory as an appropriate theoretical framework to conceptualise and analyse these issues relevant to urban land administration. This is presented in chapter three.

CHAPTER 3

INSTITUTIONS, INNOVATION AND STRATEGIC CHOICES

Too often, in environments with rapid technological change, the current rules-in-use are out of sync with the capabilities of the technologies. New rules or laws can be made based on lack of adequate information, awareness, or understanding of the true nature of the issues.

Ostrom and Hess, 2007

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3.1 INTRODUCTION

The introductory quote underlines the importance of understanding the relationship between technological innovation and the institutional environment. To do so, this chapter provides an overview of institutional theory distilled from a review of relevant literature across organisational science, sociology, economics, and knowledge management domains to establish it as an appropriate theoretical and analytical framework for pursuing research of these issues pertinent to the adoption and implementation of 3D technologies to enable management of urban land and property information.

The economic-rational paradigm has dominated strategies for understanding issues around technological innovation (Damanpour, 1991; Fichman, 2004; Dosi, 1982). However, with growing awareness of the importance of understanding the organisation itself, the traditional economic focus has been shifting towards the social environment that the innovation is to be embedded within, i.e. organisations and the people within (e.g. Giddens, 1984; Pinch and Bijker, 1987; Orlikowski and Robey, 1991; Barley and Tolbert, 1997; Orlikowski, 2000; Orlikowski and Barley, 2001; Dowell et al, 2002; Geels, 2004; and Morton et al, 2006).

Institutional theory, specifically organisational institutionalism, is playing an increasing role in furthering understanding of how organisations change when new technology or information systems are introduced (e.g. Boudreau and Robey, 1996; Björck, 2004; Mignerat and Rivard, 2009). It bridges information technology and organisational research, showing that technical transformations can only be fully appreciated if accompanied by an understanding of the institutional context (Ingram and Clay, 2000; Orlikowski and Barley, 2001). Organisational institutionalism proposes that organisational behaviour is constrained or enabled by prevailing 'invisible' social structures, and the choice to act can be conscious or unconsciously influenced or limited (Meyer and Rowan 1977; DiMaggio and Powell 1983; North, 1990; Ostrom, 1990, 2005; Scott, 1995; 2001; Ingram and Clay, 2000).

Organisational institutionalism therefore provides an appropriate theoretical basis for pursuing the objectives of this thesis. It offers apposite constructs to explore issues within the social environment, primarily – in the context of transitioning from the long-held tradition of producing and representing land and property information using 2D methods and methodologies and associated work processes, to new practices in utilising digital information, primarily in the form of producing 3D digital models.

The chapter begins with an introduction to the rationale behind the use of institutional theory, particularly organisational institutionalism, for this research. This is followed by a broad description of the philosophy and concepts endemic to institutional theory. Key constructs and arguments that are relevant are then provided in further detail, followed by a general critique of institutional theory. The chapter concludes with a summary of institutional theory and its relevance to the research agenda in this thesis.

3.2 INSTITUTIONS AND INNOVATION

There have been several dominant research perspectives that have contributed to our understanding of how innovation can be supported. Schumpeter's (1934) early work on the role of technological innovation in economic development gave rise to an economic position, reinforced by the numerous studies since that have reiterated this finding, and emphasised the contribution of technological innovation towards improvements in productivity (e.g. Solow, 1957; Clark and Guy, 1998; Nadler and Tushman, 1999; Ives et al, 2003; Melville et al, 2004).

A research paradigm based on economic rational-choice theory models has therefore tended to dominate innovation studies (Fichman, 2004). In this perspective, innovation is explained in terms of economic returns to the organisation and therefore, strategic decisions regarding innovation are based on assumptions of rationality that seek to maximise utility. An economic rationale has also provided the impetus for conceptualising innovation in terms of 'demand-pull' – market forces as the basis of technological change, and 'technology push' – technological developments as an independent factor (Dosi, 1982). However, Fichman (2004) argued that this approach is not sufficiently holistic and does not take into consideration the full range of intervening factors, nor the interactions between them.

Given the close relationship between technology and organisational structures, organisational science has also been useful in furthering insight into technological innovation (Orlikowski, 2000). Indeed, a significant portion of the literature on technological innovation has come about from a focus on the firm (Dosi, 1988) and how innovativeness is a product of strategy as much as structure at the organisational level (Hollingsworth, 2000). Moreover, the challenge of innovation lies not only in creating new physical products, but also the development of supporting processes, which requires a change to existing organisational processes and structure, and at a more individual level, a change to the cognitive models that relate to the function of the incumbent product (Henfridsson et al, 2009).

These cognitive models have become a key focus, with Barley and Tolbert (1997) observing that "organizations, and the individuals who populate them, are suspended in a web of values, norms, rules, beliefs, and taken-for-granted assumptions" (p. 93). Williams (1980) argued that these cognitive models and shared systems of values, norms, rules, beliefs and assumptions are nurtured and facilitated by social structures that are either dominant (central and stable systems of meanings and values) or emergent (new meanings and values that are being created in response to new practices or conditions) and this realisation is pushing researchers toward institutional theories to help explain issues of organisational inertia towards adoption of technological innovations (e.g. Nelson, 1988; Orlikowski and Robey, 1991; King et al, 1994; Edquist, 1997; Damsgaard and Lyytinen, 2001; Nelson and Nelson, 2002).

3.2.1 Path Dependency

Within innovation studies, inertia to innovation has been expressed as path dependency. In line with the traditional economic-rationalist approach, this notion has been predicated on the idea of positive returns, where initial processes become established as self-reinforcing due to perceived efficiencies (David, 1985; Arthur, 1989). Over time, this leads to organisations being locked into specific patterns of behaviour even though economic conditions inevitably change.

Technologists have applied the behavioural premise underscoring action and interaction between individuals and groups to explain the repetitive nature of some actions: repeated or routinised patterns of actions and relationships between different units within an organisation, or between organisations, is a form of institutionalisation. Nelson and Winter (1982) developed the concept of 'routines' as a course of action that is 'programmatic' in nature, (i.e. likely automated), and is affiliated with a set of beliefs that is centric to its appropriateness and operation vis-à-vis context. Nelson and Nelson (2002) conceived of institutions as 'social technologies' that help to coordinate and reproduce meaning and value systems as a way of organising activity within and across organisations. Such institutionalisation have come to be considered to play a productive role in path dependency because behaviour is locked in due to its repetitive nature (regardless of whether this behaviour provides a competitive edge), and therefore posing an obstacle to change (Leavitt and March, 1988; Powell, 1991; Bassanini and Dosi, 2001; Hargadon and Douglas, 2001; Fagerberg 2004).

Institutional inertia has been considered a factor in studies of path dependency. To explain organisational path dependence in the face of technological innovation, Sydow et al (2009) proposed four mechanisms that contribute to dependency: coordination effects, complementarity effects, learning effects and adaptive expectation effects. The concept of 'coordination effects' is adapted from institutional economics, primarily based on North's (1990) work on 'rules' where the development of rules regarding repeated transactions can overcome information asymmetries between actors and decrease risk, thereby improving coordination and economies of scale.

This efficiency attracts others to adopt the same set of rules to govern similar transactions. Complementary effects occur when efficiencies arise from clustering the production of sale of related goods and services. Learning effects relate to efficiencies and skills gained due to task repetition, which in turn reduces the output costs. March (2006) observed that the tension for organisations in this area would be a trade-off between 'exploitative' and 'explorative' learning. These reflect deeper motivations within an organisation that is biased towards improving familiar practices that it has become good at rather than seek out new alternatives (Sydow et al 2009). Finally, adaptive expectation effects occurs when decisions are made not based wholly on merit, but rather, influenced by expectations of what others prefer and a unconscious desire to be aligned with the popular or dominant decision, which is an alternative validation of their decision.

Drawing on both innovation and evolutionary economics literature, Coombs and Hull (1997) suggested that path dependency in knowledge management is likely to be found in three different domains within an organisation. They reside in technology-as-hardware, a reference to physical artifacts and as such, a focus on this domain only considers path dependencies as an 'output' (Coombs and Hull, 1997: 18). Path dependency can also reside in the knowledge base, which encompasses a range of micro to macro sources of information that are directly linked to operational processes, organisational culture or shared cognitive models between individuals, groups or organisations. However, a focus on this domain for analysis is difficult due to the "tacit dimensions of the knowledge", which are difficult to determine (Coombs and Hull, 1997: 7).

Coombs and Hull therefore suggested a third domain, routines, which connects an organisation's knowledge base to its technological artifacts, thereby linking the prior two domains; due the repetitive nature of routines, there is also continual reinforcement and legitimisation of the other domains. As a result, the authors suggested that the key advantages of using routines to focus analysis for understanding path dependency lay in firstly in their ability to be practically observed, as well as the fact that routines tend to have common features that can be compared across different organisations. In terms of this research, a focus on the high-rise building subdivision and registration processes provides the observable routine that links knowledge (abstraction, understanding of rights, restrictions and responsibilities) to technical artifacts (such as the subdivision plan).

The literature shows that overcoming path dependency is a highly complex task that relies on organisational management examining both business and social aspects of operations within the firm to interrupt "the logic and the specific energy of the self-reinforcing patterns of the process in question" (Sydow et al, 2009: 702). In addition to the historical and economic aspect of process development, consideration also needs to be given to the social, cognitive and political factors affecting individual decision-making, and the institutional context of the organisation for providing the impetus for the development of self-reinforcing practices (Giddens, 1984; Sydow et al, 2009).

This requires the organisation to critically consider the incumbent process and its drivers (Moon, 1999; Schön, 1983) especially since these tend to be become highly implicit, emotive and informal and therefore, exude a high degree of invisibility and resistance to discovery. Szulanski's (1996) study of transferability of best practices within a firm demonstrated that knowledge related barriers at an individual level were significant factors in overcoming path dependent behaviour in learning new practices.

The relationship between innovation and institutions is essentially a tension arising from the interaction of two diametrically opposed social forces: stability (institutions) and change (innovations). This relationship was described by Hargadon and Douglas (2001), who noted that:

> "Introducing change into otherwise stable social systems is a risky endeavour, but this is exactly what entrepreneurs with potentially significant innovations must attempt to do. To be accepted, entrepreneurs must locate their ideas within the set of existing understandings and actions that constitute the institutional environment yet set their innovations apart from what already exists" (p. 476).

Therefore, in terms of facilitating innovation, understanding how institutions are created and become dominant provides a foundation for understanding the motivations behind current thinking, actions and behaviours, critical to understanding how best to position an innovation that aligns with the current institutional environment, without being too far a leap from current practices as to be alienating and perceived as risky.

3.3 INSTITUTIONAL THEORY

Institutions exist everywhere and are a fundamental part of social interactions. Seen as instrumental in political order, institutions are important because they are the social structures that evolve from local customs and beliefs, strengthening to form normative rule-based structures (both formal and informal) that prescribe or preclude behaviours in actions at all levels of society (e.g. Ostrom, 2005). This creates expectations of consistency, which overcomes information asymmetries that frequently exist (e.g. Hodgson, 2006). If institutions are social structures, then institutional theory "attends to the deeper and more resilient aspects of social structure" and examines the "processes by which structures…become established as authoritative guidelines for social behaviour" (Scott, 2004a: 460).

Institutional theory has a long history, its early development subsumed under neoclassical economics, behaviourism in political science and (anti) positivism in sociology (Scott, 2004b). Criticisms of it being too descriptive with insufficient links to broader political and economic issues saw the discipline fall into disfavour (DiMaggio and Powell, 1991). However, in the late 1970s, institutional theory experienced a revival following the work of Selznick (1949; 1957), who argued that the process of institutionalisation was essentially a process to "infuse with value beyond the technical requirements of the task at hand" (Selznick, 1957: 16-17). This critical insight suggested that institutionalisation was not always aligned with task objectives and offered a complementary perspective to the prevailing rational choice approach in organisational studies, especially since rational choice was often found to be of limited value in empirical studies of organisational change (March and Olsen, 1984).

Institutional theory is less a single theory and more a collection of perspectives developed from philosophical foundations in economics, sociology and political science (Björck, 2004; Scott, 2008; Currie, 2009). Despite institutional theory being renowned for conceptual variety (e.g. Scott, 1987a; Zucker, 1987; Hall and Taylor, 1996; Hollingsworth, 2000; Peters, 2000), it has nonetheless played a significant role in focusing attention away from the dominant presumption of economic-rationalist motivations for behaviour, and on to the social and cultural elements that affect individual, group, organisational and even societal behaviour through the presence of formal and informal social structures, i.e. how behaviour is socially constructed (Meyer, 1977; Meyer and Scott 1983; Meyer and Rowan, 1991; Barley and Tolbert, 1997).

The application of institutional concepts to organisational study has led to the development of

organisational institutionalism (Greenwood et al, 2008), which is adopted for this research. This branch of institutional theory can be traced back to Meyer and Rowan's (1977, reprinted as Meyer and Rowan, 1991) early work on organisations and how the structure and behaviour of organisations is a function of environmental and contextual factors that impose social and cultural pressures. Consequently, scholars later argued for the need to conceptualise organisations as part of larger networks and systems (DiMaggio and Powell, 1983; Powell and DiMaggio, 1991). Similarly, Scott (2001) argues that organisational institutionalism can be considered to be an extension of open systems theory, which focuses on the inputs, outputs and environmental impacts on an organisation in times of transformation, where the environment is conceived of as consisting social and cultural forces in addition to the technical aspects (such as resources).

Organisational institutionalism recognises that organisations are "rationalised" systems but that "models of rationality are themselves cultural systems, constructed to represent appropriate methods for pursuing purposes" (Scott, 2004: 465). Further, for the purposes of this research, the arguments of Scott and Meyer (1983) are adopted, who distinguish between the technical and institutional environments. The technical environment relates to the overall environment that supports the production of goods or services of an organisation particularly control over related work processes. The institutional environment relates to the array of social structures (rules, activities, beliefs, symbols and norms) that the organisation aligns with to achieve and maintain a position of legitimacy.

Organisational institutionalism has been used in a variety of fields to identify factors that influence organisational responsiveness to external pressures to change, as well as ramifications for strategic choices (Goodstein, 1994). Similar to the experiences of organisational researchers before them, researchers in the domains of information technology (IT) and information systems (IS) are experiencing increasing awareness as to the shortcomings of the rational-choice approach in understanding adoption and use of IT innovations (Giddens, 1984; Pinch and Bjiker, 1987; Orlikowski and Robey, 1991; Orlikowski and Barley, 2001; Dowell et al, 2002; Geels, 2004). Consequently, many are leveraging the perspectives offered by institutional theory to help explain the phenomena of "widespread adoption and acceptance of IT innovations seemingly sub-optimal in economic and technical terms" (Currie, 2011: 138).

There is often an assumption that stable institutions persist simply because they are right (e.g. Williamson, 1985); however, institutions can often be less than appropriate not only because they are difficult things to change, but also because the cost of enacting change may be greater than the benefits that change might bring (e.g. Akerlofm, 1976; Mathews, 1986 in DiMaggio and Powell, 1991). For this thesis, institutional analysis plays a role in determining if and how current institutions are responding to needs, and providing indications as to the potential paths forward to support change.

3.3.1 Definition of Institutions

Institutions, have been defined as "regulative, normative, and cognitive structures and activities that provide stability and meaning for social behaviour" (Scott, 1995: 33), or commonly conceived as culture, belief systems (such as religion), legislation, regulation and norms (social or professional), to name a few broad categories. In the absence of complete information, institutions reduce risks and uncertainty by creating expectations about how others might behave in certain situations, and therefore, institutionalisation is "the process of social interaction through which actors realise that their expectations in the behaviour of others will not be disappointed" (Beckert, 1999: 782). Scott (2001) attempts to bring together the salient attributes of institutions through his "omnibus conception of institutions", shown in Figure 3.1.

- Institutions are social structures that have attained a high degree of resilience.
- Institutions are composed of cultured-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social life.
- Institutions are transmitted by various types of carriers, including symbolic systems, relational systems, routines, and artifacts.
- Institutions operate at multiple levels of jurisdiction, from the world system to localised interpersonal relationships.
- Institutions by definition connote stability but are subject to change processes, both incremental and discontinuous.

Figure 3.1 Scott's omnibus conception of institutions (Scott, 2001: 48).

3.3.2 Organisational Field and Institutional Logics

To understand what constitutes the institutional environment, it is necessary to be able to identify the organisational field. DiMaggio and Powell (1983) defined organisational field to be "those organisations that, in the aggregate, constitute a recognised area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organisations that produce similar services or products" (DiMaggio and Powell, 1983: 148). The authors further argued that the organisational field presents value as a unit of analysis because it focuses inquiry on the range of actors operating in the same institutional environment.

At a more abstract level, Scott (2001) defined the organisational field to be "the existence of a community of organisations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside of the field" (p. 84).

Organisational field as a concept therefore relates a group of organisations that are operating in the same field, who may or may not have structural similarities, but are brought together by common issues (Hoffman, 1999). This gives rise to power dynamics between organisations (Brint and Karabel, 1991) especially as competition emerges between organisations to define what these issues are for the field and to develop institutions that provide the structure for 'appropriate' organisational behaviour (Hoffman, 1999). These power relations help shape the governance structure of the field. The boundary of the organisational field can also be defined by the existence of shared cultural-cognitive and normative elements, as well as the presence of logic i.e. rules or principles that relate to how the field is organised (Scott, 2001).

Inherently, organisational field relates to a level of analysis that is necessarily inter-organisational and existing at a macro level. In this research, the organisational field, and therefore the unit of analysis, is taken for the City of Melbourne to be those organisations whose operations are concerned with the issue of high-rise subdivision and registration, and for Singapore, to be those organisations whose operations are concerned with the issue of high-rise land development.

Related to the concept of organisational field is the concept of institutional logics. This concept was developed by organisational theorists to link institutions with action (Thornton and Ocasio, 2008). Friedland and Alford (1991) proposed that each institution possesses a logic that directs the flow of action and identity of that institution – these can be integrated at an organisational level to affect behaviour of individuals, groups or the organisation itself and defined this as the "sets of 'material' practices and symbolic constructions which constitute a field's organising principles and which are available to organisations and individuals to elaborate" (p. 248).

Jackall (1988: 112) had a more simplistic view of institutional logics, describing it as "the way a particular social world works". Building on both Friedland and Alford's, as well as Jackall's definitions, Thornton and Ocasio (1999) defined institutional logics as "socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organise time and space, and provide meaning to their social reality" (p.804). More simply put, Scott (2001: 139) defined it as the "belief systems and related practices that predominate in an organisational field", or what political scientists regard as shared strategies (Ostrom, 2005).

Institutional logics provides a theoretical approach to understanding and relating behaviour as a function of social and institutional environments (Thornton and Ocasio, 2008), and are central to analysing a particular field – i.e. a group of organisations that share a common meaning system because they interact more with each other than any other organisation (Hinings, 2012). This results in a common understanding of what the goals of the group are, and how these goals should be achieved (Battilana et al, 2009). Thornton and Ocasio (2008) argued that they are fundamental as the influence "rational, mindful behaviour" (p.100) and therefore is reflected in how a social reality works.

In analysing institutional environments, the supposition therefore is that institutional logics can be deduced from operational practices as these are imbued with the culture, ideologies, value systems and rules of the organisation or institution. Competing and perhaps contradictory institutional logics may be in existence within organisations, since they engage with a variety of stakeholders and organisational fields (Scott, 2008; Thornton and Ocasio, 2008). As such, institutional logics provide a link between institutional influences and behaviour (e.g. Barley and Tolbert, 1997), and also links different levels of analysis (e.g. Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Zucker, 1991).

Relevant to this research, institutional logics have been used to consider issues of implementing new information systems and how new systems may not match current institutional logics (Gosain, 2004). This can lead to a range of issues including resistance to change. On the other hand, Berente's (2009) investigation of NASA's enterprise systems demonstrated that it was possible to resolve issues relating to misaligned institution logics by decoupling operations from structure (in this case, the enterprise system).

3.3.3 Institutional Elements

Institutional theory is concerned with "the deeper and more resilient aspects of social structure" and examines the "processes by which structures…become established as authoritative guidelines for social behaviour" (Scott, 2004: 460).

These institutions, or social structures, are affiliated with broad categories of rules, norms and cultural beliefs that can affect organisational decisions around adoption of new practices – even when the new practices appear to be more efficient (Scott, 1995). Scott (1995; 2001) developed a typology of regulative, normative and cultural-cognitive elements (or categories of institutions) described in his 'Three Pillars' framework as the three underlying structures that underpin behaviour and decision-making. Together, these elements serve to underpin a range of enduring social structures within society. Table 3.1 provides an overview of these key elements, summarising the basis of compliance and order for each, the manner in which they exert pressure and gain dominance, the logic they rely on for perpetuation, indicators of their existence, how they are considered to legitimate and how they are diffused.

Conscious ← → *Unconscious*

INDICATORS/ MECHANISMS		REGULATIVE	NORMATIVE	CULTURAL-COGNITIVE
Basis of compliance		Expedience	Social obligation	Taken-for-grantedness, shared understanding
Basis of order		Regulative rules	Binding expectations	Constitutive schema
Mechanisms		Coercive	Normative	Mimetic
Logic		Instrumentality	Appropriateness	Orthodoxy
Indicators		Rules, laws, sanctions	Certification, accreditation	Common beliefs, shared logics of action
Basis of legitimacy		Legally sanctioned	Morally governed	Comprehensible, recognisable, culturally supported
Carriers	Symbolic systems	Rules, laws	Values, expectations, standards	Categories, typifications, schema
	Relational systems	Governance or power systems	Regimes, authority systems	Structural isomorphism, identities
	Routines	Protocols, standard operating procedures	Jobs, roles, obedience to duty	Scripts
	Artifacts	Objects complying with mandated specifications	Objects meeting conventions, standards	Symbolic objects

Table 3.1 Key concepts from Scott's 'Three Pillars of Institutions' (Scott 2001; 52, 77).

The **regulative pillar** describes a category of institutional elements associated with legislation and regulation, the purpose of which is to seek to control behaviour (Scott, 2001). Rules, laws and sanctions tend to be typical indicators and serve to provide regulations around behaviour (Scott, 2001), while legal authority provides legitimacy – there is no choice for organisations but to conform (Hoffman, 1999). These institutions comprise regulative elements that are constituted by mechanisms mainly driven by "force, fear, and expedience", resulting in behaviour and actions that are conscious and concerted, reflecting a high degree of rationality (Scott, 2003: 880). This rationality reflects the costs associated with non-conformity (North, 1990). Naturally, the state (as the source of authority) tends to be a key actor in such institutions given its position of power (Scott, 2001).

At a less conscious level, the **normative pillar** relates to those institutions that influence and perpetuate behaviour and action through prevailing social patterns such as values, norms and social or professional mores. They reflect internalised morals, obligations and expectations associated with, and built into, social roles that contribute to the establishment of social order (Scott, 2001). Typical behaviour tends therefore to be morally sanctioned, and conformity to these social expectations confers individuals or groups with legitimacy and associated status within the community.

Finally, at the least conscious level, the **cultural-cognitive pillar** refers to institutions that comprise mechanisms relating to social reality – the taken-for-granted beliefs and shared systems of cultural meaning which shapes communal and individual thought and belief systems, and upon which identity, meaning and social order are predicated (Scott 1995, 2001, 2003). These institutions often underpin the logical thought processes that surface in the face of uncertainty, thereby serving as a sense-making mechanism.

Scott (1995, 2001: 77) proposed four distinct modes of carriage to explain how these institutions are transmitted over time and space: symbolic systems (e.g. rules, standards and categories; relational systems (e.g. authority systems); routines (e.g. standard operating procedures) and artifacts.

Although the distinctions between the categories of institutional elements have been criticised as less than realistic (Thornton et al, 2012), Scott argued for the applicability of this framework for the purposes of facilitating analysis. As such, in applying this conceptualisation of constraints on behaviour on innovation, it becomes apparent that technological changes can make evident the gaps in current institutional structures due to their inability to support its use (e.g. North, 1993; Healy 2002). Alternatively, it can also make certain institutional elements more significant if those elements can be leveraged to facilitate adoption and use of the new technology (e.g. Dowell et al, 2002). Further, Currie (2011) argues that activities relevant to the adoption and implementation of technological innovations are likely to be influenced by social pressures, be it from external sources, or from within the organisation itself, which result in conscious or less conscious behaviour that facilitate, or put up barriers, to successful adoption and implementation of technology. Institutional elements are therefore considered to influence behaviour of organisations by exerting a range of pressure on organisations.

3.3.4 Institutional Pressures and Isomorphism

The various elements in an institutional environment can be so dominant in terms of influencing behaviour, that it can shape organisational structure, which is more often considered to be a product of efficiency shaped by forces exerted by the market (DiMaggio and Powell, 1983). With survival closely linked to notions of legitimacy, institutional pressure from these elements results in organisations within an organisational field beginning to adopt similar structures. This process towards homogeneity is known as institutional isomorphism.

Organisational researchers have long argued that organisations that operate in the same environment tend to exhibit similar organisational forms since they are all pursuing a form that would best deliver operational efficiencies (Boxenbaum and Jonsson, 2008). This form is not only a consequence of technical, task-oriented pressures, but also conformity to social – or institutional – pressures, and an organisation's belief in what society expects of them. This is one of the main concepts in organisational institutionalism. Institutional isomorphism occurs when organisations come under significant pressure to conform to rationalised myths (DiMaggio and Powell, 1983). These rationalised myths are discussed in Section 3.3.4.

There are three sources of institutional pressures: coercive, mimetic and normative (DiMaggio and Powell, 1983). **Coercive pressure** is often a product of legislation or regulations, or similar, where the outcome is for organisations to feel there is no choice but to change (Scott, 2001). An example is changes to organisational practices due to shifts in regulatory requirements (Abernathy and Chua, 1996). As well, these forces can come from broad societal cultural expectations, or from another organisation upon which there is a dependant relationship.

Mimetic pressure occurs when, in the face of uncertainty, organisations structure themselves using similar, but more successful, organisational models as templates. This represents the way in which institutions comprising cultural-cognitive elements exert their influence on behaviour (Mignerat and Rivard, 2009). Imitation is seen to be a rational choice on two fronts: firstly, there is lower risk in adopting practices that are proven; secondly, there is assumed status in following organisations that are proving to be more successful (and therefore, more legitimate)

(DiMaggio and Powell 1983; Tolbert and Zucker, 1983; Fligstein, 1985). Such practices result in mimetic isomorphism, where organisational structures become more similar with other organisations in the same institutional environment.

Normative pressure relates to the social pressures exerted on the organisation, typically when the people within the organisation is subject to pressures to conform to standards or practices developed by an overarching industry group (DiMaggio and Powell, 1991). Some examples of this include accredited curriculum and professional training offered to reinforce and proliferate a set of skills, practices and knowledge and way of thinking (Williamson, 1975; DiMaggio and Powell, 1983).

In responding to these sources of pressure, organisations are conceived as agents that can respond in a variety of ways (Ingram and Clay, 2000). In particular, Oliver (1991) proposed five approaches that organisations tend to adopt in the face of institutional pressure, which will be reviewed in Section 3.5.

To predict the probability and likelihood of isomorphism occurring, DiMaggio and Powell (1991) identified indicators at both the organisational level, and the industry or field level. At the organisational level, predictors were based on the relationship of the organisation to external pressures (p. 74-76):

- Dependency: either between organisations, or between organisations and resource suppliers – greater dependency provides a position of power over dependent organisations that can be exploited to force organisations to change their practices.
- Uncertainty and ambiguity: relates to organisational understanding of the relationship between inputs and outputs as a predictor of organisation's likelihood to model behaviour after more successful firms; moreover, organisations with ambiguous goals are more likely to model a successful organisation to demonstrate legitimacy.
- Professionalisation: higher incidence of professionalization (i.e. personnel with specific academic credentials) indicates higher likelihood of isomorphic change as logic and thinking is conditioned through behaviour socialisation processes in education; similarly, an organisation's tendency to engage in trade and professional associations is a predictor of likeness with other firms in the field.

The rationale of organisational level predictors also means that these predictors can also play out at the field level, especially when dependencies – also indicated through lack of alternatives

– exist, such as through supply of resources. But this can also extend to transactions with bureaucratic organisations, as these typically exhibit characteristics of "rule-boundedness and formal rationality" (DiMaggio and Powell, 1991: 76). At the field level, predictors are (p.76-77):

- Variation in suppliers of vital resources: the less variation (i.e. a single supplier or few similar suppliers), the more likely the field will succumb to isomorphic pressure.
- Levels of interaction with the state: higher levels tend to create a greater extent of isomorphism.
- Visible alternative organisational models: fewer models produce faster rates of isomorphism.
- Ambiguity of goals and uncertainty of technology: greater ambiguity and uncertainty generates a faster rate of isomorphic change.
- Professionalisation: the greater the extent of professionalisation, the greater the amount of isomorphic change.
- Structuration: the greater the extent of structuration (i.e. stable and broadly acknowledged centres), the greater the degree of homogeneity.

Both sets of predictors are summarised and presented in Table 3.2 below.

TYPES OF ISOMORPHIC PRESSURE	ORGANISATIONAL LEVEL PREDICTORS	FIELD LEVEL PREDICTORS
Coercive	Dependency between organisations Dependency of organisation on resource supplier	Levels of interaction with the state Variation in suppliers of vital resources
Mimetic	Uncertainty of understanding relationship between inputs and outputs Ambiguous organisational goals	Ambiguity of goals and uncertainty of technology Visibility of alternative organisational models
Normative	Organisations that employ personnel with specific academic credentials An organisation's tendency to engage in trade and professional associations	Professionalisation Structuration

Table 3.2 DiMaggio and Powell's predictors of isomorphic change at organisational and field level (DiMaggio and Powell, 1991: 74-77).

Essentially, institutional isomorphism appears to accelerate around three main factors: level of dependency between organisations in the organisational field, level of ambiguity or uncertainty in organisational goals and whether the organisation relies heavily of professionally qualified personnel. This suggests that organisational behaviour is also a consequence of "political power and institutional legitimacy, for social as well as economic fitness" (DiMaggio and Powell, 1991: 66).

3.3.5 Legitimacy and Rational Myths

The role of legitimacy in institutional theory has roots in sociological theory and has often been attributed to the works of Weber (e.g. Suchman, 1995; Johnson et al, 2006). Weber (1978) suggested that in addition to obtaining legitimacy through adherence to formal laws, legitimacy could also be accessed through conforming with normative social practices, since these tend to reflect cultural rules and mores. There was however criticism levelled against Weber, with arguments made that it was not sufficiently salient in its conceptualisation (Meyer and Scott, 1983).

Within organisational institutionalism, legitimacy was brought into focus through the works of Meyer and Rowan (1977), who were the first to argue that legitimacy played as much of a role in future-proofing a firm as did maintaining the efficiency of its operations. Legitimacy is obtained when firms conform to society's expectations of what a 'proper' organisation should look like and behave, and Meyer and Rowan coined the term 'rationalised myths' to refer to these socially constructed, institutionalised ideas as to the form and function of organisations. Since legitimacy implied an acceptance by society, obtaining legitimacy meant that organisations were less likely to have their form or function questioned, even in times of variable performance.

Responding to these rationalised myths may not necessarily be in line with an organisation's drive for efficiency; there may also be the existence of multiple competing and contradictory rational myths. Building on the notion of organisations as tightly coupled systems in systems theory, institutionalists argued that the pressure to meet the requirements of these myths led to less tightly coupled systems (March and Olsen, 1976). Indeed, decoupling organisational task from structure enabled the appearance of – but not practical – adaptation to institutional pressures and seeming adoption of institutionalised ideas (Meyer and Rowan, 1977). Meyer and Rowan (1977) argued that rationalised myths were 'myths' because they were often only accepted superficially to enable the organisation to gain legitimacy or appear legitimate, evident in changes to job titles, role definitions, procedures and so on, masking the fact that in reality, no substantial changes had actually been made. Such superficial conformity helped organisations to mediate risks to their legitimacy, while at the same time not placing at risk their organisational efficiency.

Over the years, the notion of legitimacy has been affiliated with several variations: cultural support (Meyer and Scott, 1983); acceptance by the public and the acknowledged right of an organisation to pursue its own aims (Knoke, 1985); access to resources for survival (Brown, 1998); as "a condition reflecting cultural alignment, normative support, or consonance with relevant rules or laws" (Scott, 1995: 45). Taking into account these various intangible characteristics of legitimacy, Suchman (1995) proposed a broad definition, which will also be the definition adopted in this research:

> "Legitimacy is a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions" (p. 574).

Legitimacy is therefore both a resource that can benefit an organisation, as well as a status, which suggests that the organisation is accepted within other institutional areas (Scott, 2001). This is a key concept in understanding how new institutions emerge – for this research, this relates specifically to the institutions created around 3D practices in urban land administration. It is possible to create new institutions through regulative institutions that exert coercive pressure, such as from the state, which in turn can flow on to other organisations. However, in order to have the power to do so, this power must firstly be recognised by normative and cultural-cognitive institutions that suggest there is broader societal legitimacy (Stinchcombe, 1968, cited in Scott, 2001).

However, Oliver's (1991) typology of strategic choices (discussed in Section 3.4) shows that conforming to institutional pressures is not necessarily the only choice and that there can be other benefits to the organisation from not conforming. This further reinforces the notion that institutionalised practices are not necessarily the most efficient, especially over the longer-term (Oliver, 1991).

In summary, the appeal of institutional theory in examining the role of stable social structures in facilitating or constraining certain behaviours is also relevant for explaining why behaviours can be difficult to change (i.e. institutionalised). Upholding normative or regulatory conditions often rely on sanctions (social, moral or economic) or incentives (inducements that can be financial or otherwise) – but these may be easier to alter than the fundamental institutional logics used to provide common meaning systems and cognitive models. The cognitive aspect ultimately provides the basis for defining conditions of acceptability in behaviour (Hargadon and Douglas, 2001). Therefore, the longer the existence of an institution, the more influence it will have on action, posing greater resistance to change (Barley and Tolbert, 1997).

3.4 INSTITUTIONS AND STRATEGIC CHOICES

Organisational institutionalism has led to significant insights into how an organisation's institutional environment affects its structure and behaviour. In particular, mechanisms such as regulation and professional norms can evoke similar responses across different organisations (DiMaggio and Powell, 1983; Meyer and Rowan, 1977 and Scott, 1983).

However, given that a central premise of institutional theory is that institutions are taken-for-granted and actors become embedded in the their own models of rationalised systems, this means that action is more "the enactment of broad institutional scripts rather than a matter of internally generated and autonomous choice, motivation, and purpose" (Meyer et al, 1994: 10). This indicates a certain degree of 'blindness' within organisations as to how institutions might be constraining the breadth of available options available as strategies (Beckert, 1999).

It also indicates that organisational choice is constrained by external pressures such as the state, professions, interests groups and public opinion (Scott, 1987b), and action is mainly motivated by maintaining and ensuring the legitimacy of the organisation (i.e. "demonstrating social worthiness" (Oliver, 1991: 150) and its ability to survive is more a response to external expectations and demands rather than to rational choices (Meyer and Rowan, 1977; DiMaggio and Powell, 1983). Covaleski and Dirsmith (1988: 563) argued that, "the general theme of the institutional perspective is that an organisation's survival requires it to conform to social norms of acceptable behavior".

Such behaviour has been found to reap a range of rewards. In addition to legitimacy, organisational action or behaviour that conforms with institutional norms also brings increased status, and with this, additional resources, support and ultimately, stability; it gains acceptance by professions and therefore attracts people and commitment to the organisation; finally, it fits better into broader administrative functions, leaving the organisation less open to questions regarding its role (Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Meyer and Scott, 1983; Scott, 1983; DiMaggio, 1988; Zucker, 1988).

Institutional theory has shown how these pressures are often from various sources, and often create conflict for the organisation in terms of their strategic responses, which may be different for responding to institutional environmental pressures as opposed to task-based environmental pressures (Oliver, 1991).

It is therefore not surprising that institutionalism has come to be linked with strategy development, its theoretical perspective seen to enable a better understanding of strategic choices, particularly from an organisational perspective (Clemens and Douglas, 2005). The literature on strategy development has tended to focus only on formal actions, with limited consideration given to how formal institutions might relate, or is affected by, informal institutions (Ingram and Silverman, 2002). Broader literature on management, while acknowledging the impact of business environments on organisational choices (e.g. Meyer and Rowan, 1977; Tolbert and Zucker, 1983; Baum and Oliver, 1992), is however limited in exploring and understanding organisational strategic choice contextualised as non-rational, or non-choice (i.e. through habit, norms, obligation, etc.) responses to institutional pressures (Milliken et al, 1998). Institutional theory has played a key role in emphasising the role that social and cultural pressures have on strategic responses.

Scott (1991) noted that, "Just as is the case within their technical environments, organisations may be expected to exercise 'strategic choice' (Child, 1972) in relating to their institutional environments and responding to institutional pressures" (p. 170). Goodstein (1994), building on Child's (1972) concept of 'strategic choice', extended this to explain differences in levels of responsiveness to pressures (in the context of pressure for organisations to become more family friendly) because organisations have a breadth of options in how they can respond. Oliver's (1991) typology of strategic choices remains to date, a highly relevant and applicable framework for understanding how strategic choices are developed and actioned.

3.4.1 Oliver's Typology of Strategic Choice

To explain organisational response to institutional pressures, Oliver (1991) proposed a framework that theorised a link between institutional pressures and an organisation's strategic responses. This seminal paper on institutional pressures on strategic choice remains highly relevant even till today. She argued that response to institutional pressures, and therefore, choice, is a result of "why these pressures are being exerted, who is exerting them, what these pressures are, how or by what means they are exerted, and where they occur" (p. 159). A number of studies have been able to prove the applicability of her framework in empirical studies (Etherington and Richardson, 1994; Goodstein, 1994; Ingram and Simons, 1995; Milliken et al., 1998; Clemens and Douglas, 2004) and it remains to date, a key typology of institutional pressures and strategic responses.

In the face of institutional pressures, Oliver proposed that organisations could make a strategic response that fell into any of five categories that ranged from passive to active resistance to institutional pressures. She categorised them as acquiescence, compromise, avoidance, defiance, and manipulation (Table 3.3). Etherington and Richardson (1994) found that Oliver's typology of strategic responses could be conceived of not only as representing a continuum of active to passive resistance, but conversely also represents various levels of accommodation (negative to positive).

STRATEGIES	TACTICS	EXAMPLES
Acquiesce	Habit	Following invisible, taken-for-granted norms
	Imitate	Mimicking institutional models
	Comply	Obeying rules and accepting norms
Compromise	Balance	Balancing the expectations of multiple constituents
	Pacify	Placating and accommodating institutional elements
	Bargain	Negotiating with institutional stakeholders
Avoid	Conceal	Disguising conformity
	Buffer	Loosening institutional attachments
	Escape	Changing goals, activities, or domains
Defy	Dismiss	Ignoring explicit norms and values
	Challenge	Contesting rules and requirements
	Attack	Assaulting the sources of institutional pressure
Manipulate	Co-opt	Importing influential constituents
	Influence	Shaping values and criteria
	Control	Dominating institutional constituents and processes

Table 3.3 Oliver's strategic responses to institutional processes (Oliver, 1991: 152).

Expanding on Table 3.3, an overview of these strategic responses are provided below (Oliver, 1991: 152-159).

- **Acquiesce:** This is a passive strategy, inherently signaling that the organisation agrees and concedes to the institutional pressures, whether consciously, or unconscious. Therefore, forms of acquiescence include **habit** (less conscious acquiescence based on historical expectations), **imitation** (of more successful. organisations) and **compliance** (more conscious and active level of acquiescence).
- **Compromise:** As the term suggests, this suggests a strategy that aims to balance between organisational compliance and resistance to institutional pressures. Forms of compromise may include attempting to **balance** by accommodating the demands from multiple sources or stakeholders related to the organisation's own internal needs and

objectives; **pacification**, where the organisation attempts to only meet some of the range of external demands; **bargaining**, where the organisation attempts to trade off compliance for some gains through negotiation.

- **Avoidance:** This strategy is defined as "the organisational attempt to preclude the necessity of conformity" (Oliver, 1991: 154). These attempts play out as **concealment** tactics, which aims to disguise non-conformity as acquiescing to demands with no intention of following through; **'window-dressing**', which refers to symbolic acceptance of institutional requirements; **buffering**, where the actual internal task environment is decoupled from the formal institutional structure which is what organisational performance and status is assessed on; and finally, **escape**, when an organisation exits the institutional domain, or resorts to changing its own organisational aims and objectives to avoid complying with institutional pressures.
- **Defiance**: This strategy marks the start of more active forms of strategic responses, mostly, resistance of institutional pressures. Defiance is manifested in three tactics: **dismissal**, which refers simply to ignoring institutional rules; **challenge**, where the organisation actively challenge these pressures and make overt displays of defiance; **attack**, which is distinct from challenge simply due to the higher level of intensity and aggressiveness behind actions.
- **Manipulation**: As the most active strategy, manipulation is defined as "the purposeful and opportunistic attempt to co-opt, influence, or control institutional pressures and evaluations" (Oliver, 1991: 157). A range of tactics are associated with manipulation, including **co-opting**, which brings external pressures around to support the organisation instead; **influencing**, which is more broadly directed towards belief and value systems to shift what is considered to be acceptable practices; finally, **controlling** tactics are specifically used to dominate the external stakeholders that are exerting pressure on the organisation.

To support understanding of an organisation's decision in their choice of strategic response, Oliver also suggested five institutional factors that motivate adoption of one or several of the aforementioned strategic responses: cause, constituents, content, control and context. These factors are explained below.

- **Cause:** objectives that underpin institutional pressures for conforming – firms that feel the most pressure to conform would likely offer lower resistance.
- **Constituents:** refers to the variety of stakeholders that exert institutional pressures on organisations (such as the state, professions, interest groups and the public). The

correlation here relates more to dependence on these constituents for organisational legitimacy–the greater the dependence, the lower the resistance. For example, adopting industry standards would make organisations more dependent on external constituents.

- **Content:** refers to the requirements associated with institutional pressures, and the extent this aligns with the organisation's own goals. This alignment provides the basis for predicting strategic response: the greater the alignment, the more likely the organisation is to comply.
- **Control:** refers to the mechanisms by which institutional pressures are applied on organisations, e.g. regulatory mechanisms. Therefore, if controls tend to be more coercive and prescriptive, it is less likely that organisations will resist.
- **Context:** refers to the conditions in which institutional pressures are imposed on organisations, citing the connectivity of organisations as a key element (Oliver, 1991). This factor therefore implies that the higher the degree of interconnectedness, the more likely is that organisations will submit to institutional pressures.

Oliver's typology and causal factors have been tested and validated through a range of studies (e.g. Goodstein, 1994; Clemens and Douglas, 2004). Her findings, and those of Scott (1993) and Etherington and Richardson (1994) demonstrate that although organisations all experience institutional pressure, their compliance and subsequent strategic choice can be one of a number of choices on a continuum of passive to active resistance to these pressures. In the Singapore case study, Oliver's typology will be used to consider how effective strategies are in eliciting a positive organisational response to institutional pressure.

3.5 CONCEPTUAL FRAMEWORK

The application of the key aspects of institutional theory is presented as a conceptual framework in Figure 3.2.

An application of institutional theory supports the conceptualisation of the institutional environment to identify those elements that create institutional pressure. In the Melbourne case study, this results in pressure that constrains the organisational field to current 2D-based practices. It considers how the current institutional environment in urban land administration might be impeding efforts to change through identifying the underlying institutional elements.

In the Singapore case study, institutional pressure is conceived to stem from a range of strategies that induce conformity to change. In the event of 3D innovation occurring, changes in the institutional environment are perceived to exert a range of institutional pressures on organisations in the organisational field. A combination of institutional factors (cause, constituents, content, control, context) influences the way an organisation may choose to respond to institutional pressures. This results in various degrees of conformity to change.

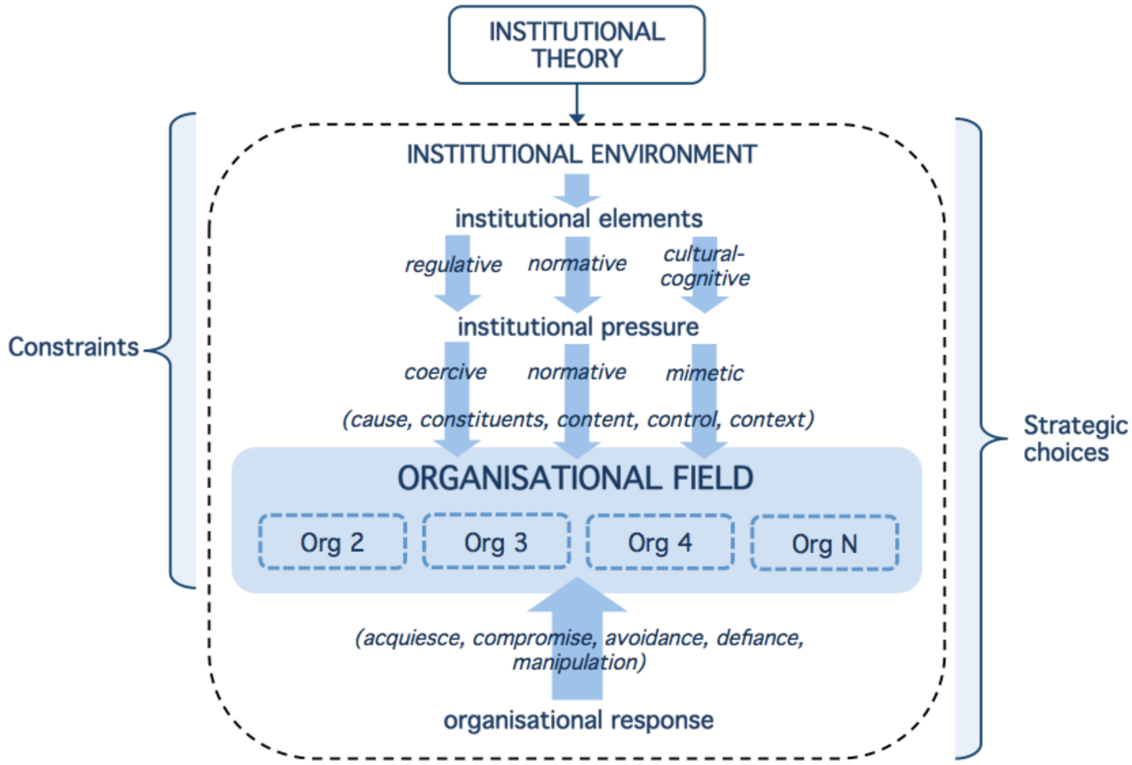

Figure 3.2 Conceptual analytical framework applying institutional theory components.

