Cadastral Data Modelling -

A Tool for e-Land Administration

By

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DECLARATION

This is to certify that the thesis has not been submitted for a higher degree to any other university or institution. The text does not exceed 100,000 words.

Parts of this work were published in books, journals and refereed conference proceedings as listed in Appendix 1.

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Saeid Mohsen Kalantari Soltanieh

ABSTRACT

Administration of land is challenged by the increasing need of clients for land information and by the creation of new land related commodities and interests. Existing modern electronic land administration (e-land administration) systems, including the latest ICT enabled systems, are not sufficiently flexible to accommodate new interests in land and complex commodities. Nor do they respond to the increasing needs of end users.

In this context, firstly, most land administration systems do not recognise the new interests in land such as informal and customary rights, water rights, biota rights, and noise restrictions. A limited number of interests in land have historically been organised in cadastres, with land parcel based data models providing the basic building block of land administration systems. Despite the relative success of the parcel based data model, it is now under pressure from the new land related commodities (e.g. 3D titles, water, biota and carbon credits) and interests in land (e.g. rights, restrictions and responsibilities). In future, the parcel based organisation of interests in land must be refined as new interests such as biota, carbon, and water have different technical characteristics. Parcel based indexing of interests in land cannot accommodate interests that are not necessarily equivalent to the extent of land parcels.

Secondly, many ICT based land administration systems are now outdated, and the maintenance of these systems is complex and expensive. Future land administration requires a comprehensive view on the utilisation of ICT. ICT should not be used in an isolated manner in each of the components and should be holistically and dynamically instilled into land administration components, so that they can communicate with each other in an efficient and cost effective manner and remain up to date. Interoperability is therefore a serious issue to be considered when enabling future land administration by ICT.

These all challenge the traditional land administration approach and reveal serious gaps in current cadastral data models. Current cadastral data models are, firstly, not sufficiently flexible to incorporate the increasing number of interests and new commodities in land and, secondly, do not facilitate interoperability between different types of cadastral data in order to meet end users' needs.

This research proposed that the data model based on the physical land parcel be replaced by a spatially-referenced data model based on the legal property object. The proposed data model is more comprehensive, capable of organising a wider range of interests, and should facilitate wider exchange of information. The legal property object is open-ended and can include complex commodities and all kinds of rights, restrictions and responsibilities. Spatially referencing these objects facilitates interoperability in land administration system.

The proposed data model was successfully developed and implemented with reference to the requirements of the international specifications in spatial domain and global statements in land administration. The model then was assessed against future land administration and effectively responded to its requirements.

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List of Acronyms

ABS	Australian Bureau Of Statistics
ACT	Australian Capital Territory
ADB	Asian Development Bank
ALB	Automated Real Estate Register
ALK	Automated Real Estate Map
ALKIS	Official Cadastral System
API	Application Programming Interface
ASCII	American Standard Code For Information Interchange
ATKIS	Authoritative Topographic And Cartographic Information System
CASE	Computer-Aided Software Engineering
CCDM	Core Cadastral Data Model
COM	Component Object Model
CPN	Council Property Number
CRV	Cadastral Record Viewer
CSD	Cadastral Spatial Data
DBMS	Database Management System
DIIS	Document Integrated Imaging System
DLI	Department Of Land Information
DLL	Dynamic Link Library
DNS	Domain Name Services
DTDB	Digital Topographic Database
E-R	Entity Relationship
EC	Electronic Conveyancing
ELDP	Electronic Land Development Process
ESCAP	Economic And Social Commission For Asia And The Pacific
FAO	Food And Agricultural Organisation
FGDC	Federal Geographic Data Committee
FTP	File Transfer Protocol
GIS	Geographic Information System
GML	Geographic Mark Up Language
GNSS	Global Navigation Satellite System
GPR	Government Property Register
GPS	Global Positioning System
GSDI	Global Spatial Data Infrastructure
HDM	Harmonised Data Model
ICSM	Inter Governmental Committee On Surveying And Mapping
ICT	Information And Communication Technology
IDS	Internet Delivery Server
INTERLIS	Data Exchange Mechanism For Land-Information-Systems

IP	Internet Protocol
IPW	Integrated Property Warehouse
ISO	International Standard Organisation
ITC	International Institute For Geo-Information Science And Earth Observation
ITS	Integrated Title System
LASSI	Land And Spatial Survey Information
LIN	Land Information Network
NAR	National Association Of Realtors
NECS	National Electronic Conveyancing System
NOS	Notice Of Sale
NRM	Natural Resource Management
NSDI	National Spatial Data Infrastructure
NSW	New South Wales
NT	Northern Territories
ODBMS	Object Oriented Database Management System
OGC	Open Geospatial Consortium
OMG	Object Management Group
ORDBMS	Object Relational Database Management System
OSR	Office Of State Revenue
P2P	Peer To Peer
PCGIAP	Permanent Committee On GIS Infrastructure For Asia And The Pacific
PDF	Package Definition File
PIN	Personal Identification Number
PRISM	Property Sales Information
QOS	Quality Of Service
RDBMS	Relational Database Management System
RNMF	Road Name Maintenance Form
RRR	Rights, Restriction And Responsibilities
RTK	Real Time Kinematic
SA	South Australia
SARS	Severe Acute Respiratory Syndrome
SDI	Spatial Data Infrastructure
SII	Spatial Information Infrastructure
SIX	Spatial Information Exchange
SLIP	Shared Land Information Platform
SMES	Survey Mark Enquiry Service
SPI	Standard Parcel Identifier
SPEAR	Streamlined Planning through Electronic Applications and Referrals
SRO	State Revenue Office
TCP	Terminal Connection Point

TRS	Title Registration Service
UK	United Kingdom
UML	Unified Modelling Language
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission For Europe
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic And Social Commission For Asia And The Pacific
URL	Uniform Resource Locators
US	United States
USA	United States Of America
VGSC	Victorian Government Spatial Council
VIC	Victoria
VOTS	Victorian Online Title System
VSC	Victorian Spatial Council
VSCO	Vendor Statement Certificates Online
WA	Western Australia
WAPC	Western Australia Planning Commission
WCS	Web Coverage Service
WFS	Web Feature Service
WMC	Web Map Context
WMS	Web Map Service
WWII	World War II
WWW	World Wide Web
XMI	Xml Metadata Interchange
XML	Extended Mark Up Language

CHAPTER 1 - INTRODUCTION

1 INTRODUCTION

1.1 RESEARCH BACKGROUND

Land is an ultimate resource without which life can not be sustained (FAO 2007). From a social point of view, land facilitates many functions in a society, from very basic activities like obtaining food, water and making shelters, to creating complicated infrastructures like telecommunication and power stations (FAO and UNEP 1999a). From an environmental perspective, survival of many species depends on land. From an economic standpoint, land is the most important asset people possess; a foundation on which wealth is built (UNECE 2005).

However, the administration of land is challenged by the increasing need of clients for land information (Masser *and others* 2007),(Williamson *and others* 2006) and by the creation of new land related commodities and interests (Wallace and Williamson 2004; Wallace and Williamson 2006; Williamson and Wallace 2007). Existing modern electronic land administration (e-land administration) systems, including the latest ICT enabled systems, are not sufficiently flexible to accommodate new interests in land and complex commodities. Nor do they respond to the increasing needs of end users (Kalantari *and others* 2005b).

A land administration system is part of the infrastructure that supports the integrated management of land (Enemark and Sevatdal 1999; Enemark 2003b; Enemark 2003a; Enemark 2005a; Enemark *and others* 2005). In a traditional context it involves the process of determining, recording and disseminating information about the tenure, value and use of land when implementing land management policies (UNECE 2005). However, a modern land administration system should provide appropriate infrastructure, which organises a broad range of social, environmental and economic interests in land to support its core policy of sustainability (Dale and McLaughlin 1999; Ting and Williamson 2000; Williamson 2006), and to service the increasing need of businesses for good governance and an enhanced quality of life.

However, land administration systems have historically organised interests using land parcels, which form the basic building block in cadastral information system. As a result, governments are trying to manage increasing numbers of interests in land through the traditional basic building block, though many interests in land are not necessarily limited to specific parcels. In other words, the first issue is that interests in land are diverse and some of the interests cannot be defined by parcel boundaries.

Besides, the vision of land administration systems anticipates the enormous impact and potential of Information and Communication Technology (ICT) (Van der Molen and Lemmen 2003). Different land administration subsystems such as land registration, land mapping, land valuation and land development have their own approaches for adapting ICT to better serve people. Existing initiatives include providing land and property information online, electronic conveyancing, electronic land tax and land development online. However, the second issue is the efficient service delivery fails as interoperability is impeded because the isolation of the implementation of the initiatives in their specific subsystems.

The solution to both issues is to develop a cadastral data model which accommodates the increasing number of interests in land while also improving communication and interoperability among e-land administration subsystems.

1.2 RESEARCH PROBLEM

A limited number of interests in land have historically been organised in cadastres, with land parcel based data models providing the basic building block of land administration systems. Despite the relative success of the parcel based data model, it is now under pressure from the new land related commodities (e.g. 3D titles, water, biota and carbon credits) and interests in land (e.g. rights, restrictions and responsibilities). Such commodities and interests have been created by various government organisations in response to the needs of other end users (e.g. emergency services, utilities) for cadastral information. These all challenge the traditional land administration approach and reveal serious gaps in current cadastral data models.

The research problem is that current cadastral data models are, firstly, not sufficiently flexible to incorporate the increasing number of interests and new commodities in land

and, secondly, do not facilitate interoperability between different types of cadastral data in order to meet end users' needs.

1.3 RESEARCH AIM AND SCOPE

The aim of this research is to develop a cadastral data model that will both incorporate a broader range of interests and new commodities in land information systems and facilitate interoperability within various organisations and end users.

1.4 HYPOTHESIS

A cadastral data model capable of incorporating the increasing number of interests in land and improving interoperability will respond to the requirements of the future land administration.

1.5 RESEARCH OBJECTIVES

As a result of the identified research problem and the aims and scope of the research, the research objectives are:

- To study and identify the requirements of future land administration;
- To identify the available options of ICT for future land administration;
- To assess ICT utilisation including interoperability issues, data models and data employed in current land administration systems using a case study approach;
- To develop an e-land administration model and the associated toolkit;
- To propose a new cadastral data model to assist establishing e-land administration system; and
- To develop and assess the new model.

1.6 RESEARCH APPROACH

The research approach consists of 3 major phases, starting with the conceptualisation of research requirements, followed by the design (including model development), and implementation phases (Figure 1-1).

The first phase investigates the requirements of future land administration systems. In particular, the research focuses on the roles that a modern land administration system should play and the associated technologies and facilities it requires. There is an additional focus upon the options that ICT offers to land administration. This phase is then complemented by observing case studies of the modernisation of land administration systems. This includes assessment of government initiatives worldwide as well as related research in this area. The aim is to identify issues, obstacles and complications as well as successful experiences and best practices in enabling land administration with ICT. Examples include interoperability, data models and data type that could help to underpin a holistic framework for e-land administration. Given the variety of unique institutional, economic, legal, and technical settings, this research uses case studies from several jurisdictions: The Australian states of Victoria, New South Wales and Western Australia; the Netherlands; Switzerland; and the United States.

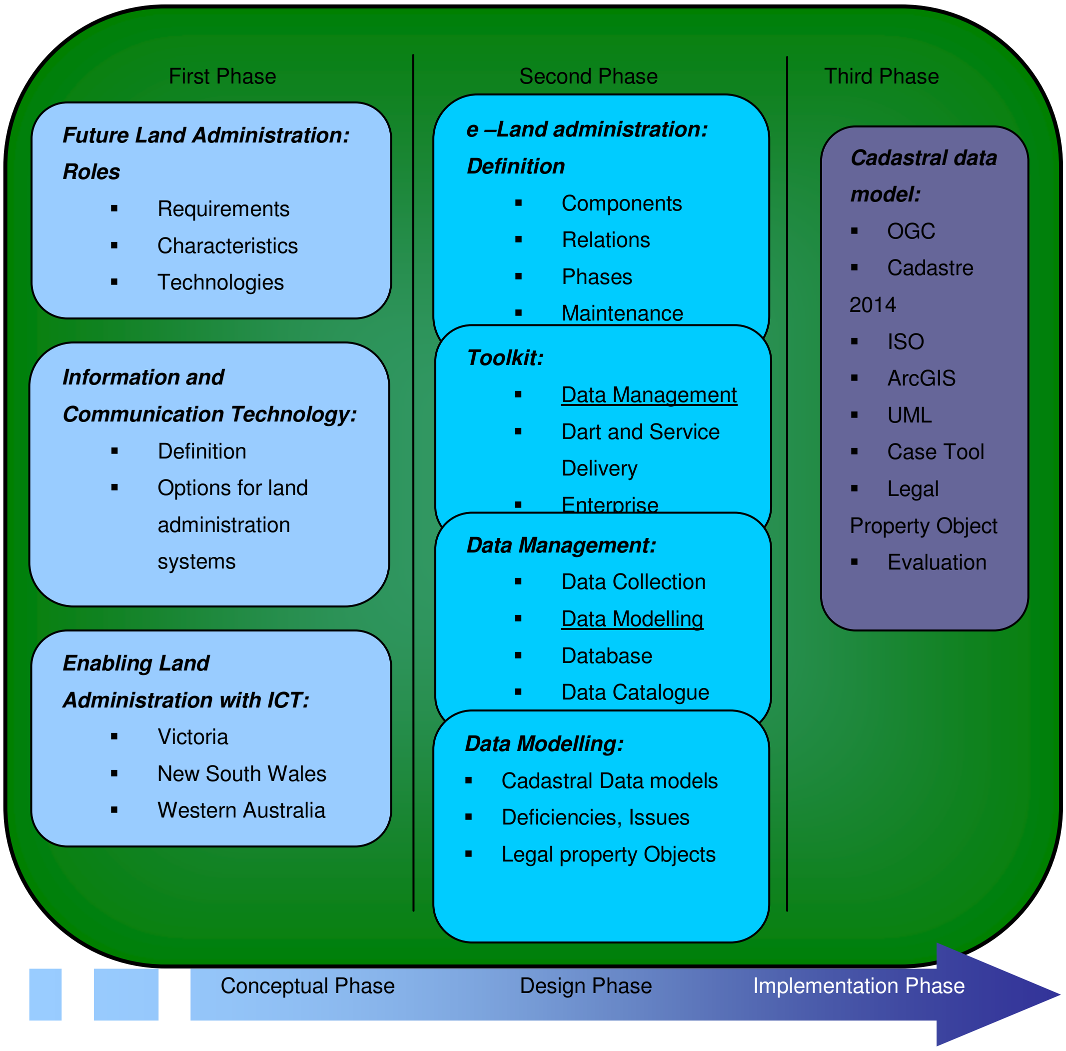


Figure 1-1: Research approach

After conceptualising the research requirements, the second phase starts by designing e-land administration. This phase identifies the stages of an e-land administration implementation. This phase afterwards develops a series of associated tools to put the e-land administration system in practice. Among the developed tools, particular attention is paid to data modelling because of its key role in land administration. The aim is to address the objectives of the research and to respond to the problems discussed earlier in this chapter. Different cadastral data models are explored and their structures discussed. Deficiencies and issues that interfere with the requirements of modern and electronic land administration are then revealed and a core data model that coincides with the needs is proposed.

The core model proposed in the design phase is developed during the implementation phase. This phase develops the logical data model, in light of international standards in the domain of spatial industry and global land administration statements. It uses the Unified Modelling Language (UML) approach. The research incorporates the logical model using Visual C++, Visual Basic, Arc GIS environment and associated facilities like Case Tool to physically implement it in a computer environment. The results are then evaluated against the requirements of future land administration.

1.7 RESEARCH STRUCTURE

Chapter Two starts with an introduction to the importance of land for sustainability and validates the key role that the land management plays in societies. The functions of land management systems are then explored and the position of land administration within land management is described. It then addresses the detailed objectives, functionalities and characteristics of land administration systems as well as the subsystems that perform the functions. A detailed comparison of traditional and future land administration in Chapter Two also reveals that land administration systems are facing a new paradigm. That changes the role of land administration systems and heavily influences their structure and characteristics. Chapter Two concludes by identifying the current issues associated with the new land administration paradigm, with a particular emphasis on ICT.

Chapter Three discusses ICT and its different components in greater detail. ICT is explored from computer science and communication technology view points and available options are introduced. Existing software engineering technologies and computer hardware options are explained. Important media such as web services and their potential are also examined. Having explored ICT, Chapter Three examines the available ICT options for spatial science and industry and in particular for land administration. It classifies the technical options that ICT provides: data management tools, data dissemination tools and enterprise facilitator tools for coordination and communication.

Chapter Four aims to develop a strategy to achieve the objectives defined in the first chapter. It uses Chapters Two and Three to present a pathway through the research. The gaps identified in the traditional way of administrating land in Chapter Two are filled with the innovative solutions that are offered in Chapter Three. To do that, the research strategy uses a case study approach to assist in understanding the use of ICT in current land administration systems. This helps to develop a framework for modern land administration systems along with the introduction of critical issues and components for e-land administration.

Three case studies are presented in Chapter Five to review current developments and the use of ICT in land administration systems in Australia, New South Wales (NSW), Victoria and Western Australia (WA). In order to achieve the research objectives, the applied research methodology in case studies consists of external and internal studies. The external study includes the identification of related organisations to the land administration systems as well as their clients. This identification allows the interoperability and communication issues in the data exchange between the organisations and external partners to be recognised. The aim of the internal study is to investigate the information systems, data model and data types employed within each subsystem.

With the case studies undertaken, Chapter Five presents an assessment of the land administration systems including communication and interoperability among their subsystems as well as the information systems they use. This assessment assists the research by providing a detailed understanding of the different stages of applying ICT.

The outcomes of this chapter will specifically help with the development of the e-land administration concepts in Chapter Six.

Chapter Six introduces the concept of e-land administration. The chapter describes the development of a multi stage model for the introduction of ICT into a land administration system based on three Australian case studies. Various technical, community, legal and semantic issues are then discussed. Chapter Six then concludes that the key to the establishment of ICT based processes in e-land administration is a holistic data model that regulates data collection, data management, data cataloguing as well as data exchange.

Chapter Seven reviews the land administration systems again, this time with an emphasis on the data elements employed in NSW, Victoria, WA, the Netherlands, Switzerland and the USA. The content, role and potential of important data elements are identified to provide an overall understanding of the arrangements supporting current cadastral data models. It explores how the data elements fit together and identifies the main issues in the current core data model arrangements.

Initiatives to improve the current core data model are also reviewed. In response to the research problem, two fundamental changes are proposed based on the concept of the legal property object. The changes firstly facilitate the incorporation of a broader range of interests in land and land-related commodities into the cadastral fabric; secondly, they promote interoperability and simplicity in data exchange processes.

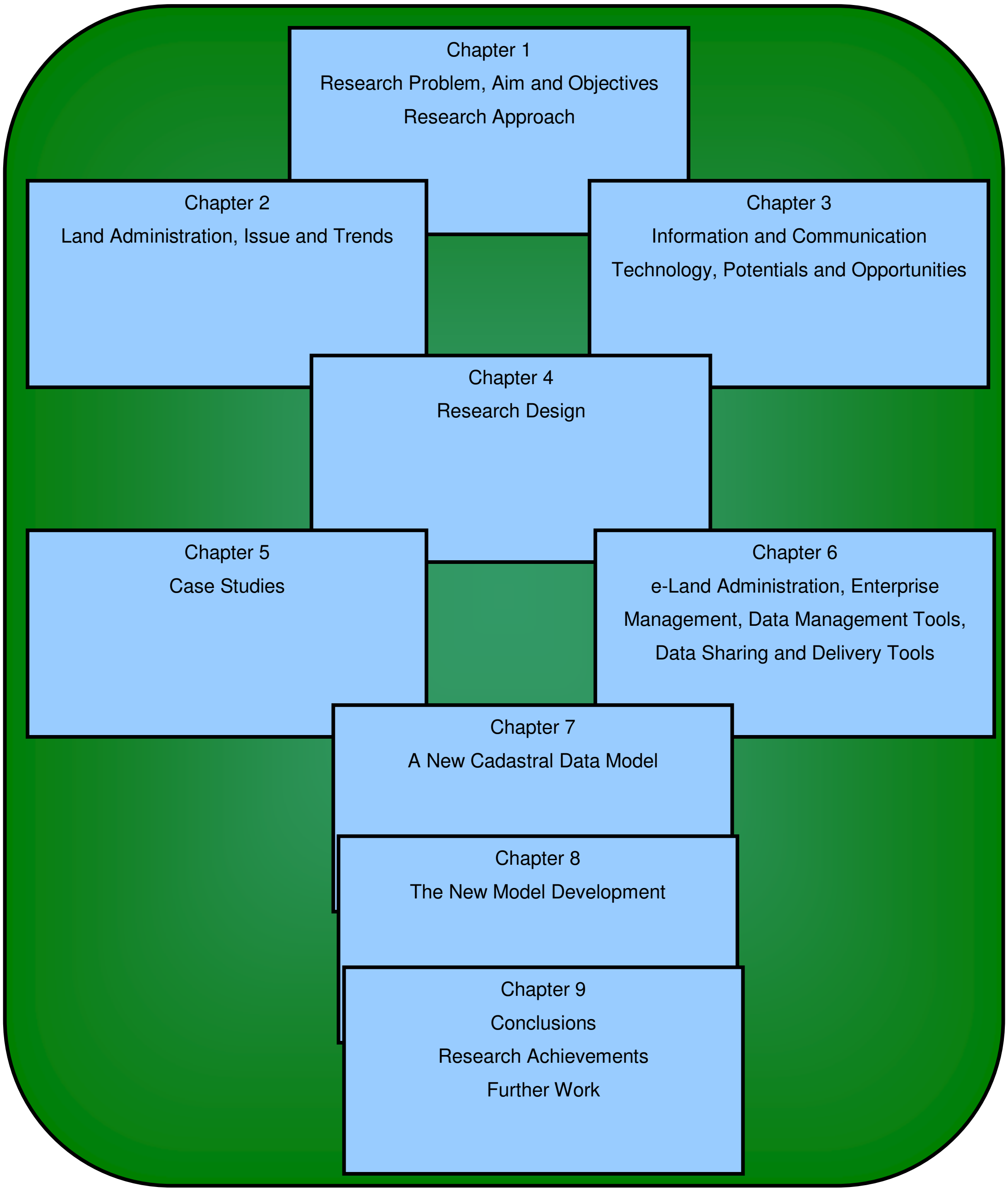


Figure 1-2: Research formulation

Chapter Eight develops the ideas of legal property objects based on international standards such as OGC and ISO and global land administration statements like Cadastre 2014. It puts forward a number of components and describes the relationships between them considering the requirements of the aforementioned statements and standards. The new data model is then developed in prototype system. Finally, the new data model is assessed against the requirements of future land administration and recommendations are then drawn in Chapter Nine. The schema of the research formulation is presented in Figure 1-2.

1.8 CHAPTER SUMMARY

This chapter has laid the foundations for the research and introduced the problem, aim and objectives of the research.

As a problem statement, it discussed how administrating land is challenged by the increasing needs of clients for land information and by the creation of new land related commodities and interests. It then added that existing administration systems, including the latest ICT enabled systems, are not sufficiently flexible to accommodate these new interests and commodities. Nor do they respond to the needs of end users.

To respond to the problem statement, the research put forward five objectives: firstly, understanding future land administration; secondly, learning from global modernisation initiatives; thirdly, designing e-land administration system and associated components in response to the lessons learnt; fourthly, proposing an answer to the research problem by using the components developed; and finally, implementing and assessing the answer.

The research approach was then designed and described based on five objectives in three phases of conceptualisation, design and implementation. The research was formulated and the thesis structure outlined in nine chapters.

The next chapter provides a background to land administration systems and their changing role.

CHAPTER 2 - LAND ADMINISTRATION AND ITS FUTURE ROLES

2 LAND ADMINISTRATION AND ITS FUTURE ROLES

2.1 INTRODUCTION

The way land is used is driven by the interplay of social, economic, and environmental factors (Williamson *and others* 2005). To manage land as a precious resource, land management systems are expected to maximise social, economic and environmental benefits for people. Within this framework, land administration plays a critical role in the regulation of land management policies (Enemark 2005b).

Land administration consists of three types of functions: juridical, regulatory, and fiscal, with land information management integral to all three (Dale and McLaughlin 1988; Dale and McLaughlin 1999). Definitions of land administration make it very clear that land administration activity is not an end in itself but facilitates the achievement of other goals (Van der Molen 2006). According to its functions, the objectives of land administration can generally be classified according to security of tenure, creation of wealth and regulation of land use (Dale and McLaughlin 1999; Enemark *and others* 2005). Land administration systems have historically existed to gather revenue, protect people's rights to land, regulate the land market and control land use.

However, land administration systems are now evolving from a focus on the core functions of regulating land use, land tenure and land valuation to an integrated land management paradigm designed to support sustainable development (Enemark *and others* 2005). In addition, it is expected land administration will play a greater social role by contributing to good governance (Ting 2002), serving the business sector (Steudler 2004b) and enhancing quality of life.

Changing the role of land administration in a society is not simple. This shift involves many issues relating to the historical, cultural, social, technical and economic situation of the society (Ting and Williamson 2000; Williamson 2001). These issues reveal that current land administration systems are unable to deliver new objectives unless their characteristics are changed.

This chapter aims to explain the objectives, functions and characteristics of future land administration systems. A detailed comparison of current and future land administration systems is presented in this chapter to identify the characteristics of modern land administration.

2.2 LAND

According to the Food and Agricultural Organisation (FAO) of the United Nations (UN), land is the most valuable asset that people hold (FAO and UNEP 1999a; FAO 2007). Mankind has diverse interests in land: it is a place to build homes, grow crops and pasture animals for food; a source of raw materials and mineral wealth, and a place for leisure activities. Land is not simply regarded in terms of soils and surface topography, but encompasses features such as underlying deposits, climate and water resources, and supports plant and animal communities. Furthermore, the results of human activities, reflected by changes in vegetative cover or structures, are also regarded as features of land (FAO and UNEP 1999b).

The interplay of social, economic, and environmental factors determines the way in which land is used (Williamson 2006). For instance, global competition puts pressure on land to produce higher financial returns as an economic interest, whilst climate change is adding further pressure as an environmental interest in land. Thus, producers face a significant challenge if they wish to stay in business whilst at the same time protecting the natural environment.

The social impact of land interests includes change in the size and composition of rural and town populations, shifting employment opportunities, and cultural changes, amongst others. Environmentally, all living creatures are dependent upon the land for natural resources, food and water. From an economic point of view, building materials and energy resources like oil, coal and gas, are all derived from land. More importantly, land is a commodity to which a value can be assigned and which can be traded through land markets. It is also a commodity that can be taxed to produce revenues that support good governance (Wallace and Williamson 2004; Wallace and Williamson 2006; Williamson and Wallace 2007).

To manage land as a precious but complicated resource, land management systems are expected to maximise social, economic and environmental interests, not damaging the land and, where possible, contributing to its enhancement. Land management is about finding the right balance of these triple, often competing, factors that allow sustainable land use (World Bank 2006). Therefore, to ensure the optimum use of land to enable societies to achieve sustainable development there must be a framework of sustainable land management. Within this framework, land administration plays a critical role to implement the policies adopted in land management (Enemark 2005a). For further discussion, land administration is defined in the next section.

2.3 LAND ADMINISTRATION

The key to understanding land administration is to recognise the relationship between people and land. In the early stages of human settlement, land was undisputedly the primary source of wealth and power. In that context, land administration's primary function was to record ownership interests and serve as a fiscal tool for managing the taxing system (Larsson 1991).

The usurping of land's position as the primary source of wealth for people began with the Industrial Revolution and the rise of capital. This in turn created a further important function of land administration as a tool to support the growth of land markets and land transfers (Ting and Williamson 1999a) to develop economic interests in land.

The post WWII reconstruction period and subsequent population boom saw the need for better spatial planning, particularly in urban areas. There was an increased need for land administration laws and systems to address broad acre subdivisions(Ting and Williamson 1999a; Ting and Williamson 1999b; Ting *and others* 1999; Williamson *and others* 1999; Ting and Williamson 2000; Ting 2002).

As today's society faces continuing land shortages and resource scarcity, the imperative exists to better manage and plan land use. The concerns about sustainable development and the environment are evident from such international instruments as Agenda 21 and the Habitat II Agenda. There are also concerns for social equity such as indigenous and women's rights (Ting and Williamson 1999a; Ting and Williamson 1999b; Ting *and* *others* 1999; Williamson *and others* 1999; Ting and Williamson 2000; Ting 2002), taking into account the new social interests in land.

Today, thinking has moved beyond giving more people the possibility of having interest in the space over and underneath the same parcel of land through land administration (Figure 2-1). Traditionally, land administration referred to the processes of determining, recording and disseminating information about the ownership, value and use of land, when implementing land management policies (UNECE 1996; UNECE 2005). Within this context, a land administration system is an infrastructure that supports the management of land. The processes of land administration include regulation of land and property development to control the creation of new interests in land, the use and conversion of the land, the gathering of revenue from the land through sales, leasing, and taxation, and the resolution of conflicts concerning the social interests, ownership and use of the land (Dale and McLaughlin 1988).

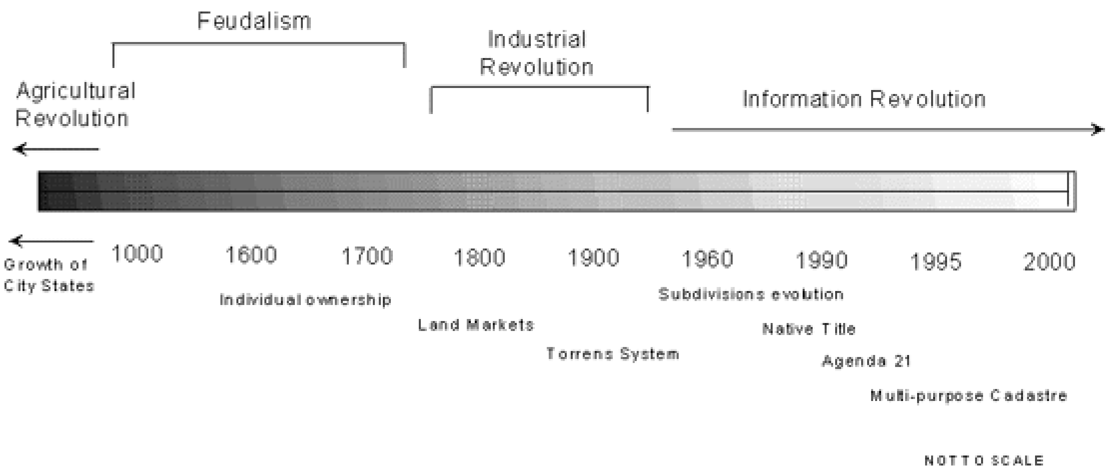


Figure 2-1: Evolution of land administration systems (Ting and Williamson 1999a)

Land administration facilitates all transaction concerning land, such as land development, and makes such transactions easier and more secure. One consequence of land administration is the stimulation of economic interests in land and land markets. Administrating land provides security and protection for the rightful claimant as well as preserving the interests of society. This security stimulates investment and development, particularly through its contributions to the banking system. Land administration reduces disputes and litigation over land resulting in better social and people relationship (Larsson 1991).

Having defined land administration and its role, the next two sections identify the key attributes of land administration together with the processes in which these attributes are brought into play.

2.4 ATTRIBUTES OF LAND ADMINISTRATION

In land administration the three key attributes of land are ownership, value and use:

i OWNERSHIP

Ownership usually means the exclusive right to use the parcel, enjoy its produce and make improvements (Larsson 1991). In a market based system it also includes the right to transfer the parcel to another person, to mortgage the property and to lease it. All of these rights may be more or less restricted by legislation. It is common today that the legal rights of the land owner are restricted to using the parcel of land in a manner that is beneficial and appropriate from a community perspective. Restrictions may also include measures to protect the environment. Ownership of the land usually includes ownership of any buildings on the land, but in some jurisdictions land and buildings may be owned separately (FIG 1995).

It is obvious that ownership comprises diverse interests in land that are not inclusive and maybe be restricted by other interests. Furthermore, many new property interests are created by governments in response to concerns for sustainability. However they are often poorly managed and understood (Bennett *and others* 2008).

ii VALUE

Value refers to the worth of a property (land parcel or building), determined in a variety of ways which give rise to different estimates of the value (UNECE 2005). There are several types and definitions of the value, including market value, value in use, investment value, insurable value and liquidation value. Land value is used for different purposes, including setting limits for the sale and purchase of properties, setting rental levels, determining compensation for compulsory acquisition, asset accounting and management, lending and associated financial dealings, property settlements, property rating and taxation systems, and property portfolio analysis(Britton and Davies 1980).

Value gives land an economic function and determines fiscal interests such as the tax liability of a country's citizens.

iii USE

Land use is defined as the way land in which land is developed and used; it is classified according to the kinds of activities allowed (agriculture, residences, industries, and so on) (UNECE 2005). It shows the degree to which the land reflects human activities (e.g. residential and industrial development, roads, mining, timber harvesting, agriculture, grazing, and so on). Land use describes how a piece of land is managed or used and what interests exist in relation to it.

iv RELATIONSHIP OF THE ATTRIBUTES

Ownership defines who can use land while, conversely, the use influences the form and substance of the tenure. Similarly, the manner in which land is valued can alter the way in which it is used (Dale and McLaughlin 1999). There is, therefore, a strong relationship between the three key attributes of land: tenure, use and value (Figure 2-2).

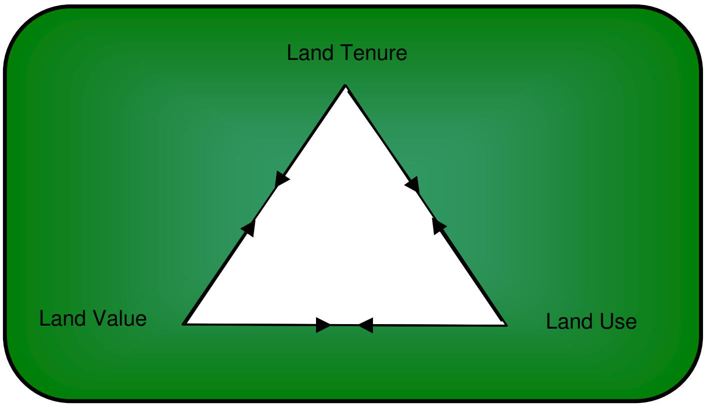


Figure 2-2: Relationship among land attributes (Dale and McLaughlin 1999)

The strong relationship between the attributes should be considered when determining future land administration requirements. This also applies when designing e-land administration and developing associated tools. The silo based data model of managing land attributes according to particular interests in land interferes with the proper communication, data exchange and interoperability of land administration systems. It also prevents the integrated management of increasing land interests by keeping them separate..

2.5 PROCESSES OF LAND ADMINISTRATION

An examination of the definition of land administration reveals three sub-processes: determination, recording and dissemination.

i DETERMINATION

The determination sub-process is the identification of an interest in land, the demarcation, measuring and mapping of the interest's boundaries or spatial extent (Larsson 1991), and the assessment of its value. Cadastral surveys, for instance, are one of the tasks in the determination sub- process that may be carried out by governmental officials and private surveyors or a combination of the two(Larsson 1991; Dale and McLaughlin 1999). Land valuation is another practice undertaken in the determination sub-process to develop the value of land.

ii RECORDING

The recording sub-process includes the checking or examination of the results of the determination sub-process and the entry of the information in land information systems. For instance, after determining boundaries of a land parcel, a unique parcel identifier is allocated in the physical data model and databases. There follows an examination of land policy matters- for instance, does the subdivision contribute to a suitable land use?; legal matters, such as the right of the applicant to conduct certain land activities; and technical matters- have the survey regulations been obeyed? (FIG 1996). Finally, the land parcel and associated information including interests, value and use are recorded.

iii DISSEMINATION

The dissemination sub process includes providing the key attributes of land to the public and private users. This process requires an infrastructure, including institutional and technical arrangements, to effectively distribute land information. For instance, spatial data infrastructures which aim at facilitating data collection, integration and sharing can be used as an enabling platform for the disseminating sub-process (Kalantari *and others* 2005a).

The way in which main attributes of land (ownership value and use) are determined directly influences how they are recorded in the land administration data models and, consequently, their manner of disseminated. The strong relation between the attributes, therefore, will also show itself in the processes and consequently affect the way e-land administration operates and a cadastral data model is designed. Table 2-1 summarises the definition of traditional land administration explaining its characteristics and features. Following land administration attributes and elements, the next section elaborates upon the functions of land administration.

Land administration	Main data elements	Main processes
Traditional	Ownership Use Value	Determination Recording Disseminating

Table 2-1: Traditional land administration, data elements and processes

2.6 FUNCTIONS OF LAND ADMINISTRATION

According to the definition of land administration and the key attributes of land, land administration consists of three functions: juridical (for land tenure), regulatory (for land use), fiscal (for land value) with land information management integral to the three functions (Dale and McLaughlin 1999).

i LAND TENURE

The way in which rights in land are held is called tenure. It is defined by a broad set of rules, some of which are formally defined through law, others determined by custom (Dale and McLaughlin 1999). There are four main areas of the law that particularly affect the land administrator:

(a) The law of "real" property that affects dealings in land;
(b) The laws on land reform such as the privatization of State-owned land, the restitution of former private land, and land consolidation;
(c) The laws that govern the conduct of land administration such as the regulations that control the operation of the cadastre; and

(d) The laws on "intellectual" property that affect such matters as the ownership of information and ideas, the protection of data and personal privacy (UNECE 1996; UNECE 2005).

In the future, however, land tenure will also describe the manner in which interest (rights, restriction, responsibilities) are held (Bennett *and others* 2008).

ii LAND VALUATION

Land valuation is the process of estimating the value of any land or property for the purpose of buying, selling, leasing or taxation. It is also used to calculate the assets held by an individual or business for the purposes of inheritance, bankruptcy or collateral (Dale and McLaughlin 1999). Valuation involves the classification of each property in accordance with an agreed set of characteristics relating to its use, interests attached, size, type of construction and improvements; market data including data on sales prices, the rental market and building maintenance costs (UNECE 2005).

iii LAND USE REGULATION

In order to make the best use of national resources and regulate interests in land, every country implements strategies for land-use planning and development so as to improve the physical infrastructure and create a better environment. Land-use regulation is the process of allocating resources, especially rights, restrictions, and responsibilities to use land in particular ways, in order to achieve maximum efficiency while respecting the environment and the welfare of the community (UNECE 2005).

iv LAND INFORMATION MANAGEMENT

The ability to meet the range of land administration functions in the areas of land tenure, land value and land use requires access to complete and up-to-date land information. A key function of land administration is the management of land and property related data through a land information system with the cadastral data model at its centre. For instance, a primary requirement for efficient and effective land valuation is land data that provides an index for compiling and maintaining valuation information. Access to inclusive and integrated information on the interests in land, value and use via a comprehensive data model helps to facilitate achieving the e-land administration (Kalantari *and others* 2005a). Table 2-2 summarises land administration functions together with main data elements and processes.

Land Administration	**Main data elements**	**Main processes**	**Functions**
Traditional	Ownership Use Value	Determination Recording Disseminating	Land tenure Land value Land use regulation Land Information management

Table 2-2: Traditional land administration, data elements and processes and functions

Various components communicate to each other, exchanging information in order for the land administration system to perform the functionalities described. The next section explains what the components are and how they relate to each other.

2.7 COMPONENTS OF LAND ADMINISTRATION

The diversity of functionalities requires land administration to have various kinds of components to deal with land. For example, the land tenure function requires placing emphasis on the holding and the registration of interests in land. On-ground identification is provided by surveyors through development plans to assist in the regulation of use. At the same time, the land use function is also concerned with use restrictions imposed through the regulatory planning mechanisms. The land value function focuses on the economic utility of land. The taxation office requires the change of land use to calculate the revenue and tax for specific purposes.

To fulfil these functions, land administration has historically been organised around four sets of components responsible for surveying and mapping, land registration, land valuation (Dale and McLaughlin 1999) and land development (Figure 2-3).

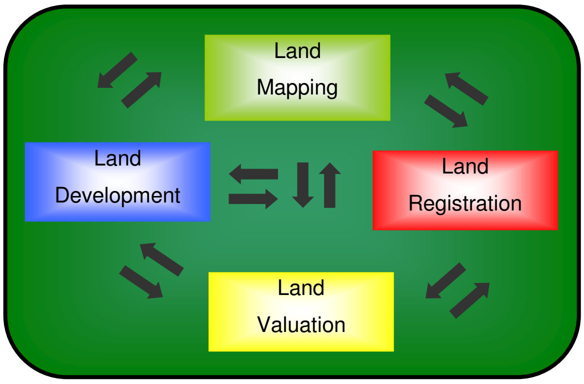


Figure 2-3: Land administration components

i LAND REGISTRY

Land registration is the process of legally recognising interests in land (McLaughlin and Nichols 1989). The function of the land registry is, therefore, to provide a safe and certain foundation for the acquisition, enjoyment and disposal of interests in land (UNECE 2005) and security of land tenure.

ii LAND MAPPING

Traditionally in a land administration system, the land mapping component is responsible for providing the cadastral map. A cadastre is normally a parcel based and up-to-date land information system containing a record of interests in land (eg. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcel and its improvements (FIG 1995). The function of land mapping is to collect and make available graphical information in support of land tenure, land valuation and land use functions.

iii LAND VALUATION

The valuation of land is a process that should result in the best available estimates of what real property is worth. The valuation component is responsible for the technical processes which determine the value of the real estate (UNECE 2005). An effective and efficient land market depends upon a good valuation component.

iv LAND DEVELOPMENT

The land development component is the most complex subsystem in a land administration system. While the other components are usually represented by one single organisation or agency, land development includes different organisations and agencies ranging from private developers and surveyors to local governments, utility organisations and planning authorities. A land subdivision process for instance, contains several stages with each organisation responsible for a specific stage.

Each subsystem has specific functions and services. These specific functions or services directly impact upon the way in which data is modelled, stored, accessed, shared and exchanged. The unique perspective of each agency causes it to implement specific functionalities to deliver their services and to develop different data modelling methods and communication regimes from the other subsystems.

Having reviewed, the attributes, functions and components of land administration, the next section explores the land administration objectives.

2.8 OBJECTIVES OF LAND ADMINISTRATION

Functions and definitions of land administration make it very clear that land administration activity is not an end in itself but facilitates other goals (Van der Molen 2006). Land administration systems have historically contributed to gathering revenue, protecting people's rights in land, regulating the land market and controlling land use. According to the functions and attributes of land administration, its objectives can be generally classified according to security of tenure, creation of wealth and the regulation of use.

i SECURITY OF TENURE

The main objective of a land administration system through the land tenure function is to ensure security of tenure. Securing land rights is particularly relevant to vulnerable groups such as the poor, women and indigenous groups. In most societies, there are many competing interests in land including development, agriculture, pasture, forestry, industry, infrastructure, urbanisation, biodiversity, customary rights, and ecological and environmental protection interests. Many countries have great difficulty in balancing the needs of these competing demands. Land has been a cause of social, ethnic, cultural and religious conflict, and revolutions have been fought over rights to land. Throughout history, virtually all civilisations have devoted considerable effort to defining interests in land and establishing institutions to administer this increasing number of interests through land administration systems (Bell 2005).

ii CREATION OF WEALTH

Creation of wealth is an important foundation for economic development. Land administration systems have contributed to this through the land valuation function. In a land market, fees and taxes on land are often a significant source of revenue. Many of the interests in land, such as land use rights, development rights, right of way, water rights, mineral and extractive resource rights, carbon rights, timber rights, air rights, view rights, aquaculture rights, marine rights, trade waste rights are now being seen as tradable commodities (Wallace and Williamson 2004). An efficient system of valuation has always had a significant impact on an efficient land and land related commodities market systems.

Furthermore, recognizing that land is a source of wealth lies at the heart of good government and effective public administration. States that prosper promote widespread and secured private ownership of land as a foundation of social and economic policy.

"Modern market economies generate growth because widespread formal property rights, registered in a system governed by legal rules, afford indisputable proof of ownership and protection from uncertainty and fraud so permitting massive low cost exchange, fostering specialization and greater productivity. It is law that defines the relationship of rights to people. Civilized living in market economies is not simply due to greater prosperity but to the order that formalized property rights bring." (Hernando de Soto 2000).

"Land is the place of all shelter, in the city, the town, the village and the home. It is the source of food, of materials for construction and manufacture, of coal, gas and oil, of springs and rivers and other essentials for life. Indestructible, immovable, it is the foundation of all human activity. Houses and factories, forests and farms, rivers, roads and railways, mines, quarries and reservoirs are all fashioned from the land. It offers endless opportunities for development and discovery. It is the ultimate source of wealth." (based on Sir Charles Fortescue Brickdale 1914).

iii REGULATORY OF USE

Land is an asset that is immovable: it is at a fixed location. It is also an asset of both a public and a private nature. The land use regulatory function of land administration aims at optimizing the productive uses of the land. These uses include agriculture, pastures, and the provision of space for housing, commercial and industrial enterprises. Land administration helps to determine how these interests are created and regulated. While the land resource of a country is finite and cannot be expanded, the resource base can be improved upon or it can be degraded. It is in countries' interests to have their land resources used in a sustainable manner to ensure that the land will remain productive for future generations.

Having explored traditional land administration systems in term of objectives, key attributes and functionalities (Table 2-3), next section looks at the new land administration paradigm and observes whether any change has occurred within attributes, functions, components and objectives.

Land Administration	data elements	processes	Functions	Components
Traditional	Ownership Use Value	Determination Recording Disseminating	Land tenure Land value Land use regulatory	Land registry Land valuation Land mapping Land development

Table 2-3: Traditional land administration, data elements and processes, functions and components

2.9 THE NEW LAND ADMINISTRATION PARADIGM

Land administration systems are now evolving from a focus on the core functions of regulating land use, land tenure and land valuation to an integrated land management paradigm designed to support sustainable development (Enemark 2005a). The paradigm includes three components for land management in a specific country context: land policy framework, land administration functions and spatial or land information infrastructures (Figure 2-4). Land information infrastructure, in particular, plays an important role by providing integrated and interoperable land information systems. Within the information system, the way in which land related data, including interests and their spatial extension, are modelled should also be taken into account.

The paradigm proposes four functionalities for a land administration system: land tenure, land value, land use and land development. The three first functions are similar to those in traditional ways of administrating land while the fourth function is included to take up new opportunities for integrated land management.

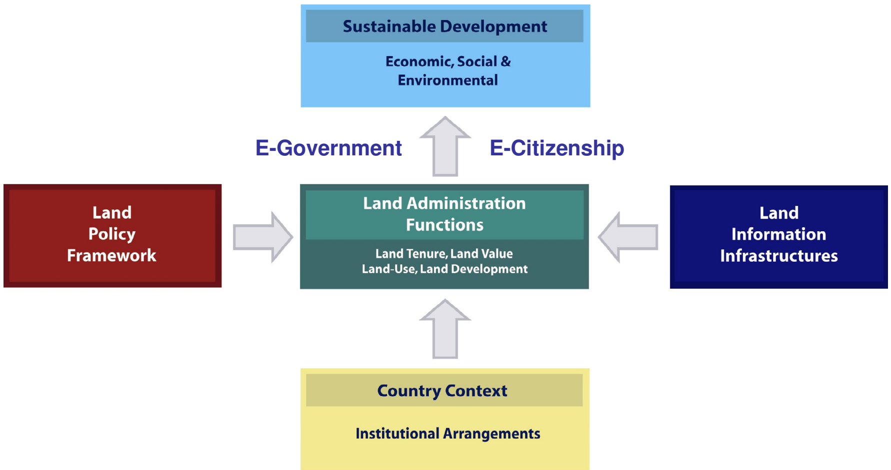


Figure 2-4: The land management paradigm (Enemark *and others* 2005)

In addition to the main goal of the paradigm, contributing to sustainability through land administration, land administration is expected to play a broader social role; contributing to good governance, facilitating activities and providing service to business, and enhancing quality of life (Figure 2-5).

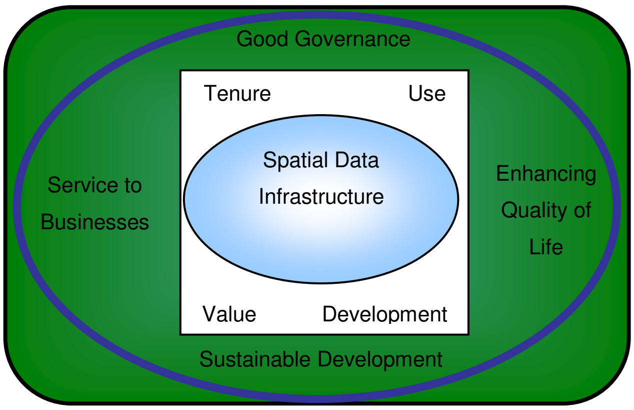


Figure 2-5: New roles for land administration

2.9.1 LAND ADMINISTRATION AND GOOD GOVERNANCE

Good governance has 8 major characteristics (ESCAP *and others* 2007). It is participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive, and follows the rule of law. It assures that corruption is minimised, the views of minorities are taken into account and that the voices of the most vulnerable in society are heard in decision-making. It is also responsive to the present and future needs of society.