3.6 CRITIQUE OF INSTITUTIONAL THEORY

Although institutional theory offers much in terms of insight into how actions can be constrained by a range of regulative, normative and cultural-cognitive elements, it has nonetheless experienced some criticisms for several issues, least of which being its lack of a salient definition. At a theoretical level, institutional theory has been criticised for a tendency towards a macro-level approach that really limits the ability to gain in-depth empirical understanding of what really underpins some of these social structures that provide it with power and durability (Hasselbladh and Kallinikos, 2000; Berente, 2009).

Institutional theory has also tended to be limited in its explanation of actors and actions (such as why they may be motivated to take up new innovations), with an underlying assumption that actors passively accept institutions as constraints on their behaviour (DiMaggio, 1988; Beckert, 1999; Fligstein, 2001). Finally, institutional theory has been criticised as being often found to be at odds with empirical findings and continues to struggle with distinguishing rational choice from institutionalised action (Donaldson, 1995).

In some way, these criticisms are being addressed by the growing use of institutional logics as an analytic mechanism, which refocuses institutional analysis at micro-levels. In doing so, it enables greater insight into actor and agency, as well as providing the empirical context to better explore rational versus institutionalised choices (Scott, 2008). However, these criticisms do not fundamentally detract from the use of institutional theory in this research since the research is an exploratory study and a macro-level approach, or a "bird's eye view of the field" (Hasselbladh and Kallinikos, 2000: 700), remains an appropriate first step.

3.7 A NEW RESEARCH AGENDA: AN INSTITUTIONAL PERSPECTIVE ON 3D INNOVATION IN LAND ADMINISTRATION

Current literature on 3D innovation in cadastral and land administration systems asserts the limited progress in adopting and implementing 3D technologies for land administration to be a consequence of legislative frameworks:

> "…if a legal system does not provide the instruments to create 3D property, there is no need for a 3D cadastre at all. On the other hand a 3D Cadastre itself does not make 3D property rights possible" (Banut, 2011, p.3).

However, as shown in chapter two, many countries around the world (e.g. Australia, Sweden, the Netherlands, Singapore) actually have provisions for ownership of 3D property (e.g. Williamson 2002; Stoter, 2004; Rajabifard et al, 2012). This legal mandate is motivated by the need for accurate, authoritiative and unambigous definition and representation of land and property RRRs and there are several ways in which the law can affect the legitimacy of 3D property, as reviewed in the previous chapter.

A reconsideration of current literature through the lens of institutional theory offers an alternative conceptualisation of the role of legislation. In addition, there is significant potential to develop other insights not only on how legislation might impede innovation, but also illuminate other fundamental sociological barriers to change that exist at organisational or individual levels. This section demonstrates that a holistic understanding of the role of institutional aspects and its influence on behaviour will contribute additional and necessary insights for identifying a change path trajectory towards the adoption of new processes to support a move towards 3D-enabled urban land administration practices.

3.7.1 Legislation as an Institutional Barrier to 3D Innovation – To What Extent?

The current emphasis on legislative frameworks as an impediment to 3D-enabled urban land administration indicates wide acceptance that these frameworks, in institutional terms, given their regulatory nature, constitutes a key institutional barrier.

However, the fact that there exists alternative practices around 3D property registration despite seemingly restrictive frameworks indicates that its significance as an institutional barrier may perhaps be overstated. In reality, many of these frameworks are based on legislation that contravene prevailing perceptions of rigidity. In fact, examples of legislation show them to be vague and non-prescriptive, suggesting limited impact as an institutional barrier, especially if conceived of as a regulatory institution.

There is no doubt that cadastral and land administration systems are often regulated, which can impact its form and relationship with other stakeholder. However, a regulated institutional environment can have other implications as well that may not have yet been considered, but pose equally significant institutional barriers. For example, arrangements which situate land registries and cadastres under the same organisation may find innovation to be less challenging, simply due to structural and situational simplification.

In contrast, countries where land administration and cadastral systems are complicated by multiple agencies (e.g. Malaysia, Greece, Philipplines), different levels of government (e.g. Poland), and different land and building registers of information with different responsible authorities (e.g. Poland, Denmark and the Czech Republic) all potentially imply significant challenges with change due not only to legislative barriers, but also likely to arise from the multitude of bureaucratic structures – particularly if there is little legislative or operational correspondence across multiple agencies. In any of these instances, endemic coordination and collaboration issues would likely exist (e.g. Burns, 2006), likely to impact upon effective and efficient administration and governance of registry information, which would affect any moves to implement changes to policies and procedures to support progress towards 3D cadastral systems and 3D-enabled urban land administration systems.

Cadastral organisations also tend to be public sector organisations (Kaufmann and Steudler, 1998), indicating a likelihood that change must be negotiated through extensive formal processes – inevitably leading to protracted timelines, which challenges innovation and change. For example, the introduction of digital plans of subdivision (known as ePlan) in Australia has met with slow progress. In 2003, a national ePlan working group established by the national-level Intergovernmental Committee on Surveying and Mapping (ICSM) developed a national standard for cadastral data transfer. The project implementation phase commenced in 2007 nationwide, but in the state of Victoria, the actual design, testing and use of the drafting (CAD) software and data transfer protocol only commenced at the end of 2010 with a small group of surveying firms in the state. Currently, enhancements are still being made to the CAD software supporting ePlan and its relevant data transfer processes and ePlan is not yet available to the industry.

Finally, the fact that there currently exists a range of alternative practices for registering 3D property and associated RRRs within the scope of current legal frameworks suggests that the significance of legislation as an institutional issue can potentially be reconceptualised. The institutional perspective considers legislation not only to be a regulatory element, but also a social structure that displays cultural-cognitive and normative elements that are equally significant in establishing legitimacy for certain types of behaviour (Suchman and Edelman, 1996). Therefore, such practices suggest that the current framework is potentially being used to facilitate innovation, by posing as a way for stakeholders to make sense of, and respond to, those new registration situations posed by complex 3D urban properties.

3.7.2 Other Potential Institutional Barriers

An institutional perspective also supports consideration of how normative and cultural-cognitive elements in current land administration systems also present significant challenges to 3D innovation.

These are likely to be associated with the dominance of the 2D practices and processes of representing land and property information amongst those design professions involved with development of the built environment. This is not an insignificant consideration: Sandberg (2001: 204) suggested that "if the survey and mapping barriers can be overcome, there should be no legal impediment to implementing three-dimensional division of parcels". The degree of persistancy presented by these cognitive aspects can be seen most notably in the use and application of current 2D registration methods for 3D property albeit with through work-arounds, as shown in Chapter 2.

Institutional barriers could also stem from highly routinised processes such as those associated with subdivision and registration given that people tend to use what they know and have become conditioned to doing as a way of developing a response to unfamiliar situations. This is a situation that is commonly found in instances of technological innovation (Kaplan and Tripsas, 2008). For cadastral and land administration systems, 'stretching' current practices to register 3D property might appear acceptable because these practices are legitimised through repetitive and historical use. An example of this are the current practices in Denmark and the Netherlands, where only new 3D legal objects are registrable if all parties agree to the registration; the fact that the register may not provide sufficient information to future owners at the time of registration is not considered to be significant (Ho et al, 2013).

The legal mandate of cadastral organisations and their responsibility for legal security of tenure also arguably engenders a culture of conservatism towards change: if current systems are not seen to be 'broken', i.e. are able to register 3D property and associated RRRs, it is unlikely there will be commitment to change.

Normative and cultural-cognitive issues present barriers because the introduction of new technologies must be accompanied by corresponding changes to practices and processes – in the case of 3D technologies, these are likely to require wide-ranging changes. For example, in Australia, current land administration systems are based on 2D-based analogue practices – plan drawings, cross-sections, etc. A move towards a 3D environment demands the use of digital information to fully leverage its benefits in improved querying abilities, reuse of data and representation of information and this requires wholesale changes to how information is collected, drawn, exchanged and even registered – a fundamental shift in the norms and values relevant to collaboration, visualisation and analytical processes.

As a result of such institutional issues, the opportunities afforded by new 3D technologies may be exploited – only to the extent of consolidating current practices and processes through digitising information. For example, when The Netherlands introduced a fully electronic conveyancing process (ELAN), the system still rquired digital legal documents to be a one-to-one representation, which ruled out the possibility of using digital information formats like 3D PDFS to better represent complex 3D property situations (Ho et al, 2013).

Although fairly generic, these suggestions are either proven issues endemic to land administration organisations or they are proven influences on successful adoption or diffusion of technological innovation in general. These issues represent of some of the new insights required, but is currently missing in the body of knowledge regarding 3D-enabled urban land administration. It is highly likely that the main barrier to innovation lies not in technological or legal issues, but more fundamental social and cultural issues that make up the institutional framework underpinning land administration systems and its inherent processes.

3.7.3 The Need for a Broader Discourse

The application of institutional theory to reconsider and reconceptualise a range of current registration practices around the world demonstrates that to realise 3D-enabled urban land administration systems requires a broader discourse being developed around how the institutional aspects of current land administration systems need to shift in parallel with technological innovation to support modern land administration needs. The adoption of an appropriate theoretical framework can enrich the current research agenda with deeper insights into the organisational and institutional aspects of evolving current systems.

A broadening of the research agenda into this area has two significant contributions: at a micro level, an ability to articulate the current 'rules' that prescribe information processes (both technical and sociological) can lead to better understanding of how to fully utilise the capabilities of 3D digital technologies. But importantly at a macro level, such a conceptualisation of institutions can lead to a better understanding of the role of stakeholder organisations in this journey of change necessary to support modern land administration needs.

3.8 CHAPTER SUMMARY

This chapter aimed to provide an overview of institutional theory, particularly organisational institutionalism, and justify its applicability as a theoretical and analytical framework for this research. The key constructs pertaining to organisational institutionalism were described with links made as to how these would apply to the research, specifically the framing and analysis of the case studies. This was developed into a conceptual framework to show how the various components would apply to support a response to the research objectives. The main criticisms towards institutional theory were acknowledged, with consideration given as to how these would affect the research.

The chapter concluded with a demonstration of how the application of institutional theory can support the broadening of the research agenda – firstly through reconceptualising current understanding of institutions and their significance, but also by providing the framework for illuminating other potential barriers to change. The pursuit of research in this area must be supported by an appropriate research design, philosophy and methodology, which are presented in detail in the following chapter.

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CHAPTER 4

RESEARCH DESIGN

But, though all our knowledge begins with experience, it by no means follows that all arises out of experience... It is, therefore, a question which requires close investigation... whether there exists a knowledge altogether independent of experience, and even of all sensuous impressions?

Kant, 1781

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4.1 INTRODUCTION

A research design is “an action plan for getting from here to there, where ‘here’ is the initial set of questions and ‘there’ are the set of answers” (Yin, 1994: 19). This chapter sets out to do precisely this: to describe the path the research will take to address the research questions and guide the journey towards destination ‘there’.

Every research design is ultimately influenced by the personal views and beliefs of the researcher, affecting the choice of philosophy, which in turn shapes the ontological and epistemological positions. In a sense, this can be construed as providing the underlying “institutional” influence that provides cognitive structure to the research process – from choice of theoretical framework and research approaches, to methods and methodologies in data collection (or rather, data construction, as befits the type of research here) and analysis. The elucidation of these positions is fundamental in qualitative research traditions, creating validity in the research process by being transparent about the philosophical beliefs of the researcher and how this positions them in the research context (Klein and Myers, 1999).

This research adopts an interpretive paradigm, which indicates an ontological belief in a socially constructed reality, and an overall subjective epistemology. This determined the use of a case study approach – specifically the use of two case studies (City of Melbourne and Singapore), which aimed to explore and understand the perspectives of multiple stakeholders on the social and cultural issues encountered in moving towards the use of 3D technologies. These perspectives were constructed using a combination of unstructured and semi-structured interviews, participant observation, and secondary data (such as public documents, media reports, organisational documents, etc.) to provide corroboration. The research was conducted over a period of almost two years, from August 2012 to March 2014. Overall validity of the research was facilitated through subscription to a set of seven principles developed by Klein and Myers (1999) for interpretive research.

This chapter is structured into two main parts. The first part of this chapter explains the underlying philosophical framework, including an elaboration on the inherent assumptions. Throughout this first part, the relationship between the framework and the research strategy is discussed and made explicit, providing justification for the actions used to pursue the research objectives and arrive at answers to the research questions. The second part of the chapter introduces the general research strategy. This includes the use of interpretive case studies, interview methodology, data analysis procedures and a discussion of how the research meets the criteria for good interpretive research. A summary provides a conclusion to the chapter.

4.2 RESEARCH PHILOSOPHY AND ASSUMPTIONS

This is an interdisciplinary study that seeks to respond to the issue of paradigmatic shift in technical processes through the theoretical lens of organisational institutionalism. The adoption of other theoretical approaches has been necessary as the research agenda, to date, has tended to focus only on external phenomena – technology, processes etc. – that is indicative of a positivist philosophy, which tends not to be able to provide sustainable solutions to the challenges of technological innovation (e.g. Davis and Songer, 2002).

Such a positivist approach ignores the fact that the relationships between people and technologies are constantly being negotiated, with corollary shifts in response to environmental pressures (Myers, 1994). In the domain of information systems, this research approach has tended to reduce complex organisational landscapes to simplistic causal analysis, where only external and observable phenomena are investigated, but none or little consideration is given to the social underpinnings of these phenomena (e.g. Galliers, 1991; Orlikowski and Baroudi, 1991). Therefore, this research rejects positivism and aims to contribute a different dimension to the existing knowledge by adopting an alternative philosophy.

4.2.1 The Interpretive Paradigm

Eschewing positivism, the research design is based on an interpretive paradigm. This paradigm indicates studies that seek to understand a phenomenon as it is experienced subjectively and therefore, has philosophical roots in constructivism – particularly social constructivism, of which key proponents and conceptual thinkers were German philosophers and sociologists such as Immanuel Kant, Max Weber and Emile Durkheim.

At a broad level, constructivism is a branch of philosophy with origins owed to several other philosophies, with particular attribution to idealism. The work of Kant relevant to reasoning and rationality (e.g. Kant, 1781) has been considered to be seminal in the development of constructivism. Kant fervently argued that the subjectiveness of the human experience necessarily impacted on the creation of knowledge about the world – ultimately manifested as the general laws of nature presumed to underlie every experience. Kant asserted that world views are essentially phenomenal, even as we perceive things to be objective and absolutely of-themselves, their very existence as an objective entity is ultimately informed by our perception, experience and understanding of the world (Durant, 1991).

Social constructivism is a branch of constructivism developed by sociologists, who specifically attributed the cause of subjectiveness to the influence of myriad social structures (institutions) that people are embedded within, as well as their interpersonal relationships. This provides the basis for individuals' construction of meaning and understanding of the world: the world does not exist objectively but differs subjectively according to context and time, and reality is therefore conceived to be 'constructed' socially by the people who operate within its realm – a proposition that there is no one 'truth' but the existence of as many 'truths' as there are people, groups or communities (Berger and Luckmann, 1967).

This subjective reality is "set against a backdrop of shared understandings, practices, language and so forth" (Schwandt, 2000: 193), and therefore the interpretive paradigm aims to identify the underlying patterns and rules to gain insight into how reality is constructed by the inhabitants. Interpretivism is characterised by a pluralistic view of the world, reflecting its fundamental belief that reality as it is experienced, is a complex phenomenon since it is made up of numerous meanings and interpretations from people's lived experiences (Guba and Lincoln, 1994; Schwandt, 1994; Hurworth, 2005).

The interpretive paradigm was advanced by neo-Kantian sociologists such as Max Weber in direct critique of positivism, arguing that human sciences were fundamentally different from the natural sciences and therefore, could not be pursued using the same research methods (Schwandt, 1994). Where positivists hold as absolute truths that facts are direct, observable phenomena, and that humans would react in the same way to external stimulation, interpretivists argue the need to understand meaning, intent and choice behind human behaviour (Creswell, 2007).

Meaning is therefore central to interpretivism, and for researchers, decoding this meaning requires interaction with the subjects, understanding and interpretation. In the German intellectual tradition, this was termed '*verstehen'*, or interpretive understanding, which is a precondition to interpretation. Weber (1964) provided a typology of three main types of subjective meanings that researchers may arrive at: the actual meaning intended by the actor; an aggregated meaning commonly reflected across a number of actors; a representative meaning that can be assigned to theoretical actor.

Similarly, Schwandt (2000) provided a summary of four ways of achieving *verstehen*. He noted that Wilhelm Dilthey (a German philosopher, sociologist and historian) saw achieving *verstehen* as requiring 'empathetic identification' with the subject and aligning and sharing their feelings and intent. Secondly, Alfred Schütz's (an Austrian social scientist) conception of subjective interpretation provided a more general way of understanding meaning, where meaning for one actor's action is used as the basis for making sense of the same action for other actors. Thirdly Peter Winch (a British philosopher) argued that understanding actors' actions could not be isolated from understanding the rules and system of meanings that actors act within. Fourthly, Hans-Georg Gadamer (a German philosopher) argued that the process of understanding and interpretation necessarily involved the researcher and brought to bear their own social and cultural histories, and therefore achieving *verstehen* required an understanding of the researcher's own impact on interpretation.

Further, this understanding is being negotiated through interactions with the subject and the notion of what constitutes a 'correct' interpretation shifts throughout the course of interactions. Interpretive research is therefore characterised by the co-constitutive experience involving researcher and the subjects, where no distinction is made between the researcher and the participants and the research process is often considered to be "subjective, dialectic, and value laden" (Hurworth, 2005: 210).

In line with interpretivism, the **ontological assumptions** inherent to this research is one consistent with a belief in multiple realities and that social reality is constructed according to local context, with notions of reality given meaning through the interactions between people (Berger and Luckman, 1967; Guba and Lincoln, 1994; Creswell, 2013). Such assumptions reflect the researcher's position on the "form and nature of reality" (Guba and Lincoln, 1994: 108).

For some, interpretivism is a philosophy in itself (e.g. Schwandt, 2000); for others, interpretivism is more reflective of an epistemological position since it refers to ways a specific perspective, posited on understanding of the meanings that people attach to actions, is a means of gaining knowledge of the world (O'Reilly, 2009). The **epistemological assumption** here is therefore a subjective one, reliant on a co-constructive experience between the researcher and participants (Creswell, 2013). This endorses the evolution and refinement of themes that emerge from the research, as more understanding and insight is gained into the experiences of the participants through the course of the data collection and interpretation process (Guba and Lincoln, 1994).

Interpretive approaches to research in the related domain of information systems have tended towards "producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context (Walsham, 1993: 4-5). It supports the pursuit of 'how' and 'why' behind technological use patterns (Boland, 1991; Orlikowski and Baroudi, 1991). Similarly in this research, an interpretive approach facilitates the objective of understanding the context of high-rise subdivision, with the plan of subdivision as the technical artefact in question. An application of an interpretive perspective will support the development of understanding around the institutional issues that pervade the land administration industry and how this potentially impacts on moves to introduce 3D innovations.

It should be noted that although an interpretive approach is often used interchangeably with a qualitative approach, the two should not be considered as synonymous. Qualitative research in general refers to an approach based on language and meaning-based data for analysis to provide a basis for generalisation (instead of numerical data); therefore some consider qualitative research to represent a broader conceptualisation of a research process that draws on subjects' perceptions, use of language and ascribed meanings, which "may or may not be interpretive depending upon the philosophical assumptions of the researcher" (Klein and Myers, 1999: 69).

There are also others that consider the two to be overlapping due to their reliance on textual data but interpretive research is differentiated through its emphasis on locating research within the shared systems of meaning that provide a deeper level of understanding with regards to a particular phenomenon, but with such specificity leading to limited generalisability (Bevir and Kedar, 2008).

4.3 RESEARCH METHODOLOGY

The research methodology has been developed to suit the nature of the research and the research questions raised. The appropriateness of an interpretive approach has been outlined in the previous section, and this section aims to present how such an approach dictates the selection of the research methods used.

Research methodology generally refers to the processes involved in the research, mainly relevant to the collection and analysis of data. Figure 4.1 illustrates the overall research methodology adopted for this research and shows how constructivism underpins an interpretive approach, which results in the use of case studies for data collection.

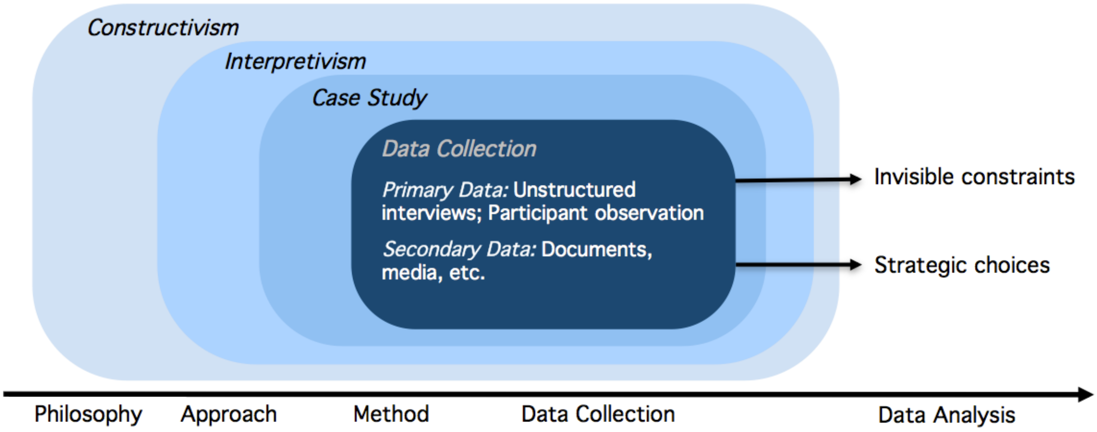

Figure 4.1 Research methodology.

Interpretive research employs research methods that help to reveal the meanings behind actions, with key methods being case studies, participant observation and documentary analysis. This is a legacy of Weber's work, where he believed that it was not possible to gain knowledge of the world simply through a sensory approach; necessarily, the researcher had to interpret the world as it was being observed by drawing on culture, values and belief systems (O'Reilly, 2009). Flyvberg (2006: 221) also argued that by providing "context-dependent knowledge", case studies could play a productive role in supporting and progressing human learning.

The main method of data collection in this research was therefore through the use of in-depth interviews, but this was augmented by another level of analysis using other text-based data such as documents, publicly available media reports, etc. This secondary analysis also serves in a way to provide validation pertaining to the interview data.

Interpretivism also endorses the use of inductive logic in general, ultimately supporting an emergent design for constructing the research outcomes (Denzin and Lincoln, 1994; Miles and Huberman, 1994; Strauss and Corbin, 1990). Analysis is therefore typically data-driven, employing inductive logic to develop key themes, or in other instances, theory development (Creswell, 2007).

Finally, the typical criteria used to determine validity in research is a positivist construct and do not apply in the traditional sense in interpretive research. Interpretive researchers argue that the traditional, empirically driven construct of "validity" should be forsaken, and that the benchmark for validity should rest instead on whether arguments are persuasive and of "utility", rather than provision of empirical "proof" (Guba and Lincoln, 1994: 108). This is explained in greater detail in the following section.

4.3.1 Exploratory Case Studies

Since this research addresses a gap in the current body of knowledge in terms of the limited understanding as to why 3D innovation to support land administration is still yet to be realised operationally, the research aligns well with the use of case studies as a research method (Johnson and Laepple, 2003).

Case studies are particularly useful in situations where better understanding of reality is required, in particular, the "revelatory case" (Yin, 2003). Alternatively, this could be conceptualised as an exploratory case study, defined by Yin (1994) as one where the aim is to define the issues to be researched; therefore, the data collection precedes any specific formulation of research questions or theories. In terms of generating understanding of a phenomenon, case studies enable the researcher to develop a greater, and holistic, understanding of the nature and complexity of the problem since it is conducted in a natural setting, and is most adept at responding to questions of "how" and "why" (Yin, 2003; Andrade, 2009). Consequently, analytical outcomes from exploratory case studies provide the basis for further case studies or other investigation.

The use of the case study approach has strongly featured in the research traditions relevant to this research. It has also been endorsed by researchers in the land administration domain (e.g. Williamson and Fourie, 1998; Bennett et al, 2011), as well as institutional analysts (e.g. Alston et al, 1996; Ostrom, 2005; Hodgson, 2006), including a case study approach used by Benbasat et al (1987) to investigate institutional factors and strategic responses in the implementation of Enterprise Asset Management systems. This approach has also been evident in the domain of information systems, where researchers have found that case studies have been well-suited to facilitating better understanding of how humans relate to technology in social settings (Orlikowski and Baroudi, 1991).

However, the uses of case studies have tended to originate from a positivist approach that prescribes an empirical approach to data collection (e.g. Eisenhardt, 1989; Yin, 1994, Benbasat et al, 1987). Therefore, to be aligned with a constructivist philosophy, an interpretive approach will be applied to the case studies.

Within the context of understanding the complexities of social realities, Schwandt (1994) has argued that an interpretive approach can be useful in facilitating significant insight into "lived experience" (p. 118). The link between interpretivism and case studies lies in the assumption that case studies provide greater opportunity to explore and understand people's perceptions of their realities in situ (Hussey and Hussey, 1997). In undertaking interpretive research, the researcher becomes the key conduit for revealing how reality has been socially constructed (Cavana et al, 2001; Walsham, 1995). Therefore, this approach provides a unique opportunity to document the subject's perspectives and perceptions but also include the researcher's own interpretation in the overall narrative (Guba and Lincoln, 1994; Walsham, 1995; Andrade, 2009).

4.3.1.1 Multiple case studies

In general, this research studies the phenomenon of institutional issues around 3D technologies to enable land administration, particularly in the area of representing tenure information – the geometric extent of ownership and all the associated rights, restrictions and responsibilities.

However, given that no jurisdiction has successfully adopted 3D technologies at the operational level for the purposes of supporting the processes of subdividing, registering and management of 3D properties and representing ownership information, it was necessary to pursue the research objectives using separate case studies, in line with a multiple case study approach.

The selection of the case study sites is motivated by a combination of logical and practical considerations. In a multiple case study approach, each of the sites selected can be used to investigate complementary aspects of the research aim, i.e. to determine the conditions in which the same outcome can be reached, or to use contrasting sites to deliberately illuminate key differences (Yin, 2012). In this instance, the latter was the justification and the cases were selected because they offered insight into contrasting experiences of success with 3D innovation, although this is not to say they are representative cases of these experiences.

The cases were also selected for practical reasons where these sites presented better access to the required experts and data sources to facilitate a research process that was intended to be revelatory (Yin, 2014). In both case studies, research partners and research connections were able to facilitate this access.

Primarily, a case study on the City of Melbourne provided the real world context for examining the range of institutional issues constraining practices to current 2D methods in detail. This was facilitated by two extensive industry placement programs at the state's land registry office as well as at the local council. However, in the course of the research, it became clear that even though 3D-enabled urban land administration was not a reality in this jurisdiction, the findings suggested that there were opportunities that could be harnessed to develop strategies to support change.

To better understand how these strategies could be shaped to target institutional barriers to change, a secondary case study on the Republic of Singapore provided the real world context for understanding this aspect. This international case study examined the mandatory adoption and implementation of Building Information Models (BIM) in the land development process. Since land development is one of the key functions of land administration, findings from this site was considered to be appropriate to develop understanding as to what strategies had the potential to facilitate 3D innovation.

4.3.1.2 Case study generalisation: Cross-case analysis and synthesis

Generalisability as a research concept relies on inferences to statistical probability in terms of: whether the findings can be applied to other populations (e.g. Ryan & Bernard 2000) or whether it can be used to explain other instances of similar occurrences (e.g. Grbich, 1999). Based on this, the ability to generalise from case studies has become accepted as being key to developing scientific knowledge (e.g. Metcalfe, 2005).

This wisdom has been rebutted by some, arguing that findings can also be useful if considered in terms of transferability, which is affected by the degree of similarity between cases (Lincoln and Guba, 1985). The determination of how transferable the research findings are is very much reliant on the researcher who is arguably the expert in understanding both situations (Kemper et al, 2003). Patton (2002: 584) suggests redefining generalisability as extrapolations, reflecting learnings that are 'logical, thoughtful, case derived, and problem oriented, rather than statistical or probabilistic'.

This conceptualisation is fundamental to this research as the case studies used are not intended to be a representative sample and therefore, generalisation based on statistical probability does not apply here. Additionally, interpretive research does not typically lend itself to generalisations. However, because institutional theory is used as the basis for analysis for both case studies, this supports the ability to perform analytic generalisations through problem-oriented cross-case synthesis (Yin, 2014).

In multiple case studies where each case is treated as a separate case, but analysis of findings is undertaken using the same theoretical framework, interpretive arguments facilitate comparison of similarities and differences between the cases (Khan and Van Wynsberghe, 2008). In this research, Przeworksi and Teune's (1982) 'most different design' approach to analysis is adopted since it specifically focuses on using the findings from single cases to inform another case to support discovery of similarities and differences despite the differing contexts.

4.3.2 Sampling

In general, interpretive research methods do not set out to test hypotheses or quantify variables in relationships (Walsham, 1995). In this research, generalisations are not the key outcome; instead the intention is to develop a deeper understanding of the basis for the resilience of existing social structures that are proving to be barriers to change and consequently, to use this understanding to frame potential strategic choices in support of change.

There is therefore no qualification made as to number of sites to justify a representative sample of the population; instead, sites have been specifically selected to facilitate development of a holistic perspective, and as well, the opportunity to have good access to potential participants. Each of the two case studies in this research is intended to function as single, standalone case studies where contextual developments in the Melbourne case study provided more of a focus on invisible constraints, while the Singapore case study provided the ability to explore the institutional effectiveness off strategic choices. This is not to say however, that one situation was focused on to the exclusion of the other.

In total, 49 individuals (34 in Victoria and 15 in Singapore) from 31 organisations participated in a total of 45 interviews with some requiring multiple sessions to reach topic saturation.

4.3.2.1 Melbourne case study

Since the research focuses on the land administration industry, key participants necessarily needed to be stakeholders who were involved in the production, management and use of legal property information – in this instance, building subdivision plans. Therefore, priority was given to identifying suitable persons within the land registry, the surveying profession, including the office of the Surveyor-General, the local council and strata managers. Figure 4.2 shows the distribution and functional level of the participants in the Melbourne case study site.

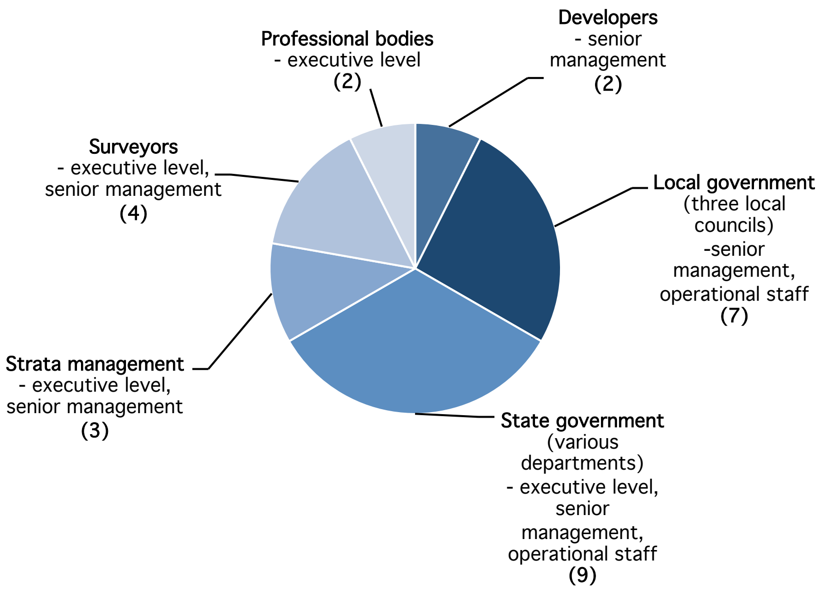

Figure 4.2 Distribution of interviews[3] and functional roles of CoM participants across sectors.

Participants were firstly identified using purposive sampling (Kruger, 1988; Hycner, 1999), with the broader ARC research project's industry partners providing the initial round of contacts. From there, snowball sampling (Babbie, 1995) provided further contacts throughout the industry, and participation at three industry-based workshops provided further opportunity for identifying and engaging with potential participants, as well as providing opportunities for data collection.

4.3.2.2 Singapore case study

The case study on Singapore focused on land development, which is a core function of land administration systems. In supporting the production of information and processes around land development, Singapore presented an opportunity to examine the impact of the introduction of the mandatory use of BIM for regulatory purposes, an initiative managed by a public sector organisation on the industry in terms of strategic initiatives and responses. Key participants were therefore the public sector organisation itself, but also a broad representation of stakeholders involved in high-rise development. Since this was an international case study, time and resource constraints played a significant role in participant sampling.

Preliminary discussions with key stakeholders in Singapore identified relevant individuals and/or organisations. Purposive and snowball sampling identified 26 different organisations representing a range of architects, construction companies, engineering companies, consulting

[3] Some interviews included more than one person.

and management companies, regulatory bodies and professional associations known to be engaged with BIM. Of these, 13 organisations were able to meet within the prescribed dates and available times; practically, it was only possible to fit in 15 interviews within a one-week visit. Figures 4.3 and 4.4 show the distribution of interview participants across discipline and functional levels.

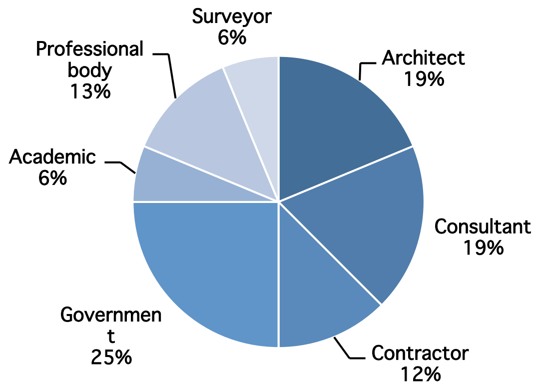

Figure 4.3 Distribution of Singapore interview participants by discipline area/sector.

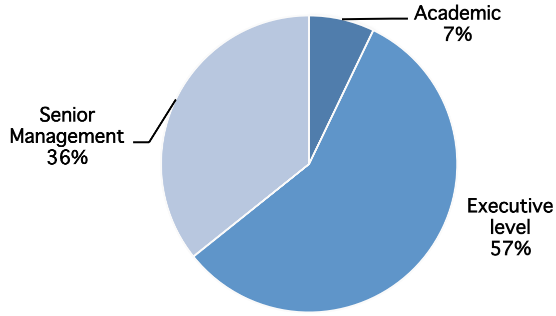

Figure 4.4 Distribution of Singapore interview participants by functional level.

4.3.3 Data Collection

The data for the case studies was obtained through three main ways: the use of interviews supported by a questionnaire to strata managers in Victoria, participant observation facilitated by industry placement programs with the land registry and local council, and documentary analysis.

For interpretive research, interviews are fundamental to enabling the researcher to understand, interpret and subsequently construct the realities as experienced by the participants through detailed descriptions (Walsham, 2006; Kvale, 2007). An interview approach was also selected as it was not susceptible to the risk of low response rates, typically affiliated with a questionnaire approach. Additionally, interviewing as a data collection approach was also highly recommended by primary contacts within the public sector organisation in the Singapore case study.

Given this setting, unstructured interviews provided the main way of eliciting data. Unstructured interviews are well suited to facilitating holistic understanding of structure and agency, as they do not impose limitations on the field of inquiry (typical of structured interviews due to the preconceived assumptions on the part of the interviewer in shaping interview design) (Punch, 1998). Patton (2002) noted that unstructured interviews are ideal mechanisms in the context of participant observation as they leverage the spontaneity of interactions between observer and participant for generating questions. Although unstructured interviews have been commonly used in sociological studies (Fontana and Frey, 2005), its effectiveness as a means of gathering information to develop insight into social realities has seen its use popularised in information science and systems design research into information use practices (Ellis and Haugan, 1997).

Two broad lines of inquiry were overarching: the nature of the individual's experience and contextual influences on the experience (Moustakas, 1994). However, a range of themes was also developed from the literature review and a list of topics was prepared to provide a basic guide to the interview, facilitating a degree of consistency across the various interviews (Burgess, 1984). For the Singapore interview, key themes from the Melbourne case study were also used in the development of the interview guide. Each interview was however individually prepared to be as relevant to the participant's background and experience as possible.

For the case study in Melbourne, the topics for discussion with the selected practitioners were:

- Experience with the 2D plan of subdivision and high-rise subdivision process.
- Perceptions of the 2D plan of subdivision and the high-rise subdivision process.
- Perceptions of issues and challenges regarding the use of 2D plans for representing property RRR information in high-rise buildings.
- Perceptions of opportunities or constraints in moving to 3D-based RRR information.

Similarly, for the case study in Singapore, the topics for discussion with the selected practitioners were:

- Experience with adoption/implementation of Building Information Models.
- Key strategies used to support BIM adoption/implementation (internal and external strategies).
- Successful strategies and perceptions of success.
- Perceptions of ongoing challenges yet to be addressed.

Interviews in Melbourne were conducted jointly with other researchers undertaking other areas of research under a broader research project in land and property information in 3D. This offered several advantages: firstly, it reduced the burden on participants, as researchers from the various streams of the project would often target the same participants. Secondly, this joint setting offered opportunities to observe the participants and to listen carefully to what was being discussed with other researchers as a way to elicit indirect insights into their actions and behaviour. Finally, such a setting provided the opportunity to make detailed notes and observations and record relevant verbatim quotes. This enabled a relatively substantial data collection process, with follow-up via email or phone being made if required. Events and data were systematically recorded to facilitate reliability and validity (Silverman, 2001).

Prior to the interviews, participants who were not industry partners were provided with a brief overview of the research and the aims of the interview to enable them to have a contextual understanding of the research and to manage expectations (Appendix 1). Interviews were typically scheduled for one hour but some extended beyond this timeframe.

To build internal validity within the case study, other data collection methods were used to construct stronger evidence (Eisenhardt, 1989; Silverman, 2001). Two industry placements at key Melbourne organisations over a period of four months (land registry and the local municipal council) provided opportunities for access to not only participants and situations, but also internal documents and opportunity for participant observations. Participation in three relevant industry-based workshops held locally by various organisations and/or professional associations provided additional opportunities for data collection and corroboration of views at industry level. Finally, secondary data sources derived from organisational artifacts, websites, newspaper articles, and a range of publicly available documents were used to both augment and verify interview information where possible and to provide corroboration.

4.3.3.1 Questionnaire to strata managers in Victoria

To gain a better understanding of the issues around management of multi-storey residential properties, a brief survey comprising 20 questions was disseminated to the Victorian community of strata managers (Appendix 4). This was conducted in partnership with one of the project's industry partners, the Victorian chapter of Strata Communities Australia (SCAV).

The aim of the survey was to capture a snapshot of the issues faced by strata managers, as well as their perceptions on the effectiveness of the plan of subdivision in supporting their roles and the objectives of managing common property. The survey was publicised through several issues of SCAV's electronic newsletter, as well as disseminated personally at an SCAV professional development event (which was attended by approximately 200 strata managers).

In this instance, determining a statistically significant response rate was difficult due to the lack of absolute statistical data on strata managers. SCAV estimates that they represent 80 per cent of all strata managers in VIC (approximately 450 individuals) (SCAV, 2013). At a confidence level of 95 per cent and a confidence interval of five, the sample size would have been 207. In discussions with SCAV, they indicated this was almost impossible to achieve and their sentiments were supported by a range of other stakeholders who have had have had significant interactions with the industry. Instead, there was fairly unanimous agreement that 30 responses would be considered a good outcome.

In total, 23 completed questionnaires were received (eight by paper, 15 via online). In comparison, submissions to Consumer Affairs Victoria in response to a state-wide review of the *Owners Corporation Act 2006* in 2013 only attracted 17 submissions across industry and public stakeholders. Respondents were fairly senior within their organisations, with ten responses from executive level staff (managing directors, CEOs, directors, owners, etc.), 11 responses from management level staff, and two responses from operational staff (e.g. assistants to managers). The respondents tended to manage properties within the CBD or inner city suburbs of Melbourne (Melbourne, Brunswick, Carlton, Collingwood, Fitzroy, Southbank, South Melbourne, South Yarra, Thornbury), eastern and south-eastern suburbs (Armadale, Balwyn, Brighton, Caulfield, Elsternwick, Elwood, Gardenvale, Glen Iris, Hawthorn, Kew, Malvern, Mentone, Sandringham, St. Kilda) and the northern suburbs.

Ultimately, in-depth understanding of strata managers' experiences was mostly developed through four individual interviews in the Melbourne case study (including one on-site at a development where experiences and meaning could be observed and understood in context).

4.4 THEMATIC DATA ANALYSIS

Thematic analysis is a way of organising qualitative information around "codes" or themes to support pattern recognition and distil the essence of the experience. Boyatzis (1998: 4) describes a theme as "a pattern found in the information that at minimum describes and organises the possible observations and at maximum interprets aspects of the phenomenon". This process of analysis enables the inclusion of a variety of information types to support the researcher's "accuracy or sensitivity in understanding and interpreting observations about people, events, situations, and organisations" (Boyatzis, 1998: 5).

It was specifically chosen as an analytical method for this research because it is widely used and accepted across a variety of disciplines and is not specifically bound to any one epistemology (Boyatzis, 1998). More appropriately for this research, its ability to communicate findings across different disciplines enhances the accessibility of this research to other researchers in the same domain who have mostly been from an engineering discipline, i.e. bridging interpretive and positivist research (Silverman, 1993; Denzin and Lincoln, 2011).

Themes can be derived in three main ways: theory-driven, a priori and data-driven (Boyatzis, 1998). This research employed a data-driven approach, which was broadly adapted from Thomas' (2006) general inductive coding process. It does not prescribe separate stages in the coding process (e.g. open, axial and selective coding) as it does not explicitly seek to build theory – its main function is to support the elicitation and description of the more salient categories of meaning (Thomas, 2006). This is appropriate for the purposes of constructing meaning and perspectives across multiple stakeholders in the exploratory case study.

The process of analysis, which is an iterative and lengthy process, is illustrated in Figure 4.5 and shows how the emergence of key themes was induced. The initial interview notes were read and re-read extensively to facilitate familiarisation of the data. This supported the coding process, where an iterative process of comparison supported further modification of emergent codes and themes. This allowed the volume of information to be increasingly condensed and codified till the multiple initial codes and themes could be distilled into fewer key categories. This provided the research with its key themes.

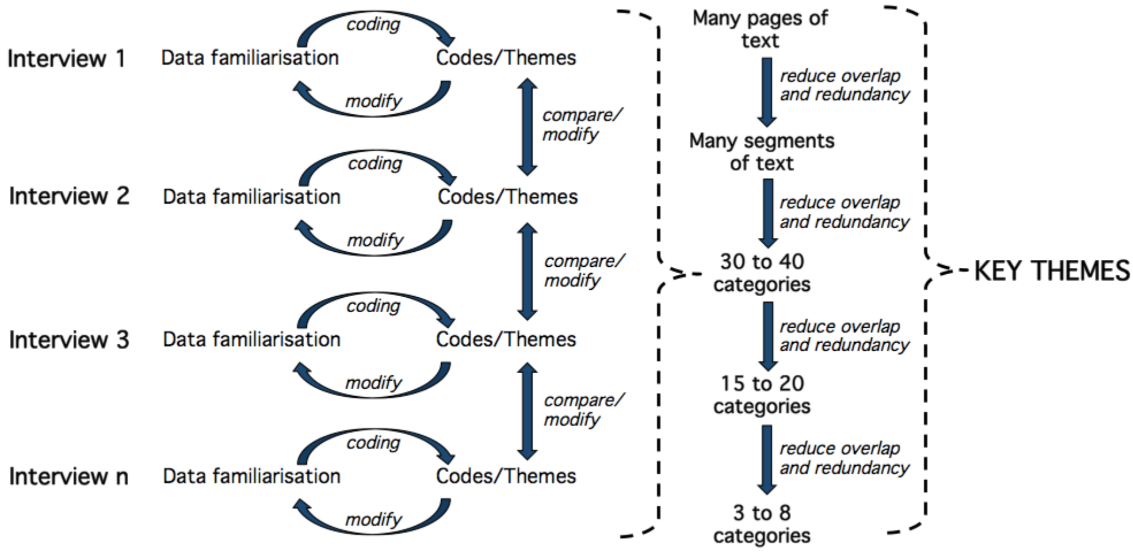

Figure 4.5 Generalised iterative and inductive process of thematic analysis as used in the research (adapted from Thomas (2006: 242)).

To support the coding and analysis process, six out of seven of Spiggle's (1994: 493-496) set of 'data manipulation operations' was employed (integration was not used as this is more aligned with theory building):

- **Categorisation**: process of classifying or labelling units of data to denote an instance of representing, belonging, or being an example of, some phenomenon.
- **Abstraction**: builds on categorisation to collapse categories into higher-order concepts by grouping previous categories into more general conceptual classes.
- **Comparison**: explores differences and similarities across incidents within the data collected; may also lead to additional data collection.
- **Dimensionalisation**: involves identifying properties of categories and constructs
- **Iteration**: involves moving through data collection and analysis in such a way that preceding operations shape subsequent ones.
- **Refutation**: involves deliberately subjecting one's emerging inferences (categories, constructs, propositions or conceptual framework) to empirical scrutiny.

4.4.1 Example of Thematic Analysis of Melbourne Case Study

This section provides an example of the coding and analytical processes that supported the research findings. Direct text and quotes that were noted verbatim were first analysed to ascribe meaning to experiences. Initial categories were supported with examples, including notes about the properties of the meaning that is emerging. Field notes and reflections were then considered and linked to these categories.