A consensus oriented land administration can enhance the participation of all members of a society through securing both women's and men's interests in land. For instance, given women's centrality to diversified livelihoods, and their increasing political agency, their interests in land (both as wives/daughters within male–dominated households and as members of vulnerable social classes and communities that face the risk of land alienation) are more politicised today as well as being more contested (Razavi 2003). With the deceleration of more formal forms of employment, the diversification of rural livelihoods, and the intensification of casual labour in agriculture and the informal sector, the land question has taken on a new urgency and needs to be answered in land administration.

A transparent land administration system can enforce the rule of law and accountability. Responsive land development can increase efficiency and effectiveness of governance. In an integrated and interoperable environment like e-land administration, with a proper data arrangement land administration subsystems can contribute to better governance in a society.

2.9.2 LAND ADMINISTRATION AND SERVICE TO BUSINESS

Land administration has not traditionally offered many services for businesses, but the land information management function and spatial data infrastructures and their relationship with land administration is changing the field.

Private and public businesses, such as building inspection, transportation planning and management, emergency response, waste management and disposal, protected area designation, monitoring of parks and open space, infrastructure management, and public utilities can be assisted by the provision of comprehensive land related data and interoperable communication among the land administration agencies.

Forest fires, foot-and-mouth disease devastating livestock, the outbreak of severe acute respiratory syndrome (SARS) — all of these disasters have at least one thing in common: the role played by land information to help authorities make crucial decisions.

The US Department of Labour identified land information technology as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Job opportunities are growing and diversifying as geospatial technologies prove their value in ever more areas (Gewin 2004).

2.9.3 LAND ADMINISTRATION AND QUALITY OF LIFE

Quality of life is an elusive concept approachable at varying levels of generality from the assessment of societal or community wellbeing to the specific evaluation of the situations of individuals or groups (Felce and Perry 1995).

Quality of life is defined basically as a constellation of components which can consist of objective living conditions and/or of subjectively perceived wellbeing. The objective living conditions are usually monitored by experts from the social and natural sciences; these objective conditions exist independent of the awareness of the population exposed to them. Their range may vary from personal conditions through the community domain to the world's environmental conditions (Glatzer and Mohr 1987).

Quality of life, by almost any definition, is important to people. In land administration context it is applied to the relationship between people and public land management (Razavi 2003). Land administration systems, therefore, are a tool of great inherent potential for better living management. For instance, the attributes of land offered by land administration are directly applicable to an understanding of the spatial variation of disease and its relationship to environmental factors and the health care system.

In summary, the largest benefit of a land administration system is the availability of comprehensive land information to the citizens through integrated land information systems and data models, and the ease by which they can access this information through e-land administration. Parents sending their children to universities can access crime statistics about a specific area where they are thinking of leasing or purchasing property. Developers and engineers can access zoning type, building setbacks, minimum lot areas, and property ownership, through the Internet. Real estate agencies can access appraised value information on properties they are looking to list, or investors can get ownership information on properties they want to purchase. Citizens can see what precinct they need to vote in as well as their polling location, what amenities a certain park has, or find a dearly departed relative in the city cemetery. They can find out when their rubbish pickup or recycling day is or what year the historic home across the street was built.

It can be seen from above, that the evolution of land administration system follows its changing role in societies rather than its change of functionalities (Figure 2-5). The functionalities described for land administration remain with the addition of extra roles.

Land tenure, land use, land value and land development, together with land information management, can contribute to good governance. An open land registry, for instance, means that land information is freely available and directly accessible to the participants of the society. It also means that comprehensive and integrated information is provided by the land information management and that it is provided in interoperable forms and media. Good governance also requires that land administration institutions and processes try to serve all clients within a reasonable timeframe primarily through all time available media such as internet based land administration systems.

Land administration also requires a broad and long-term perspective of what is needed for businesses and how to provide appropriate services. This can only result from an understanding of the historical, cultural and social contexts of a given society or community. Land information management, with cadastral data modelling at its core, can enhance institutional and technical arrangements, enable better communication among the land administration functions, and thus provide better service to business.

Furthermore, wellbeing in a society depends on ensuring that all its members feel that they have a stake in access to land, can have interests in, and do not feel excluded from the mainstream of society. This requires that all groups, but particularly the most vulnerable, have opportunities to improve or maintain individual well being by access to land administration services such as e-conveyancing, e-plan of subdivisions and e-land taxation.

The above discussion demonstrates how a land administration system can potentially contribute to good governance, service to business and quality of life. Very few countries and societies have come close to using the potential of land administration in this way. However the new roles for land administration are challenging tasks. The next section identifies these issues.

2.10 CHANGING ROLE OF LAND ADMINISTRATION AND ISSUES

Changing the role of land administration in a society is not straightforward. Many issues are involved in this shift relating to historical, cultural, social, technical and economic conditions. Different societies face different issues. For instance, countries with informal and customary rules will face different issues to those in post conflict situations. The technical requirements of a changing land administration system for developed countries are different to those of developing countries. However, this section investigates the issues within the scope of the research.

2.10.1 INTEROPERABILITY

Land administration systems in developed countries and in some of the developing countries have utilised ICT in order to achieve e-land administration. Many implemented their electronic and computerised systems between ten and twenty years ago. Those systems are now outdated, and the maintenance is complex and expensive. (Blaikie 2003; Bruggemann 2003; Dijkstra T. and Booij A.S. 2003; Hawerk 2003; Hoffmann 2003; Ljunggren 2003; Meadows and Formby 2003; Mladenovic 2003; Onsrud 2003; Sanz 2003; Selleri and Fabrizi 2003; SuchanekI and Jirman 2003; Vahala 2003; Van der Molen and Lemmen 2003) The land administration systems are increasingly being confronted with rapid development in technology, internet, databases, modelling standards, open systems as well as growing demands for new services, enhanced user requirements, e- governance. e-Land administration systems, including the information system and data models they use, should be able to adapt themselves with the fast pacing innovations. This in particular requires a proper maintenance regime for e-land administration components such as cadastral data models when designing and developing.

In addition, because enablement of land administration with ICT was undertaken so long ago, it has happened individually by subsystems or even departments in a subsystem without considering other subsystems. Existing initiatives include providing land information on line, electronic conveyancing, and electronic subdivisions. Thus far, the implementation of these initiatives is isolated in their specific components without reference to the broader land administration system or its core policy. Communication among the components needs interoperability. Without interoperability between the components, e-land administration, and e-government cannot be achieved (Kalantari *and others* 2005b). Different components of land administration have developed their own computerised system without paying enough attention to the objectives of the entire land administration system.

Consequently, one of the big problems in ICT enablement, computerising and having interoperability in e-land administration, is the lack of standards. The need for standardisation has been discussed in various literature (Astke *and others* 2004; Bjornsson 2004; Hecht 2004; Kaufmann 2004; Oosterom *and others* 2004b; Ottens 2004; Paasch 2004a; Steudler 2004c; Stubkjaer 2004; Wallace and Williamson 2004; Zevenbergen 2004). International standardisation could resolve many of these communication and interoperability problems. There are several motivations for interoperability, such as meaningful exchange of information between organisations, and efficient component-based system development through applying standardised models.

Interoperability is now becoming a serious issue as most land administration activities have been computerised. Competition among technology providers presents new challenges. A variety of solutions for the same problem bring diversity in the technologies that are used. This issue in particular can be observed within different organisations. Interoperability is not a big issue until the need for communication, data exchange, data sharing become of interest.

2.10.2 INCREASING NUMBER OF INTERESTS IN LAND

Property rights are managed well by modern economies. They are supported both theoretically and administratively by a framework of legal and economic theory and sophisticated registration systems. But the current literature on cadastral and land administration issues replaces rights with the three R's of Rights, Restrictions and Responsibilities (Lemmen *and others* 2005). In contrast to the rights, the restrictions and responsibilities imposed on land users in support of sustainable development are not well managed (Bennett *and others* 2008). They lack theoretical support, administrative coherence and basic information systems. Land administration literature now suggests that all rights, restrictions and responsibilities (RRRs) should be included in the land administration system (Bennett *and others* 2006). In a modern context the key questions then are how new interests and RRRs might be incorporated into a cadastral fabric, especially when they are remote from physical objects or even spatial identification (Wallace and Williamson 2004).

RRRs or interests in land have historically been organised through land parcels as the basic building block of land administration systems. As a result, governments are trying to manage new commodities and interests in land through this traditional basic building block.

However, land parcels are not sufficiently flexible to accommodate or support the growing number of complex commodities (e.g. water, biota, mining rights, and carbon credits) and other interests (e.g. environmental, heritage, use restrictions) in land(Kalantari *and others* 2008).

For instance, the increasing complexity of modern cities suggests that modern land administration systems need an improved capacity to manage the third dimension of height (Zlatanova and Stoter 2006). From a land resource management perspective, the definition and identification of land parcels remains fundamentally important, however, the parcel is not the only unit essential for effective land management. Spatial identification of interests requires more flexible objects.

Having explored the changing role of land administration and the issues future land administration systems face, the characteristics of future land administration systems will now be summarised and compared with current land administration.

2.11 FUTURE LAND ADMINISTRATION

Future land administration involves processes of contributing to sustainable development as a primary aim and also helping with good governance, service to business and enhancement of quality of life through the land tenure, land value, land use and land development functions. While land administration systems were traditionally designed to provide security of tenure, to create wealth and control land use, today they are expected to contribute far more. Issues described in previous section clarify the inability of current land administration systems to deliver new objectives unless their characteristics are changed.

Most land administration systems do not recognise the new interests in land such as informal and customary rights, water rights, biota rights, and noise restrictions. This hinders the equity and inclusiveness in good governance. Modern land administration is expected to bring more interests into play.

In a modern context the key questions are how new unbundled interests in land imposed by governments might be incorporated into cadastral information systems. In future, the parcel based organisation of interests in land must be refined as new interests such as biota, carbon, and water have different technical characteristics. Parcel based indexing of interests in land cannot accommodate interests that are not necessarily equivalent to the extent of land parcels.

Consequently, land information management will play a greater role in modern land administration systems by utilising the powered spatially enablement and using potential of information and communication technologies.

However, many ICT based land administration systems are now outdated, and the maintenance of these systems is complex and expensive. Modern land administration requires a comprehensive view on the utilisation of ICT. ICT should not be used in an isolated manner in each of the components and should be holistically and dynamically instilled into land administration components, so that they can communicate with each other in an efficient and cost effective manner and remain up to date. Standardisation and interoperability are therefore serious issues to be considered when establishing an e-land administration system in the context of modern land administration. In this way ICT is central to development of e-land administration. Table 2-4 juxtaposes the characteristics of future land administration against those of current land administration.

	Current Land Administration	Future Land Administration
Objectives	Tenure Security Wealth Creation Use Regularity	Good Governance (Tenure Security, …) Support Sustainable Development (Wealth Creation, Use Regularity, …) Enhancing Quality of Life Service to Businesses
Characteristics	Parcel Based Limited Bundled Interest ICT Enabled Isolated Processes Parcel Based Indexing Private Interests	Object Based Broader Independent Interests e-Land Administration Spatially Enabled Land Administration Public and Private Interests

Table 2-4: a comparison between current land administration and modern land administration

2.12 CHAPTER SUMMARY

This chapter began with an introduction to the importance of land for sustainability and validated the key and important role that land plays in societies. It then proceeded with the objectives, functionalities and characteristics of land administration systems as well as subsystems that are involved in the functions. Land administration systems are faced with change, and are now expected to contribute not only to the sustainable development of a society, but also to good governance, enhanced quality of life and service to business. It further revealed that the evolution of land administration systems is more about changing the roles they play in a society rather than changing the functions they perform. Chapter Two identified the issues associated with the change and classified them according to interoperability and increasing number of interests in land. This chapter concluded that the changing role of land administration is revolutionising its technical characteristics. In light of ICT, future land administration should be object based not parcel based, spatially enabled and inclusive in terms of both public and private interests. More importantly isolated ICT enablement should be replaced by the interoperable e-land administration. The next chapter therefore identifies the available ICT options for land administration.

CHAPTER 3- ICT OPTIONS FOR LAND ADMINISTRATION

3 ICT OPTIONS FOR LAND ADMINISTRATION SYSTEM

3.1 INTRODUCTION

The Internet and other information and communication technologies (ICT) are increasingly being utilised by land administration organisations. These technologies provide opportunities for better service delivery, improved customer satisfaction and a reduction in operating costs.

ICT enabled land administration is broadly understood as the use of ICT by land administration systems, however it is also important to examine ICT to identify what options it provides for land administration. ICT covers a wide range of technologies from mobile phones and internet banking to very complicated computer hardware and sophisticated communication networks. Needless to say, ICT plays a vital role in every aspect of any business, including land administration. But what is important here is how ICT contributes to the core business of land administration. This core business carries special characteristics that distinguish land administration from any other business.

In this chapter, a detailed identification of ICT options for land administration starts with the definition of ICT, and its overall impact in society. Because of the diverse understanding of ICT and its tools, facilities and products, a matching approach is used to identify ICT options in land administration. This approach uses land administration processes to identify the possible contribution points of ICT.

This chapter identifies three areas where ICT has direct influence- data management, data dissemination and enterprise facilitation- and examines them in more detail.

3.2 INFORMATION AND COMMUNICATION TECHNOLOGY

Information and communication technology has become one of the basic building blocks of future land administration. Many countries now regard an understanding of ICT as part of the core of land administration. ICT permeates the business environment, it underpins the success of modern services, and it provides land administration systems with an efficient infrastructure.

ICT enabled land administration is broadly understood as the use of ICT by land administration systems to enhance the range and quality of land information and services provided to clients in an efficient, cost-effective and convenient manner, while making land administration processes more accountable, responsive and transparent.

ICT enabled land administration is necessary for improving good governance, the quality of life of citizens and service to businesses. ICT enabled land administration potentially offers a number of compelling benefits, including better-quality land administration services, increased citizen satisfaction, higher efficiency, reduced costs, a lower administrative burden, shorter processing times (Figure 3-1).

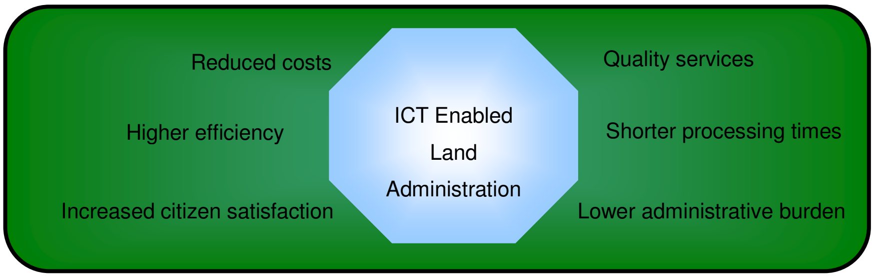


Figure 3-1: Benefits of ICT enabled land administration

Several definitions are used identically for ICT. The convergence of information technology, telecommunications and data networking technologies into a single technology (Bouwman *and others* 2005) is called ICT. The Oxford dictionary refers to ICT as a term which encompasses all forms of computing systems, telecommunications and networks across. However, in the context of this research, ICT stands for hardware, software, networks, and media.

Because of the very broad range of tools, services and facilities like mobile devices, computers, local networks, Internet, web sites, software packages etc, that ICT provides; it is hard to form an all-purpose classification to feature ICT tools. However, for a specific purpose and according to the aim, objectives and requirements, it is possible to put constraints on and categorise tools that ICT provides for a particular need.

According to Chapter One, in land administration, "ICT tools" denotes the available technical options for determining and recording land information, it also refers to the technical options for disseminating it. Further, ICT should promise to provide an infrastructure for effective coordination and communication between data management and data dissemination. ICT provides, with land administration, a series of technical options that include data management tools, data dissemination tools and enterprise facilitator tools for coordination and communication (Figure 3-2). The term "communication" is therefore more about connectivity and exchange of information rather than the communication infrastructure.

Figure 3-2: ICT options for land administration

3.3 *DATA MANAGEMENT*

Data management tools facilitate and manage the development or intensification of land information. Data management tool provide a facility for data modelling, data capture, database systems, data catalogue and data conversion as a means of holding land information in a standard way to be deliverable across multiple servers for access and sharing (Kalantari *and others* 2005a).

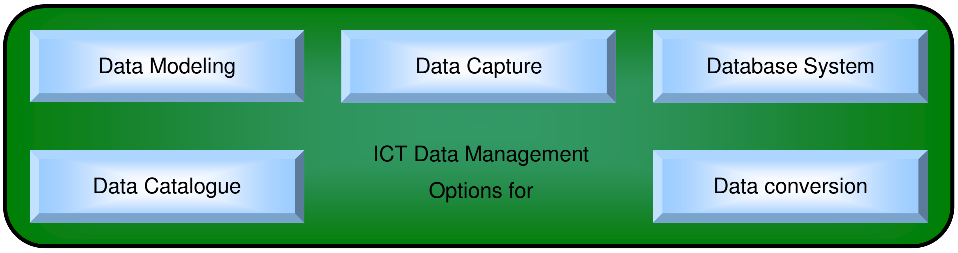


Figure 3-3: ICT data management options for land administration

3.3.1 DATA MODELLING TOOL

Data modelling is the process of defining and structuring data that can contribute to the recording process of land administration. When defining, data modelling will impose constraints or limitations on the data placed within the structure. These data structures are then typically organised in a database management system.

A database is specified by a data model describing what sort of data will be held and how it will be organised. The most common alternative approaches to data modelling are the entity relationship (E-R) and the object oriented approach (Simsion and Witt 2005).

The E-R data model views the real world as a set of basic entities and relationships among these objects. An entity is an object that exists and is distinguishable from other objects and a relationship is an association between several entities. When defining a relationship, cardinality defines the number of occurrences of one entity for a single occurrence of the related entity. For instance, a road is an entity which has relationship with another entity such as a land parcel; a road may have a relation with many land parcels. Each entity will normally have one or more attributes such as property value and interest in land parcel. Attributes describe an entity to the degree it is necessary for the application.

On the other hand, a core object-oriented data model consists of object and object identifier, object attributes and methods and classes. In the object oriented approach any real world entity is uniformly modelled as an object (eg. land parcel), every object has a state (eg. rights associated) and behaviour (eg. area). Objects are then organised through classes as a means of grouping all the objects which share the same set of attributes and methods (eg. building belongs to the property class). An object must belong to only one class as an instance of that class. In addition to that there is concept of class hierarchy and inheritance which allows for the deriving of a new class called sub-class from an existing class called superclass (eg. public is a subclass of the rightful claimant class). The subclass inherits all the attributes and behaviours from super class.

To implement the concepts mentioned above, there are different techniques, such as Information Engineering (IE), the Oracle approach for E-R and Unified Modelling Language (UML) for object oriented approach (Hay 1999).

The IE technique is simple and easy to read, and is well suited for high-level logical and enterprise data modelling. The assumption is that the attributes will be modelled with another diagram or simply described in the supporting documentation (Finkelstein 1990). The Barker notation is one of the more popular ones; it is supported by Oracle's toolset, and is well suited for all types of data models. (Barker 1990)

The Object Management Group (OMG) released UML. One of the purposes of UML was to provide common design language that could be used to develop and build computer applications. UML was not design just for data modelling but for any modelling activity like business modelling, work flow modelling and so on UML consists of a number of diagrams for different aspects of modelling. The most useful, standard UML diagrams are use case diagram, class diagram, sequence diagram, state chart diagram, activity diagram, component diagram, and deployment diagram(Eriksson and Penker 2000).Class diagram is used for data modelling.

The E-R techniques were dominant until late 1990 and cadastral and spatial databases were therefore developed based on the E-R approach. Some land administration authorities such as cadastral group in FGDC in USA still rely on this method.

Since the late 1990, with the emergence of object oriented analysis and design, the UML approach has gained in popularity. UML is a richer language that provides a set of graphical notations with significant benefits to both system designers and database designers. UML can be used not only for spatial databases but also to describe the business process of land administration, the relation between subsystems and external entities (Oosterom *and others* 2004a).

The data modelling is the primary facility offered by ICT to analyse, design and model the relationship between interests in land and their spatial extent in a cadastral information system.

3.3.2 DATA CAPTURE TOOL

The data capture tool contributes to the determination process of land administration. There are different tools and techniques to capture land data depending on the nature of applications that can be classified into ground and aerial surveying. For instance ground surveying methods are used for high accuracy needs and aerial surveying methods are used for larger areas. The tools used in land administration in the early 19th century, chain measurements, in principle, differ from the instruments used today.

The chain is replaced by the tape then the theodolite, which has been used for many years (Wakker *and others* 2003b).Over time, developments in ICT have steadily improved and modern instruments, such as the total stations used in boundary definition, measure angles to within five seconds of an arc and distances of 1000 meters to a precision of better than five millimetres (Elfick *and others* 2005). In parallel, the most common method of building cadastral databases was by digitizing boundaries from the old cadastral maps. With the development of ICT, a new and exciting era of positioning on land began with the launch of the first satellite positioning system called a global positioning system (GPS), changing the angle/distance principle to the coordinate principle. Satellite positioning systems were primarily designed for military applications in timing and positioning; however, the potential benefits for civilian application became quickly apparent (Leick 2004).

While ground survey techniques have been extensively used for cadastral mapping, photogrammetric and satellite imagery methods have contributed less to cadastral surveying. Under suitable conditions, photogrammetry can, however, produce maps and measurements that are as accurate as or even more accurate than those obtainable by standard ground methods.

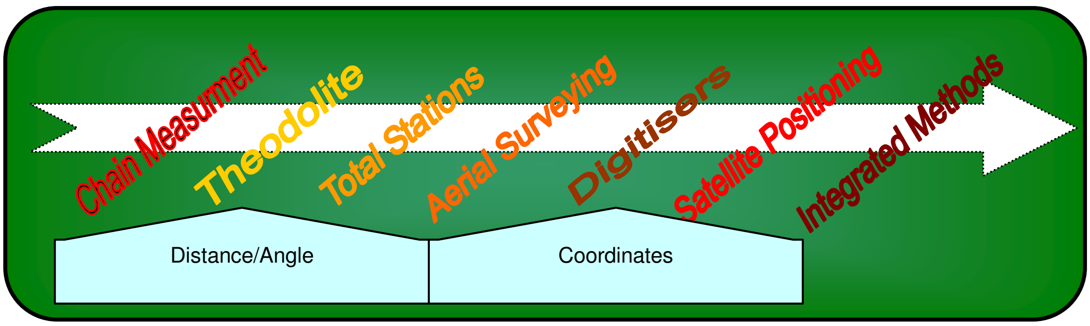


Figure 3-4: Evolution of data capture technologies

Today, along with the evolution of the mentioned data capture tools and techniques, ICT offers many techniques and tools to integrate them. Real-time kinematic (RTK) GPS has matured to the stage where it has become another tool for the professional surveyor (Roberts 2005). A commercial integration of GPS and total stations assisted by wireless modems, Internet and number crunching servers to replace the conventional geodetic control points are now available (CRANENBROECK 2005). GPS controlled aerial photogrammetry is, in its current guise, a mature technology that has found near universal acceptance in the mapping community(Ellum and El-Sheimy 2005).

ICT today pushes land administration data capture towards an interoperable approach, enabling all capture tools and technologies with common standards and protocol to benefit from and assist each other. Conversion softwares, interface devices will be assisting capture technologies to stay connected for the quality mapping. In addition, cadastral data models now can take the advantage of coordinate bases capture method to improve the integrity and interoperability of different land administration databases.

3.3.3 DATABASE MANAGEMENT SYSTEM TOOL

A database is a collection of data, typically describing the activities of one or more related organisations. A database management system or DBMS is software designed to assist in maintaining and utilising large collection of data (Ramakrishnan and Gehrke 2003). Databases are traditionally used to handle a large volume of data and to ensure the logical consistency and integrity of data; this has also become a major requirement in cadsatral data handling.

DBMS can be classified according to the way they model the data, relational DBMSs and object DBMSs. A relational DBMS comprises a set of tables (property and parcel), each a two dimensional list of records containing attributes (rights, value, owner) about the objects under study. ODBMS were originally designed to address several weaknesses of RDBMS. This includes the inability to store complete objects directly in the database. Because RDMS primarily focused on business applications such as banking, human recourse management, stock control and inventory, they were never designed to deal with rich data type such as geographic objects sounds and video. In spite of technical elegance of ODBMS, they have not proven to be as commercially successful as some predicted. This is largely because of the massive installed based of RDBMS and the fact that RDBMS vendors have now added many important ODBMS capabilities to their standard RDBMS software to create hybrid object relational DBMS (ORDBMS) (Longley 2001; Egenhofer and Mark 2002; Cho 2005; Longley 2005).

In recent years spatial cadastral and land information databases have become increasingly large and complex. Land administration systems continue to face increased data volumes (converting from original maps, new development, increasing number of interest), largely attributed to growing businesses and a greater need for real-time information (online services, interoperable data exchange mechanism). For instance, over 10.2 million land parcels in Australia or 7 million cadastral parcels in the Netherlands (The University of Melbourne *and others* 2008) show that a huge amount of cadastral data has to be kept and maintained through DBMS. Beside the spatial database, land administration systems include a separate database containing data on interests and rightful claimants, which historically have been kept and maintained separately from its spatial counterpart.

Today, with the development of ICT, DBMS vendors are continuing to emphasise the enhanced capabilities of databases, which provide ease of operational complexity. With ever-growing cadastral databases, scalability continues to be a key consideration for many land administration systems: features such as manageability, availability, scalability, reliability and interoperability have become increasingly important to manage very large, cadastral databases. DBMS vendors are pushing for increased capacity support for databases in the range of petabytes (1,024 terabytes) (Silberschatz *and others* 1996).

In addition to the issue of the large volume of data, land administration systems are now looking to provide fast and updated availability of land information to their users. The ICT industry is witnessing a remarkable shift towards real-time and online data update. Competitive pressures and opportunities to differentiate customer service are driving demands for frequently updated information real-time or close to it (Son and Kang 2002).

Furthermore, over the coming years, it is expected that DBMS mashups technology will be the future approach of choice. The numerous applications of land information will be make building composite land related interoperable applications more relevant (Jhingran 2006). Such mashups will shape the way in which data is made available. Google map mashups in real estate websites is one of many examples of interoperable cadastral databases. In the future, the demand for composite applications, which have traditionally been used to serve specific needs and functions in land administration systems, will include various third party cadastral databases while maintaining their service focus. With the support of ICT, land administration will begin to treat mashup components as a commercial asset.

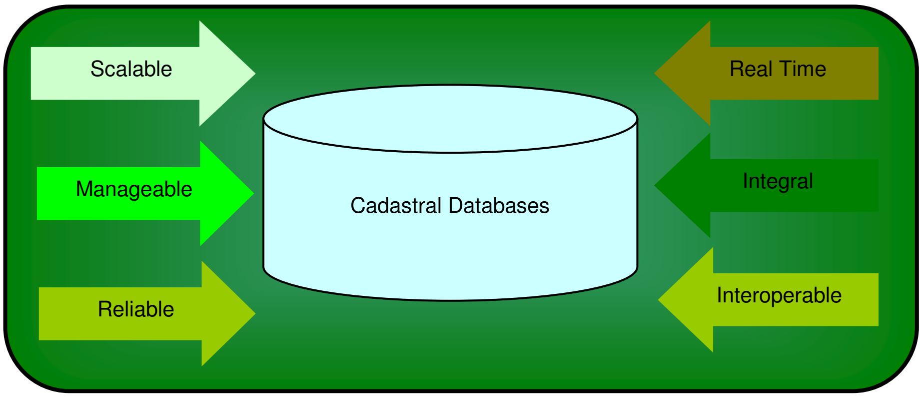


Figure 3-5: ICT supports future cadastral databases

According to the above discussion, the DBMS tool of ICT promises to change the process of recording and organising land data as land administration systems and end-users alike seek better interoperable solutions that have greater impact on service delivery.

3.3.4 DATA CATALOGUE TOOL

The evolution of ICT has brought about significant changes to the role of land administration. ICT facilitates production of enormous amount of land information that can be useful for businesses, governance and sustainability. Compared to a decade ago, decision makers and people in businesses today are more likely to use land administration portals for spatial information. While the importance of land information has become obvious, the tools for selecting, organising, indexing land information and data catalogues remain scarce.

The data catalogue tool can facilitate interoperability and organise the land information contained in the in-house databases of land administration subsystems. Indeed, data available in a land administration system can be called a digital land information library. It is very apparent that there is valuable data in such a library, for example, rights, restriction and responsibilities in land. Land administration systems clearly need a catalogue system to handle spatial and non spatial search criteria.

According to the Oxford dictionary a catalogue is a complete list of items arranged in alphabetical or other systematic order. Data catalogue is a listing of data sets approved and currently available. Similar to how a card catalogue organises library books, a data catalogue describes and provides links to available data.

A data catalogue is usually accompanied by metadata. Metadata is data about data. Metadata elements and schema are used by data producers to characterise their data. Meta data facilitates data discovery, retrieval and reuse. (OGC 2003) has developed a standard conceptual metadata schema, to be used by information systems, program planners and developers of spatial information systems like cadastral databases.

Unlike other catalogues; the design of land information catalogue must address two important characteristics unique to its metadata content. The first is spatial attributes which allow the metadata to be associated with locations and shapes on a map. These are known as the geospatial metadata. It is necessary for the data catalogue to support digital interoperable land information library services dealing with geospatial metadata. The second is a standard metadata structure. The broad range of geospatial data formats suggests that there is need for a single structure that can be used to represent land information metadata.

The data catalogue tool design and implementation is at a critical juncture where ICT must integrate land information with governance, business and sustainability so that users can locate place-based information from documents and data. Allowing users to access land information via cataloging and information retrieval services and the integration of non spatial and spatial criteria is an obvious development path. With the support of ICT, such services will ease the cost and effort required to extend land information access to all types of information.

3.3.5 DATA CONVERSION TOOL

Many land information sources and applications have been created by various agencies, departments, local government within a land administration system. However, interoperability, data sharing and exchange continue to be a challenge. Spatial datasets are produced and distributed in a variety of formats: vector, raster, point, line, polygon, image, and so on Often datasets are designed for certain computer systems or software programs. In the likely event that an important dataset is available, but in the wrong format, the land administration systems must be aware of the issues, methods, and tools for converting cadastral data to a format which is compatible with the particular software. Additionally, many geospatial projects require significant amounts of data conversion. It is not uncommon to spend as much as 80 percent of the time converting data between formats and fine-tuning the way the data is organised overcoming interoperability issues.

The diversity of spatial databases currently in use demands an equally diverse set of format options for users who are requesting data. ICT offer two options to overcome this issue. The issue of interoperability can be met in two ways: special-purposes translators or the use of a common format such as Geography Markup Language (GML) or LandXML. The latter is based on an interface approach while, the former is a direct approach by which the data of interest can be extracted and converted through ad-hoc routines.

Direct conversion involves the transformation of one system's format to another system's format. Under this technique, software is specifically developed to manage the differences between various data formats. Several programs may be required in order to accommodate the format differences between software vendors. An example of direct conversion is converting a vector ARC/INFO data file into a vector GRASS file.

The interface method requires a system to translate its internal data format file to a universal or standard format so that other systems can translate the standard file into their own internal file.

For instance, GML is an XML grammar written in XML Schema for the modelling, exchange, and storage of geographic information. The key concepts used by GML to model the world are drawn from the OpenGIS® Abstract Specification and the ISO 19100 series. GML provides a variety of objects for describing geography, including features, coordinate reference systems, geometry, topology, time, units of measure and generalised values (ISO and OGC 2004).

LandXML is a new international standard for digital interface with surveyor's software. The LandXML schema facilitates the exchange of data created during the Land Planning, Civil Engineering and Land Survey process. Land development professionals can use LandXML to make their data more readily accessible and available to anyone involved with a project (www.lanxml.org).

Advances in ICT enabled land administration services are to a large extent driven by the development of the World Wide Web, client-server architectures and distributed processing. The WWW itself provides a clear example of a successful global infrastructure enabling international telecommunication and commerce. Its success derives from the universal acceptance of transfer protocols, easy procedures for content publishing and access, availability of free or inexpensive web client and web publishing software (Zaslavsky *and others* 2000). Similarly, for efficient service delivery, land administration systems in terms of land information require versatility, and interoperability. These are achieved through the use of efficient data conversion and exchange services.

The data management tool offered by ICT provides a facility for data modelling, data capture, database systems, data catalogue and data conversion. Table 3-1 summarises the most innovative data management tools offered by ICT. The next section explores what tools ICT does offer for data dissemination.

Data Management Tools	ICT offers
Data model	Object/relational Modelling
Data capture	Multi method integrated data capture
Database	Real time data handling, mash ups, petabyte databases
Data catalogue	Geospatial metadata
Data conversion	Standard exchange protocol

Table 3-1: Summary of innovative data management tools offerd by ICT

3.4 DATA DISSEMINATION

As discussed in Chapter Two, the dissemination of land information is one of the most important aspects of land administration. The process of land information dissemination has its own complexity caused by the diversity of involved organisations, clients and users, as well as the variety of other processes. Dissemination may include the order, packaging and delivery, offline or online, of the data (Nebert 2004).

Meanwhile evolution in Internet and WWW technologies offers a variety of tools for data access and sharing. The access and sharing tool facilitates the development of a web-based access to land information in a seamless and integrated view. These tools provide recent interoperable sharing techniques, based on international standards like (OGC 2003) and the ISO International Standard. Technically, land information dissemination is driven by GIServices, supported by interoperability and web services, and distributed by computing technology such as Grid, P2P and Agent (Tao 2006).

3.4.1 WEB SERVICES TOOL

The Web is an immensely scalable information space filled with interconnected resources. A service is an application that exposes its functionality through an application programming interface (API). A Web Service is therefore defined as an application with a Web API. Web services support heterogeneous communication because they all use the same data format: XML. Web services communicate by passing XML messages (Manes 2003).

Meanwhile, Spatial web services make it feasible for multiple organisations that need to access the same data to do so from a single database hosted as a web service rather than by simply duplicating the data in each organisation. They make it possible for users to access data and functionality through the Web and to integrate them with their own systems and applications without the need to develop or host specific tools and datasets themselves (Tang and Selwood 2003). The National Association of Realtors (NAR) in the United State for instance, established an Internet portal web site for home sale searches using spatial service technology. (Tait 2004).

Furthermore, (OGC 2005) proposes a series of specifications to support spatial web services, which include the Web Map Service (WMS), Web Map Context Document (WMC) Web Feature Service (WFS), and Web Coverage Service (WCS). The common aspects of these specifications include operation request and response contents; parameters included in operation requests and responses; and encoding of operation requests and responses.

A WMS produces maps of georeferenced data. A "map" is a visual representation of geodata; it is not the data itself. There are three WMS operations: GetCapabilities returns service-level metadata, which is a description of the service's information content and acceptable request parameters; GetMap returns a map image whose geospatial and dimensional parameters are well defined; GetFeatureInfo (optional) returns information about particular features shown on a map. This specification defines a syntax for World Wide Web (WWW) Uniform Resource Locators (URLs) that invokes each of these operations. Also, an Extensible Markup Language (XML) encoding is defined for service-level metadata(OGC 2005).

In addition to WMS, OGC provides a specification for so called WMC. This specification demonstrates how a specific grouping of one or more maps from one or more map servers can be described in a portable, platform-independent format for storage in a repository or for transmission between clients. There are several possible uses for Context documents. The Context document can provide default startup views for particular classes of user. Such a document would have a long lifetime and be publicly accessible. The Context document can save the state of a viewer client as the user navigates and modifies map layers. The Context document can store not only the current settings but also additional information about each layer to avoid having to query the map server again once the user has selected a layer. The Context document could be saved from one client session and transferred to a different client application to start up with the same context. Contexts could be discovered and catalogued, thus providing a level of granularity broader than individual layers (Open Geospatial Consortium Inc. 2005).

The OGC Web Map Service allows a client to overlay map images from multiple Web Map Services on the Internet. In a similar fashion, the OGC Web Feature Service allows a client to retrieve geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services (Open GIS Consortium Inc. 2005).

The Web Coverage Service (WCS) supports the electronic retrieval of geospatial data as "coverages" – that is, digital geospatial information representing space-varying phenomena. A WCS provides access to potentially detailed and rich sets of geospatial information, in forms that are useful for client-side rendering, multi-valued coverages, and input into scientific models and other clients. The WCS may be compared to the OGC WMS and the WFS; like them it allows clients to choose portions of a server's information holdings based on spatial constraints and other criteria. Unlike the WMS, which portrays spatial data to return static maps (rendered as pictures by the server), the WCS provides available data together with their detailed descriptions; defines a rich syntax for requests against these data; and returns data with its original semantics which may be interpreted, extrapolated, and so on – and not just portrayed. Unlike WFS which returns discrete geospatial features, the WCS returns coverages from space-varying phenomena that relate a spatio-temporal domain to a (possibly multidimensional) range of properties (Open Geospatial Consortium Inc. 2006).

With the development of ICT all cadastral databases can now be accessed online. But more importantly, in the future they will be accessible through a simple standard set of interfaces. Future web service technologies will enable users to subscribe to dynamic web feeds from any of the services to create their own service that accepts these web feeds and dynamically computes statistics, demographics and so on

Whenever there are changes in cadastral information, users might be alerted in a real time manner.

3.4.2 DISTRIBUTED COMPUTING TECHNOLOGY TOOL

In the distributed architecture, services are built upon a more advanced networking scheme. The significant difference is the adoption of interoperable distributed component technology, which can interact with heterogeneous systems without the constraints of traditional client/server relationships. Under a distributed architecture, there is no difference between a client and a server. Every node can act as a client or a server based on the task. A client is simply defined as the requester of a service. A server is simply the machine that provides the service. This architecture permits dynamic linkages between data and software. Given the possibilities in distribution of resources and components, there are various methods which can be considered.

i AGENT COMPUTING

An agent is a computer system suited in some environment and that is capable of autonomous action in this environment in order to meets its design objectives. There are several characteristics for an agent, some of them are ideal characteristics and are far from reality. But some characteristics like mobility, communication ability, reactivity and inferential capability can enhance spatial service applications in various fields (Kalantari 2003). Agent technology can be used for registry search, service discovery and integration, parallel administration, parallel service evaluation. The combination of this variety of facilities with spatial service can therefore enhance the performance of complex land administration processes.

ii P2P COMPUTING

The internet as originally conceived in the late 1960 was a peer-to peer (P2P) system. P2P computing marks a contrast with the currently dominant client/server architecture. The basic strategy is to use all P2P-networked computers to serve not only as clients but also as servers. P2P computing provides an infrastructure for sharing the widely untapped computing power within in-house computers in a land administration system (Oram 2001). Communication and coordination between all peers is still an issue. Agent technology especially mobile agent systems are considered to be useful alternatives for addressing this issue (Kalantari 2004).

iii GRID COMPUTING

Grids are persistent environments that enable software application to integrate instruments. They display computational and information resources that are managed by diverse organisations in widespread locations (Foste and Kesselman 1999). They bring together geographically and organisationally dispersed computational resources and human collaborators to provide advanced distribution of high performance computing to users (Foste and Kesselman 2004).

The core Grid technology is developed for the general sharing of computational resources and is not especially designed for geospatial data and land information. The Geospatial Grid must be able to deal with the complexity and diversity of geospatial data and large land information volume. Grid technology is another option available for disseminating land information.

The tools introduced in data dissemination are those which organise content and services, such as search, information access, support resources, data and applications. This section traced the emergence of web services as well as distributed computing architecture, outlining the significance of them in spatial data dissemination. The objectives are principally to relate the development of tools to land administration systems and to review recent technological breakthroughs (Table 3-2).

Data Dissemination Tools	ICT offers
Web services	Standard universal data access approach
Agent Technology	Mobility, communication ability, reactivity, inferential capability
P2P Technology	sharing the widely untapped computing power
Grid Computing	sharing of computational resources

Table 3-2: Summary of innovative data dissemination tools offered by ICT

3.5 ENTERPRISE FACILITATOR

Needless to say land administration is a very complicated business with its own special characteristics, such as dealing with spatial information. However, it comes with characteristics and ICT needs which are common to other businesses as well. Internet, mobile communication, wireless network, Intranet, web pages have been integrated to every data business of any organisation, including land administration systems. Although some of these ICT based tools may be used in the everyday business of any organisation like internet banking, electronic fund transfer, they are of particular interest to land administration systems. This section explores these technologies.

3.5.1 ONLINE BANKING

Electronic banking is a foundation to the establishment of an electronic conveyancing. e-Conveyancing and online settlement is considered as an essential tool in an e-land administration for creating more efficient property related finance transactions.

With the development of ICT people no longer have to do all their banking in person. Online banking allows people to sit at a desk and check accounts, transfer money, check the status of loans, track investments, pay bills electronically, and trade stock or other investments. From a technical point of view there are three ways to bank online: through the internet, via the software a bank provides or through personal finance software (B.V 2001).

ICT is responding to the developing markets for Web pages, Internet banking applications, and bill presentment and payment services. Many in the banking industry expect significant growth in the use of the Internet for the purchase of goods and services and electronic data interchange (Claessens *and others* 2002). Meanwhile, key components that help maintain a high level of confidence in Internet banking include security, authentication, trust, privacy, and finally, availability (J.P. Morgan & Co. 2000)

3.5.2 DIGITAL SIGNATURE

A digital signature is an electronic signature that can be used to authenticate the identity of the sender of a message or the signer of a document, and possibly to ensure that the original content of the message or document that has been sent is unchanged. Digital signatures are easily transportable, cannot be imitated by someone else, and can be automatically time-stamped. The ability to ensure that the original signed message arrived means that the sender cannot easily repudiate it later. The digital signature has remained a serious issue in very important transactions like land and property transfer. However, it is another foundation for electronic banking and electronic conveyancing.

3.5.3 ELECTRONIC DOCUMENT

Electronic document refers to documentary information expressed in an electronic-digital form which has properties that allow its authenticity to be identified. Such a document should be accompanied by an electronic document's sender, who can be natural or legal persons themselves sending electronic documents or on whose behalf they are sent, with the exception of those who act as intermediaries in relation to the sent document. An electronic document also carries a natural or legal person to whom it is addressed. The validity of such a document is assessed against an electronic documents circulation which is a collection of processes used to check completeness and validity.

The push for efficient service delivery and technology is driving land administration systems towards performing even the financial part of their activities online. The multi billion dollar business of land administration requires very careful use of ICT. Three important issues have been identified in this section: reliable internet banking systems as well secure digital signatures and digital documents, which are vital to the interests of any land administration system.

3.6 CHAPTER SUMMARY

The emerging technologies offered by ICT provide opportunities for better service delivery, customer satisfaction and a reduction in operating costs. ICT covers a wide range of technologies from mobile phones and internet banking to very complicated computer hardware and sophisticated communication networks. This chapter examined how ICT contributes to the core business of land administration and considered the changing roles of land administration and the associated issues of interoperability and the increasing number of interest in land. Chapter Three used land administration processes to identify the possible contribution points of ICT. ICT directly contributes to data management, data dissemination and enterprise facilitator. These were identified and followed with a detailed discussion.

From the data management perspective, ICT provides a facility for data modelling, data capture, database systems, data catalogue and data conversion. Innovative tools include object/relational modelling, multi method integrated data capture, real time data handling, mash ups, petabyte databases, geospatial metadata and standard exchange protocol. From the data dissemination perspective, ICT contributes to the organisation of content and services such as search, information access, support resources, data and applications by web services, agent technology, P2P technology, and grid computing. Finally, internet banking systems, digital signatures and digital documents were identified as examples the enterprise facilitators.

The next chapter develops a research methodology based on the findings of these two background chapters to respond to the identified research problems.

CHAPTER 4- RESEARCH METHODOLOGY

4 RESEARCH METHODOLOGY

4.1 INTRODUCTION

The first part of this thesis explored the changing role of land administration. It found that land administration systems are facing change and must now contribute not only to the sustainable development of a society but also to good governance, enhancing quality of life and service to business. Furthermore, it revealed that land administration systems are changing the roles they play in society rather than the functions they perform. Having investigated these roles and associated functions, a number of issues were identified: land administration renovation, interoperability, standardisation, land related objects and integrated interest management.

To address these issues, background chapters identified ICT as an important factor to offer efficient tools. The emerging technologies offered by ICT provide opportunities for better service delivery, customer satisfaction and a reduction in operating costs. ICT's contribution includes data management, data dissemination and enterprise facilitating. This contribution provides a well-organised structure for addressing the issues. Needless to say, while utilising ICT is not the entire solution for the issues mentioned, it certainly offers an efficient infrastructure for problem solving.

The second part of the thesis is dedicated to investigating how ICT can be employed by land administration systems, and how can ICT-enabled land administration address the issues identified in the first part of the thesis.

This chapter explains the research development model and then outlines the research design for empirical investigations of the interoperability, data type and data model issues through the case study. It also reveals a preliminary framework design to be questioned and developed during the case studies. The research methodology described in this chapter leads the way for applying the case study results to address the research problem.

4.2 RESEARCH DEVELOPMENT

Over the past few years, ICT has been used to promote administrative procedures in various aspects of government. But recent governments have realised that, in the future, this promotion would be problematic without first designing and establishing essential infrastructures. The concept of e-Government emerged as a solution for the problem.

e-Government introduces applications to support various dimensions and outcomes of government. It includes the delivery of public services as well as the conduct of government business (Radwan *and others* 2005) . e-Government is accepted in many countries with land administration playing an important role in delivering sustainable development objectives, enhancing quality of life, good governance and service to businesses. Despite this realisation, the increasing number of interests in land as well as interoperability and effective communication in land administration and cadastre have not received attention in ICT-based land administration projects (Azad 2002).

ICT is heavily used by land administration organisations. The existence of more than ten online land information services in the various states proves that Australia is one of the leading countries in ICT usage. Also, most of the subsystems have individually initiated projects such as electronic conveyancing and electronic lodgement of plans of subdivisions which need to be interoperable (Kalantari *and others* 2005b).

In New Zealand, the Landonline program commenced in 1996, following amalgamation of the two government departments responsible for cadastral survey and land title registration (Grant 2004). The approach of Landonline is to develop a fully digital cadastre incorporating the various records with plans and images in an intelligent data form, and to transform institutional knowledge and expertise into business rules in an integrated information system The information system must automate data flows and processes, integrate the intelligent record and business rules, and create an effective environment for communication.

In Great Britain, the Land Registry proposes a fully electronic conveyancing system in England and Wales. This would include e-lodgement of applications, e-certificates and deeds and electronic settlement of payment due on completion. The database for this system must bring together information from the Land Register with other information relevant to users, especially buyers and sellers who will be able to launch single, comprehensive searches of property and associated rights, restrictions and responsibilities. The land registry's role will be to provide an electronic system linking conveyancers to each other and to the land registry's database (Beardsall 2004) and bringing together all imposed interests in land in a single integrated view.

In the Netherlands all deeds since 1999 have been scanned as a first step in applying ICT to the land administration process. New deeds are scanned on receipt and an automatic proof of receipt is generated. The digital signature is an essential part of this process (Louwman 2004; Stolk 2004). Work flow management is another feature required to increase interoperability and keep data up-to-date in the land administration process (Louwman 2004).

All German states are currently developing the Official Cadastral System "ALKIS" which will integrate the cadastral data of the older Automated Real Estate Register (ALB) and the Automated Real Estate Map (ALK) solution. In addition, the data model of ALKIS will be identical to the updated Authoritative Topographic and Cartographic Information System (ATKIS). The challenge of this project is to reach interoperability between different solutions within towns and counties, because in most cases different geo-information systems are installed for different applications (Bruggemann 2004).

The Polish Government has applied two major stages including building a technological framework and modernising the organisational, institutional and legal frameworks for e-land administration. Their aim is to gain three major components for their service including an Integrated Electronic Platform, New Land Book and improvement of fiscal cadastre. An e-conveyancing process is also being introduced to the traditional notary service (Sambura 2004).

The Austrian CYBERDOC is the electronic document archive for civil law notaries. Documents are scanned, generated and allocated attributed key words and sorted permanently and unalterably in electronic form on the archive server (Brunner 2004).

CARIS Land Information Networks (LIN), the New Brunswick province land information system in Canada, features one centralised and integrated authoritative database. The database is distributed through a provincial intranet that needs to be interoperable. CARIS LIN supports a semi automated land transaction business and work flow. It supports the transfer of name based system to parcel based system and online title conversion. An interoperable data model for integrating land information from different land related database is critical for this e-land administration initiative. These features have led to a "virtual office", conforming with initial visions for the system to allow users of real property information to "serve themselves" (Ogilvie and Mulholland 2004).