CATEGORY LABELS	INITIAL LABELS	EXAMPLES (QUOTES/NOTES)
Building subdivisions are complex	Complex drafting; visualise boundaries; importance of design stage; sense of being "tricky"; limitations of 2D plans for representing buildings	"Building subdivisions are always complex and drafting problems are typical because you have to visualise how boundaries would affect management of property." "The tricky part is staging and how stages interact...phases need to match up on plan" Increasing complexity that needs to be resolved at the design stage, the local council frequently holds pre-application meetings with developers. This was also where the use of 3D models seem to be most prevalent in the current process, even ones as basic as simple objects representing building envelopes. Both developers and government representatives were in agreement about the utility of models at this stage, with both short- and long-term benefits apparent to users
Drafting problems are typical	Regulatory process catches problems; multiple changes; need a lot of resources and skills	"Building subdivisions are always complex and drafting problems are typical because you have to visualise how boundaries would affect management of property." "50 per cent of plans are knocked back at acceptance stage (due to lack of administrative information), two-thirds need amendment from surveyor, one in 10 to 20 will require significant amount of change."
Plans are labour intensive	Drafting is labour-intensive; expensive information production; lengthy production	"80 to 90 per cent of drafting work (are) in car parks and dimensions and this costs tens of thousands of dollars and takes months and months."

Table 4.3. Example of initial stages of inductive theme development for representing surveyors' experiences.

Table 4.3 provides some examples from coding interview data to induce themes around participants' social realities in terms of engaging with 2D plans of subdivision. The column 'Initial labels' shows the initial categorisation and the column 'Category labels' shows the abstracted label as the data is iteratively processed and manipulated; more detailed examples are appended to the thesis. Using the Melbourne case study as an example, almost a hundred categories (in total) were initially identified. Abstracting these categories to eventually arrive at superordinate categories was achieved through an iterative process of re-reading, reflection on the literature to reduce overlap and redundancy, or subsequent data collection if required

Ultimately, this supported the elucidation of key emergent themes. Subsumed under each theme were various sub-themes, which illustrated various dimensions of each theme. These themes are discussed further in chapters five and six.

4.5 ADDRESSING LIMITATIONS OF THE RESEARCH DESIGN

The main criticism regarding interpretive research has been around the assumption that actors are aware of their intentions behind their actions (Giddens, 1984). Although interpretive research methods have been acknowledged to provide deep contextually based insight, they are often criticised on grounds of lack of validity and generalisability, and in this instance, compounded by the use of the single-case study approach (Denzin, 1970; Eisenhardt, 1989; Perry, 1998).

However, it can be argued that from an interpretive perspective, that a focus on creating a narrative which facilitates a persuasive and cogent interpretation of social reality, means that the use of a single case can be sufficient to foster a deep understanding of the phenomenon and provide adequate material for subsequent analysis (Miles and Huberman, 1994; Walsham and Waema, 1994; Sigglekow, 2007). Moreover, the use of a single case is suitable for establishing the existence of the phenomenon in question (van Maanen, 1988), which suits the aims of exploratory research (Remenyi et al, 1998).

In addition, Flyvberg (2006) has argued that the current conventional wisdom in qualitative research traditions that dismisses single case studies as being of limited basis for building generalisations is misguided. His argument is based on the fact that the conventional definition of generalisability, i.e. through multiple instances of substantiation, is not the only way to support the development of generalisations. Instead validity of the generalisation should be assessed based on what the case study represents and why it has been selected. He also goes on to provide examples of how generalisation of findings as a means of developing knowledge is but one of many viable channels.

4.6 BUILDING TRUSTWORTHINESS IN THE RESEARCH

The various philosophical foundations of interpretive research and its influence on research activities means that interpretive research does not lend itself easily to conventional measures of data validity, generalisability and objectivity – measures which have come from assuredly positivist traditions (Guba and Lincoln, 2005). Instead, interpretive research is judged more on whether the researcher's construct is persuasive and cogent, bringing into play measures such as trustworthiness, credibility and confirmability (Denzin and Lincoln, 2005; Myers, 2009).

To facilitate both the conduct and evaluation of interpretive research, Klein and Myer (1999) developed a set of seven principles for interpretive field research that remain seminal to this day. The set of principles were derived from foundations considered germane to the development of interpretivism such as anthropology, phenomenology and hermeneutics. These were applied to the research, both in its conduct and evaluation, specifically to principles regarding contextualisation, abstraction and generalisation and multiple interpretations.

Klein and Myers (1999) suggested that the application of the principles is subjective and dependent on the researcher as to how and which principles are relevant for their research. These principles should therefore not be regarded as linear progressions. For this research, all the principles were relevant and applied – at times to the entire research (i.e. the first principle), but mostly as they were relevant to data collection (i.e. second, third, sixth and seventh principles) and data analysis (i.e. fourth, fifth and seventh principles). Table 4.4 provides an overview of the principles and how these were applied to support validity in the research. The rigorous application of these principles was intended to facilitate the plausibility, and therefore persuasiveness, of this research.

PRINCIPLES	EXPLANATION	APPLICATION TO RESEARCH
1. Fundamental Principle of the Hermeneutic Circle	This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all the other principles.	This was implicitly applied throughout the research.
2. Principle of Contextualisat-ion	Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.	The historical description of high-rise development in the city of Melbourne is used to show how institutional pressures on high-rise development have emerged.
3. Principle of Interaction Between the Researchers and the Subjects	Requires critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and participants.	This was elucidated throughout this chapter.

PRINCIPLES	EXPLANATION	APPLICATION TO RESEARCH
. Principle of Abstraction and Generalisation	Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action.	Abstraction and generalisation has been supported through the use of organisational institutionalism in both the definition and analysis of the research.
5. Principle of Dialogical Reasoning	Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tell") with subsequent cycles of revision.	This is reflected through the iterative process during data collection and analysis, and explained in this chapter as a fundamental characteristic of interpretive research.
6. Principle of Multiple Interpretation s	Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts even if all tell it as they saw it.	The perspectives of multiple stakeholders and discussion of multiple interpretations are provided in the narrative of the research.
7. Principle of Suspicion	Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.	The data received through interviews, observations and secondary sources have been considered and analysed critically, often rereading and revisiting the data, with attempts to use other sources to corroborate where possible.

Table 4.4 Application of Klein and Myers' set of principles for interpretive field research to research process (Klein and Myers, 1999: 72).

In addition, the outcomes of the research, as they were developed, were presented frequently in a variety of professional settings to partner organisations, or to meetings of relevant professional organisations. This provided opportunity for verification that was a key strategy for ensuring qualitative rigor was maintained throughout the research process.

4.7 ETHICAL CONSIDERATIONS

The nature of this research depended on the professional perspectives of a range of stakeholders. Additionally, placements within organisations were undertaken to provide opportunities for engagement with stakeholders on a day-to-day basis to facilitate participant organisation. As such, the ethical considerations associated with this research were submitted to a rigorous assessment process governed by the University's Human Research Ethics Committee. Consequently, this research was deemed to be one that would be conducted with minimal impact on its participants.

The organisations and individuals contacted for this research provided early support and agreement to participate in the research. Plain language statements were provided to participants and verbal consent was deemed sufficient. In the instance of the online questionnaire conducted with strata managers, online consent provided a substitute avenue.

To fulfil ethical obligations, comments made by individuals have been coded to retain anonymity. Additionally, the data that was collected as part of this research will be used only for the purposes of this research and is being stored securely in accordance with the requirements of The National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council, 2007).

4.8 CHAPTER SUMMARY

In summary, this chapter had set out to describe and explain the philosophy and assumptions that underpin this research, and how this has influenced the choice in research approach and methods. This is characteristic of the axiological assumptions typical to all qualitative research that situates the researcher within the study (Creswell, 2013).

The chapter has shown how an interpretive position provides a philosophical stance that will facilitate understanding of the social and cultural issues related to the resilience of current attitudes and actions around 2D-based processes for managing land and property information, as well as the issues related to the adoption and implementation of 3D technologies within organisations in the land administration industry.

For a topic that has had little exploration to date within land administration literature, the use of standalone case studies is justified given their function as "revelatory" case studies. Selection and sampling relevant to the respective case study sites were provided, as were explanations on the data analysis process, which relies on intentional analysis. Finally, descriptions of the case study sites were provided, which will lay the foundation for the institutional context discussed in chapters five and six.

The research design is summarised in Table 4.6 and presents an overview of the research protocol employed for this thesis. In outlining the philosophical framework linking constructivism, social constructivism and interpretivism, and the inherent demands these place on the researcher and research activities, this chapter has served to also function as a way of generating validity in the research as suggested by the principles developed by Klein and Myers

(1999). Specifically, this chapter relates to those principles pertaining to the relationship between researcher and participants, as well as dialogical reasoning.

ACTIVITY	DESCRIPTION
Research question	To investigate the social and cultural barriers to change and their basis to facilitate the identification of strategies to support change
Research method	Interpretive case study
Critical incident	Producing, registering and using the plan of building subdivision for high-rise land administration
Case selection process	Access to stakeholders was prioritised
Case Access	Identify stakeholders in high-rise land administration. Negotiate access to stakeholders and observation of work processes where possible. Meet for interview(s). (August 2012 to March 2014)
Research instrument	Researcher as primary research instrument
Boundary device	Framework as developed in chapter three
Research techniques	Unstructured interviews; semi-structured interviews; participant observation; extensive notes, reflective notes; verbatim quotes; information conversations; perusal and analysis of publicly available documents; perusal and analysis of internal documents; internal statistics
Data management	Audit trail of data, collection methods and process, also in accordance to obligations of research ethics conditions

Table 4.6 Summary of chapter as research protocol (adapted from Klein and Myers, 1999).

The following chapter presents the background and description of both case study sites.

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CHAPTER 5

CASE STUDY SETTINGS

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5.1 INTRODUCTION

This chapter provides the description for the case study sites used in this research. Several issues influenced the selection of the cases, with access to the relevant organisations and information being a key consideration. The fact that the jurisdiction of the City of Melbourne (CoM) suited the purposes of the study for contextual reasons as much as ease of access to key stakeholders, such as the land registry, meant the selection was a clear choice. Additionally, this chapter focuses more on the background of CoM as this is directly related to subdivision and registration, key processes for producing and formalising land and property rights, restrictions and responsibilities, and the main focus of this research.

In selecting a site to study the phenomenon of 3D technology adoption and implementation for complex developments, it was evident that this would be in the context of BIM for structural information purposes, given the lack of slow progress in using 3D technologies for tenure information. In addition to pre-existing research and industry relationships with Singapore, Singapore had also recently commenced a public sector led initiative in mandatory use of BIM for regulatory development purposes. For these reasons, Singapore presented a site with better access opportunities than other countries that demonstrated similar initiatives in BIM adoption and is used to explore the implementation of 3D innovation in a predominantly 2D industry.

5.2 UNIT OF ANALYSIS

The unit of analysis for a case study defines what the focus of the case study is about. In the Melbourne case study, the focus is on the organisational field for this research (i.e. the macro level of analysis comprising inter-organisational relationships as explained in chapter three). This was defined by the issue of subdivision and registration of high-rise buildings and therefore involves (cadastral) surveyors, land registry and the local council. In the Singapore case study, the focus of the case study is about the range of strategies that are supporting 3D innovation in the land development process. This necessarily defined the organisational field to encompass developers, architects, consultants and relevant regulatory and professional bodies.

In both case studies, participants constituted a representation of the various key stakeholders involved with high-rise development and management, within the domain of land administration activities, with each unique stakeholder forming a sub-unit of analysis. Their perspectives were then aggregated to represent the required macro level perspective.

5.3 HISTORICAL CONTEXT OF HIGH-RISE DEVELOPMENT IN AUSTRALIA

Australia has never been short of land, as evident in the popular concept of the 'Great Australian Dream', i.e. owning a house built on a quarter-acre block in the suburbs. This notion was as much a product of the economics of construction as it was a consequence of government planning policies in the post-war period, both of which resulted in the dominance of broad acre, low density, greenfield developments as the country's main urban form in its capital cities, a form which subsequently spread to newer outer suburbs (Forster, 2006). At the same time, high automobile ownership, low fuel prices and infrastructure investment in metropolitan roads and new freeways coalesced to support the rapid development of these suburbs (Urbis, 2013).

All these factors started to change drastically from the turn of the 21st century. Changes in planning policies and more restricted land supply resulted in decreasing housing affordability, increasing road congestion and most significantly, an almost 80 per cent increase in fuel prices. All this culminated in a shift in housing preferences that drove greater desire to be located nearer to city centres, and improvements in community attitudes toward high-density living (Urbis, 2013). State governments also developed policy platforms that actively supported high-rise development, for example in New South Wales, the state government reduced the release of new housing sites by 80 per cent as a mechanism to force higher density development (Recsei, 2014). In addition, the introduction of the Strata Title in the 1960s provided another means of facilitating higher density development (Easthorpe and Randolph, 2008).

These drivers have been augmented by immigration trends: new migrants preferring to live in medium to high-density areas (Urbis, 2013). The influx of international students from Asian countries led to the development of new types of high-rise residential developments within city centres and inner suburbs due to property developers' perceptions of students' housing preferences (Fincher and Costello, 2003; O'Connor, 2005).

More than 70 per cent (approximately 15 million) of Australia's population (of almost 23 million) is concentrated within its five largest urban regions – the capital cities of Sydney, Melbourne, Brisbane, Perth and Adelaide (Department of Infrastructure and Transport, 2012). 40 per cent of the country's population reside in Sydney and Melbourne alone. Australia's state of urbanisation is only surpassed by city states like Singapore and Monaco (Department of Infrastructure and Regional Development, 2013).

The country is currently experiencing high ongoing population growth rates in many of its cities, reaching up to 20 per cent in some capital cities (Productivity Commission, 2011). This growth has mainly been absorbed by Melbourne and Sydney, which in turn are witnessing proportionate growth rates in the number of new dwellings approved – in the period between 2007 to 2010, just over 50 per cent of all new dwellings approved in Australian capital cities were in these two cities alone (36 per cent and 18 per cent respectively) (Productivity Commission, 2011).

These urbanisation pressures have exerted significant influence on the way people live in Australia, culminating in a sharp shift towards high-rise living, particularly over the last decade or so. The recent 2011 Census of Population and Housing in Australia showed that the growth in higher density developments was twice the growth rate of single dwelling developments, driven by a marked shift towards medium-and high-density living (Urbis, 2012). Since the last census in 2006, Statistical Areas Level 2 (SA2s)[4] with a majority of medium- to high-density dwellings have increased nationally by 17 per cent (Table 5.1) and approvals for flats and apartments have increased by 36 per cent from 2012-13 alone (Urbis, 2013). According to Urbis (2013: 1), this is a “major nationwide shift towards higher density dwellings that has never been seen on a widespread scale in Australia”.

STATE	NO. OF SA2S WITH MAJORITY OF DWELLINGS AS MEDIUM/HIGH-DENSITY		
	2006	2011	Intercensal Change (%)
NSW	70	81	16%
QLD	37	44	19%
VIC	37	39	5%
ACT	10	12	20%
WA	7	11	57%
NT	9	10	11%
SA	4	5	25%
TAS	1	1	-
Total	**175**	**205**	**17%**

Table 5.1. Trends in medium/high-density dwelling types in Australia by SA2 (adapted from Urbis, 2013).

The high-rise development trend has also resulted in residential real estate becoming the

[4] Statistical Areas Level 2 (SA2s) aim to better represent suburbs and localities and provide better granularity in analysing Census data, especially for urban areas (represent on average 10000 people). Although they do not align to Local Government Area boundaries, they closely reflect them. There are 2214 SA2s covering the whole of Australia without gaps or overlaps. (Australian Bureau of Statistics, n.d)

country's largest investment asset class, currently worth $5.4 trillion (Green, 2014b; Isherwood, 2009). It is estimated that high-rise residential developments will continue to form a major part of this investment asset since almost 40 per cent of all new developments now fall in this category, again with most of the activity occurring within Sydney and Melbourne (Wargent, 2014).

While Sydney has traditionally been the destination *du jour* for high-rise developments, in recent years, Melbourne has overtaken Sydney: between 2010 to 2012, 22 506 apartments were completed with an additional 39 000 to be completed over the next few years, mostly located within CoM and adjoining suburbs (Birrell and Healy, 2013). One of the main reasons for this is that the capital city of Melbourne (a broader metropolitan region comprising 30 out of 79 Victorian municipalities) has absorbed much of the ongoing population growth rates in recent years and is expected to be the most populous capital city within Australia by 2053 with an expected eight million people (Milman, 2014).

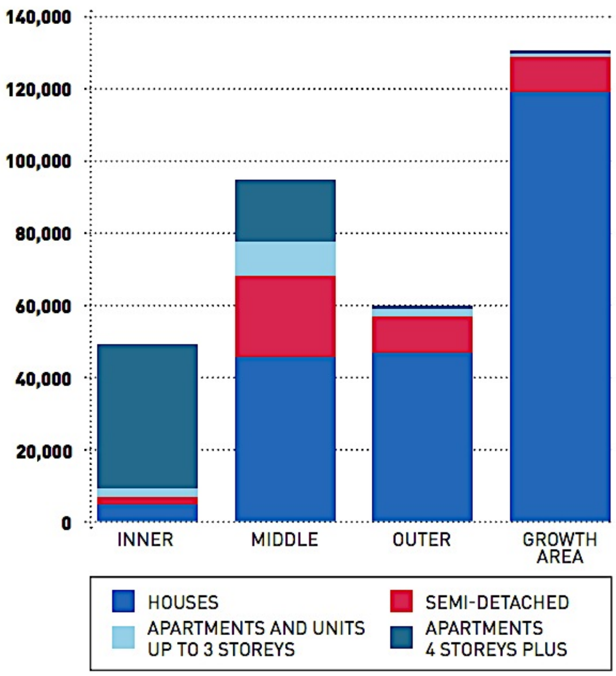


Figure 5.1. Types of housing development across capital city of Melbourne, 2004-2012 (Department of Transport, Planning and Local Infrastructure, 2014: 64).

Figure 5.1 illustrates the trends in housing types across the capital city for the period 2004 to 2012, showing that while a clear trend for freehold dwellings still dominates in the suburban areas, within the inner city areas, development trends favour apartment dwelling. In the period 2012 to 2013, the fastest growing area in Australia was its central business district (CBD) (within CoM), with adjoining areas also witnessing significant growth (Milman, 2014). All these areas fall within the municipal boundaries of CoM (Colebatch and Dowling, 2013; Martin, 2014).

However, despite these recent trends in high-rise development, Australia remains unreconciled with the phenomenon of high-rise, higher density living. High-rise dwellings still only make up approximately four per cent of all dwelling types, home to approximately 3.5 million Australians (Australian Bureau of Statistics, 2013). Moreover, to date, the definition of 'high-rise' in Australia as a structure of four storeys or more, although an incongruous one for many other countries, is still considered apposite for Australia (Australian Bureau of Statistics, 2013).

High-rise development has, to date, been cast in the light of an uber urban phenomenon, but the state's latest metropolitan planning strategy, 'Plan Melbourne', is formalising medium- to high-density high-rise development as a key response to housing requirements (Department of Transport, Planning and Local Infrastructure, 2014). Projected trends in dwelling supply developed by the National Housing Supply Council, shown in Figure 5.2, shows that higher density developments will continue to be the preferred dwelling form to meet housing needs in urban areas for at least Sydney and Melbourne in the coming decade (National Housing Supply Council, 2011).

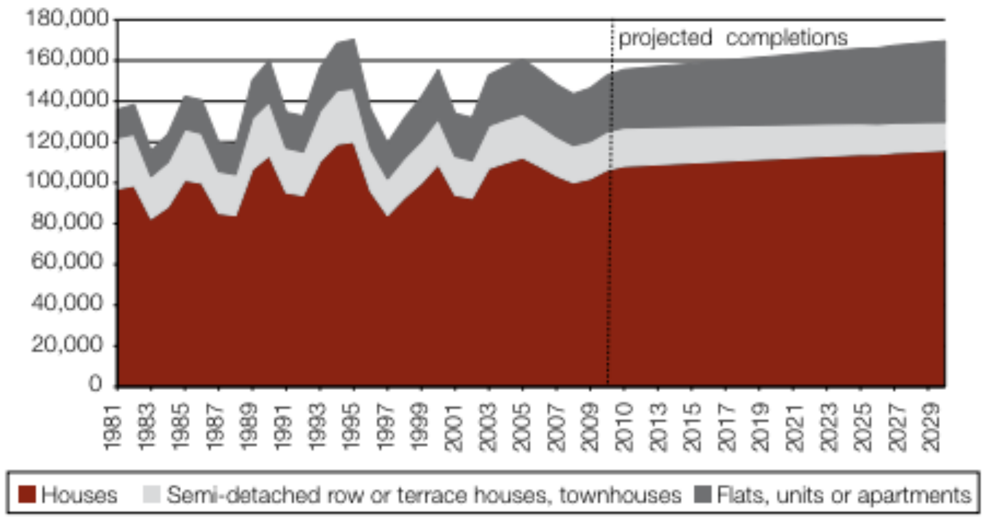


Figure 5.2. Trends in housing production by development type (National Housing Supply Council, 2011: 68).

5.3.1 High-Rise 'Land' Administration in Australia

Within Australia, high-rise land administration is supported by the processes of subdivision and strata titling (registration), which has been in place since the 1960s. These processes facilitate building subdivisions for apartment living. As a regulatory mechanism, the Australian strata model was once something of a success story: the Conveyancing (Strata Title) Act introduced in 1961 in the state of New South Wales (NSW) was really the first instance of strata legislation in Australia, and indeed, amongst the Commonwealth countries. Based on its merits, it provided a legislative model for other Australian states, and the foundation for systems in other Commonwealth nations including Brunei, Canada (British Columbia and Alberta), England, Indonesia, Malaysia, New Zealand, Singapore and South Africa (Christudson, 1996; Easthorpe et al, 2012).

5.3.1.1 Strata titling

Strata titling facilitates independent ownership of units through the process of subdivision and is patterned after the traditional model of (freehold) land ownership (realistically, this translated to ownership of 'land' as airspace between the apartment walls as well as any on-site car-parking or storage areas). But where apartments may be independently owned, the rest of the apartment complex is held in common ownership (known as common property) amongst all apartment owners – and strata titling was developed to provide some regulation over this interdependent aspect of ownership. Strata titling is facilitated through the process of subdivision, which creates multiple units from an original piece of land or property. This can be horizontal or vertical and applies to both land and buildings (Christudson, 1996). A strata title therefore applies to the individual unit created and represented on a plan of subdivision (Ball, 1984).

One of the key information products used to deliver strata titling is the plan of subdivision. The plan of subdivision is produced by licensed (cadastral) surveyors and is defined using a mix of measurements and monuments (e.g. building structures are commonly used – walls, floors and ceilings) to define the legal limits of apartment ownership. The plan is central to representing, recording and ultimately, understanding the extent of private and communal property, and its associated rights, restrictions and responsibilities (RRRs), yet its role is seldom considered in the literature regarding issues pertaining to strata ownership or strata living. Cultivating and facilitating understanding and awareness of these RRRs is arguably, fundamental to the ongoing management of the complex, and the amenity and well being of the community of residents.

Within Australia, the eight states and territories have different ways of legislating strata titles, although they remain similar at a broad level. In their review of the respective legislative frameworks that define strata titles within Australia, Everton-Moore et al (2006) found increasing diversity and complexity among the states and territories as laws have developed in response to jurisdiction-specific needs, which is likely an adverse outcome for stakeholders within the community, especially those with interests in multiple states. This was underpinned by the observation that the respective frameworks were essentially addressing similar problems and that the there were "no compelling reasons why each Australian jurisdiction should not seek to make their laws more consistent" (p.35).

The model of strata titling in Australia has also essentially remained unchanged, and Bugden (2007) argues that the context for which these laws were designed for – the simple "three-storey 'walk-ups' with minimal common facilities" – have been replaced by complex, high-density developments with multiple common properties. Similarly, Easthorpe and Randolph (2008) argue that the Australian model is under pressure to change:

> "The Australian strata title system dates from the early 1960s and since this time a number of contradictions in the regulatory framework have emerged in the face of a growing and increasingly complex higher density residential sector. This complexity, coupled with the reliance on strata title to underpin the delivery of major strategic planning and housing policies, suggests that greater attention as to the effectiveness of strata title to deliver a long term socially sustainable housing framework is needed" (p. 1).

Higher density apartment living has really only taken off in Australia over the last ten years, and the sudden growth of this market has highlighted issues both in terms of legislative support for people living in strata, as well as a traditionally 'suburban' ethos that struggles both with high-rise development itself as well as making it difficult to acculturate to the demands of higher density communal living (Recsei, 2014).

The situation in Australia exists in contrast to a country like Singapore, where the sheer scale of higher density residential developments has driven the need for strata legislation to evolve and improve – to the extent that a reversal of roles have occurred and some states within Australia are now looking to the Singaporean model for its own strata reform (Hurley, 2011). Importantly, for these countries, the mainstreaming of higher density living has facilitated social mores more attuned to the idiosyncrasies of communal living.

5.3.1.2 Owners or Body Corporations and associated legislation

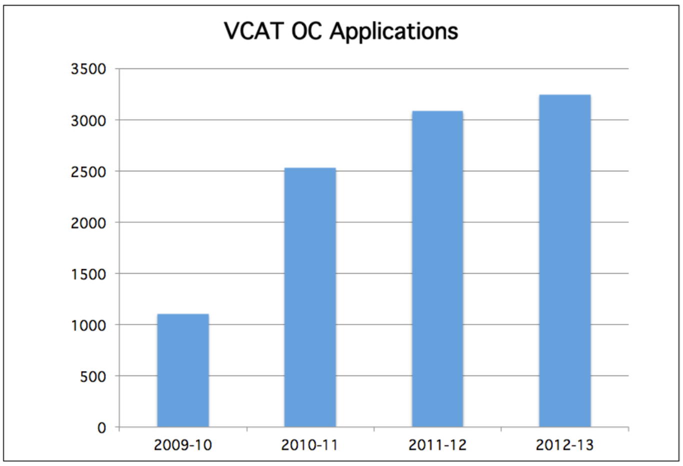
The pressures of urbanisation that are culminating in a sharp shift towards high-rise living has also facilitated the emergence of a multi-billion dollar industry associated with the management of these properties. The growth of this sector – assets cumulatively valued to be worth around $500 billion – has also stimulated the growth of an industry focused on managing these properties, in particular, the common properties in line with legislative requirements (Strata Community Australia Victoria, 2011, cited in Easthorpe et al, 2012).

One of the functions of strata legislation is to regulate responsibilities towards common property through titling. In general, some of the simpler horizontal strata (land) subdivisions may not have any common property, but mostly where common property exists, a body comprising all lot owners is formed to oversee the management of common property or facilities. This body functions as a separate incorporated entity with legal rights and responsibilities and is commonly referred to as a body corporate or owners corporation. Although a significant stakeholder, owners corporations are only one of a diverse range of stakeholders that have interests in strata developments. Warnken (2005, cited in Easthorpe and Randolph 2008**)** suggested at least 20 other relevant interested parties, depending on the function and occupancy type of the development. Given the potentially diverse range of interests and interested parties, a key function of strata legislation is to facilitate dispute resolution (Bugden, 2007).

REGION	1998-1999	1999-2000	2003-2004	2012-2013	% CHANGE 1998/ 2013
VIC total					
Without OC	6686	5783	6408	5409	-19.1
With OC	1425	1327	1679	2448	71.8
Multi-storeyed	320	242	354	436	36.3
Metropolitan Melbourne					
Without OC	4140	3549	3000	2995	-27.7
With OC	1159	1159	1217	2100	81.2
Multi-storeyed	313	242	306	436	39.3
Regional VIC					
Without OC	2546	2234	3408	2414	-5.2
With OC	180	168	462	348	93.3
Multi-storeyed	7	6	48	41	485.7

Table 5.2. Trends in the use of body corporates/owners corporations in Victorian subdivisions (no. of plans) in the period 1998-2013 (VicMap Property, 2013).

With the introduction of the *Owners Corporation Act* in 2006, Victoria has witnessed an increase in the number of subdivisions with common properties (see Table 5.2), a pervasive trend witnessed even in regional Victoria (VicMap, 2013). One in four Victorians lives in some form of strata (a multi-unit development) that is affected by owners corporations. There are now almost 88 500 owners corporations managing approximately 747 000 lots in Victoria, making this the largest strata sector in Australia (Strata Communities Australia Victoria, 2014b).



Claim Value	2011-12	2012-13
less than $10000	2550	2677
$10000-100000	138	112
more than $100000	5	6
no value	391	451

Figure 5.3 Number of disputes appearing before VCAT (2009-2013) (VCAT 2010; 2011; 2012; 2013).

This, alongside the increasing complexity of vertical subdivisions, implies a greater potential for disputes amongst residents. In Victoria, the number of disputes being heard before the Victorian Civil and Administrative Tribunal (VCAT) has risen significantly since cases were first heard in 2009-2010 (see Figure 5.3), largely due to changes in legislation which mandated how disputes were to be resolved. Although approximately 80 per cent of these disputes are related to fee recovery issues (i.e. administrative in nature), the remainder are relevant to non-administrative disputes such as building repairs, with most claims being less than $10 000 (VCAT 2010; 2011; 2012; 2013).

5.4 CITY OF MELBOURNE CASE STUDY

The City of Melbourne (CoM) is one of 79 municipalities that make up the capital city of Melbourne and is home to the state's central business district (Figure 5.4). CoM comprises 16 suburbs over 37.7 square kilometers, but oversees 47 square kilometers of street land and floor space (approximately 75 per cent is built up). It has one of the highest population densities in the state – 1400 persons per square kilometer, and is consistently one of the fastest growing municipalities: given current growth rates, an estimated additional 42 000 dwellings will need to be built by 2031 to accommodate approximately 80 000 more people (Melbourne City Council, 2013a).

Having earned the mantle of "most liveable city" for four years in a row (awarded by the Economist Intelligence Unit), questions are now being raised as to whether CoM's status and repute as a liveable city will be threatened by projected rapid rates of growth in the medium term (Smyth, 2014).

5.4.1 Background: Capital city of Melbourne

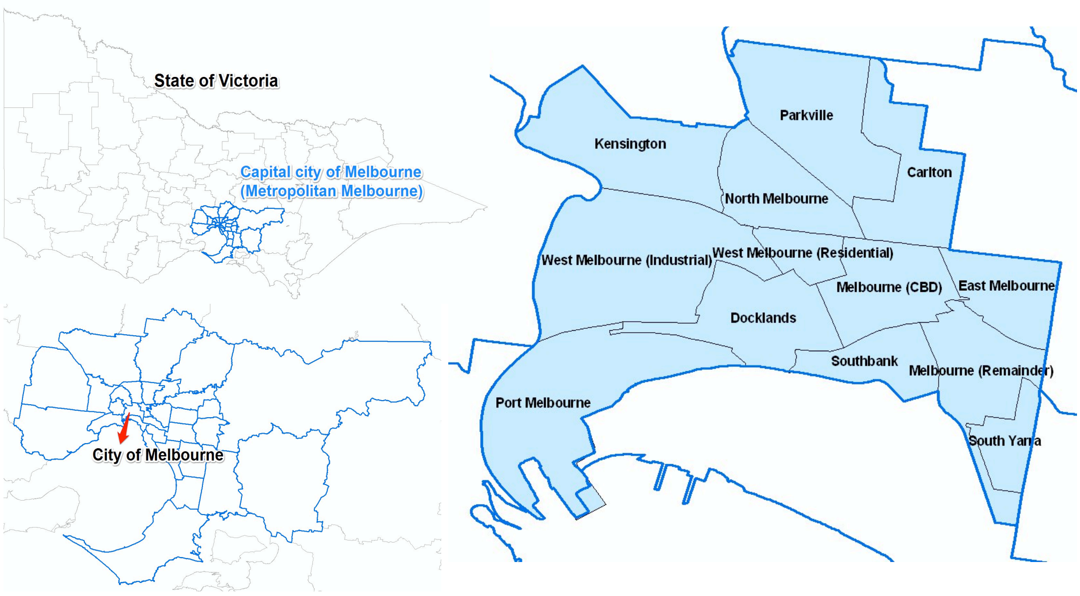


Figure 5.4 Geographical relationship between the state of Victoria, capital city of Melbourne and the City of Melbourne.

The capital city of Melbourne (refer to Figure 5.4) (i.e. the broader metropolitan area known as Melbourne) is the second largest capital city in the country (after Sydney) with an area covering almost 7700 square kilometers and is home to a population of approximately four million, projected to reach 6.4 million by 2050 (Department of Transport, Planning and Local infrastructure, 2014). Over the last ten years, Melbourne has experienced the largest growth rates amongst all Australian capital cities and has been growing faster than Sydney – at current rates, it will be Australia's most populous city in 2053 with a projected population of eight million people (Australian Bureau of Statistics, 2014; Milman, 2014).

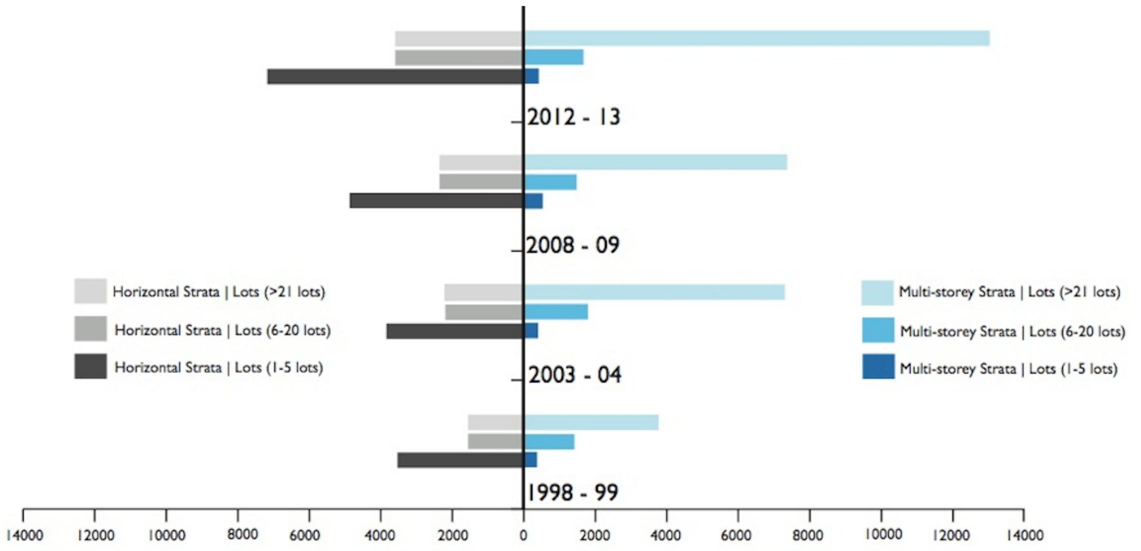


Figure 5.5 Trends in horizontal vs. vertical strata subdivision in Victoria, 1998-2013 (VicMap Property, 2013).

The planning response from the Victorian state government has actively articulated higher density living as a way of responding to population growth rates (Department of Transport, Planning and Local Infrastructure, 2014). This is supported in Victoria's subdivision statistics over the last 15 years (shown in Figure 5.5), which shows a clear trend towards high-rise subdivisions, particularly in the category of subdivision producing more than 21 lots per development (VicMap Property, 2013). Much of this high-rise subdivision activity has been focused on urban centres, leading to the majority of apartments built in the state being concentrated with the boundaries of the city of Melbourne (CoM) (Table 5.3).

DWELLING STRUCTURE	CoM		CAPITAL CITY OF MELBOURNE		VICTORIA		AUSTRALIA	
	NO.	%	NO.	%	NO.	%	NO.	%
Separate house	2022	5.1	990761	71.9	1495970	76.9	5864574	75.6
Semi-detached, row or terrace house, townhouse etc.	6665	16.7	163949	11.9	185737	9.6	765980	9.9
Flat, unit or apartment	31161	78	217350	15.8	250493	12.9	1056237	13.6
Other dwelling	88	0.2	5883	0.4	11692	0.6	66666	0.9

Table 5.3 2011 High-rise dwelling trends (based on 2011 census statistics of occupied private dwellings) (Australian Bureau of Statistics, 2013).

For these reasons, CoM is an appropriate study site since it has some or the highest concentration of residential high-rise buildings (i.e. population densities) in the state (Australian Bureau of Statistics, 2013).

5.4.2 Institutional Context of High-rise Development in CoM

Following the architectural commentator, Norman Day's public lament of CoM as an "empty, useless city centre" in 1979, politicians and municipal authorities sprung into action. Political and planning initiatives were designed specifically to bring people – and life – back into the desolate city centre, mainly through high-rise residential development in CoM.

Firstly, the relaxation of land use controls in the CBD resulted in more high-rise developments overall. Secondly, the introduction of mixed-use land use planning categories ('office and retail' and 'residential and retail') into the planning system in the mid 1990s facilitated the introduction of residential components in high-rise developments and shifted the traditional commercial purpose of high-rise buildings towards mixed-use (see Table 5.2). Such mixed usage had consequences for building structure, architecture and design in the access and use of space within buildings (e.g. Ali and Moon, 2007). Records held by the local council shows that most of the high-rise development that occurred within the municipality occurred from the 1970s onwards, with trends towards mixed-use high-rise buildings occurring from the 1990s (Tsutsumi and O'Connor, 2006). Finally, CoM's 'Postcode 3000' plan published in 1992 set out to increase the number of residential apartments in the CBD by more than tenfold – from 800 to 8000 – the aim of which was to increase the permanent resident population to reinvigorate the city centre.

Over the last ten years, state metropolitan strategies have led to more intense high-rise development by prioritising urban renewal (Birrell and Healy, 2013). This stimulated an increase in high-rise development within the boundaries of the CoM, particularly by foreign investors attracted by the affordability of sites, as well as the investment in public infrastructure (Birrell and Healy, 2013). Indeed, many of the more stratospheric buildings being planned in CoM – like the 100 storey high-rise residential building projected to be the tallest in the southern hemisphere when completed in 2019 – are being developed by foreign developers (such as those from Singapore) and being marketed to offshore Asian investors, particularly from China (Green, 2014b; Smyth, 2014).

The surge in high-rise residential developments has led to a more than a 25 per cent increase in the number of residential dwellings in CoM in just over the last five years (Melbourne City Council, 2013a). There are now approximately 28 000 apartments; however in the last two years, 20 more high-rise developments were approved by the current planning minister (with 100 more applications pending in the system) resulting in 14000 more apartments to be delivered over the next five years (Lucas, 2013).

CoM is consistently one of the fastest growing municipalities in the country and given current rates of growth (Australian Bureau of Statistics, 2013). Over the last ten years, 78 per cent of development in the city involved layered properties, of which 52 per cent had a residential function (as compared to 38 per cent commercial function). Figure 5.6 shows the trajectory of high-rise development over the short span of the past 40 years. This shows the intensity of high-rise development within the boundaries of the city as well as the dominance of complex building subdivisions to realise this environment and support planning objectives.

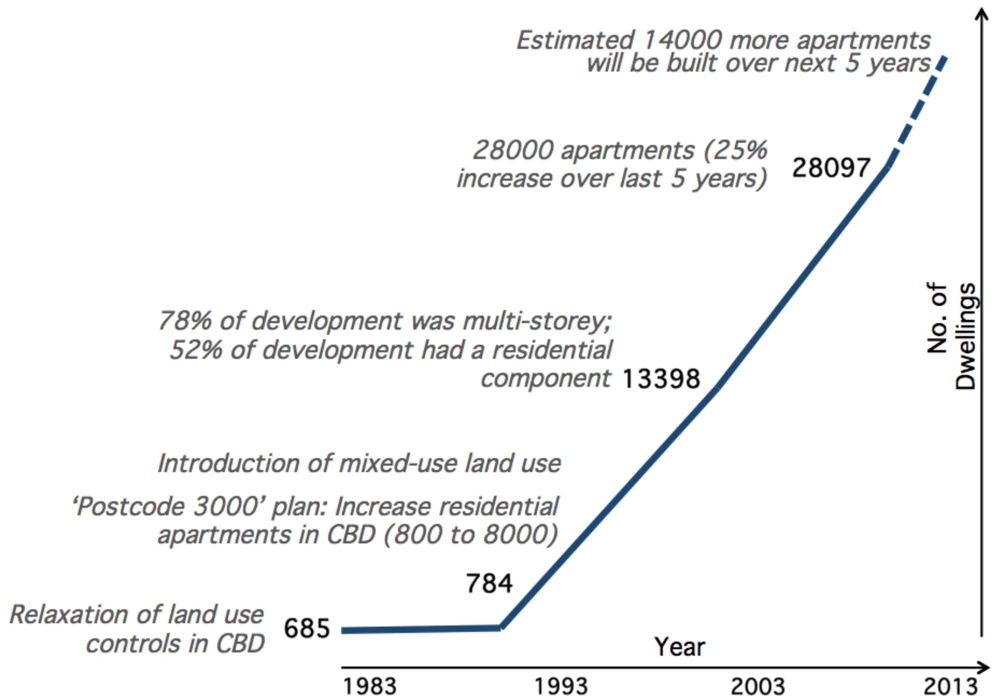


Figure 5.6 History of high-rise development in City of Melbourne (Melbourne City Council, 2010; Melbourne City Council, 2013b; Melbourne City Council, 2013d).

5.4.2.1 Density and complexity of development

As a consequence of these development trends, vertical subdivisions within CoM occur at rates that exceed other areas within the state. They are also far more productive – i.e. the number of lots being registered per plan is significantly higher. Figure 5.7 illustrates this clear trend, with the graph representing subdivisions in the City of Melbourne a significant distance above the state's average.

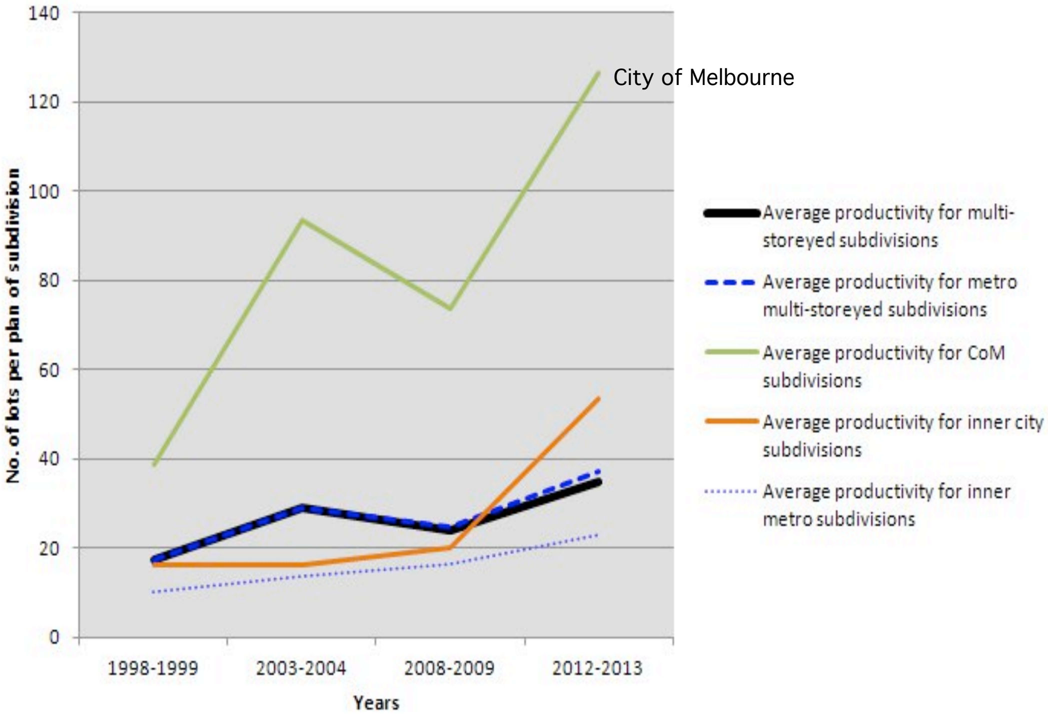


Figure 5.7 Average productivity (lots per plan) of multi-storey subdivisions in the inner metropolitan area (VicMap Property, 2013).

This intense development of multi-unit high-rise buildings within the boundaries of the CoM has led to the emergence of a phenomenon termed 'super dense' city blocks. These describe a development density of between 150 to 500 homes per hectare and at the current rate of development, the number of super dense city blocks has increased exponentially: where in 2002, there were only three, by 2012, this had grown to 24 and by the end of 2015, there will be at least 37 (Butt and Zhou, 2014). Currently, some developments even have a density of more than 5000 homes per hectare, which is four times more than the maximum density permitted in cities like Hong Kong, New York and Sydney (Green, 2014a).

One of the contributors to the increasing incidence of these super dense blocks has been the decreasing size of apartments being built in Melbourne. A recent draft housing strategy by CoM's council found that 40 per cent of apartments within Melbourne currently have a floor area of less than 50 square metres – in stark contrast to the cities of Sydney, Adelaide and even London, where the planning laws mandate minimum floor area of one-bedroom apartments to be at least 50 square metres (Green, 2014a). The shrinking floor area is being attributed to the fact that CoM's apartments have become a booming export industry where 85 per cent of new apartments are purchased by foreign investors and there is growing concern about what "shoebox living", lack of access to natural light, and other associated rights, restrictions and responsibilities might have on the city's famed reputation for liveability (Birrell and Healy, 2013; Melbourne City Council, 2014a; Green, 2014a).

The complexity inherent in dense developments is also exacerbated by a clear trend towards mixed-use development in CoM. Figure 5.8 illustrates data derived from CoM's Development Activity Monitor, which reinforces the trend towards mixed-use developments, particularly those with a residential component, in high-rise buildings within the municipality.

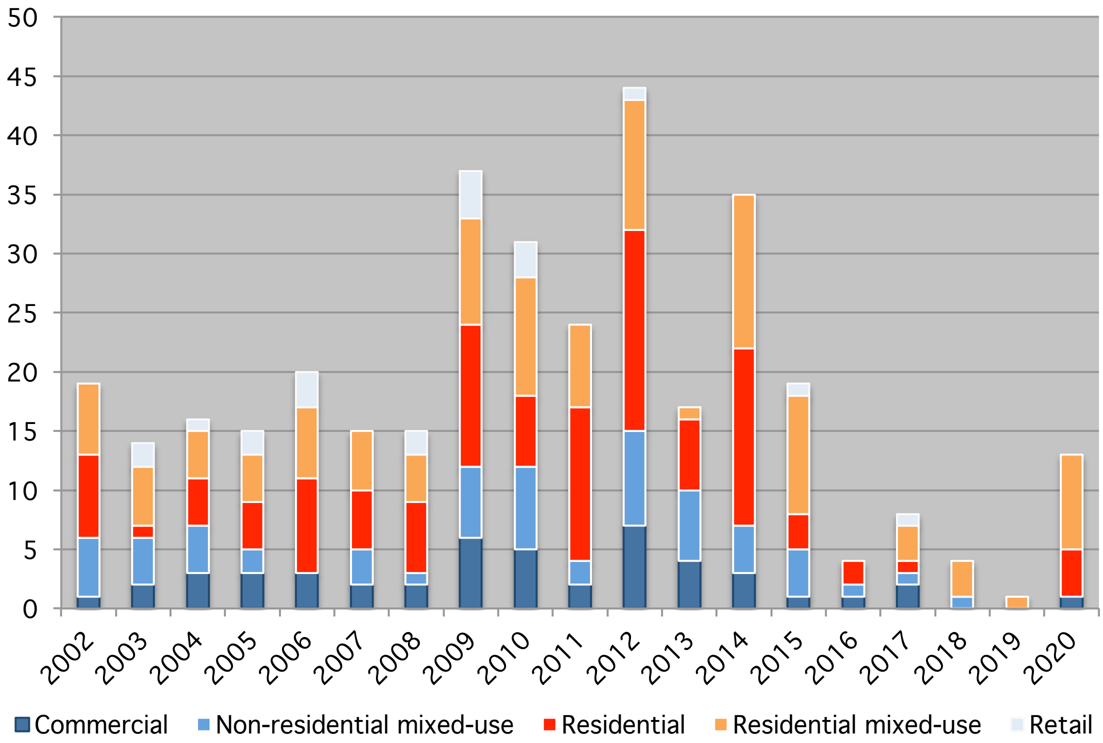


Figure 5.8 Development trends favouring resident and residential mixed-use developments in the City of Melbourne (Melbourne City Council, 2014b).

In summary, Sections 5.3 and 5.4 of this chapter described the historical and current context of high-rise development in Australia and the state of Victoria that has culminated in the current intensity of high-rise development within the boundaries of CoM. This intensity has contributed to residential real estate becoming the country's largest asset class for investment, but the economic benefits is being offset by the perceived social and environmental effects of development density, with CoM now recognised as having one of the highest residential densities in the world.

The processes of building subdivision and registration are therefore key urban land administration processes and form the focus of the Melbourne case study. This directs the case study to engage with stakeholders such as the land registry, local council, surveyors, state planning services, developers and strata managers to better understand how information about these developments are produced and used to support high-rise development as social and economic assets.

5.5 SINGAPORE CASE STUDY

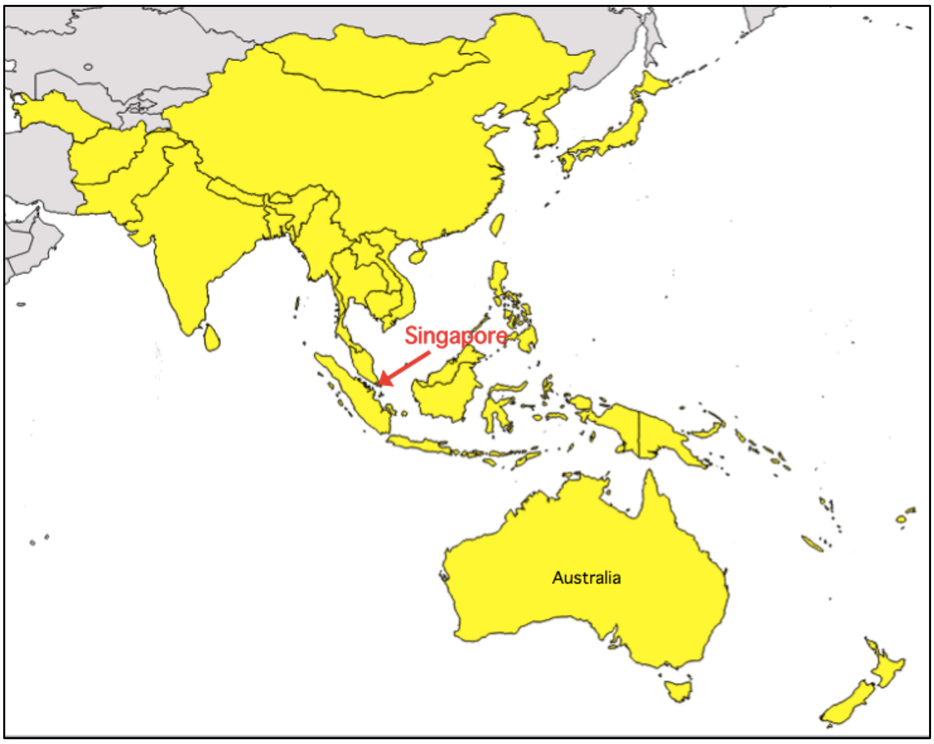


Figure 5.9 Singapore's geographic location within the Asia Pacific region (in yellow).

Singapore is an island-state located at the southern tip of the Malaysian peninsula (see Figure 5.9) and is one of the smallest countries in the world with a land area of 716 square kilometres and with a population of almost 5.4 million people (Ministry of Trade and Industry, 2014). Recording almost 7 500 persons per square kilometre (Department of Statistics, 2013), it does however have one of the highest population densities in the world, consistently ranking among the top three most densely populated countries over the last decade (UN-DESA, 2012). Much of this is a function of the prevalence of high-rise development in the country to deliver housing, but also providing commercial spaces for industry.

In post-war 1947, Singapore had the ignominy of being labelled as "one of the world's worst slums…a disgrace to a civilised community" by the British Housing Committee (Colony of Singapore, 1947: 16 in Yuen, 2007). At that time, Singapore had a population of less than one million and only around 40000 dwellings (Yuen, 2007). 75 years later, in 2012, Singapore has, at last count, just over 1.2 million dwellings, of which 93 per cent are multi-storeyed apartments (public housing comprises 76 per cent are private apartments comprises 17 percent), home to approximately 90 per cent of the population (Department of Statistics, 2013). High-rise buildings as a development type is so prolific in Singapore, it is embedded in the physical landscape and led to the rise of a new culture of high-rise living – to the extent that Chang (2000) suggested that this specific building typology is a new type of vernacular architecture for the country.

However, the country's limited land resources have necessitated vertical development for other aspects apart from buildings and the country is rife with many instances of complex stratified developments – from subterranean malls to overland freeways and underground tunnels. In addition, the island's mass rapid train system is rapidly expanding, with the government aiming to double its rail network by 2030, delivering 360 kilometres of subterranean and above-ground rail line, with an aim for 80 per cent of the population to be located within a ten-minute walk of a train station (Land Transport Authority, 17 January 2013). The scale and nature of vertical development reflects an ethos towards development best encapsulated in the Singapore Land Authority's vision of "Limited land, unlimited space" (Singapore Land Authority, 2013).

Many of these developments have implications for effective public and private land administration. Acknowledging this, the Singapore Land Authority is now leading a whole-of-government initiative to develop a 3D national topographic map (Singapore Land Authority, 2013), in addition to its own initiatives to establish a 3D cadastre, which it has noted will be "fundamental information for building virtual Singapore" (Soh, 2011: 22).

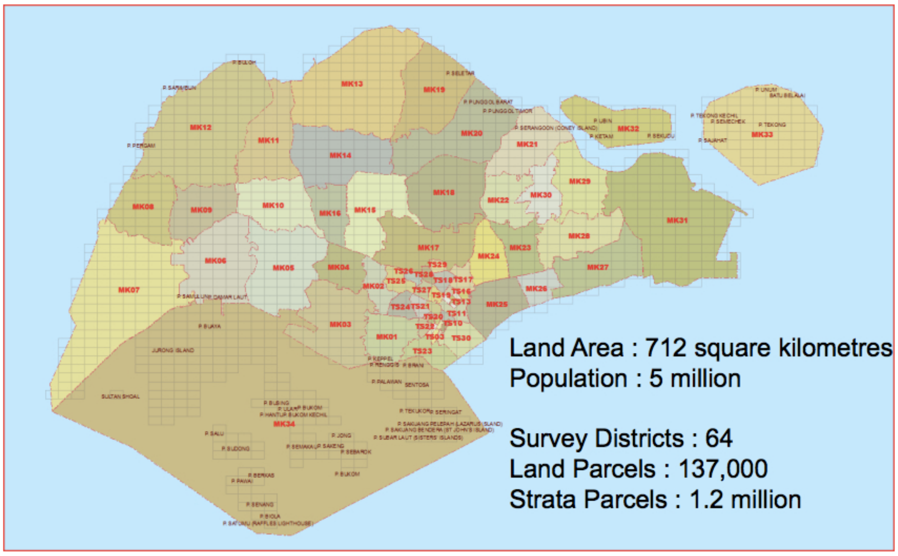


Figure 5.10 Number of parcels in Singapore (Soh, 2011: 4).

In terms of land administration, Singapore has approximately 1.34 million parcels, of which almost 90 per cent are strata parcels (see Figure 5.10). To meet future housing needs, an estimated 700 000 new homes will need to be built. It is unsurprising then that residential development makes up almost half of all construction work in the country – contracts worth approximately $11 billion (Department of Statistics, 2013). High-rise and complex developments for commercial and tourism purposes are also common due to government positioning of Singapore as a prime business location and tourism destination (Economic Development Board, 2012).

5.5.1 Institutional Context of BIM in Singapore

The use of Building Information Models (BIM) and associated modelling processes are gaining widespread use in the construction industry internationally to produce intelligent models that are populated with information about the building throughout its lifecycle. BIM and its processes are gradually replacing traditional 2D-based processes and documentation (Wong et al, 2010). BIM has been shown through a range of studies that it can deliver benefits in better information integration, better collaboration, better documentation, increased efficiency in planning, understanding and managing building projects, as well as provide the impetus for other value-add activities (e.g. Centre for Integrated Facility, 2007; Cooperative Research Centre for Construction Innovation, 2007; Brown, 2008; Eastman et al, 2008; Allens Consulting Group, 2010; McGraw-Hill, 2012).

It is therefore not difficult to understand Singapore's desire to adopt and implement BIM for productivity gains. Productivity as a key driver was formalised as national policy in 2005. The public release of the country's ten year master plan "The Intelligent Nation (iN2015)" set out the government's agenda for leveraging information and communication technologies (ICT) for enhancing Singapore's productivity, in which the construction industry was identified as a key sector (Goh, 2009).

With this mandate to improve productivity, the Building and Construction Authority (BCA), along with the Ministry for National Development, and in collaboration with industry and international experts, developed the Construction Productivity Roadmap to provide an overarching strategy for realising productivity gains within the construction industry. The Roadmap was endorsed by the government in 2010 and aimed to realise the vision of "a highly integrated and technologically advanced construction sector that will be led by progressive firms and supported by a skilled and competent workforce in 2020" (BCA, 2010a: 1). This roadmap was developed around a "three-prong strategy… focused on raising the quality of the workforce, incentivising workforce development, technology adoption and capability building, as well as enhancing the buildability framework" (BCA, 2010b).

Affiliated with this was also the politically sensitive topic of Singapore's reliance on foreign workers in the construction sector, with the government putting emphasis on technological interventions and up-skilling of the workforce as an operational response to the issue, in addition to introducing policies to regulate foreign labour (Fu, 2012). The establishment of a SGD$250 million Construction Productivity and Capability Fund was to help assuage concerns over policy changes – in particular, higher levies on foreign labour – and help defray costs for organisations as they transitioned their workplaces (BCA, 2010a).

Promoting the use of BIM therefore was seen to fit both political and technological agendas. The use of BIM forms part of a broader strategy to improve the productivity of the construction industry by up to 25 per cent over the next decade (BCA, 2011b). Within the Construction Productivity Roadmap, although BIM fell under the use of regulatory requirements for improving the take-up of technology, its adoption was also a natural progression of a shift to an electronic environment for regulatory services related to construction that had been put in place from the 1990s.

5.5.2 CORENET and BIM

The foundation for Singapore's journey towards BIM can therefore be traced back to earlier governmental policy that led to the establishment of the Construction and Real Estate Network (CORENET) project in 1995 as part of Singapore's IT2000 Master Plan. Led by BCA, CORENET aimed to "reengineer and streamline the fragmented work processes in the construction industry, so as to achieve quantum improvements in turnaround time, quality and productivity" (Teo and Cheng, 2006: 117). This was contingent on using information technology to provide the infrastructure for information exchange between all stakeholders in building projects, including the range of regulatory authorities involved. There are three major components of CORENET: e-submission, e-Plan Check and information services but only the first two components directly relate to BIM.

The CORENET **e-Submission system** has been in operation since 2002. It facilitates submission of building project electronic documents through a web-based system for regulatory approval. Prior to this, document submission was a notorious pitfall of the regulatory system, entailing 16 different government agencies from eight different government ministries, 209 different applications requiring 845 different forms, all of which placed a huge administrative burden on system to the detriment of the industry (novaCITYNETS, 2012).

Parallel processing by the various government agencies responsible for interests in land ensures that approval and processing times have vastly decreased: currently, only one submission is required versus the previous average of five to six submissions per project (buildingSMART Singapore, 2006; buildingSMART Norway, n.d.). The system has been widely successful: almost all planning applications are lodged via the e-Submission system delivering estimated savings of at least $160 million annually (The New Paper, 2001). It has also greatly reduced the time required to obtain a construction permit – from 102 to 38 days in 2008, which was a key reform that helped Singapore secure top ranking in the World Bank's annual study on countries that facilitate international business (Chan, 2008). In 2010, this was further reduced to 25 days (Wong, 2009) and only 231 forms are now required (novaCITYNETS, 2012).

The second part of CORENET is the **ePlanCheck** initiative, which involves eight regulatory authorities across five government ministries (buildingSMART Norway, n.d.). This initiative aims to automatically check the digital design information in submissions against building codes. The process is based on a proprietary platform called FORNAX, which extends the Industry Foundation Classes (IFC) data model to enable automated code checking functionality. This is the key motivation for the recent move towards widespread adoption and use of IFC-based BIM in Singapore. In 2008, BCA led the initiative that brought together various government agencies to develop the world's first BIM e-submission system (BCA, 2011).

5.5.3 BCA and BIM

In 2009, BCA began communicating a BIM Roadmap to the construction industry aimed at supporting the adoption and implementation of BIM (Cheng, 2011). Through this roadmap, BCA aimed to realise the use of BIM for e-submission purposes by 80 per cent of the construction industry by 2015. The roadmap identified four major challenges facing the industry, and set out five relevant strategies to respond to these issues. This roadmap is shown in Table 5.4 along with key activities associated with each strategy. These key activities are described in further detail below.

CHALLENGES	STRATEGIES	KEY ACTIVITIES
Lack of demand for BIM	Public sector takes the lead	BCA has collaborated with Government Procurement Entities (GPEs) to request the use of BIM for new public sector building projects from 2012.
	Regulatory approval	BIM e-Submission has been officially accepted by participating agencies of the Construction and Real Estate Network (CORENET), followed by engineering BIM e-Submission in April 2011. Starting July 2013, BIM e-Submission for regulatory approval will be made mandatory in phases.
Entrenched in the current 2D CAD drafting practices	Remove impediments	BCA developed a set of submission templates and guidelines to help professionals understand the new process of regulatory submission using BIM. BCA is also working with GPEs, professional bodies and buildingSMART Singapore to develop project collaboration guidelines and an object library standard.
Steep learning curve to build up BIM expertise	Build BIM capability and capacity	BCA's training arm, the BCA Academy, launched short courses on BIM. BCA engaged various tertiary institutions to include BIM training in their curricula. BCA also provided 'chaperone' services to businesses that needed assistance when doing BIM project implementation and regulatory submission for the first time.
Lack of ready pool of skilled BIM manpower	Incentivise early BIM adopters	The BIM Fund was introduced to help defray initial investment costs for BIM training, consultancy services and purchase of hardware and software for businesses and projects.

Table 5.4 BCA's BIM roadmap (BCA, 2013: 3).

5.5.3.1 Mandatory BIM e-submission

To move the land development industry in Singapore towards a BIM-oriented environment, the first step was for BIM to become mandatory for all public sector projects, which came into effect from 2010. Nine regulatory agencies also began accepting architectural 3D BIM submissions through CORENET (Swaddiwudhipong, 2012). The country's Housing Development Board reported labour savings of approximately 45 per cent in one project from using BIM over traditional plan preparations (BCA, 2011c). Consequently, BIM e-submission was mandated for regulatory approval processes for projects with a gross floor area in excess of 20 000 square metres – firstly for architectural aspects in 2013 followed by engineering aspects in 2014; from 2015, BIM e-submission would be mandatory for all projects with a gross floor area in excess of 5 000 square metres (BCA, 2011c).

5.5.3.2 Financial incentives

The roll out of BIM in Singapore has been facilitated by perhaps one of the most lucrative incentive schemes provided by a government internationally. By aligning the adoption and use of BIM with productivity goals, BCA was able to tap into SGD$250 million Construction Productivity and Capability Fund consisting of three streams of incentives aimed at supporting workforce development, technology adoption and capability development (BCA, 2010a):

- **Mechanisation Credit Scheme**: to assist with costs of new machinery (up to 50 per cent of costs or SGD$100 000).
- **Productivity Improvement Project Scheme**: to assist with the costs of adopting more productive work processes (up to 70 per cent of costs or SGD$1 million).
- **BIM Fund (SGD$25 million)**: to assist adoption and incorporation of BIM into organisations (up to 50 per cent co-funding or SGD$20 000 to SGD$210 000).

In terms of the BIM Fund, two kinds of funding were made available. The Firm Level Scheme provided up to 50 per cent of funds (limited at SGD$20000) required for BIM related training, software and hardware. The Project Collaboration Scheme provided additional funding towards consultancy costs (limited to SGD$210 000).

5.5.3.3 Other initiatives

In addition to mandatory e-submission and financial incentives, one of the key ways that BCA has been driving change is to work with other Government Procurement Entities (GPEs) to mandate the use of BIM for new public sector projects from 2012. In 2013, 15 GPEs were in agreement including the Housing Development Board, who is responsible for public housing development in Singapore, a major housing type in Singapore (Ong, 2013).

BCA has also developed a range of guidelines, templates and resources to support organisations in their transition to BIM e-submission. The BCA Academy also began to provide a range of short to longer-term courses to suit the broad needs of the workforce, as well as working with local universities and polytechnics to introduce BIM into their curriculum (Figure 5.11).

Figure 5.11 BIM training framework (Build Smart, 2011: 5).

Finally, BCA started an industry professional magazine, 'Build Smart', to showcase success stories and communicate changes, as they occurred to ensure that the industry remained well informed through the transition period.

5.5.4 Progress to Date

According to BCA, there is good progress being made by the construction industry in the use of BIM for e-submission. Between 2010 and 2013, BIM usage in the construction industry had increased by 33 percent, to the extent that 65 per cent of the industry is now using BIM (Ong, 2013). More than SGD$13 million of the BIM Fund has been awarded to more than 500 firms, benefiting more than 3 500 workers and achieving a 21.5 per cent improvement in efficiency (Ong, 2013).

The strategies used to support BIM adoption and use in the land development process therefore form the focus of the Singapore case study. This directs the case study to engage with key stakeholders such BCA to understand the motivations behind their strategic choices, but also with a wide range of industry stakeholders to understand how these strategies were received. Specifically, the case study seeks to understand why strategies were able to elicit a positive response to change from the industry.

5.6 CHAPTER SUMMARY

This chapter described the contextual setting of the case study sites: the City of Melbourne and the Republic of Singapore. The description for the City of Melbourne focused on providing the background for high-rise development in the boundaries of the city including the institutional context of this development. High-rise development has now resulted in the City of Melbourne becoming one of, if not the most, densely developed city in the world. Consequently, motivations for this development, primarily in attracting foreign investment, has led to a significant portion of the apartments becoming colloquially regarded as 'shoeboxes'. These developments continue to be commoditised through the same land administration processes of subdivision and registration that are applicable for all types of multi-unit developments, high-rise or otherwise.

For the Singapore case study, a broad description of the country's development provided the backdrop for the current drive towards using BIM for compliance checking. The institutional context of BIM adoption and implementation was described as well as the current strategic framework being implemented by the Building and Construction Authority of Singapore, the lead government agency with responsibility for facilitating the take-up of BIM by the architecture, engineering and construction (AEC) industry in Singapore.

This concludes the end of the research background for the thesis. The outcomes of the case studies will now be presented over chapters six and seven.

CHAPTER 6

INVISIBLE CONSTRAINTS ON 3D-ENABLED URBAN LAND ADMINISTRATION: A CASE STUDY ON THE CITY OF MELBOURNE

‘Parcel’ is an ancient term.

(Strata manager in Melbourne)

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6.1 INTRODUCTION

This chapter presents the findings of the first case study in this research. As described previously in Chapter 4, the primary focus of this case study, which was on the City of Melbourne, was to develop a deeper understanding of the institutional environment and how institutional elements presents constraints on 3D innovation in the land administration industry.

The City of Melbourne's (CoM) evolution as a dense, high-rise, environmentally complex urban centre, while similar to other city centres around Australia, is also atypical in other ways. Australia's expansive land resources have privileged low-rise, low-density housing and a resulting national psyche hooked on the dream of owning a house on a quarter-acre block. The story of CoM presented in this chapter is as much a tale of physical development as it is a narrative of a country coming to terms with an emergent urban identity that no longer aligns with traditional representations of home ownership. Therein lies the rub: how do we reconcile the old with the new? How do we preserve processes that work for the majority, while responding to the needs of an increasingly important minority?

Drawing on a range of analytical measures, this chapter presents the institutional environment underpinning urban land administration, in this instance, in the production and use of the 2D plan of subdivision in CoM. Content analysis of a range of documents and data supports the elucidation of institutional characteristics, while in-depth interviews provide insight into the perceptions of stakeholders regarding the benefits and limitations of current 2D-based processes. Thematic analysis of all sources of data indicates ways in which stakeholders are currently constrained – consciously and less consciously – to current 2D-based ways of acting. The case study also reveals how aspects of the institutional environment are shifting as a result of the limitations of current 2D practices, and on the back of close inter-organisational and interpersonal relationships, providing opportunities for change and potential levers for developing strategies to support change.

This chapter begins with a description of the institutional environment underpinning subdivision and registration processes constituting to some extent, the shared reality that connects the various stakeholders. The key themes are then presented, in which sub-themes are used to illustrate some of the more distinctive aspects of the themes. Subsequently, institutional theory is applied to facilitate the interpretation of these themes to suggest how current institutional elements are constraining stakeholders to current 2D-methods of working.

To support understanding of the interview quotes used in this chapter, Table 6.1 presents a breakdown of the various participants by sector, and the corresponding citation codes used to reference the verbatim quotations presented in this chapter. For example, a quote by a participant from state government would appear in this chapter as:

> "Architecture challenges are not supported by legislation…currently (the Subdivision Act) is being stretched to its limits (G-S09)",

where the citation code (i.e. G-S09) at the end indicates where the participant is from i.e. state government.

SECTOR	CITATION CODES
State government	G-S01, G-S02, G-S03, G-S04. G-S05, G-S06, G-S07, G-S08, G-S09
Local government	G-LC01, G-LC02, G-LC03, G-LC04, G-LC05, G-LC06, G-7
Developer	ID-LC- 10, ID-LC-11
Professional body	ID-LC-01, ID-LC-02
Strata manager	ID-LC-03, ID-LC-04, ID-LC-05
Surveyor	ID-LC-06, ID-LC-07, ID-LC-08, ID-LC09
Industry workshop	W01, W02, W03
Strata managers questionnaire	QSM01

Table 6.1 Melbourne case study interview participants and in-chapter citation codes.

6.2 THE INSTITUTIONAL ENVIRONMENT

Due to the regulated nature of property rights information, regulative elements are a primary aspect of the institutional environment, determining a range of processes and actions. The legal framework is first explained as this provides meaning to action and helps guide the way stakeholders relate to each other (Jost et al, 2009). Such common frameworks constitute the institutional logic – the shared system of socially constructed meaning (e.g. language, practices, etc.) and historical patterns that have led to the current high-rise land development and management process shown in Figure 6.1 (refer to pp. 148-149), and serves to underpin subjective realities of stakeholders in the organisational field.

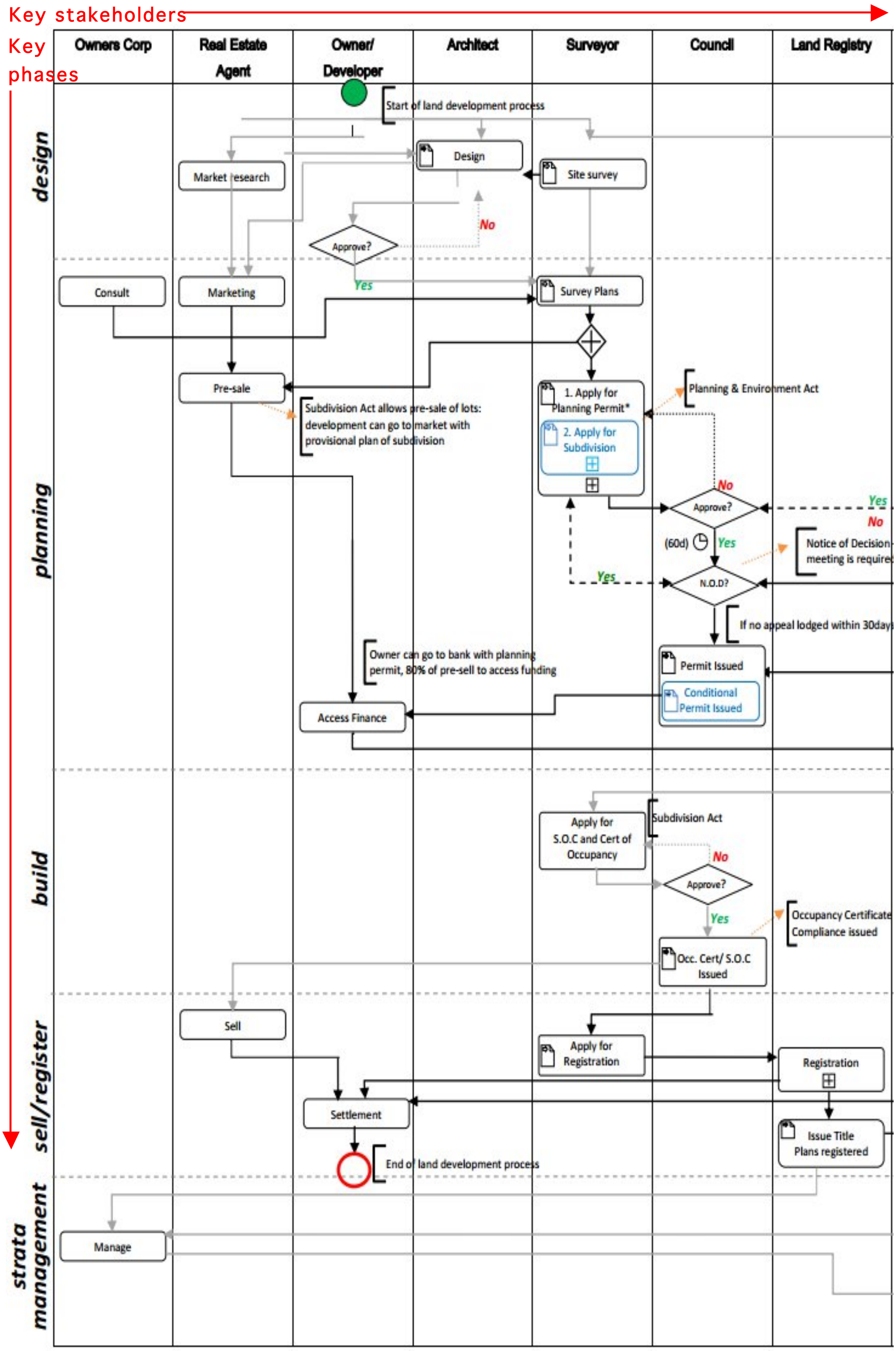
6.2.1 Legislative Framework

The legislative framework plays an important role in land administration: due to the important role that property titles play in wealth creation, many land administration activities are regulated. Consequently, this also means that stakeholders rely on a range of legislation and regulations as a common framework. From the perspective of subdivision and registration, there are four major pieces of legislation that relate to high-rise buildings. These are:

- *Planning and Environment Act 1987*, which governs the use of the land.
- *Subdivision Act 1988*, which governs the development of the land including the *Subdivision (Registrar's Requirements) Regulations 2011*, which provides clarification on the definition of boundaries and clarifies the contents of plans.
- *Transfer of Land Act 1958*, which governs procedures to facilitate buying and selling of land, including powers vested in the Registrar providing the legal mandate for the processes, activities and information managed by the land registry.
- *Owners Corporation Act 2006*, which governs the management of common property once the building is registered and occupied.
- Other pieces of legislation that come into play are more relevant to the physical aspects of development, such as the Building Code of Australia (part of the National Code on Construction), or those which affect professional practices such as the *Surveying Act 2004*.

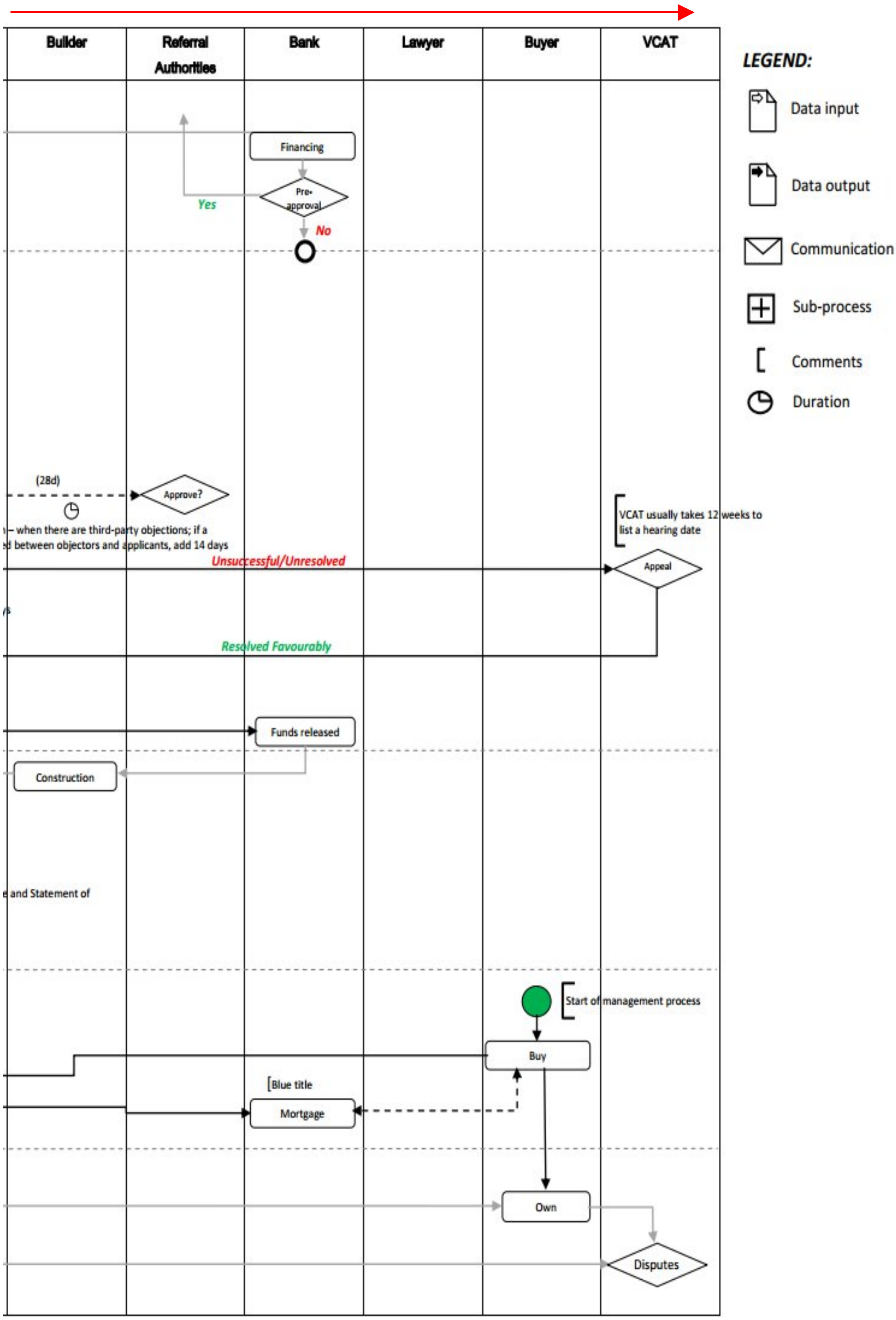
In this institutional environment, key regulatory organisations include the land registry, state planning services and local government who all have a role in ensuring legislation is being complied with. Key professions that are involved are the surveying profession, architects, planners and increasingly, strata managers – all these stakeholders constitute the organisational field in question.

High-rise development is primarily facilitated through the regulated process of subdivision. Once constructed, buildings with a residential function are managed through owners corporations comprising all unit owners to manage common properties. The processes relevant to these land administration activities were mapped for CoM to provide a standardised process from which the various subjective realities could then be explored. The process has been constructed using data from the interviews and supplemented with information from a range of publicly available documents. Figure 6.1 provides a diagrammatic view of the urban land administration process, idealised using business process modelling. The diagram shows the various stages of land development and management processes, and reflects how the main information product, the 2D plan of subdivision is produced and subsequently used within the community.



*assume planning permit

Figure 6.1 High-rise land development and management process.


Builder
Referral Authorities
Bank
Lawyer
Buyer
VCAT
LEGEND:
Data input
Data output
Communication
Sub-process
Comments
Duration
Financing
Pre-approval
Yes
No
(28d)
Approve?
– when there are third-party objections; if a
between objectors and applicants, add 14 days
VCAT usually takes 12 weeks to list a hearing date
Unsuccessful/Unresolved
Appeal
Resolved Favourably
Funds released
Construction
and Statement of
Start of management process
Buy
Blue title
Mortgage
Own
Disputes

6.2.2 Transactional Processes as a Shared Reality

In CoM, two key land administration processes underpin high-rise building development: the subdivision process and the registration process. Subdivision, as formally defined in section three of the Subdivision Act, is the "division of land (including buildings and airspace) into two or more parts which can be disposed of separately" (State Government of Victoria, 2013: 8). The certification process as carried out by the council is significant as well, although not so much in defining or checking the legal extent of new property, but more so because it checks that the plan complies with relevant legislation and has met all the conditions set out in relevant planning permits. Once a plan is certified, it can then be submitted to the land registry for registration. With the recent introduction of the Owners Corporation Act, a legislative framework around the management of common properties in strata developments has begun to become formalised. However, this is not strongly linked to the other pieces of legislation through formal associations or linkages in the Acts.

6.2.2.1 Design phase

This is a preparatory phase undertaken by the developer to research a range of physical, social and economic conditions to determine suitability for development. Developers typically seek input for the design of the development from a range of sources including real estate agents, who provide insight into market conditions and preferences. One of the developers interviewed indicated that it was not unusual for this phase to take up to three years. The physical design is drawn up by architects (mainly using 2D CAD, although some are producing drawings in 3D CAD), which is sent to surveyors as 2D CAD floor plans and cross-sections; tracing over these drawings provides surveyors with the basis for creating building subdivision plans, both of which are required for the planning phase.

The production of the plan of building subdivision is the main activity discussed here. The increasingly architectural and structural complexity of high-rise residential developments has had ramifications on the preparation and production of plans of subdivision. Firstly, the scale of development, e.g. developing multiple towers of residential apartments, often requires consolidation of multiple old titles to form a new land parcel for development. Secondly, large developments are often built in stages due financing limitations and the various stages need to be reflected in the 2D subdivision plans, where visualisation of how various stages interact and fit together is predominantly a mental exercise by the responsible surveyor. Thirdly, the sheer volume of information, in terms of drafting the legal ownership boundaries for all apartments as well as common properties, has become significantly more manual and laborious (ID-LC-

08).

Finally, the challenge in conceptualising boundaries and visualising or understanding how the layers of rights, restrictions and responsibilities (RRRs) and common properties might impact on the future management and use of the building has meant that pre-application meetings between developers and surveyors, and various council officers, has become more commonplace, especially if a development appeared to require multiple owners corporations. This was becoming an increasingly important design process as poor design of owners corporations could not only impact on the effective management of the development and hamper resident amenity, but of greatest concern to developers, could provide a way for buyers to break pre-sale contracts if changes to entitlements and liabilities eventuated (G-LC03, ID-LC-08, ID-LC-06). This was also where the use of 3D models has become prevalent in the current process, even ones as basic as simple objects representing the building envelope.

6.2.2.2 Planning phase

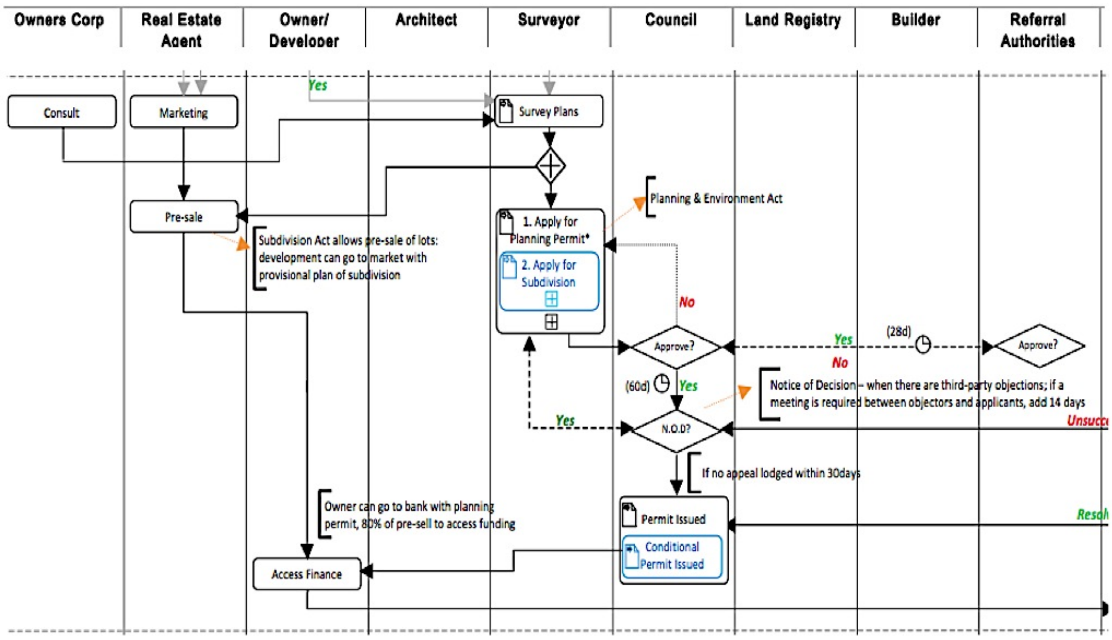


Figure 6.2 Processes in the planning phase.

The main aim of this phase (see Figure 6.2) is to obtain planning and subdivision permissions as required. These are two separate regulatory processes but the council in CoM requests for a joint application where applicable since "95 to 98 per cent of all developments will require planning permissions" (G-LC04). These tend to be lodged on behalf of the developer by the surveyor. Expediency is highly desirable as the Subdivision Act allows for pre-sale of lots (i.e.

sold off-the-plan) once permission to subdivide is obtained. Developers can approach financial institutions to access funding for construction once 80 per cent of a development has been pre-sold. Subdivision plans are sent to various referral authorities (e.g. utility companies) to determine if easements have been properly identified and defined.

It is worth highlighting here that (only) in CoM, the state's Planning Minister becomes directly involved when a development's total floor space is in excess of 25,000 square metres. In these instances, development assessment (i.e. issue of planning permits) is a ministerial responsibility (local council retains responsibility for subdivision assessment).

The processes for this phase are 2D-based but electronic. CoM requires all applications to be lodged via the online system, SPEAR (Surveying and Planning through Electronic Applications and Referrals), which facilitates electronic transactions regarding planning permit and subdivision applications throughout the state. In contrast, applications requiring Ministerial Permits need to be lodged in person with the state government (i.e. a 2D paper-based application process). To facilitate development assessment, the state government request the submission of a 3D model showing building envelopes and external aspects of the built form.

6.2.2.3 Build phase

Once the required permissions have been obtained and funding secured, construction begins. The main information transaction for this phase pertains to obtaining both the 'Certificate of Occupancy' and the 'Statement of Compliance' that shows the building has met all of its planning conditions and meets building regulations for occupation. The plans are also updated by the various professions to reflect the as-built condition of the structure.

6.2.2.4 Sell/Registration phase

The aim of this process (see Figure 6.3) is to register the properties to commence settlement. Registration requires a range of administrative and graphical information including the previous phase's Certificate of Occupancy and Statement of Compliance from the local council (i.e. the certification process) to show that the building has met all the planning conditions and is fit for occupation, as well providing the most current version of the plan of subdivision.

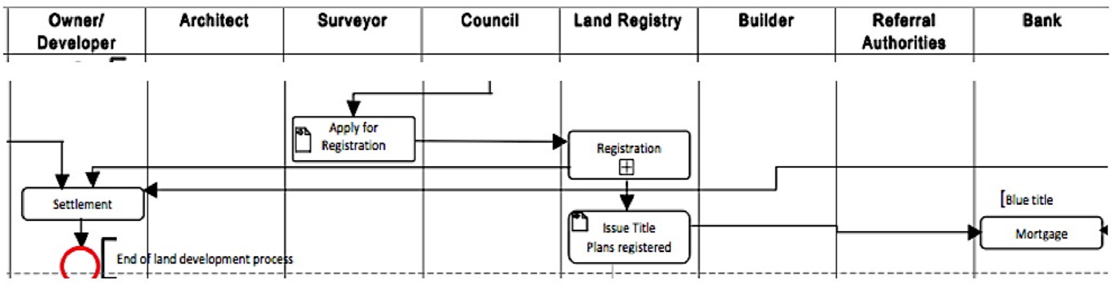


Figure 6.3 Processes in the selling or registration phase.

Plans are examined to ensure that the boundaries for all spaces are represented logically in accordance with regulations as the government guarantees all titles in the state. For a large development of approximately 1500 lots, registration could take up to three weeks (G-S05, G-S09). To prevent fraud, a blue copy of the title is held by the financial institution that administers the mortgage of the owner. The conclusion of this phase marks the end of the land development process and the start of the management process.

6.2.2.5 Strata management phase

This phase mainly concerns owners and strata managers. Some larger developments, especially those with mixed residential and commercial use, may have building managers on site as well. The main source of information used in this phase is the plan of building subdivision, which strata managers receive from the developer after registration. The plan is considered to be of such importance that those strata managers that were interviewed regularly referred to the plan as the 'bible'. Engineering schematics for the building are typically held on site as paper copies, and are available mainly to the building manager and the strata manager. All disputes between owners (or tenants) and owners corporations are now heard before the Victorian Civil and Administrative Tribunal (VCAT) as mandated by the Owners Corporation Act.

6.3 PERCEPTIONS OF THE ORGANISATIONAL FIELD: CURRENT 2D LAND ADMINISTRATION PRACTICES

The various social realities experienced by the stakeholders in the organisational field in the context of facilitating development and strata management of high-rise buildings in CoM are presented here. These perceptions help to identify the range of institutional pressures that the stakeholders feel in the context of current 2D practices. The subdivision plan provides the basis for showing how the stakeholders relate to each other, and how the institutional pressures cascade through the field.

6.3.1 Producing Subdivision Information for Development

Participants were emphatic that the current development process worked well for most buildings – **except** for the complex superstructures common to CoM (ID-LC-06, G-LC03). For these buildings, the experience of the participants from both private and public sectors reflect a strong awareness that the current legislative framework was not designed with these structures in mind, and its limitations in supporting complex building information using traditional 2D methods were surfacing, for example:

> "…architecture challenges are not supported by legislation…currently (the Subdivision Act 1988) is being stretched to its limits" (G-S09).

In response to these limitations, the land registry had spent 18 months developing the Subdivision (Registrar's Requirements) Regulations (G-S09). These prescriptions for drafting of boundaries have been well received as they are perceived to provide clarification on how to represent and understand boundary definitions:

> "Subdivision Regs [Regulations] will help clarify boundary issues…instructive even for retrospective cases" (ID-LC-02).

The sheer scale of information required and the investment needed to get the information right exacerbates the ramifications of these limitations. This was illustrated by one of the interviewees, an experienced and senior surveyor on a current large-scale development in CoM who noted that (ID-LC-08):

> "11 old titles were consolidated [in the design phase]";

> "…The tricky part [in the planning phase] is staging and how stages interact… phases need to match up on plan";

> "80 to 90 per cent of drafting work [are] in car parks and dimensions and this costs tens of thousands of dollars and takes months and months";

> "…The [subdivision plans for the] first stage [of the development] was 110 pages, land registry took three weeks [to examine and register]…and then it [the plans] got requisitioned…".

The scale and complexity of the buildings were perceived to be creating challenges amongst professions in abstracting and representing boundary types (i.e. logically designating boundaries as internal, external and median so as to minimise impact on effective management of the building), logic of designing access rights using multiple common properties (as mentioned in the normative aspects), representing boundaries that are not on the same plane, representing new ownership situations (e.g. car stackers), as well as representing easements that flow vertically through a building. This is a significant conceptual challenge and not getting it right has long-term impacts for the community of users:

> "Building subdivisions are always complex and drafting problems are typical because you have to visualise how boundaries would affect management of property" (G-S05).

Due to the increasing information complexity requiring resolution at the design stage, the local council frequently holds pre-application meetings with developers. This was also where the use of 3D models was becoming prevalent in the current process (as mentioned in section 6.2.2.1). Both developers and government representatives were in agreement about the utility of models at this stage, with both short- and long-term benefits apparent to users:

> "…Models are helpful at that stage [in reference to the pre-application stage]– easier for developers to see what needs to be done [in terms of how owners corporation structures impact access]";
>
> "3D models would deliver greatest benefit if introduced at the start of the land development process to help everyone be on the same page e.g. compliance checking can be reduced by almost half [three months vs. six to eight months]" (G-LC03);
>
> "…It answers questions quickly" (ID-LC-02);
>
> "[3D models are useful in] proving or disproving architectural sketches" (G-S07).