As seen above in the selected examples, ICT provides opportunities for better service delivery and customer satisfaction and a reduction of operating costs. However, the key question in the second part of this thesis is why has the establishment of ICT-enabled land administration not fully responded to the issues of increasing numbers of interests in land and interoperability among subsystems. To answer this question a case study approach is adopted.

The aim of conducting the case studies is to achieve a better understanding of the current situation for land administration systems in respect to ICT usage. The investigation assists with providing a comprehensive framework of utilising ICT, also known as the e-land administration framework. The framework presents a strategy to provide effective interoperability through coordination among various subsystems of land administration system including front office operations like online customer services and private partnership services, and back office operations like designing data models and organising of databases.

The results of Chapter Three, in particular, will help with the development of an e-land administration toolkit. The tools that are identified in Chapter Two can be combined with the lessons learnt in Chapter Five to formulate an e-land administration toolkit. The e-land administration toolkit can then assist in addressing the issues associated with the increasing number of interest in land and interoperability, as identified earlier. The tools that are developed in Chapter Five are described and the functionalities of each are explained.

Consequently, these combinations will lead to discover which tool within e-land administration plays the critical role and why. The tool should support effective communication among the different land administration subsystems by making data and functionalities interoperable, that is, capable of being used by all subsystems. This tool in e-land administration facilitates the ability to effectively link land administration subsystems in order to share the resources, find the data, and organise functions to serve the public. It also will assist with handling the incorporation of a broad range of interests in land. Following the identification of this tool, the special focus will be on developing the critical tool (Figure 4-1).

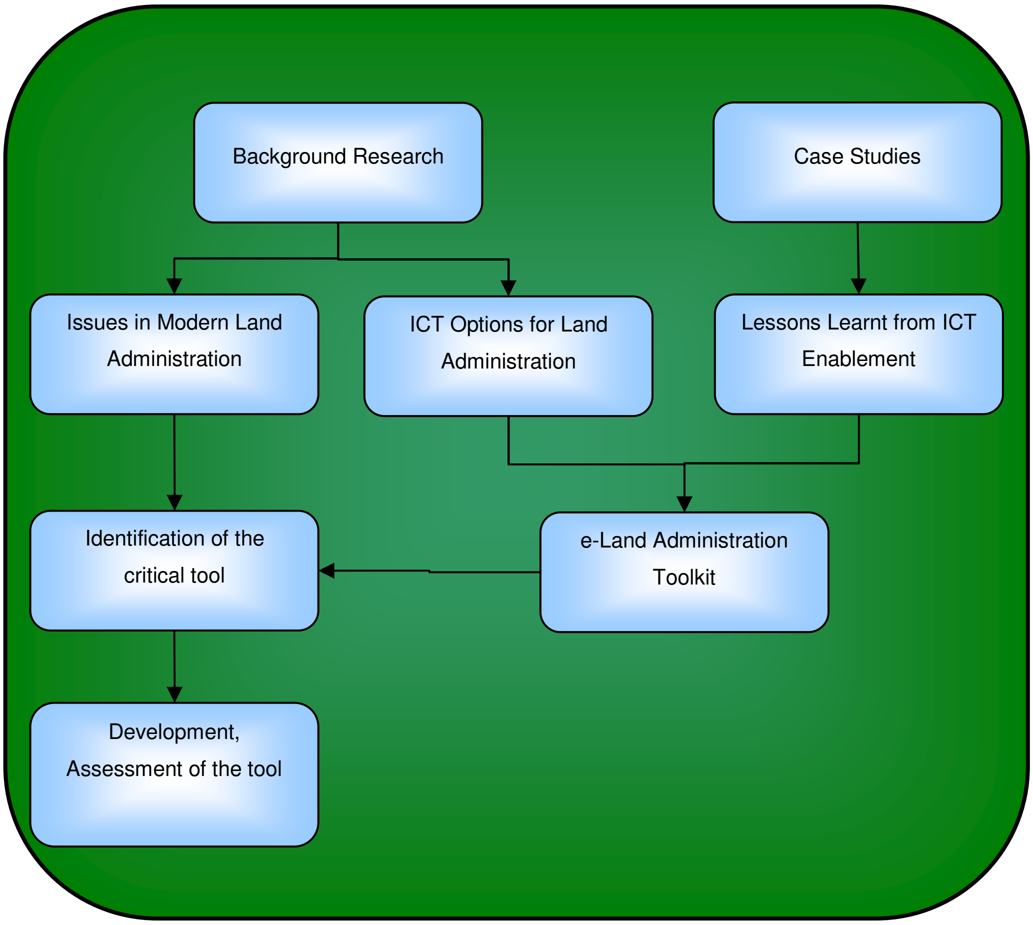


Figure 4-1: Research development model

4.3 CASE STUDY APPROACH

As it was mentioned earlier, to assist with the detailed understanding of interoperability in land administration and handling the increasing number of interests in land, an analysis of country experiences has been put in the thesis development agenda using a case study approach in three states of Australia, Victoria, New South Wales and Western Australia. Analysing these experiences and determining good practice assists in proposing effective and innovative ways to respond to the research problem.

4.4 INVESTIGATION METHOD IN THE CASE STUDIES

To undertake the case studies, the researcher used the applied research method, conducting external and internal studies of each land administration system. The methodology used is a common practice of organisational studies called Structured System Analysis and Design Method, which is builds on the work of different schools of development methods (Bryman 1989; Clegg 1996; Checkland 1999).

4.4.1 EXTERNAL STUDY

External study aims at identifying interoperability issues in the land administration system. External study includes the identification of main players in the land administration system. Analysing the results of the identification facilitates the recognition of the data exchange and workflow. This, in particular, assists with the determination of interoperability level and associated issues in the case studies (Figure 4-2).

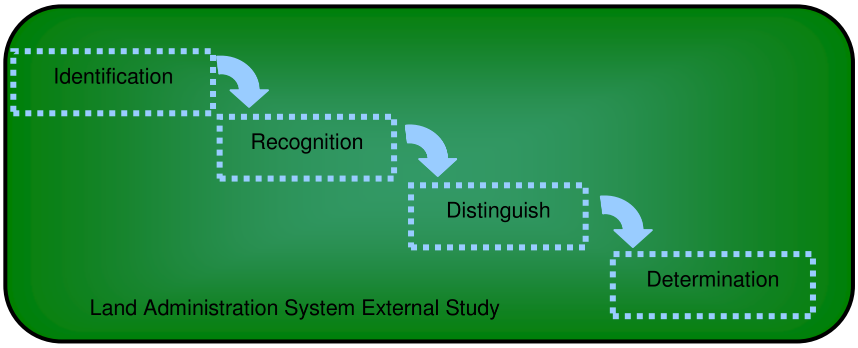


Figure 4-2: Steps of external study

4.4.2 INTERNAL STUDY

Internal study aims to investigate the information system, data structure, data model and data types employed in the case studies. For internal study of land administration systems, the methodology divides the internal work flow into four phases: reception, process, support and follow up. In the reception phase, data entry is investigated in terms of the type of data, data format and data provider. Then in the process phase, the type of the action like conversion or value adding on data is determined. This is followed by the support phase, which includes the determination of output data, its format and to whom it is supplied. The mentioned phases are sustained with an implicit phase named Follow up. It does not explicitly include any action or process, and exists to insure the action undertaken.

The methodology applied to internal phases includes four steps as illustrated in Figure 4-3. Firstly, analyse the land administration system's organisational chart to locate the internal sections, their job duties and procedures. This complements the external study by providing a detailed understanding of the system components. The second step of the internal study is to review the documents and reports of the land administration system to recognise the vision, mission, plan, exiting projects, and potential program. It allows the future direction of the land administration system to be identified and helps to identify necessary actions for meeting the system objectives. In order to investigate the data elements employed, the third step consists of a prepared questioner which includes the input data, input data format, input data supplier, processes and procedures in section, output data, out data format as well as output data customers. This is followed by an interview about other existing issues and related matters. The fourth step is an investigation on data samples, data models and information systems.

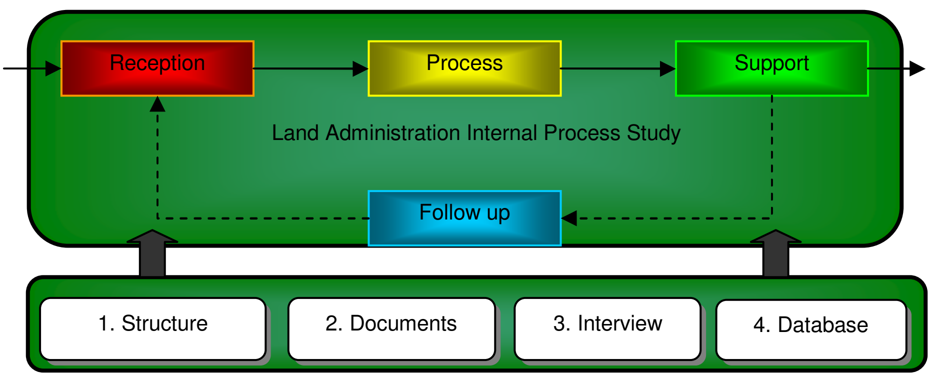


Figure 4-3: Steps of the internal study

4.5 RESULT ASSESSMENT

Once the case studies were undertaken, different functions and processes were identified within the land administration systems. Following this identification, the research methodology proposes a four phase model in order to assess the use of ICT in the processes identified. This helps with a detailed understanding of the relationship between interoperability and data models. The model includes emerging, applying, infusing and transforming phases (Figure 4-4).

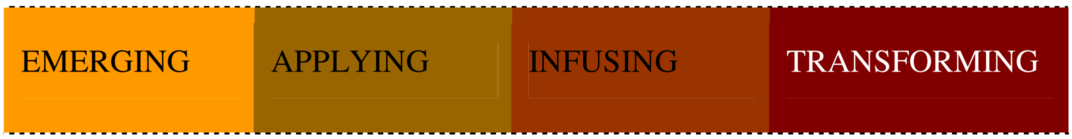


Figure 4-4: The assessment model for ICT utilisation

4.5.1 THE EMERGING PHASE

In this phase, process is in the beginning stage of ICT enablement. The model of ICT enabled and related data model, databases and service delivery process have been designed but are not operational. In this initial phase, the process partners are just beginning to explore the possibilities and consequences of using ICT and have not been faced with the implementation issues. ICT reveals a promising future. Partners at this emerging phase are still firmly grounded in traditional practice but there is an awareness of the uses of ICT.

4.5.2 THE APPLYING PHASE

In the secondary phase, process partners use ICT for tasks already carried out in land administration systems. Traditional processes dominate, but at the applying phase they adapt the ICT enabled process in order to optimise the work flow management, data organisation and service quality by offering information system, data models, and internet based interoperable solutions. This phase assists movement to the next phase if so desired.

4.5.3 THE INFUSING PHASE

At the next stage, the infusing phase, the traditional approach has gone. The process partners explore new and efficient ways in which ICT can solve communication sharing and data exchange issues among the subsystems, by offering better interoperable solutions.

4.5.4 THE TRANSFORMING PHASE

Land administration systems that use ICT to rethink and renew the traditional, ICT enabled processes and create and streamline new processes exist at the transforming approach. ICT becomes an integral though invisible part of productivity and professional practice.

Using this model, land administration systems can be assessed against the level of interoperability and data comprehensiveness. This is actually the qualitative method proposed in this research for assessment of ICT utilisation in land administration systems.

4.6 CHAPTER SUMMARY

This chapter outlined the second part of this thesis. While the first part was dedicated to reviewing the related literatures, it concluded that the role of land administration is now changing and identified issues such as interoperability and the increasing number of interest in land. The first part also demonstrated how ICT can offer an efficient infrastructure to address the issues.

With the results of the first part in hand, this chapter outlined the second part of the thesis. The research methodology in this chapter presented the pathway to answering key questions of this research: how can ICT be employed by land administration systems, what would be the issues, and how can ICT enabled land administration contribute to addressing the issues identified in the first part of the thesis?

To answer the questions a case study approach was adopted for the second part of the thesis. This chapter explained the investigation method behind the case studies. It also demonstrated the methodology used to assess case study results.

Chapter 5 - ICT Enablement in Land Administration Systems; Australian Case Studies

5 ICT ENABLEMENT IN LAND ADMINISTRATION SYSTEMS; AUSTRALIAN CASE STUDIES

5.1 INTRODUCTION

In order to achieve the stated research objectives, this chapter investigates and analyses three case studies. The chapter is dedicated to reviewing current developments and the utilisation of ICT in Australian land administration systems, including Victoria, New South Wales (NSW) and Western Australia (WA).

In light of the case studies examined, Chapter Five presents an assessment of land administration systems including communication and interoperability among their subsystems as well as the information systems they employ. This assessment provides a detailed analysis of the different stages of applying ICT.

Firstly, the chapter briefly explains the investigation method and the system of land administration used in Australia. Following that, it investigates the three case studies, starting with an introduction to the subsystems, their responsibilities and relations and concluding with discovery of the ICT utilisation within the land administration systems. ICT development is examined against major procedures and associated issues are identified and explained.

5.2 INVESTIGATION METHOD

As mentioned in the previous chapter, an investigation method consisting of external and internal studies is applied to the case studies.

The external study includes identification of the organisations associated with the land administration systems along with their clients and partners. This identification allows an understanding of electronic service delivery and communication between the organisations and external partners to recognise the interoperability issues. On the other hand, the aim of the internal study is to uncover the data employed: the data management strategies, data models, databases and information systems used. Together, the external and internal studies help to develop a framework to respond to the research problems. These methods of study facilitate analysing ICT development within the case studies.

To better analyse the case studies, the analyses are fulfilled according to land administration specifications. As described in Chapter Two, a land administration system includes four major subsystems: land registration, land mapping land valuation, and land development and use regulatory. In the case studies, all land administration procedures are divided according to these four subsystems and all other associated processes are mapped accordingly.

The next section briefly introduces the land administration system in Australia and explores the case studies chosen.

5.3 LAND ADMINISTRATION IN AUSTRALIA

Australia is a federation of six states: New South Wales (NSW) Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic), Western Australia (WA). In addition, there are two mainland self governing territories: the Australian Capital Territory (ACT) and the Northern Territory (NT). These two territories have been granted a limited right of self-government by Federal Government of Australia. In these territories, a range of governmental matters, including land administration, are handled by a locally-elected parliament. Outside of government, the ACT and the NT are often treated like states because of their significant population sizes. Each state has its own constitution, which divides the state's government into the same divisions of legislature, executive, and judiciary as the Federal Government.

Australia maintains centralised land administration offices in each jurisdiction. There is no prescribed organisational structure common to all states; land administration is a state government responsibility performed under a range of government departments such as Environment, Planning, Lands or Land Administration.

Embedded in these departments are the State’s land registry and titles office, Crown lands management office, surveyors board, land valuation offices, land development organisations, land mapping agencies and business units for land information and resources.

Combinations of the services mentioned above can be found in each state. With the current development of ICT, this combination is being assisted by the computerisation of spatial and non-spatial information and the service delivery.

The diversity of strategy, their legislative differences and the different technologies employed by each state enable this thesis to explore various points of view and to understand the practice of ICT utilisation in land administration and associated issues.

Three states were chosen from the eight states and territories: NSW, Victoria and WA. This is mainly because of their leading roles in ICT utilisation. The case studies were conducted in August and September 2005.

5.4 LAND ADMINISTRATION SYSTEM OF VICTORIA

Victoria is located in the south-eastern corner of Australia. It is the geographically smallest mainland state, but the most densely populated and urbanised. Victoria is the second most populous Australian state, after NSW, with an estimated population of 5,205,200 as at June 2007 and a total land area of 227,420 Km2 (ABS 2007).

The Victorian land administration system consists of two main units: Land Victoria and Spatial Information Infrastructure (SII). Each group works together with local governments, utility companies, mapping firms, development companies, and a range of public and government departments, banks, solicitors and conveyancers.

Land Victoria is responsible for land titles and records, surveying, online property information and services, and property valuation. Its mission is to provide Victoria with authoritative, comprehensive and easily accessible land administration and land information and to thus facilitate effective decision-making and appropriate use of land. The SII group is responsible for spatial information policy with the Victorian Spatial Council (VSC) as a high level advisory board and Victorian Government Spatial Council (VGSC), management of spatial datasets and service delivery. Within Land Victoria, the Surveyor-General of Victoria is the primary government authority on surveying and the cadastre (land property boundaries and tenure). Roles and responsibilities for the Surveyor-General are prescribed under a diverse range of Parliamentary Acts and Regulations that includes land administration, planning, surveying, electoral system, geographic place names, regulation, geodetic infrastructure and survey control network, protection of the cadastre and industry leadership.

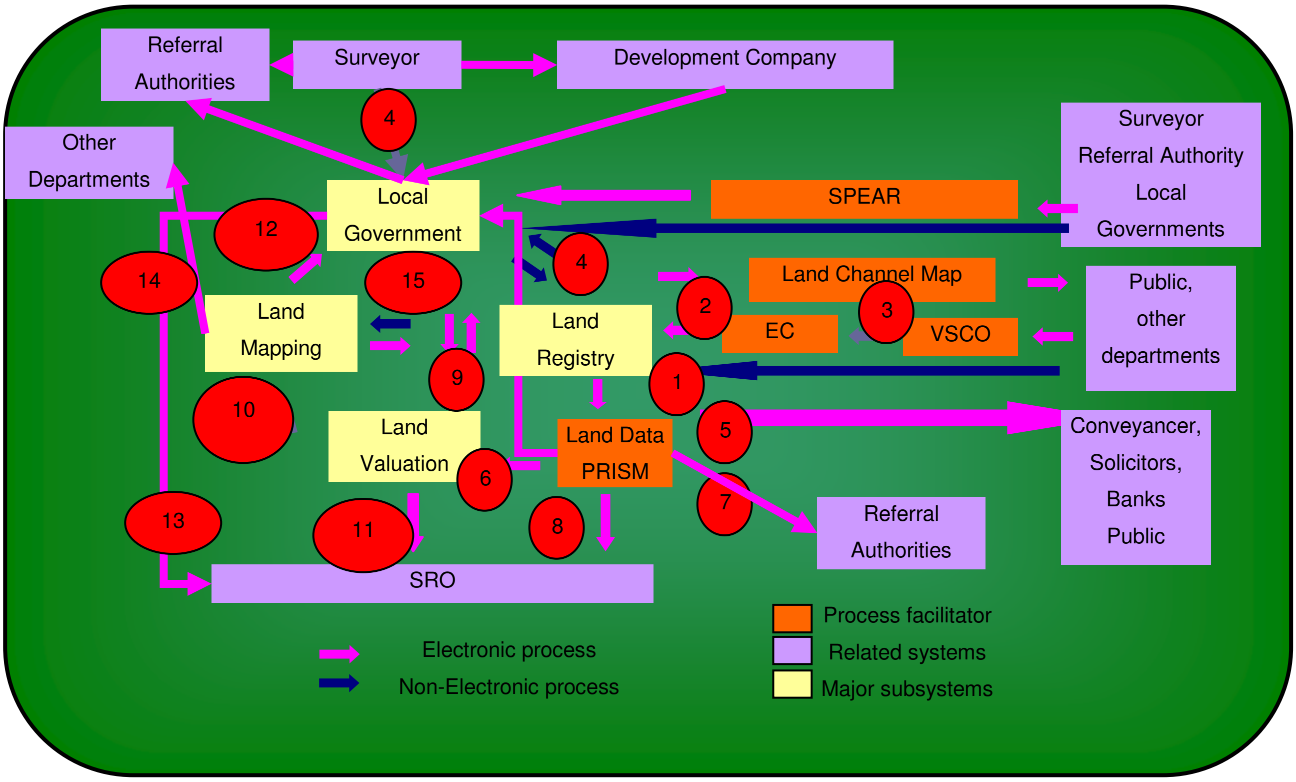


Figure 5-1: Land administration system in Victoria

As a result of the external phase, the components, their relation, data flow among them and electronic and non-electronic process were mapped in a diagram. Figure

5-1 shows the work data flow among the components of land administration in Victoria. The system consists of four major subsystems that are collaborating with a number of external partners, users, local and government agencies. The collaboration is facilitated through a number of ICT enabled application or direct association between them. In the following sub-sections the data and process flow are explained in detail. .

5.4.1 LAND REGISTRY

Within Victorian land administration, the land registry subsystem provides authoritative land related information services through guaranteed title (including ownership right, covenants, caveats, right of way) and tenure registration, provision of Crown land status information (to manage the public interests), property valuation and survey advice and access to title, survey and property sales information.

The role of the Victorian land administration in guaranteeing land title means that the land registry subsystem employs surveyors to check the correctness of cadastral surveys (Figure 5-1, No.4). An examination of the spatial cadastral data therefore involves checking that the new survey information is consistent with all registered plans surrounding the new subdivision. This examination process is conducted largely by hand on hardcopy plans. Moreover, the data models in land registry provide no facility to examine new development whether they are spatially correct.

There is a growing trend for plan examinations to concentrate on those spatial aspects that verify the consistency with adjoining land parcels, leaving the internal integrity and correctness of the subdivision plan the responsibility of the individual surveyor (Effenberg 2001).

Land registry through the Title Registration Services (TRS) provides registration services for land dealings and plans and conversion of land from General Law. Before the Torrens system was introduced in 1862, a General Law system operated in Victoria.

5.4.2 LAND MAPPING

The land mapping subsystem in Victoria is managed by the Spatial Information Infrastructure (SII) group which corresponds to three major activities: providing spatial information policy based on Victorian Spatial Council (VSC) and Victorian Government Spatial Council (VGSC), management of datasets, and service delivery. The land mapping subsystem maintains a broader view on spatial data and provides spatial data for the entire state, which includes geodesy, address, property, roads, images, elevation, administrative boundaries and hydro. This data forms part of the Victorian spatial data infrastructure to serve information to a range of government departments that includes forestry, emergency management, education, police, and and so on (Figure 5-1, No.14). The departments which currently use the land mapping subsystems' services are the Department of Sustainability and Environment, Department of Primary Industries, Department of Justice and Department of Infrastructures, Victoria.

Within the land mapping services, Vicmap Property is the cadastral map base for Victoria, providing information about land parcels and property details. The database is continuously maintained, obtaining maintenance information from authoritative sources within local and state government that is captured at various scales up to 1:25,000. It includes property polygons in metropolitan areas and parcel polygons in rural areas.

The simplified cadastral data model of Vicmap Property has joined the parcel and property attributes to their respective spatial representations. Whilst this data model is easier to use, there will still be a requirement to perform table joins to obtain relationships between parcel and property (within Vicmap Property), or to determine which property has what address (with Vicmap Address) using Standard Parcel Identifier (SPI), lot & plan number, council property number (CPN) and cross reference to Vicmap Address data model.

5.4.3 LAND DEVELOPMENT

The land development subsystem in the Victorian land administration system is mainly represented by local councils, but other development organisations like utility companies and referral authorities for development such as water, electricity and telephone agencies are also involved in land administration processes.

Land development agencies have their own method of modelling, organising and handling land information. This explicitly interferes with the interoperability in Victorian land administration. However, they communicate with the other databases using addresses, property number, assessment number, council reference number and parcel numbers in the data models.

M1 and M2 and PIE and Road Name Maintenance Forms are examples of efforts to improve the interoperability of information (Figure 5-1, No.12). M1 is a spreadsheet excel file which is used for attribute and property changes. M2 is in paper format and used for parcel changes. PIE form is used for parcel identifier enhancement and is a paper based form. Road Names Maintenance Form (RNMF) is, like M2, paper based.

Local Government also provides valuation data for the land valuation subsystem. The valuation data are sent in digital format (Figure 5-1, No.13). In addition to the local governments, the water utility companies provide cadastral data for land mapping subsystem to update the property database.

5.4.4 LAND VALUATION

The primary function of the valuation system in Victoria is to provide protection to the probity of government by ensuring that valuations are properly made and based on defensible valuation methodologies when used in government property transactions and by rating authorities. Valuations are used for a myriad of purposes, including setting limits for the sale and purchase of properties, setting rental levels, determining compensation following the compulsory acquisition of property; asset accounting and management; lending and associated financial dealings, property settlements, property rating and taxation systems, and property portfolio analysis.

Every two years, Victorian local councils revalue all rateable properties in their municipality. The valuation subsystem has the statutory responsibility for overseeing the making and return of municipal rating valuations. Spatial information systems are used by its contract valuers to check the accuracy of valuations while identifying value shifts across a municipality. The subsystem's spatial information specialists prepare maps indicating valuation trends across suburbs, municipalities, regions or the state. Councils are now using these systems to prepare user-friendly maps of their valuation data for strategic planning purposes.

The land valuation subsystem receives property value information from local councils in digital formats (Figure 5-1, No.9). The land valuation database is a flat file which contains one record per property connected to the other related databases using council property number identifiers. Land Valuation receives zoning information from government planning authorities and spatial data from the land mapping subsystem (Figure 5-1, No.10). There is also a close relation between the land valuation subsystem and the SRO for exchanging information (Figure 5-1, No.11). Valuation data model in not a spatial data model rather it uses non- spatial identifiers to improve interoperability when exchanging information.

5.4.5 ICT IN THE VICTORIAN LAND ADMINISTRATION

After a brief introduction to the subsystems, their responsibility and work flows, this section explores and analyses ICT utilisation. The aim of this analysis is to observe how interoperability, data types employed and data models are affected by ICT and how this effect influences other subsystems.

i ICT IN LAND DEALINGS

In Victoria, land dealings' documents are submitted in paper format to be recorded in databases. There are two major clients submitting land dealings: individual private citizens and agents such as banks that usually submit their documents in bulk. However, the registration process for both is same. All land titles are recorded in a database called the Victorian Online Title System VOTS (Figure 5-1, No.1). In Victoria, a land title is an official record of who owns a piece of land. It can also include information about mortgages, covenants, caveats and easements. In other word, VOTS is a non spatial database recording the ownership interests in land along with a limited number of restrictions using volume/folio method of indexing. This non-spatial database is then connected to the spatial cadastral database using the lot and plan numbers and cross referencing with volume/folio numbers.

In addition to the paper based method of transferring land titles, the Victorian Land administration system is pursuing an all–encompassing electronic conveyancing model for a fully electronic process from contract exchange through to settlement, lodgement and registration. It is a parallel process to the existing paper based dealing process (Figure 5-1, No.2). This fully electronic process not only influences VOTS but also has an impact on all related databases. For instance, the volume/folio method of indexing titles should be reconsidered while other methods of indexing are employed in the land mapping subsystem (SPI) or in land development subsystem (CPN). Besides, the VSCO project is working to enable online ordering for the retrieval and delivery of vendor statement certificates (Figure 5-1, No.3). This further complicates the interoperability process as an additional electronic process is appended with its data indexing, referencing and exchange requirements.

ii ICT IN SUBDIVISION

Plans of subdivisions are submitted to the land registry subsystem by a land development subsystem that includes surveyors, development firms or local councils. All the plans are examined in paper format to be registered in the VOTS database. The nature of this survey examination has changed over the years, as a result of the reduction in the number of examining surveyors being employed, the requirement to fast track land registration, and the impact of technology. Also, the land registry subsystem advises local councils of all related changes in a paper format (Figure 5-1, No.4). After this, the land mapping subsystem receives the spatial data of the plans of subdivision to update the property database and to transmit the updated database property back to the land registry (1Figure 5-1, No.5).

However, via the SPEAR (Streamlined Planning through Electronic Applications and Referrals) program, Victoria is reducing its reliance on paper and reducing the effort required to send and track applications through the subdivision process. SPEAR allows subdivision applications to be compiled, lodged, managed, referred and tracked online anytime, anywhere. This brings an opportunity for better service delivery and customer satisfaction. However, this effort requires special attention to interoperability among a variety of databases (Vic map Property, VOTS, utility and local governments databases) which maybe used in the process.

iii ICT IN DATA MANAGEMENT AND INFORMATION DELIVERY

There is a variety of online services provided by the Victorian land administration system. Land Channel is a web based service delivery portal that represents the gate way for land administration services in Victoria. Land Channel offers the following services:

a LANDATA

Land Records and Information Services division of the land registry subsystem through the LANDATA service provides land, property and survey information services and Crown land registry functions to Government, conveyancing, subdivision, land development, land management, property valuation and surveying industries (Figure 5-1, No.5). LANDATA also keeps historic property sale data in a database called PRISM. The PRISM database is presented to the valuation subsystem and real estate agencies and the State Revenue Office (SRO) of Victoria (Figure 5-1, No.6 and 8). LANDATA is an example of the need to integrate land information from different subsystem to improve interoperability in Victorian land administration system.

In addition, LANDATA takes the responsibility of acquiring certificates from development authorities such as water, electricity, telephone agencies as well as local governments. LANDATA also issue planning certificate using planning information from the government planning authorities (Figure 5-1, No.7).

b Interactive Map

The Interactive Map is a web based land information service and is mostly based on property and parcel information. Spatial data and associated attributes are available online on the Interactive Map for public access.

c LASSI Portal

To provide professional information for the land administration industry, Victoria maintains an online system supplying data such as lot on plan, survey marks and other survey labels associated with the land registry documents in a so called service LASSI portal.

d Urban Development Program

The Urban Development Program is an online portal which provides information in different development themes: broadhectare residential land, major residential redevelopment sites and industrial land, each theme has the location of land parcels, their development status, area and estimated dwelling. This program is a major initiative to support the implementation of the Victorian State Government's metropolitan strategy. The purpose of this program is to provide an integrated view of land related urban development databases. This integration is the first step will need interoperable data model: a data model that is capable of incorporating a wide range of land information.

e Property Report

Property Report is an online service for identification of properties that includes information such as address details, local government area, council property number, street directory reference, a list of planning zones applicable to the property with links to the relevant planning provisions , a planning zone map , a list of planning overlays applicable to the property with links to the relevant planning scheme provisions, a planning overlays map address details (street address, lot on plan number, standard parcel identifier), council property number, street directory reference, state electorates (legislative council and assembly) and utilities (power and water suppliers and a map of the area with a site diagram & dimensions). In the future, this service will need to provide a wider range of land information including water and biota rights, carbon credit, heritage and environmental restrictions and so on to the users.

f SMES

SMES is a web portal for providing survey marks data to the public and to surveyors. Using this service authorised surveyors use a login and password detail to provide feedback such as updates to survey marks or new marks. This service is an example of e-land administration, which improves the communication between the system and users. Survey marks are a critical database to improve interoperability through the spatial enablement power they offer to land administration.

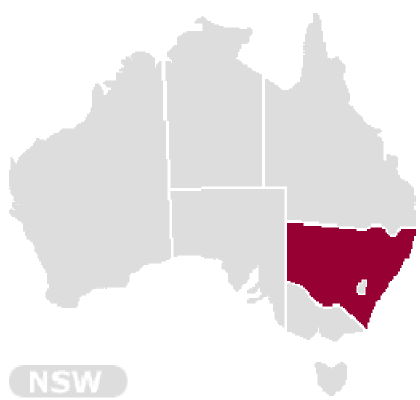
g Crown Land Status Online

The Crown Land Status Online system facilitates the identification of Crown land and the determination of its status. To verify Crown land status, various sets of information are required. They include parish plans, which are drawings of the land shape, and government gazettes that record the history of government proclamations and land status information. This service is an initiative to digitise non-private and public land information in spatial database. However, keeping the private and non-private land information using separate data models hinders effective data exchange, integration and interoperability.

Having investigated the Victorian land administration system, it was revealed that, firstly, ICT enablement should be treated holistically rather than in isolation: land administration attributes, processes, functions and components are strongly tied together. Secondly, e-land administration requires effective communication in the particular interoperability of information and data. Thirdly, interoperability very much relies on data models employed in the land administration system. Finally, data models should be kept up-to-date in terms of the growing number of incoming interests in land.

5.5 LAND ADMINISTRATION SYSTEM OF NEW SOUTH WALES

New South Wales (NSW) is Australia's most populous state, located in the



south-east of the country, north of Victoria. The estimated population of New South Wales at the end of June 2007 was 6.89 million people with a total land area of 800,640 Km2.

Through its Land and Property Information division, the Department of Lands is the key provider of land administration services in New South Wales. The Land and Property Information division of the Department of Lands is the key provider of land and property information for NSW. This Division provides mapping, titling, valuation, survey and related land information services to individuals, businesses, government agencies and non profit organisations throughout NSW, Australia and internationally.

As a result of the external phase of case study in NSW, the components, their relation, data flow among them and electronic and non-electronic process were mapped in a diagram. Figure 5-2 shows the work data flow among the components of land administration in NSW. The system consists of six major subsystems that are collaborating with a number of external partners, users, local and government agencies. Similar to Victoria, the collaboration is facilitated through a number of ICT enabled applications. In the following sub-sections the data and process flow are explained in detail.

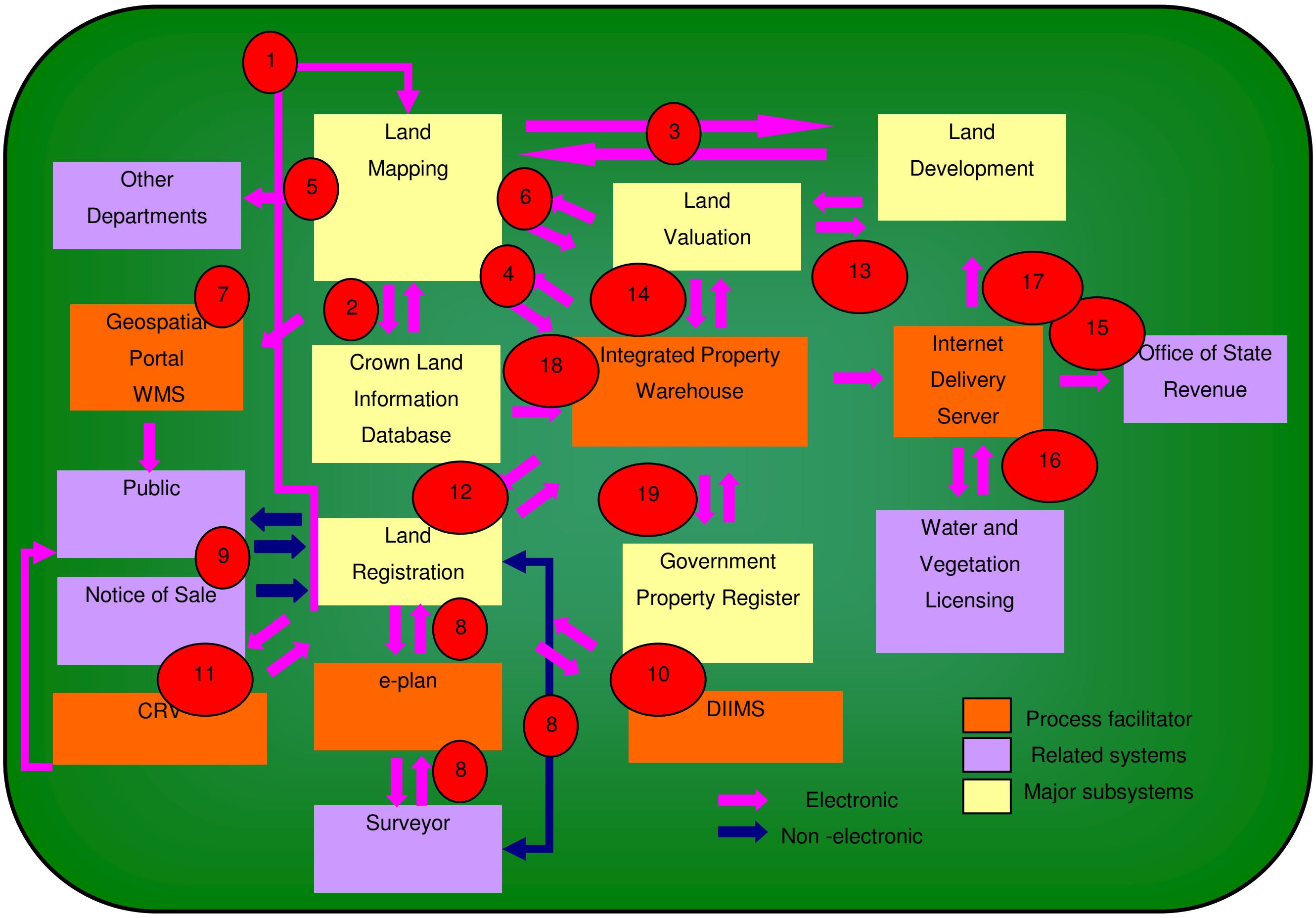


Figure 5-2: Land administration system in NSW

5.5.1 LAND REGISTRY

The land administration system in New South Wales maintains a secure, efficient and guaranteed system of land ownership for NSW. The land title registry defines the legal ownership and boundaries of land parcels throughout the State, both private and public, and records changes as they occur. The land registry provides, titling services to individuals, businesses, government agencies and non-profit organisations. It is responsible for keeping and maintaining titling database which is called the Integrated Titling System.

5.5.2 LAND MAPPING

The land mapping subsystem of the NSW land administration system collects a comprehensive and authoritative range of online and hard copy mapping products and services. These products and services help support a vast range of community, business and government activity such as tourism and land management, electoral boundaries and bush fire control. As the official source of land information for NSW, the land administration system is responsible for maintaining a digital cadastral map of the State, which shows legal and other approved boundaries applying to land, as well as a digital topographic map, which shows its physical and surface features. It also provides aerial photography, satellite imagery, addressing information, touring maps and a unique customised mapping service that tailors spatial information to meet specific needs. The land mapping subsystem is also responsible for the surveying of the Crown lands and provides digital maps for the Crown Land information Database (Figure 5-2, No.2). Land Mapping also provides DCDB (Digital Cadastral Database) information for the IPW (Integrated Property Warehouse) in order to integrate the other related property information like valuation and title (Figure 5-2, No.4). Also, other government departments such as the Department of Primary Industry, Departments of Mineral Resources, Forestry, Education and Health are users of DCDB (Figure 5-2, No.5). The land mapping also provides spatial cadastral data for the land valuation subsystem for the purpose of valuation. Furthermore, the land valuation subsystem is interested in topographical data (DTDB) and Mining database (Figure 5-2, No.6).

5.5.3 LAND DEVELOPMENT

The land development subsystem in NSW is represented by land developer, surveyors, local government and corporate bodies. This subsystem mainly interacts with the other subsystem via the Internet Deliver Server (IDS) (Figure 5-2, No.17). In addition, local governments receive digital cadastral data of their boundaries from the land mapping subsystem. Local governments can advise the land mapping subsystem of the specifications and configuration of the required data which facilitates interoperability (Figure 5-2, No.3).

5.5.4 LAND VALUATION

Valuations undertaken by the land administration system in NSW refer to land value only, which does not include the value of the building or other improvements. The land value does not generally reflect the full sale price that could be obtained for the property. The land valuations are provided to the property holder and the local council every three years using a valuation database called VALNET. Each Council that is re-valued is provided with the latest values of properties and the landowner is advised with a Notice of Valuation issued by the Valuer General. A general valuation of land within Council areas occurs at regular intervals, which are subsequently used as the basis of the rates notices issued by local Councils (Figure 5-2, No.13). The valuation subsystem also provides VALNET information for IPW in order to integrate with the other related property information like ITS and DCDB (Figure 5-2, No.12). All land and property valuations are provided annually for the Office of State Revenue, which requires the information for land tax purposes via IDS using IPW database (Figure 5-2, No.15).

5.5.5 ICT IN LAND ADMINISTRATION OF NSW

After a brief introduction to the subsystems, their responsibilities and work flow, this section explores and analyses ICT usage. This analysis has been considered land dealing, subdivisions, data management and information delivery. Similar to the Victorian case, the aim of this analysis is to observe how interoperability, data types employed and data models are affected by ICT and how this effect influences the other subsystems.

i ICT IN LAND DEALINGS

Property transactions in NSW still depend on the initial completion and lodgement of paper documents. All land dealings including the transfer of land or property are submitted to the land registry in a paper based format. Parallel to the dealing submissions, Notice of Sale (NOS) information is gathered for NOS database that is maintained for valuation and taxation purposes (Figure 5-2, No.9). All the dealings such as new subdivisions documents are scanned and kept in a database named Document Integrated Imaging System (DIIS). It is an isolated database without any communication to other databases. Although this database is linked to ITS in order to retrieve data (Figure 5-2, No.10), the raster based data format utilised by it obstructs effective data exchange and, consequently, retains a poor interoperability.

Like Victoria, NSW is also involved in a project called NECS (National Electronic Conveyancing System) in order to move to an electronic platform for the land dealings. NECS is Australia's joint government and industry initiative to create an efficient and convenient way of completing property based transactions and lodging land title dealings for registration.

Implementing e-conveyancing requires the provision of a proper data integration and exchange mechanism among ITS, DIIS and NOS, IPW as well as DCDB. A data model supporting interoperability is essential for e-conveyancing.

ii ICT IN SUBDIVISIONS

NSW has started to work on a new program that will build capability for the electronic processing of digital land title plans. The land registry currently, receives plans of subdivisions from registered surveyors using two methods: the traditional paper based method and the e-Plan portal. It aims to ease communication between surveyors within the land administration system. Despite this relative success, it does not facilitate interoperability as the principles of current e-plan practice in NSW are the same as paper based systems. The e-plan portal allows surveyors to submit their plans in raster formats that are PDF versions of the plan. Surveyors should follow e-Plan specifications in order to submit a plan of the subdivision (Figure 5-2, No.8). Following the approval of the plan, the land mapping subsystem receives imaged plans of subdivisions from land registry and updates the Digital Cadastral Database (DCDB) (Figure 5-2, No.1).

iii ICT IN DATA MANAGEMENT AND SERVICE DELIVERY

Like the Victorian Case study, NSW land administration also provides a variety of online services using the Internet technology. The early adoption of new technologies in the 1970s and 1980s paved the way for a range of online services in NSW.

a Cadastral Record Viewer

The land registry subsystem is undertaking a project for delivery of integrated title and cadastral information via the Cadastral Record Viewer (CRV). CRV is a tool that allows cadastral enquiries. It provides interactive access to related and supporting datasets like titles, plans, dealings, charting maps and survey information and also access to other datasets like the Government Property Register (GPR). The CRV database receives information from IPW, ITS and DCDB (11). This service needs to link a range of NSW's land related databases. A data model with linking capability for each database is essential to improving data interoperability and providing inclusive land related data including a wider range of land rights, restriction and responsibilities.

b Integrated Property Warehouse

The land administration system in NSW maintains a data warehouse- the Integrated Property Warehouse (IPW). The IPW is used as an environment for exchanging data between applications within the land administration system and external parties. The IPW needs to be updated through an interoperable and inclusive data model so that other databases can connect to it. Its purpose is to draw together data from a range of systems and transform and integrate different and wide ranging data. The data is then used to produce reports and provide data to other systems, both internally and externally. The IPW holds historical data as well as current data (Figure 5-2, No.12, 14, 18 and 19). The land registry subsystem also provides ITS information for IPW in order to integrate with other related property information like valuation and DCDB (Figure 5-2, No.12).

c Internet Delivery Service

To take advantage of the IPW, the land administration system in NSW enjoys an Internet Delivery System that enables Local Government and Office of State Revenue (OSR) to access batched up title and valuation changes and associated DIIMS images. Although IDS maintains a specific database, sourced primarily from the IPW, it also receives notices of registration from ITS (Figure 5-2, No.15, 16 and 17).

d Geospatial Portal

The land mapping subsystem provides access to spatial data including the DCDB via web based portal. The Geospatial Portal is a web based GIS portal for spatial information delivery. It's development is based on Web Map Service (WMS) specifications (Figure 5-2, No.7).

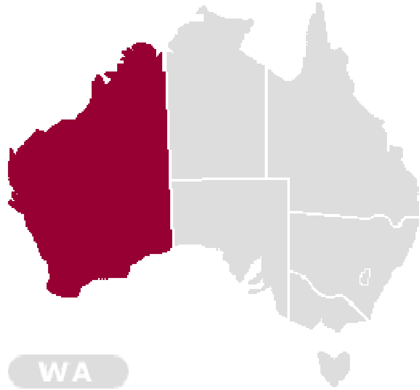
e SIX

The Spatial Information eXchange (SIX) is a collaborative working space established by the NSW land administration system for use by government, business and the community. The SIX Gateway provides a single entry point through which to search, access and utilise the wealth of geospatial services and data managed by Lands, in many cases free of charge. It also provides opportunities for users to contribute to this state-wide resource. The SIX Gateway contains a wide range of property and topographic features as well as cadastral (land tenure) and address information that can be searched against. In addition, a new land tax online service is also available. By using this service clients are able to view properties and land values and to advise if they have purchased or sold a property. They can request a new exemption or update a current exemption.

Having explored the land administration system of NSW, a considerable number of databases was observed. There are several reasons for observing such a large number. Firstly, there is a growing number of data types needed to contribute to the land administration: titles, plans, value, charting maps and survey information, Crown land, environmental restriction and so on Secondly, isolated initiatives for ICT enablement; it means that each subsystem has developed its technical solution without considering overall objectives and the relation between the subsystems. The third reason is that land administration has, over the time, realised the problems with isolation and tried to overcome them via integrating databases without proper attention to interoperable solutions.

5.6 LAND ADMINISTRATION SYSTEM OF WESTERN AUSTRALIA

Western Australia is Australia's largest state in area, covering the western third of the mainland, and is bordered by South Australia and the Northern Territory. 2,105,800 populations inhabit in total land area of 2,529,880 Km2.



Department of Land Information (DLI), today known as Landgate, provides the land administration services. Landgate is the statutory authority responsible for Western Australia's land and property information. As an authority, Landgate maintains the State's official register of land ownership and survey information and is responsible for valuing the State's land and property for government interest.

As the result of the external phase of the Western Australia case study, the components, their relation, the data flow among them and electronic and non-electronic process were mapped in a diagram. Figure 5-3 shows the work data flow among the components of land administration in Victoria at a glance. The system consists of four major subsystems that are collaborating with a number of external partners, users, local and government agencies. Similar, to Victoria and NSW, the collaboration is facilitated by a number of ICT enabled applications; however, the model shows that land administration processes are not as complicated as they were in the other two states. In the following sub-sections the data and process flow are explained in detail.

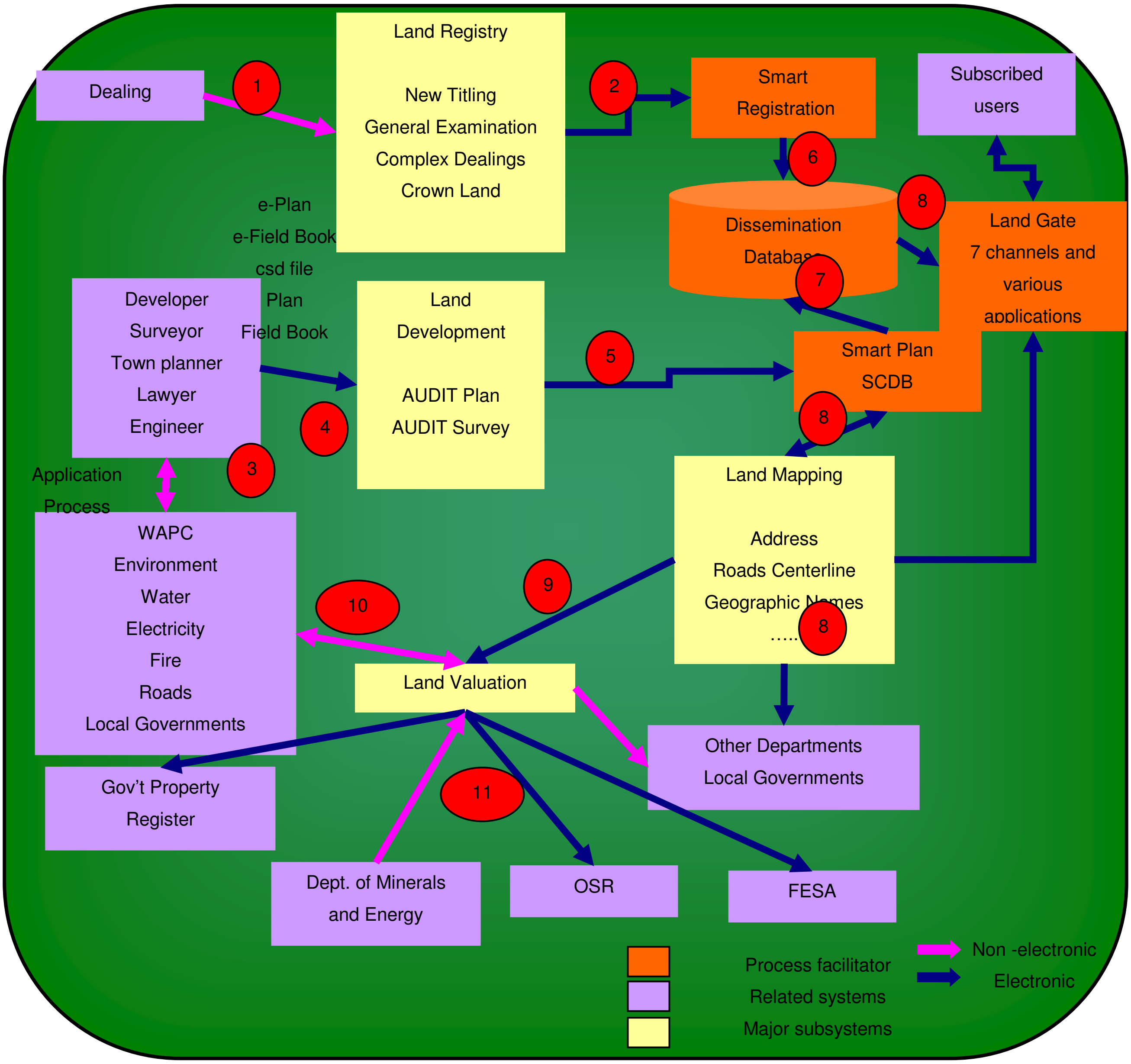


Figure 5-3: Land administration system in WA

5.6.1 LAND REGISTRY

The registration process in the land registry subsystem includes four sections: new titling, general examination, complex dealings, and crown land registration. New parcels in new subdivisions are processed through the New Titling process. The process for other cases or dealings is undertaken in the general examination, or complex dealing, sections. The crown land section is responsible for recording the crown land information and issuing their titles (Figure 5-3, No.1).