It was also becoming common practice for the structure of multiple owners corporations to be "workshopped at the start" and more likely than not, a design would be recommended by the project's surveyor (ID-LC-08). This was an increasingly important design process as bad design of owners corporations was perceived to impact on the effective management of the development, hamper resident amenity, but of greatest concern to developers, could provide a way for buyers to break pre-sale contracts if changes to entitlements and liabilities eventuated (G-LC03, ID-LC-08, ID-LC-06).

Some developers were currently using 3D models to support some information processes, and they, as well as interviewees from both state and local governments, were unequivocal about the benefits for representing and managing complex building information:

> "3D helps when things aren't on the same plane, like curves and ramps" (G-LC03);
>
> "[3D building models are] more resolved e.g. services clash detection… [3D models] halve the drafting time – a 40 storey building – about 500 lots and 200 car spaces that would usually take a year to draw, only took six months" (ID-LC-02);
>
> "…computational rules [developed] in the eighties regarding the Shrine [of Remembrance] was a thick book; now it's in the model" (G-S07);
>
> "…The city exists at different levels…a 3D model is important for effective administration" (ID-LC-01).

However, the current use of 3D models tended to be mostly simplistic or superficial, e.g. using only external features:

> "Mostly it's a pretty picture…trying to link up with more data" (W03).

If they were detailed models, these tended to be used only for supporting information through the development process and did not carry over through to the management process (ID-LC-02). Partly, this was a resource issue in terms of building capacity and skills, or simply that current computing resources were not sufficient for 3D-based programs, for example:

> "One of the biggest challenges has been installing [the 3D program] on desktop" (W03).

6.3.2 Using Subdivision Information for Management of High-rise Properties

6.3.2.1 Interview data

From the interviews as part of the Melbourne case study, those participants on the receiving end of these plans such as local councils and the land registry, confirm increasing issues with the quality of subdivision plans:

> "Surveyors may represent car stackers differently [for example] as common property with carriageway easements" (G-LC07);

> "Two-thirds [of subdivision plans] need amendment from surveyor, one in 10 to 20 will require significant amount of change" (G-S05).

The reality for participants who use subdivision plans is that the plans are limited and ambiguous in their representation of legal and administrative information in high-rise developments:

> "…There are limitations to plans because it's a simplification and [you] lose detail" (ID-LC-08);

> "…Some things are hard to show [for example] storage areas under stairs" (G-LC07).

The limitations are also exacerbated by the fact that the plans exist in a non-digital format (either in paper form or electronic). In one visit to a large mixed-use development, the building manager showed how he had resorted to drawing all the accessory lots shown on the plan of subdivision in a spread sheet program–in effect creating a digital plan–just so he could easily search for spaces and update associated information. He had done so as he continually faced queries from new tenants as to where their relevant car park or storage spaces were and was tired of continually spending time searching through the paper plan of subdivision; in addition, accessory spaces are not necessarily ordered numerically.

Participants also raised issues regarding the continued use of the surveying-centric concept of the (2D) terrestrial land parcel as the basis for recording land and property information as it provided limited value for the administration and management of high-rise properties:

> "Parcel is an ancient term" (ID-LC-03);

> "…We have a property view of the world, not parcel" (G-LC02).

This reliance on abstract, surveying-specific concepts also impacted on the community of (lay) users' ability to understand a building:

> "That's unintelligible to anybody except for Titles [Office]… nobody outside [of] Titles Office and surveyors understands vinculums [a symbol used to show a change in level along the same boundary plane]" (ID-LC-08);

> "In some ways the accuracy isn't the issue, it's the relativity…[the plan of subdivision] will be more understandable with architect boundaries" (ID-LC-08).

This resulted in ongoing roles for surveyors in clarifying the information encoded in plans:

> "…We still get calls [from the public] 10 years later" (ID-LC-06).

This reality was supported by the views of strata managers who are not trained surveyors, but who deal with subdivision plans in their daily roles:

> "…It [fully understanding a plan of subdivision] took a long time…it was pretty scary to start" (G-LC-07);

> "…Takes a few months to get your head around the plan of sub [division]…a year to understand, would help to have [information about] the physical structure as well" (ID-LC-04);

> "External wall may make sense from surveyor's point of view, but not from management point of view" (ID-LC-03).

Participants generally agreed that the cultural 'newness' of communal living in complex high-rise apartments compounded issues of understanding and awareness, which stimulated increasing dependence on plans of subdivision for educating apartment owners as to their RRRs (ID-LC-02, G-S05). However, the recent regulation of owners corporations has also led to increased reliance on plans for determining and clarifying these RRRs, particularly since the

Owners Corporation Act has blurred the traditional paradigm which used to have a clear delineation of responsibilities between common and private properties as belonging to body corporations (the old term for owners corporations) and private owners respectively.

At an industry workshop, feedback emerged that the new legislation has now made the management of common properties even more complex by creating responsibility for owners corporations to manage services outside of common property (Sections 4bii and 46b), requiring higher levels of interaction between owners and owners corporations. For example, the answer as to who owns the balcony tiles inside the boundary of a property can vary depending on the experience and perspective of the person responding. Tiles and membranes of floors are represented in subdivision plans only through text notations; they are not represented in engineering plans as a structural feature. This is an issue as owners corporations are now responsible for chattels, fixtures etc. (*Owners Corporation Act 2006*, S.4bii), therefore owners corporations might be considered responsible for upkeep of tiles and membranes (W01).

The plan of subdivision still fulfils a role in supporting the interpretation and understanding of who is responsible for what, but the absence of other building information within the plan means that other sources of building information are being sought and utilised – typically other sets of 2D plans all drafted according to relevant professional standards.

6.3.2.2 Strata managers' questionnaire data

In addition to interviewing strata managers, some findings derived from a short questionnaire seeking to establish sentiments regarding current issues in management of common properties in the strata management industry, provided further insight as to how the current 2D plan of subdivision supports the role of strata managers.

This topic was the focus of three yes/no questions in the questionnaire (out of a total of 20 questions), but there was also scope for respondents to provide additional comments. The three questions and the response rates are provided in Table 6.2.

THEME	RESPONSE
Are the Plans of Subdivision important to your role?	• Yes: 100%
Do you use the Plans of Subdivision to help resolve issues such as those raised previously?	• Yes: 100%
In your opinion, could the Plans of Subdivision be improved?	• Yes: 95% • No: 5%

Table 6.2 Responses related to plan of subdivision in questionnaire to strata managers.

According to comments from the strata managers, the importance of the plan of subdivision lies in its authoritative definition and demarcation of common and private properties, particularly important are those boundaries that lie between private and common properties, as this enabled the identification of affected lot owners, and therefore determined responsibility in terms of repair and maintenance of the development. This makes the document fundamental to both strata managers and the operation of owners corporations.

The visual element of the plan was also perceived to be instrumental in assisting strata managers to reach resolution on common issues such as parking in the wrong car park space:

> "I frequently send a plan of subdivision to residents/owners that are parking in the incorrect position. Visual aids are easy to understand for the majority of people" (QSM01).

The plan was also important because it can be used as legal evidence in getting owners to comply with maintenance of private property:

> "An owner refuses to pay for a window repair when the plan highlights the window is private. Notice is service pursuant to Sec 129 and 48 and the plan becomes evidence to support this notice" (QSM01).

However, in the experience of the respondents, older plans of subdivisions were of poorer quality in terms of representing such information:

> "Most of our issues are over older plans that are silent on some matters. Additional building information on all location of all services on older and smaller developments is often only determined by site investigation" (QSM01).

However, strata managers also commented that the quality of information has improved since the recent clarification of boundary types by the land registry (the Subdivision (Registrar's Requirements) Regulations 2011). Most agreed that plans could still be improved upon in terms of less ambiguity and greater consistency as the quality of information being produced is very much dependent on the skill of the individual surveyor and their experience with strata developments. This is illustrated in the comments below:

> "The way the plans are portrayed needs to be kept the same, currently depends on who draws the plan" (QSM01);

> "Could all be uniform instead of each plan being marked with different lines and boundaries changing" (QSM01);

> "More direct wording of boundaries, so that anyone can pick up a plan and understand. I think that the language used on the plans of subdivision can be modernised and more informative" (QSM01).

Essentially, the strata managers felt that greater value could be derived from the plans if the information could be more easily communicated and understood, essentially "so that anyone can pick up a plan and understand [it]" (QSM01). This related to both the graphical elements as well as the language and terminology used within plans. Only one respondent felt that there was no further scope for improvement.

6.4 KEY THEMES: DOES THE CURRENT INSTITUTIONAL ENVIRONMENT SUPPORT 3D INNOVATION?

Thematic analysis of the interview data, field notes and observations, as well as secondary source materials supported the identification of four superordinate themes. Table 6.3 provides a summary of the key themes and sub-themes and the key characteristics of each theme. These themes describe the institutional environment underpinning the production and management of a key source of information in urban land administration – the 2D plan of subdivision – and how this manifests as reluctance to change to embrace 3D innovation. These plans are not only essentially for registration of high-rise property, they are only fundamental to the ongoing management of private and common properties within high-rise buildings. The key aspects of these themes are detailed through the use of sub-themes within each category where relevant.

THEME	SUB-THEMES	DEFINITION AND CHARACTERISTICS
History and tradition of 2D	• 2D methods as the norm • 2D methods don't work for big buildings • 2D entrenched in legislation	Inference to longstanding use of 2D methods, demonstrating almost a 'taken-for-granted' attitude or strong expectations around using 2D methods, as well as awareness and acknowledgement of the proficiency of this method.
Development vs. management	• Focused on registration • No meeting community needs	Sense that development and management activities and processes occur in isolation from each other (existence of 'silos', or only depend on informal relationships for linkages.
Somebody else is the problem	• Surveyors mainly responsible for what is in plans • Land registry as key actor	Implicit assumption that the land registry is the key actor in any movement to shift from 2D to 3D practices, given their mandated role in registration.
Change opportunities		Refers to on the ground changes that signal changing social expectations, obligations, roles and processes around land administration practices.

Table 6.3 Key themes derived from the City of Melbourne case study.

6.4.1 Theme 1: History and Tradition of 2D

The emergence of this theme was unsurprising, given that the surveying profession, similar to other design professions such as architecture and engineering, have a long history of professional practices predicated on 2D processes. This theme reflects the emerging tension from both producers and users of subdivision information as they attempt to negotiate the adaptation of current professional practices of encoding land and property information using longstanding 2D practices to respond to the demands and information challenges of modern buildings.

Depending on their position and stake in the process, participants provided different dimensions of this theme, which is described in the three sub-themes. The sub-themes show how these different dimensions all work to provide strength to this theme as a constraining influence on innovation.

6.4.1.1 2D methods don't work for big buildings

Comments from the development and surveying sectors reveal increasing frustration with accepted 2D processes, whose historical development suggest they were never intended for the level of complexity that is now typical of modern high-rise buildings. This theme reflects the challenge facing stakeholders in finding the middle ground between methods that are proficient most of the time…except when it comes to structures at the upper limits of drafting complexity. Many of these limitations are associated with architectural or structural designs, which result in boundaries needing to be represented on different planes (such as curves and ramps) (G-LC03); as such, there was a sense that the legislation itself was not keeping up with architectural developments (G-S09).

These perceptions appear developed by experiences where the production of complex building information (using accepted 2D methods) is now costing substantial time and money (ID-LC-08). The frustration felt around being constrained to using these methods is exacerbated by the knowledge that the consequent information products (subdivision plans) are more than likely to require further resources to modify or rectify, given the high level of perceived difficulty in abstraction and representation (ID-LC-08).

This frustration extends as well to those who are users of this information. Comments from strata managers, involved with the management of common property, indicate difficulties in using and understanding 2D subdivision plans, but have no other recourse since it is the only source of available information that defines common property RRRs – to the extent that most of the strata managers interviewed refer to subdivision plans as their "bible". Nonetheless, most strata managers conveyed an increasing lack of certainty regarding the interpretation of information encoded in the plans, notably position and function of boundaries.

The frustration was not only with 2D as an information format, but also around enduring use of profession-specific 2D-based constructs, particularly with the longstanding and accepted use of the concept of the terrestrial land parcel as the basis for recording land and property information. The concept of the land parcel was perceived to provide limited value, particularly for the administration and management of high-rise properties. The level of granularity needed for representing information about buildings was perceived as not being met by parcels, given its historic origins (ID-LC-03, G-LC02). The perception was therefore that subdivision plans offer limited value to local government in managing and administering the use and occupation of high-rise properties, and this stimulated their take-up, or creation, of other sources of information (ID-LC-01; G-LC-02; G-LC-05). Additionally, the constraints of non-digital information were proving also to present as a significant management issue.

6.4.1.2 2D methods as the norm

Related to the previous sub-theme, this theme reflects the perception that stakeholders are aware that many in the industry are simply used to 2D methods of engaging with subdivision information, and are comfortable with using these methods. As such, innovative practices are perceived to be potentially disincentivised by prevailing demographic characteristics of the industry.

On one hand, there was a perception by some stakeholders that 2D methods posed no barrier to understanding complex building information. Many informal, 2D-based practices were now the norm, such as for the physical design to be drawn up by architects (mainly using 2D CAD, although some are producing drawings in 3D CAD) and thereafter, sent to surveyors as 2D CAD floor plans and cross-sections; tracing over these drawings provides surveyors with the basis for creating subdivision plans (ID-LC-06). This was driven by the fact that these stakeholders had interacted with such information for a significant amount of time, to the extent that even though plans were in 2D, they could visualise and conceptualise the information as 3D, and therefore saw no real advantage in moving towards 3D-enabled information.

Other participants also perceived personal attitudes to technology and change to inevitably be strong influences on the likelihood of adopting 3D technologies. In discussing the impact of changing technologies used in their daily roles, there were admissions that this would take some time to get used to (based on previous experiences), while others may be predisposed to resistance due to demographic attributes.

Additionally, perceptions around 2D-based formats for transacting information (paper or electronic) were that these were normal practices within the industry. However several participants made mention of the fact that the Surveying and Planning through Electronic Applications and Referrals (SPEAR) system, an online system facilitating planning and certification applications, reinforced the use of PDFs.

Ultimately, there was significant consensus among participants that a move from 2D to 3D methods is a fundamental change for some, and would “require a mindset shift” (ID-LC-02).

6.4.1.3 2D entrenched in legislation

Despite acknowledging that the plans of subdivision were limited and limiting, there was a strong perception that the current process that resulted in these plans was highly regulated, and as such, difficult to change (G-LC02). This was reflected in comments such as:

> "[Subdivision and registration is a] fairly rigid process…set in legislation so it's difficult to change" (G-LC04).

Almost all participants made mention of some or all of the following key pieces of legislation: the Planning and Environment Act, the Subdivision Act, the Subdivision (Registrar's Requirements) Regulations and the Owners Corporation Act, which were considered essential components of the legislative framework. However, apart from being framed around words such as 'plans' and 'documents', the legislation – specifically the Subdivision Act – makes no actual specific reference to mandatory use of 2D methods.

The main issue for participants was the fact that the current the current development process worked well for most buildings – **except** for the complex superstructures common to CoM (ID-LC-06, G-LC03). For these buildings, participants from both private and public sectors were of the opinion that the current legislative framework was not designed with these structures in mind, and limitations in its ability to support complex information were surfacing.

Acknowledging the limitations of current legislation, the land registry had spent 18 months developing the Subdivision (Registrar's Requirements) Regulations, which built on current practices. These prescriptions for drafting of boundaries have been well received amongst stakeholders in development and even amongst those involved in management, as they are perceived to provide clarification on representation and understanding of boundary definitions (ID-LC-02).

6.4.2 Theme 2: Development vs. Management

This theme reflects perceptions that development and management activities and processes occur in isolation from each other, or depend on informal relationships for linkages – a phenomenon that could be described as the fact that 'silos' exist. This theme was experienced mostly from the perspective of strata managers, which as the sub-themes suggest, is a function of the recent development of a legal framework around the management of common property, which constitutes the scope of their responsibilities.

6.4.2.1 Focus on registration

In contrast to the established regulatory environment of the development process, the management environment has only recently become regulated with the development of the *Owners Corporation Act 2006* initiated by Consumer Affairs Victoria:

> "VIC (Victorian) strata laws were vague 20 years ago but have (now) become more prescriptive" (ID-LC-02).

This piece of legislation governs use, management and maintenance of common property and relevant disputes and attributed greater legal responsibilities to owners corporations.

Participants perceived the current subdivision plans to have a narrow focus predicated on surveying codes and oriented towards registration, and therefore felt that the plans were not actually effective in communicating and perpetuating knowledge about a building in a community of users. Ongoing processes around information maintenance, such as Section 32 of the Subdivision Act (re-subdivision of boundaries) were also perceived to be developed solely for the purposes of keeping land registry information up to date, with no secondary processes in place to keep the community of users updated:

> "…We don't get notified of changes to accessory lots e.g. swapping car parks, which may change units of liability" (ID-LC-03).

Finally, many participants indicated that the plans of subdivision, with their representation of abstract legal spaces prepared for the purposes of property registration, presented ongoing cognitive challenges to the community:

> "…In some ways the accuracy isn't the issue, it's the relativity…[the plan of subdivision] will be more understandable with architect boundaries" (ID-LC-08).

In effect, this demonstrated a broad opinion that the abstract nature of the 2D plan was a significant disadvantage and improved comprehension of high-rise subdivision information could be achieved through more realistic representation of the information, perhaps in conjunction with real-world objects such as the building itself.

6.4.2.2 not meeting community needs

There was a clear perception on the part of strata managers that issues existed regarding the formalised flow of subdivision information between development and management processes, especially in the context of ongoing changes to boundaries or property rights throughout a building's lifecycle. Section 32 of the Subdivision Act (re-subdivision of boundaries) permits changes that are not captured other than on title. However, there is no catalyst in the process to alert other stakeholders to what these changes are, an issue also due to the frequency of occurrence of these changes (ID-LC-06).

Many of these changes impacted owners' liabilities and entitlements, and therefore strata managers felt that they could play a greater role in design processes, especially aspects affecting common property areas and access, but were currently not formally included, unless the developer also operated a strata management firm that was to be associated with the development (ID-LC-03; ID-LC-08).

From the perspective of strata managers, there was no doubt as to the important role that the plan of subdivision had for executing their roles and responsibilities, with the plan frequently referred to as "the Bible" (ID-LC-02; ID-LC-03; ID-LC-04). However, there were clear issues from their experience in understanding the plan due to its abstract nature. This was supported by the views of others who were not trained surveyors, but who needed to deal with subdivision plans in their daily roles, such as local government officers.

There was also increasing frustration with the apparent lack of appreciation for how the design of boundary information relevant to common property and arrangements regarding multiple owners corporations impacted on the ongoing management of the building:

> "Building surveyors need to learn how to write up plans properly so they can be clearly read and understood. Creating 3xOCs [three owners corporations} for a block of 4 [four] units is crazy" (QSM01).

This also reflected the separate nature of the process, which tends to exclude strata managers from the process, but that the nature of these complex developments did not lend itself well to such continued 'silo' practices and necessarily demanded a more collaborative approach.

6.4.3 Theme 3: Somebody Else is the Problem

The final theme that emerged was really indicated strongly by its absence rather than presence. Throughout the interview process, and through examination of secondary data sources, there was no instance where a stakeholder directly took responsibility for 3D innovation, or 'owned' the problem. All participants consistently perceived this responsibility to lie with others, as the sub-themes below will suggest.

6.4.3.1 Surveyors mainly responsible for what is in plans

Perceptions from strata managers, as key users of subdivision plans, show that they directly correlate the quality of plans with the surveyors who produce them (QSM01 and QSM02). This is turn affect how plans are used to support their roles and responsibilities in terms of common property management.

6.4.3.2 Land registry as key actor

Implicitly, the land registry was perceived by many of the participants involved in producing subdivision plans to be a key stakeholder – if not **the** key stakeholder – in the process to shift from 2D to 3D methods since the information produced related primarily to meeting the objectives of registration.

Participants felt that the move from 2D to 3D had to be supported and led by the land registry, but felt that such a scenario would be highly unlikely given that the complex superstructures that were challenging for the current 2D-based subdivision process only made up a small percentage (comprising only five per cent of all subdivisions in the last year) of subdivision applications lodged at the land registry (ID-LC-06; ID-LC-07; G-LC03).

However, interviews with land registry reflect a perception that current 2D methods are not impacting negatively on their ability to register complex structures, and indeed for the purposes of examining plans of subdivisions, 2D plans are considered to be a more effective and efficient format as they are able to “tick off lines as we go” and that “even though plans are in 2D, I think in 3D” (G-S05).

6.4.4 Theme 4: Change Opportunities

The interviews also demonstrated that, despite the range of social and cultural issues that are still exacting significant pressure on participants to continue with current 2D-based ways of thinking and behaving, there was also an emerging interest around leveraging 3D technologies for representing land and property information.

Primarily, the Ministerial stream for planning applications with a floor area in excess of 25000 square metres actively encourages the submission of 3D models for impact assessment purposes. While not mandatory, the state’s planning services currently receive enough interest that they have published guidelines pertaining to these models for developers and their architects. To date, the state government has already received between 150 to 200 3D models (G-S07). Currently, only the building envelopes are required so models with internal geometries provided have these information removed by planners.

It was also observed that CoM council staff have been equally keen to leverage 3D technologies to better manage and visualise the urban environment and have been broadening their use of this technology. Consequently, CoM staff provide leadership to other councils where such initiatives are only just emerging. The growing acceptance of 3D technologies, particularly within local government, has led to the emergence of a grassroots movement, spearheaded by key individuals, which has led to the recent establishment of a local government 3D user group relevant to the use of 3D models for local government administration (G-LC02, G-S07). At a meeting of this user group attended as part of this research, it was observed that the environment was one of enthusiasm, with participants being highly collegial and collaborative, and individuals who were skilled and experienced in using these technologies for representing 3D land and property information were more than willing to share and cultivate resources for other interested parties, such as models, methods, processes and object libraries.

Another opportunity for change that was observed relates to the small size of the current community of interest pertaining to land administration within CoM. It was observed that close and long-standing working relationships enabled stakeholders to leverage strong connections and breadth of experience to negotiate difficulties arising from information issues pertaining to complex developments such as the representation of new types of rights, restrictions and responsibilities within developments. This informal network is providing to be an effective platform for resolving the types of information issues and challenges that are pushing current regulatory boundaries (e.g. car park stackers).

More importantly, the nature of development for high-rise buildings, and the need to facilitate inter-disciplinary discussion at the start of the development process is stimulating a shift in the traditional pattern of interaction between the various professions. Specific to land administration, it appears that surveyors now have a greater level of input from the start of the project due to the increasing tendency to use multiple owners corporations to control access rights in multi-function developments, or multi-block developments. The surveyor's input into the layout of these owners corporations is necessary as it can have an impact on the physical design of the development. This departs from the typical interactions experienced in simpler subdivisions, where the surveyor only tends to become involved with the Architecture, Engineering and Construction (AEC) industry prior to the registration process (illustrated in Figure 6.4) (ID-LC-06; ID-LC-08).

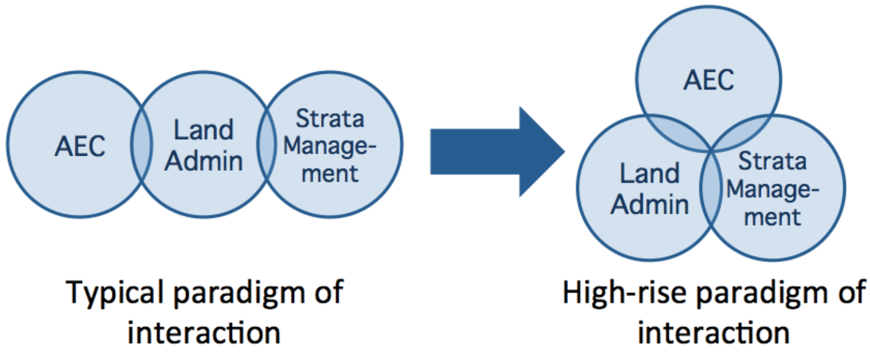


Figure 6.4 Changing paradigms of interaction between stakeholders in urban land administration.

Finally, analysis of registration statistics for subdivisions demonstrates that continued use of the traditional parcel-based paradigm potentially obscures the significance of the issue of high-rise subdivision for the land administration industry. Most participants estimate that high-rise developments only account for approximately five per cent of applications lodged at the land registry. This is supported statistically. However, this five per cent of plans lodged with land registry actually equated to 26 per cent of all lots examined and registered in the period 2012 to 2013 (VicMap Property, 2013). Such a statistical perspective immediately indicates a much higher proportion of public stakeholders – at least a quarter of all apartment owners now have a vested interest in the management of information about buildings in a way that is accessible and comprehensible to them. Expressed in this manner, the weight of public interest could lead to shifting social expectations around the management and representation of land and property information.

6.5 INTERPRETATION OF KEY THEMES

This section applies institutional theory to interpret the findings of the Melbourne case study to identify plausible ways in which current stakeholders are being constrained to current ways of working by the pressure exerted through the regulative, normative and cultural-cognitive elements within the current institutional environment. The constraints are framed around the core institutional concept of legitimacy: constraints are therefore those elements that support or sustain legitimacy around the current 2D paradigm of representing land and property information for land administration purposes. These interpretations are elaborated in further detail in this section, but an overview is provided in Table 6.4.

THEMES AND SUB-THEMES	REGULATIVE CONSTRAINTS	NORMATIVE CONSTRAINTS	CULTURAL-COGNITIVE CONSTRAINTS
	Coercive Pressure	*Normative Pressure*	*Mimetic Pressure*
HISTORY AND TRADITION OF 2D • 2D methods don't work for big buildings • Used to 2D methods • 2D entrenched in legislation	Perceived dominance and rigidity of legislative framework; Legislative framework legitimises 2D ways of representing building information and methods for processing information; New regulations still aligned with current ways of doing things	2D methods of representing building information are traditional and there is historical expectations around 2D formats Surveying profession more oriented towards regulative elements due to licensing and auditing checks	Professionally entrenched methods of abstracting and drafting building information in 2D, also common to all design professions Dominant cultural norms Personal attitudes
DEVELOPMENT VS. MANAGEMENT • Focused on registration • Not meeting community needs	Current institutional environment oriented around registration–difficult for other stakeholders that are not traditionally part of this to have any influence.	Information content of subdivision plans intended for registration and governed by relevant legislation–does not take into consideration broader needs of community for using the information	Lack of cultural support for high-rise buildings
SOMEBODY ELSE IS THE PROBLEM • Surveyors responsible for plan content • Convince land registry	Land registry perceived to be the key to the issue–but seen to be difficult to convince due to small number of buildings	Issue perceived to be somebody else's problem–lack of awareness of how poor building information is a macro-level issue	Complex buildings perceived to be a small proportion of all developments

Table 6.4 Interpretation of key themes as constraints on innovation.

6.5.1 Regulative Elements as Constraints

The perceived dominance and rigidity of the legislative framework could be interpreted as a constraint on change in several ways. Although participants were unequivocally cognisant of the fact that current information processes and products were not keeping pace with requirements associated with high-rise living and stratified use of space in urban areas, they could not readily identify opportunities for change.

Mainly, this could be attributed to key pieces of the legislative framework having been in operation for at least 25 years: the current regulatory framework for development was established in the late 1980s and its institutional force is evident in widespread acceptance of the logic of the requirements prescribed by the *Subdivision Act 1988* – a highly routinised process which till now, has been simply taken for granted. Such an extensive duration also implies ample time for the industry to become familiar with its requirements and idiosyncrasies, which support its dominance as an institutional driver at both conscious and unconscious levels.

This also indicates a significant degree of path dependency in the system, likely due to the legislative framework producing learning effects, where skills and knowledge gained in terms of subdivision and registration have efficiencies attuned towards broad acre, lower density subdivisions that are the majority.

There is little doubt that the interviews reflect a reality dominated by the legislative environment. This suggests the presence of coercive pressure to abide by current 2D-based ways of working, i.e. the perception is that there is no choice but to do so. This pressure is not insignificant, especially as it does not seem that the law actually explicitly rules out the use of 3D-based information or technologies.

In this instance, there is also significant normative and mimetic pressure inherent in the institutional environment, which results in an unconscious meaning being attached to terms such as 'plans' and 'documents'. These are traditionally associated with 2D-based information, but appear to be construed as legitimising 2D methods. Alternatively, this could also be interpreted as a lack of legitimacy around 3D innovation. Importantly, participants are interpreting such a lack of explicit support for 3D-enabled information as a restrictive factor in their ability to innovate. The participants appear caught between awareness that the processes are increasingly inefficient and the need to act; the only recourse has been to fall back on familiar ways for sense-making purposes.

The current structure also does not provide any enablers and continues to constrain them to current (2D-based) behaviour – a clear emergence of an institutional 'gap'. There is evidence of attempts made to plug these gaps, such as the development of the Subdivision (Registrar's Requirements) Regulations, but these are still wholly aligned with current 2D-based ways of thinking and acting.

The current framework is also oriented around registration, and therefore participants associate the role of key actor with the land registry. This however, appears to be a constraint because complex high-rise subdivisions are seen to represent only a small percentage of subdivisions, and therefore is difficult to mount a persuasive argument for change, as is the fact that the land registry remains resolute that 2D methods do not present as a significant obstacle.

6.5.2 Normative Elements as Constraints

Normative constraints were interpreted to relate to four main aspects:

- The surveying profession being more oriented towards regulative elements.
- Traditional use of 2D methods for representing building information.
- Content of subdivision plans intended only for registration and governed by relevant legislation.
- Lack of awareness of how poor building information is a macro-level issue.

Firstly, in terms of the perceived dominance of regulative elements in the institutional environment by the surveyors interviewed, the significance associated with these elements could be interpreted to be a function of the profession itself. Cadastral surveyors, or land surveyors as they are more commonly known, need to undertake specific licensing requirements to practice as cadastral surveyors, and the basis for professional legitimacy. Their work is often audited and checked by the Surveyor-General's Office and any non-adherence could result in the loss of their license and professional sanctions – fostering a strong culture of compliancy. Their professional perspective could therefore be interpreted to be more oriented than usual towards regulative elements given the nature of their work is typically in accordance with legal specifications.

Secondly, the longstanding tradition of representing information of producing building information in 2D formats could be interpreted as a significant normative constraint. Drafting conventions encode knowledge, with each of the design professions having its own frame of reference: "interpretive schema that simplifies and condense the "world out there" by punctuating and encoding objects, situations, events, experiences, and sequences of action" (Snow and Bensford, 1992: 137). These conventions are reinforced and reproduced through education, through professional standards and are expected of these professions.

There is little doubt that although 3D methods of representing building information are gaining ground and social expectations around 3D models of information are growing, it has yet to achieve a level of acceptability within the regulated environment of land administration that is implicitly associated with 2D methods. Even though there is clear feedback from participants that current drafting standards are being challenged by the requirements of complex structures, there is still little movement in shifting to a 3D paradigm.

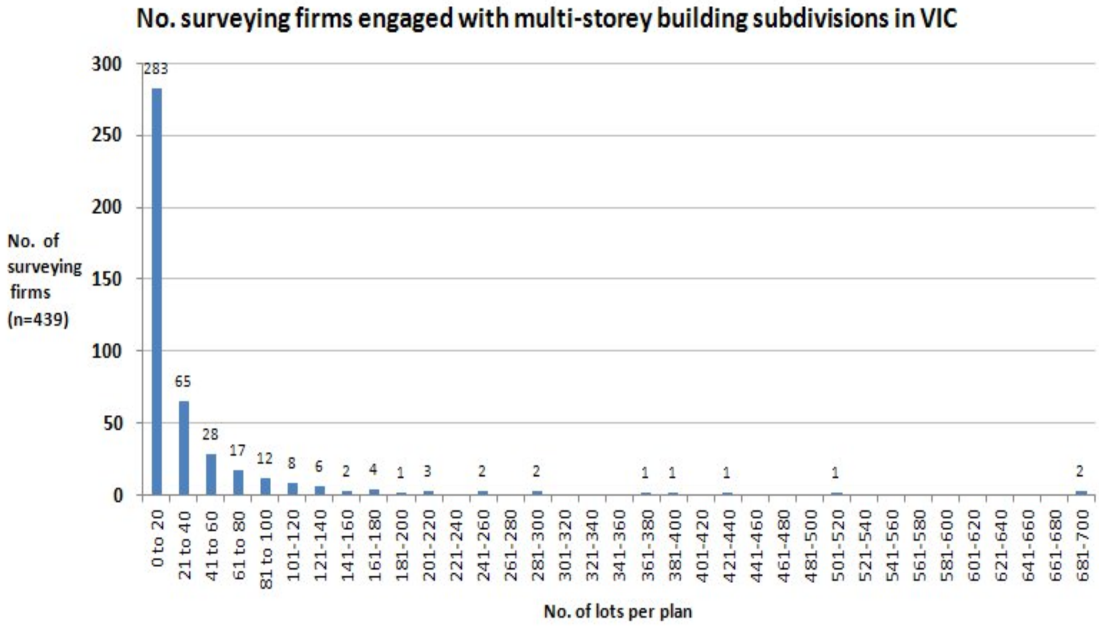


Figure 6.5 Distribution of surveying firms producing plans of subdivisions for multi-storey developments in Victoria (VicMap Property, 2013).

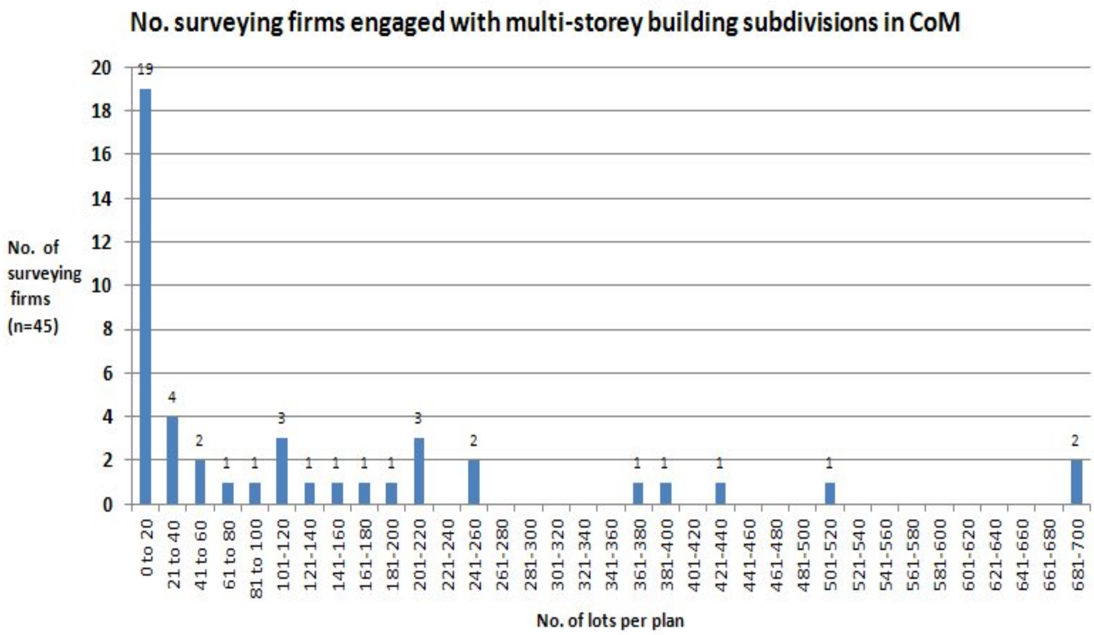


Figure 6.6 Distribution of surveying firms producing plans of subdivisions for multi-storey developments in CoM (VicMap Property, 2013).

The growing variance in professional skills and abilities to tackle these complex structures can also be interpreted to be a function of the small pool of surveyors who currently engage with these projects, and the long tail of surveyors who dabble in them from time to time. Statistics for the year 2012 to 2013 show only a small number of surveying firms were involved with multi-storey subdivisions in Victoria; within CoM, this trend is even more stark, with just four surveying firms accounting for more than half of the 45 plans lodged in this period (see Figures 6.5 and 6.6). This signals gaps in normative frameworks such as procedures and approaches, where skills are less developed in the context of high-rise structures.

Thirdly, the plans and the information represented within them were originally intended for registration purposes only. This original intention and narrow focus has resulted in established 'silos' of practice and governance. A common one that emerged from the interviews is an apparent disconnect between registration and management. The current environment makes little allowance for bringing other stakeholders in – in terms of institutional theory, the organisational field is strongly bounded and stakeholders with a growing presence, such as strata managers, are struggling to find a way to fit in. This is evident in responses alluding to the lack of information flow to strata managers, and clear issues arising from their co-opting of the prevailing institutional logic around subdivision, represented by the subdivision plan, and their frustrations with its misfit for management purposes.

Finally, the case study findings and key themes suggest a lack of ownership around the change process from 2D to 3D. This could be interpreted as a constraint, particularly in a regulated industry such as land administration, which would require some explicit expression around the use of 3D-based practices and processes within the legislative framework as one of the key drivers to build legitimacy around change.

6.5.3 Cultural-Cognitive Elements as Constraints

Dominant cultural norms can be interpreted to constitute intractable obstacles to reform, and the case study indicates that there are at least several in existence.
Firstly, the tension expressed by stakeholders with regards to balancing subdivision and registration processes and products that are still effective and efficient for most of the (simpler) strata developments typical within the state of Victoria against their limitations in the context of complex urban high-rise strata developments. The acceptance of these methods is now culturally embedded, having been in existence for almost 40 years.

Secondly, although strata titling and subdivision practices in Victoria set out to recognise a different type of tenure, the dominance of simple two-lot subdivisions and broad acre subdivisions are very much still in the mould of traditional freehold dwelling types. Arguably, these practices have been acculturated and are now aligned with the dominant 'land' paradigm. This is evident in the use and meaning of terms, where there is no difference made in the legislation between land and buildings: Section 3 of the Subdivision Act provides evidence of this, where "land includes buildings and airspace" (State Government of Victoria, 2013: 3). To date, current cultural norms around land administration practices and processes, especially in subdivision, is a product of the dominant development type in the state, which means practices and processes pertaining to complex high-rise subdivisions have very much become a somewhat specialised practice, and not seen to be a unilateral issue.

Cultural norms can also be framed through social patterns rather than literal instructions. For example, the current Transfer of Land Act places no restrictions on the medium or format of the information held in the register of land, and instead provides the registrar with the discretion to make changes as and when "he or she thinks fit" (State Government of Victoria, 2014: 53). In addition, the current Subdivision (Registrar's Requirements) Regulations, which mandates the form and content of subdivision plans, does not explicitly reject the use of 3D models or 3D representations of the statutory information: Part 2, Section 7.1 states that "The Registrar may accept a plan for lodgement that is… (c) a plan in any other form approved by the Registrar" (State Government of Victoria, 2012: 3-4).

But within the professions associated with land administration, the tradition of 2D drawings is strong. Even though the plans are costing valuable time and money to produce, and despite their detail, are difficult for the community to understand and use, for the professions, 2D is culturally embedded in their training and work experiences, it is normatively legitimised by standards and conventions and in some instances, legally sanctioned. To change this 'mindset', mandatory measures are essential. Further, the land registration system within Victoria is celebrated and known for its success – the status that has been developed around this well-functioning system is one that stakeholders are likely unwilling to interfere with.

The intractability of cultural norms can be seen in the limited acceptance and understanding of the Owners Corporation Act, which was developed to better suit the needs of strata communities by expanding the definition of 'common property'. However, though these changes have the force of legislation behind them, the community's struggle to correlate (and therefore, understand) the new and old paradigms of common property and their associated rights, restrictions and responsibilities indicate how cultural norms can present as significant constraints. Finally, given the requirement of personal investment to support technological change, the attitudes of individuals could also be interpreted to be a constraint. Participants often associated this with the aging surveying profession in Victoria, and personal affinities (or lack thereof) with technology.

6.6 CHAPTER SUMMARY

The aim of this chapter was to present the findings from the case study on the City of Melbourne. In line with the research approach, it provided a description of both the shared and subjective realities of the various stakeholders who are part of urban high-rise land administration – from development stages leading up to registration, and subsequently, the management of high-rise buildings in terms of private and common properties.
This provided the backdrop for elucidating the key themes of the case study, which concentrates focus on the dominant aspects of the current institutional environment underpinning the production, management and use of the (2D) plan of subdivision. Key themes were: history and tradition of 2D, development versus management, somebody else is the problem and change opportunities.

Consideration of these key themes through the lens of institutional theory sensitised the interpretation of the themes as a range of regulatory, normative and cultural-cognitive constraints. This framed the themes in the context of the roles they play in reinforcing the continued and persistent use of 2D-based methods of representing land and property information, thereby impeding the take-up of 3D innovations.

However, the case study also revealed that in response to the overall pressures of development and general trends in producing 3D models as part of the architectural design process, there is now an emerging interest around leveraging 3D technologies for representing land and property information. This interest has translated into a range of formal and informal intiatives. In terms of the latter, for the land administration industry, this is currently perpetuated by leveraging the network of close interpersonal, working and organisational relationships amongst stakeholders. All this presents potential opportunities that can be leveraged to develop strategies to support change. This topic of strategic choices is explored in greater detail through the Singapore case study, which is presented in the following chapter.

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CHAPTER 7

STRATEGIES TO SUPPORT 3D INNOVATION: A CASE STUDY ON BIM ADOPTION AND IMPLEMENTATION IN SINGAPORE

First and foremost, I think the compulsory submission is one. Second, is [sic] all the carrots that's been given. Third, there is a backup system where there is training given by the government and there's also very good vendor support. It's a perfect storm of positive things.

(Consultant in Singapore)

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7.1 INTRODUCTION

This chapter presents the findings of the second case study in this research. In contrast to the first case study, the focus of this case study, which draws on the experiences of Singapore, was to develop a deeper understanding of the range of strategies used to support 3D innovation in urban land administration. A particular emphasis is on discovery of the institutional underpinnings of these strategies that make them particularly effective in producing a positive response to change.

The innovation in question here is Building Information Models (BIM). There are many versions of what BIM may be, but the essence is that BIM is a 3D, object-oriented, parametric, digital information model that stores and represents information acquired through all stages of a building's development (e.g. Eastman et al, 2011; National BIM Standard – United States, 2014). An increasing number of countries are now mandating the use of BIM to address the declining efficiency of traditional 2D-based methods of representing and coordinating building design information in complex structures in the development phase (Davis Langdon, 2012). The context of moving to BIM to support land development purposes can be considered an instance of 3D innovation in land administration since development is one of the key functions of land administration systems.

The mandatory push by the Singaporean government to use BIM for regulatory purposes in the development process of high-rise buildings provides context for understanding the devices through which 3D innovation is introduced and diffused to improve current 2D-based land administration practices. The land development industry, like many around the world involved with building and development, reflects a tradition of work and thought processes oriented around 2D practices (Eastman et al, 2011). Yet Singapore has been remarkably successful: it is nearing the end of its first five-year plan and already, BIM adoption rates are reported to be around 65 per cent (Ong, 2013).

What explains the country's successes in 3D innovation, particularly in overcoming the range of intractable social and cultural issues that have stymied similar efforts to evolve the 2D paradigm in other countries? This question motivates the research presented in this chapter, where the aim of the case study was to explore the strategies used to support change and perceptions around how and why these have proven successful.

Similar to the previous case study, the comments presented in this chapter are mostly verbatim quotes from interview data and are used to illustrate the perceptions of participants in their own words. Table 7.1 shows the representation of participants across the various sectors, and the citation codes used in the chapter to help readers identify the organisational or professional context for these quotes. The 'SG' in the codes indicates that these are participants from Singapore.

SECTOR	CITATION CODES
Architect	SG1, SG2, SG3, SG4
Consultant	SG5, SG6, SG7
Contractor	SG8, SG9
Government	SG10. SG11, SG12, SG13
Professional body	SG14
Surveyor	SG15

Table 7.1 Singapore case study interview participants and in-chapter citation codes.

The structure of the chapter is set out accordingly: first, the institutional environment is described before perspectives of the organisational field in the context of BIM adoption and diffusion is presented. Key themes that emerged from the interviews relevant to strategies used to support BIM adoption are presented and described, before the application of institutional theory is used to support the interpretation of why these themes represent successful strategic activities. Finally, the chapter concludes with a brief discussion and summary.

7.2 THE INSTITUTIONAL ENVIRONMENT

Similar to the Melbourne case study, land development as a key function of land administration, is also a highly regulated area that depends on a range of qualified professions in the production of building information.

There are several statutory organisations involved, with primary organisations being the:

- Urban Redevelopment Authority, who has responsibility for land use planning and conservation.
- Singapore Land Authority, who are the land registration authority for the country (which extends to managing and maintaining the national land survey system) as well as the statutory authority for state-owned property.
- Housing Development Board, who is responsible for land development for public housing, which is the dominant housing type in the country.
- Land Transport Authority, who is responsible for land development relevant to

transport infrastructure requirements.

However, since the organisational field here is defined by the issue of BIM use for compliance checking, the institutional environment narrows to be those directly involved with this process, therefore the Building and Construction Authority of Singapore (BCA) is a key stakeholder, as are developers, architects, engineers, construction companies and quantity surveyors. Due to the issues faced by stakeholders in negotiating the use of new technology, consultants are also considered to be part of the field. As the environment around 3D practices are relatively new, the institutional logic is considered to be in the process of being developed and established.

7.3 PERCEPTIONS OF THE ORGANISATIONAL FIELD: 2D TO 3D CHANGE EXPERIENCE

Within the organisational field, there exists a range of experiences of change in leveraging 3D technologies to support land administration processes – in this case regulatory compliance checking for land development.

A mandated approach to BIM adoption and implementation in Singapore necessarily indicates leadership in drawing together the range of stakeholders to support the development of processes that will continue to meet the needs of all in the face of changing technologies. The Building and Construction Authority (BCA) of Singapore occupies this role, which is the public sector organisation charged with leading the BIM initiative.

For BCA, their reality appears straightforward – momentum is gaining in getting the construction industry to shift towards this more efficient method of representing and managing building information; success is within reach, measured against the intentions set out in the country's first BIM roadmap. Singapore is fast approaching the end of its first five-year roadmap targeted at facilitating BIM adoption, with approximately 65 per cent of the industry showing that they now use BIM – the target set for 2015 was to convert 80 per cent of the industry to practices oriented around BIM.