Certificates of title, otherwise known as title deeds, are issued by the land registry subsystem with one original and one duplicate copy. The original is always kept at Landgate. The duplicate copy is normally held by the registered proprietor (owner) or by a lending institution as security for a loan. The important difference between these two Title Deeds is that the duplicate certificate of title does not include all encumbrances such as caveats and warrants. They are, however, always listed on the original certificate of title that is kept at the land registry.

5.6.2 LAND MAPPING

Spatial data is gathered from ground surveys, aerial photographs and satellite imagery. This information is used to produce a wide range of digital and hard copy products and services. There are numerous databases related to spatial cadastral data in the land mapping subsystem such as geographic names, property street address road centreline and building footprints.

The geographic names include street, suburb and post code. The results of the property street address will be used in the cadastral database. In order to manage natural hazards like earthquake, flood and etc, a project to determine footprints of the properties in the cadastral database is being undertaken. The process is undertaken by extracting foot prints from aerial photographs and spatially matching them with existing cadastral database or land parcels.

The road centreline is a project to identify the roads centreline. This project is interested in physical definition of lines rather than legal definition. It means that the roads in the cadastral database should be updated based on the physical roads not the legal definition of groups of parcel defining a piece of land. This project brings all roads related databases together to set up a single unique database for all roads state wide.

5.6.3 LAND DEVELOPMENT

The land development subsystem in Western Australia consists of two parties: Internal and External. The external party includes developers, lawyers, engineers, licensed surveyors and town planners. Licensed surveyors are responsible for surveying work as well as for most of the application process documents. The licensed surveyor submits applications to WAPC (WA planning commission) for clearance and approval from the water corporation, electricity, roads, environments authorities and the local governments. These authorities are generally not equipped with GIS or digital maps for their activities.

5.6.4 LAND VALUATION

The land valuation system in Western Australia is a standalone system in Ladgate. It is called VALSYS with capability of multiple valuation types. The exchange of information is in electronic format using compact discs (CD) or online file transfer protocols (FTP). The VALSYS contain non-spatial information about the property including car park, rooms and and so on The information about address, area, owner, sales, zoning local government info is supplied with the land mapping and land registry subsystems (Figure 5-3, No.9). Also any changes in subdivision are sent by local government or the Water Corporation to land valuation (Figure 5-3, No.10).

Other information is also supplied to the land valuation system such as unique land identifiers from the plan and strata plan, spatial links like Centroids and PIN, Title, ownership information and GPR details, Land zoning information from the Ministry of Planning, the restriction information from the heritage authorities, listing and contaminated site, sale evidence information, soil classification for rural area valuation, building types and building details and history by the local government as well as the rental information from real estate agencies (Figure 5-3, No.11).

5.6.5 ICT IN LAND ADMINISTRATION OF WA

After a brief introduction to the subsystems, their responsibilities and work flow, this section explores and analyses ICT utilisation. This analysis has considered land dealing, subdivisions, data management and information delivery. Like the other cases, the aim of this analysis is to observe how interoperability, data types employed and data models are affected by ICT and how this effect influences the other subsystems.

i ICT IN DEALINGS

The land administration system maintains the registration process using a system called Smart Registration (Figure 5-3, No.2). Smart registration consists of various registration applications as well as an internal database to keeping the title information. The internal database is connected to dissemination database for delivery purposes (Figure 5-3, No.6).

Dealings are submitted in paper based format to the land registry. Documents are scanned and put in the Smart Registration system. Titles are identified with (Prefix/ Volume/ Folio/ Suffix) in Smart Registration. This identifier is used to facilitate interoperability by creating a linkage to the other related databases like the digital cadastral database or valuation database.

ii ICT IN SUBDIVISIONS

Surveyors can lodge the plans of subdivisions both in e-plan or paper based methods. The e-plan is the PDF version of the traditional plans. The survey data is therefore not submitted in vector format and only the process is being undertaken in digital format. But the surveyors should submit another file along with the plans which is called cadastral survey (CSD) file (4). It includes the new land parcel boundary information in an ASCII format. It is a flat file includes information about the parent parcel points, bearings, distances, azimuths and new points in a standard format. This initiative, to some extent, responds to the interoperability issue; however, the flat file method of data handling requires particular attention when examining the correctness of plans. As the flat files do not carry any data model, the examination constraints still needs to be considered with professional examiners. For instance, there are two ways to create the CSD file: one is coordinated and the other is un-coordinated. If the CSD file is submitted in an uncoordinated format there is need for a quick least square transformation to the proper coordinate system in order to fit is spatial cadastral database. Interoperability adversely is affected without having a proper data model in place.

iii ICT IN DATA MANAGEMENT AND INFORMATION DELIVERY

WA benefits from a series of advanced data management and information delivery services. Smart plan and Smart register are the major database management system of WA. In addition WA benefits from a sophisticated structure of spatial information delivery such as the Landgate portal and the shared land information service (SLIP).

a Smart Plan and Smart Register

In WA, all spatial cadastral data are recorded through a system called the Smart Plan. The Smart Plan system includes a series of applications for recording and maintaining cadastral database (Figure 5-3, No.5). For instance, once a new parcel is added to the database, using Smart Plan system the area of the parcel for a temporary maintenance will be locked. At this stage the new parcel is located in a layer called the lodged layer and is now ready to assign the related title to it. At this stage, once the application for the new title is approved in the Smart Registration system, the associated land parcel is connected to the title. Now both the Smart Register and Smart Plan systems will be updated and the Smart Plan database is now ready for dissemination database (Figure 5-3, No.7) and is now added to the delivery portal for service delivery (Figure 5-3, No.8). The dissemination database is the one day older version of the Smart Plan database.

Smart Plan and Smart Register together are an example of on integrated land information database. Although, the single view of delivery portal using this integrated database facilitates interoperability to some extent, it excludes other land related database to be connected and liked. In particular, the use of non-spatial identifiers such as volume/folio/suffix interferes with spatial enablement of the land administration, and consequently does not provide a comprehensive interoperability.

b Land Gate

Land Gate is the delivery portal of WA's land administration system. There are 6 major channels with various applications available for the clients and are designed based on the requirement of the clients. Langate includes the Business Channel, Conveyancing Channel, Farm Channel, Government Channel, and the Planning

Channel. A number of user-friendly applications are also available through Landgate such as Land Enquiry, EAS2 and Easiform.

Land Enquiry is an online application for searching land and property information and ordering the certificate of title. The search can be undertaken based on the name, address, parcel identifier, certificate of title. Land Enquiry is linked to another application called Map Viewer which is a web based land information service with various GIS functionalities.

Furthemore, there are number of initiatives to optimise communication between users and land administration system of WA.

EAS2 is an application for online ordering of Advice of Sale. The Advice of Sale includes the clearance of payable rates on the property tax, local government rate as well as water corporation rates. Also via this application the certificates related to the Western Australian Planning Commission (WAPC) can be issued. After the online ordering, associated agencies will receive the applications via XML or PDF based email. Then the result will be sent back to the applicants online via email or faxing.

To prevent possible errors in the process of transferring land, the Easiform application facilitates filling in associated forms. Easiform connects to the dissemination database and collects correct information needed to be added in the forms. Easiform uses XML technology to receive the data from the dissemination database.

In order for these two facilities to contribute to interoperability, there is a need for databases employed in the land administration system to be linked to these facilities.

c Shared Land Information Platform

The Shared Land Information Platform or SLIP is a shared information delivery system which provides fast and easy access to the State's land information. It is a response to increasing needs of users to land information. It is based on an enabling framework of connected servers to deliver real time spatial data. These data services are web enabled to allow direct use within end user software and the WA Atlas.

SLIP is also comprised of focus areas delivering information products to meet end user needs in the specific focus area. There are currently four focus areas of Emergency Management (EM), Natural Resource Management (NRM), Interest Enquiry (IE), and Electronic Land Development Process (ELDP). Future focus areas may include but are not limited to resources and health.

Investigating land administration in WA, how holistic consideration of ICT enablement can improve interoperability and consequently brings along better service delivery. SLIP and Landgate as responses to increasing needs of user to land information together with their comprehensive data model containing variety of land information can be referred as a good practice of interoperable ICT enabled land administration system. However, WA is far from spatially enabled land administration as non-spatial identifiers such as unique land identifier and volume/folio are still dominant.

5.7 IDENTIFICATION OF THE ISSUES

As was concluded in Chapter Three, the emerging technologies offered by ICT provide opportunities for better service delivery, customer satisfaction and a reduction in operating costs. In the case studies, it was explicitly observed that ICT enablement promotes land administration and offers better prospects for better service delivery. However the enablement always faces issues and deficiencies as well. Identification of these issues can consequently maximise the benefits of using ICT.

Chapter Three classified the aspects that ICT directly contributes into three classes: data management, data dissemination and enterprise facilitator. To identify the issues this classification is utilised.

According to Chapter Three, the data management aspect should provide tools for data modelling, capturing and converting, management and cataloguing (see table 3-

1). The data dissemination facilitates data and information delivery among the subsystems of land administration and to the external partners (see table 3-2). Finally, the enterprise facilitator should provide tools to adapt the organisational structure of the land administration system in a digital and electronic format (see table 3-3).

5.7.1 DATA MANAGEMENT

Data management tools facilitate and manage the development or intensification land information, possibly from multiple distributed sources. Cadastral data that are stored for use in local databases can often be used in external applications once they are published. The data management tool facilitates data description, data modelling, data capture, database design, and data conversion and migration as a mean to holding cadastral information in a standard way to be deliverable across multiple servers for access and sharing.

Considering the data management aspect, there is a lack of an interoperable database management system in the land administration systems. Interoperability issue in data management was observed in all states. For instance, in Victorian Standard Parcel Identifier is an initiative to mange ambiguus and duplicate parcel identifiers in cadastral database. This solution temporary answers to lack of interoperability and joining the land registry, local government and cadastral database together.

Cadastral Spatial Data (CSD) in WA is another example of an interoperability solution for the data management. It enables direct data entry from the plans of subdivision into spatial cadastral database.

Although efforts such as the e-plan program are put together to overcome the interoperability issue, a more sophisticated approach is required to create an interoperable database management system. Such a system involves joining the most commonly used data from various land administration databases. It requires a holistic data modelling approach to cover and assimilate various land administration databases. A data model with this specification can consequently maximise the interoperability among land administration subsystem.

5.7.2 DATA DISSEMINATION

Access and tool sharing facilitates the development of web-based access in a seamless and integrated view. These tools provide recent interoperable sharing techniques, based on international standards like OGC (2003) in realizing simple inter-operability through specification that is considered also in the ISO International Standard. Access may include the order, packaging and delivery, offline or online, of the data (Nebert 2004). Once cadastral data of interest have been located and evaluated, using the data management and sharing techniques, access to detailed cadastral data is allowed by web services.

For land administration systems there is a need for a single online entry point to the spatial services and information such as Landgate and SIX. However, the issue is the provision of a spatial data viewer that enables users to integrate and view a wide selection of spatial datasets, including property, cadastral and topographic information, satellite data and aerial photography together with attributed data like interests in land. This issue requires a holistic view of the data model employed.

5.7.3 ENTERPRISE FACILITATOR

Enterprise architecture design tools facilitate and support the development of plug-and-play enterprise systems and architectures using a web-based foundation. The Open GIS Consortium (OGC 2003) believes that applications will be based on compositions of services discovered and marshalled dynamically at runtime (just-in-time integration of services). Service (application) integration becomes the innovation of the next generation of e-business. As businesses move more towards web services, a set of standards is needed to create service oriented architecture. For example, for interoperability with external software, the use of web services standards is one of the approach (Hecht 2004).

The lack of strategic information architecture has been identified as an important issue within the land administration system. All land administration systems consist of different subsystems including variety of services. As these subsystems have only recently trying to form a single approach of land administration system, the ICT infrastructure and associated business processes were developed in isolation resulting in uni-channel, single business solutions. This has driven the need for the land administration systems to adopt an approach for a target environment that will leverage existing applications and systems to create an environment that best services customers' needs.

In the enterprise facilitator aspect, the provision of a framework that enables co-ordination of the subsystems is essential. Such a framework establishes policies and standards that ensure the effective management of this vast collective resource. The framework provides the opportunities for private sector partnership, local governments, and authorities.

5.8 SUMMARY OF THE ASSESSMENT

As was described in Chapter Four, in documenting and assessing ICT utilisation in land administration systems, it is useful to have a model for ICT development. Such a model shows the development of processes the systems and aids in better understanding. A four stage model has been developed to examine the ICT development in the case studies as follows. This model includes four phases; emerging, applying, infusing and transforming.

Four major procedures in land administration system have been made out: land information delivery, land parcel subdivision, conveyancing and database management. Individual processes are in different development phases as illustrated in (Figure 5-4).

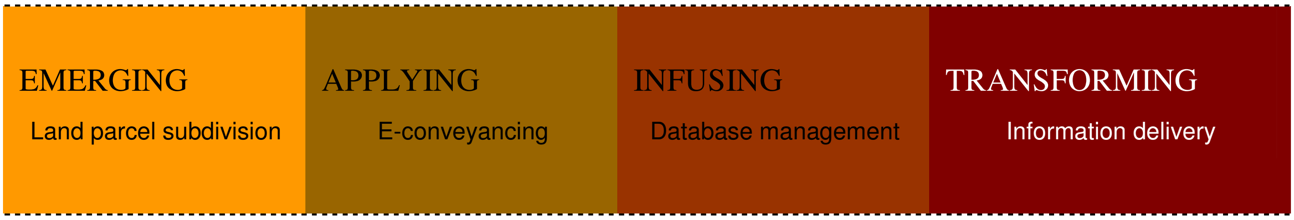


Figure 5-4: ICT development model in land administration

5.8.1 THE EMERGING PHASE

Process appears in the beginning stage of ICT enablement. The model of ICT enabled process has been designed but it is not operational. In this initial phase, land administration systems are just starting to explore the possibilities and consequences of using ICT. Land administration at this emerging phase is still firmly grounded in traditional practice. There is an awareness of the uses of ICT that assists the movement to the next approach if so desired.

Electronic conveyancing procedure is still in the emerging phase. All land administration systems in the case studies are developing an online conveyancing system in parallel with existing paper based system. However, none of them are operational for the public use yet. The benefits of such a system has been realised and efforts are put to make the system available.

There are a number of issues associated with developing and operating an online and electronic conveyancing system. User identification, accreditation and training system access and usage, lodgement process and security, settlement process and payments are currently being discussed.

As the banks in Australia operate nationally and land administration is the role of the state government, different legislative systems in land administration interfere with national rules operating the banks during the financial settlement. In other words, banks are expecting a nationwide legislation for electronic conveyancing. Other issues such as security of the associated processes, audits, digital signature, electronic document like titles, mortgages are also being worked out.

Among the issues discussed above, proper data models for e-conveyancing related databases and interoperability among the partners' databases were identified in the case studies.

5.8.2 THE APPLYING PHASE

In this secondary phase, land administration systems use ICT for tasks already carried out. Traditional processes largely dominate, but at the applying phase they adapt the

ICT enabled process in order to increase the use of ICT. This phase assists movement to the next phase if so desired.

The electronic lodgement of plans of subdivision and authority certificate occur in the applying phase. Land administration systems in the case studies have so far partially adopted electronic submission of the plans of subdivision. The processes are therefore not completely electronic. Although the Internet has been widely used for communication among the partners of the subdivision process, interoperability still remains an issue. That is mainly because the data models employed are standard and do not provide the facility of data exchange and conversion. That indicates although the process is increasingly changing to an ICT base process but the full potential of ICT has to date not fully exploited

Recently, to overcome the interoperability and standardisation issue, Intergovernmental Committee on Surveying and Mapping (ICSM) ePlan working group develops an Australasian standard for the transfer of digital cadastral and survey data. Consisting of a series of projects, the ePlan program is expected to deliver significant benefits to the surveying profession, property industry, and other key stakeholders involved in land development. By providing a more efficient electronic environment, the program will substantially enhance the quality of plan data, reduce requisitions and improve plan processing and turnaround times.

One of the aims of the program is to develop a plan information management system incorporating automated electronic lodgement, examination, registration and data capture for the cadastre that uses digital plan data lodged in a file modelled on the LandXML format. LandXML is specifically developed and tuned for exchanging design data used in the design/build process for land development industry.

The working group has developed a cadastral model to produce a generic LandXML export/import format for cadastral plan data that includes jurisdictional specific elements. The ePlan Model accommodates all of the survey geometry, administrative and titling data required to process a plan from lodgement to registration and Digital Cadastral Database (DCDB) update. e-plan is the most promising initiatives for the

ICT enablement of the process of land subdivision that will contribute to facilitating interoperability.

5.8.3 THE INFUSING PHASE

At the next stage, the infusing phase, land administration systems are embedding ICT across the process and traditional approach has gone. Land administration systems explore new ways in which ICT changes their productivity and professional practice.

The database management process is in infusing phase. Needless to say, database management system is entirely dominated in every aspects of land administration system that includes land administration processes. Today recording and maintaining data can not be imagined without having databases.

In particular for handling large amount of spatial data being created every day, digital spatial database are progressively more dominate to the traditional paper based maps. That indicates database management are now moved from applying phase to infusing phase. Almost traditional methods of determination and recording data in land administration system is gone, however in some aspects the paper still playing its role although it can be considered as a ceremonial role. An obvious example is the certificate of title which is still kept in paper format while registry databases also doing so.

Despite the large domination of databases in land administration system, there are some reasons why they remain in the infusing phase. One is that paper based methods are still dominant outside of land administration. Plans of subdivision, conveyancing document settlement document mortgages are still operating in paper based processes in the case studies. On can argue that paper based processes are unavoidable, but it is one of the reasons why database maintenance and management is not fully electronic or at least not using complete potential of ICT. The second and important reason is the considerable number of databases employed in the land administration system.

5.8.4 THE TRANSFORMING PHASE

Land administration systems that use ICT to rethink and renew and streamline the processes are at the transforming approach. ICT becomes an integral though invisible part productivity and professional practice.

Out of the identified major procedure the land information delivery is in its transforming phase. All of the case studies maintain a web portal for online information and service delivery. Web portals in early days were not playing significant roles while today they have become as integral part of the land administration system. Form provision information to people in past to online service delivery today, land administration system have significantly evolved.

Today Internet and online technologies are pushing land administration systems to change their traditional land administration strategies to innovative solutions. Several online services are now being provided to the public through the Internet were identified in the case studies.

5.9 CHAPTER SUMMARY

In this chapter using a case study approach, three leading Australian land administration systems were explored and analysed.

Four major land administration procedures land dealings, land subdivision, database management and information delivery were examined and a number of issues associated with the procedures also identified. The case studies revealed that interoperability still remains a serious challenge for data management in land administration. Besides, variety of land related services requires a single unique and integrated entry point for service delivery and finally, the lack of strategic information architecture has been identified as an important issue within the land administration system.

A four stage ICT development model was used in order to summarise the issue within the ICT utilisation in the land administration system. This four stage model starts with the emerging phase followed by applying and infusing phase and ends up to transforming phase. It was revealed that while ICT is largely dominant in information delivery and database management side of land administration while suffering from lack of interoperability, the use of ICT in land dealings and land parcel subdivision process is still immature and requires more effort to instil interoperability.

CHAPTER 6 - DEVELOPING E-LAND ADMINISTRATION

6 DEVELOPING E-LAND ADMINISTRATION

6.1 INTRODUCTION

Land administration systems are going online and using the Internet to provide public services to their clients. Electronic land administration refers to land administration's use of ICT, particularly web-based Internet applications to enhance the access to and delivery of land information and service to clients, business partners, the private sector, and government entities. It has the potential to help enhance land administration systems for clients by making interaction smoother, easier, and more efficient.

However, the case studies showed as difficult the experiences with e-land administration initiatives and the development of online transactional services in its infant stage despite recent initiatives in ICT enablement. e-Land administration initiatives in the case studies presented a number of issues. While there are many emerging programs and initiatives in e-land administration throughout, this chapter indicates that an implementation framework will be required, as infrastructures must be built, communication issues resolved, and interoperability established.

This chapter describes the concept of e-land administration and the different phases of conducting e-land administration systems along with an e-land administration toolkit.

The phases of conducting e-land administration systems outline the structural transformations of land administration systems as they progress toward ICT-enabled land administration and how the Internet-based land administration models become amalgamated with traditional land administration, implying fundamental changes therein. This five-phase model is based primarily on the researcher's observations on ICT enablement and the issues of interoperability and data modelling within the case studies described in Chapter Five. However, the underlying theory of this development model shall be applicable to all land administration systems.

6.2 CONCEPT OF E-LAND ADMINISTRATION

In the past few years, ICT has been utilised in various aspects of land administration systems to promote administrative procedures. But recently governments have realised that in future this promotion would be problematic without first designing and establishing essential infrastructures.

Early land administration activities adopting digital technologies were often intended to enhance the performance of specific government programs or activities. Various land administration agencies established computer systems for land record keeping, service delivery, internal work flow management and so on. However, developed in isolation within agencies, these systems were generally standalone, that is, agencies often developed their own internal computer systems that were independent of and not interoperable with other systems.

Meanwhile, confluence of information, and telecommunication technologies that began in the mid 1980s and extended to the graphic-based web in 1994, have brought the potential for an ICT-enabled land administration (Aldrich *and others* 2002).

(Williamson *and others* 2006) describes the technical evolution of land administration in five stages (Figure 6-1). The first stage recognises that cadastral systems originally depended on manual systems with all maps and indexes in hard copy. The 1980s saw the computerisation of hard copy cadastral records with the creation of a digital cadastral database and computerised indexes.

Figure 6-1: Technical evolution of land administration (Williamson *and others* 2006)

With the growth of the Internet, the 1990s saw governments start to web-enable their land administration systems as they became more service oriented. Access to cadastral

maps and data over the Internet became possible. Digital lodgement of cadastral data and
e-conveyancing followed the e-land administration idea (Kalantari *and others* 2005b).

In the future, ICT will drive more developments. These developments underpin the idea of i-Land, a collaborative, whole-of-government approach to managing spatial information using SDI principles (Rajabifard *and others* 2005) by better understanding the role played by land administration systems and mapping in integrated land management (Williamson *and others* 2006).

e-Land administration is defined as the capacity to transform land administration through the use of ICT. e-Land administration includes the coordination of various subsystems of land administration including front office operations like online customer services and private partnership services, and back office operations like internal workflow processes and database management through interoperable mechanism and tools as well as inclusive land information.

This definition covers two different perspectives. One is the sum of all electronic communication between land administration agencies, the private sector and citizens that is interoperable. The other perspective is the sum of electronically provided land information that has to be available to the public due to land administration objectives.

In addition to the expectation of an e-land administration one could consider whether e-land administration is the provision of what citizens want or conversely e-land administration is what agencies want. This raises another question for e-land administration, that is, the reengineering of current land administration system using ICT. There is a need to build e-land administration evaluation efforts that assess the degree to which anticipated agency and citizen outcomes are being met and agency and user anticipated outcomes are at some level synchronised (Aldrich *and others* 2002).

The next section proposes different phases that should be undertaken to implement an e-land administration, their functionalities and associated issues.

6.3 E-LAND ADMINISTRATION IMPLEMENTATION PHASES

Following on from the four-stage ICT development model presented in Chapter Five, this chapter suggests that e-land administration is an evolutionary phenomenon and therefore e-land administration initiatives should be derived and implemented accordingly.

To establish an e-land administration system, five phases are suggested: the first is Internet-based land administration. This includes delivering organisational information to customers over the Internet and via Intranets to the land administration systems' staff on private internal networks – which is as far as most land administration systems today have gone. The second phase is transacting with customers over the Internet, that is, the organisation offers products and services to their customers over the Internet. The third phase is integrating services with transactional e-land administration by connecting internal enterprise applications and transactional e-land administration systems. The fourth phase is external integration with partners and suppliers through connecting internally integrated applications to the enterprise applications of external partners. The final phase is conducting e-land administration by undertaking real-time monitoring and understanding of the e-land administration service.

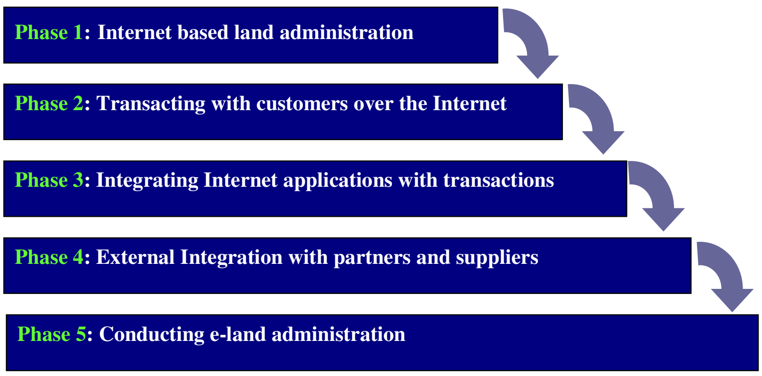


Figure 6-2: Developing e-land administration from phase one to phase five

6.3.1 INTERNET-BASED INFORMATION DELIVERY

In the first phase of implementing e-land administration, land administration systems are initially focused on establishing an online presence for services. Many land administration system initiatives on web development and online services belong to this stage. Examples of functionalities at this stage are mostly limited to online presentations of the services and related land information. Toward the end of this stage, mostly pushed by clients' demands, land administration systems begin to establish index pages or a localised portal site for their services in which scattered electronic documents and data are organised so that clients can search for and view detailed related information.

i DESIGNATION

In phase one, land administration systems create a website due mainly to pressure from the media, technology-educated employees, demanding clients, and competition with the other organisations to get their services on the net. At this stage, land administration systems prefer to minimise risk by undertaking small projects. For instance, the SPEAR project in Victoria, consisting of VSCO, e-conveyancing and e-plan initially started with VSCO. Parts of the services' non-transactional information were put on the site.

Accordingly, more and more clients will look for services and information on the web instead of processing systems in person, and they will be disappointed if they cannot find proper information in online services. From the management point of view, the web presence is also beneficial since much staff time is consumed in answering basic questions about services and procedures; the web presence will increase clients' convenience and reduce the workload on front office employees. Easiform in Western Australia offers one example of reducing workload by providing an online guide for customers. With services presented on the web, clients can use this information to learn the specifics of policies and procedures, and find out where to go for specific services. Clients could still make use of existing service processes such as standing in line in person, but to a lesser extent. For that percentage of clients not online, e-land administration requires that some offline capabilities continue. The e-plan project in NSW is running parallel to the paper-based method of submitting plans of subdivisions.

ii FUNCTIONALITIES

Phase one offers the least amount of functionality for the user. As this phase progresses, the quantity of posted information increases, and land administration systems will begin to see the need for an index site because more information is going online. The typical service home pages at this stage have a description of the services. It establishes a presence rather than providing services.

iii ISSUES

The technology in this phase is relatively simple but the main issue is the maintenance of the information. Along with procedural and policy changes, web pages need to be maintained and some data presented on websites may be temporal. Date and time stamping may be essential at this stage, along with issues of consistency in format and user-friendly interfaces. The issues at this stage are not very complicated.

6.3.2 TRANSACTING WITH CUSTOMERS OVER THE INTERNET

In the second phase, e-land administration initiatives will focus on connecting the internal systems to online interfaces and allowing clients to transact with the land administration system electronically. At this stage, e-land administration efforts consist of putting database links onto online interfaces, so that, for example, citizens may ask for a certificate online. The Langate channels in Western Australia and VSCO in Victoria are examples of this stage. In ideal cases, web transactions should be posted directly to the internally functioning government systems with minimal interaction with land administration staff.

i DESIGNATION

As land administration websites evolve, the value of the Internet as another service channel for clients is realised. Clients demand to fulfil service requirements online instead of having to go to a specific location, for instance land registry, to complete paperwork. Electronic transactions offer a better hope for improved efficiency for both the client and the subsystem than simply providing information online.

Needless to say, a fully interoperable e-land administration will make service delivery more efficient and increase savings for both land administration and clients. This second stage is the beginning of e-land administration as a revolutionary entity changing the way clients interact with it. This stage empowers clients to deal with their land administration systems online anytime, saving hours of paperwork, the inconvenience of travelling to a land administration office and time spent waiting in line.

ii FUNCTIONALITIES

In this phase, clients can be served online by e-land administration. While the first phase helps clients find appropriate services, this phase presents land administration services on the other side of the Internet as an active respondent. It is now a two-way communication. Clients transact with government online for example by filling out forms and land administration responds by providing confirmations, receipts and so on.

According to the International World Status (http://www.internetworldstats.com/), the number of Internet users increased by 265.6 per cent between 2000 and 2007. With this increasing number of people connected by the Internet, land administration at all subsystems has no other choice but to provide a transactional service channel.

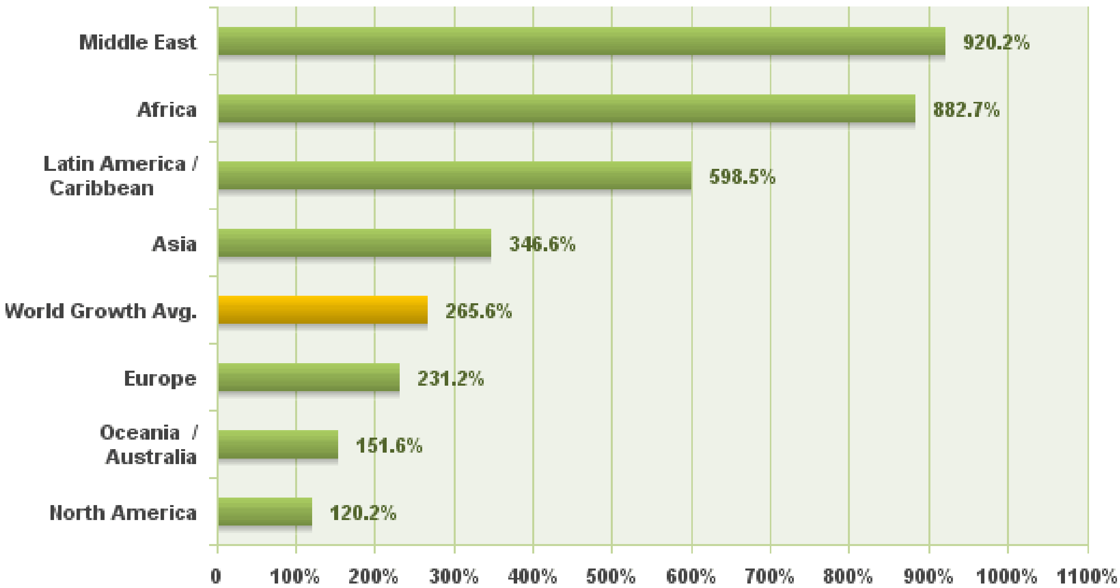


Figure 6-3: Internet users in the world. Growth between 2000 and 2007. (http://www.internetworldstats.com/)

iii ISSUES

The issue of transaction fulfilment is most critical at this stage. How will the responsiveness and quality of the online system compare to the offline system? The issue of interoperability comes into play. Land administration systems must answer questions like “should the web interface be integrated with existing databases?” If yes, what kinds of facilities are necessary to support online activities? When and how are online and offline systems going to be integrated? Existing electronic data models must be reprogrammed to handle such changes.

6.3.3 INTEGRATING INTERNAL SERVICES WITH TRANSACTIONS

As the quantity of e-transactions increases, in the third phase land administration systems will be pressed to integrate their systems with these web interfaces, or in some cases, build online interfaces directly connected to their functional intranet. Clients’ demands and technology evolution push land administration to go further as the critical benefits of implementing e-land administration are actually derived from the integration of internal processes with online transactions. By having online transactions and internal process integrated, clients will see land administration as an integrated service provider. Ultimately a client can contact land administration online and directly complete a transaction. Also, from the viewpoint of land administration, this could eliminate redundancies and inconsistencies in their services for clients.

i DEFINITION

The full potential of ICT, from the clients’ perspective, can only be achieved by integrating land administration services across different information silos. This phase will considerably improve those efforts. Databases across different functional areas will communicate with each other and ideally share information, so that information obtained by one subsystem will spread to others. In addition, clients could conduct business across a wide variety of requirements. For example, when a client lodges an application for a subdivision through local governments, the application record could be propagated to different functional services of land administration such as land mapping, land registry, and utility companies so that the client does not have to follow up the rest of the process in person.

ii FUNCTIONALITIES

The integration of internal processes and online transactions is driven by visions of efficiency and effectiveness in using information technology, but also pulled by clients' demands on a transformation of land administration functions to more service-oriented ones. The third phase of e-land administration offers the best hope for improved efficiencies through administrative reform because of ICT. Such integration will facilitate one-stop shopping for clients. If a client conducts a transaction such as a vendor certificate with the land registry, the transaction information will be propagated to land mapping. These various levels of systems talk to each other so that the results of transactions from one system can be interchanged with another system. Physically, this may be integrated as a central database or a connected web of databases communicating with each other.

iii ISSUES

Technically, the interoperability of heterogeneous data models and resolving conflicting system requirements across different functions and subsystems are major stumbling blocks for any land administration. Data and process requirements in the land registry's title recording data model may not be comparable to the requirements in the land mapping's cadastral data model. However, this is not only a technical challenge but also a management challenge. This integration requires a change in the mindset of directors. This silo structure may have worked well in the past. However, in spite of the support of the Internet, the land administration processes today may not be efficient, effective, or client-friendly without proper communication and interoperability between the silo-based data models. Current processes may not be suitable for e-land administration.

6.3.4 EXTERNAL INTEGRATION WITH PARTNERS AND SUPPLIERS

Once online transaction services become integrated with internal processes, prevalent and mature, in the fourth phase a natural progression will be the integration of scattered services with different land administration partners and suppliers. External partners often maintain separate databases that are not connected to each other. For example, the State Revenue Office data model is different from the valuation subsystem data model. Further, the real estate agencies' valuation database is not connected to the land administration system.

i DEFINITION

At phase four land administration subsystems and external suppliers and partners are expected to connect or at least communicate with each other online. While some subsystems' websites currently provide links to other partners at different levels, functional integration goes beyond this simple interconnection. As was experienced in the case studies, the external integration across different partners of land administration happens last. For instance, in Australia many development partners such as surveyors, development firms, land registry, and utility companies are now trying to interact more closely through the e-plan lodgement system.

ii FUNCTIONALITIES

Perhaps at this stage what should be considered is system-to-system transaction. In this respect, many interoperable data models will emerge. These data models may not be located physically at one place or be physically one, but by talking to each other, the connection will become more transparent. For example, data that is submitted to land mapping would also become part of land development.

iii ISSUES

Implementing the fourth phase of e-land administration makes the interoperability issue more outstanding. Reconsideration of land information data models and reengineering them into an interoperable structure should seriously be taken into account. Also maintaining robust technical infrastructure like special exchange language for cadastral databases and special information delivery infrastructure for spatial information will be helpful.

6.3.5 CONDUCTING E-LAND ADMINISTRATION

Having implemented the four first phases, e-land administration is now in place. The last phase will be dedicated to assessing, monitoring, and maintaining e-land administration.

i DEFINITION

There are various factors that influence the efficiency of an e-land administration system. Maintaining e-land administration requires identification of these factors and a methodology to monitor e-land administration systems and analyse it using the identified factors. The assessment should consider factors such as performance, functionality, user-friendliness and popularity.

ii FUNCTIONALITIES

The main task in the last phase of implementing e-land administration is developing methods and performance indicators to assess the services and standards of e-land administration. In order to maintain e-land administration services for the needs of clients, assessments should examine clients' needs, and their capacity to find and use relevant information. Assessments of e-land administration should also investigate infrastructures that underpin the use of e-land administration.

(Steudler *and others* 2004a) has developed an evaluation framework by considering four evaluation elements – objectives, strategies, outcomes, review process – and by linking these with the different stakeholders within the organisational pyramid. The proposed method contributes to the evaluation of land administration systems by considering the systems as an entire entity: by suggesting the evaluation of the three organisational levels (policy, management and operational) plus the external factors (human resources, capacity building, technology, research and development).

In the evaluation framework, the technical requirements that have been taken into account are the development of data standards, spatial reference framework, base mapping, standards for the compilation and continued maintenance of the cadastral overlay, the design and assignment of parcel identifiers and other access and linkage mechanisms, and acquiring and using appropriate technology (Steudler 2004a). This section, however, adds more criteria including technical requirements, with particular emphasis on the customer satisfaction of e-land administration. To assist with the assessment of e-land administration, the following criteria are helpful: performance, functionality, user requirements and popularity.

a Performance

The two major criteria for measuring performance are throughput and response time. Throughput is a server-oriented measurement that measures the amount of work done in a unit of time. Response time is the amount of user-perceived time between sending a request and receiving the response (Peng and Tsou 2003). An interaction for retrieving a web page is needed in order to measure performance. Any interaction can be broken into four stages and the time of each stage together represents the total time of the transaction. "D" or DNS (domain name services) is the resolution time, which is the time the Internet's system takes to allow users to utilise normal English descriptions for communicating with servers that must be addressed by an IP address. "T" or TCP is the connection time, which is the time of the connection process to the server. The FirstByte Time of "F" represents the time the browser waits between the request and receipt of the first byte of data from the web server responding to that request. The content time is directly related to the size of the downloaded file or "H".

Recognising the times taken during each of the stages assists in finding any hold-ups or problems in the stages. Any of the stages are related to a component of the service including network, server and client machine.

b User Interactivity and Functionality Support

The amount of functionality of a service is a usability issue. The functionality of online land information services can be divided into three categories including technical, general and cadastral factors.

Technical factors of online applications can be underlined as light-weight download, JavaScript for a more dynamic system, and metadata or data catalogue support for the usage of data in the services.

Minimising requests is a key for increasing the performance of online land information services and this relies heavily on transactions with clients. Using JavaScript, requests over the server can be sorted and arranged before they are submitted to the online service, effectively reducing the number of interactions between the user and the online land information service. (Green and Bosomair 2001).

Metadata helps users understand data, provides consistency in terminology, focuses on key elements of data, helps users determine the data's fitness for use, and facilitates data transfer and interpretation by new users(Williamson *and others* 2003). Metadata accessibility describes the presentation of the data content within services.

Important general functionality issues in the online land information services include: displaying wide regions on a small screen; supporting various methods of zooming and panning (11 per cent of time is spent on these tasks) (TheEuropeanCommission 2002); producing different views with the scale change; producing different cartographic displays for a special object in different scales; and allowing the users to express ad hoc queries and other orders and to receive information from the system.

Accessibility to property rights, responsibilities, restrictions, descriptions of their extent, support for land transfers, provision of evidence of ownership, information for property taxation, monitoring of land markets, and support for land market and land use planning are important cadastral functionalities in the context of land administration which could be supported by online services.

c User Requirements

Understanding the users' abilities and goals can positively influence the entire service design, development and customisation process (TheEuropeanCommission 2002). For the purposes of this research, users of land information services have been categorised into three major groups, including decision-makers, information specialists and interested citizens, each requiring special facilities in the service.

The information specialist usually needs raw data and various kinds of functions and analyses to produce information from data. The service for this group should be large and flexible and linked to other packages and services. Good accessibility and interfaces for other services could be keys for this group.

For decision-makers, the service should provide proper and optimistic decision-making models. Another key component of services for this group is the availability of strategic data, although services should be compact, small and manageable and provide interfaces to other similar services that assist the policy decision-makers.

Interested users' services should be practical, possibly to solve their daily location-related problems, and data on the service must be meaningful.

d Popularity

There are several criteria for measuring the popularity of online land administration services including traceability, number of return visits, length of time on website and so on; research for this paper used the number of web references and visitors to measure the popularity of the website within the Internet network.

iii ISSUES

Given that the main goal of e-land administration is to provide a better service to clients, a citizen-focused approach should be maintained on an e-land administration system. e-Land administration is a modern way of serving well-educated people with high technology infrastructure. e-Land administration should be as simple as possible, however, also to attract the involvement of ordinary clients who do not have the ability to deal with new technology. Meanwhile capacity building for human resources should be taken into account. Unless clients know what is available from e-land administration, they are unlikely to use it, defeating the purpose of the development of e-land administration services (Thomas and Streib 2003).

The factors that have a positive impact on the development of e-land administration are the inclusion of efficient and new technologies within services, the clarity of purpose of the services for various types of users, the provision of good communication channels, and the creation of user-friendly interfaces with clear terminology. Addressing these factors will go a long way towards meeting the needs of effective land administration.

As was described in this section, implementing e-land administration faces a series of issues – most importantly, interoperability. However, there are various aspects for interoperability in an e-land administration system that are discussed in the next section.

6.4 INTEROPERABILITY IN E-LAND ADMINISTRATION

Existing initiatives in e-land administration include providing land information online, electronic conveyancing, digital lodgement of survey plans, and online access to survey plan information. The case studies showed that the implementation of these initiatives is isolated to specific subsystems with a limited reference to the broader land administration system.

The solution to this isolation is to develop effective communication among the different e-land administration subsystems by harmonising data and functionalities through interoperability, so they are capable of being used by all subsystems.

Interoperability in information systems is the ability of different types of computers, networks, operating systems and applications to work together effectively, without prior communication, in order to exchange information in a useful and meaningful manner (Inproteo 2005). Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units (Rawat 2003).

In the domain of spatial information interoperability is cooperation – the compatibility of an information system to run, manipulate, exchange and share the data of different organisations related to spatial information on, above, and below the earth's surface; for any kind of application to serve the society over networks (Rawat 2003). The idea is then extended to businesses and organisations as well as public administration to improve collaboration and productivity in general, increase flexibility, enhance services' efficiency while reducing the costs.

The complexity of land administration systems raises issues related not only to technical aspects of the subsystems' interoperability framework but also to the semantics, legal and intercommunity aspects which need to be addressed to achieve an interoperable e-land administration system. An interoperability framework in e-land administration facilitates the ability to link land administration subsystems cost-effectively to share resources, find data, and deliver functions and processing to serve the public. Interoperability covers a wide scope, to be classified in various aspects. There are four aspects to the interoperability framework in e-land administration: semantic, legal, intercommunity and technical (Figure 6-4).

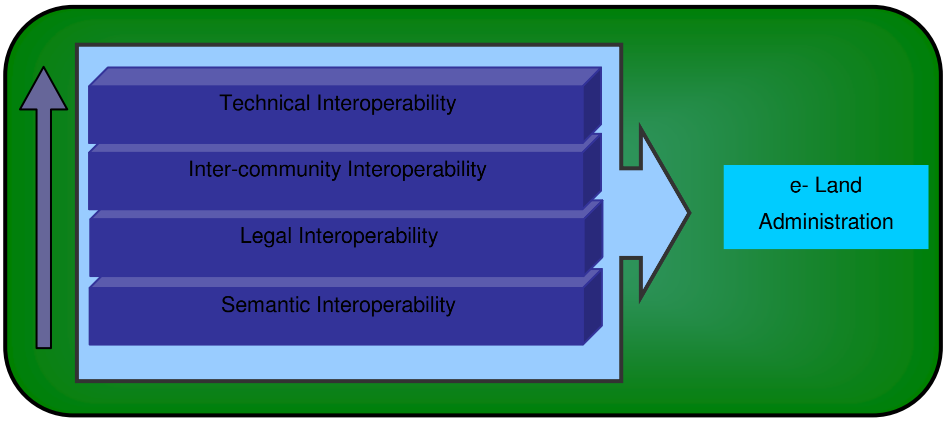


Figure 6-4: Interoperability aspects in land administration

i SEMANTICS INTEROPERABILITY

Land administration is viewed from different perspectives. Physical planners may think of it as actual space in which people live and work; the lawyer may think of it as an asset of real property rights; the economist and accountant may see it as an economic commodity. Others may see land administration as a part of nationhood and cultural heritage (United Nations 2004). From whatever perspective, land administration as an infrastructure that supports land management should include harmonisation. The lack of semantic interoperability and heterogeneity occurs where there is a disagreement about the meaning, interpretation, or intended use of the same or related data in various domains (Tuladhar *and others* 2005). In other words, the different but related domains in land administration need to be harmonised, as within one domain such as the cadastral, there are already difficult to agree on concepts and semantics: it will be even more difficult then when dealing with other domains like registry, taxation and so on. A single standard might not be possible but a core standard based on common concepts should be achievable; there should be common concepts that allow talking across boundaries (Lemmen *and others* 2005). Semantic interoperability represents harmonised terminology and the interpretation of concepts, for example, a unique definition for the third dimension of height in all land administration organisations.

ii LEGAL INTEROPERABILITY

Land administration organisations have internal process and workflow management solutions. However, for effective administration across the related organisations, there is a need for a range of guidelines and policies. For example, to ensure the optimum use of space and to enable e-conveyancing to operate efficiently and effectively, there must be a framework of laws (United Nations 2004) which facilitates legal interoperability among the organisations.

Furthermore at the international level it is interesting to observe that property registration infrastructures remain mainly regional/local while banking infrastructures are global. The real estate market can, at least for a subset of society, become global as well (Roux 2004). The global land market needs internationally accepted policies.

Legal interoperability will develop directives, rules, parameters and instructions for managing business work flow, considering information and communication incorporation in the business.

iii INTERCOMMUNITY INTEROPERABILITY

Intercommunity interoperability is concerned with the coordination and alignment of business process and information architectures that span people, private partnership and the public sector. Intercommunity interoperability leads land administration systems to be built on a basis covering the whole sector for land administration, so users should not have to turn to a number of systems to get a complete picture of the services(Ljunggren 2004).

The World Bank reports on the lack of national interoperability of land administration systems in various areas of a comparative study. For example, multiple agencies with overlapping land administration roles and responsibilities, each supported by empowering legislation, is a critical issue in some countries in Asia. Another issue that affects almost every Latin American country is the separation, at the information and institutional levels, between the property registry and the cadastre. Also coordination is a critical issue in Africa where there are major problems surrounding the flow of spatial information for land administration purposes both within government, between departments at national level, between national and lower level tiers of government, and between government, the private sector and users (WorldBank 2003).

Intercommunity interoperability includes ensuring consideration of providing a unique portal to perform various tasks and application in land administration. A simple and single portal instance for intercommunity interoperability is the Google account. Google is a unified sign-in system that gives users access to free Google products, including iGoogle, Gmail, Google Groups, Picasa, Web History and so on. (Figure 6-5). This extremely simple interface hides some very complex logic and operations – a concept that we should seek to provide in land administration and real estate management (Roux 2004).

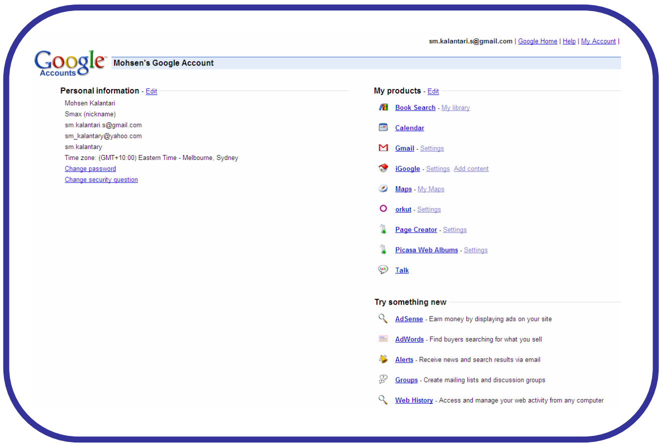


Figure 6-5: Interface of Google account

iv TECHNICAL INTEROPERABILITY

Many types of heterogeneity are due to technological differences in land administration systems, for example, differences in databases, data modelling, hardware systems, and software and communication systems.

The differences in DBMSs are largely in data models which have direct impact on data structure, constraints and query languages (Radwan *and others* 2005). Also, in order to satisfy market needs, the data must be reliable and timely for all users. In order to minimise data duplication, data sharing partnerships between data producers are coordinated so that there are fewer conflicts on their data standards (Tuladhar *and others* 2005). Another example of technical interoperability is the benefit of web services for cadastral information, which is the ability to use functions between any kinds of platform regardless of programming language, operating system, computer type and so on. (Hecht 2004). The uniform description of the cadastral domain, too, allows cost-efficient construction of data transfer and data interchange systems between different parts (Paasch 2004b).

Consideration of technical interoperability includes ensuring an involvement in the continued development of standard communication, exchange, modelling and storage of data information as well as access portals and interoperable web services equipped with user-friendly interfaces.

The interoperability toolkit was developed in order to achieve the introduced aspects of interoperability in land administration.

6.5 INTEROPERABILITY TOOLKIT

The e-land administration system includes range of processes that should be undertaken on a variety of land information and related data. Examples include the establishment of a car space register, water trading register, natural resource register and aboriginal heritage register which are added to the classic processes of land administration offered by land registry. The holistic and comprehensive treatment of such an e-land administration system requires a range of tools to cover such interoperability aspects.

Semantic, legal and intercommunity aspects relate more to administrative and political levels. They are related to the arrangement of data sharing and process among the land administration subsystems. Spatial data infrastructure is a tool used to facilitate meeting the objectives of these interoperability aspects (Rajabifard *and others* 2005). This can be considered from organisational SDI based on SDI hierarchy (Figure 6-6). The example provided is how to integrate built environment and natural environment data to support sustainable development objectives (Mohammadi *and others* 2007).

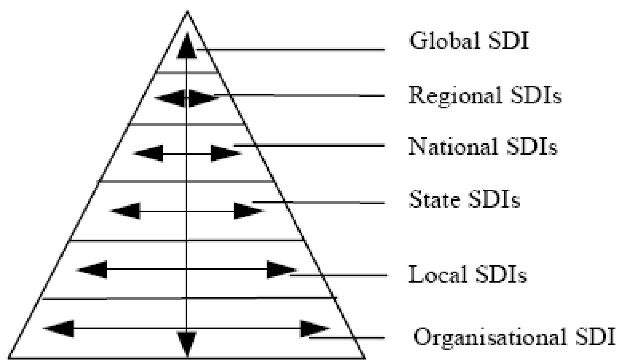


Figure 6-6: Organisational SDI in SDI hierarchy (Rajabifard *and others* 2005)

The implementation of technical interoperability is influenced by the lower levels of interoperability and needs a range of tools to cover the scope of the other interoperability levels. In fact technical interoperability tools are instruments by which the idea of interoperable land administration will have been realised.

A technical interoperability toolkit offers a wide range of facilities to cover the requirements of the other levels. It provides tools for managing data including modelling, capturing, converting and so on. The toolkit also provides tools to adapt the organisational structure of the land administration system to a digital and electronic format. Access and sharing tools are needed for facilitating the data and information exchange among the subsystems of land administration. After providing accessible data in a proper electronic architecture, the toolkit supplies the proper models and functionalities for decision-making. Therefore the technical interoperability toolkit includes four major tools, which are illustrated in Figure 6-7.

i DATA MANAGEMENT TOOL

Data management tools facilitate and manage the development or intensification of land information from multiple distributed sources. Cadastral data that is stored for use in local databases can often be used in external applications once it is published. A data management tool provides facility for data description, data modelling, data capture, database design, data catalogue and data conversion and migration as a means of holding cadastral information in a standard way to be deliverable across multiple organisations for access and sharing.

ii ENTERPRISE MANAGEMENT TOOL

The enterprise management tool facilitates and supports the development of plug-and-play enterprise systems and architectures using a web-based foundation. Applications will be based on compositions of services discovered and marshalled dynamically at runtime (OGC 2003). Service (application) integration becomes the innovation of the next generation of e-business, for example, for interoperability with external software the use of web services standards is one approach (Hecht 2004).

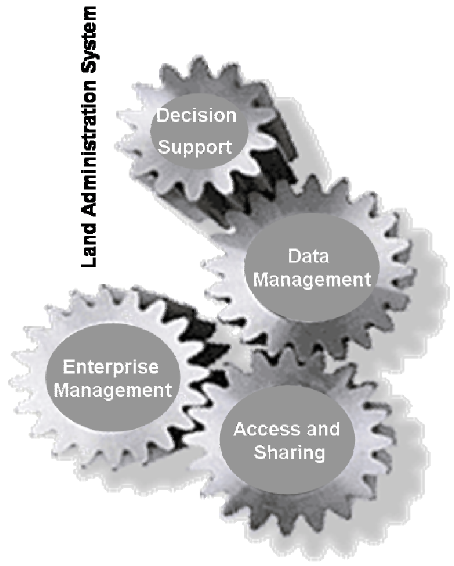


Figure 6-7: Land administration interoperability toolkit

iii ACCESS AND SHARING TOOL

The access and sharing tool facilitates the development of web-based access in a seamless and integrated view. These tools provide recent interoperable sharing techniques, based on international standards like (OGC 2003), to realise simple inter-operability through specification that is considered also in the ISO International Standard. Access may include the order, packaging and delivery, offline or online, of the data (Nebert 2004). Once cadastral data of interest has been located and evaluated, using the data management and sharing techniques, access to detailed cadastral data is required by web services.

iv DECISION SUPPORT TOOL

The decision support tool is what the consumer does with the data for their own purpose. Decision support and exploitation tools, especially in land use and land development functions of land administration, facilitate decision-support applications that draw on multiple, distributed cadastral data resources. The initial focus of the interoperability is to improve the quality and accessibility of related knowledge, information, and data.

Within the interoperability toolkit, the data management tool contains data modelling components. Data modelling components play an important role both in data and business management in land administration systems. The next section discusses the importance of data modelling in order to achieve interoperability in e-land administration.

6.6 CADASTRAL DATA MODELLING

The solution to implement an efficient e-land administration is to develop effective communication among the different land administration subsystems by harmonising data and functionalities, so they are capable of being used by all subsystems. The key to harmonisation is data modelling which both recognises and reengineers existing business processes. Modelling allows every single process in land administration to influence the cadastral data model and vice versa. This section describes the importance of cadastral data modelling in data management as well as coordination among subsystems in an
e-land administration system.

The data modelling formulates the proper way of capturing spatial and non-spatial cadastral data. Database design is based on data modelling. Data modelling is a conceptual level which underpins the design of logical and physical models of the database. The modelling component allows the data catalogue to fit metadata in the proper position whether it is separate or integrated with other data. Also, modelling introduces standards for the exchange and conversion of data among the various services for different organisations.

Furthermore, a data model is a basic step toward efficient service delivery, because data is defined in the context of business processes. It allows every single process in land administration subsystems directly to influence the core cadastral model. The modelling process should recognise the business processes and mirror them in the reference cadastral model.

An interoperable cadastral data model which recognises all subsystems requirements will facilitate interoperability in e-land administration. It helps data to be exchanged efficiently without missing data in the process of converting one data model into another. Using the interoperable cadastral data model, two methods can be proposed for data exchange between subsystems.

6.6.1 CADASTRAL DATA MODELLING AND DATA MANAGEMENT

Cadastral data refers to all data related to value, ownership and use in the land administration subsystems. Studies show that data management of land administration systems is one of the major cost items: figures of between 50 and 75 per cent of related total costs have been quoted. The data component includes items such as data modelling, database design, data capture, and data exchange (Roux 2004), and data catalogue.

i CADASTRAL DATA MODELLING AND CAPTURE

Cadastral data must be able to be updated and kept current. As discussed in Chapter Three, although recent advantages in data capture technology make this easy, these initiatives are made in “isolation” and no common view is formulated for the handling of cadastre and other related data (Meyer 2004a). Consequently, the data sets cannot be easily integrated and shared because of the lack of harmonisation between them. Further, no effective measures or supporting digital tools exist for the direct data access and propagation of updates between them in order to keep data sets up to date and in harmony (Radwan *and others* 2005). The process of boundary data capture is an example of the problem. To gain maximum benefit from existing data, the building process should not only extract data from the documents and build the boundary network, but it should also analyse the data and provide a measure as to the reliability and accuracy of the computed coordinates. This opens the way for coordinates to be used more widely as the primary way for surveyors to convey instructions on how to locate the physical boundaries of a property (Elfick *and others* 2005). If efficient and cost-effective methods for capturing cadastral data, including spatial and non-spatial data, are realised in the cadastral data modelling, effective data management in e-land administration is possible.

ii CADASTRAL DATA MODELLING AND DATABASE DESIGN

The cadastral database should join the attribute and spatial data and present them in an integrated portal since attributes are as important as spatial information for decision support (Meyer 2004a). However, the integrated portal does not necessarily allow attribute data and spatial data to be put together. They enable the user to access various distinct databases using a unique portal. Systems architecture design changed in response to the growing need to access data sets which were developed individually but simultaneously from various distinct databases within various divisions of large organisations; these datasets increasingly have to be accessed at an integrated level (Vckouski 1998). Introduction of a new cadastral data model facilitating access to cadastral databases whether spatial or non-spatial should be recognised to achieve an interoperable e-land administration.

iii CADASTRAL DATA MODELLIING AND DATA EXCHANGE

Data must be standardised so that information can be shared across jurisdictional boundaries (Meyer 2004a). Therefore, cadastral data needs to have its own exchange language better to communicate among various organisations. Because of the nature of cadastral data, especially in a spatial context, a specific language is needed for cadastral objects and elements to permit exchange and migration of the data. Cadastral data modelling which understands specialised exchange language for cadastral data will facilitate data exchange among various subsystems.

iv CADASTRAL DATA MODELLING AND CATALOGUING

Data will provide linkages to more detailed information that can be obtained from data producers (Meyer 2004a). The catalogue is a way to provide consistent descriptions about the cadastral data. The objective of the cadastral data catalogue is to develop a description of each object class, including a definition, a list of allowable attributes, and so on (Astke *and others* 2004). An expanded cadastral data model, including a metadata, facilitates data publication across a network.

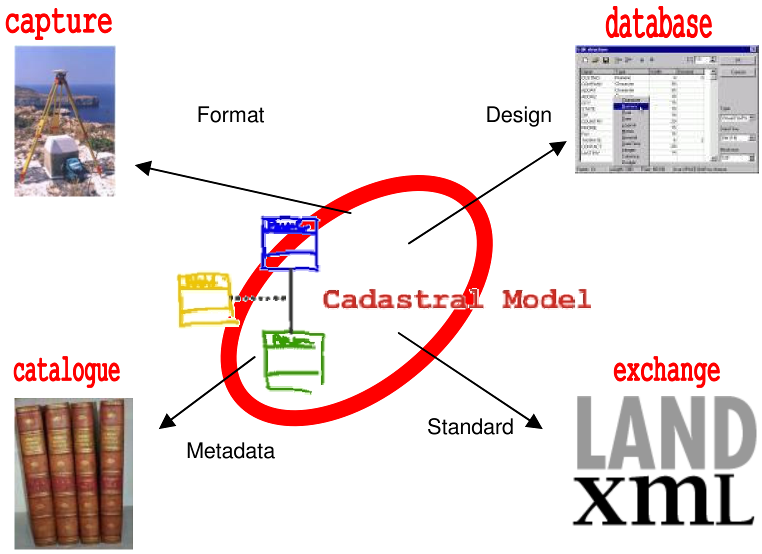


Figure 6-8 : Role of cadastral data model in data management

Figure 6-8 illustrates the role of modelling data management. It formulates the proper way of capturing spatial and non-spatial cadastral data. Database design is based on data modelling. Data modelling is a conceptual level of modelling which underpins the design of logical and physical models of the database. The modelling component allows the data catalogue to fit metadata in the proper position whether it is separate or integrated with the other data. Also, modelling introduces standards for the exchange and conversion of data among the various services for different organisations.

6.6.2 CADASTRAL DATA MODELLING AND COORDINATION AMONG SUBSYSTEMS

An effective cadastral data model must describe what is fundamental to a business, not simply what appears as data. Entities should concentrate on areas of significance to the business.

The existing cadastral data models include the owner, land parcels or properties and the rights and some restrictions associated with them. They follow a classic concept for the cadastral domain within land administration, based on historical arrangements made for land registration, surveying, building and maintaining the cadastre (Wallace and Williamson 2004).

Huge efforts to improve land administration are focused on the utilisation of ICT: for example, the electronic submission and processing of development applications, e-conveyancing, the digital lodgement of survey plans, online access to survey plan information and digital processing of title transactions as a mean of updating the database. A comprehensive e-land administration needs to incorporate the data requirements of all these processes in all subsystems in the cadastral data model

For example, the electronic conveyancing system should be developed in conjunction with the land taxation subsystem and land registry subsystem to ensure that all data requirements are met in one simple process. For instance, in Victoria the tax system relies on properties not parcels and there is a property identifier that links the title, local government and tax systems. They are interested in property price and land use. The descriptions of vacant land, residential property, industrial property, rural property and commercial property are crucial for many taxation regimes. Only some of that information can be achieved from land registry.

An expanded cadastral data model which realises both land taxation and land registry requirements facilitates the processes within an electronic conveyancing system. Local governments independently gather data layers, like dog exercise reserves and sites, walking trails, location of recreation clubs like horse riding clubs, as well as open spaces within the local government boundaries. This sort of information is associated with land parcel and property layers, which are not found in the digital cadastral database of a country or state.

An expanded cadastral data model that realises this kind of large-scale and local land information can facilitate data flow in the subsystems. It allows easy plug and play between local land information and the cadastral database.

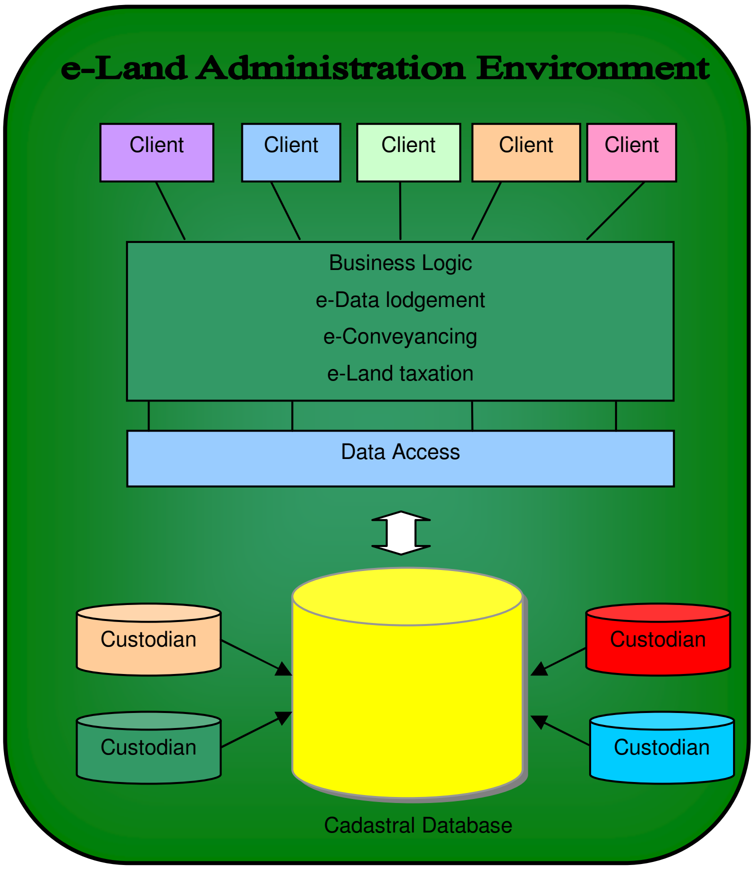


Figure 6-9: Role of cadastral data modelling in coordination with subsystems

To achieve e-land administration, cadastral data modelling is a basic step toward efficient service delivery (Figure 6-9), because data is defined in the context of business processes. It allows every single process in land administration subsystems to influence directly the core cadastral model. The modelling process should recognise the business processes and mirror them in the core cadastral model.

6.7 CHAPTER SUMMARY

This chapter focused on introducing the concept of e-land administration along with the pathway to implement and maintain it. A five-phase implementation approach was brought in, detailing online information delivery, transacting over the Internet, integrating the transactions with internal processes, and integration with external partners. The implementation was finalised with a maintenance regime to keep e-land administration active and responding through an introduced assessment methodology.

Next, to help with the implementation, the chapter introduced a toolkit in order to put the phases into practice. To develop the toolkit, land administration systems were examined against four levels of interoperability: semantic, legal, intercommunity and technical interoperability. To achieve the technical interoperability, the toolkit contains four major tools including data management, data access and sharing, enterprise architecture tools and the exploitation tool.

Following discussion of the different aspects of the e-land administration toolkit, data modelling in data management was identified as a critical tool to improve interoperability and help with the efficient development of e-land administration.

The next chapter will propose a new cadastral data model that responds to the research problems.

CHAPTER 7 - PROPOSAL FOR A NEW CADASTRAL DATA MODEL

7 PROPOSAL FOR A NEW CADASTRAL DATA MODEL

7.1 INTRODUCTION

To meet government needs for up-to-date, complete and comprehensive information, e-land administration intends to treat the data and services of each of the subsystems holistically, by improving data management and coordination. Cadastral data modelling is one tool offered by the e-land administration toolkit to implement this strategy.

Cadastral data modelling is particularly important in the domain of land administration. The modelling of a cadastral system has received special attention focused on the International Joint FIG Commission 7 and COST Action G9 Workshop on Standardisation in the Cadastral Domain in 2004. Therefore, the second section of this chapter discusses the importance of cadastral data modelling in data management and coordination in e-land administration.

Meanwhile, according to the results of Chapter Two, delivering land administration's objectives requires effective management of social, environmental and economic aspects of land. Historically, land administration systems have contributed to this by recording and organising interests in land, primarily through land registration, land mapping, land valuation and land development subsystems. Unfortunately, these subsystems have established diversified services and functions to manage interests in land each from their own perspective, and often operate in unconnected information silos. Interoperability between these information silos is impeded by use of often incoherent and unique identifiers in the data models used in each subsystem. Efficient interoperability in the wider sense is adversely affected by an inability to exchange land information between subsystems.

At the same time, land administration systems are not sufficiently flexible to accommodate or support the growing number of complex commodities (water, biota, mining, carbon credits, and so on) and other interests (environmental, heritage, use restrictions) in land. This inflexibility is caused by traditional concentration on a data model based on the physical land parcel (the cadastral parcel) as a single means of organising land information.

To address the research problems, this chapter proposes that the data model based on the physical land parcel be replaced by a spatially-referenced data model based on the legal property object. The proposed data model is more comprehensive, capable of organising a wider range of interests, and should facilitate wider exchange of information. The legal property object is open-ended and can include complex commodities and all kinds of rights, restrictions and responsibilities. Spatially referencing these objects facilitates interoperability among the subsystems. The key for putting the proposed model into practice is the use of spatial identifiers to regulate relationships among legal property objects.

7.2 A NEED FOR A NEW CADASTRAL DATA MODEL

According to Chapter Two, land administration systems are evolving from a focus on core functions of regulating land and property development, land use controls, land taxation and disputes (Dale and McLaughlin 1999) to a focus on an integrated land management system designed to support sustainable development (Enemark *and others* 2005).

Sustainable development requires the management of social, environmental and economic interests in land. However, land administration subsystems use diversified services and functions to manage interests in land (Figure 7-1). For example, the land registry subsystem emphasises the management of private rights, restrictions and responsibilities (RRRs) related to land parcels. At the same time the land development subsystem is concerned with use restrictions imposed by planning authorities. The valuation subsystem focuses on the economic functions of land. The land tax office requires the change of property use as well as owner updates to calculate revenue and tax.

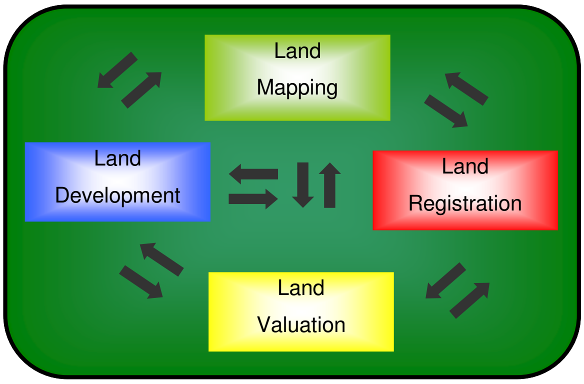


Figure 7-1: Relationship among land administration subsystems

Although these processes seem to be independent, each relies on, or is related to, land parcels or properties for referencing or indexing. In other words, a limited number of interests in land are generally organised through land parcel or property data models in the cadastral information systems.

This chapter encourages the land administration system to take up new opportunities for more integrated management of diverse internal approaches and overall delivery of land administration system policies by adopting a comprehensive and interoperable data model. Comprehensiveness refers to a holistic inclusion of a wide range of interests, each with potentially different dimensions. Interoperability refers to a common and efficient way of organising interests and their spatial dimension to simplify the land administration processes; in particular, data exchange between subsystems.

Each cadastral information system, however, follows a specific method of data modelling, using specific data elements to manage interests in land. Identification of the main data elements in each land administration subsystem assists to reveal the potential of the data elements (Simsion and Witt 2005) and assists reengineering data models to respond to modern land administration requirements.

7.3 LAND ADMINISTRATION DATA ELEMENTS

Some land administration systems with emphasis on data elements employed are reviewed in this section. The content, role and potential of important data elements are identified to provide an overall understanding of the arrangements supporting current cadastral data models.

Current data models in five jurisdictions were studied: three Australian states (New South Wales, Victoria and Western Australia), and two European countries (Netherlands and Switzerland). These case studies illustrated a broad range of data elements and their functionalities in different legislative systems.

As it was stated, Australia is a federation which operates separate land administration and cadastral systems in each of its eight states and territories. The cadastral systems in Australia are historically based on registering land transactions generated by land markets. The cadastral systems support the registration of private land parcels for legal ownership, identifying important rights, restrictions and responsibilities. In their fiscal capacity, they facilitate valuation of land and taxation. More widely, in multipurpose systems cadastres assist in land management and land use planning for local government, and also emergency response and risk management (Dalrymple *and others* 2004).

In the Netherlands, a fiscal cadastre was introduced after annexation of the Kingdom of the Netherlands by France (Wakker *and others* 2003a). In 1992, a major revision of the Civil Code (originally from 1838) and the Cadastre Act changed the legal base of the cadastral and land registration (Zevenbergen 2002; Wakker *and others* 2003a). The land registers and cadastral maps assumed a multipurpose role aimed at providing legal security of tenure, facilitating the land market, and supporting many government activities such as physical planning, development control, public acquisition of land, land taxation and management of natural resources.

Switzerland also has a long-established tradition in cadastres. After the introduction of the federal constitution in 1848, all cantons (states) began to implement local land registries (Kaufmann *and others* 2002). Art. 942 in Swiss Civil Law requires all rights on real estate to be registered in the land registry; thus, the Swiss cadastre has a legal and not fiscal base (Williamson 1981). The land registry is given the joint tasks of land registration and cadastral surveying (Kaufmann *and others* 2002). The primary aim is to register the title to real estate. However, along with a list of registered proprietors, other information – such as land use, covenants, caveats, restrictions, lease, easements, mortgages and valuation – might appear (Williamson 1981). Furthermore, the Swiss maintain a cadastre of three-dimensional services. All underground services are charted, including all cadastral boundaries, all buildings and structures within the parcel, and all structures and visible utilities within the road reserve. Swiss cadastre enjoys form descriptive languages for their cadastral data model called INTERLIS (Steudler 2005); INTERLIS consists of a conceptual description language and a transfer format.

Within each jurisdiction, various organisations contribute to these data elements. In NSW, for example, valuation data is recorded through land transactions in the land registry subsystem and in local governments or real estate agencies through the land development subsystem. As seen in the case studies, these organisations usually have a range of in-house databases. The data components in the databases used by each responsible organisation are structured through specific data models to suit the internal functionality of the organisation. Communication of data between responsible organisations is typically achieved by adding linking elements to the data models to connect different databases together. In Victoria, different identifiers, such as parcel identifiers, property identifiers, addresses and geographical positions, are used to match databases in different organisations.

Data Element	VIC	NSW	WA	Netherlands	Switzerland
Land Parcel	*	*	*	*	*
Property	*	*		*	*
Third dimension	Some	Some		*	*
Public	Some	*	*	*	
Individuals	*	*	*	*	*
Rights	*	*	*	*	*
Responsibilities					
Restrictions	Some	Some	Some	Some	*
Land Value	*	*	*	*	*
Land Use				*	*

Table 7-1: Important data elements in land administration systems

Table 7-1 illustrates existing data elements of cadastral information systems of the jurisdictions. The elements are not necessarily integrated into a single database or managed by a single organisation. The data elements are explored below.

7.3.1 LAND PARCELS

The definition of a parcel varies according to the jurisdiction. For practical purposes, a parcel is a closed polygon on the surface of the Earth (United Nations 2004). Although the land parcel is identified as the building block of each land administration system, it might have originally been recorded by non-cadastral organisations. So far, cadastral data models have relied on land parcels as their foundation. However, land parcels are a fallible organising tool, lacking sufficient flexibility to incorporate the increasing number and diversity of interests in land.

7.3.2 PROPERTY

Properties have different meanings in different countries and are often used in conjunction with land parcels (Steudler *and others* 2004b). Practically, a property is often defined as the building(s) associated with land. A property may also consist of one or more adjacent or geographically separate land parcels. Additionally, a parcel can contain several properties. Land parcels are linked to properties in a one-to-many, many-to-one or one-to-one relation. Multiple interests can exist on a property and the attached interests can be shared between two or many holders in separate titles. Properties usually play a greater role in valuation and taxation data models. However, properties, similar to land parcels, are not flexible enough to provide an effective means for organising interests in land.

7.3.3 THIRD DIMENSION

The third dimension of height facilitates subdivision into strata, creating separate parcels above or under the original area. The most typical objects located above the surface are apartments or buildings registered as separate property (Stoter and Oosterom 2003). Increasingly, constructions below or above the surface, such as tunnels and platforms used as foundations for buildings and so on, are also treated as separate objects in a subdivision process, and are capable of being registered as separate real property (United Nations 2004). In some jurisdictions, networks such as telecommunication lines may also be registered, either within the cadastre (as has been proposed in the Netherlands) or in a separate register (as for high-voltage power lines in Norway) (United Nations 2004; Bennett *and others* 2005). The third dimension also can include interests related to trees, vegetation, minerals, hydrocarbons, as well as water. In current data models, the third dimension is usually modelled as a 3D tag linked to the parcel record (Stoter 2004). The increasing complexity of modern cities suggests that modern land administration systems need an improved capacity to manage the third dimension (Zlatanova and Stoter 2006).

7.3.4 PUBLIC AND INDIVIDUALS

Interests can be held by individuals or groups of individuals, legal persons (organisations such as companies or cooperatives), or by governments (including municipalities). However, historically land registries were involved in registration of private ownership of land parcels. This trend led most land administration systems to keep separate records of the public and private interests in land. Now modern land administration requires an integrated and holistic treatment of land, including a seamless registration of titles to all public, government and private interests (Bennett *and others* 2005).

7.3.5 RIGHTS, RESTRICTIONS, RESPONSIBILITIES (RRRS) ON LAND

RRRs are intangible concepts, even though most of them deal with a tangible object such as a piece of land. Land affected by RRRs can be divided into parts; for instance, possession of land and a right of a way over it. The division of land into separate identifiable RRRs can be further complicated, for example, by sharing of the ownership of various rights, occupancy, tenancy or lease. The consequence is RRRs are broken into smaller parts in which there may be a multiplicity of interested individuals.

RRRs can be presented both spatially and non-spatially. The results of exercise of rights to give, sell or lease land to someone else can be recorded in non-spatial databases linked to individual land parcels. But, the rights of land use or right of a way can be considered as a spatially physical entity on the surface of the Earth regardless of their configuration in relation to or connection with a specific land parcel. In other words, their existence is not necessarily subject to any land parcel. Organisation of RRRs remains an important issue in cadastral data modelling processes.

7.3.6 LAND VALUE

Value information is usually captured through the land registration or stamp duty collection processes when the land is transferred. This data is captured and sent to a valuation subsystem. Data models in the fiscal cadastre place emphasise on the land value data element rather than the other data elements. Valuation subsystems are therefore not truly spatially enabled. Valuation or taxation data comes in as attributes associated with property identifiers.

7.3.7 LAND USE

Physical planning is the process of defining and controlling the use of land to meet sustainable development objectives. Land administration systems employ land parcels to allocate land use information in land. Although from a land resource management perspective definition and identification of land parcels are fundamentally important, the parcel is not the only unit used in land management. Spatial identification of interests requires a more flexible data element. Land use, in fact, is a form of interest in land and can be incorporated in RRRs data element.

As seen, each data element in a land administration system has a specific functionality; it is therefore difficult to accommodate the data elements in a single data model. However, an examination of the arrangements among data elements would assist reconfiguration of the current core data model into a single comprehensive and interoperable data model.

7.4 CURRENT CORE DATA MODEL

Data elements with different functionalities contribute to a cadastral information system in land administration systems. This section explores how the data elements fit together and identifies the main issues in the current core data model arrangements. Initiatives to improve the current core data model are then reviewed.

Firstly, land parcels constitute the basic building block in land administration systems. Parcels were employed to identify the areas related to interests in land. Besides that, land parcels have been used as indices for organising land information in various land administration subsystems or within other related agencies.

However, an interest in land is not necessarily equivalent in area to an exact extension of a particular land parcel; indeed, it may be applied across several land parcels (Figure 7-2). Land parcels are not flexible enough to accommodate non-parcel based interests.

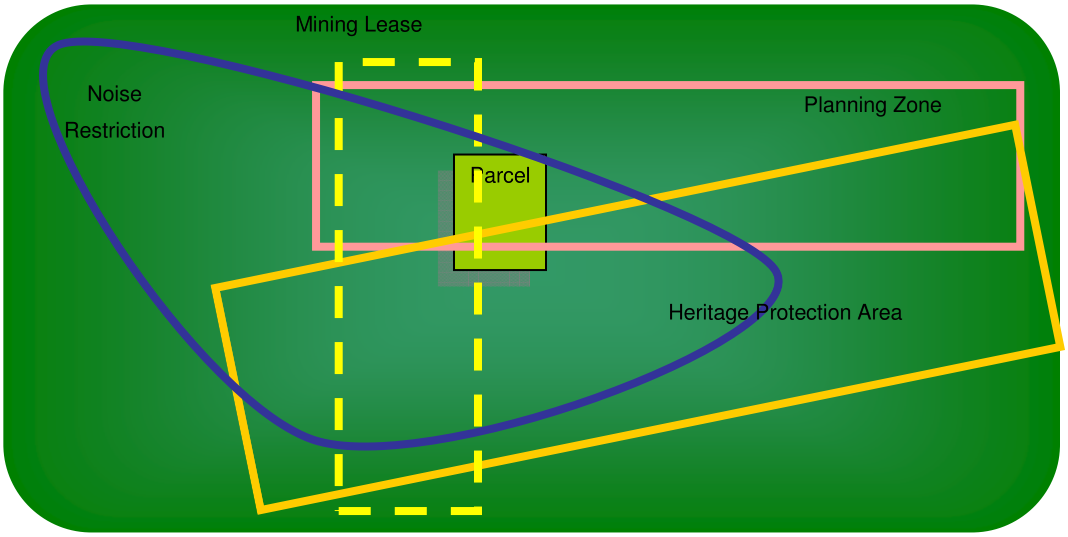


Figure 7-2: An example of non-parcel based interests (Bennett *and others* 2006)

Moreover, it is not the actual spatial dimension of a land parcel which plays the indexing role; rather, it is the parcel identifier employed for organising land information. Non-spatial identifiers remain an issue in land administration systems, especially for organising numbers of properties, buildings and apartments in a single land parcel. Advances in spatial and computer sciences now offer various applications allowing spatially enabled indexing methods (Longley *and others* 2005).

Secondly, interests recorded in land administration systems are traditionally those associated with private ownership. In other words, the most important interest in land is the ownership of land, sometimes represented as a series of opportunities equivalent to "a bundle of sticks". Ownership is usually recorded along with restrictions, most commonly caveats, mortgages and rights of way.

However, interests in land are now much more diverse that those held in registries. For instance, land use restrictions are recorded by planning authorities, separately from the ownership. Further, for economic purposes, governments have created new commodities such as rights of biota and water. Whether these are managed in land registered or not, they demand flexible systems of recording and identification.

Thirdly, land administration systems have so far focused on private interests rather than public interests. Land registries and cadastres constitute the basic records of private land holdings. Although, some government agencies are responsible for management of public lands, their systems are usually not as mature as those used for managing records of private land and are usually separately maintained. Distinctions between private and public interests still challenge the capacity of land administration systems to manage all land in a jurisdiction.

Finally, in view of the above, the current core data model consists of the parcel or property and the owner, with a private ownership linking these together (Figure 7-3). Other information mentioned earlier is centred on the core functionality of the cadastre. This model describes how a piece of land or property relates to a person via the ownership right held.

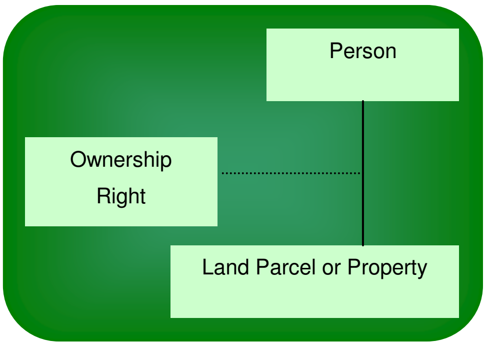


Figure 7-3: Current core data model

However, worldwide initiatives have attempted to improve the current cadastral data model in order to address these issues (Table 7-2).

The core cadastral domain model (CCDM) developed by (Lemmen and Molen 2003; Lemmen and Oosterom 2003; Oosterom *and others* 2004b; Lemmen *and others* 2005; Lemmen *and others* 2006; Oosterom *and others* 2006) is the most outstanding effort in the area of cadastral modelling.

The heart of the model is its three components: registered objects (movable and immovable), RRRs, and persons. The model is then expanded with specialisation of each component.

Immovable registered objects are expanded to a parcel family package, a building class that is associated to a unit class as well as a class representing other registered objects. The model is based on survey points that are organised through geometry and topology. The model enjoys from a rich package for handling the person component of a cadastral data model.

However, in the model the spatial reference system, for example, does not play a key role. This results in loss of potential to improve interoperability by spatial enablement. In general, the model seems to be a comprehensive approach to handling cadastral information, however it suffers from unnecessary and complicated relations among different components. For instance, the model includes the money provider, conveyor and surveyor in the cadastral data model while missing the land valuer or even the valuation requirements of a land administration system (for more details see Appendix 2).

The Intergovernmental Committee on Surveying and Mapping (ICSM) has developed a Harmonised Data Model (HDM) for Australia. The HDM incorporates cadastre, topography, place names and street addresses. The cadastral package model consists of four elements as follows:

Public Objects: Contains non-spatial classes associated with the public administration of land (Property, AdminArea).
Private Objects: Contains non-spatial classes associated with the registration of land rights (Parcel, Title, Plan, Easement, Reserve, RoadReserve, SecondaryInterest).
Surveying: Contains classes associated with measurements obtained during field surveys and determined for the preparation of cadastral survey plans.
Topology: Contains spatial classes providing the geometric representation of the cadastre, topology being provided through associations.

The model intends to be a practical solution for organisation of cadastral information Australia wide. Developing the data model, the specification of Australian cadastre and land administration has explicitly been considered. However, the data model is outdated considering new roles that are expected from land administration systems. For instance, the model is limited to a number of restrictions in land (easement, secondary interests, reserves and road reserves) without considering growing numbers of interests in land (for more details see Appendix 3).

In the United States, the FGDC Standard Reference Model defines data content standards as standards that provide semantic definitions of a set of objects. The Cadastral Data Content Standard provides semantic definitions of objects related to land surveying, land records, and landownership information. The core model consists of three main components: Land Parcel, Legal Area Description and Agent.

The rights and interests in real property are all managed through land parcels as a single cadastral unit. The model facilitates describing the specific rights and interests that are related to a parcel. In the model, rights and interests are considered as benefits or enjoyments in real property that can be conveyed, passed, or otherwise allocated to another for economic remuneration. Besides, model allocates an entity to organise restrictions in land. The restriction entity captures information related to administrative, judicial, or other limitations or permissions for the use and enjoyment of land by the land right holder. These are not transferred rights, although succeeding owners may agree to the same restriction on a Parcel.

Land parcels are connected to persons through an agent that can be an individual, organisation, or public agency that holds rights, interests, or restrictions in land, holds or files land records, or has established a land description, a coordinate value or a monument. However, to provide the structure for assembling the components of a single legal description into one, the model employs an entity called Legal Area Description. Intersecting Legal Area Description with the Parcel entity will result in The Parcel Legal Area.

All spatial description of Land Parcels and Legal Area description is based on Corner Point concept. It is a point feature, which marks the ends of Record Boundaries or the extremities of a Legal Area. A Record Boundary is the linear feature that represents the edge of a feature, which may be a Parcel or a legal area. The Record Boundary is the information for each boundary segment. All Record Boundary features come from the same source and have the same units of measure (for more details see Appendix 4).

Complementing the FGDC efforts in developing a cadastral data model, the ArcGIS parcel data model is an implementation of this standard. In the implementation of the model there are seven themes: corners, boundaries, parcel frameworks, tax parcel, rights and interests, administrative areas and parcel-related uses. These seven themes apply to the parcels.

The corner theme comprises points that define the corners of parcel boundaries. The boundary theme then contains the lines that form the edges or sides of the parcel areas. Complementing the two first themes, the parcel framework provides the supporting outline for parcel-related features. These are typically based on major subdivisions as defined in the United States.

To support the valuation function of land administration, this model uses a thematic layer called tax parcels. The tax parcel theme recognises that a single tax parcel could be made up of several polygons. This in particular supports the idea of aggregated tax or multi-unit tax.

The right and interest theme contains the ownership parcel links to an index about documents related to ownership, and features classes for the many types of rights and interests that can be held and sold; for instance, the ownership consideration, including separated rights and encumbrances such as right of ways, leases, mineral rights and other interests separated from the ownership. This in particular facilitates the incorporation of more interests in land, however the interests are harnessed through land parcels without considering them as interests in their own rights.

The administrative area theme facilitates the definition of those areas used to manage or allocate resources and services in governments. It is a very specialised theme for the purpose of land administration in the United Sates. The model provides further facility to include zoning plans and regulation in the parcel-related theme.

	Person			Property									Legal /Fiscal						Geometry								Multi Purpose					
																			Surveying					Topology								
	Natural person	Public	Organisational	Parcel/land	Unit/apartment	Parcel complex	Apartment complex	Part of Parcel	3D objects	Volume Property	Public Objects	Private Objects	Rights	Responsibility	Restriction	Taxation	Valuation	Legal Documents	Point	Line	Polygon	Plan	Surveying Documents	Face	Node	Edge	Topographic	Mining	Marine	Agriculture	Utility	Environment
ICSM				✓							✓	✓	✓		✓				✓	✓	✓	✓	✓	✓	✓		✓					
CCDM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓			✓	✓				✓	✓	✓	✓						
FGDC	✓	✓	✓	✓									✓		✓				✓	✓												
ArcGIS	✓	✓	✓	✓									✓		✓	✓			✓	✓	✓											

Table 7-2: Summary of initiatives, improving cadastral data models

In summary, current data models are very much focused on the right of ownership and on restrictions and responsibilities that reduce ownership. However, future land administration requires development of an open-ended packaging method, avoiding restriction of particular RRRs into particular real estate objects. Land parcels are dominant in the data models interfering with the legal independence of interest in land.

Current cadastral data models include only the physical land parcels, owner, and rights, but without attention to the collaborative objectives of land administration subsystems. This missing element impedes the interoperability and efficient communication in land administration.

7.5 THE NEW DATA MODEL: LEGAL PROPERTY OBJECTS

The earlier discussion about the current data elements revealed that the core cadastral data model is based on three important data elements: person, land parcel or property, and the rights. However, in current thinking and literature on cadastral and land administration issues, usually the rights are replaced by three Rs of Rights, Restrictions and Responsibilities (Lemmen *and others* 2005). Besides that, to improve the capacity of land markets, new interests in land and commodities such as biota, water and mining are being recognised.

The key questions then are how and why new interests and RRRs might be incorporated into a cadastral fabric, especially when they are remote from physical objects or even spatial identification (Wallace and Williamson 2004). RRRs are a result of cultural, social and political activities in each country, and describing the variety of existing rights and restrictions in a common model is difficult (Ottens 2004; Paasch 2004b).

In an administrative context, there is no difference between private rights, public restrictions or a licence for organising interests in land. Some relate to parcels and some do not, however they must all be transparent. To achieve transparency, all these matters are treated as generic “interests in land”. Therefore, from an administrative modelling viewpoint where the focus is on abstracting the real world as a principle, land is not a legal entity until an interest is attached to it. When an interest is recognised and is recorded, whether in a parcel basis such as right of ownership or in a non-parcel basis such as road sidewalk restriction, then the spatial dimension to which the interest applies becomes a legal entity. Each interest in land with its spatial dimensions forms a specific legal entity; when the interest is abolished, the legal entity will cease. Consequently, the relation between interest and its spatial dimension is that they together are a unique entity in the real world.

Any kind of interest, whether a right or a restriction, has the same logical construction for purposes of spatial identification. Therefore answers to the above questions involve applying this principle to the modelling processes. For example, a biota right exists as an interest that often appears to be attached to land parcels, but the commercial exploitation of the opportunities arising from biota may not neatly align to individual land parcels (Sheehan and Small 2004). Nevertheless, the biota right could be identified within a spatial dimension.

For this reason, the very close relationship between each interest and its spatial dimension in the real world should also be recognised in information systems. To put it another way, they should be maintained together as a unique entity in a cadastral information system. This unique entity must define both the interest and its spatial dimension. The interests are open-ended and can include all political, environmental, social and economic interests. Spatial dimensions of the interests can include a variety of shapes, limited by the ability of computer systems to present them. The spatial dimensions can currently be presented in points, lines, polygons and volumes. The combination of the interests and their spatial dimension creates a variety of legal entities (Figure 7-4).

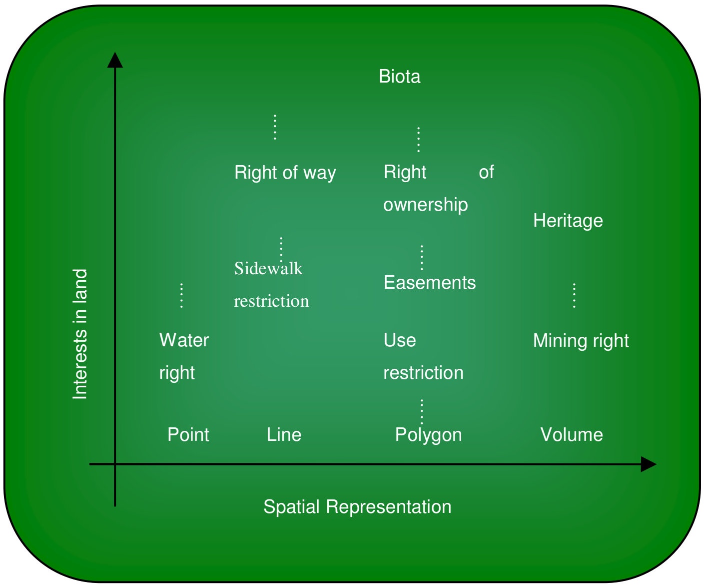


Figure 7-4: Creating the objects using combination between spatial dimension and interests

Thus, introduction of the concept of legal property objects can combine an interest and its spatial dimension into an entity: an entity defined by a law or regulation which relates to a physical space on, below or above the earth. This can apply to a new land-related commodity, a land parcel with ownership rights, or an interest within a particular dimension in land. The challenge of organising interests in land, such as biota, lies in harnessing these departures from the land parcel without producing such a degree of independence as a legal entity. A further instance of this is a tax responsibility (Meyer 2004b). A tax assessment classification usually employs an aggregative method for calculation of dispersed taxable land-related commodities. A combination of all taxable land-related commodities of a particular person into a single legal property object would facilitate the tax assessment process.

As a consequence, different kinds of interest in land are reflected in various legal property object layers in a cadastral information system. This definition creates virtual information layers out of intangible RRRs and new commodities. The legal property object allows users to visualise both the interest and its spatial identification. Instead of using land parcels to find out the related interests, the point is to use the spatial dimension of each legal property object to provide the basic functionality. Additionally, this facilitates incorporation of RRRs and new commodities into the cadastral fabric and their spatial representation in a cadastral information system.

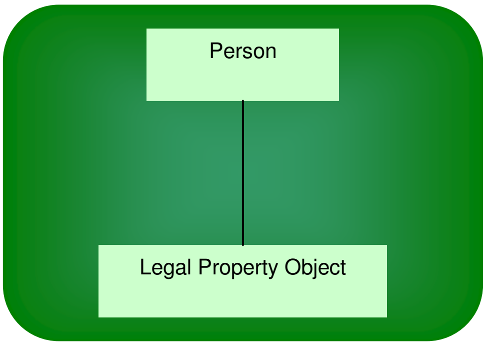


Figure 7-5: New core cadastral data model

The concept of the legal property object changes the current core data model from three components into two components: legal property object and the person (Figure 7-5). The legal property object includes a particular interest with its spatial dimensions. The legal property object will be the basic building block and is the centre of the model for organising land information. The person includes all the private, natural and non-natural individuals as well as the public.

The advantage of this model is the comprehensive inclusion of all interests in land. The proposed model addresses the issue of the ever-growing number of interests in land and shifts the whole land administration functionality to be based on a data model with legal property objects at its heart. In short, ultimately the system allows all rights, restrictions and responsibilities, and commodities to be registered spatially in a holistic way as illustrated in Figure 7-6.

Furthermore, the new model facilitates the land administration system to be more extensible and scalable in terms of new legislations and land-related laws. The new laws can be applied to individual legal property objects. Therefore the relationship between various legal property objects, like relationship between a water right and a land right on a specific location, can be formulated using specific rules in the data model.

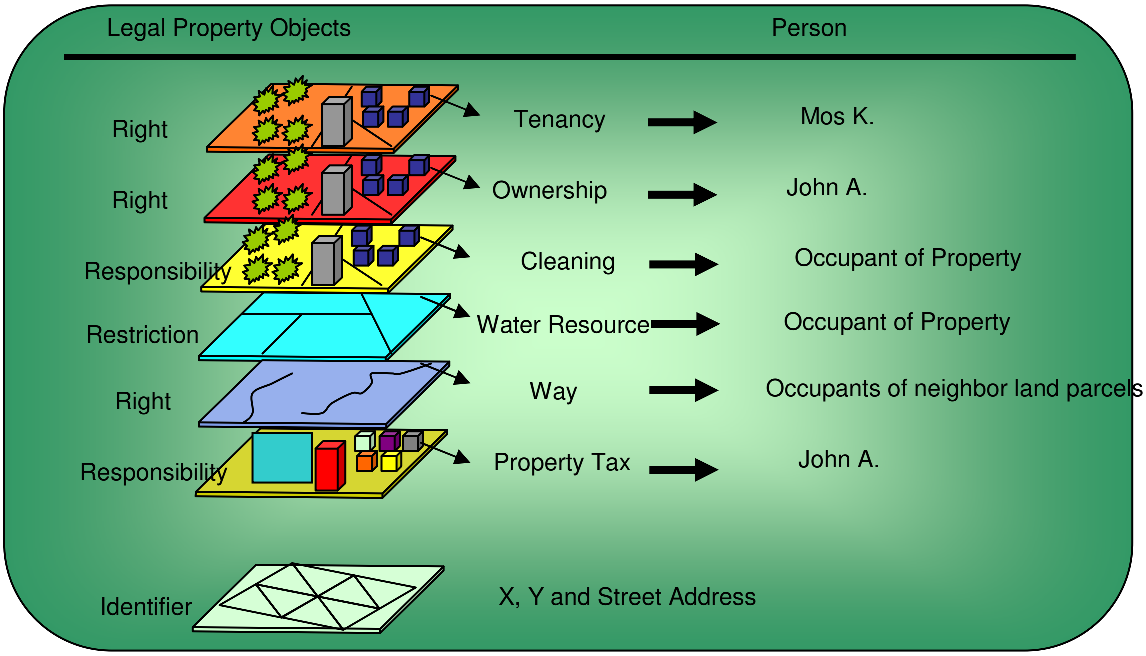


Figure 7-6: Spatially registering legal property objects

Incorporation of this change into a cadastral data model not only responds to the increasing number of interests in land but also the use of a spatial referencing system in the data model helps address the issue of interoperability.

For indexing purposes, every land parcel or property recorded in a land registry or a cadastral information system must have an identifier (Meyer *and others* 2002). In fact identifiers are the most important linking data element in the land administration databases helping with interoperability. There are various ways of referencing land parcels and property based on historical evolution and geographical location. The known identifiers, namely addresses, cadastral maps and coordinates, are examples.