Yet for the rest of the industry, the reality of change is that is a subjective experience, coloured by all the shades of certainty and uncertainty that is characteristic of a state of transition and negotiation. There is an observed variance in the status quo. The way in which stakeholders understand their obligations in the shift towards adopting BIM for regulatory processes has been, to a large extent, a constant negotiation between what they are used to, and what they are now expected to do. This section presents the experiences of the industry in moving towards a shared system of meaning and the implications this has had on stakeholders' experience of change.

7.3.1 The Reality of Leadership

The drive for change to implement the mandatory use of BIM models has filtered down from a national agenda to improve national productivity rates by leveraging information technology (IT) developments. This was articulated from as early as the 1990s through the IT2000 Master Plan, with the construction sector identified as one of the key sectors that would benefit. BCA led and delivered several initiatives to shift the construction industry from a paper-based industry to a completely electronic-based one. This change was predicated on a range of technical undertakings:

> "[There were] things we need to do, build up: network infrastructure, information infrastructure and e-submission process…get industry together to sign an MOU to collectively work on data format…want to organise ourselves in some structure and info layers" (SG11).

However, these changes were not just a technical exercise. Even after ensuring that the necessary infrastructure and technical architecture were in place, BCA was still faced with a difficult task: persuading the industry to shift from paper-based operations to an electronic environment. The evident difficulty is demonstrated in personal experiences such as the one illustrated below where resentment and frustration with these changes often spilled over into personal exchanges between government and industry.

> "When I first started this electronic submission from paper-based to electronic-based, it was a very difficult journey for us. When we were trying to get people to shift, both the industry and government agencies, for one whole year, I get (sic) scolding from both parties because people are reluctant to change. I still remember the first meeting with industry – before I even open my mouth – they already curse and swear at me: why do I force them to change. But once they move over the barrier, from paper to electronic, after one year of difficulty, now they will scold me if the system goes down. Nowadays they are very happy to send in electronic [documents] because there are a lot of cost savings" (SG11).

One of the strategies that the government used to speed up the transition was to switch entirely to electronic submissions after allowing for a period of transition:

> "Once we made the decision to move to electronic from paper-based, the government as a whole, made the decision not to retain two systems…because it will cost us more" (SG11).

Although it appeared that such a move was orchestrated as an economic strategy and was seen to be largely financially motivated, it also served to put the industry on notice that while organisations could change at their own pace, a full shift was expected by a certain date to facilitate maximum macro-economic benefits to the industry. It is also likely that due to the defined and truncated timeframe, many of the emotions associated with cultural change were experienced more intensely as people may have had to change at a pace quicker than that which they would have preferred, or are comfortable with.

The initiatives that were used successfully to support the change from a paper-based to an electronic operating environment are being employed once more in the move to support a shift from 2D-based practices to a BIM-oriented environment, particularly the use of regulatory initiatives to induce changes. However, there was recognition that driving change purely through the use of mandatory measures would likely result in public backlash and negative consequences:

> "The regulatory part, if I don't have the incentives, will make people very angry. It's intended that while I have the regulatory lever, I have to make sure that you are also very happy to comply. Otherwise I actually do not need the fund at all, I just have to regulate it and you still have to comply…it's to soften the blow" (SG11).

Recognising such potential pitfalls led to the establishment of a range of resource and incentive schemes by BCA to support the change process, which has been recognised as one of the most lucrative schemes provided to date by any government in the world (SG14).

7.3.2 The Realities for those Conforming to Change

> "The BIM journey has been rocky…on one hand it's been plagued with sales speech that BIM is like a utopia, a panacea… people don't realise it's not that easy – you have to follow certain steps to get the benefits" (SG6).

From the perspective of the stakeholders, the change experience in transitioning from 2D computer-aided drawing (CAD) systems to BIM has been varied. Mostly, this is due to the fact that the changes do not affect all stakeholders equally, and those who are most affected (and therefore, likely have the most to gain if they are successful in transitioning) are architects and engineers. Some disciplines were perceived to be finding the transition easier, due to their current method of producing and representing building information:

> "Yes… the structural ones [referring to engineering disciplines] are easier. When they put their model in SAP [structural analysis program], in a way, they are already doing it in BIM. Those [engineers] doing MEP [Mechanical, Electrical and Plumbing engineering discipline] oil and gas is (sic) already in BIM. Archi [architects] is having an issue but they are fast catching up – there are so many components – there may be a thousand components" (SG6).

The differing level in which BIM is being used has had consequences on the usability of the BIM model downstream (in terms of accuracy), and differing levels of commitment and acceptance of change amongst the stakeholders:

> "We use models for visualisation only. Model files take too long to load. We don't do a full model; we just do individual units, sections. For example, in a project with four levels of podiums and two towers, we just do BIM [BIM model] for podium and BIM for towers. Smaller files are easier to manage. We model individual units" (SG9).

There was also a clear perception that the current design-bid-build process in construction did not align well to the inherent collaboration principles of BIM, and this to some extent, determined how BIM was being used across the industry:

> "Most of the [construction] jobs in Australia are [based on] private-public-partnerships – everyone is gathered at [the] start. In Singapore the approach is design-bid-build – this affects how BIM is being rolled out" (SG4).

Participants also made a distinction between the experiences of larger organisations versus the smaller firms, where larger companies were perceived to be having an easier time transitioning to new ways of working. Some participants felt that such distinct experiences were likely to result in the emergence of "silos of standards and silos of information" (SG6), which would not be an ideal scenario. However, this was perceived by the organisational field to likely be inconsequential for the government in the short term, as long as targeted adoption rates were met (SG1).

For those for whom change is yet to be mandatory, some are adopting a pro-active approach, envisioning that current changes will inevitably change the market and create future expectations around BIM proficiency; therefore these participants are embarking on a change process motivated by the desire to remain competitive (SG9). There was also awareness that some professions (for example, quantity surveyors) felt threatened by BIM technology, which was construed as having the potential to make certain aspects of their professional roles redundant (SG1).

7.3.2.1 Different understandings of BIM

Within the organisational field, there was also awareness that there were currently very different understandings and interpretations of what BIM entailed. This has led to different behaviours, ultimately presenting a challenge to the fundamental benefit of BIM (which is improved productivity through better collaboration and coordination of information among stakeholders). These different conceptualisations were perceived to be the result of a variety of factors, including lack of education, misconceptions and being risk-averse. These were expressed across several interviews as shown in the transcriptions below.

> "Some at entry level don't even know what is BIM, what it's about, it's something so Greek to them. It's a lack of education, lack of understanding, then it's a lot of BIM-washing…you say, "Hey, I'm BIM ready", but you're not. It's very superficial. Even the level 100, they don't know how to design it properly, so much so that if this whole area is grass, and this is water, I should have grass minus water, but no – I will get two different layers overlaid. It's not modelled properly" (SG6);

> "There is a misconception about what BIM is… [Surveyors] thinking that total station is sufficient for capturing data. There is a perception that [the] role of [the] surveyor is only in data capture, collection" (SG15);

> "They [the big developers] are all reluctant and think, "Hey, what is this?" Some of them think BIM is a technology…luckily CAG [Changi Airport Group] thinks it's

> not a technology, it's a process – it's a process that can change my organisation, my organisational structure" (SG5);
>
> "Owners don't see BIM as an advantage" (SG2).

These varying levels of conceptualisations and understanding of what BIM represented also led to participants raising the issue of a continuum of accuracies being experienced, where models that were being produced for the purposes of submission were not feasible for other stakeholders to use downstream:

> "BCA BIM submission [is] at level two, three, can't use for construction; can have early visualization – the building end-product. It depends on where you stand: for owners, low details are enough, but not for contractors" (SG9).

The varying levels in quality of BIM models was also perceived to be motivated in part by assumptions that producing a model that exceeds current requirements was not beneficial, but also by concerns around liability for inaccurate information:

> "I think it's more about current practice because to do a proper BIM model, the effort from the architects and engineers are important. But these people are very reluctant to do it because they are not being compensated for the extra effort. Second thing is that after they finish, they also wonder why they should give the BIM model to the contractor? So if they want to give the BIM model, they should charge them – so these are the operational issues on the ground" (SG11);
>
> "If you ask me, I think the BCA approach is wrong. Shouldn't approach the consultant. Should push the client and contractor side. Now people are modelling for the sake of submission only" (SG4);
>
> "There's a lot of discovery… then people discover there are liabilities so they start taking things out of it [the BIM model] and now it's a skeletal thing" (SG6);
>
> "Quality of model coming through from consultants is an issue. Proper BIM will be much more productive than traditional CAD" (SG9).

In the long term, such issues have the potential to limit the benefits of BIM.

7.3.2.2 Adoption vs. implementation

The different levels of understanding what BIM is and does, as well as the differing levels of quality of BIM models emerging, are essentially resulting in more work for organisations as they continue to produce 2D CAD models and drawings, as well as producing BIM models for submission purposes. Many have flagged that the experience so far has been difficult, with the emotive statement below reflecting a common sentiment among participants.

> "The transition period is a nightmare, a lot of double handling" (SG4).

This also led the participants to question the veracity of claims that BIM adoption in Singapore had reached the current level as indicated by BCA (approximately 65 per cent of the industry is estimated to have adopted BIM). This was justified by the distinction made between adoption and implementation, which was broached by many of the participants. The participants defined their concept of adoption and implementation in a variety of ways but the commonality appears to be whether BIM is used to facilitate knowledge and decision-making over the entire development process:

> "Many are using BIM software, but whether it's truly implemented, e.g. only 20 per cent [use of BIM] over whole process" (SG7);

> "Although BCA says 60 per cent of companies have adopted BIM, what we see is 10 to 20 percent. 60 per cent of the projects are doing BIM, but adoption is not [just that]… where adoption is I can value add with BIM – 4D, 5D, 6D, 7D… all these reflect capabilities – very few organisations can do that, [that is] have fully adopted BIM [although they] can talk the 'right language'. True BIM adoption means the company is using the BIM model for everything" (SG5).

This distinction, whether consciously or intuitively made by participants, between adoption and implementation appeared to be partly driven by the way BIM has diffused in Singapore. However, it was also attributed to the existence of fundamental, culturally entrenched attitudes towards the use of 2D methods that meant that operating in a fully 3D environment (which would indicate full implementation) was not yet something that is expected – and therefore improper modeling was to some extent, an accepted outcome:

> "Everyone still uses 2D drawings – we have not really moved on to a virtual 3D world. And things are still not modelled properly. It's an accepted norm because of the situation we are in – but this may change in five or ten years" (SG6).

One of the participants also observed that the reality for the construction industry was that labour costs are relatively low (due to foreign labour) and so in many instances, for organisations, this meant that it would be easier (and cheaper) to physically rebuild than to negotiate the challenges and costs of moving towards using BIM models (SG4).

7.3.2.3 Costs of change

The participants perceived the costs of changing to BIM to be a significant ongoing investment. The first reason provided was with regards to the ongoing costs associated with using and maintaining the licenses associated with the software (SG2, SG3). Additionally, although there are several options with regards to BIM software, there is a clear dominance of the use of Revit in the industry, especially as it is also the software being used to teach BIM at the BCA Academy, which gives the software an implicit level of perceived preference and status (SG7).

The other reason was around skills – both the level of skill and the availability of it:

> "The modellers are always snatched by people. Skill shortage [is] everywhere – in the modelling, in management, because we are too fast" (SG6).

However, for those participants who were committed to implementing BIM throughout their organisation, it was clear that they perceived the costs of change to be par for course. Their philosophical position was that it would inevitably cost more in the long term if they did not start the shift now as it was looking highly likely that BIM would be the accepted way to do business in future:

> "BIM it's an investment to get projects to get business; ROI [return on investment] is later once your team is solid" (SG4);
>
> "It'll become the norm in the future" (SG9).

It was clear for organisations that their ability to flourish in the future would be predicated on their ability to move their operations to leverage BIM.

7.4 KEY THEMES: WHAT IS THE INSTITUTIONAL BASIS OF EFFECTIVE STRATEGIES?

The interviews, field notes, observations and secondary data sources were subjected to thematic analysis to support the emergence of four superordinate themes. These themes are organised around the key reasons perceived by the participants to underpin the success of strategies used to facilitate institutional changes required to support BIM adoption and use. Within each theme, a range of sub-themes illustrates different dimensions of the themes. These themes are presented in Table 7.2 and are described in greater detail in this section.

THEMES	SUB-THEMES
Government leadership	• Mandatory measures • Provision of resources to support change • Step-by-step approach to making changes
Creating legitimacy	• National agenda • Industry engagement
Organisational culture	• Right mindset • Champions
Environmental conditions	• Societal attributes • Existing conditions

Table 7.2 Key themes derived from the Singapore case study.

These themes describe various types of institutional pressure exerted on the organisational field to induce conformity to change. They reflect strategies that are multi-level and multi-direction (i.e. top-down, across and bottom-up) and work in various ways to bring about change, both practically and culturally, over the short and longer terms, to support the evolution of the land development industry towards a 3D-enabled environment. The key aspects of each theme are detailed through the use of sub-themes within each category.

Although in its early phase, success so far has been attributed to the cumulative effect of the various strands of activities – in the word of one of the participants, it appears to be a "perfect storm of positive things" (SG6). The effectiveness of the strategies appear to lie less with its form and more with its function: whether intentional or otherwise, most of the strategic choices around the types of activities used to support adoption and implementation of BIM all exerted some form of institutional pressure that induced conformity to change. Mostly, these appeared intentional given the range of strategies in place, but there were also other factors that were incidental, which also played a role in motivating change.

7.4.1 Theme 1: Government Leadership

The first major theme that emerged brought into focus the role of government leadership in effecting change. The theme was articulated through references to the dominant and instrumental role that BCA played in kick-starting the BIM journey. As such, the theme of government leadership reflects an explicit strategic response, interpreted as an unapologetic use of regulatory levers to force change where required. This was a universal theme that emerged although its success as a long-term strategy was regarded with mixed feelings. From the interviews, it appeared that its significance as a strategic choice was considered to relate to specific aspects, classed under the various sub-themes of mandatory measures, provision of resources to support change, and a step-by-step approach to making changes.

7.4.1.1 Mandatory measures

Many participants agreed that the mandated use of BIM models directed by BCA was mostly responsible for building the current momentum in BIM adoption and implementation. As a strategy, mandatory measures had been effective in igniting the innovation process and galvanising the industry to take the necessary steps to shift towards a BIM oriented environment. These perceptions were reflected in statements like the following:

> "If BCA hadn't stepped in, BIM may not take off " (SG9).

In addition to this catalysing effect, some participants' experiences of change led them to believe that mandatory measures could also be used as a potential strategy to support change in other ways, such as coordinating the diversity of stakeholders that are affected by the move to use BIM:

> "Regulation should be about coordinating stakeholders because there is such a diversity of requirements" (SG15).

This reflects to some extent, an inherent cultural notion around what is expected of government and a perception among the public that some tasks fell clearly within the remit of government and not industry, which perhaps supports the justification by participants that such a strategic manoeuvre lay with the government.

However, there were also some unintended consequences to these measures, impacting the manner in which organisations acquiesced to the mandatory changes, and ultimately, affected the way in which the new technology was being diffused. Participants considered a push from the government as being a limited solution: organisations were making changes insofar as to meet the government's requirements, which did not require a full implementation of BIM to support the whole lifecycle of the building. Therefore, the maximum benefits that could be derived from using BIM technology were not being delivered to organisations and change was perceived to be, in a way, fairly superficial:

> "For Singapore, because of BCA push [there is BIM adoption and implementation], but not everyone is implementing 100 percent, so we are not really getting the benefit… versus Australia, push coming from client and contractor" (SG4).

This suggests that while mandatory measures were an effective short-term strategy to build momentum for change, it may not necessarily be a sufficiently strong incentive for motivating organisations to make the necessary changes at a deeper, more sustained level to realise longer-term benefits.

7.4.1.2 Provision of resources to support change

Perhaps of equal significance to a strategy of regulating change has been the government's concerted effort to provide a range of incentives and inducements to encourage change.

Participants agreed that the abundant resources provided by the government were useful in facilitating change. These resources were in the form of financial support, an array of training and up-skilling programs provided through the BCA Academy as well as developing appropriate curriculum through tertiary institutions, and resources such as guidelines and templates. It was evident that these resources have helped to accelerate change:

> "BCA incentives gives us a bit of help, without it would be slower" (SG4).

From the government's perspective, providing these incentives were not considered to be an obligation on their part, but there was a recognition that pursuing such a strategy provided benefits, mainly in minimising the risk of backlash from the public, which could be politically damaging.

While the government might accept that provision of resources is a necessary accompanying strategy to mandatory measures (the proverbial 'stick and carrot' approach), the level of resources provided in Singapore – particularly financial resources – is unmatched by other BIM adoption programs around the world. However, from the perspective of the participants, there was wry acknowledgement that such significant levels of resourcing were fairly common for Singapore and in this sense, they felt that the strategy was successful because it was based on an awareness of what the industry would best respond to:

> "Singapore is very unique: we need incentives for things to move. Our industry players are very spoilt" (SG1).

However, through the interviews, it also emerged that BIM adoption required significant investment on the part of organisations, for example:

> "We have 35 people and have spent more than $100,000 since 2011 [on 28 Revit licences and subscriptions]. It is like the mafia – you keep paying and paying" (SG2).

Investments on such a scale would simply be beyond the reach of smaller firms and therefore, it is likely that the larger firms would have found the move towards BIM more easily attainable simply from a resourcing point of view. This could also be why the government chose to phase in larger buildings first.

Access and opportunity was also facilitated through the development of a range of training and professional development courses:

> "…It's [the resources, guidelines] successful, the take-up rate is there… the education is part-funded, so people do go for it. It's successful in a way" (SG6).

Over the last few years, Singaporean universities and polytechnics have been developing curriculum around BIM use and modelling. BCA also established the Centre for Construction IT in 2010 to support training and development specific to BIM. While undeniably a good strategy aimed at supporting long-term capacity building within the industry, participants flagged that simply undertaking training in BIM did not ensure the proper use of BIM within the industry. Most reported that it was hard to find people who could demonstrate skills that were a product of good technical experience as well as real-world experience in construction

(SG4). In light of this, it was almost better if they had no prior experience with CAD (SG2). Additionally, due to the partial funding of training, many were inclined to take-up training, but could not apply this new knowledge in a sustained manner resulting in the new knowledge being unsustained and inevitably, lost (SG15).

7.4.1.3 Step-by-step approach to making changes

This sub-theme mainly emerged from interviews with executive-level consultants, who tended to have a more macro-level understanding of the changes that were happening and were able to articulate the importance of BCA's roadmap in driving change:

> "It's the small things that are driving BIM adoption. BCA is doing a step-by-step operation. You can't push it all at once. There is a roadmap. They know it's difficult to push. That is working well in Singapore" (SG5).

BCA's simple four-step roadmap has been widely published and communicated to industry through various formats since 2010. Its role as a strategic document was further enhanced through endorsement by an international panel of experts invited by the Singapore government. However this theme could also be interpreted to refer to the incremental steps taken to roll out the requirements for mandatory BIM e-submission, where large applications (defined in terms of gross floor area) were first targeted, leading up to all submissions with a gross floor area of 5 000 square metres by 2014.

7.4.2 Theme 2: Creating Legitimacy

The second theme developed around the various initiatives perceived to create legitimacy around the move towards a 3D paradigm. In terms of the external environment, the platform for change was strongly linked to a broader national productivity agenda. At an industry level, support for change was garnered through a significant push to engage industry players to help develop guidelines for change. Both sub-themes reflect activities that have encouraged and cultivated industry perceptions of BIM adoption and use as desirable and appropriate.

7.4.2.1 National agenda

Singapore's lack of natural resources and small population base has meant that since its independence in the 1960s, its government has been careful to plan and direct the economic development of the country through a pro-technology approach that favoured knowledge and skill-based industries rather than labour-intensive industries (Economic Development Board, 2012). The move to implement BIM for the construction industry is linked to a national productivity agenda that has existed since the 1990s, which specifically identified the construction industry as one of the country's key sectors that could contribute to improving economic development by leveraging information technology (IT) to increase productivity (Fu, 2012).

Part of the success of the strategy to support change management is also likely highly correlated to the fact that the current architect behind the BIM initiative is the same person who directed the last major IT change in the construction industry and who arguably, has developed a keen understanding of what motivates the industry and how best to coerce and incentivise change.

7.4.2.2 Industry Engagement

For many of the participants, there was a strong perception that the government consciously adopted a strong industry engagement strategy since this served a dual purpose of casting changes as being supported by industry, but could also be used to provide additional peer pressure on organisations:

> "Although it's BCA led, they say it's supported by the private sector. They have committees that's made up of private sector and they'll say, "Your colleagues have said that…" (SG6).

Engaging industry to provide guidance and relevant direction to support change has been an explicit part of the set of strategies that constitutes BCA's BIM roadmap. Specifically, this has included the development of BIM requirement guidelines, which has been led by the Real Estate Developers' Association of Singapore and major government procurement entities; e-submission guidelines and templates, the development of which has been led by all government regulatory agencies, and the development of project collaborations and object library standards by buildingSmart Singapore (Build Smart, 2011). This is a potent source of both legitimacy and pressure.

It was also observed that significant effort has been made to highlight BIM leaders within the industry, and communicating industry sentiments for implementing BIM within organisations. BCA has produced a BIM-specific industry magazine to provide a platform for showcasing industry leaders and current BIM-based practices. This served to create perceptions of stature, where notions of desirability could be interpreted from the use of terms such as "BIM leaders"

(SG2). However, the value of this publication also potentially lies in its cultivation of a sense of community within an industry made up of a diverse range of stakeholders and to foster the acceptance of new norms and a new BIM-based culture of operation.

7.4.3 Theme 3: Organisational Culture

This sub-theme describes the perceptions those organisations that considered themselves to be successful in responding to the BIM initiative and implementing change were consistent in attributing their success to the presence of organisational leadership.

In addition, there was broad recognition across the participants that given the nature of changes to move from 2D ways of working to a BIM-based approach, organisations that tended to be more successful in their adoption and use of BIM often demonstrated an appropriate attitude and approach to change.

7.4.3.1 Champions

It was evident from the interviews that the presence of champions within organisations was critical to facilitating BIM adoption as they helped to develop their organisation's approach to change and support for the investment in appropriate activities in the transition period:

> "Important that management pushed BIM – push training, also conduct in-house training, hands-on experience… [You need] support from top management…need a key person – like a captain in an army "(SG2, 3).

Some participants were more specific regarding how an organisational champion could influence the rollout of BIM within their organisation as they played a key role in connecting organisational strategy with operational capabilities:

> "To be frank, yes – only then will it work. We've seen this in Ascendus, in CapitaLand…the thing is, it depends on the capability of this person to influence his top management and influence his bottom people. That also defines how the BIM is working" (SG5).

Organisational champions fulfilled the role of a leader personified, providing direction and leadership that people within the organisation could look up to. From the interviews, it was also apparent that champions were required to be at a sufficiently senior position within the organisation to direct resources to change strategies as well.

7.4.3.2. Right mindset

Some participants were also convinced that approaching change with the right attitude was more important than securing the technical aspects such as skill development:

> "I don't think skill is a big problem, the only thing is whether you want to do it or not…whether I want to take a step or not" (SG5).

Given that the move from 2D to BIM was a significant change, the ability to successfully adopt and use BIM was contingent on organisations on both acknowledging, and committing fully, to what was inherently a paradigm shift that necessitated a "BIM mindset":

> "The first is that the culture of the people that they have is there – they have the right BIM mindset, they know how to use it, they are not sceptical, they have the responsibility to design and model properly and populate the right information" (SG6).

One of the participants suggested that one of the main barriers to the adoption and use of BIM lies with 'cultural baggage' that stems from operational traditions aligned with 2D-based practices and thinking:

> "Mindset is the common challenge e.g. always comparing to CAD, to fully adopt BIM, it is easier to not have any experience" (SG2, SG3).

7.4.4 Theme 4: Environmental Conditions

This final sub-theme reflects the perception among participants that the BIM initiative in Singapore has both benefited and been discouraged by existing conditions, both social and technical.

7.4.4.1 Societal attributes

Participants suggested that a culture of subservience and acquiescence to government policies has worked in favour of BIM adoption; additionally, the small size of Singapore is seen to lend itself well to change management:

> "Yes, we are small, easy to manage. We are in a conformist society so we don't question" (SG6);

> "…If government mandates, people will adopt; otherwise will look to cut corners" (SG15).

However the BIM initiative was also likely to have been timely, building on international and industry momentum around BIM use such that the industry was already experiencing a growing trend in requests for BIM by the private sector:

> "BCA was a push but almost every client is asking for BIM; contractors [are] also asking for BIM" (SG4).

Comments from participants reflected awareness that change was afoot and that they needed to look at how their businesses should change in response; whether this was mandated by the government was less relevant to them:

> "We are preparing ourselves for the future when people tender in BIM…to remain competitive, you must be in line with the market" (SG9).

Conversely, there remains a level of conservatism and concerns that BIM could ultimate supplant professional roles, therefore threatening job security. This was evident in third-party comments communicated by some of the participants such as the following:

> "BIM isn't seen to be within the scope of surveyors…[instead there is] a 'wait-and-see' approach amongst surveyors as the market for BIM is not developed" (SG15).

> "Quantity surveyors don't want BIM as they are worried [that] they'll lose their job" (SG1).

7.4.4.2 Existing conditions

There was recognition that the BIM initiative has benefited from existing conditions brought about by previous IT initiatives that established the necessary legal and technical infrastructure for BIM:

> "…Lucky we are already on the high-tech wave …fortunate in a sense that we had already moved to an electronic environment. That helps a lot" (SG11).

Specifically, the CORENET initiative to realise a fully electronic environment was singled out as a key environmental condition that was beneficial for the BIM movement (SG6).

7.5 INTERPRETATION OF KEY THEMES

Institutional theory is applied as an analytical framework to support the interpretation of the basis for the success of various strategies in institutional terms. In particular, the notion of institutional pressure on organisations provides an appropriate way to interpret the success of the range of strategic initiatives in stimulating change, leading to successful adoption and use of BIM within the land development industry.

Institutional pressures can manifest as coercive, mimetic or normative pressure, with the aim being to drive organisational conformity. In this instance, although BIM adoption and implementation is still in the early stages, it is likely that the purpose of this pressure is to effect a change within organisations so as to orchestrate a shift from current 2D-based practices towards a BIM-oriented approach. An overview of what constitutes these pressures for each of the key themes is presented in Table 7.3.

These pressures ultimately rely on regulative, normative and cultural-cognitive institutional elements to provide mechanisms through which pressure can be exerted. These elements also facilitate the development of new notions around what constitutes legitimate behaviour in the land development industry as to information practices, processes and products, i.e. the establishment of new rationalised 'myths' that legitimises a 3D paradigm.

THEMES AND SUB-THEMES	COERCIVE PRESSURE	NORMATIVE PRESSURE	MIMETIC PRESSURE
GOVERNMENT LEADERSHIP • Mandatory measures • Resources • Step-by-step approach	Strategies leverage existing dependent relationships for power to force organisations to conform to changes. The range of resources offered disguised the force of coercive pressure.	Phasing in BIM e-submission requirements from larger to smaller developments – likely to firstly affect larger organisations with status. Development of training and curriculum.	Provision of guidelines and templates. Production of 'Build Smart' magazine. Financial resources help reduce perceived risk of change.
CREATING LEGITIMACY • National agenda • Industry engagement	Competitive pressure where BIM is seen to be the future of the market	Engage industry in the development of guidelines. Create expectations around BIM use through showcasing various organisations. Emergence of BIM-specific organisational designations helps create expectations regarding BIM-related skills. Increasing demand for BIM models from clients.	Featuring industry 'leaders' and range of organisational practices helps other organisations gain insight into potential structures for their own organisations.
ORGANISATIONAL CULTURE • Right mindset • Champions		Organisational champions provide leadership and establish expectations around change.	Respond well to mimetic pressure
ENVIRONMENTAL CONDITIONS • Societal attributes • Existing conditions	Respond well to coercive pressure. Respond well to incentives.		

Table 7.3 Interpretation of key themes in the Singapore case study as sources of pressure to align with change.

7.5.1 Coercive Pressure as Strategy

Strategies that rely on coercive pressure for success leverages the existence of dependent relationships (DiMaggio and Powell, 1983). In this case study, the introduction of the mandatory use of BIM models for compliance checking in the construction industry had significant power because it was a regulation that was legally sanctioned and administered by an organisation in a position of power within the industry – those who wanted their designs approved had to comply with the new BIM-based prescriptions.

The government consciously developed a strategy that tapped into the dependent relationship that organisations in the construction industry have with statutory authorities – in this instance, it was the architects and the engineers that were first targeted. In turn, these professions are likely to be in dependent relationships with other organisations, thereby generating momentum that would support the diffusion of BIM-oriented changes throughout the industry.

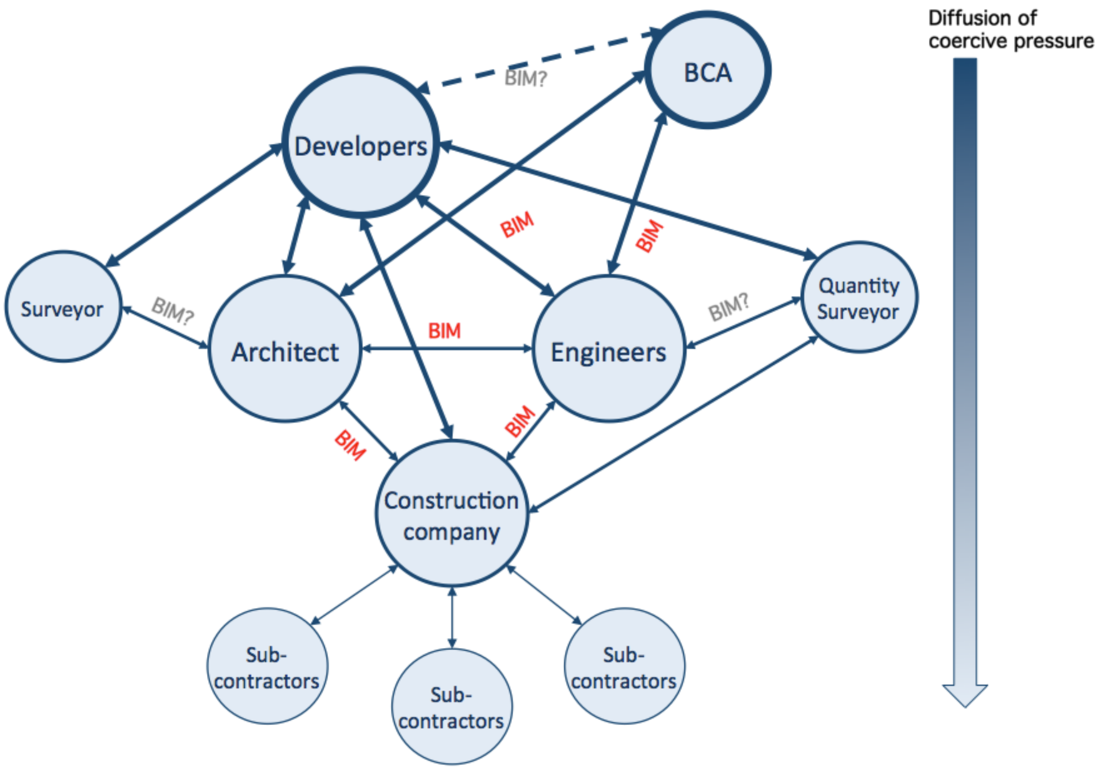

Figure 7.1 Dependent relationships that emerged in the case study.

The range of dependent relationships that emerged in the case study is shown in Figure 7.1. Although unlikely to be exhaustive, the figure serves to illustrate how these current relationships have been leveraged to support the use of BIM, where stakeholders depicted in circles with a thicker outline are in a position of power over those with a thinner outline. In relationships that are more equitable, such as those between the architect, the engineers and the construction company, the mandated use of BIM for architects and engineers has also resulted in an increasing use of BIM by construction companies, although they are not required to do so. Using a similar rationale, it is possible that stakeholders in a similar position – such as surveyors and quantity surveyors – could also move towards using BIM. Over a long-term period, the hierarchy of dependency would direct the flow of coercive pressure towards other stakeholders.

At present, a strategy of change built around a regulatory mechanism has proven to be a successful strategy for the government, to the extent that it is one that will surely be used again to catalyse further changes. This is supported by comments from both the government and across industry:

> "Submission requirements only affect architects and engineers to date, under our regulations… how can I bring on board the contractors now that are not regulated? There are many approaches that can use, we have some other levers like construction productivity score… also planning to impose a requirement for a contractor to deliver an as-built BIM model as part of the requirement – I'm thinking about that, I haven't decided yet" (SG11);

> "Half of the [construction] projects are public, I believe the tender will be in BIM from government. It can be mandatory for public projects otherwise defeats the potential" (SG9).

However, strategies using coercive pressure can have unintended consequences that may run counter to the original intention of the strategy:

> "If you ask me, I think the BCA approach is wrong. Shouldn't approach the consultant. Should push the client and contractor side. Now people are modelling for the sake of submission only" (SG4).

Making explicit the specific condition of compliance can encourage organisational responses that are superficial in nature, resulting in partial conformity to institutional pressures. In the Singapore case study, this is evident in comments reflecting a reality where some organisations are complying with changes only to the letter and not necessarily making changes that would support adoption and use of BIM throughout the organisation.

Coercive pressure can also be seen in the guise of competitive pressure, where some organisations who have not been required to change, are already moving to adopt BIM as they consider it to be vital to the ability of the organisation to compete.

The investment in software can construed as exerting a coercive pressure that encourages its sustained use especially since it appears that once firms have committed to the software, they feel like they have little choice but to maintain the investment, regardless of the costs. The use of a term like "mafia" suggests that participants felt a sense of being held ransom to the software and there was little choice in making any changes.

7.5.2 Normative Pressure as Strategy

In addition to adopting strategies that exert coercive pressure, the case study provides a range of examples of strategies that encourage people within organisations to change through exerting normative pressure.

The strategy to engage industry – both from private and public sectors – extensively to provide overarching guidance in the development of industry guidelines can be interpreted to be a source of normative pressure since the guidelines effectively encourage certain behaviour. Industry engagement as a strategy was also likely to be successful as it heightened the pressure on organisations to conform to new practices developed by industry-based groups, as indicated by comments in the interviews. Recommendations regarding BIM-relevant practices and operating procedures contribute to the further legitimisation of a BIM-oriented environment by creating expectations around such practices.

The nature of how the government phased in the BIM e-submission requirements can also be perceived to be a mechanism that had the effect of building up normative pressure. The targeting of the larger developments first (with a gross floor area of 20000 square metres) is likely to affect larger, more established organisations, likely to have more resources to accede to the required changes. However, these organisations, which are likely to have greater status within the industry, and positive experiences from these organisations could exert subtle but clear pressure on other organisations to follow suit.

Throughout the interviews, it was also observed that the industry appeared to be developing jobs and roles that are specific to BIM, evident through professional designations such as 'Director of BIM', 'BIM Rep' and 'BIM Manager'. What these roles suggest as well is the development of an expectation in the industry of a certain suite of skills required to support BIM use within organisations, and BCA has responded to this by developing professional accreditation along with a specialist training courses.

Therefore, the development of new curriculum around BIM at tertiary institutions is also likely to be another source of normative isomorphism, although often more positively framed as capacity building. However, ultimately, the aim is to encourage conformity to standards and practices and this is often reinforced and proliferated through educational and professional training.

The dominance of Revit as a software package can also be a source of normative pressure and an example of a 'rationalised myth'. The use of Revit in education and industry gives it status and legitimacy even though some participants do not consider it to be the most effective platform. Here we see an instance of an innovation taking hold due to social influence rather than rational motivations.

The presence of organisational champions has also been highlighted as being critical to successful, organisational-level, strategies to support change. These champions provide leadership and establish specific examples within organisations as to how individuals should be responding to change.

These specific strategies are also being facilitated by an increasing demand for BIM models from clients: BIM is becoming a new norm and this is driving expectations around what organisations should be able to do, suggesting that a new 'rational myth' is in the process of being developed.

7.5.3 Mimetic Pressure as Strategy

In the Singapore case study, the sources of mimetic pressure are not as evident as explicit strategies. However, aspects of various strategies can be interpreted as providing sources of such pressure on organisations. For example, in this period of transition, the provision of guidelines and templates that have been developed by industry provide an example of legitimate behaviour to organisations that are unsure of how to behave.

The production of the *Build Smart* magazine, which often profiles practice leaders and asks them to describe success factors, provides a similar type of information that is published for other organisations within the construction industry to learn from. Figure 7.2 provides some examples of these profiles from a range of *Build Smart* issues.

Figure 7.2 Examples of industry profiles in the Build Smart professional magazine (Build Smart, 2011: 15; 2012: 11; 2013: 6).

The provision of financial resources and incentives also acts to decrease the risk associated with change. Provision of funding by the Singapore government as a strategy, could therefore be construed to be successful simply because it made the change to BIM more viable for a larger number of firms in the industry. However, a potential adverse outcome of this has been instances where the training has not translated to sustained knowledge through lack of practical experience.

The different levels of understanding in terms of what BIM is imply the presence of mimetic pressure to bring about change. Mimicry may only deliver superficial organisational responses, particularly in the early stages of change where there is much to be gained in terms of legitimacy, from appearing to be aligned with institutional changes. Further evidence of this is in the perceived skill shortages related to BIM-experienced personnel and the emergence of terms such as “BIM leaders” in the industry.

What these initiatives achieve is similar to a strategy that may be developed to intentionally exert mimetic pressure, i.e. these resources help organisations understand what might be viable ways to structure their operations using more successful organisations as examples.

7.5.4 Exerting Institutional Pressure

The purpose of exerting institutional pressure is to bring about conformity, evidence of which is seen in the rate and degree of homogeneity in organisational structures within a certain institutional environment (DiMaggio and Powell, 1983). There is certainly evidence of this occurring in this case study.

In Singapore, there is clear institutional pressure being exerted in all three forms. Coercive pressure has as its broad basis, a political and social mandate to improve productivity levels in the country. More specific to BIM, coercive pressure is being exerted through changes to regulatory requirements which now mandate BIM models for certain types of developments. This is possible because of the dependency of the sector on the government for regulatory approval of plans – there are no other alternatives.
In many ways, the government is not being explicit in telling organisations to change their structure or business models – but this must necessarily occur in the face of such a disruptive shift in the industry. There is uncertainty as to how to behave within the industry, and the ongoing process of trying to define a new way of working drives mimetic pressure where successful organisations provide the leading template. This is actively encouraged by the government through its frequent profiling of successful firms, projects and individuals, but also in the diversity of resources being made available such as templates and guidelines which provide a legitimate mode of operation. That mimetic pressure is surely being felt is evident in the difficulty in retaining staff with BIM experience and training.

Finally, given the highly professionalised nature of the industry, e.g. architects and engineers, is being reinforced through the aim to develop BIM qualifications, and the high level of industry engagement into the change process are also signs that the industry itself is highly susceptible to normative pressures. This is being cultivated, but also actively fostered by the government, industry and academia through their combined efforts to develop education and training material for both the short and long term, and targeting multiple levels of personnel within the industry.

7.6 CHAPTER SUMMARY

The aim of this chapter was to present the findings from the case study on the Republic of Singapore on the context of BIM adoption and diffusion in the construction industry. This chapter described how a shared system of meaning has been evolving, shaped by the actions of BCA, the government agency spearheading this change. The four key superordinate themes that emerged from the interviews identified strategies perceived to be successful in facilitating the changes required for BIM adoption and use were then presented: government leadership, creating legitimacy, organisational culture and environmental conditions.

The success of the strategies were interpreted to lie in their ability to exert a range of coercive, normative and mimetic pressure that served to create expectations around the use of BIM and motivate organisations to conform to new BIM-oriented ways of thinking and behaviour through compelling or incentivising compliance with new practices. However, the success of these strategies was also perceived to partly be a product of existing environmental conditions considered to create some level of predisposition to change. The outcomes of this case study, and of the one before, are brought together for the purposes of cross-case analysis and synthesis in the following chapter.

CHAPTER 8

TOWARDS 3D-ENABLED URBAN LAND ADMINISTRATION: A FRAMEWORK FOR CHANGE

A strongly progressive surveying and mapping industry depends on a shared understanding of the industry as it exists, some shared vision or imagination of what it might become, and some shared action plan capable of bringing about a realization of that vision.

Cook, 1999

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8.1 INTRODUCTION

There is increasing recognition that complex 3D land and property rights, restrictions and responsibilities (RRRs) common in urban environments are being inadequately recorded and registered in a variety of ways throughout the world. This has spurred international efforts to leverage 3D technologies to enable land administration practices. These efforts have been focused on technological aspects and a clear gap in the current body of knowledge has emerged: a lack of understanding pertaining to institutional aspects around such a change.

The overarching aim of this thesis has therefore been to provide a better understanding of the institutional environment underpinning urban land administration to develop knowledge that addresses the research gap. Through the use of a case study on the City of Melbourne, which focused on the key land administration function of tenure, the research revealed those institutional factors that are constraining efforts to innovate. Subsequently, in a bid to understand how to respond to such constraints, a secondary case study on Singapore, which focused on the key land administration function of land development, provided insight into how and why certain strategies are particularly useful in addressing institutional barriers, thereby stimulating a positive response to innovation.

Cross-case analysis of the findings supports and develops the relationship between institutional constraints and those strategies best placed to respond to them. This analysis was synthesised and used to develop the basis of four main principles that are recommended for supporting strategic choices in the design and development of activities to support change – a framework for change. This framework was then applied to the City of Melbourne to demonstrate how it could be used to develop an industry roadmap that could potentially support the shift towards 3D-enabled urban land administration in Victoria.

This chapter firstly presents the key lessons derived from each individual case study, before providing a discussion on the cross-case analysis and synthesis. The framework for change is then presented followed by a contextual application of its principles.

8.2 INSTITUTIONS AS CONSTRAINTS: OVERVIEW AND DISCUSSION OF KEY THEMES

One of the key objectives of this research was to develop a deeper understanding and appreciation for how the current institutional environment underpinning land administration may actually be constraining efforts to leverage 3D innovations in the technical environment. The City of Melbourne (CoM) case study revealed these constraints to be reflected in three of the four key themes: history and tradition of 2D; development versus management; and somebody else is the problem.

8.2.1 Overview of Key Themes

The first theme, **history and tradition of 2D**, references the longstanding use of 2D methods. This is firmly embedded as part of the organisational field's institutional logic, evidenced in a 'taken-for-granted' attitude around such methods by participants and strong expectations regarding its use. In many ways, it is the epitome of the 'rationalised myth' except in this case; it literally is perceived to a proficient method in facilitating the majority of subdivisions in the state since these are dominated by land subdivisions.

The second theme, **development versus management**, reflects the current perceived boundaries of the organisational field. The production of subdivision plans is perceived to be primarily for the purposes of registration, implying that this is the issue that defines the relevancy of the organisations within the organisational field and its boundary. However, in higher density developments like high-rise buildings, subdivision processes produce multiple common properties that are invoking the engagement of strata managers. Recent legislation regarding owners corporations is considered to constitute evidence of the burgeoning legitimisation of this industry. However, this has only provided limited influence in terms of shifting the primary issue of the organisational field and its boundaries, to include those organisations involved in high-rise management. The ongoing distinction between the development and management process indicates the presence of 'silos' of practice, which forces the community to use information that is not ideal to facilitate ongoing management of high-rise buildings.

The third relevant theme, **somebody else is the problem**, reflects two main issues. Firstly, the legislated dependency of organisations (within the field) on the land registry leads them to believe that change must originate from the land registry for it to be considered legitimate. Secondly, the boundary of the current organisational field essentially leaves those outside of the field blaming those within it for issues regarding lack of comprehensibility and usability of subdivision information. This essentially, reflects a sense of powerlessness from those external to the organisational field, and therefore a perception that change must come from within the field.

These themes were interpreted as constraints since they appear to be constituted by regulative, normative and cultural-cognitive elements that exert a range of institutional pressure; this has led to current established 2D practices as the legitimate way for the organisational field to structure its practices. This in turn perpetuates their dominance.

8.2.2 Discussion: Institutional Constraints

Primarily, as discussed previously in chapter six, the current institutional environment is a product of regulations, practices and processes established to support the needs of a period in time where development, particularly multi-storey development, was far simpler. While this environment, encompassing practices, processes, mindset and attitudes are still appropriate for subdivision situations that continue in this trend, CoM, with its inherently far greater complexity, exposes the limitations of persisting with this approach. Yet the dominance of the current environment cannot be underestimated, especially when it is perceived to still be working well, and that practically, change could very well be limited to the boundaries of CoM and perhaps those municipalities that exhibit similar trends in development.

8.2.2.1 Structural constraints

The emerging tension between a process that works for most (land) subdivisions and is simultaneously also a process that is increasingly being challenged by complex high-rise building subdivisions goes to the heart of the issue. What confronts stakeholders is how to negotiate a balance that preserves an industry structure that is working well, with changes to safeguard those developments and associated RRRs. Yet these developments impose a substantial economic and social footprint; that this is occurring within the boundaries of the city centre, the key economic driver of the state and the country, gives additional pause for concern. These structural issues reflect the limits of current shared systems of meaning and institutional logic.

The perceived limited ability to move – either to reject or embrace 3D technologies outright – can be seen to arise from the regulated aspects of property RRRs, which stimulates the professional orientation of surveyors towards regulatory elements for sense-making purposes. This is clearly evident from the weight given to regulatory elements, and subsequently, presenting these elements as a constraint during the course of the case study. Yet a closer look at the wording of current regulations suggest no explicit rejection of 3D methods, but terms such as ‘plans’ and ‘documents’ formalised within the legislative framework are likely to have been potentially taken-for-granted to denote that only 2D documents are acceptable.

The current regulatory framework has also established a divided approach to planning, development, use and management of the built environment. The emergent 'silos' of practice and consequent information and attitudes do not lend themselves well to moving towards the more holistic, collaborative approach that the development and management of high-rise buildings have been shown to demand, and that 3D technologies can facilitate.

Finally, many participants identify the land registry with a change leadership role in the take up of new technologies and systems concerning land and property information. However it appears that the registry remains constrained by its highly institutionalised statutory framework and historical legacies, reflected in their institutional view of boundary formation and identification.