One method for identifying a basic property unit is to use the name of the owner in what is sometimes called a grantor/grantee index. The grantor is the person by whom a grant or sale is made, while the grantee is the recipient – as in vendor/vendee or seller/buyer (United Nations 2004).

Another method relies on title numbers, similar to references on letters. Some geographic filtering may occur by providing a regional or municipal name or code number, but essentially the system is designed to support document retrieval.

In many land book registers, a single-page entry is used for each real property. Each basic property unit can then be referred to as the volume and folio or book and page number on which the information is recorded. The volume refers to the particular registry book in which the entry is made, and the folio is the page on which the details of the real property are recorded (Meyer *and others* 2002).

Many cadastres use a block-and-plot numbering system, the block being an administrative area, or an area marked on the map for the convenience of registration. Another identifier, the street address, is the most common form of real property referencing system that is used by the general public. Street addresses are easy to understand but depend on the existence of consistent street naming and building numbering systems. Street address is used increasingly by government departments.

Also, buildings may or may not be recorded in the land registers. For the purposes of land administration, generally it is not appropriate to number buildings by using the postal address since not all buildings will have an address. Identification of buildings by their street addresses makes it easy for people to identify properties on the ground, but creates problems in a land administration system if, for example, street or building names are changed. Land administration requires stable addresses. By contrast, postal addresses often change.

Traditional identifiers, like grantor/grantee indices, title numbers and volume and folio systems, can all operate without maps or any other spatial connotation apart from an indication of the local administrative area. They are commonly found in land registers and can be applied to both basic property units and parcels. In the cadastre, the focus tends to be specifically on the land parcel (United Nations 2004).

In addition, land administration organisations link their databases together using the identifiers. The most common identifiers are volume–folio in land registration subsystems, parcel identifiers in land mapping subsystems and property identifiers in valuation and development subsystems.

Spatial referencing systems are generally not used as identifiers for matching various databases together. Use of relational or object-oriented databases is the common way for integrating various databases, but a spatial referencing system could simplify land administration database management. The new model, therefore, requires the coordinates of all legal property objects to be linked via geocodes.

A spatial referencing system for legal property objects that includes some form of geographic reference has many advantages. It facilitates the management of various layers of information related to legal property objects, and facilitates spatial presentation of rights, restrictions and responsibilities. Finally, setting the related legal property objects on top of each other facilitates the institutional data exchange process between those responsible and optimises the interoperability among organisations.

7.6 CHAPTER SUMMARY

Cadastral data modelling was identified as playing a key role in e-land administration especially for data management and coordination among subsystems.

The main data elements in land administration systems as well as current core cadastral data models were described. The reliance of the current core cadastral data model on three main data elements – land parcel or property, the ownership right and the private interested person – reflects the historical function of the systems. These parcel-based models are challenged by a need to accommodate the growing number of interests in land and new commodities out of land. More importantly, non-spatial parcel identifiers employed in the models do not facilitate interoperability among land administration subsystems.

To address these issues, the chapter proposed two changes in current core cadastral data models. One change is to modify the building block for land administration systems from physical land parcels into legal property objects. This facilitates the incorporation of a wide range of rights, restrictions and responsibilities into the cadastral information system. The second change makes the spatial referencing systems the centre of the cadastral information system as the legal property object identifier. This change promotes interoperability and simplicity in data exchange processes.

The next chapter will be dedicated to developing and implementing the proposed data model in a prototype system.

CHAPTER 8- DEVELOPING THE NEW CADASTRAL DATA MODEL

8 DEVELOPING THE NEW CADASTRAL DATA MODEL

8.1 INTRODUCTION

In Chapter Seven, the new cadastral data model was conceptualised. The two-entity core cadastral data model was proposed and the semantics behind the new model were portrayed. The conceptual model described the semantics of the domain and the scope of the model. It explains entities (representing kinds of facts of significance in the domain) and relationships (assertions about associations between pairs of entities).

In addition to the conceptual model development phase, the development of a data model also consists of two more stages; the logical model and the physical model.

The second stage of data modelling is development the logical data model. A logical data model describes the representation of the data model with regard to a particular modelling technology. This consists of descriptions of the attributes and the role of each data element. In this chapter a logical data model of legal property objects is designed and developed through the unified modelling language approach. In addition, for compliance of the model with international standards and declarations, the development will be based on Cadastre 2014 principles and Open Geospatial Consortium specifications.

The third stage of data modelling is development the physical model, where the actual implementation of the model occurs. It describes the physical means by which data are stored. Following the development of the logical model, this chapter presents the process by which the model is physically implemented in a prototype system.

Finally, in order to test the model, it is evaluated against the requirements of future land administration that were described in Chapter Two.

8.2 THE NEW MODEL: BASIC REQUIREMENTS

Developing the new core cadastral model, some considerations should be taken into account; firstly, the model development method that includes modelling language; secondly, the international standard in the domain of spatial industry that mainly includes OGC and ISO, and finally, the global vision for land administration systems. Before designing the logical model, this section is dedicated to discussing these basic requirements in detail.

8.2.1 UML

As it was discussed in Chapter Three, UML is among the options that ICT offers for data management in land administration. UML is the result of the merging of several object-oriented methods that appeared as an attempt to end the diversity of object-oriented methods. It is now becoming widely used and accepted. Since UML provides a standard notation for modelling and design, it ensures the ease of communication between designers and developers (Eriksson and Penker 2000). Therefore, using UML, one can develop an extendable cadastral data model capable of efficiently being maintained and developed.

This section presents a detailed introduction to UML methodology for a system design. It is important to emphasise that UML is a standard notation that defines a number of diagrams to describe a system using object oriented concepts (see Chapter Three), and what these diagrams mean. Such a process description includes a list of tasks that need to be done, in which order they should be done, the deliverables produced, the kinds of skills required for each task and so on.

UML contains several important diagrams including usecase, class, and sequence diagrams and so on, which are useful in different software development phases. For instance, a usecase diagram provides a way of describing the external view of the system and its interactions with the outside world. The class diagram describes the types of objects in the system and various kinds of static relationships that exist between them. A sequence diagram is used to represent a scenario and shows the temporal ordering of events. In this research, the class diagram is used for data modelling and design.

i CLASS DIAGRAM

The class diagram is a central modelling technique that runs through nearly all object-oriented methods. This diagram describes the types of objects in the system and various kinds of static relationships that exist between them. Figure 8-1 shows a sample class diagram in the spatial domain. Four classes are designed in this model: Road, Plot, House and Owner. Roads are associated to the plots in the area. A number of Houses are aggregated into a plot in a House class and they are associated to their owners.

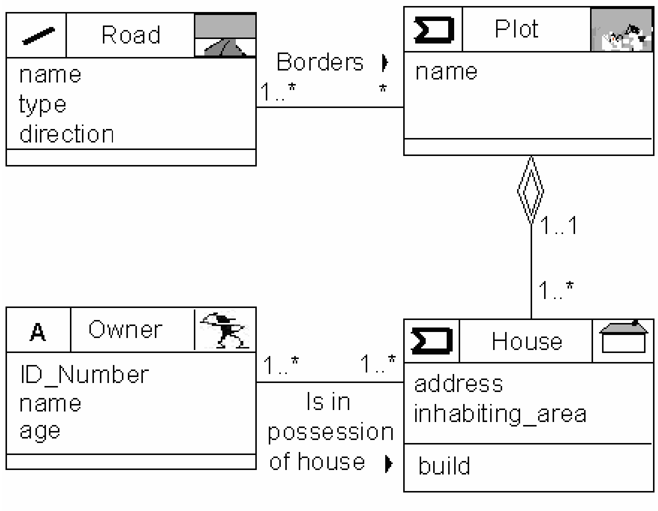


Figure 8-1: A sample spatial Class diagram

Identifying a set of objects or conceptual classes is at the heart of data modelling. The identification of conceptual classes is part of an investigation of the problem domain. The following definitions of elements described in the diagram are summaries derived from (Schmuller 2001), (Gimenes and Barroca 2002), (Fowler 2003) and (Larman 1997).

- Class

A class is expressed by a rectangle with three parts inside (Figure 8-2). The first part is the class name. For example, Road is a class name. The second part contains all the attributes of the class. For example, name is an attribute. The third part contains all the operations within this class, for example, build is an operation.

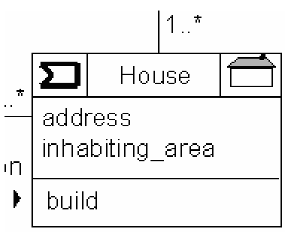


Figure 8-2: A class in UML in three parts

ii OBJECT

An object is an instance of a class, with specific values of the attribute and methods. The notation of object is a colon plus underlined class name, for example: House is one of instances of the House class.

iii METHOD

A method is a function or transformation type that is applicable to objects of the class. Only operations specified by the class can be applied to objects in that class. An operation may also involve objects of other classes, as specified by parameters of the operation signature (Figure 8-3).

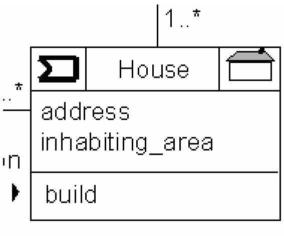


Figure 8-3: The build method in the house class

iv MULTIPLICITY

Multiplicity defines how many instances of a class can be associated with one instance of another class. The multiplicity value communicates how many instances can be validly associated with another, at a particular moment.

v ASSOCIATION

Associations represent relationships between instances of classes.

vi CONSTRAINTS

A constraint is a condition imposed on the elements of the model. Constraint is not behaviour, but some other kind of restriction on the design or project. It is also a requirement, but is commonly called “constraint” to emphasise its restrictive influence.

UML uses the brace {} notation to show constraints on the structural model. For example, {Only land valuation system can use the property sale prize}

vii GENERALISATION

Generalisation is the activity of identifying commonality among concepts and defining superclass and subclass relationships. For example, Property and Land Parcel are very similar, both have common attributes as Area, Post Code, Address, but they do have their own attributes as well, so it is useful to generalise them into class hierarchy to ensure that inheritance is possible. The notation is a line between superclass and subclass with an open triangle on the line near superclass.

viii AGGREGATION

Aggregation is another kind of association among objects. Sometimes a class consists of a number of component classes; this special type of relationship is called aggregation. For example, parcels1, parcels2 are part of map (Figure 8-4). The notion in UML is a line that joins a whole to a component, with a black diamond on the line near the whole. The notation of interface is a small circle connected by a line to a class.

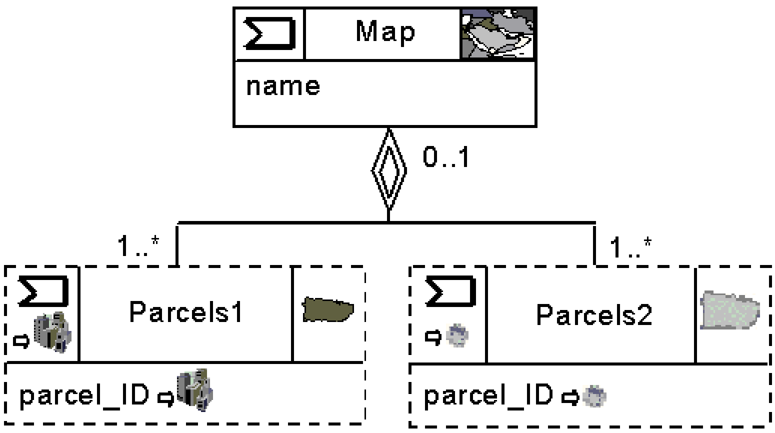


Figure 8-4: A model for aggregation of parcels

UML has quickly become the de-facto standard modelling language in the software industry (Arvanitis and Hamilou 2004). It is appropriate for both new system developments and improvements to existing systems in land administration systems

(Tuladhar 2005). UML models respond well to an incremental development environment such as cadastral databases (Tuladhar 2004). These characteristics identified encourage developers to use UML for cadastral data modelling. However, UML simply acts as a general tool to facilitate designing a data model, and does not provide any specification for designing a data model for land administration system.

A data model in a land administration system has two particular characteristics; one is cadastral information that is spatial data and accordingly should follow the standards in the spatial domain, and secondly they should comply with international land administration principles. The following two sections discuss the requirements for cadastral data models from the Cadastre 2014 view point as a guideline for future land administration and he Open Geospatial Consortium view point as a reference model for spatial industry.

8.2.2 CADASTRE 2014

Development of a cadastral data model to respond to the future needs of land administration requires consideration of the global trends and international activities in this area. Initiatives of the International Federation of Surveyors (FIG) highlight the changing roles of the cadastre (FIG 1995; FIG 1996; FIG 1999; FIG 2002), particularly the Statement on the Cadastre, (FIG, 1995), Cadastre 2014 (FIG, 1998) and the Bathurst Declaration on land administration for sustainable development (FIG, 1999). Cadastre 2014 is the result of the FIG-Commission 7 working group 1 "Vision Cadastre", looking at trends and developing visions for cadastral systems. Cadastre 2014 provides a series of statement and principles such as land objects, legal situation of land, legal independence, and reference system, for the future of the cadastre.

Today, these statements are widely being used by land administration systems worldwide to benchmark their systems. In developing the data model, the cadastre 2014 principles have been adopted and the specifications stated have been embedded. This vision has been investigated as a benchmark to develop the new cadastral data model. Following are the principles of Cadastre 2014 identified as key statements that have impact on the development of the new cadastral data model: land objects, complete legal situation of land, legal independence and reference system.

i LAND OBJECT

According to Cadastre 2014, a land object is a piece of land in which homogeneous conditions exist within its outlines. If a law defines phenomena, rights, or restrictions which are related to a fixed area or point of the surface of the earth, it defines a land object. Examples of land objects are: private property parcels; areas where traditional rights exist; administrative units such as countries, states, districts, and municipalities; zones for the protection of water, nature, noise, pollution; land use zones and areas where the exploitation of natural resources is allowed (Kaufmann and Steudler 1998).

This means that land parcels, the basic building block of land administration, are expected to take more information than they used to. The traditional approach of organising information based on land parcels is fallible (see Chapter Seven), and far from the concept of the land object. The proposed core cadastral data model based on legal property objects should coincide with the land object principle, and is able to respond the future needs of land administration. The legal property object provides a means to organise non-parcel based interests, rights, restrictions, responsibilities and new land related commodities and harnessing them without land parcels.

ii COMPLETE LEGAL SITUATION OF LAND

Statement 1 of Cadastre 2014 emphasises that future land administration should show the complete legal situation of land including public rights and restrictions. The growing world population and the development of new technologies lead to an intensified use of natural resources including land. Consequently, land use planning, environment protection, noise protection, construction laws, protection against danger caused by natural phenomena, and so on, were regulated by public laws (Kaufmann and Steudler 1998).

The boundary definition process of the rights and restrictions defined under public law corresponds to the consent principle because it follows democratic legal rules. However, there is no boundary verification, no title verification, and no registration in an official legal register. Therefore, legal security of public interests can be violated easily.

For that reason, the new model must cover a wider field than the traditional cadastre has since its introduction. To manage the natural resources by restricting the absolute right to use them, creating new interests in land and adding land related complex commodities to current economic use of land, the new model should treat land in a complete legal situation. It will be necessary in future for cadastral data models to consider a mechanism to define and include all private and public law.

iii LEGAL INDEPENDENCE

The principle of legal independence is a key item in the realisation of Cadastre 2014. The principle stipulates that land objects, being subject to the same law and underlying a unique adjudication procedure, have to be arranged in one individual data layer; and for every adjudicative process defined by a certain law, a special data layer for the legal land objects underlying this process has to be created (Kaufmann and Steudler 1998).

Cadastre 2014 is therefore based on a data model, organised according to the legislation for the different legal land objects in a particular country or district. The Cadastre 2014 system is documenting all of these different categories of legal land objects, adjudicated to different rightful claimants, independently but in a common reference system.

The mechanism to present a complete legal situation of land can be achieved only by independently identification of legal situation of land. Laws and regulation that affect the land should be clearly modelled in the new data model.

iv REFERENCE SYSTEM

To make sure that legally independent organised land objects can be combined, compared, and brought into relation to each other, Cadastre 2014 expects that they will be localised in a common reference system. A common reference system is clearly needed when establishing the data model based on the land objects, and more importantly to be able to mange and tie different layers of the land objects.

The concepts of land object, legal independence, the complete legal situation of land and reference systems are in fact the serial requirements of the new cadastral data model. To administer the complete legal situation of land, underlying a reference system is the first step to organise the land objects. Once this is achieved, legal independence can be regulated within the data model.

Cadastre 2014 provides a number of statements for future land administration. As seen, some of the statements specify the technical requirements for cadastral data modelling. However, to fully reflect the cadastre 2014 vision, some additional technical considerations and specifications should be also taken into account, as discussed in the following section.

8.2.3 OGC SPECIFICATIONS

When developing a data model for future land administration, the international technical standards should be taken into account. This consideration in particular helps in compliance of the data model development with the world wide accepted standards.

Within the standards, the specifications of the Open Geospatial Consortium empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications (OGC 2003). The Open Geospatial Consortium, Inc (OGC) is an international industry consortium of companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications. OGC provide a number of specifications which are now widely being used as a reference by geospatial software vendors to support for the interfaces or encodings into their products and services.

It is also worth to mention that OGC provides fast-paced specification development and promotion of standards adoption, similar to other industry standards consortia such as ISO. However, the standards tracks of OGC and ISO are fully coordinated through shared personnel and through various resolutions of ISO TC211 and OGC. They are often complementary and where they overlap, there is no competition, but common action (e.g. in the geometry model). Through OGC's cooperative relationship with ISO, many of OGC's OpenGIS Specifications either have become ISO standards or are on track to become ISO standards (OGC 2003).

Meanwhile, the OpenGIS reference model specification provides a description of the OGC Standards focusing on the relationships between the OpenGIS Specification documents (OGC 2003). This general specification is useful to develop a cadastral data model with a variety of requirements such as reference systems, metadata, geometry, topology and so on. The specification and standards ensure maximum interoperability and consistency in the data model. This will consequently result in a cohesive and coherent cadastral data model. The following sections identify the requirements when developing a cadastral data model based on the OGC specification.

i GEOGRAPHIC FEATURE

The starting point for modelling of spatial information is the concept of geographic feature. A feature is an abstraction of a real world phenomenon. A geographic feature is a feature associated with a location relative to the Earth. The legal property objects mentioned in Chapter Seven, supported by the land object described earlier in Cadastre 2014, is the equivalent of a geographic feature in the cadastral information system. According to the general feature model provided by OGC, a feature may have a number of properties such as locator, metadata, geometry and topology. Consequently, to follow the OGC pathway, the cadastral data model should cover theses properties.

ii LOCATOR

According to the OGC specification, ach geographic feature in a spatial data base requires a locator. Many terms in a cadastral information system refer to locations near the surface of the earth, such as identifiers described in Chapter Seven. Non-spatial identifiers are ambiguous, e.g. addresses, requiring additional information to be resolved into a specific location. However, OGC recommends spatial identifiers. Spatial referencing with identifiers is when the identifier uniquely indicates a location.

Coordinates are unambiguous only when the coordinate reference system to which those coordinates are related has been fully defined. A necessary requirement of a cadastral data model to handle legal property objects is consideration of a referencing system. A coordinate reference system is a coordinate system that has a reference to the Earth. A coordinate reference system consists of a coordinate system and a datum.

iii METADATA

As was discussed in Chapter Three, ICT offers a data cataloguing tool with the spatial metadata at the core. To ensure interoperability among the users of cadastral information, OGC recommends offering a metadata manipulation mechanism. Metadata elements and schema are used by data producers to characterise their geographic data, which in the case of land administration are legal property objects. Metadata enables the use of legal property objects in the most efficient way by knowing its basic characteristics. Metadata facilitates the discovery, retrieval and reuse of objects.

iv GEOMETRY

Geometry in a cadastral information system provides the means for the quantitative description, by means of coordinates and mathematical functions, of the spatial characteristics of legal property objects, including dimension, position, size, shape, and orientation. The mathematical functions used for describing the geometry of legal property objects depend on the type of coordinate reference system used to define the spatial position in the cadastral data model. Geometry is the only aspect of spatial information that changes when the information is transformed from one geodetic reference system or coordinate system to another. OGC recommends treating a legal property object as a combination of a coordinate geometry and a coordinate reference system. According to OGC, the geometry for legal property objects should be a set of geometric points, represented by direct positions. A direct position holds the coordinates for a position within some coordinate reference system.

v TOPOLOGY

To reduce the computational task of cadastral information systems with regard to the relationships among the legal property objects, topology provides information about the connectivity of geometric primitives that can be derived from the underlying geometry. According to the OGC specification, topology in general, deals with the characteristics of geometric figures that remain invariant if the space is deformed elastically and continuously. Within the context of cadastral information, topology is commonly used to describe the connectivity in cadastral fabric, a property that is invariant under continuous transformation of the fabric. OGC proposes that a topological complex consists of collections of topological primitives of all kinds up to the dimension of the complex. Thus, a 2-dimensional complex in a cadastral data model must contain faces, edges, and nodes, while a 1-dimensional complex or graph contains only edges and nodes. Considering global statements in land administration and international spatial standards, Table 8-1 summarises the basic requirements for the development of the new cadastral data model.

Land administration considerations	Spatial standard considerations
Object based Legal independence Complete legal description	Spatial referencing Complete geometrical support Holistic topological relations Spatial Metadata

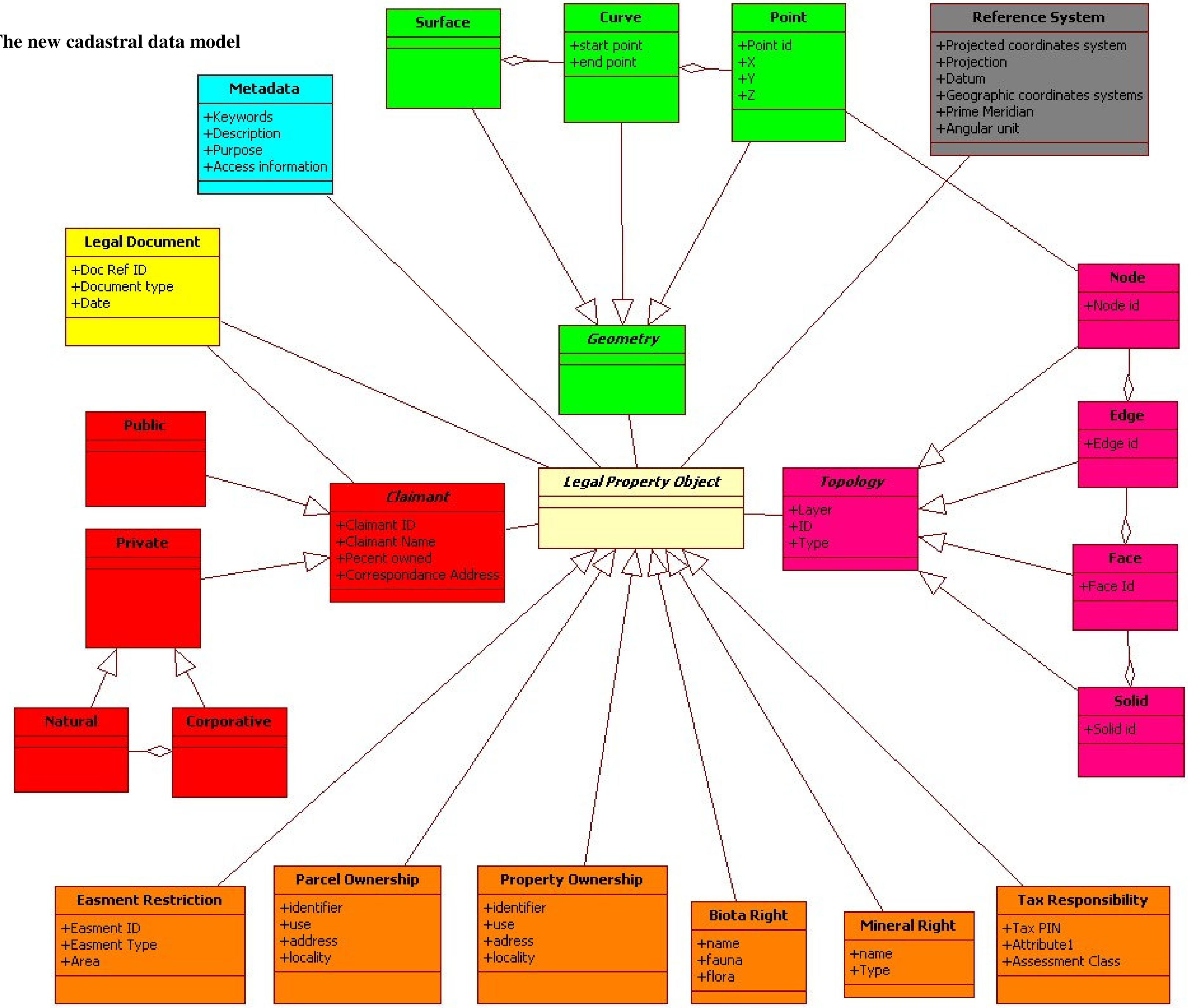
Table 8-1: The basic requirements for the data model development

8.3 THE NEW MODEL: DEVELOPMENT

Having discussed the requirements of a cadastral data model based on Cadastre 2014, OGC specifications and the legal property object concept introduced in previous chapter, seven packages are suggested to develop the new cadastral data model. In Chapter Seven it was revealed that the core data model consists of two main entities; one is the legal property object and the other is the person. These two main entities are described by two packages in the model, the Legal Property Object package (orange) and the Claimant package (red). However, to design the logical data model, five more packages should be added to cover the requirements discussed in section 8.2 as illustrated in Figure 8-5. Different colours represent different packages in the data model.

- Legal Documents (yellow)
- Geometry (green)
- Reference System (grey)
- Topology (purple)
- Metadata (blue)

Figure 8-5: The new cadastral data model



8.3.1 LEGAL PROPERTY OBJECT CLASS

The concept of the legal property object combines the interest and its spatial dimension, and plays the basic building block role for the cadastral information organisation; it was described in Chapter Seven. In parallel to this, it was discussed that Cadastre 2014 also comparatively supports a similar concept called the land object. According to the definitions, a land object is a piece of land in which homogeneous conditions exist within its outlines (Kaufmann and Steudler 1998) while a legal property object is not necessarily a piece of land, but rather is a spatial extent in which an interest exists (Kalantari 2007). It also relates to a physical space on, below or above the earth. The legal property object is a more comprehensive concept for cadastral data modelling. The legal property object is considered as the super class of the new data model.

Therefore, the legal property object super class consists of a set of sub-classes each related to a particular interest in land (Figure 8-6). To provide an effective method of administering interest in land, the practical effect of legal property objects will be that all interests attached to land will be held separately from the land ownership, and the other interests attached to land will be viewable on a title search, putting the world on notice of the interests and complex commodities that flow with that land. The model proposed in this research has picked up the most common interests and complex commodities that currently land administration systems are dealing with. The sub classes are:

- Parcel Ownership
- Property Ownership
- Tax Responsibility
- Biota Right
- Mineral Right
- Easement Restriction

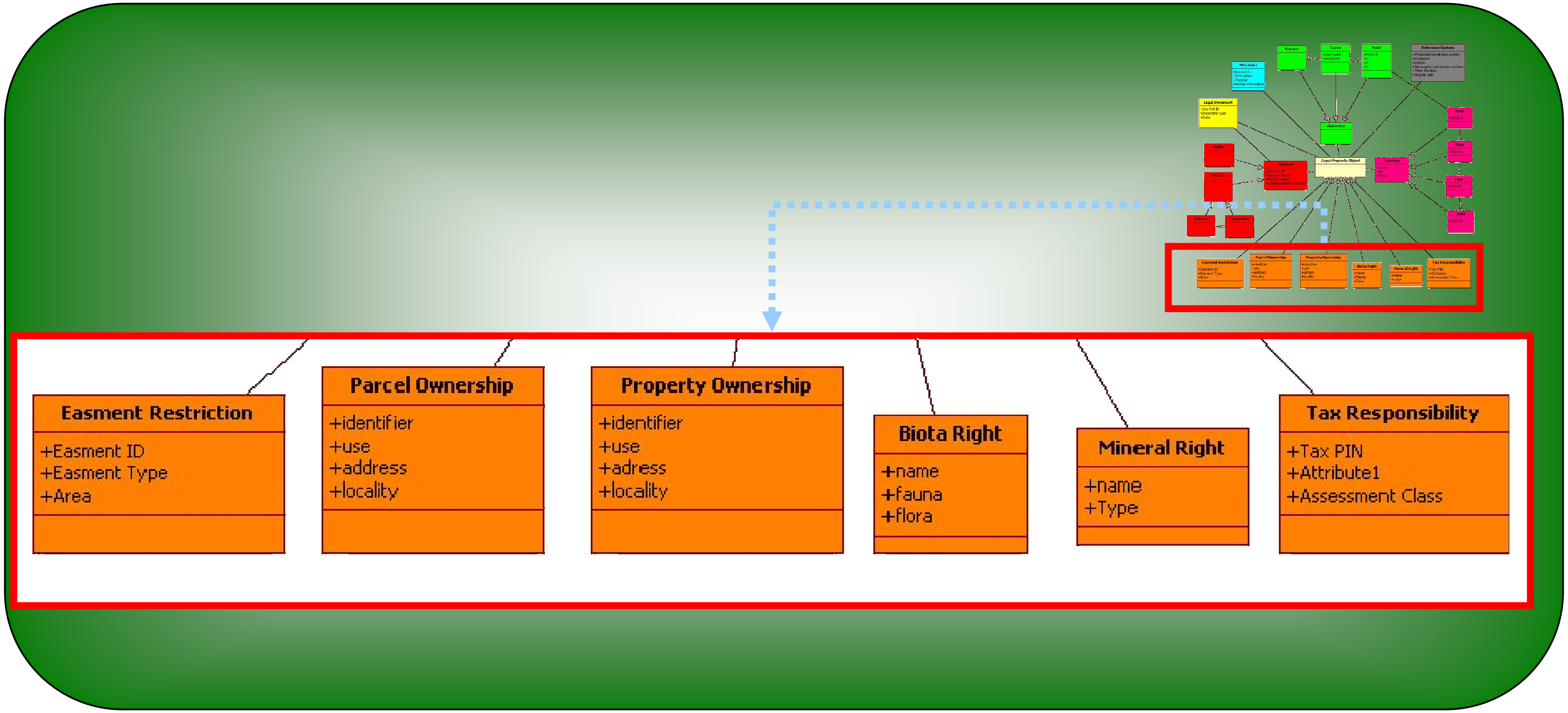


Figure 8-6: The legal property object package

i PARCEL OWNERSHIP

This class defines the spatial dimension of the ownership interest which a claimant has in land. This class has five sample attributes including an identifier, use, address and locality to identify the region it locates. The Parcel Ownership class is represented as a separate layer in the cadastral data model. There will be no interest other than the ownership attached to the parcels in this layer.

ii PROPERTY OWNERSHIP

This class defines the spatial dimension of the ownership interest which a claimant has in a property. Similar to the parcel ownership, this class also contains a number of attributes. Because in some jurisdictions there is a difference between parcels and properties, Property Ownership is considered as a separate layer of information in the cadastral data model. Likewise, as was described for the Parcel Ownership class, there will no interest other than the ownership attached to the parcels in this layer.

iii TAX RESPONSIBILITY

This class defines the aggregated tax responsibility of a claimant in particular spatial dimension. As most land administration systems aggregate the values of separate parcels or properties of land owned by the same claimant, the tax responsibility class will facilitate the taxation and valuation process. In addition, using this method of modelling, where a claimant or related claimants own more than one property or parcel of land, land tax can be straightforwardly determined on the combined value of the jointly owned property.

iv BIOTA RIGHT

This class defines the spatial dimension of the biota right which is associated to rightful claimants. Using this class, the ownership of land or property can be separated from the ownership of biota. For instance, ownership of plants is traditionally attached to ownership of the land; however the issue is more complicated with much other biota. This class can further organise the fauna and flora rights in specific dimension of land.

v MINERAL RIGHTS

This class defines the spatial dimension of the mineral rights which a claimant holds. A claimant may own all of the mineral rights for a specific extent of land or any fraction of the rights. Using this class it will be possible to determine whether a claimant owns rights to only one kind of resource, such as oil and gas, or to only one formation or depth interval. Therefore, the ownership of the mineral rights in a specific extent of land can be determined by using this class.

vi EASEMENT RESTRICTION

This class defines the spatial dimension of the right to use another person's land for a stated purpose. This class can be further classified to sub-classes such as right of way. A right-of-way is a type of easement that gives someone the right to travel across property owned by another person, and restricts the owner. This class can be further divided to more specific restrictions.

This method of organisation of interests in land has a number of advantages. Firstly, it ensures the legal independence of interests by which each responsible organisation can retain their own data while sharing the data at the same time. Secondly, the model is open-ended and scalable, new interests can be added without interfering with current organisation of data. Thirdly, boundaries of all the interests can be presented independently from the land parcel. This means harnessing the interests without relying on the traditional method of creating land parcels. Finally, through creating legal property objects, the complete legal situation of land will be achievable.

8.3.2 CLAIMANT CLASS

Each legal property object is associated with class called the claimant (Figure 8-7). To record the information about the rightful person, the data model uses the claimant super class consisting of two sub-classes: public and private. This association carries a many to many multiplicity. This class therefore presents an inclusive method of bringing together traditionally separated public and private interests in land.

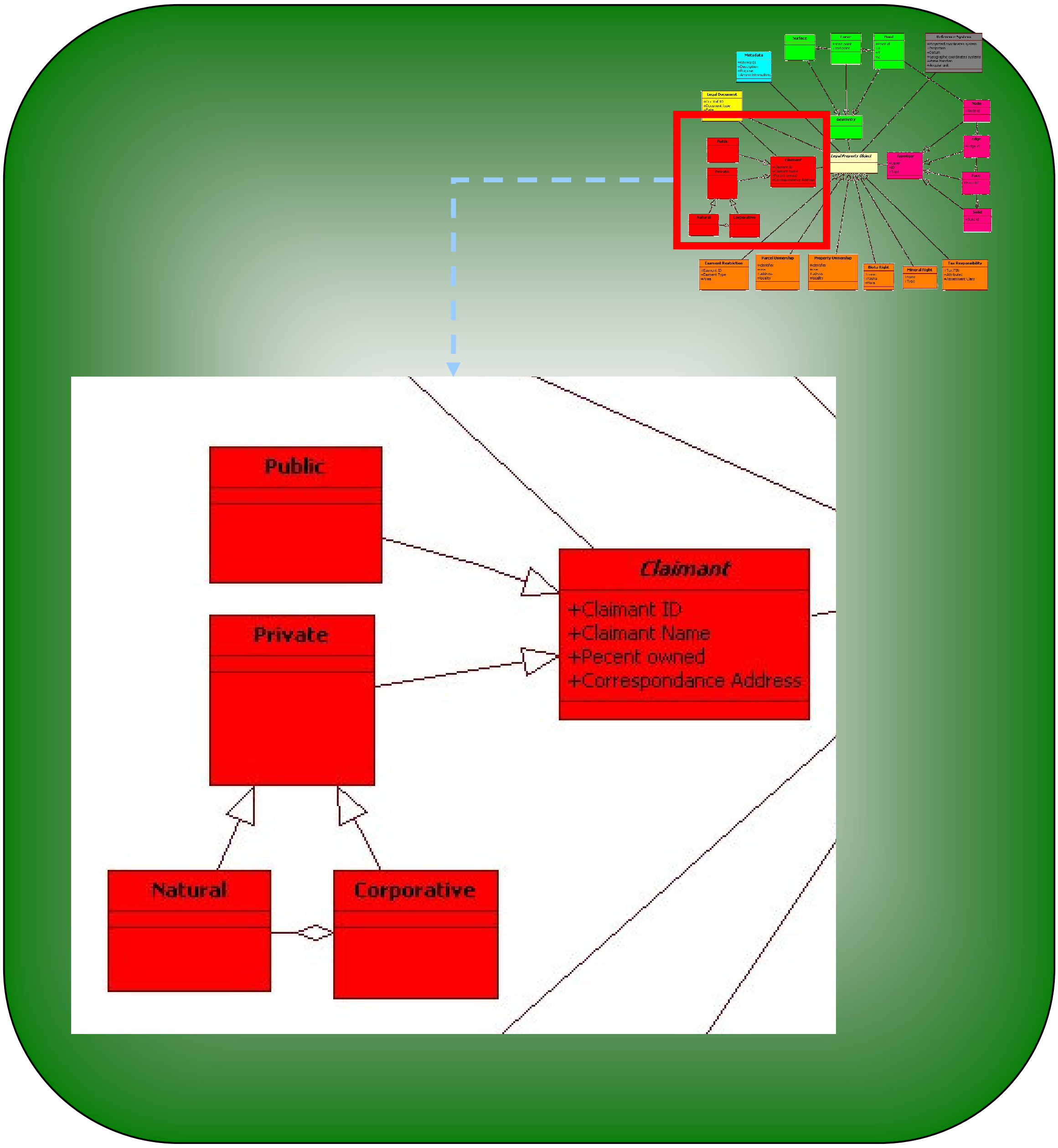


Figure 8-7: The claimant package

Moreover, unlike the traditional practice, using this class the registration system can exclude unlawful claimants in a legal property object by combining it to different legal property objects (Figure 8-8). The private class itself is also divided up into natural and non-natural claimants. This method of modelling will explicitly improve securing people’s interest in land by a holistic administering of relationships involving people.

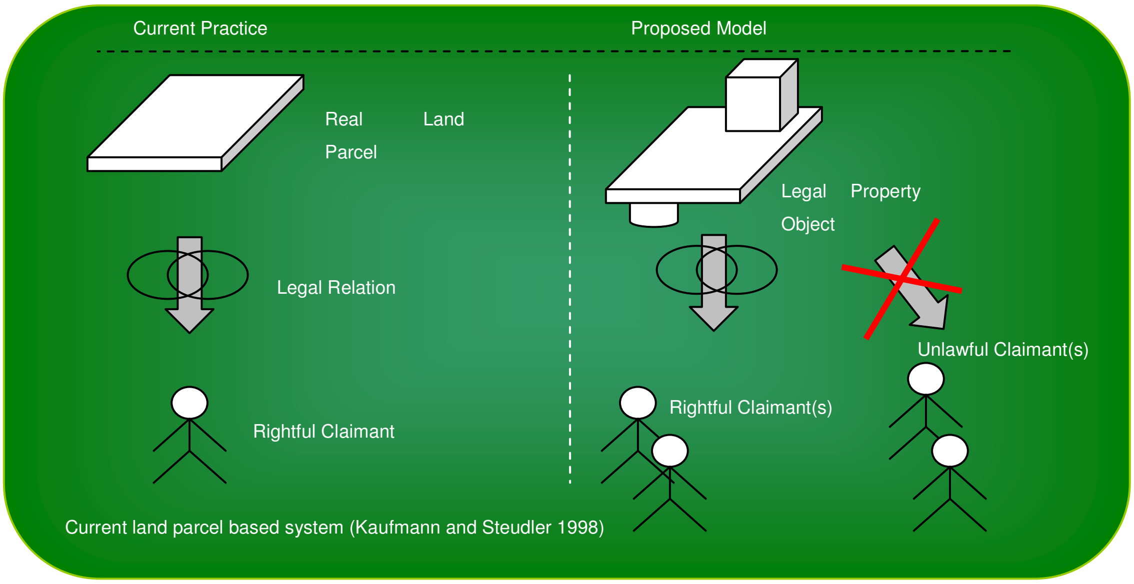


Figure 8-8: Public and private interests in land- comparing the traditional and new methods

8.3.3 REFERENCE SYSTEM CLASS

The legal property object class in the data model is associated with the reference system class. In fact, the referencing system is the most important linking element in the model. The new model therefore, provides for the coordinates of all legal property objects to be linked via a common reference system (Figure 8-9).

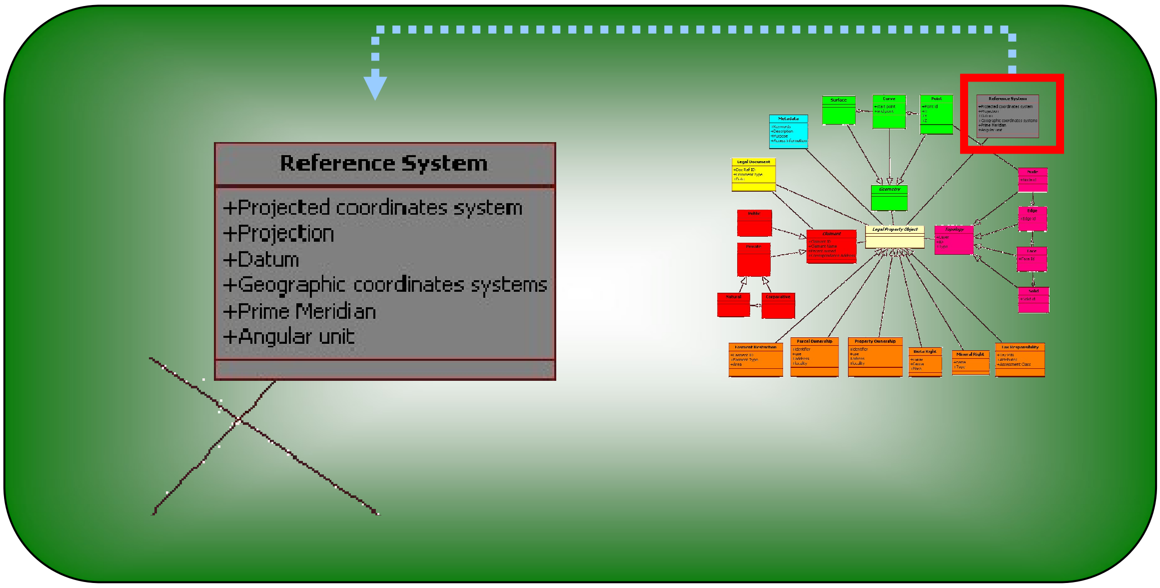


Figure 8-9: The reference system class

The spatial reference class provides a combination of an ellipsoid, a datum using that ellipsoid, and either a geocentric, geographic or projection coordinate system. The projection also always has a geographic coordinate system associated with it. This in particular facilitates the transformation of the data at state and national levels, where it may need different datum, projection or coordinate systems.

A spatial referencing system for legal property objects also facilitates an accurate boundary identification for non- ownership rights, restrictions and responsibilities. More importantly, this class provides a facility for the institutional data exchange process between those responsible, and optimises the interoperability among organisations.

8.3.4 GEOMETRY CLASS

The geometry package contains spatial classes providing the geometric representation of the legal property object instances. In this model, the geometry package is a set of geometric points, represented by direct position. A direct position holds the coordinates for a position within the spatial reference system defined in the model (Figure 8-10).

Combining the positions in the point class of the geometry package, curves are created to define the boundaries of legal property objects. Having a curve class instead of a line class provides more flexibility and accuracy while presenting the legal property objects. A curve class in fact is an aggregation class of the point class.

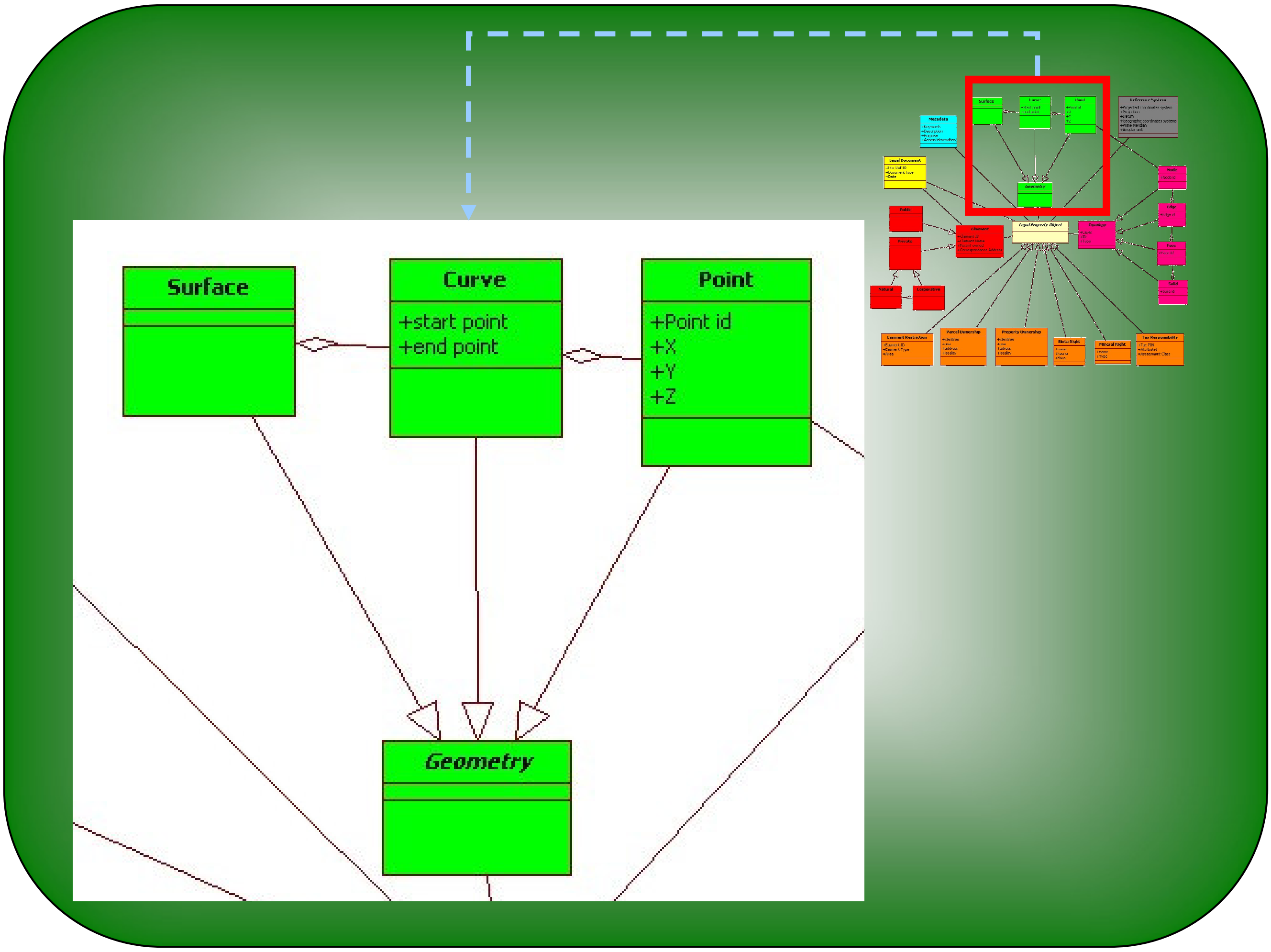


Figure 8-10: The geometry class

Aggregating the generated curves in the curve classes will result in legal property object surfaces. This method of aggregating from points to a curve and then from curves to a surface will reduce data redundancy while storing legal property objects in the cadastral database. Moreover, it will facilitate the creation of required relations among legal property objects.

To determine spatial relationships between legal property objects the aggregation method used in this model is helpful. For example, one might want to determine which water right extent overlaps with a particular property ownership. The curves defining the water right extent are a set of points, and it can be determined whether any of the points fall inside the surface of the land parcel.

8.3.5 TOPOLOGY CLASS

The topology package is the pre-computed geometry of the legal property object (Figure 8-11). It facilitates the efficient computation of geometric queries. The most productive use of this package is therefore to accelerate computational geometry. For example, when the dimension of one legal property object, such as an owned land parcel, is changed, the neighbouring legal property object will be affected. Another advantage is related to update consistency. Object sharing makes maintenance for consistency and updates easier. The topological relationship can quickly find neighbouring legal property objects.

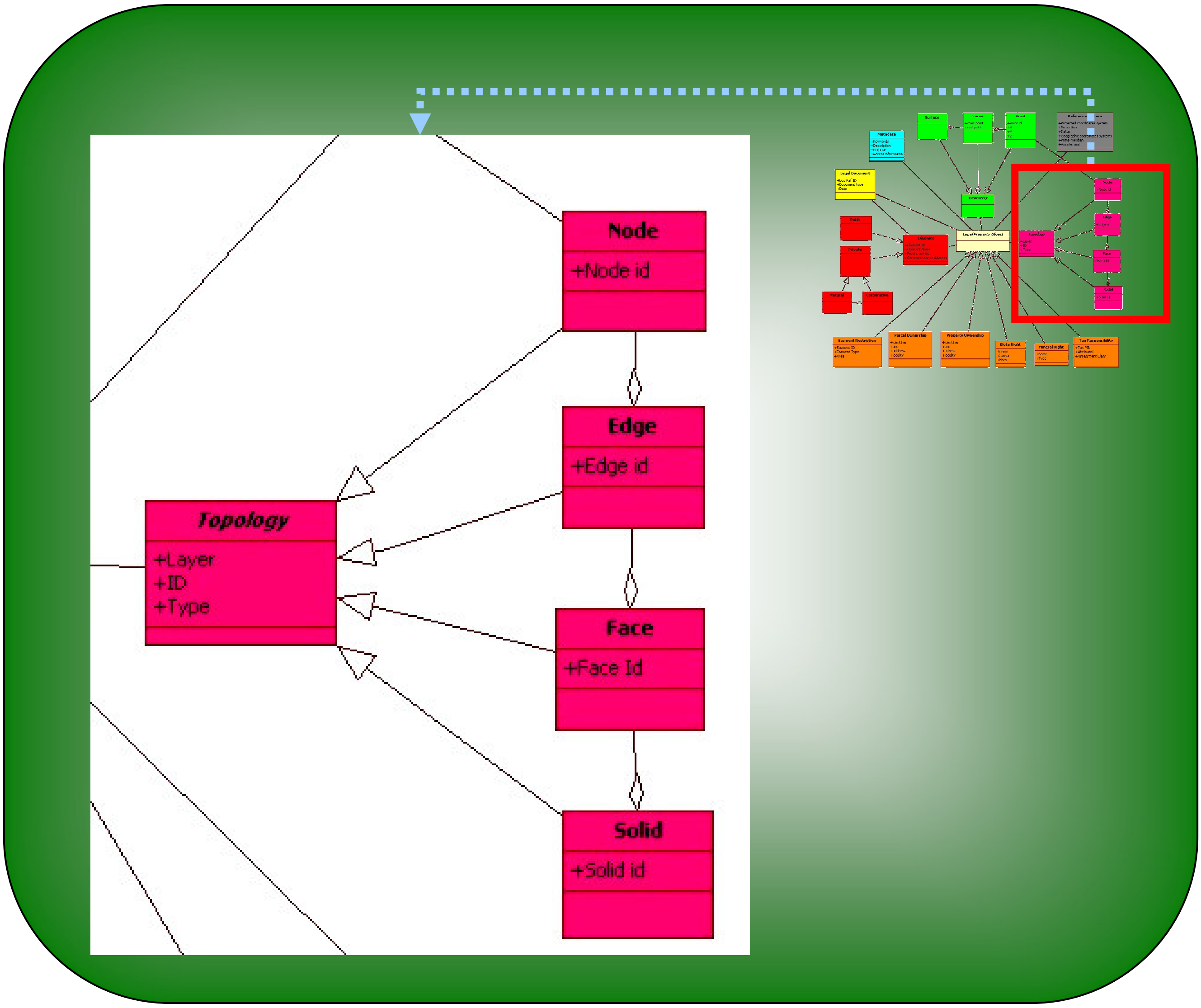


Figure 8-11: The topology package

This package consists of topological primitives of one, two and three dimensional complexes to create relationships between features. Every node in the node class of the topology class is referred to a point in the point class of the geometry package. The edge class is the aggregation of the node class. Faces in topology are created from the edges.

To deliver vertical integrity the topology package supports the solid package. This package enables the ability to relate legal property objects from one data set with legal property objects from another. Practical instances include utilities overlaying their facilities (gas lines, water pipes, electricity cable runs, etc) over a property base. When the solid class delivers highly accurate spatial identifiers for legal property objects, the replication alignment between the two legal property objects and the maintenance process can be streamlined.

8.3.6 METADATA

The metadata package is intended to be used by land administration analysts, program planners, developers and clients in order to understand basic principles and overall requirements of legal property objects. It is a service to describe the whole package. Metadata is one of the requirements of an e-land administration system as described in Chapter Two (Figure 8-12).

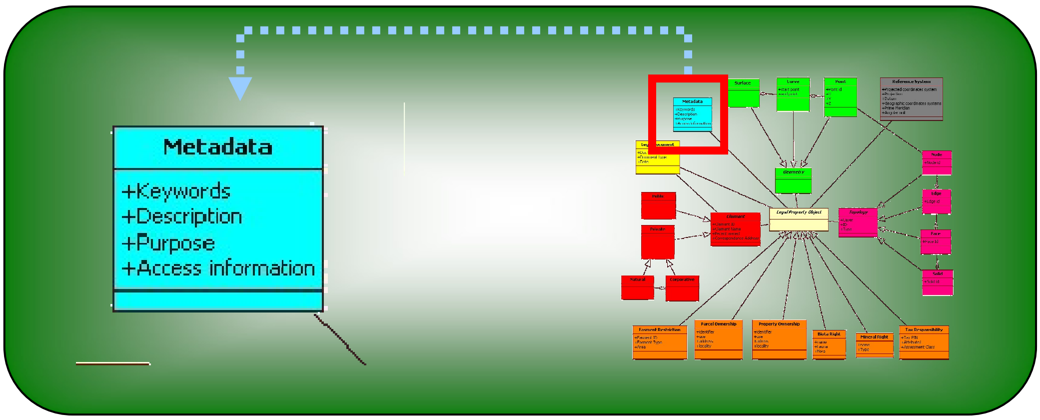


Figure 8-12: The metadata class

8.3.7 LEGAL DOCUMENTS CLASS

A legal document stated in this model certifies the interests to be granted to a rightful claimant. A very common legal document would be a land ownership title. The legal document class in fact has an external functionality by providing an evidence of legal property object for a rightful claimant to a third party. Each legal document is the description of a legal property object and associated rightful claimants (Figure 8-13).

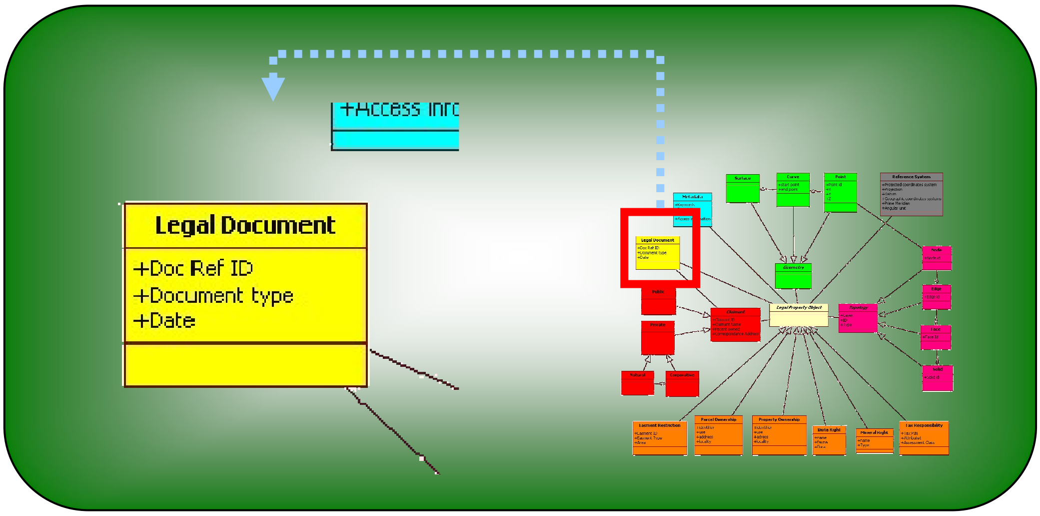


Figure 8-13: Legal document class

8.4 THE NEW DATA MODEL: IMPLEMENTATION

The key to implementing the proposed data model based on its component the legal property object is the use of spatial identifiers to regulate relationships among the objects. Introduction of the data model based on legal property objects and use of spatial identifiers in the model requires far-reaching change in cadastral information systems. The aim of developing the prototype system is to examine the possibility of regulating legal property objects using spatial identifiers. By this regulation it will be possible to create relationships between the legal property objects without relying on non-spatial identifiers.

Firstly, for putting the new data model into the prototype system, the Arc Info UML model template diagram is used to implant the legal property object model. The Arc Info UML model contains the relevant parts of the geometry, topology and spatial referencing system components needed for the creation of legal property objects. The Arc Info UML model has four packages: Logical View, ESRI Classes, ESRI Interfaces, and Workspace. These packages act as directories where different parts of the entire data model are maintained. The Logical View package is the root level and contains the other three packages (Figure 8-14).

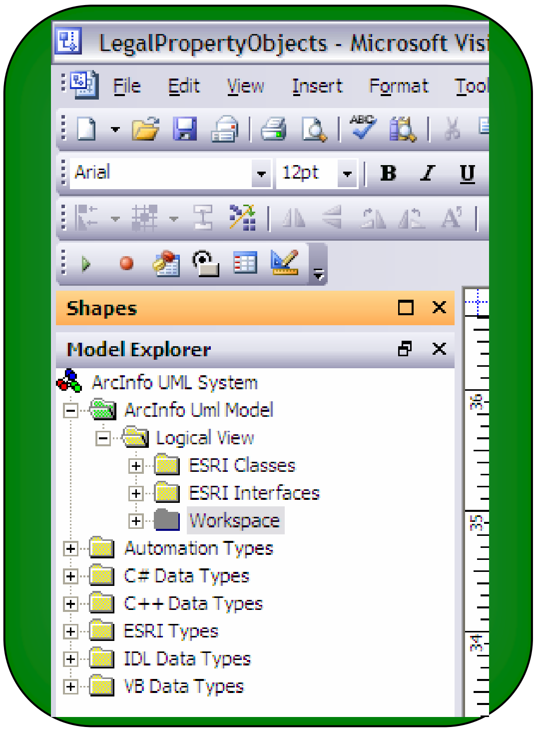


Figure 8-14: Packages in the Arc/Info data model

The Workspace package represents the place that the new data model should be developed. Under it all legal property objects can be created. To hold the legal property objects classes, a legal property package is created under the "LandInformation" package inside the workspace package (Figure 8-15).

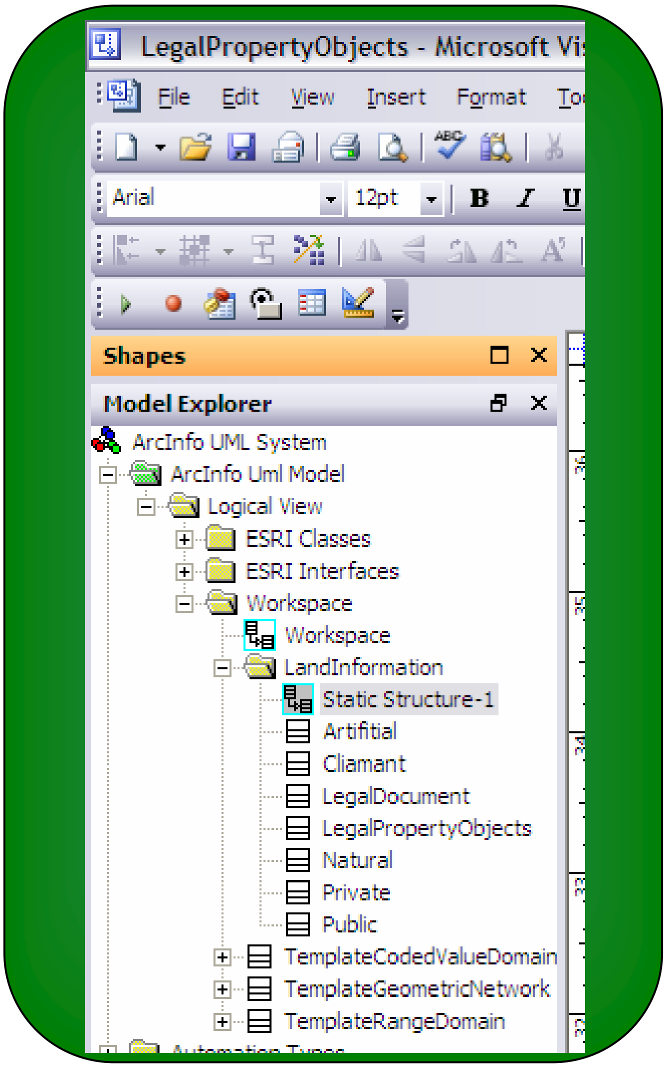


Figure 8-15: Classes under the workspace package

Secondly, to regulate the relationship between legal property objects, series of code need to be generated. To do, the CASE tool was initially used to convert the data model into a format that is understood by the computer system. After this conversion, the classes in the data model will be represented by COM classes in the system.

Component Object Model (COM) is the name of a family of Microsoft technologies that enable software components to communicate. These COM classes provide services through interfaces. Figure 8-1 illustrates the architecture of a prototype system based on the COM technology. It can be seen that the relationships among the legal property objects are regulated through the COM technology. Each legal property object is represented by a COM class that may implement a number of interfaces. These interfaces are used to generate the necessary coding for regulating the relationship between legal property objects. Each interface may represent a particular relation between legal property object. For instance, using the interface IEasment, the system asks the Easement Class (as a legal property object) to perform a task using a pre-created method.

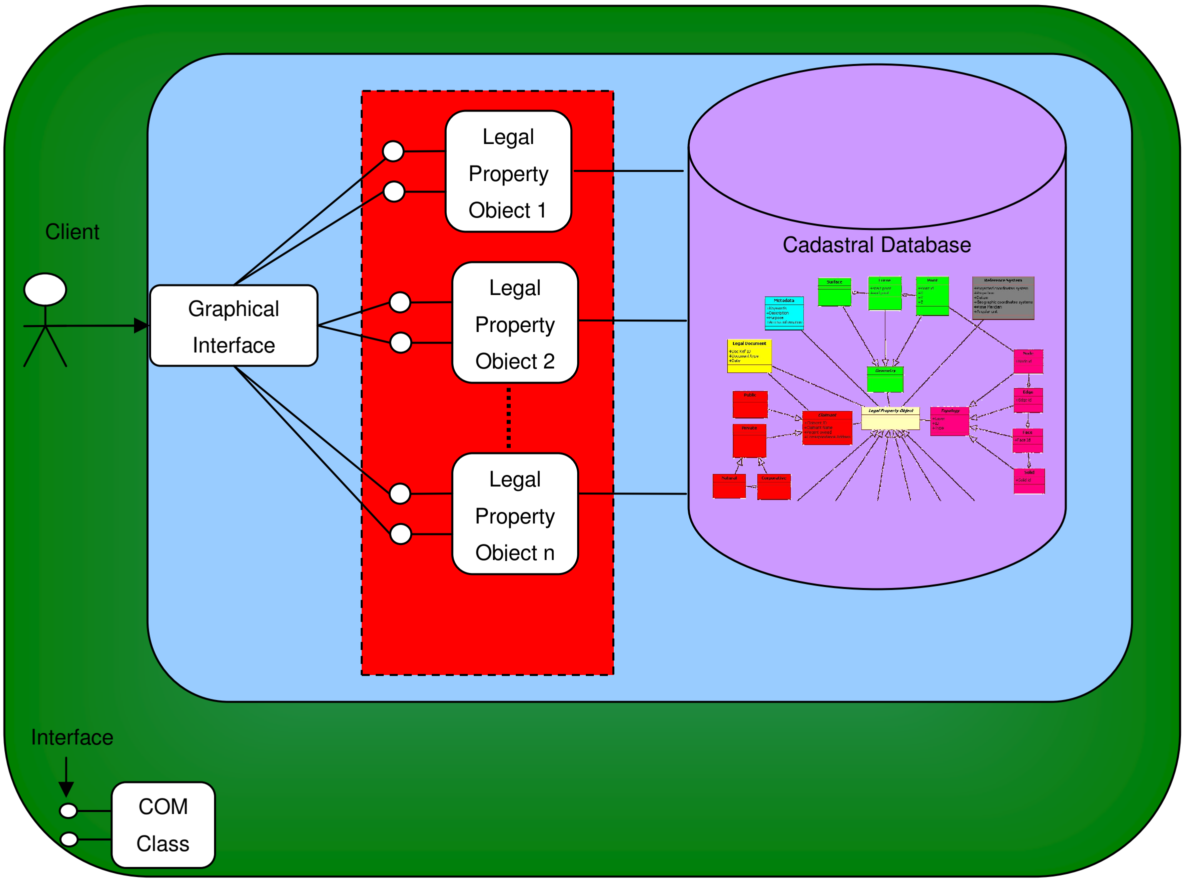


Figure 8-16: The architecture of the cadastral information system based on the new data model

The detailed implementation steps are presented below. There are six major steps involved in the algorithm of implementing the new data model as illustrated in Figure 8-17:

- Creating legal property object classes
- Creating the foundation for regulating relationships between legal property objects
- Creating necessary constraints for legal property objects
- Exporting UML model to an interface format
- Generating the database
- Generating necessary codes

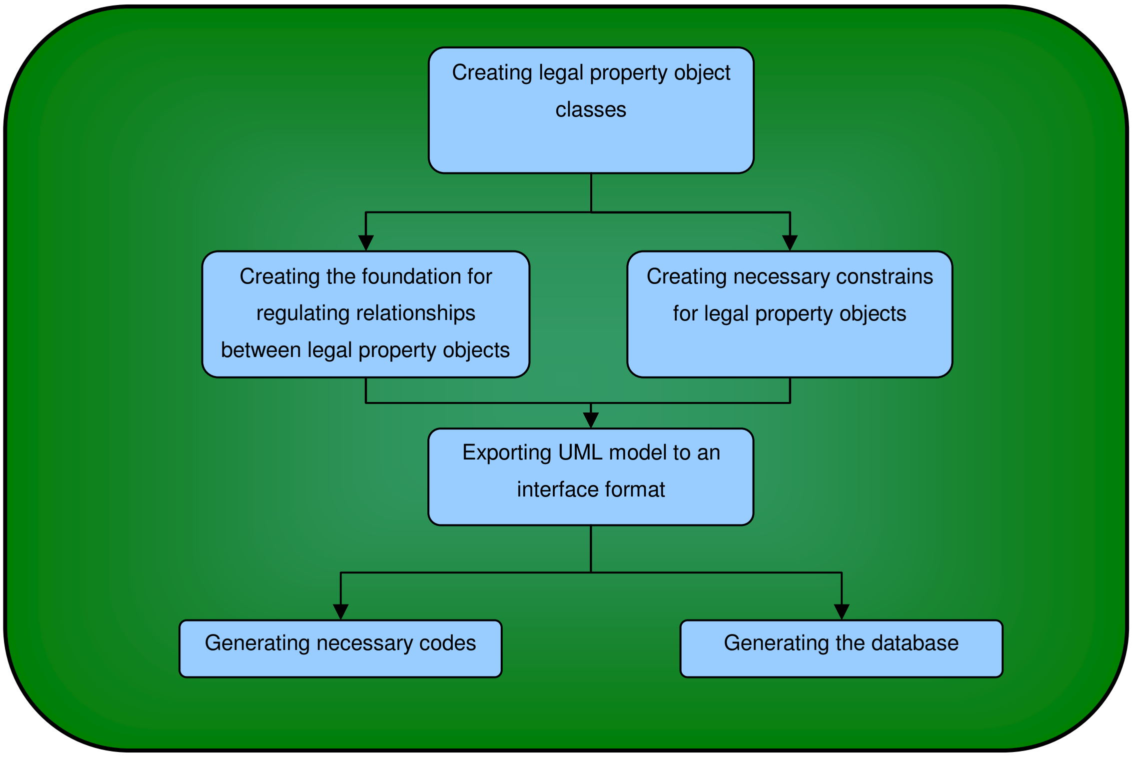


Figure 8-17: The implementation algorithm

i STEP 1: CREATING LEGAL PROPERTY OBJECT CLASSES

Each legal property object is represented by a UML Class diagram in the data model. Parcel Ownership, Property Ownership and Easement Restriction are shown as sample legal property objects created in the model. Once each class is created, the properties of the newly created class are set (Figure 8-18). For instance, the Parcel Class has the parcel value attribute, or the Easement Class has Easement ID and Easement Type as attributes.

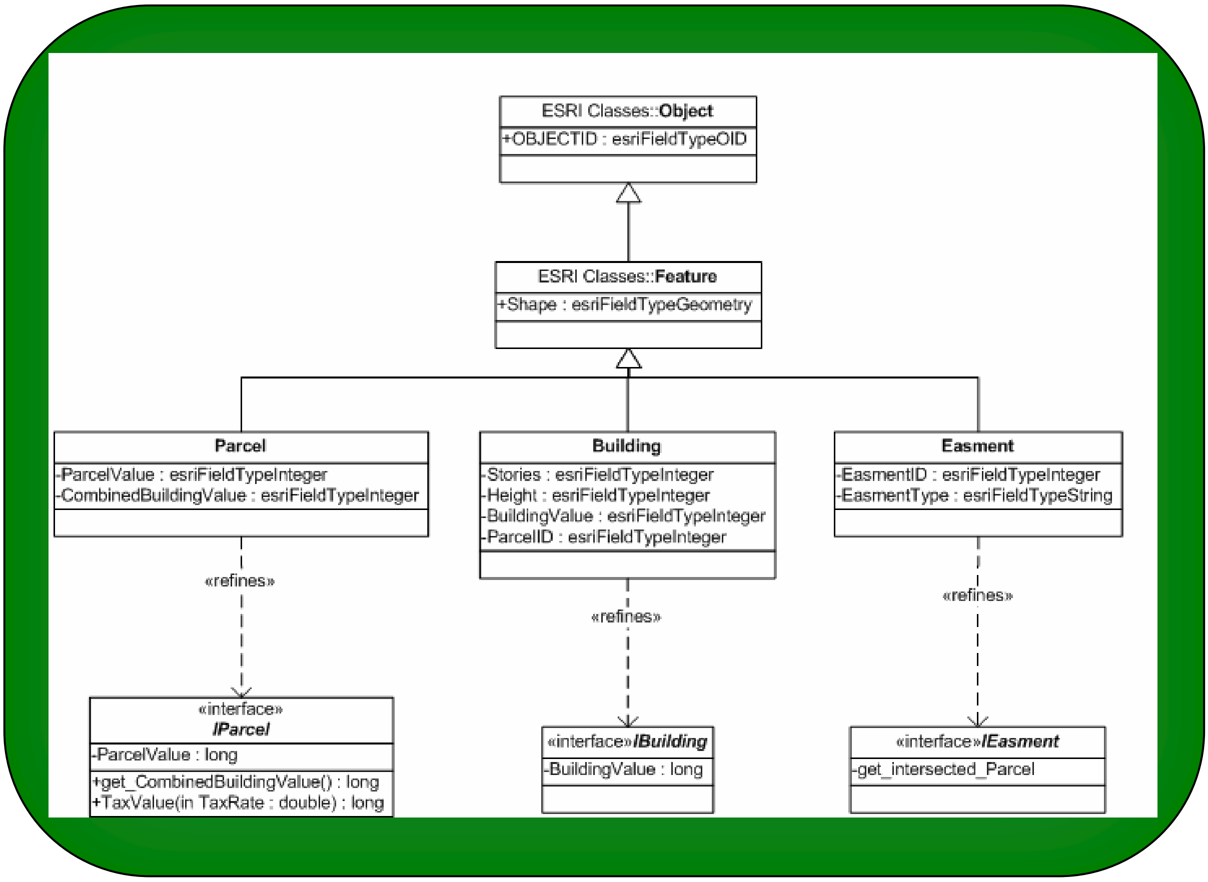


Figure 8-18: Legal property objects as Features

Having set the properties, legal property objects will then behave like features because they will implement all the interfaces implemented by Feature in ESRI package. However, the prototype system requires extra relationships to be defined among legal property objects, for instance an application may require finding whether an ownership right is limited by the restrictions applicable to an extent of land. In that case it would be more efficient to provide the service through a pre-defined mechanism.

ii STEP 2: CREATING THE FOUNDATION FOR REGULATING RELATIONSHIPS BETWEEN LEGAL PROPERTY OBJECTS

The second step to implement the data model in the prototype system is to develop the pre-defined interfaces for legal property objects. The interfaces will provide a convenient way to add extra functionalities. These interfaces in particular are helpful to regulate the relationships between legal property objects. To add functionalities to the model, the operations are used. An operation is a service that an instance of a class may be requested to perform. The behaviour of a class is represented by a set of operations.

Each operation has a name and a list of arguments and parameters. A parameter is an unbound variable that can be changed, passed, or returned. A parameter may include a name, type, and direction of communication. Parameters are used to specify operations, messages, events, templates, and more. For instance in the developed model, IEasment has the get_intersected_Parcel operation. (Figure 8-19).

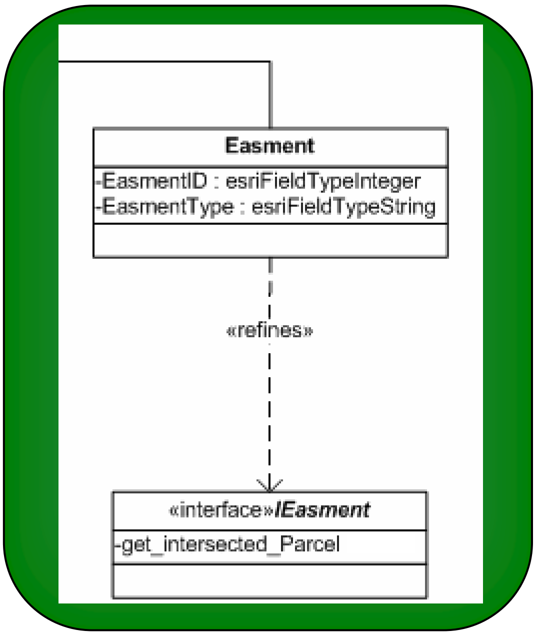


Figure 8-19: Creating interfaces for extra functionalities

iii STEP 3: CREATING NECESSARY CONSTRAINTS FOR LEGAL PROPERTY OBJECTS

To control the relationships between the created classes, the class extension approach has been utilised. The class extension is a COM class that implements behaviour pertaining the whole set of legal property objects in the data model, in contrast to behaviour that belongs to a singular feature. Class extensions are created in the same way that legal property objects are created. For instance, the PropertyOwnership class extension will contain the code for a custom validation rule. This validation rule, for instance, specifies that a property ownership right can exist in the extent of only one land parcel ownership (Figure 8-20).

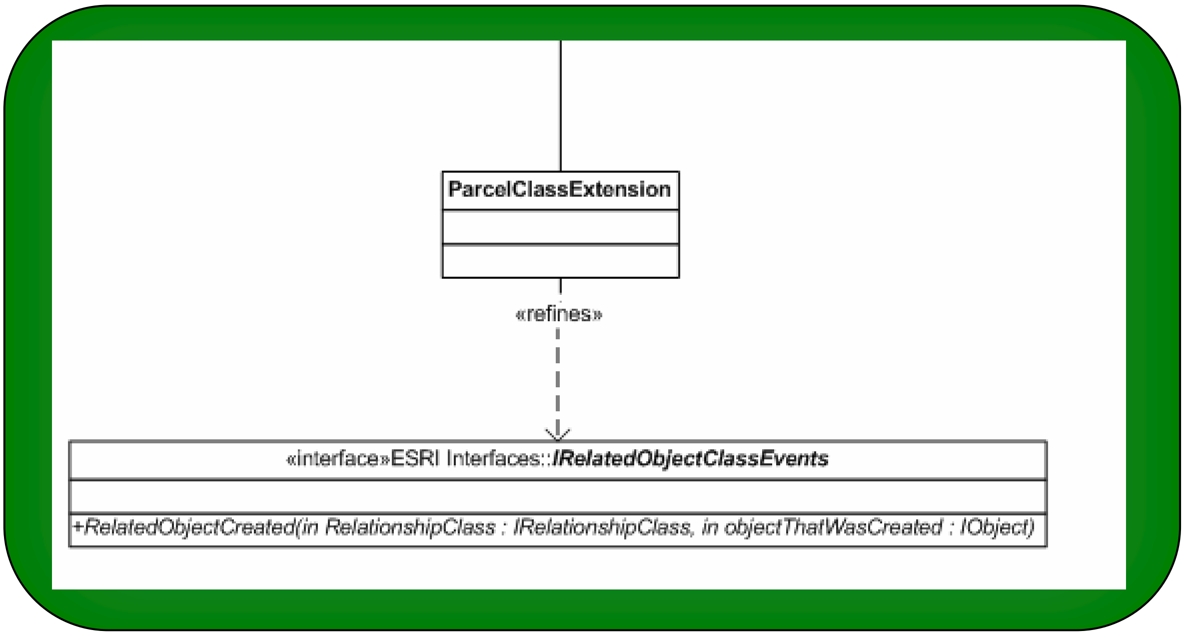


Figure 8-20: Creating constraints for the legal property object using class extensions

iv STEP 4: EXPORTING THE UML MODEL TO AN INTERFACE FORMAT

In this step, the whole model including the legal property objects and interfaces is exported to an interface format such as XMI (XML file format). As a result of this step, the data model, including the legal property objects and interfaces for adding extra functionalities is exported to the Microsoft Repository (Figure 8-21). The Microsoft Repository is an object-oriented repository that includes a set of interfaces that a developer can use to define data models, and a repository engine that is the underlying storage mechanism for these data models.

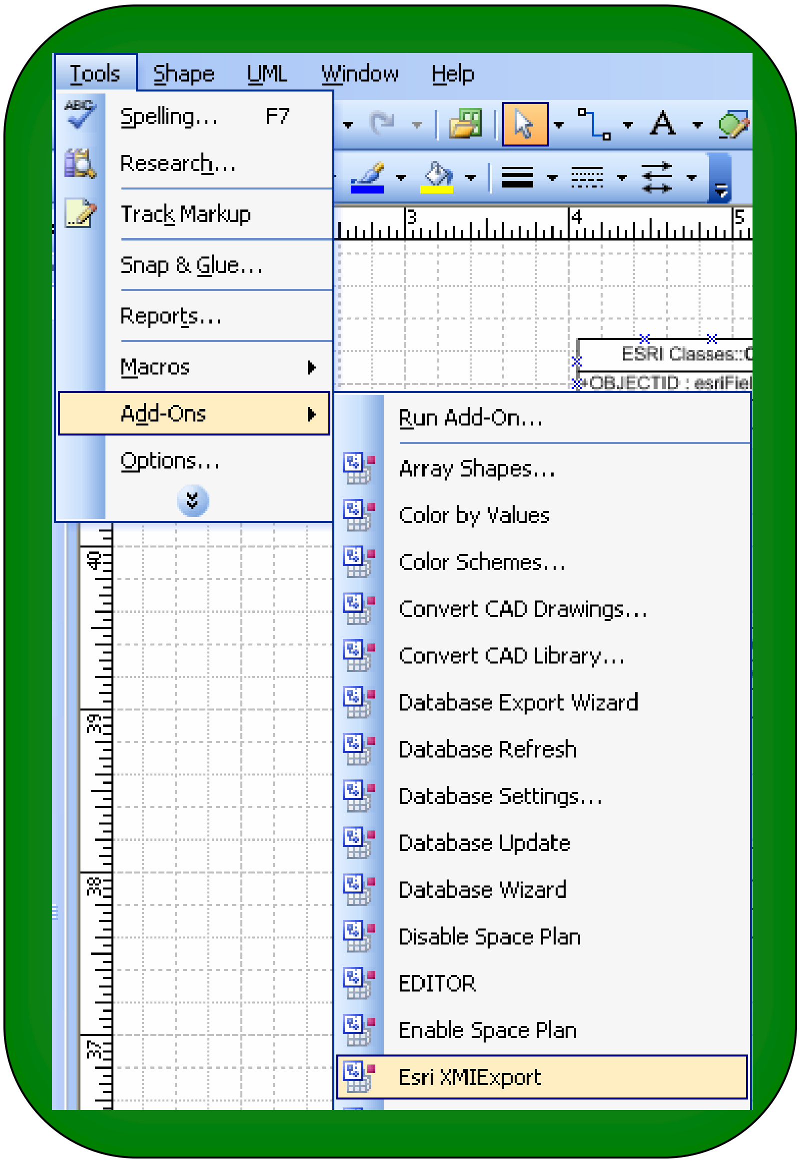


Figure 8-21: Exporting the data model to an XML file format

v STEP 5: GENERATING THE DATABASE

The fifth step of the model implementation is to create a schema for the UML model in a database, the database used in the prototype system is Geodatabase. Using the schema wizard in Arc GIS environment, a table is created for each UML class in the model. For each UML attribute in the class, a field in the table is created (Figure 8-22). As the schema wizard looks for the COM classes in the system's registry, it is necessary to register the classes beforehand.

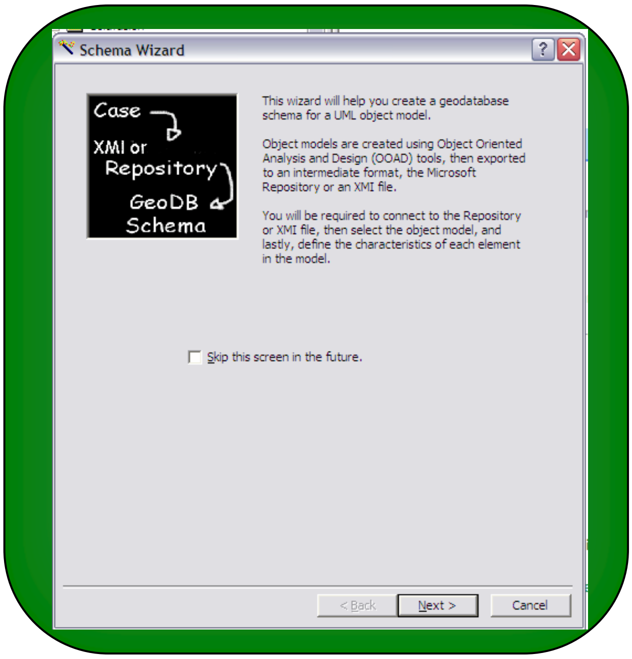


Figure 8-22: Creating database

vi STEP 6: GENERATING NECESSARY CODES

The sixth step of the model implementation is the creation of the code for the legal property object. Upon compilation of the code, a dynamic link library (DLL) with COM classes will be created. Legal property objects in the model selected for code generation will become COM classes in the DLL, along with a COM class for the associated class extension. Now, each legal property object will be modified in order to include specific behaviour. The behaviour that is important for the prototype system is the relationships between two layers of legal property objects. To create a relationship between two independent legal property objects from different layers, the code takes the geometry of one instance of a legal property object layer and, using the spatial reference class searches for the possible legal property object instances from the other desired legal property objects underneath.

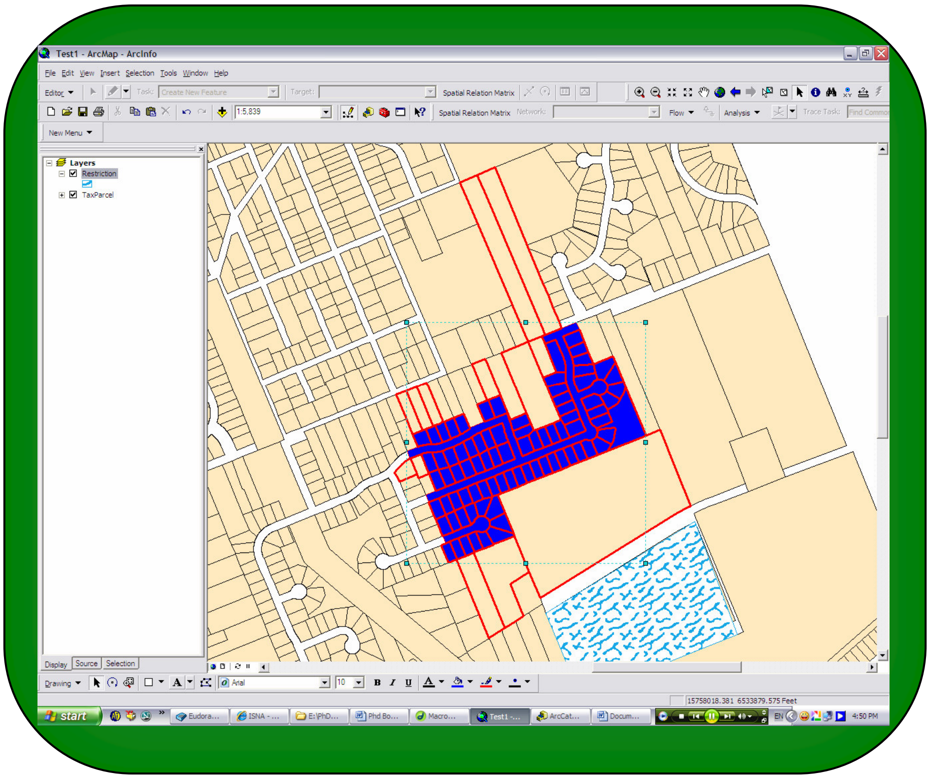


Figure 8-23: The prototype system

Figure 8-23 illustrates the result of the relationship implementation in the prototype system. The prototype system uses the geometry and topology class to select legal property objects based on intersections between the inner, outside, an edge of a selected legal property object (Land Parcel Ownership) and the members of the other legal property object (Covenant Restriction) class. If any legal property object is found, a vertical relationship is then determined between them. In the illustrated example, 96 Land Parcel Ownerships with total area of 2888094.621004 are affected by the restriction described below (Table 8-2):

Description	Value
Restriction ID	7
Restriction Type	Restrictive Covenant
Restriction Description	No boats on the lot
Restriction Agency	CONDO association
Restriction Area	1266276.5622
Total Area Affected	2888094.621004

Table 8-2: The result of prototype system implementation

As was observed in the model implementation, the spatial referencing system and spatial identifiers play a critical role in regulating relationships between legal property objects. The prototype system implementation showed that the traditional non-spatial identifiers can be replaced by spatial identifiers. The prototype system employed the COM technology to create the spatial relationship between legal property objects.

The new cadastral data model was implemented in the prototype system. The new model is capable of incorporating the ever growing number of interests in land. Also the implementation demonstrated that the use of spatial identifiers is possible in cadastres however the system architecture requires sophisticated technologies.

The next section presents an assessment of the new model. The assessment uses the requirements of future land administration systems to determine whether the new model is able to respond to its needs or not.

8.5 THE NEW DATA MODEL: ASSESSMENT

Future land administration will involve the processes of contributing to sustainable development as a primary aim, and also helping with good governance, service to business and enhancement of quality of life through land tenure, land value, land use and land development functions. Such a system has its own technical requirements as described in Chapter Two. Therefore, this new data model is evaluated against these requirements to see how it is able to respond to the needs of future land administration.

According to the discussion presented in Chapter Two, the requirements of a future land administration system are: to be object based, to include broader independence interests in land, being spatially enabled and more importantly interoperable.

8.5.1 OBJECT BASED

An object based method of organising the ever-growing number of public and private interests in land is inevitable in future land administration systems. The model developed and implemented in this research showed that the legal property based organising land and cadastral information is a comprehensive method for putting the increasing number of interests in land in order. The legal property object showed itself as a trustworthy means of organising interests as they do not necessarily coincide with the exiting land parcels in cadastral databases.

8.5.2 BROADER INDEPENDENT INTERESTS (PUBLIC AND PRIVATE)

As was seen in the case studies, many organisations, government and non government bodies are involved in the production and utilisation of land information. The increasing number of interests in land will not necessarily be retained by a single agency. This means that each agency expects that the maintenance of the associated interest in land is reserved for it. Land information therefore should be organised independently in cadastral and land information systems. Assigning each interest to a legal property object layer will help to maintain interests in land independently from each other.

8.5.3 SPATIALLY ENABLED E-LAND ADMINISTRATION

e-Land administration was defined as an interoperable environment to facilitate information sharing and better service delivery in land administration. Spatial identifiers employed in the new data model positively improve interoperability as non-spatial identifiers employed in the current data models are fallible entities for the integration of different layers of interests. Therefore, using spatial identifiers will facilitate interoperability and provide an efficient environment for e-land administration and its components to share land information. Information sharing will become more and more demanding while many businesses in future expect e-land administration to assist them by providing information available to and interoperable with their information system. The key for interoperability is spatial enablement, or using spatial identifiers instead of traditional non-spatial identifiers in the new data model.

The model developed and implemented in this research is a scalable, open ended model for organising the increasing number of interests in land. Inclusion of non- parcel based interests via the legal property objects along with incorporating public and private interest leads to having a comprehensive and holistic legal situation of land. To respond the increasing number of end users of land information, the new data model supports organizing the interests in land independently. Finally, via spatial enablement, the data model facilitates interoperability in land administration systems.

8.6 CHAPTER SUMMARY

This chapter put the idea of replacing land parcels with legal property objects into practice. The proposed core data model in Chapter Seven was developed based on the requirements of the international specifications in spatial domain and global statements in land administration. The model was then implemented in the ArcGIS environment assisted by extra coding using Visual C++ and Visual Basic. The key to implementing the proposed data model is the use of spatial identifiers to regulate relationships among the legal property objects. After implementation, in order to evaluate the data model, it was assessed against the requirements of the future land administration system which were described in Chapter Two. The assessment confirms that the new model is capable of responding to the needs of future land administration.

CHAPTER 9 - CONCLUSIONS AND RECOMMENDATIONS

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

Administration of land is challenged by the increasing need of clients for land information, and by the creation of new land related commodities and interests. This research confirmed that existing administration systems, including the latest ICT enabled systems, are not sufficiently flexible to accommodate these new interests and commodities. Nor do they respond to the needs of end users. This research was conceptualised and designed in order to address the issue above.

9.2 RESEARCH AIM AND OBJECTIVES

As detailed in Chapter One, the central aim of this dissertation was to

"Develop a cadastral data model that will both incorporate a broader range of interests and new commodities in land information systems and facilitate interoperability within various organisations and end users."

In Chapters Six, Seven and Eight, a new cadastral data model was conceptualised and developed through the integration of the results from the case studies of interoperability, data models and data types employed in land administration systems in three states of Australia, in Netherlands, Switzerland and USA.

A Structured System Analysis and Design Method was utilised to study three Australian land administration systems. This methodology provided a number of advantages, including the ability to investigate interoperability in land administration systems and its association with cadastral data models.

The non-Australian case studies and their comparison with the Australian case studies in particular provided better understanding of the data types employed in land administration and their organisation in current cadastral data models. To summarise the case studies, current core cadastral data models were challenged by an increasing number of interests because of the concentration on the parcel based method of organising interest in land, and the lack of interoperability because of the employment of non-spatial identifiers.

The research proposed that the data model based on the physical land parcel be replaced by a spatially-referenced data model based on the legal property object. The proposed data model is more comprehensive, capable of organising a wider range of interests, and should facilitate wider exchange of information. The legal property object is open-ended and can include complex commodities and all kinds of rights, restrictions and responsibilities. Spatially referencing these objects facilitates interoperability in land administration system.

The proposed data model was successfully developed and implemented with reference to the requirements of the international specifications in spatial domain and global statements in land administration. The model then was assessed against future land administration and effectively responded to its requirements.

The objectives of the research aim will now be reviewed and discussed.

9.2.1 OBJECTIVE 1: TO STUDY AND IDENTIFY THE REQUIREMENTS OF FUTURE LAND ADMINISTRATION

Chapter One discussed that land administration systems are faced with changes, and are now expected to contribute not only to the sustainable development of a society, but also to good governance, enhancement of quality of life, and service to business. The changing role of land administration influences their technical characteristics. Subsequently, the outcome of Objective 1 highlighted a number of issues associated with these characteristics. Firstly, as the need for communication, data exchange, and data sharing become of interest in future land administration systems, interoperability becomes a serious issue as most land administration activities have so far been developed and computerised in isolation. Secondly, land administration systems are trying to manage new commodities and interests in land through the traditional basic building block: land parcels. However, land parcels can be criticised as they seem not be sufficiently flexible objects to accommodate or support the growing number of complex commodities and interests in land. Undertaking Objective 1, these findings had a significant impact on the way that research methodology was designed and developed.

9.2.2 OBJECTIVE 2: TO IDENTIFY THE AVAILABLE OPTIONS OF ICT FOR FUTURE LAND ADMINISTRATION

The study of information and communication technologies helped in identification of possible options to address the issues highlighted in the outcome of Objective 1. This study examined how ICT contributes to the core business of land administration. Three aspects that ICT can potentially contribute to land administration were highlighted: data management, data dissemination and business facilitation.

Innovative data management tools including data modelling, multi method integrated data capture, real time data handling, mash ups, petabyte databases, geospatial metadata, and standard data exchange protocols were listed. Web services, agent technology, P2P technology, grid computing appear to be helpful in data dissemination contributing to the organisation of content and service, information access and service delivery. Finally attention was drawn to the business facilitators such as internet banking system, digital signature and digital document provided by ICT. The outcome of Objective 2 in particular assisted with the fulfilment of Objective 4.

9.2.3 OBJECTIVE 3: TO ASSESS ICT UTILISATION INCLUDING INTEROPERABILITY ISSUES, DATA MODELS AND DATA TYPES EMPLOYED IN CURRENT LAND ADMINISTRATION SYSTEMS USING A CASE STUDY APPROACH

Assessment of the ICT utilisation contributed to a detailed understanding of the interoperability issue and its origins. Three leading Australian land administration systems were explored and analysed. Within the systems, four major land administration procedures; land dealings, land subdivision, database management and information delivery, were examined and a number of interoperability issues associated with the procedures identified. The outcome of the Objective 3 revealed that the interoperability issues primarily originate from the data models, databases and even the data type employed. Additionally, this study highlighted that the lack of strategic information architecture also interferes with the interoperability in land administration system and that interoperability can also be optimised through a single unique and integrated entry point for service delivery.

To help with the accomplishment of Objective 4 "the development of e-land administration and associated toolkit", a four stage ICT development model was employed summarising the outcomes of Objective 3. Considering the development of an e-land administration, it should be noted although ICT is currently largely dominant in information delivery and database management side of land administration but is suffering from lack of interoperability, the use of ICT in land dealings and land parcel subdivision process is still immature and requires a particular attention to instil interoperability.

9.2.4 OBJECTIVE 4: TO DEVELOP AN e-LAND ADMINISTRATION MODEL AND THE ASSOCIATED TOOLKIT

Development of e-land administration contributes to addressing the interoperability issue through the understanding of different phases of ICT enablement. A five phase e-land administration implementation approach was brought in, starting with online information delivery, then transacting over the Internet, followed by integrating the transactions with the internal processes, and afterwards integration with external partners. The implementation is finalised with a maintenance regime to keep e-land administration active and responding through an assessment methodology introduced. Four levels of interoperability; semantic, legal, intercommunity and technical interoperability, were introduced to establish a successful e-land administration along with the associated toolkit. The toolkit contains four major tools including data management, data access and sharing, enterprise architecture tools and the exploitation tool. Having discussed different aspects of e-land administration toolkit, data modelling in data management was highlighted as a critical tool to improve interoperability and help with efficient development of e-land administration. The outcome of Objective 4 confirmed that e-land administration requires a proper data model to improve the interoperability.

9.2.5 OBJECTIVE 5: TO PROPOSE A NEW CADASTRAL DATA MODEL TO ASSIST ESTABLISHING AN E-LAND ADMINISTRATION SYSTEM

The outcome of Objective 5 conceptualised a new cadastral data model in order to respond to the research problem.

Firstly, in order to better understand the issue of increasing number of interests in land, the main data elements in land administration systems as well as current core cadastral data models in the Australian case studies as well as the Netherlands, Switzerland and the United States were analysed. The reliance of the current core cadastral data model on three main data elements - land parcel or property, the ownership right and the private interested person - were revealed. These parcel based models are then challenged by the need to accommodate the growing number of interests in land and new commodities out of land. To address this issue, the new model proposes to modify the building block for land administration systems from physical land parcels into legal property objects. This facilitates the incorporation of a wide range of rights, restrictions and responsibilities into the cadastral information system.

Moreover, the non-spatial identifiers employed in the current models are highlighted as weakening interoperability. The second change makes the spatial referencing systems the centre of the cadastral information system as the legal property object identifier. This change effectively promotes interoperability and simplicity in data exchange processes.

9.2.6 OBJECTIVE 6: TO DEVELOP AND ASSESS THE NEW MODEL

The outcome of objective 6 showed a successful implementation of the new cadastral data model. A prototype system put the idea of replacing land parcels with legal property objects in practice. The proposed core data model in Objective 5 was developed with reference to the requirements of the international standards in the spatial domain and global statements in land administration. It was highlighted that the key to implementing the proposed data model is the use of spatial identifiers to regulate relationships among the legal property objects. The spatial identifier not only facilitates this regulation but also assists interoperability in land administration systems. Being object based and spatially enabled, incorporating broader interests in land, the new model appeared to be successful in addressing the requirements of future land administration.

9.3 CONCLUSION ON RESEARCH PROBLEM

The research problem was that

"current cadastral data models are firstly not sufficiently flexible to incorporate the increasing number of interests and new commodities in land and secondly do not facilitate interoperability between different types of cadastral data in order to meet end users' needs."

This research problem was addressed through conceptualisation, development and implementation of a new cadastral data model capable of accommodating ever growing number of interest in land independently from each other. The new model employed legal property objects instead of land parcels to overcome the inflexibility.

Additionally, the new model took advantages of spatial identifiers to address the interoperability in land administration. The new model replaced non spatial identifiers by using a reference system and regulating the relation among legal property object layers.

9.4 FUTURE DIRECTIONS

The outcomes of this research highlight the following directions for further investigation in future.