8.2.2.2 Sense-making and cultural constraints

There needs to be greater recognition of the semiotic aspects to the role of legislation. From an institutional perspective, language and associated meaning is a primary way of developing the institutional logic for an organisational field. In this case, we clearly see how perceived meaning derived from traditional and practical interpretations of terms can be so indelibly imprinted on the organisational, professional and industry psyche that it effectively restricts the conception of new 3D-based interpretations.

The entrenched use of the concept of the land 'parcel' as the basic unit of organising land and property information also appears to offer limited value to those involved in the management of use and occupation of high-rise properties, stimulating their take-up of other sources of information. Subdivision plans may be an authoritative source of land and property information, but they offer limited utility to the large community of users who are interested in the ongoing management of high-rise buildings. The continued use of the term 'land' to broadly refer to all land and buildings within the legislation should perhaps be considered a hallmark of the past. A question hangs over the appropriateness of retaining such an all-encompassing term, which is conflating expectations, skills, roles and functions of land administration.

Finally, it became evident through the course of the interviews that current 2D-based practices and processes are fairly entrenched and taken-for-granted, providing the basis for assumptions around the mandatory and normative use of 2D practices. This provides a level of resistance to change that is compounded by the limited number of surveying firms that are engaged with complex high-rise developments as seen in CoM, as well as the greying profile of the surveying industry.

8.2.2.3 Multi-stakeholder environment constraints

The land administration industry is in effect, a networked environment of multiple stakeholders – land registry, local government, surveyors and strata managers. Through investigating their experiences in CoM, and through understanding their subjective realities in terms of interacting with the 2D plan of subdivision, it became evident that the plan of subdivision was not just a plan, i.e. its role extended beyond that of an absolute physical artefact. The plan of subdivision actually plays a crucial role in supporting notions of professional and organisational legitimacy in different ways amongst the network of stakeholders and sometimes, in a conflicting manner.

For example, the 2D plan offers the local council a way to engage with the community, but this was becoming increasingly limited due to inconsistent representation of information about RRRs and encoding information that was not at the right scale for managing the built environment.

For the land registry, the 2D plan was acknowledged to be problematic due to the inconsistent quality of plans, with current practices being challenged by the need to administer new ownership situations such as car park stackers. Yet the 2D plan was considered an efficient format for the purposes of plan examination, a vital step towards registration of strata titles, and therefore supported the registry's ability to operate within statutory timelines. Often, through the course of the research, the land registry was emphatic that registration of 3D property RRRs was successful *at the moment* – with the insinuation being, is there a need for change?

For strata managers, the 2D plan presents an ongoing source of frustration with information considered to be inconsistent, ambiguous and limited in its reflection of the *Owners Corporation Act 2006*. Yet for all its shortcomings, the 2D plan is unanimously considered as the profession's "bible" and a good understanding of the plan is closely associated with professional capability.

These sentiments are expressed in Figure 8.1 using some of the terms and phrases captured within the interviews. The figure shows how these notions of legitimacy can be simultaneously aligned with the experiences of others, yet also exist in direct contrast. This makes negotiating a change path that is amenable and acceptable to all stakeholders highly challenging. Any path that fails to take into consideration these varying and disparate notions (multi-value) is unlikely to gain purchase.

Figure 8.1 How the plan of subdivision supports professional and organisational legitimacy across various stakeholders in the City of Melbourne.

Additionally, statistics identify an increasing number of public stakeholders, who have been relatively silent (or perhaps, voiceless) parties in this issue. For example complex high-rise subdivisions currently account for approximately five per cent of all plans, which appears insignificant. However, statistics based on lots per plan provide a different perspective: this five per cent of all plans accounts for approximately 26 per cent of all lots examined and registered at land registry in 2012-13 (VicMap Property, 2013). In plainer terms, a quarter of all apartment owners are now potentially interested in management of information about complex buildings. Moreover interview comments suggest a wider audience, with land registry noting that 15 to 20 per cent of all queries relate to subdivisions. Yet the needs of this increasingly prominent stakeholder do not appear to factor in the current institutional environment.

Presently, even though at a state level many of the public sector organisations relevant to planning and development have come under the same department, the existence of separate legislative acts continues to reinforce and justify the continued existence of administrative boundaries. Such a divided environment has led to the absence of a clear problem owner in the bid to move from 2D to 3D-enabled representation of land and property information –

leadership is severely missing.

8.2.2.4 Emerging institutions

Despite the range of institutional constraints that emerged, the case study also identified areas where 3D technologies are making inroads into current land administration practices, signalling the emergence of new institutions and perhaps, the definition of a new organisational field that encompasses both development and management aspects of high-rise buildings.

These opportunities are appearing at grassroots level, where those at the coalface of experiencing how complex high-rise structures 'stretch' current processes are also those with the greatest need for a solution to move forward. These include developers as well as relevant local and state government units. At the governmental level though, this change has been driven by those in an organisational position to lead and support the use of 3D technologies. The powerful political process where large developments are approved directly by the standing minister of state for planning is also likely to be a significant factor in institutional change.

In institutional terms, what this suggests is that the current organisational field may be undergoing a process where the issue that defines the boundary of the field is being redefined. This creates opportunities for new power relationships to become established that may influence the use and diffusion of 3D technologies in land administration. This supports an initial economic motivation for change espoused in institutional theory; however, it remains to be seen when it will reach a point where adoption will be more for socially motivated reasons, especially if the regulatory authorities remain absent from a leadership role.

8.2.2.5 Implication of findings

Currently, in terms of negotiating the challenges presented by high-rise buildings and the limitations of 2D practices, and charting a path towards 3D-enabled urban land administration, the land administration industry is only armed with a legislative framework that was not intended for complex developments as the key sense-making mechanism.

This has left stakeholders unsure of how to act in the face of growing challenges presented by the physical design and layout of spaces in complex high-rise buildings, as well as a tendency to use these buildings for mixed-use purposes. This complexity is presenting increasing challenges in terms of the reliance of 2D formats and practices for representing subdivision information for high-rises. Consequently, this leaves a longer-term impact on the broad community of users who have need to access this information over the lifecycle of the building.

Yet, although some participants remain adamant that 2D plans are easier to engage with, by far, the challenges presented by 2D representation of land and property information are acknowledged. This is not only on the immediate investment required of stakeholders to produce this information, but more particularly in thinking broadly about the impact on the community who require them for managing the rights, restrictions and responsibilities associated with living in a strata community.

Lack of understanding of 2D plans, diversity in drafting practices, the limited value that the use of parcels in organising land and property information and long-term ramifications in terms of making sense of plans, all point towards a growing fragmentation of the shared frames of meaning at societal and professional levels. While the plan of subdivision is currently produced to primarily meet the objectives of registration, and formal recording is undeniably important, it is apparent that the information does not meet the requirements of a growing community of users interested in the management of these buildings, from local government to public stakeholders.

Two key conclusions can be drawn here. Firstly, that there are strong signals that a shift towards an information product that is more readily accessible to these broad communities is necessary – perhaps less in terms of physical access and more in terms of communication and understanding. The product must preserve information of who owns what and where, and should meet the statutory requirements that the land registry needs to uphold, but in a medium that lay communities can understand. Ineffective encoding of knowledge for current and future users limits the ability to better understand, appreciate and plan for the requirements of vertical communities. This in turn dampens the ability to truly establish a new cultural norm that is attuned to the requirements of high-rise living, perpetuating the ongoing effects of current institutional constraints that lock in current approaches.

Secondly, there are intimations that the land administration industry might need to consider that structural changes are necessary to preserve its relevancy into the future. For example, the process currently works for most subdivisions but it is coming under significant pressure from the information demands of complex high-rise buildings; the small pool of surveyors who currently engage with complex high-rise developments in CoM indicates a growing variance in skills and expertise; there is a growing public interested in information regarding high-rise RRRs. This builds up to the inevitable question as to what role the land registry should play, as a regulator, in managing change to meet public interest needs going forward into the future.

Ultimately institutional constraints on 3D innovation can be framed in clear terms: **there is a lack of legitimacy around change**. From an institutional perspective, the constraints associated with the Melbourne case study inherently supports a baseline conclusion that the move towards 3D-enabled urban land administration is really yet to be legitimised. However, there is evidence that this is slowly shifting given the organic developments at the grassroots level that support the use of 3D-technologies. As well, a source of legitimacy could very well come from the emergence of another (arguably more powerful and political) institutional environment in the ministerial stream for big buildings. The process has been enabled by political structures, and there is evidence that its requirements are becoming widely accepted.

In many ways, the structural issues are likely to require explicit responses because this firstly, provides recognition and definition of the issues. The dominance of regulative elements, and the perceived rigidity of the legislative framework, suggests that new legislation regarding high-rise subdivision, and the use of 3D-based practices, will be a productive catalyst for change. This is less because new legislation is actually required, but more because stakeholders perceive such change to be warranted. The organisational field has become so used to the regulated nature of their work that such a move will offer a primary way of changing their shared system of sense-making to enable 3D innovations to become a reality in urban land administration.

8.3 INSTITUTIONAL PRESSURE EXERTED BY STRATEGIC CHOICES: OVERVIEW AND DISCUSSION OF KEY THEMES

A natural consequence of developing a deeper understanding and appreciation of how the current institutional environment acts as a constraint on innovation was to explore feasible ways to respond. As discussed in chapter seven, the Singapore case study focused on elucidating industry perceptions as to how and why strategies were successful in producing a positive response to 3D innovation and revealed how institutional pressure to change exerted by strategic choices was perceived to lie with four key themes: government leadership, creating legitimacy, organisational culture, and environmental conditions.

8.3.1 Overview of Key Themes

The first theme, **government leadership**, describes success as being achieved through strategic choices that explicitly leveraged government leadership. This resulted in strategies that were explicit, and unashamedly exploited the power of the government's position to exert coercive pressure to change. However, at the same time, it also took a longer-term view towards exerting normative and mimetic pressure on organisations. Short-term strategic choices reflected a 'carrot-and-stick' approach to, at once, force and encourage stakeholders to move away from traditional 2D methods and operations. Longer-term strategies were more aligned with building status around BIM practices and qualifications, as well as capacity building.

The second theme, **creating legitimacy**, interpreted the findings of the interviews to indicate that the ability of strategic choices to create legitimacy was a less explicit and obtrusive strategy, perhaps even to some extent unintentional, but one that was no less authoritative. From the grudging acknowledgments of participants, it was clear that this had been a fairly effective approach for engendering change. As such, the ability to exert pressure to induce change was again experienced as all three types of institutional pressure.

The third theme, **organisational culture**, was almost a universal theme among the participants, which suggests its significance as a factor in a positive change experience. This fostered interpretation of the responses to represent a significant level of recognition that change at the organisational level was really a function of leadership adopting the right mindset. This in turn appears to have affected the way various organisations have approached change management. This is aligned with normative pressure at a local scale.

Finally, the fourth theme, **environmental conditions**, refers to participants' recognition that success in moving towards BIM can also be attributed to beneficial incidental environmental conditions. In part, the existing infrastructure that was developed to realise electronic submissions in the early 2000s has delivered the unintended benefit of establishing many of the legal and technical preconditions necessary for BIM. As well, a culture of subservience to government initiatives that has been cultivated by the ruling government since the independence of Singapore has meant that there has been a greater responsiveness to institutional pressure to change.

8.3.2 Discussion: Institutional Pressure to Conform

There is no doubt that the move towards BIM would not have occurred as rapidly if it had not been steered so visibly by a significant statutory authority. It also helped that the mandate of the Building and Construction Authority of Singapore (BCA) enabled it to define the issue, and therefore the organisational field. If BCA was not already in a position of power as a regulatory authority, then by doing so, it established a position of institutional power within the organisational field.

Within this new organisational field developed around compliance checking, BCA was able to make key strategic choices that exerted deliberate institutional pressure. This was clearly signalled in its well-publicised roadmap. The various coercive, normative and mimetic institutional pressure exerted on the organisational field delivered changes in two key aspects: structural and cultural levels, both of which effectively served to legitimise 3D-enabled processes as the new norm.

8.3.2.1 Pressure to change at a structural level

With new regulations developed simply around the mandatory submission of BIM models for compliance checking, BCA managed to use a fairly simple regulation to bring about significant structural changes. To be able to abide by the new regulation inherently required new skills, new roles, new organisational structures, new technologies and new processes.

With a statutory responsibility for ensuring quality of the built environment, BCA fully exploited its mandate that gave it control over parts of the information supply chain. While the exertion of coercive pressure on the industry to bring about change is widely considered to have been effective in bringing about change, participants do not necessarily consider it to have stimulated those deeper changes within organisations necessary to realise longer-term benefits. This can be seen in the experience of the organisational field in terms of differing conceptualisations and understanding of what BIM entails, and the prevalence of improper modelling.

The response to this strategy can be interpreted to be a compromise, where there is some attempt made to accommodate the pressure to change being exerted by the government, seen as meeting the demands of the government to submit BIM models for compliance checking. However, there is a level of resistance to fully adopt BIM that is likely to stem from the organisation's internal needs and objectives.

8.3.2.2 Pressure to change culture and shared systems of meaning

Strategies that exerted pressure to change at a cultural level derived legitimacy from a range of sources. The BCA's ability to focus broader national and international trends was a key enabler of strategies that targeted cultural change. This occurred at several levels.

Firstly, the drive for change to implement the mandatory use of BIM models represents the latest iteration of a longstanding national agenda to improve national productivity rates by leveraging information technology (IT) developments. This has been around since the 1990s, with the land development (particularly construction) industry constantly a key focus. This implies a history of changes, with a likely consequence that productivity as a key motivator for change has a certain level of endemic legitimacy that the BIM movement could leverage.

However, from the government's perspective, there is recognition that the productivity agenda is an opportunistic lever and may not be sufficient to deliver the deep changes required to realise the full potential of BIM that only comes with full adoption by all stakeholders. Such a driver may lie with value-add motivations that may come through a whole-of-government push to develop a virtual Singapore to facilitate a move towards smart cities.

There is also the fact that there is a growing worldwide momentum with regards to BIM use. An ability to move with this trend is highly aligned with the government's agenda to position Singapore as a country that is highly innovative and technologically advanced since a successful BIM movement would provide the Singapore government with a level of status international legitimacy that is desirable. Legitimacy derived from such external factors can be significant, suggested by positive comments that the current scheme of resource provided by the government to support BIM is one of the most lucrative in the world. Additionally, according to participants, this aligns with the government's constant aspiration for the country to be recognised for its superlative state.

The deliberate engagement of industry in the change process can be seen to be exerting pressure at a cultural level in several aspects. Firstly, cross-industry engagement served to sanction BIM changes as legitimate and appropriate practices within the land development industry. Secondly, there were a significant number of organisations engaged, representing a cross-section of reputable local and international firms. Therefore their endorsement likely served to provide the basis for some critical mass towards the establishment of new industry values and norms. Thirdly, in addition to the provided guidelines and templates, the publication of profiles of successful BIM experiences also built up expectations of best practices around BIM use.

The establishment of new professional norms is a vital first step towards engendering longer-term and more sustained changes. Other strategic initiatives that delivered such pressure were the provision of incentives and resources to encourage action, and in terms of building in these new norms into the future of the profession, the development of a range of professional development training options and changes to the curriculum at tertiary level. These all reflect a collaborative effort to bring about change, albeit coordinated at the national level by BCA. Intrinsically, the development of specialist training for professionals could also be seen to create status among the profession, and serves to support the development of new norms and new ways of thinking necessary for BIM-oriented practices to become entrenched. The engagement of industry – both locally and internationally, are all examples of facilitating an element of aspiration with regards to the move towards BIM – that organisations would rise in stature if they moved to adopt and use BIM.

A time of change is one characterised by uncertainty. Mimetic pressure stems from the differing levels of success of change being experienced – as such, institutional theory posits that the less successful organisations will tend to model behaviour on the more successful ones. Many of the strategic initiatives can therefore be viewed as providing a model to behave as a way to guide those organisations unsure of how to take the first steps to move away from a 2D environment to a 3D one.

One of the key ways has been through high-level industry engagement as indicated before, but the profiling of successful firms and individual experiences with BIM can also be considered to provide another avenue for modelling behaviour. The high BIM-related staff turnover currently being experienced by organisations throughout the industry also indicates mimetic processes at work, where less successful firms are attempting to change their organisational models through attracting experienced personnel who can bring their BIM knowledge to support change.

8.3.2.3 Strategies for multi-stakeholder environments

The way in which stakeholders understand their obligations in the shift towards adopting BIM for regulatory processes has been, to a large extent, a constant negotiation between what they are used to, and what they are now expected to do.

The differing social realities of the organisational field in the Singapore case study in terms of how they experience change suggests that innovation is complicated by the presence of multiple professions within the field, each with their own ways of thinking and acting that are reinforced through education and training. Even when innovation is successful, underlying work patterns such as design-bid-build processes that link the various organisations in the field are seen to inhibit innovation. It may imply that 3D innovation in cadastral systems may be less complicated due to the presence of only one dominant profession (surveying).

However, similar challenges seen in Singapore, such as varying quality of information, differing expectations and a continuum of accuracies, and a focus on the lifecycle of a building will likely to be experienced if the benefits of using 3D-enabled information are to be fully realised since this will require surveyors to connect into the broader information supply chain and interact with the other key professions.

The varying expectations around change in the organisational field can also become an issue in successful innovation. In the Singapore case study, stakeholders' expectations are around true implementation of BIM, which they consider to be in excess of the immediate need of the government to meet set targets. Arguably, truly successful innovation can be impeded by political ambitions, which may result in the selection of strategies wholly designed to afford the appearance of adoption, but no further. Consequently, there is contention as to whether strategies have been truly successful in establishing new norms with the perception of some in the organisational field being that it is currently acceptable practice to produce improper BIM modelling.

The interview comments from the Singapore case study also suggest that participants perceive strategies that exert a coercive pressure to be effective for a networked environment, where coordination of the diverse requirements is necessary. This may be a useful consideration for the broader land administration industry.

8.3.2.4 Persistent barriers to change

There is significant recognition by the state of the importance of cultural shift for change to be successful. This is borne of previous experiences, seen in the comments regarding industry backlash when the construction industry moved from paper to electronic operating environments. This is however, not a conservative expectation, as it appears that some professions in Singapore have felt threatened by the changes. Participants' comments also reflect resistance to change as stemming from a lack of education, misconceptions and organisations being risk-averse.

Awareness of the significance of cultural issues can be seen in participants' references to mindset as a common challenge and a professional orientation to CAD. This is likely to reflect those shared systems of meaning that are perpetuated by education and training, and therefore require strategies that exert normative pressure to create new systems of meaning in the medium to long term.

8.3.2.5 Implication of findings

DiMaggio and Powell (1983) observed that organisations within an organisational field would shift towards exhibiting similar organisational structures (i.e. institutional isomorphism) in an institutional environment as a consequence of institutional pressures. The Singapore case study provides evidence of this shift beginning to occur in the wake of mandated requirements around the use of BIM models for compliance checking.

Deliberately designed strategies, particularly the key strategy regarding the mandatory requirement of a BIM model for compliance checking in the development process, consciously leveraged dependent relationships within the industry to ensure success. This strategy owes its effectiveness to coercive pressure that is legitimised through the force of legal authority, which enabled an almost immediate effect in terms of galvanising the industry into action. However, it is also likely that such strategies are only effective in the short term.

As well, the assembly of an international panel of BIM experts strategically manoeuvred the BIM-related changes in Singapore as being in line with international trends in the construction industry. Institutional theory suggests that the high incidence of trained professionals in the industry (e.g. architects, engineers, etc.) lends itself well to these types of normative pressure on the local industry (DiMaggio and Powell, 1983).

Change in Singapore was also facilitated (by the participants' own admission) by a culture of subserviency within the country, its scale and its existing infrastructure. Therefore to what extent these strategies have been effective in their own right might be debatable, but there is no doubt that the choice of strategy appears to be have been based on explicit or intuitive understanding by the government of the national psyche and an ability to appropriately leverage environmental conditions.

What was interesting to note in the Singapore case study was the clear absence of any strategy involving the development of a business case – which might be expected in a situation where change was being introduced on such an extensive scale – to argue for the necessity of change. Although a wealth of financial resources was provided to industry, at an organisational level, it was clear that costs were still quite significant. Yet there was no perceived need – nor conversely, demand – for a business case to convince broader industry of the economic arguments for moving towards BIM. Any economic arguments that were mounted were generic in nature, and linked to the delivery of macroeconomic benefits for the country.

Ultimately, the case study suggests that within a relatively short timeframe, it was possible to legitimise 3D-enabled urban land administration practices as a new operating environment, suggesting that the perceived intractability of institutional barriers in the Melbourne case study may not be insurmountable.

The interpretation of the key themes made salient those institutional pressures that strategies were able to exert to induce conformity to new BIM-oriented ways of behaving. In general, successful strategic activities were interpreted as bringing to bear the social infrastructure[5] necessary for change. Social infrastructure essentially consists of institutions, aligned with strategies that consciously or less consciously create institutional incentives to change (where incentives are the "positive or negative changes in outcomes that individuals perceive as likely to result from particular actions taken within a set of rules in a particular physical and social context" (Ostrom et al, 1993: 8).

Of course, the fact that there exists a growing momentum worldwide with regards to BIM offered opportune support for the initiatives in Singapore. Participants were also honest about how change has been facilitated by existing conditions – both in terms of an endemic culture that tended to be conformist, a small scale in terms of country size, as well as the existence of legal and technical infrastructure that was suitably for BIM. However, it remains a clear outcome that one of the most critical factors in facilitating change has been the clear and strong leadership provided by BCA. Whether participants agreed or disagreed with their actions, they were unequivocal that this leadership had positively impacted on the speed of change and their leadership in designing deliberate action, as well as clearly communicating the variety of changes that were taking place. However, the overall movement to support the use of BIM also benefitted from the champions that emerged at the grassroots level who were undoubtedly central to facilitating success within organisations.

Although the strategic choices in Singapore are perceived to be effective, there is emerging evidence that organisational response to institutional pressure falls between acquiescence and compromise. Acquiescence can be observed to be occurring where organisations concede to the institutional pressures and make changes through mimicry of more successful models and obeying rules and accepted norms – the rapid turnover in BIM-experienced staff provides some evidence of this. There is also compromise where organisations are trying to accommodate the changes being asked of them while balancing their own needs. Evidence of

[5] Ostrom et al (1993) defined social infrastructure as consisting of institutions: "the people and the patterns of regular, repetitive interactions among them that transform inputs into outputs (p. 6).

this is in the double-handling occurring as many organisations operated in BIM for the specified purposes, or for nominal purposes to provide a semblance of conformity, but still retained their 2D operating environment for all other purposes.

Other structural issues can disincentivise true BIM adoption and implementation, such as the relative affordability of foreign labour in the construction sector as it is perceived to be cheaper to rebuild in reality than to properly model.

The fact that BIM requirements are perceived to shift as the building progresses through the various stages of development also suggests that the strategies that are currently used may need to be adjusted to address the needs of stakeholders through different parts of the information supply chain.

The first BIM roadmap is currently under review. The journey over the last five years has proven to be highly dynamic with tight stewardship provided over the deliberate activities to support change. It will be interesting to continue to observe how Singapore grows and adapts its strategies to the changing global and local environment and if it can facilitate the evolution of its "perfect storm" to guide BIM diffusion for the next five-year implementation phase.

Finally, it is worth noting here that all the strategies that emerged were not really about technology at all – the term 'BIM' could be replaced with any other innovation and the strategies would likely still be entirely appropriate. The issues raised by the participants, and the position taken by the government, tend to be commonly heard and found in any negotiation during a change process. This case study has returned lessons that have been recurrent throughout history – a familiar rhythm of disruption, building up of status quo, new norms driven by the momentum of change, which finally becomes entrenched as social and cultural reality.

8.4 CONSTRAINTS AND CHOICES: CROSS-CASE ANALYSIS AND SYNTHESIS

The case studies were selected specifically for their context: juxtaposing the conditions around the absence of innovation with those that support its presence. In many ways, the case studies are vastly different, but upon analysis, it appears they are also similar in intrinsic ways.

Importantly, the outcomes of the case studies, which were both analysed using institutional theory, demonstrates a level of correlation between the constraints faced by CoM and the lack of progress around 3D innovation, and the choices made by Singapore to drive BIM adoption.

8.4.1 Similarities and Differences between Case Studies

The similarities and differences between the case studies are mostly related to their respective contexts. The discussion in the previous sections relative to each individual case study shows key aspects of each case study to lie along four key institutional areas: structure, sense-making systems and culture, multi-stakeholder environment, and persistent versus emerging institutions. These are the areas where institutional constraints were most apparent in the Melbourne case study, and conversely, in the Singapore case study, these were areas that strategies appeared to target.

8.4.1.1 Structure

Melbourne was concerned with tenure-related land administration processes of subdivision and registration that produce legal information about a building's internal spaces, which were mostly, but not always, defined by the building's physical structure. A focus on such processes necessarily indicated the involvement of stakeholders like the local government, surveyors, land registry and strata managers. In contrast, Singapore provided insight into development-related land administration processes, specifically how compliance checking is now based on BIM models that hold information about structural elements. This relatively new requirement has really only targeted architects and engineers but the nature of the construction process, and the use and flow of such information, necessarily meant that other stakeholders such as contractors and consultants were also involved in the interviews.

The scale and characteristics of the sites also impacted how the innovation was diffused. In Singapore, the small scale of the industry and the relatively homogenous development environment (i.e. overwhelmingly high-rise) has resulted in strategies to create the development of only one system. This is not applicable for land administration practices like those in the Melbourne case study, where development is not homogenous throughout the state, and the current 2D-based system is still seen to be effective for the majority of subdivisions.

As well, there is no doubt that the innovation in question is different. While there has been developments and case studies showing how the Land Administration Domain Model (LADM), might be a suitable data model for tenure information about 3D parcels and 3D rights, restrictions and responsibilities (RRRs), and within Australia itself, the land registries organise their RRR information using the ePlan data model, there is no holistic package yet that the international land administration industry is unified behind. In contrast, the use of BIM, underpinned by the Industry Foundation Class data model, and manifest through a range of authoring tools and software packages, is a dominant trend within the land and property development sector at the moment globally.

However in both case studies, the characteristics of the institutional environment have clear parallels. The fact that regulatory processes are involved, brings a level of interaction with bureaucratic structures in both sites – for Melbourne, it is with the land registry and local government, for Singapore, it is with BCA and other development-related authorities. This sets up a level of dependency within the industry on the state since there are no other alternative methods of attaining regulatory approval for plans. Essentially, the processes are part of the same broader land development and supply process – or in institutional language, constitute part of the same broader organisational field, but the nature of the industries involved, the information products being generated, and in many cases, the mandate of specific legislative requirements conflate to produce distinct and separate spheres of practice.

As such, the institutional basis for those strategies in the Singapore case study that target structural elements in the organisational field could arguably be applicable to Melbourne. Strategies like the need to legitimise reasons for change as aligned with broader social demands and expectations are often part of the political agenda of governments. The centrality of the state in both organisational fields suggest that the initial momentum to catalyse a break from the current 2D-based environment would be most effective if it stemmed from a strategic choice that originated from the state, and leveraged its position of authority and influence to coerce other organisations in the field to conform. However, what the Singapore case study also indicates is that this is not necessarily a strategy with longevity. In the Melbourne case study, it is apparent that regulative elements (like the law) in the institutional environment can, over time, move to become normative and cultural-cognitive elements.

8.4.1.2 Sense-making systems and culture

In both of the case study sites, sense-making systems and culture are a key theme, presenting as both institutional constraints and consequently, areas that strategies target. Partly, the structure of the industry is a factor: the industries featured in both case studies are highly reliant on professions. This similarity provides the basis for arguing for the transferability of findings between the two case studies.

In Melbourne, this relates mainly to the surveying profession, while in Singapore, this is mainly through architects and engineers, and increasingly a profession being developed around BIM-related expertise. However, in the Melbourne case study, there was a clear absence of a new sense-making framework, with stakeholders continuing to rely on current ones, which are still oriented around 2D ways of working to abstract and encode increasingly complex 3D property RRRs. Reflecting the opposite scenario, the array of resources dedicated to helping create and establish new systems of meaning in Singapore was significant. These included guidelines, templates, profiling, new curriculum, and new professional development courses.

To a large extent, the scenario in Singapore is complicated by the presence of multiple professions, so there is an added challenge of creating an overarching framework to connect the various ways in which the professions make sense of the built environment. The attempts to connect change to broader societal level objectives can be interpreted as one way to do so.

8.4.1.3 Multi-stakeholder environment

The way 3D innovation has been received in each case study site has differed. In Melbourne, 3D innovation is ad hoc and piecemeal, relying on grassroots efforts to build momentum. There was no clear direction from a government organisation, nor was there any effort to position such innovation as necessary.

In direct contrast, the situation in Singapore reflects almost the opposite: 3D innovation has been clearly led and directed by the government through a key statutory authority, and momentum has very much been built using a top-down approach. The number of organisations involved were incrementally affected, though not through a direct strategy, but by changing regulatory requirements that had a flow-on effect. Finally, the internalisation of change at the individual and organisational levels was supported through a range of short to long-term training mechanisms. Internal mechanisms such as the presence of organisational champions were also considered to be a significant factor in organisational change.

In both case studies, it became clear that the multi-stakeholder environment presented challenges in terms of how various organisations conceived of their legitimacy within the field, and likely outside of it. In the Melbourne case study, this was demonstrated through the various ways in which the plan of subdivision supported organisational legitimacy. In Singapore, this was demonstrated through the varying degrees of comprehension of what a change to BIM entailed.

8.4.1.4 Persistent vs. emerging institutions

A central theme that emerged in both case studies was the notion of legitimacy. This was defined in chapter three, but essentially refers to cultural support, societal acceptance, an organisation's perceived right to pursue a certain aim and consonance with the prevailing context. In terms of realising 3D-enabled urban land administration, constraints can be summarised as those institutional elements that reinforce 2D-based land administration practices as the prevalent and appropriate; put more simply, there is an absence of legitimacy around 3D-enabled urban land administration as shown in the Melbourne case study. Conversely, 3D-enabled urban land administration, evident in 3D-enabled land development processes in Singapore, is realised on the back of a range of successful strategies that position 3D-based practices as desirable and accepted by society.

For the land administration industry, the legal importance of having accurate information about land and property RRRs means that many practices and processes are regulated and underpinned by a legislative framework. The legislative mandate, as well as the fact that the current legislative framework has been in operation for almost 25 years, provides current 2D-based practices with an inordinate amount of legitimacy. This will be difficult to shift. The strong legislative requirement has also led to the dominant perception that moving towards 3D-based urban land administration processes is foremost predicated on legislative changes, which is likely to be challenging and time-consuming. Subsequently, for the broader industry, there is a perception that the land registry is the ideal organisation to lead change.

The 2D plan of subdivision is highly legitimised within the current institutional environment. Its role and function is underpinned by legislation and a strong culture of professional practices has been established based on it. It is likely that realising 3D-enabled urban land administration lies in achieving similar levels of legitimacy around the use of 3D technologies and information formats – although the use of 3D may not necessarily be to the exclusion of 2D methods, given that 2D methods still adequately support land subdivisions and simple building subdivisions.

8.4.2 Synthesis of Case Study Findings

The similarities and differences between the case studies suggests that there is a basis for mounting an argument to develop some generalised findings. These relate to two key areas: legitimacy and leadership.

8.4.2.1 Legitimacy as key to change

The case studies support a generalised finding that the existence of legitimacy around the innovation is fundamental for facilitating change. In CoM, the paucity of legitimacy around 3D can be construed as a function of the profuse legitimacy around 2D in terms of "cultural norms, symbols, beliefs and rituals" (Suchman, 1995: 571) that serves to constrain organisations and actors within to current 2D-based ways of thinking and practice. There is no formal and explicit recognition that the current fragmented model to managing the built environment is no longer appropriate and that a sustainable future lies with adopting a model where the sum is more important than the parts.

Therefore, there is much to learn from Singapore's efforts to construct legitimacy on several fronts. Foremost, deliberate strategies to leverage a national productivity agenda provides the platform to construct expectations in the form of obligatory change to support and sustain economic development for the good of the country. The affiliation with this political platform achieved two further outcomes that was also important for fostering legitimacy: the clear mandate for a specific organisation to lead the change, as well as the ability to provide a broad range of incentives and resources and to develop training programs, which had the specific purpose of inducing conformity with the required changes.

Secondly, the use of compulsory mechanisms to compel change accelerates the development of expectations. This was achieved through the use of mandatory measures to require BIM for regulatory processes. How and which organisations and professions would be affected was widely communicated from the start, which served to create expectations around change and to allow the industry to prepare itself. The development of new norms through industry engagement, provision of submission templates, and targeted communication strategy, all served to normalise expectations around using BIM. These all reflected proactive strategies that also limited potential negativity towards to change.

Thirdly, expectations around change across the industry that is fostered through industry engagement, broad communication and provision of a range of resources, incentives and training. However, what also emerged as a success factor, was the ability of the lead government organisation to react to new national initiatives and develop emergent strategies, key amongst which is the new association with a whole-of-government initiative to develop a virtual 3D model of the country, in line with a vision to develop a smart city (SG-SPACE, 2012), which would create new opportunities for value-add activities derived from 3D spatial information.

8.4.2.2 Leadership as key to change

The case study outcomes support a generalised finding that leadership is a key factor in realising change. In CoM, the constraints associated with the absence of a key strategic actor or problem owner, exists in clear contrast with the Singapore case study, where the dominant presence of the lead government agency was perceived to be a key factor in the current success being experienced in pushing BIM across the construction industry.

It is evident that an organisation with the (perceived) authority to act should do so and provides the leadership in terms of defining the vision and plan of action. Importantly, this presents to the broader community, an explicit and visible expression of the desire and will to change. This can be seen as supporting the development of legitimacy around the innovation, particularly in specifically creating strategies that linked BIM to organisational and professional legitimacy.

The Singapore case study shows that the presence of a lead agency was important, not necessarily because they were in the position to exert such pressure on other organisations, but because they were instrumental in coordinating all the relevant statutory organisations (government procurement entities) to agree to receive BIM models for e-submission purposes and were able to use this as a key mechanism to compel change.

8.4.2.3 Other generalised findings

Apart from legitimacy and leadership, the synthesis of the case studies also indicate a range of other findings that could potentially be generalised and extrapolated to other land administration jurisdictions.

Firstly, the regulated nature of information practices and processes, and the role of statutory organisations in both case studies suggest that strategies that exert coercive pressure can be an effective way to commence the change process.

In terms of addressing the entrenched nature of 2D-based practices, Singapore's BIM roadmap highlighted two main activities, mainly around the provision of resources: developing and providing BIM submission templates and guidelines, as well as developing project collaboration guidelines and an object library standard (Build Smart, 2011). These served the aim of providing explicit examples of how organisations should be behaving in a BIM-oriented environment, albeit only for the purposes of regulatory submission. In institutional terms, this could be perceived as facilitating the creation of new social structures around BIM. Further provision of other incentives and resources likely served to lower the risk associated with change; creating opportunities for training and development at various levels likely served to ensure that these new types of behaviour would endure in the longer term. These strategic initiatives, along with the development of a range of education opportunities exerts both normative and mimetic pressure on the organisational field, pressures that are keenly felt when the field is made up of professions.

All of these activities reflect motivations that would be appropriate for responding to the constraints posed by similarly entrenched 2D practices in the land administration industry in Melbourne, if not even more broadly. They all serve to facilitate the creation of new norms around BIM-oriented practices and help ensure the appropriate structures are created to support these changes. They are also aligned with the institutional characteristics of the environment in Melbourne, which is not altogether too different from other institutional environments underpinning property rights and registration.

To foster legitimacy, a possible compromise to support progression, is to build legitimacy around 3D-enabled practices only for those buildings that demand it – i.e. those complex high-rise buildings within Melbourne. Shifting the platform for change could create the necessary opportunity to undertake appropriate action for change that does not detract, nor threaten the stability of current practices that have proven to be proficient for most of the developments. Finally, one of the constraints facing the land administration industry is the fact that the challenges presented by 2D-based representations of subdivision information is currently perceived to be a unilateral issue, affecting only the large complex developments that tend to only be constructed in CoM. Singapore's stepped approach in phasing in the submission requirements – where large developments were first targeted – presents a potential template for responding to this issue.

8.5 DEVELOPING A FRAMEWORK FOR CHANGE

The cross-case analysis and synthesis argued the similarities of the institutional environment in both case studies. Although how this is manifest (e.g. structurally) differs between the case studies, the consistency in institutional characteristics establishes the basis using the outcomes to extrapolate some generalised findings.

These findings are given shape as a framework of principles, developed to provide a conceptual view as to how the institutional environment can cultivated and leveraged to direct strategic choices to support the move towards 3D-enabled urban land administration.

This framework comprises four main principles that build on, and reinforce each other, and should underpin the choice of strategic activities to support change. The principles are:

1. Cultivate legitimacy.
2. Strategic leadership.
3. Support change and action.
4. Undertaking periodic reviews.

This is illustrated in Figure 8.2.

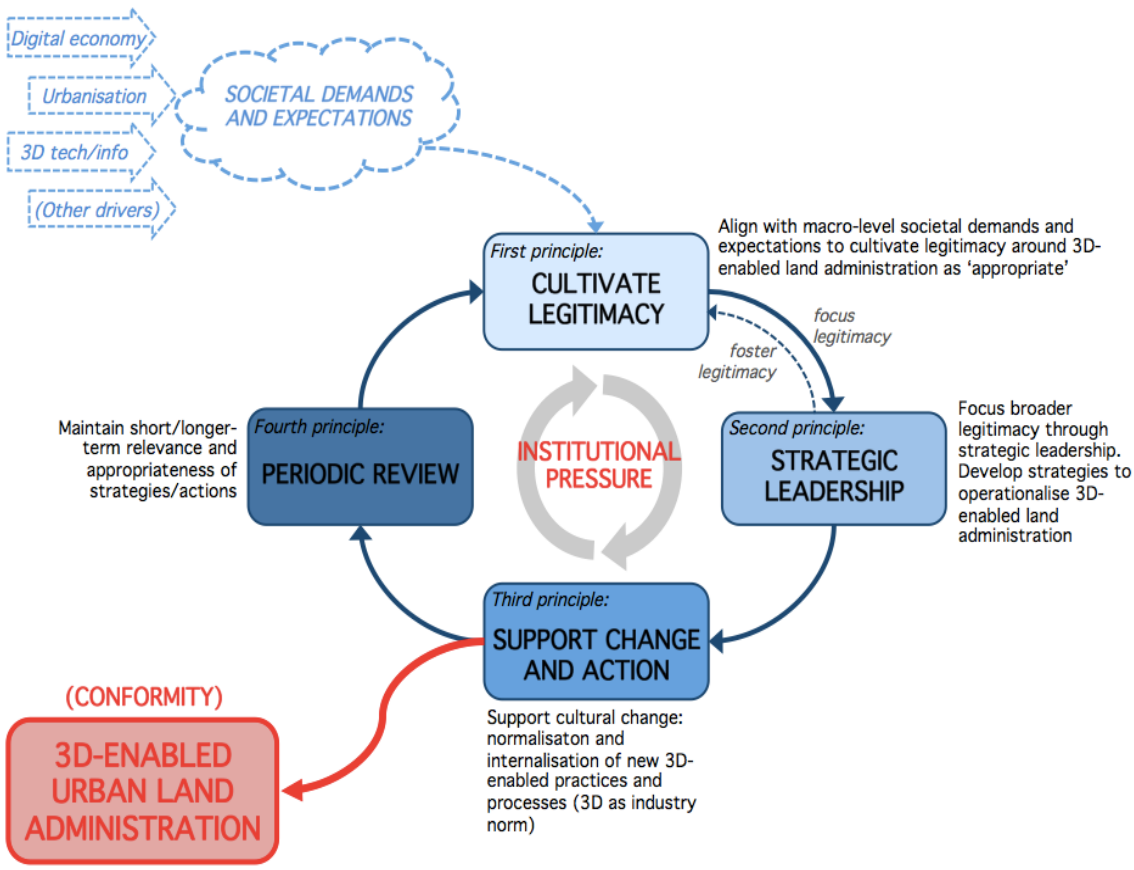

Figure 8.2 Framework of principles to support realisation of 3D-enabled urban land administration systems.

The framework is cyclical, with the intention that the principles, particularly principles two, three and four, will need to be repeated over and over to enable institutional pressure to be reinforced. This is likely to continue up to the point that conformity is reached. Once that is achieved, it is more than likely that 3D-enabled urban land administration systems will be a reality.

8.5.1 Cultivate Legitimacy Around 3D Innovation in Urban Land Administration

In this framework, cultivating legitimacy around 3D innovation in land administration is held as a first principle, reflecting its importance as a key influencer in determining the strategies for supporting change. It is fundamental to change, since its purpose is to motivate those strategic choices that can facilitate the necessary preconditions to change.

What form and shape legitimacy is cultivated in and around, is very much a consequence of social demands and expectations often driven by broad drivers such as urbanisation, increasingly common use of 3D technologies creating expectations around its use, the digital economy and so on. In the case of Singapore, visible association with national agendas to improve productivity for the country's economic sustainability was used to cultivate legitimacy around the BIM movement. For the construction sector that was specifically targeted, emphasis was placed on leveraging information technology to facilitate productivity – a seemingly perfect and opportune political platform. However, the explicit choice was made to make that agenda the backdrop to the BIM movement by BCA.

Legitimacy was also cultivated on several fronts: there was legitimacy in terms of conforming to nationalistic values – the function of the construction industry was no longer only about (literally) construction, it now also had a fundamental function in terms of supporting the economic development of the country. By explicitly singling out the construction sector, the national agenda also served to create societal expectations around reform and change – a 'proper' organisation should be demonstrating efforts to leverage technology to improve processes and output. Therefore, while required changes may not necessarily be in line with organisational ideas of efficiency, organisations that were not seen to be making an effort to change placed themselves at risk of being considered by the broader society to not be behaving 'properly'. It is essentially these aspects of legitimacy that sets the foundation for other strategic activities to progress.

8.5.2 Strategic Leadership of 3D-enabled Urban Land Administration

The principle of strategic leadership motivates the next level of activities where the primary focus should be to select strategies that leverage the growing legitimacy around change and provide some form and function as to how these changes should take place.

Leadership is important because it serves as a focusing mechanism for the broader legitimacy that may already be developing around change, but also because clear and visible leadership can play a role in subsequently fostering more legitimacy around change. This is illustrated by the feedback (dashed line) between the second and first principles in the diagram.

Strategic leadership should focus on providing a definition and scope around the issue and relevant actions required. However, these are contingent on establishing a problem owner – some organisation (or person) to whom responsibility to drive change can be accorded to, and the ability of the problem owner to define a vision that the industry can identify with, and align their expectations against. A problem owner also provides a focal point around which further expectations regarding change management can solidify as well as stimulating the necessary communication to engage with all sectors of the industry.

The validity of this principle is supported in both case studies. In Melbourne, the absence of strategic leadership to drive change was evident in the theme regarding a lack of ownership around the issues. Alternatively in Singapore, this was clearly expressed and one of the first themes to emerge, as well as observed in the range of documents collected. The coercive pressure that can be exerted from this principle is also particularly relevant for land administration, where regulated processes means a higher level of interaction with the state, and a dependency between the state and stakeholders, particularly in aspects such as getting approval for proposed plans.

Subsequently, leadership should culminate in the development of a range of strategies and activities to bridge the gap between current systems and 3D-enabled urban land administration systems.

8.5.3 Support Change and Action to Realise 3D-enabled Urban Land Administration

This principle provides the rationale for the selection of strategic activities that offer the best outcomes in terms of translating strategies into sustainable operational behaviour. These activities essentially work at various levels across the industry and the ultimate aim is to ensure capacity building is occurring to meet both short and longer term needs.

Key activities that reflect this principle are likely to include activities that can compel action such as the introduction of new legislation or regulations, or even new professional standards that organisations need to adhere to. The use of disincentives can also achieve a similar effect. Activities that facilitate the recognition of the creation of new norms around work practices would also be ideal, including engaging with industry to develop guidelines or best practices as well as utilising organisational champions. Finally, the provision of a range of resources and incentives can serve to lower resistance towards taking action as well as help to minimise any perceived risks associated with change.

The efficacy of this principle rests on the ability to exert all three types of institutional pressure – coercive, normative and mimetic. Sources of coercive pressure would likely become more dominant as new regulatory processes become defined. As more organisations conform and become successful at change, this would create mimetic pressure that supports change in organisations that are less sure since they would try to mimic the successful practices. Once actions like new curriculum and new education and training programs are initiated, longer-term normative pressures that produce compliance to change will begin to be exerted.

8.5.4 Periodic Review

Any period of change, particularly in the early stages, is likely to be highly dynamic with people, processes and organisations all in a state of fluctuation. Therefore, the fourth and final principle, which is periodic review, is necessary to ensure that strategic choices remain necessary and relevant. As times change, it may be necessary to adjust strategies as well to ensure that sources of pressure remain legitimate and can continue to be leveraged to ensure strategies continue to be successful. Otherwise, shifts in strategies and actions will be necessary to remain on course to deliver the necessary changes to bring about 3D-enabled urban land administration.

It is also likely that any implementation of 3D technology will be in phases for practical reasons, as seen in Singapore, where the phases were related to different sized developments (starting with the largest). Building in periodic reviews will also better support each subsequent implementation phase through identifying areas of success and continued challenges before moving to the next phase. This will also assist in determining when to possibly move to the next level of development type.

The ability to undertake activities with this principle in mind is contingent on various preceding activities, particularly those around establishing open lines of communication across all levels of industry, and as well, having a problem owner to lead this process and action any changes that emerge from the review process.

8.6 TOWARDS 3D-ENABLED URBAN LAND ADMINISTRATION IN THE CITY OF MELBOURNE: POTENTIAL ROADMAP AND STRATEGIES

This section applies the principles previously discussed to demonstrate how the framework could be used to support the development of a roadmap comprising potential strategies for change to achieve a move towards 3D-enabled urban land administration within the City of Melbourne (CoM).

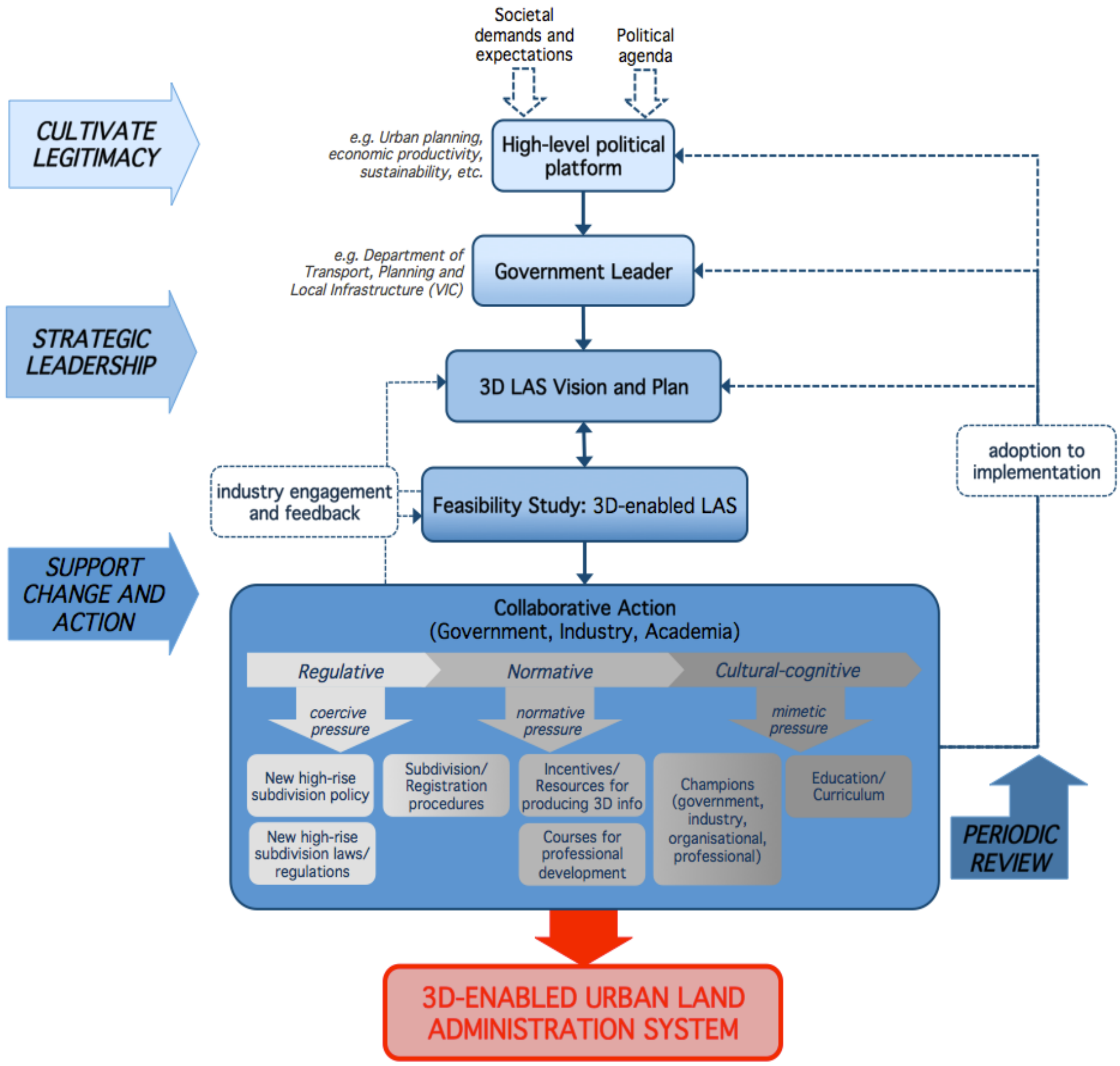

Figure 8.3 Potential roadmap to support change.

8.6.1 Cultivating Legitimacy for City of Melbourne

The move towards 3D-enabled urban land administration cannot be conceived of as a move for and of itself, but one that facilitates broader development objectives. This agenda needs to have a sufficiently visible profile so that its political power can be harnessed to shift organisational legitimacy. It should be at a sufficiently high level that organisations feel a need to conform to changes, or at least appear to do so. It would also need to have the political weight and macro-economic justification to provide a strong platform for pursuing this paradigm change.

The roadmap reflects the likelihood that this will be derived from two main sources: societal demands and expectations, as well as the demands associated with the government's political agenda. Often these are similar, but not necessarily so. Examples of such broader community needs could be associated with productivity, like it is with many BIM initiatives, or it could be more directly relevant to urban development.

Future-proofing the development of cities provides such an agenda. As urbanisation intensifies, the role that cities play in ensuring global economic health is solidifying. Currently, the top ten urban regions of the world, where less than three per cent of the world's population lives, generates more than 20 per cent of the world's economic activity (Florida et al, 2009), and Australia's high rates of urbanisation concentrated within its 11 cities enables the country to contribute almost one per cent to the global GDP; by 2025, 60 per cent of the world's GDP will be generated from the top 600 cities in the world (Dobbs et al, 2011).

Economic development has been identified as one of the seven strategic goals of CoM's local council (Melbourne City Council, 2013c). It also features significantly in Future Melbourne, a community-driven long-term plan to direct the development of the city. A recent report by Kelly and Donegan (2014) showed that Australia's economic success was being powered almost wholly by its cities, where "Eighty per cent of the value of all goods and services produced in Australia is generated on just 0.2 per cent of the nation's land mass – mostly in cities" (p. 1). In the report, the authors noted that the capital city of Melbourne contribute 81 per cent ($216.3 billion) of the state of Victoria's economic activity for the period 2011 to 2012. CoM contributes almost 25 per cent towards this activity (generating economic activity valued at $53.9 billion), making it the most economically significant municipality in the state of Victoria.

The importance that is being placed on economic development through development of the built environment is also evident from the state's Minister of Planning's decision to intervene in the regulatory process for large high-rise developments. The use of these developments for residential purposes has driven an exponential increase in the development of super dense city blocks (blocks that have between 150 to 500 homes per hectare) – from just three in 2002, to a projected 37 by 2015 (Butt and Zhou, 2014). Social sustainability and cultivating a sense of community in such high-density environments will likely rely on negotiating private and communal property RRRs and therefore place increasing pressure on stakeholders in the land administration industry who are responsible for defining, designing and registering these RRRs.

Concepts around smart cities, urban ecosystems and intelligent decision-making are gaining traction because they are responsive, recognise and respond to the unique challenges and opportunities of urban environments. These concepts reflect philosophies aimed at future-proofing cities by tapping into the growing connectivity that is being facilitated by technology, by leveraging the volumes of data and information for decision-making, by offering a vision tailored to the importance and idiosyncrasies of cities as powerhouses of economic and social capital.

For places like CoM and Singapore, these philosophies are a way to ensure that cities are ready for the challenges of the future. These philosophies are predicated on technology and information, and 3D land and property information is likely to be a key pillar as it offers a way to integrate information about all aspects of the built environment.

8.6.2 Government Leader

Such an agenda then raises questions as to where leadership should lie. Constitutionally, responsibility for land and property within Australia lies with the state governments. Currently, the Department of Transport, Planning and Local Infrastructure appears a logical fit with regulatory activities regarding planning, registration and management all subsumed under this department, albeit within different business units. The Department also reports to the state's Planning Minister, who is currently heavily involved with large-scale developments, and who has positioned urban high-rise development as a key investment for the economic future of the state. The land registry currently sits within this Department and it may be that the convergence of planning and development bureaucratic structures might finally deliver the change process with the much-needed key strategic actor.

8.6.3 Developing a Feasibility Study

The development of a feasibility study should aim to provide a test environment that attempts to mimic the conditions of a 3D-enabled operating environment. The reliance and perceived centrality of the legislative framework for recording and representing land and property RRRs creates a more conservative approach to change. Such a strategy would provide a fairly low-risk approach to testing capacity and current tolerance to change and to help the land registry determine how new rules, new practices and processes, and new information products could be developed to suit the needs of stakeholders.

For CoM, the existence of the separate Ministerial process for assessing planning applications for developments in excess of 25 000 square metres provides a potential starting position. This process specifically targets those developments that are particularly challenging, high-value and increasingly inclusive of a residential function. In addition, 3D models of potential developments are currently already being requested for impact analysis, which indicates there are in place, expectations around this technology.

Restricting change to these buildings for now also tests the ability to divide the current subdivision and registration system into two streams. The first stream preserves the processes and practices currently used and which effectively serves the needs of most land subdivisions. The second stream targets the more complex building subdivisions, which although is small in number, underpins high-value investments and are the very buildings where issues lie. This enables legitimacy to be built around a way forward that does not undermine nor interfere with the current system.

A feasibility study would ultimately provide a test-bed to facilitate better understanding of how surveyors, land registry and local government, and increasingly, strata managers and the broader community, might use and interact with these models for land administration purposes as well as community management. It would also help illustrate in greater detail where and how changes might need to occur, and the implications this might have on the development of strategies that would make 3D-enabled urban land administration a reality.

8.6.4 A Collaborative Approach to Change

Although the roadmap recommends a strategic leader, change is also very much dependent on a collaborative approach that sees engagement across government, industry and academia.

The case studies have shown that industry engagement is a vital component of change as it can be a multiple source of institutional pressure, depending on the nature of the engagement. Additionally, the engagement of industry is also important as it creates ownership of the solution and can be a motivating factor to stimulate conformity to change. If lead professional organisations are involved, this can also provide legitimacy around the proposed solution.

The complexity of the information being produced out of the urban environment, and the complexity of the dynamics between stakeholders – particularly if true integration is to occur across development and management of buildings, requires integrating structural, legal and functional aspects of buildings. To this extent, academia can play a role in fostering both technical and non-technical understanding of issues associated with innovation.

8.6.5 Suggested Areas of Strategic Focus

The nature of the issues raised within the Melbourne case study suggests some key potential areas of strategic focus. These are outlined below.

8.6.5.1 Separating land and buildings to support high-rise subdivision and registration

The case study identified the issue of an emerging tension within current processes, where subdivision and registration processes were perceived to be effective for most developments except for the complex high-rise developments primarily found within CoM.

There is little doubt that a land administration model that continues to treat urban development as being equal to the needs of other less populated and complex regions is not ideal. The range of examples provided in chapter two demonstrated that land subdivisions (either two-lot or broad acre) have different demands to building subdivisions. The tendency for high-rise development to occur in areas of higher land value such as cities also places greater pressure on demands for more responsive processes.

An undertaking to separate subdivision and registration of land and buildings and treat them as separate processes can provide the room needed for making changes. It enables legitimacy to be built around a new process that does not detract, nor undermine the legitimacy already established around current processes. Such an approach also presents an strategy with less risk attached since the stability of the current system is not seen to be threatened to support a small, albeit significant, proportion of development.

This would also require new ways of sense making, foremost of which might be linked to a discontinuation of the use of the concept of the land 'parcel' for organising land and property information related to complex building subdivisions and the development of new terminology. Within CoM, the term 'base property' is used, suggesting that the concept of 'property' may be more appropriate as a basic unit, especially as it provides the flexibility for referring to a range of different property types that may exist in the same development.

8.6.5.2 Authority for high-rise subdivision and registration

The emphasis that stakeholders placed on the importance of the legislative framework in subdivision and registration suggests that a reasonable starting point for change would likely be a legislative review.

From a reactive perspective, the interviews suggest that since expectations around how surveyors practice are closely linked to the regulatory framework, this would be a key mechanism for constructing legitimacy around a 3D paradigm. It is also likely to be necessary and timely, as the legislation governing subdivision was developed for a time in Melbourne's history where something such as a super dense block was not in existence.

At the same time, while there is nothing specifically wrong with the registration process at the moment, since even the large developments are being examined and registered within recommended statutory timelines, a proactive perspective suggests that the current context of development warrants a consideration of what the regulatory role of the land registry should be into the future with regards to complex high-rise developments.

8.6.5.3 Responsibility for high-rise subdivision and registration

The current fragmented model around development and management of high-rise buildings should be challenged. What is the regulatory purpose for separating the frameworks governing development (the *Planning and Environment Act 1987*) and use (the *Subdivision Act 1988*)? Are the reasons, if they exist, still relevant? Within CoM, the local council has indicated that almost all developments apply for permits under both Acts simultaneously, suggesting that from a community's perspective, and indeed, the council's own requests for both applications to be lodged together where applicable, expectations around a more holistic approach are developing organically.

Additionally, how would these pieces of legislation interact with the *Owners Corporation Act 2006*? The range of issues indicated by strata managers in the Melbourne case study suggests that a process that links development with management stands to deliver substantial benefit to communities of interest. This would serve to limit potential issues regarding how the design of boundaries that define the layout of private and common properties might impact on amenity and to recognise the role that strata managers play in facilitating liveability in vertical communities.

8.6.5.4 Industry (human) capital to support high-rise subdivision and registration

The profile of surveying firms engaged with developments within CoM, alongside broader trends that show a greying profile of the surveying profession, indicates that the profession is in need of capital development. This is likely to involve considerations around curriculum development at tertiary level, but also short-term professional training for qualified surveyors. The Allen Consulting Group (2010) estimated the involvement of surveyors in the network of stakeholders involved with building development to be less than two per cent (in terms of employment). It would therefore appear necessary that any effort to build capacity within the profession needs to be aligned with broader knowledge trends pertaining to the development of high-rise buildings – an obvious example being conversant with the processes and technologies around Building Information Models (BIM). To do otherwise puts the profession at risk of being isolated from broader trends in the construction and development sector, and being perceived by the community to be out-of-step.

8.7 CHAPTER SUMMARY

This chapter provided a discussion of the outcomes of the case studies in their own right, before proceeding to perform a cross-case analysis and synthesis to support the derivation of some generalised outcomes.

The potential links between the case study conclusions were identified and discussed to demonstrate potential correlations between invisible constraints and strategic choices. This provided the basis for the development of a framework comprising four institutional principles recommended for supporting strategic choices in the design and development of activities to support change. These principles were then applied to demonstrate how it could support the development of a roadmap and associated strategies that could potentially be used to support the shift towards 3D-enabled urban land administration in the City of Melbourne. However, it is also likely that these outcomes could be applicable to other jurisdictions within Australia, and potentially around the world, which exhibit similar urban development characteristics and institutional environments.

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CHAPTER 9

CONCLUSION AND FUTURE DIRECTIONS

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9.1 INTRODUCTION

This concluding chapter of the thesis summarises the main conclusions and outcomes of the research to demonstrate that the main aim and objectives of this research has been met. This provides a platform for presenting an outlook for the future, including potential areas for further research.

9.2 ADDRESSING THE RESEARCH PROBLEM

The main aim of this research, as set out in Chapter 1 was:

> **To investigate the current environment underpinning urban land administration to identify potential institutional barriers to 3D innovation as well as potential strategies to support change.**

Both case studies undertaken as part of this research were designed specifically to meet this aim. The first component of this aim was met through the case study on the City of Melbourne. This was a detailed study into the current environment underpinning urban land administration, focusing on the processes of subdivision and registration of high-rise ownership information. Through the use of publicly available as well as organisational documents, detailed interviews and participant observation, the research explored how those institutional elements that underpinned and influenced the production, management and use of 2D subdivision information, i.e. the plan of subdivision, could also be perceived as a range of regulatory, normative and cultural-cognitive constraints on efforts to leverage 3D innovations.

The second component of the aim was met through a secondary case study on Singapore, where emphasis was on understanding why and how strategies elicited a positive response to change that facilitated 3D innovation. The case study environment encompassed broader land development, which is considered a key function of land administration but is not related to cadastral systems. Therefore the innovation in question was the use of 3D Building Information Models (BIM) to support the regulatory process of compliance checking. Interviews with a cross-section of stakeholders, including the lead government agency, provided the basis for firstly identifying the range of strategies used to support 3D innovation, but also in understanding stakeholders' perceptions as to why certain strategies were successful.

Since the analysis of both case studies was based on institutional theory, cross-case analysis and synthesis of the main outcomes from each case study site supported the extrapolation of the findings. These were used to develop a cyclical framework of four effective principles that are likely to be more broadly applicable to underpin the selection of strategies for change.

The viability of this framework was demonstrated when the principles were applied to the City of Melbourne to show how they could support the design of a potential industry roadmap as well as help identify potential strategic choices to support change towards realising 3D-enabled urban land administration in Melbourne, and potentially other jurisdictions with similar urban development characteristics.

The success of the research in meeting its aim is also based on the sequential process of meeting the research's five research objectives. These objectives were defined in chapter one to be:

1. **Identify** the strengths and weaknesses of the current 2D paradigm relevant to urban land administration.
2. **Identify** an appropriate theoretical framework that supports investigation and pursuit of the research aim and objectives.
3. **Explore** the current land administration environment to **identify** those institutional elements that pose as barriers to 3D-enabled urban land administration.
4. **Explore** an instance of a 3D-enabled urban land administration environment to **identify** the institutional aspects of strategies that have produced a positive response to change.
5. Based on the findings, **recommend** potential strategies for responding to institutional barriers in the land administration industry to support change towards realising 3D-enabled urban land administration.

9.2.1 Research Objective One

> Identify the strengths and weaknesses of the current 2D paradigm relevant to urban land administration.

Chapter two drew on literature from a range of sources to provide the context for meeting this research objective. It was first necessary to provide an overview regarding the increasingly complex development within urban areas, specifically in the prolific use of high-rise buildings as a response to infill housing in city centres, as this has been the primary motivation for driving awareness and acceptance regarding the limitations of current 2D-based practices and processes for representing complex ownership situations defined in 3D.

A review of the current literature relevant to 3D-enabled cadastral systems and 3D-enabled urban land administration provided the basis for understanding the strengths and weaknesses of these current 2D-based practices and processes – effectively, the 2D paradigm – relevant to urban land administration. The literature review showed that the building block of cadastral systems, the land parcel, effectively an area-based 2D concept for defining ownership RRRs, is increasingly dissonant with the volume-based definition requirements of complex urban RRRs. The chapter used real examples from Victoria, Australia, to demonstrate ways in which the 2D paradigm manifests. For countries like Australia, it appears the 2D paradigm is effective for most ownership situations associated with land subdivisions, but is not coping with the increasingly complex building subdivisions becoming common in cities. This indicates that urban land administration should be considered a very specific subset of land administration practices.

Although the 2D paradigm may still be able to accommodate the registration of 3D RRRs, it is limited in its ability to clearly and unambiguously represents these RRRs, with ramifications for visualising such information in cadastral maps and facilitating the community's understanding of the nature of these RRRs. The chapter presented ways in which land administration systems around the world are developing ways to deal with 3D properties and 3D RRRs, but these are very much still based on 2D, extant practices. Reasons for the persistence of the 2D paradigm was provided, supported by the use of real life examples.

9.2.2 Research Objective Two

> Identify an appropriate theoretical framework that supports investigation and pursuit of the research aim and objectives.

The **second objective** was met through the identification and justification for the use of institutional theory, the arguments for which were presented in chapter three. Institutional theory, specifically the use of organisational theory was appropriate for several reasons. Firstly, it underscores the current lack of a sociological position from which to pursue this research agenda, potentially resulting in the current dearth of knowledge around the central problem of this research. Secondly, the growing use and acceptance of organisational institutionalism reflects recognition that the technical and the institutional environment cannot continue to be explored in isolation.

9.2.3 Research Objective Three

> Explore the current land administration environment to identify those institutional elements that pose as barriers to 3D-enabled urban land administration.

The **third objective** was met through the case study on the City of Melbourne. Chapter six reported the findings gathered from 34 interviews conducted across a range of stakeholders, attendance at various industry seminars and workshops, placements with two different government organisations and a short questionnaire conducted with strata managers. These avenues all provided opportunities of varying depth, intimacy and scope for understanding the range of social and cultural issues around the production, use and management of land and property information – in this instance, the plan of subdivision relevant to complex building subdivisions.

Institutional theory provided a sensitising mechanism for the interpretation of the key themes that emerged from the case study. This enabled the themes to be interpreted in the context of regulatory, normative and cultural-cognitive constraints – the 'invisible' constraints that exert significant influence on stakeholders to constrain them to current 2D ways of working. Importantly, the cumulative effect of these constraints led to the conclusion that change remains difficult as there is currently limited legitimacy developing around the need for change, a likely consequence of a system that is widely regarded to have worked well in the past, and is still in good order – except when it comes to the complex building subdivisions prolific within the boundaries of the City of Melbourne.

9.2.4 Research Objective Four

> Explore an instance of a 3D-enabled urban land administration environment to identify the institutional aspects of strategies that have produced a positive response to change.

The **fourth objective** was met through the case study on Singapore. Chapter seven reports the findings gathered from 15 interviews conducted in Singapore, supplemented by a range of secondary data sources. Again, institutional theory was used as a sensitising mechanism for the interpretation of the key themes that emerged from the case study. Key themes regarding the institutional aspects of successful strategies were interpreted to stem from the ability of these strategies to exert institutional pressure. Institutional pressure could be exerted in the form of coercive, normative and mimetic pressures on stakeholders to incentivise, compel and motivate conformity to changes. However, the strength of these pressures can also be affected positively or negatively by existing environmental conditions. Fundamentally, the case study demonstrated that key enablers for change lies with the ability to construct legitimacy around the need for change and having a key strategic actor to focus and direct efforts to realise change.

9.2.5 Research Objective Five

> Based on the findings, recommend potential strategies for responding to institutional barriers in the land administration industry to support change towards realising 3D-enabled urban land administration.

The **fifth objective** was met through undertaking a cross-case analysis to synthesise and extrapolate the findings from both case studies to support the development of a framework of strategic principles to support change, as presented in chapter eight. The potential utility of this framework was indicated through an application of the principles to the City of Melbourne to show how this framework could stimulate the design and development of a roadmap for the land administration industry to progress efforts to realise 3D-enabled urban land administration. These outcomes are arguably likely to be applicable to other jurisdictions that exhibit similar characteristics.

9.3 RESPONSE TO THE RESEARCH PROBLEM AND MAIN OUTCOMES

The research problem defined in chapter one (section 1.4) recognised that adoption and implementation of 3D technologies in the land administration industry will enable accurate, authoritative and unambiguous recording and representation of 3D land and property RRRs, which is fundamental to ensuring security, comprehension and ongoing commoditisation of complex vertical tenure arrangements common in urban environments. However, the ability to achieve this is being inhibited by existing institutional issues that support and reinforce the use of 2D-based land administration practices and processes.

Through exploratory investigations, this research has confirmed that this problem indeed exists. The literature suggests that legislative frameworks are the main institutional issue; however this research has shown this not necessarily to be the case and that the law is often sufficiently flexible or sufficiently vague to accommodate practices that leverage 3D technologies. Instead, the research identified various elements in the current institutional environment that presented deep-seated and difficult barriers to change, including the history and tradition of using 2D methods among the professions, a focus of current land administration processes on registration instead of meeting community needs, the fact that high-rise buildings are a minority, and finally that there is no ownership around resolving current issues despite acknowledged limitations of current practices. It also went on to identify the institutional bases for successful strategies to support change, particularly those that were especially responsive to the nature of the land administration industry.

The findings were generalised to support the development of a framework of strategic principles to show how these could be used to address institutional barriers. The appropriateness of these principles were demonstrated through an application on the City of Melbourne, producing a potential roadmap and supporting strategies for change for the land administration industry that offers a way to guide the industry towards realising 3D-enabled urban land administration systems.

9.4 CONTRIBUTION TO KNOWLEDGE

This research represents one of the first in-depth investigations into institutional issues impacting on the land administration industry's ability to introduce 3D innovations to realise 3D-enabled urban land administration. It therefore provides a contribution to a well-established gap in the current discourse on 3D innovation in the domain of land administration and provides the basis for establishing a new research direction for an agenda that to date has been dominated by technological investigations.

In summary, this research has achieved five key contributions to knowledge:

1. Understanding and defining the strengths and weaknesses of the current 2D paradigm in the context of urban land administration practices around recording and representation of 3D property RRRs.
2. Understanding stakeholder perceptions regarding current 2D-based practices, processes and information products to support high-rise subdivision and registration.
3. Revelation of institutional barriers to 3D innovation within the land administration industry.
4. Revelation of institutional aspects of strategies that produce positive responses to change in the context of 3D innovation within the land administration industry.
5. Development of a framework of strategic principles that can potentially be used to support the design and development of industry roadmaps and associated strategies to

facilitate the realisation of 3D-enabled urban land administration systems.

9.5 FUTURE RESEARCH DIRECTIONS

As an exploratory study, this research provides a platform for developing future research opportunities. Some of these are associated with the limitations of the research and the research design; others aim to extend the work that has been achieved here.

Testing and validating framework of strategic principles

There is opportunity to improve the validity and applicability of the framework of strategic principles developed in this research through further application in a variety of contexts through other case studies. This could also lead to refinement and better understanding of the underlying conditions that may impact on the success of consequent strategic choices.

Developing a new research agenda

This research has argued for the applicability and appropriateness of institutional theory as a basis for understanding social and organisational issues associated with technical innovation and information systems. The use of institutional theory here presents one of the first instances of application in land administration literature. Additionally, the research has argued that there is significant potential for developing further research to develop understanding of how institutional issues impact technical innovation in land administration. This could be achieved in several ways:

- Findings from these exploratory studies can be used to develop hypotheses for further research into institutional aspects of 3D innovation in land administration.
- Research on introducing 3D innovation into cadastral and land administration systems is being investigated in almost 30 countries, presenting significant opportunity for other case studies to be undertaken to build up a critical level of empirical understanding into institutional influences on 3D innovation in land administration. The ability to generate more data would facilitate comparative studies as a way to validate outcomes.
- The research undertaken here was at a very broad, industry level. This suggests opportunities for developing multi-level studies that seek to investigate institutional influences at profession, organisation, process and individual levels. This would establish a basis for a more holistic understanding into how change can be more effectively introduced into land administration systems.

Towards a collaborative urban land administration practice

The research here shows 3D innovation occurring in land administration, differentiated only in terms of the land administration functions: tenure versus development. The research has shown that complex high-rise buildings require a collaborative approach and there is significant scope to apply the institutional framework used here to understand the barriers that prevent such collaboration from occurring. To be able to undertake such research would go a long way towards potentially diffusing successful innovations such as Building Information Models for cadastral purposes.

9.6 RESEARCH OUTLOOK

The research documented in this thesis has drawn on institutional theory to produce new insights into those social and cultural issues endemic to current land administration (particularly registration) practices that constrain efforts to leverage and adopt 3D technologies to better represent the range of rights, restrictions and responsibilities associated with complex 3D properties. Research in this domain has been dominated by systems or survey-practice oriented technical investigations, leaving unattended the social considerations associated with such changes.

Exploratory investigations revealed that resistance to change is essentially associated with a limited build up of legitimacy around the need for change, a consequence of history serving to consolidate and deeply-embed 2D-based practices into the psyche of organisations, professions and industry. This is perceived to be immensely difficult to shift. Yet the research also revealed that it is possible to shift these seemingly intractable institutional issues. The findings suggest that the characteristics of the land administration industry, such as dependency on the state for regulatory approval and the clear dominance of professions, indicate the potential of using strategies that exert institutional pressure to produce conformity to change. Most importantly, the research showed that change was possible if sufficient legitimacy was cultivated around the reasons for change, and this could be directed into clear action through visible, incisive leadership.

It would be foolhardy to expect that land administration systems will remain unchanged for long. The rate of technological progress, the embrace of the digital economy and the panoply of 3D technical applications evident in so many aspects of daily life all contribute to shifting and changing cultural expectations on public sector use of technology. What is in question is the rate and degree of success of change. The purpose of this thesis is to provide the land administration industry with the beginnings of an institutional framework to support their understanding of invisible constraints on innovation, which can only lead to an improved ability to make appropriate strategic choices to establish 3D-enabled urban land administration systems. These systems will be fundamental to future-proofing the property rights of urban populations and safeguarding the ability to capitalise on cities as economic assets.

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APPENDICES

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APPENDIX 1. PLAIN LANGUAGE STATEMENT

The following text constitutes the content of the Plain Language Statement sent to potential participants in the research.

Introduction

You are invited to participate in the above research project, which is being conducted Prof. Abbas Rajabifard (supervisor) and Ms Serene Ho (PhD candidate) of the Centre for Spatial Data Infrastructures at the Department of Infrastructure Engineering, University of Melbourne. This research project is part of an Australian Research Council (ARC) Linkage Project investigating land and property information in 3D and will form part of Ms Ho's doctoral thesis. Please note that this research project has been approved b the Human Research Ethics Committee at the University of Melbourne (ID. 1238295.1).

What is the aim of this project?

The aim of this research is to map and understand the prevailing institutional environment underpinning land and property information, hypothesising that the use of 3D land and property information can be a potential conduit for ameliorating inefficiencies in current processes if the mechanisms of the current environment are understood. The project will use the Institutional Analysis Development Framework as the main methodology for structuring empirical data collection and analysis.

What will I be asked to do?

(*Insert organization name*) has been selected for participation in this research as it has been identified as a key stakeholder in the land development process pertaining to urban developments in the preliminary stages of research. Your organization may also already be an industry partner connected with the broader ARC project. Consequently, your involvement – in the capacity of the professional position that you occupy within this organization – was a consequence of discussions held with our contact in your organization (*insert name and title here*).

Should you agree to participate, you will not be required to do anything that falls outside the scope of your normal daily professional duties. The information and data that is to be collected will be done by observing individuals in their daily professional duties. You may however, be asked to participate in an interview at the end of the observation period to clarify and confirm a diagrammatic representation of the observed actions and behaviours. The observation period is scheduled from (*insert dates and duration here).*

How will my confidentiality be protected?

We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the boundaries of achieving the research objectives and the limits of the law. However, please note that in this type of project it is normal to give the names of people who have contributed information. We would like to seek your permission to use your name in the final thesis. If you would prefer some comments to be made off the record, please indicate accordingly. If for any reason you choose not to be named, we would refer to you by your job title/description, and remove any contextual details that might reveal your identity. Your name and contact details will be kept in a separate, password-protected computer file from any data that you supply. This will only be able to be linked to your responses by the researchers. The data will be kept securely in the Department of Infrastructure Engineering for five years from the date of publication, before being destroyed.

How will I receive feedback?

Once the thesis arising from this research has been examined, a copy of the thesis, along with relevant publications, will be made available online at www.csdila.unimelb.edu.au. It is also likely that the results of the research will be submitted for publication in academic journals and presented at academic conferences.

Will participation prejudice me in any way?

Please be advised that your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

How do I agree to participate?

If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it in the envelope provided or directly in person to the researchers. The researchers will then contact you to arrange a mutually convenient time to discuss observation arrangements.

Where can I get further information?

Should you require any further information, or have any concerns, please do not hesitate to contact either of the researchers – Prof. Rajabifard: 8344 0234, Ms Ho: 8344 0888. Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073, or fax: 9347 6739.

APPENDIX 2. EXAMPLE OF THEMATIC ANALYSIS: CITY OF MELBOURNE CASE STUDY

EMERGENT THEMES	SUB-THEMES	AGGREGATED THEMES	EXAMPLES OF INITIAL CODES/THEMES
HISTORY AND TRADITION OF 2D	2D methods mostly work	Stretched to limits	Limits of current practices; architectural challenges of modern buildings
		Process mostly works	Process works well for most buildings
	Used to 2D methods	Think in 3D	Personal ability; proficiency with 2D information
		Personal practices	Personal approach; capacity for change; comfort with technological change
		Don’t want to learn new ways	Industry demographics; aging profession
	2D entrenched in legislation	Accuracy enshrined in legislation	Mandates on behaviour; adherence
		New subdivision regulations	Prescriptions; address legislative shortcomings
		Process a function of legislation	Strong influence of legislation on process; Behaviour a function of process
SEPARATION OF DEVELOPMENT AND MANAGEMENT	Focused on registration	Surveying-relevant terms and principles Does not take into account management needs	Old-fashioned terms; surveyor-centric; regulation of common property management
	Not meeting community needs	Abstract nature of information	Relativity of boundaries; abstract concepts; need structural info; takes a long time to understand; daunting; not everyone can easily understand
		Abstraction too simplistic	Simplification; lose details

EMERGENT THEMES	SUB-THEMES	AGGREGATED THEMES	EXAMPLES OF INITIAL CODES/THEMES
		Cognitive challenge	Cognitive issues; abstracting reality; visualising; logical issues; 2D not an effective format; examination and registration
		Different concepts of property	Property vs. parcel; point of view; subdivision plan cater to different needs; different applications need different types of land information
		Plans unsuitable for other purposes	Traditional professional practices in encoding information difficult to understand; clarity; no room for misinterpretation; format; concepts; location of services; limitations of older plans
		Inconsistent forms of plans	Unclear representation of private and common property; lack of clarity; insufficient information
		New ownership situations not represented consistently	New ownership situations represented inconsistently
		Queries from public	Community issues; impact; terminology and concepts; ambiguity
		Relationship with OC Act	Design of common property and creation of OC in subdivision plan affects management; unclear representation of private and common property
	Information flow between development and management	Design impacts on management	Importance of design stage; pre-app meetings at local council; use of 3D models for decision-making
		Different sets of info	Lack of integrated source of information; different sets of plans; different professions involved; different building characteristics; no overall representation
		S32 changes	Lots of changes during building lifecycle; ongoing changes to boundaries; re-subdivision; lack of formal communication process
		No opportunity for strata managers to be involved	Involvement of strata managers in design

EMERGENT THEMES	SUB-THEMES	AGGREGATED THEMES	EXAMPLES OF INITIAL CODES/THEMES
SOMEBODY ELSE IS THE PROBLEM	Surveyors responsible for what is in plans	Quality of information in plans	Ambiguous;
	Land registry as key actor	Convince land registry	Land registry as key stakeholder; unilateral issues relevant to building subdivisions
		Legislative foundation	Land registry has legal mandate for implementing relevant legislation
CHANGE OPPORTUNITIES			Local council activities; developer initiatives; state planning 3D models; state planning requirements

Table 10.1. Sample of how initial themes were abstracted and aggregated to support theme development in Melbourne case study (chapter six).

Emergent themes	Sub-themes	Examples	Notes/Observations
HISTORY AND TRADITION OF 2D	2D methods don't work for big buildings	"3D helps when things aren't on the same plane"	Demonstration of practices
	Used to 2D methods	"Lots of surveyors getting to retirement and don't want to learn new ways" "Requires a mindset shift"	Some participants observed to be very comfortable with 2D plans, but reluctant to consider 3D models.
	2D entrenched in legislation	"...fairly rigid process...set in legislation so it's difficult to change"	
DEVELOPMENT VS. MANAGEMENT	Focused on registration	"External wall may make sense from surveyor's point of view, but not from management point of view" "Strata managers should be involved right at the start" "We don't get notified of changes to accessory lots e.g. swapping car parks, which may change units of liability" "Section 32 of the Subdivision Act [Resubdivision of boundaries] permits changes that are not captured other than on title"	Interpretation and understanding of who is responsible for what compounded by different sets of (2D) plans, all drafted according to respective professional standards, no overall representation of the features of the building on one set of plans (ID-LC-03) no catalyst in the process to alert other stakeholders to changes e.g. swapping accessory lots (car parks and storage spaces), re-subdividision or amalgamation of lots throughout a building's lifecycle, particularly those zoned for commercial purposes (ID-LC-03)
	Not meeting community needs	"we have a property view of the world, not parcel" "Recent plans are much more user friendly… show an understanding of the [Owners Corporation] Act and how it is enforced concerning boundaries and practicalities and cost sharing/responsibility" "...because engineering assets are privatised, we need to have a better way of coordinating all the things happening underground" "That's unintelligible to anybody except for Titles [Office]… nobody outside (of) Titles Office and surveyors understands vinculums]"	In one visit to a large mixed-use development, a building manager showed how he had drawn all the accessory lots shown on the plan of subdivision using a spreadsheet program – in effect creating a digital plan – just so he could easily search for spaces (ID-LC-05) increasing number of public stakeholders (VicMap Property statistics; G-s09).

Emergent themes	Sub-themes	Examples	Notes/Observations
		"We receive on average 350 subdivision queries – approximately 15 to 20 per cent of all queries"	
LACK OF A KEY STRATEGIC ACTOR (or WHOSE PROBLEM IS IT?)	Surveyors responsible for what is in plans	"Building surveyors need to learn how to write up plans properly so they can be clearly read and understood. Creating 3xOCs for a block of 4 units is crazy." "Sometimes the boundaries between common and private property are still unclear... we have had to seek advice from the original surveyor"	Strata managers feel surveyors should bear greater responsibility for ensuring consistency of information in plans (strata manager questionnaire responses)
	Land registry as key actor		Complex buildings only make up a small percentage of applications going through land registry, and there was a sense from industry stakeholders that it would not be easy to convince land registry to change a process for a relatively small number of buildings (ID-LC-07; ID-LC-08).

Table 10.2. Examples of recording of quotes and observations relevant to the various themes in Melbourne case study (chapter six).

APPENDIX 3. EXAMPLES OF THEMATIC ANALYSIS: SINGAPORE CASE STUDY

EMERGENT THEMES	SUB-THEMES	AGGREGATED THEMES	EXAMPLES OF INITIAL CODES/THEMES
GOVERNMENT LEADERSHIP	Mandatory measures	Mandate as a driver; regulated changes; regulation	Regulatory lever; trigger; initial step; mandatory BIM models; compliance checking
	Resources	Templates; guidelines; funding schemes; capacity development	Guidelines; templates; need incentives; training; education; grants; carrot and stick;
	Step-by-step approach	Phased implementation	Small things; step-by-step operation; catalyst; push from government; roadmap
CREATE LEGITIMACY	National agenda	-	IT2000; productivity through IT; national agenda; pro-technology/pro-innovation; skill-based industries
	Industry engagement	-	Experts; working groups; colleagues; peer pressure; supported by private sector; BIM leaders
ORGANISATIONAL CULTURE	Right mindset	Right attitude; BIM mindset	Take a step; cultural baggage; right attitude; right BIM mindset; paradigm shift; preparing for the future
	Champions	Internal leadership; industry BIM leaders	Organisational leadership; BIM leaders; captain in an army; senior management
ENVIRONMENTAL CONDITIONS	Societal attributes	Societal characteristics	Conformity; subservience; do-as-told; industry players ‘spoilt’; need incentives; small; easy to manage; contractors asking for BIM; preparing for the future; wait-and-see approach
	Existing conditions	Preconditions for change	Paper to electronic environment; technical infrastructure; legislation

Table 10.3. Sample of how initial themes were abstracted and aggregated to support theme development in Singapore case study (chapter seven).

EMERGENT THEMES	SUB-THEMES	EXAMPLES
GOVERNMENT LEADERSHIP	Mandatory measures	"Use regulatory lever to force change" "Regulation should be about coordinating stakeholders because there is such a diversity of requirements."
	Resources	"...and they have thrown in $250 million." "The regulatory part, if I don't have the incentives, will make people very angry. It's intended that while I have the regulatory lever, I have to make sure that you are also very happy to comply. Otherwise I actually do not need the fund at all, I just have to regulate it and you still have to comply...it's to soften the blow." "It's (the resources, guidelines) successful, the take-up rate is there. It's...the education is part-funded, so people do go for it. It's successful in a way." "BCA incentives gives us a bit of help, without it would be slower."
	Step-by-step approach	"Things we need to do, build up: network infrastructure, information infrastructure and e-submission process" "BCA is doing a step-by-step operation. You can't push it all at once. There is a roadmap. They know it's difficult to push. That is working well in Singapore" **"**It's the small things that are driving BIM adoption**"**.
CREATE LEGITIMACY	National agenda	"Productivity driver is only for us today, it's only a lever". "we are forced to do it because there is a national agenda, we have to cut down manpower" The problem is how to leverage IT to improve national productivity, of which construction was one of the sectors"
	Industry engagement	"Although it's BCA-led, they say it's supported by the private sector. They have committees that's made up of private sector and they'll say, "Your colleagues have said that..."" **"...**get industry together to sign an MOU to collectively work on data format (CPA3/standards) – want to organise ourselves in some structure and info layers"

EMERGENT THEMES	SUB-THEMES	EXAMPLES
ORGANISATIONAL CULTURE	Right mindset	"Some are keen to embark, lots of challenges especially staff turnover" "We are preparing ourselves for the future when people tender in BIM" "I don't think skill is a big problem, the only thing is whether you want to do it or not...whether I want to take a step or not" "The first is that the culture of the people that they have is there – they have the right BIM mindset, they know how to use it, they are not sceptical, they have the responsibility to design and model properly and populate the right information." "Mindset is the common challenge e.g. always comparing to CAD, to fully adopt BIM, it is easier to not have any experience. To successfully build a BIM model, need construction experience."
	Champions	"BCA was a push but almost every client is asking for BIM; contractors also asking for BIM" "You need support from top management and you need a key person – like a captain in an army" "To be frank, yes [re. whether organisational champions are necessary] – only then will it work. We've seen this in Ascendus, in CapitaLand...the thing is, it depends on the capability of this person to influence his top management and influence his bottom people. That also defines how the BIM is working" "Most staff trained in BIM; management pushed for all projects to be in BIM. Important that management pushed BIM – push training, also conduct in-house training, hands-on experience."
ENVIRONMENTAL CONDITIONS	Societal attributes	"Yes, we are small, easy to manage. We are in a conformist society so we don't question. "Private sector just follows whatever BCA is asking." "We are much smaller, it's easier." "We are unique – most countries don't provide subsidies." "If government mandates, people will adopt; otherwise will look to cut corners" "Singapore is very unique: we need incentives for things to move. Our industry players are very spoilt."

EMERGENT THEMES	SUB-THEMES	EXAMPLES
	Existing conditions	"...lucky we are already on the high tech wave" "Fortunate in a sense that we had already moved to an electronic environment. That helps a lot" "CORENET has been the push since 1994."

Table 10.4. Examples of recording of quotes and observations relevant to the various themes in Singapore case study (chapter seven).

APPENDIX 4. STRATA MANAGERS' QUESTIONNAIRE (VIC)

MANAGING STRATA PROPERTIES

A SURVEY TO CAPTURE A SNAPSHOT OF RELEVANT INFORMATION ISSUES FROM THE PERSPECTIVE OF STRATA MANAGERS

THE UNIVERSITY OF MELBOURNE

CSDILA
THE CENTRE FOR SPATIAL DATA INFRASTRUCTURES & LAND ADMINISTRATION

Land and Property Information in 3D

The University of Melbourne is currently conducting a research project investigating the use of three-dimensional (3D) modelling of land and property information. The ***"Land and Property Information in 3D"*** project, undertaken at the Centre for Spatial Data Infrastructures and Land Administration, explores the use of 3D digital models of land and property information as a tool to facilitate understanding of ownership and management of multi-storey residential properties. As part of the objectives of this project, this questionnaire aims to capture a snapshot of some of the issues regarding the management of strata in multi-storey properties in Victoria.

This questionnaire consists of four short sections comprising 20 questions in total. The sections aim to collect information regarding demographics, experience with strata management, management issues and information issues. The questions require short answers or selection of multi-choice answers; however, in some instances we encourage you to provide extended comments. ***This questionnaire should take approximately <u>10 minutes</u> to complete.***

We appreciate your voluntary participation in this study. However, should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice. The information that you have provided will be kept confidential subject to any legal requirements. In addition, please note that if you are in a dependent relationship with any of the researchers your involvement in the project will not affect ongoing assessment and management. The results of the questionnaire will be stored at the University of Melbourne in a secure database and will be destroyed after five years.

Thank you for your participation and input to this questionnaire.

Serene Ho
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☐ **I hereby provide INFORMED CONSENT to take part in this questionnaire.** *

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SECTION 1: DEMOGRAPHIC INFORMATION

1. Name of organisation:

2. Your position in your organisation: ***(mandatory question)***

3. Contact details (phone or email):

SECTION 2: STRATA MANAGEMENT EXPERIENCES

4. What is the length of your experience in managing strata properties?

- ◯ Less than 1 year
- ◯ Between 1-3 years
- ◯ Between 3-5 years
- ◯ Between 5-10 years
- ◯ More than 10 years

5. How many properties do you currently manage?

6. What proportion (%)of these properties are multi-storey* developments?

**The Building Commission of Australia defines a multi-storey residential building as one that has more than three (3) storeys containing two (2) or more separate dwellings.*

7. What type of properties do these multi-storey developments tend to be (please tick the most common type)?

- ◯ Residential
- ◯ Commercial
- ◯ Mixed-use
- ◯ Other:

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8. In which suburb(s) are these properties mostly located?

9. Please describe the characteristics of the largest multi-storey property that you currently manage:

No. of blocks/towers:	
Average no. of storeys per block:	
No. of residential lots:	
No. of commercial lots:	
No. of car spaces:	
No. of storage lots:	
No. of Owners Corporations:	
Other comments:	

SECTION 3: MANAGEMENT ISSUES

10. In your experience in managing multi-storey developments, what is an approximate proportion of the types of issues that tend to occur?

Administrative issues (e.g. fee recovery, etc) (%)	
Non-administrative issues (e.g. maintenance, repairs, etc) (%)	

11. Of the non-administrative issues, please list the five (5) most common issues (e.g. noise, pets, building defects, etc). Please list them in order of frequency of occurrence (with 1 being the most frequent).

1	
2	
3	
4	
5	

2

12. Why do you think these issues arise?

13. How have you resolved these issues?

- Owners Corporation meetings
- Face-to-face interaction
- Mediation
- VCAT
- Other methods:

14. Would you describe the multi-storey development(s) that you manage as being complex?

- Yes
- No

Please provide a short explanation in support of your answer.

15. In your opinion, do you believe owners fully understand the implications of apartment ownership?

- Yes
- No

What aspects do owners tend to understand or not to understand (e.g. communal living, boundaries, etc)?

16. In your opinion, do you believe that current legislation adequately supports the needs of strata ownership?

- Yes
- No

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Please provide a short explanation in support of your answer and any suggestions you may have.

SECTION 4: INFORMATION ISSUES

17. Are the Plans of Subdivision important to your role?

- ◯ Yes
- ◯ No

Please provide a short explanation in support of your answer.

18. Do you use the Plans of Subdivision to help resolve issues such as those raised previously?

- ◯ Yes
- ◯ No

Please provide a short explanation in support of your answer.

19. What other sources of information do you tend to use and why?

20. In your opinion, could the Plans of Subdivision be improved?

- ◯ Yes
- ◯ No

Please provide a short explanation in support of your answer.

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Thank you for taking part in our survey.

Your response is very important to us. If you are willing to be contacted by our researchers to expand on your responses, please provide your details below.

First Name:	
Contact (phone/email):	

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