Firstly, as was discussed, the key to implementing the proposed data model was the use of spatial identifiers to regulate relationships among the objects. These relationships allow the possible changes in one legal property object to affect other legal property objects in a cadastral information system. However, different types of relationship can exist among the legal property objects in a cadastral information system, such as topological, spatial, general and vertical relations. A comprehensive approach implementing these relations in the cadastral data model will further promote the actual employment of legal property objects in land administration.

Secondly, as was highlighted, spatial dimension of the interests can include a variety of shapes such as points, lines, polygons and volumes. Identification of technical characteristics of the interests involves regulating the measurement methods, standardising the accuracy and precision of the measurement and standardising the spatial representation. The introduction of legal property objects requires far-reaching change in cadastral information systems.

Finally, although data modelling was highlighted as a critical tool for establishment of an interoperable e-land administration system, the other tools introduced in this research are definitely fruitful to this establishment as well. The options offered by the interoperability toolkit have the potential to optimise the current practice of ICT enablement. Investigation of the current land administration practices from data dissemination, enterprise strategies and decision making points of view will be the future direction in e-land administration.

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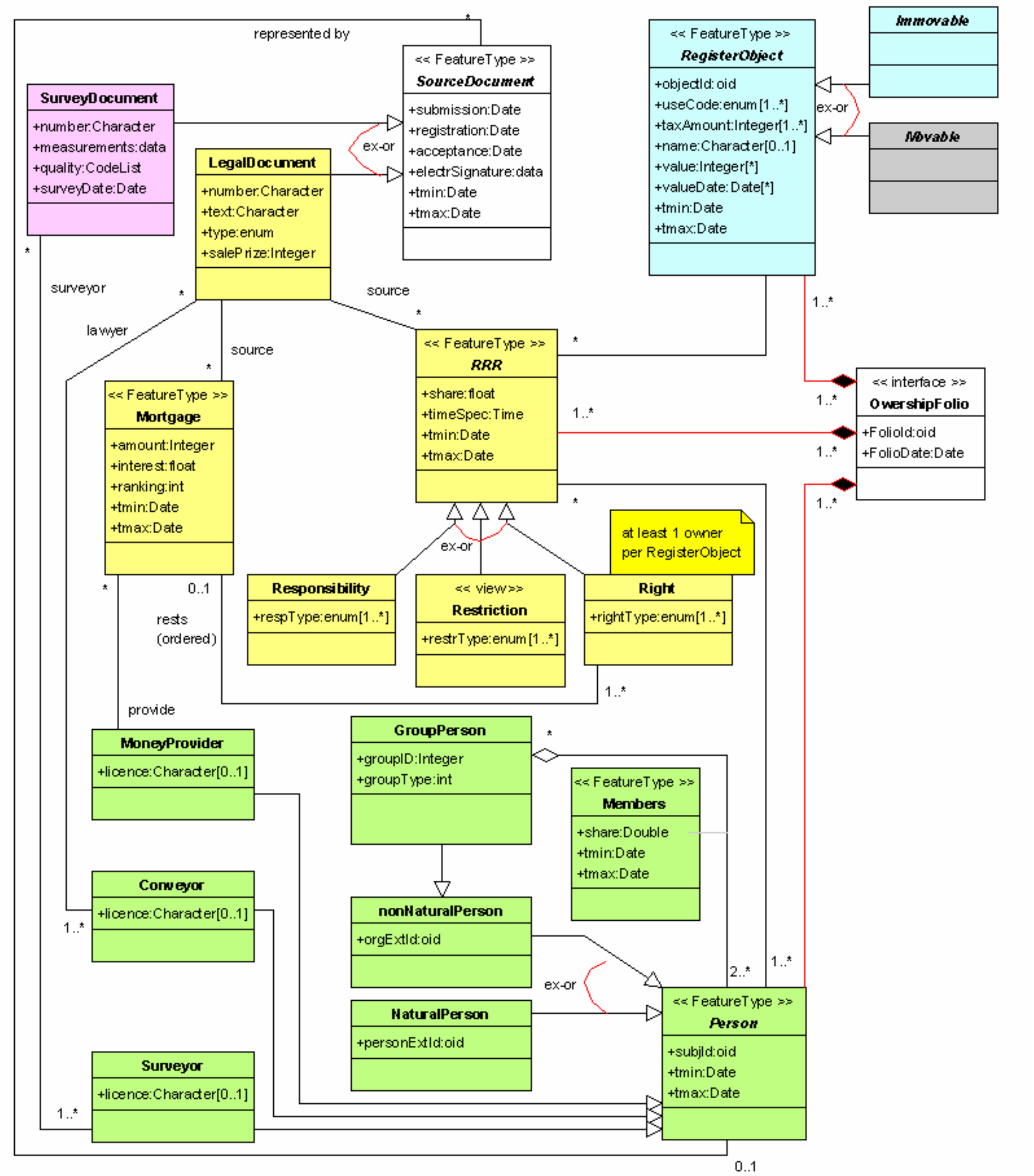
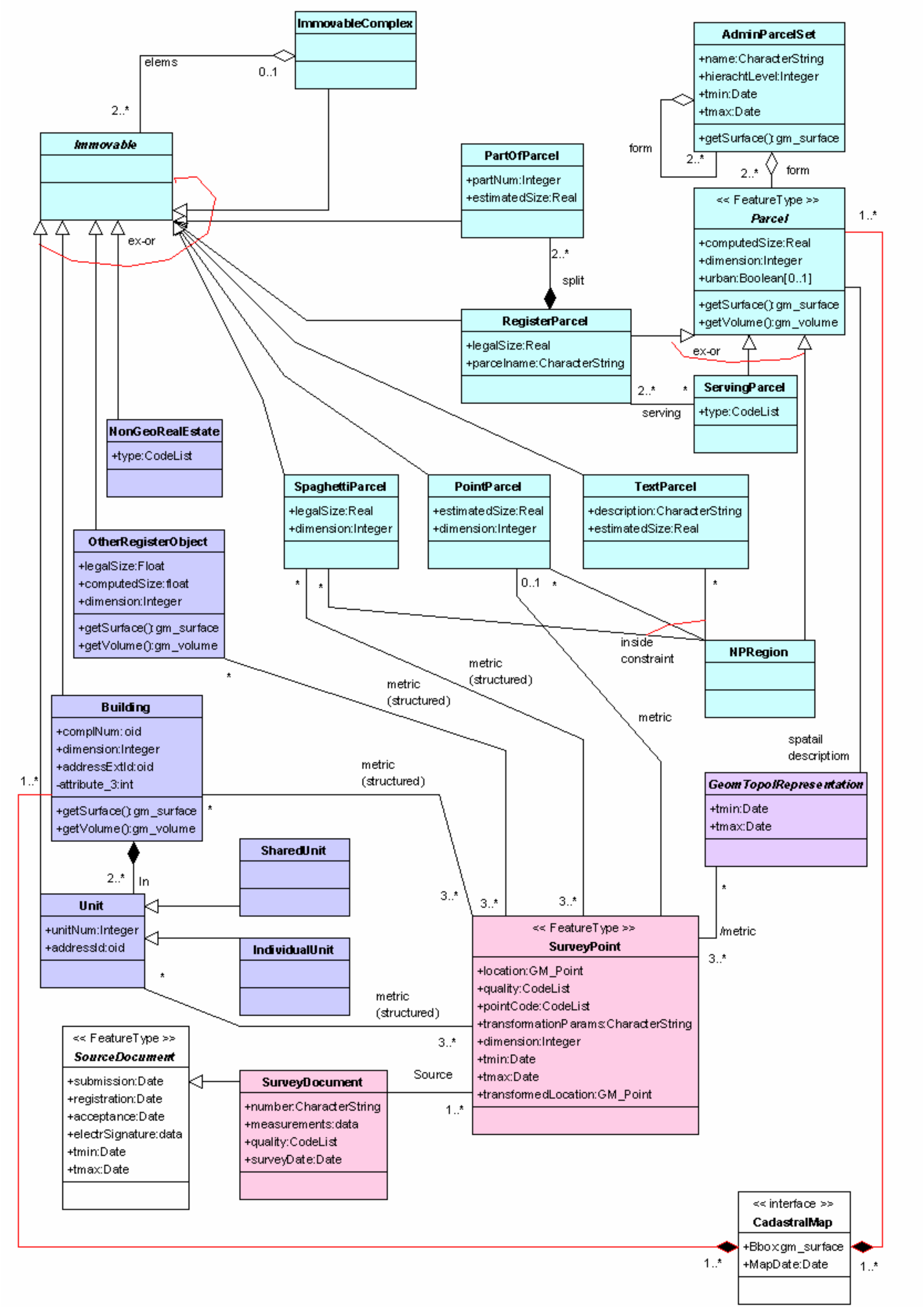
APPENDIX 2: THE CORE CADASTRAL DATA MODEL, VERSION 1



APPENDIX 2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0..1
2..*
Immovable
ex-or
PartOfParcel
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form
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form
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+getVolume():gm_volume
1..*
split
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+parcelname:CharacterString
ex-or
ServingParcel
+type:CodeList
serving
NonGeoRealEstate
+type:CodeList
SpaghettiParcel
+legalSize:Real
+dimension:Integer
PointParcel
+estimatedSize:Real
+dimension:Integer
TextParcel
+description:CharacterString
+estimatedSize:Real
OtherRegisterObject
+legalSize:Float
+computedSize:float
+dimension:Integer
+getSurface():gm_surface
+getVolume():gm_volume
inside
constraint
NPRegion
metric
(structured)
metric
Building
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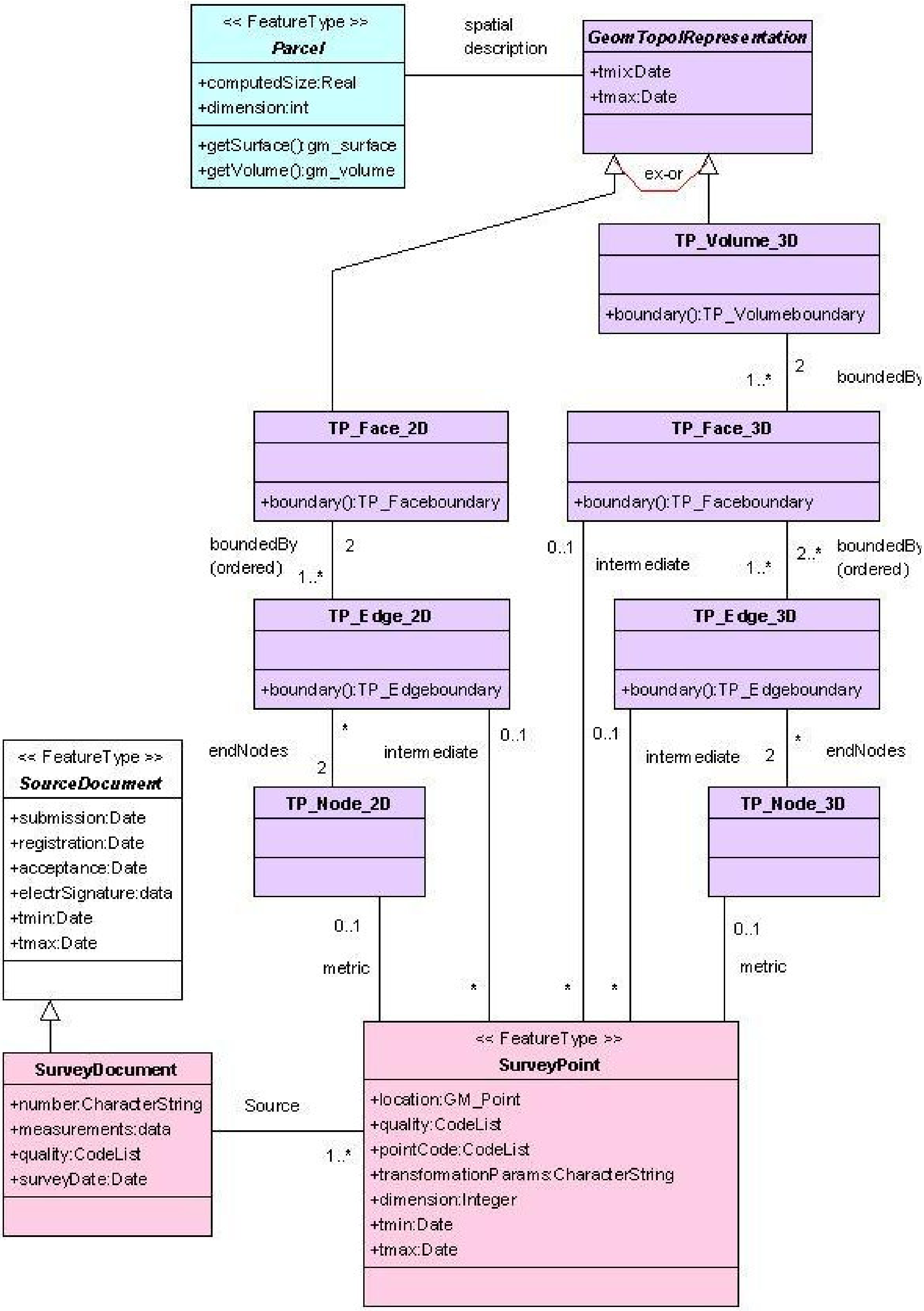
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GeomTopolRepresentation
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+tmax:Date
ex-or
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+boundary():TP_Volumeboundary
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1..*
boundedBy
TP_Face_2D
+boundary():TP_Faceboundary
TP_Face_3D
+boundary():TP_Faceboundary
boundedBy (ordered)
2
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0..1
intermediate
1..*
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TP_Edge_3D
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intermediate
0..1
0..1
intermediate
2
*
endNodes
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+tmax:Date
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APPENDIX 3: ICSM CADASTRAL DATA MODEL, VERSION 1

Diagram 4.0 - Cadastral - Cadastral Sub-Packages

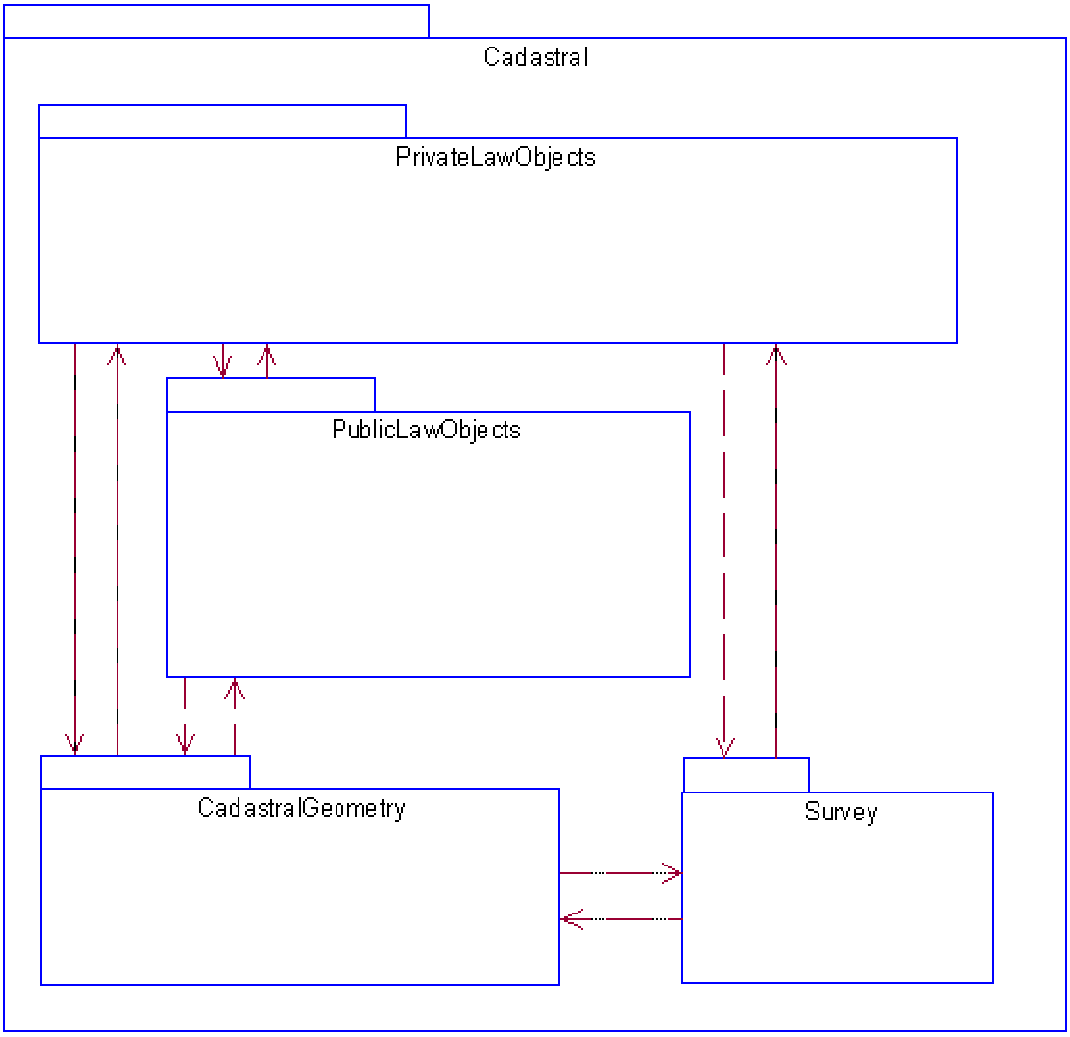


Diagram 4.1 - Cadastral - Non-Geometric Classes

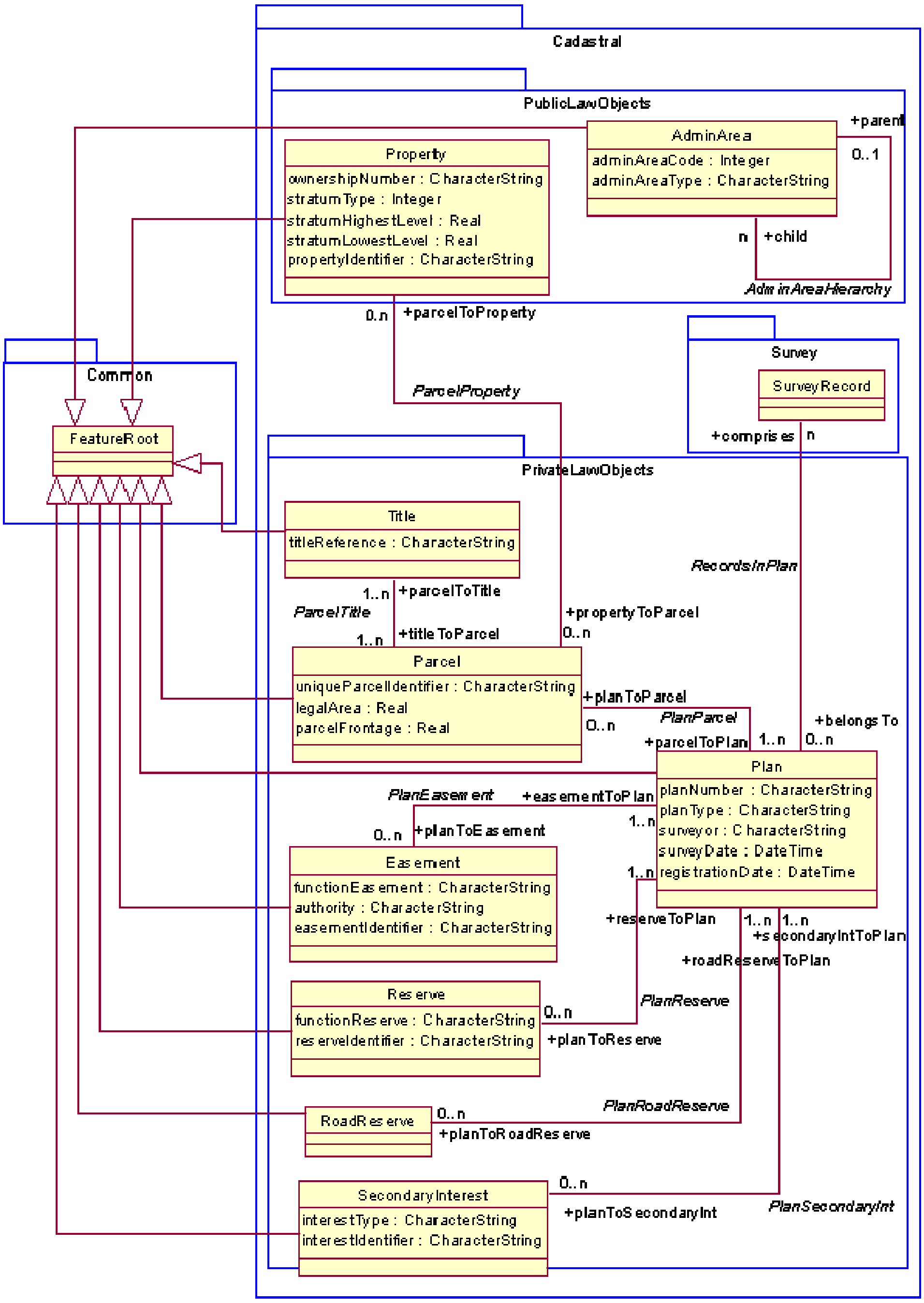


Diagram 4.2 - Cadastral - Associations with Polygon Representation

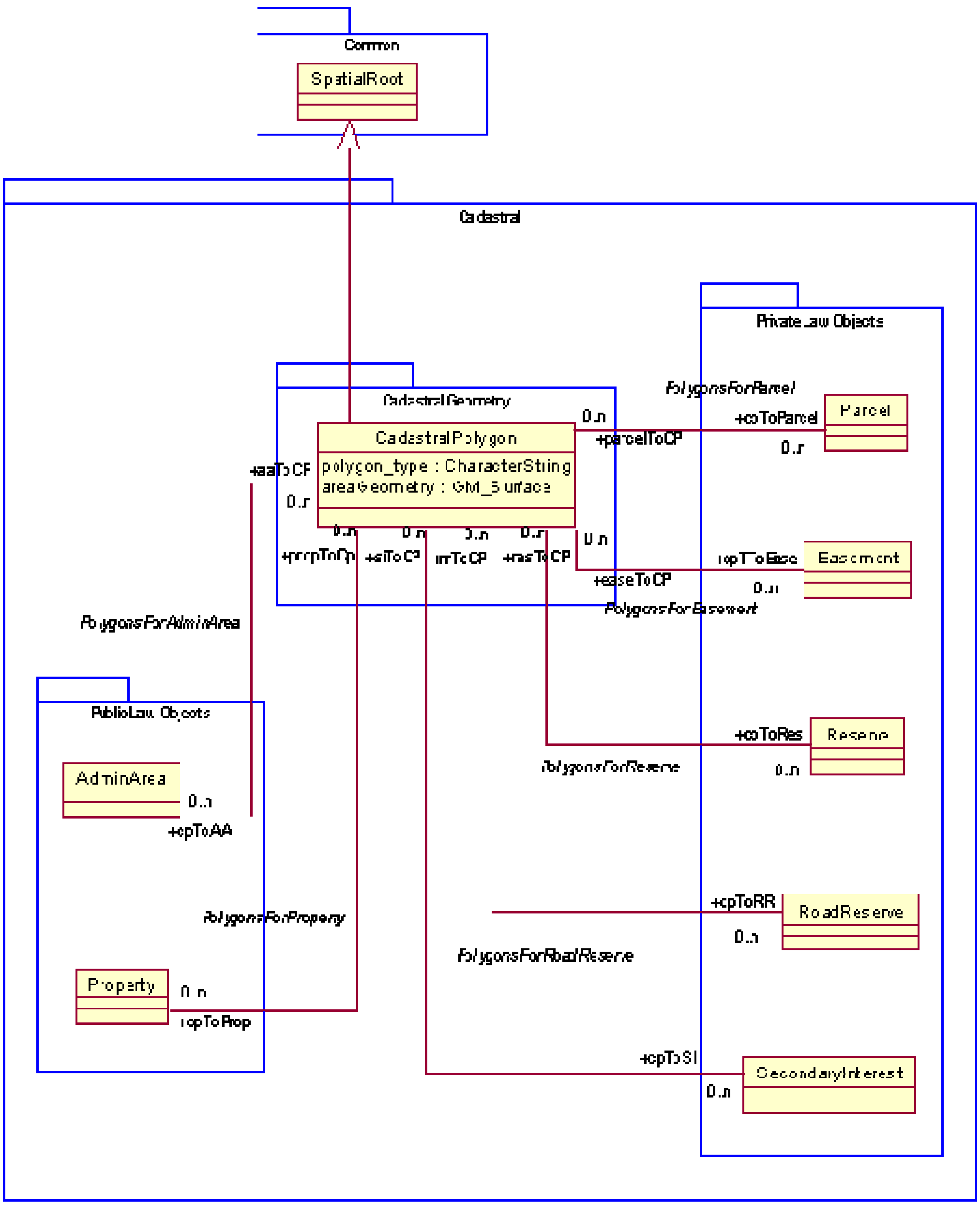


Diagram 4.3 - Cadastral - Associations with Area Point and Place Names

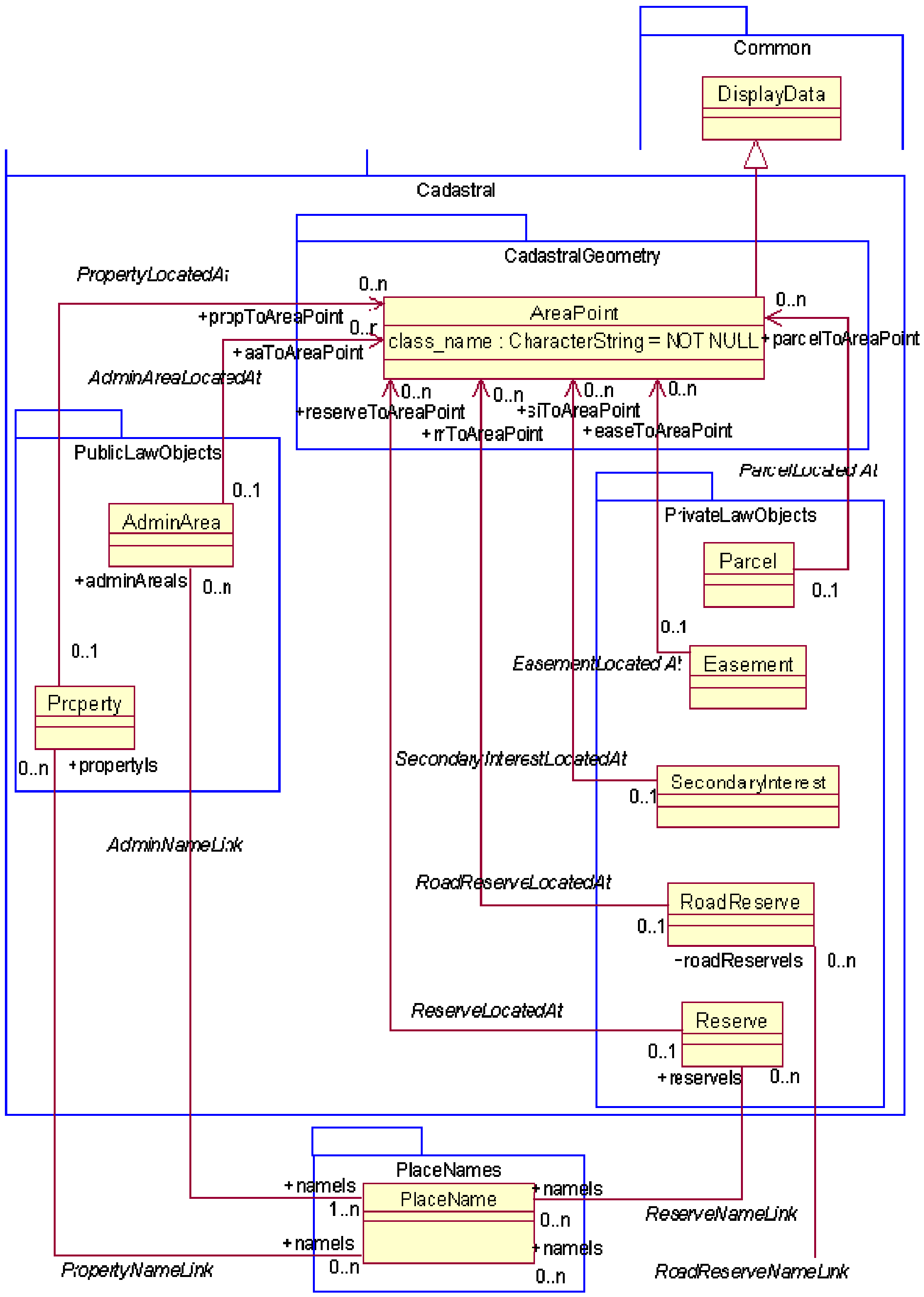


Diagram 4.4 - Cadastral - Geometry and Topology,Associations with Survey

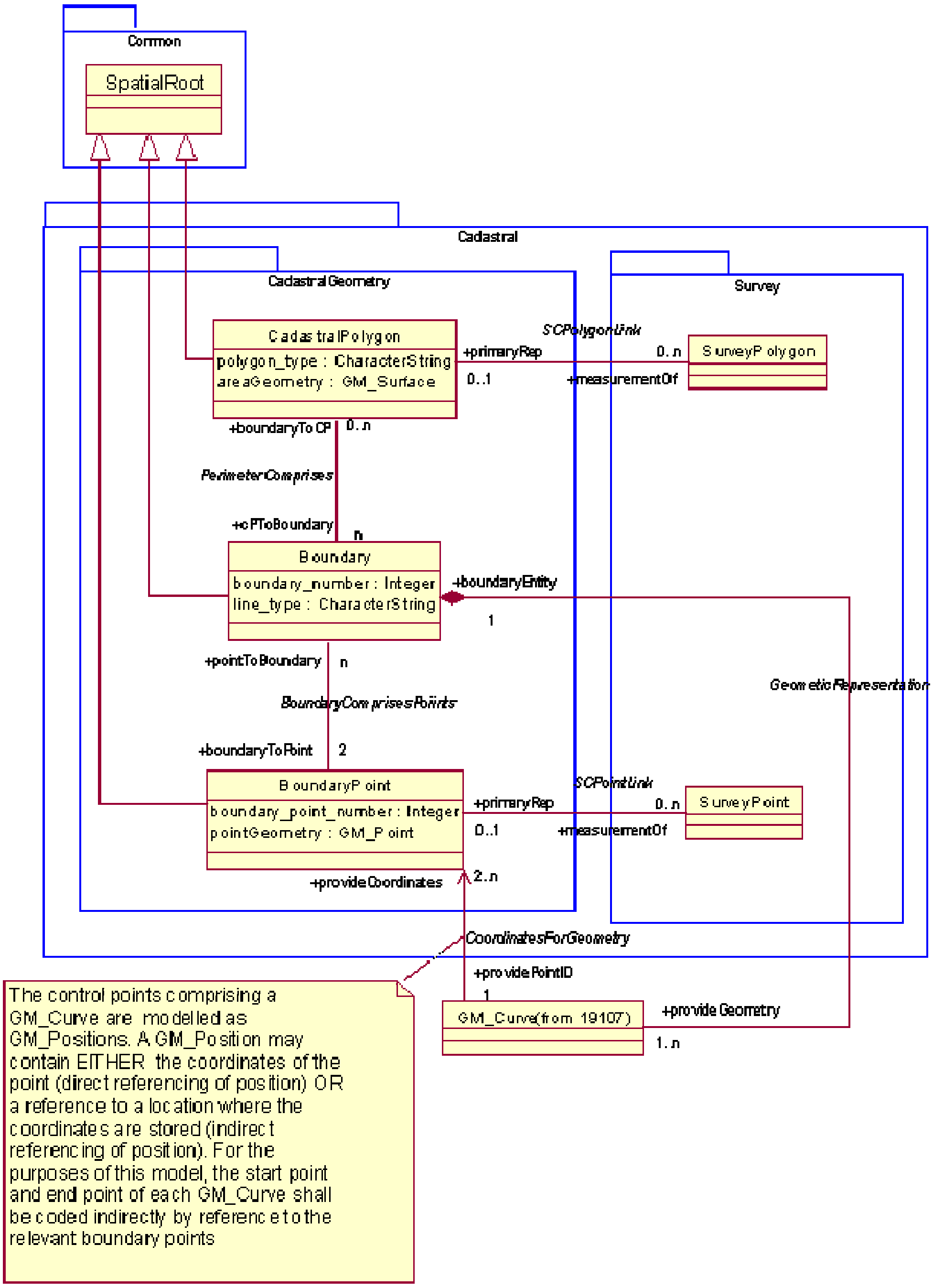
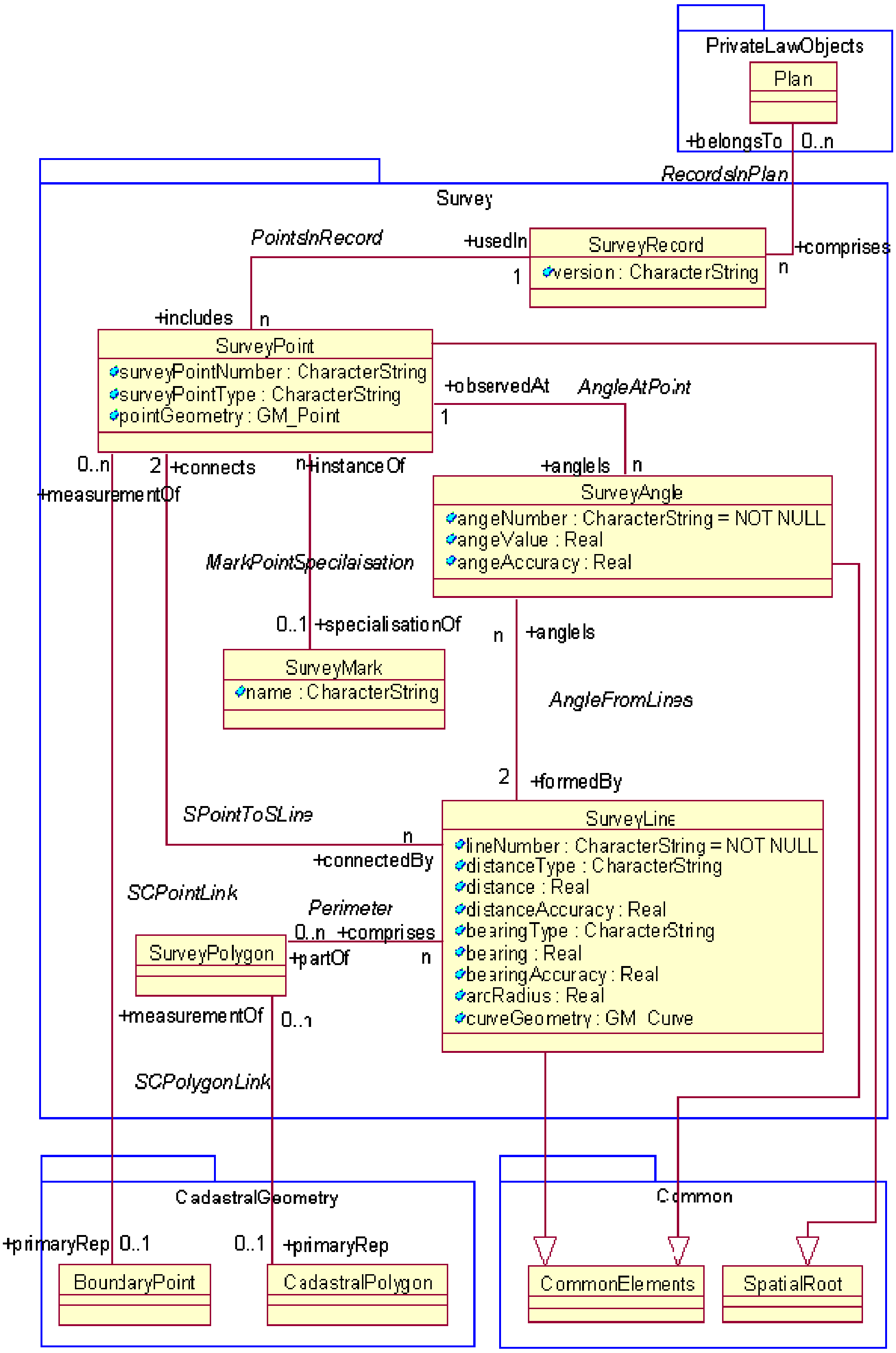
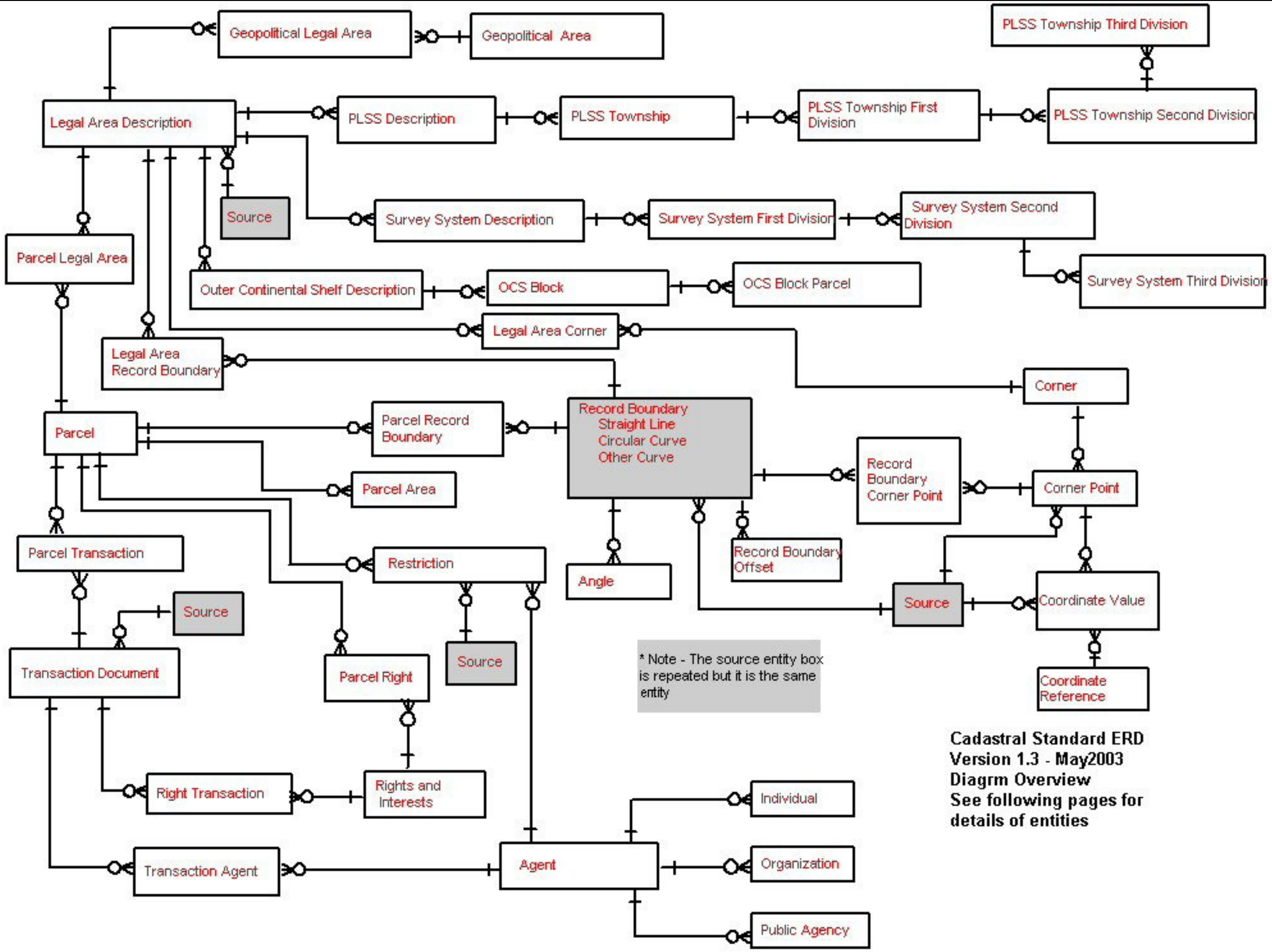
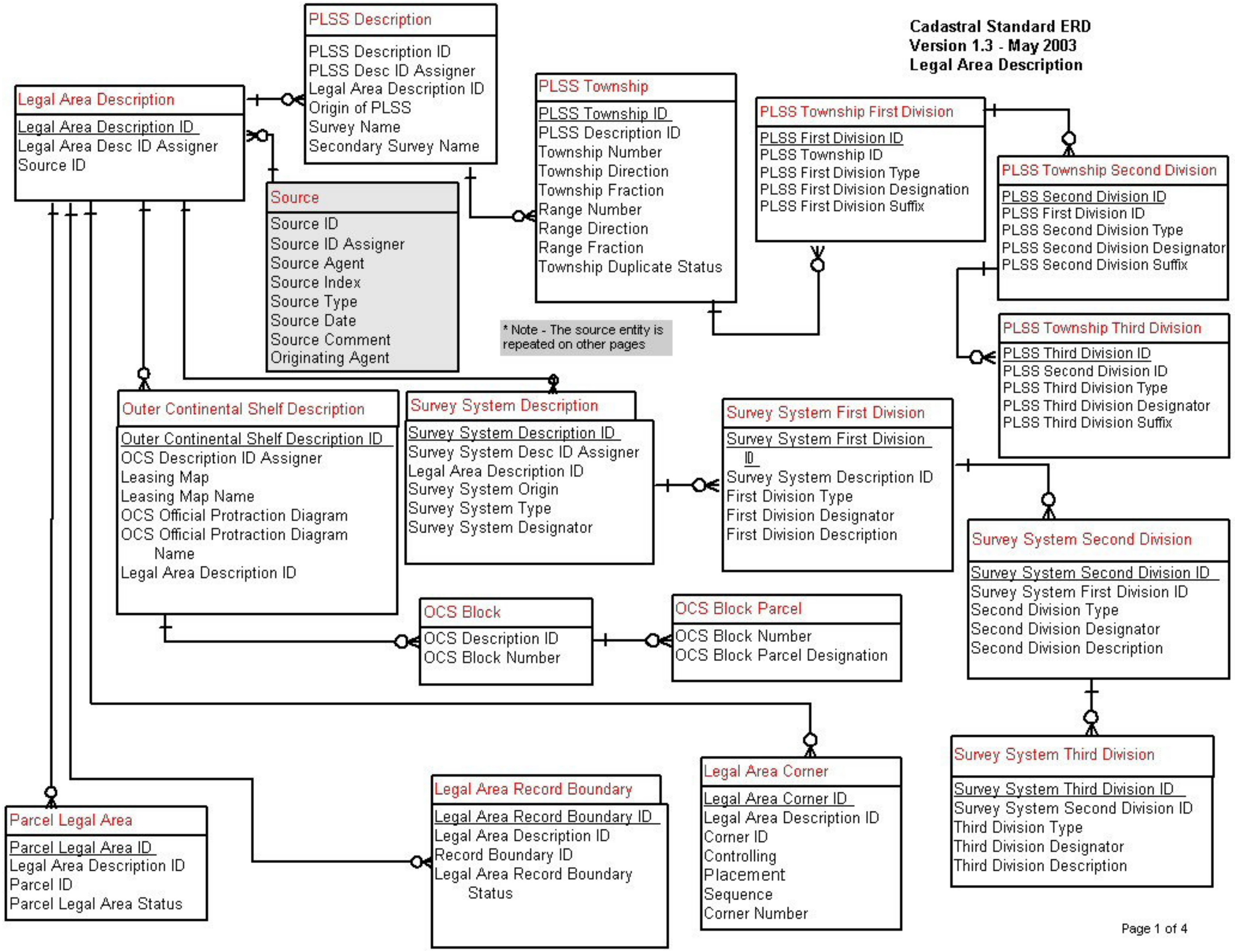


Diagram 4.5 - Cadastral - Survey and Associations



APPENDIX 4: FGDC CADASTRAL DATA CONTENT STANDARD FOR THE NATIONAL SPATIAL DATA INFRASTRUCTURE, VERSION 1.3 – THIRD REVISION




Cadastral Standard ERD
Version 1.3 - May 2003
Legal Area Description
Legal Area Description
Legal Area Description ID
Legal Area Desc ID Assigner
Source ID
PLSS Description
PLSS Description ID
PLSS Desc ID Assigner
Legal Area Description ID
Origin of PLSS
Survey Name
Secondary Survey Name
PLSS Township
PLSS Township ID
PLSS Description ID
Township Number
Township Direction
Township Fraction
Range Number
Range Direction
Range Fraction
Township Duplicate Status
PLSS Township First Division
PLSS First Division ID
PLSS Township ID
PLSS First Division Type
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PLSS Second Division Type
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Source Type
Source Date
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Originating Agent
* Note - The source entity is repeated on other pages
Outer Continental Shelf Description
Outer Continental Shelf Description ID
OCS Description ID Assigner
Leasing Map
Leasing Map Name
OCS Official Protraction Diagram
OCS Official Protraction Diagram Name
Legal Area Description ID
Survey System Description
Survey System Description ID
Survey System Desc ID Assigner
Legal Area Description ID
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Survey System Type
Survey System Designator
Survey System First Division
Survey System First Division ID
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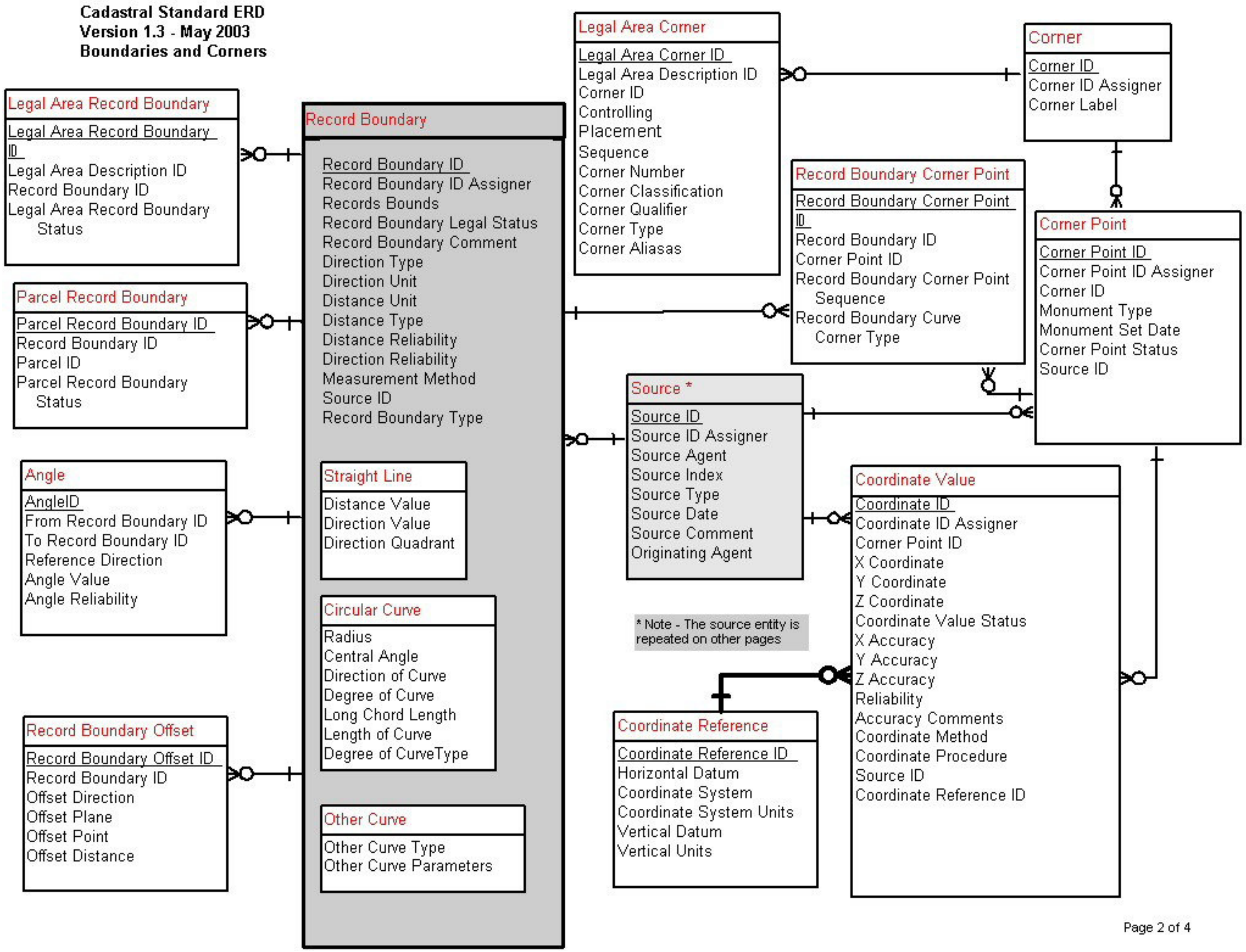
First Division Designator
First Division Description
Survey System Second Division
Survey System Second Division ID
Survey System First Division ID
Second Division Type
Second Division Designator
Second Division Description
OCS Block
OCS Description ID
OCS Block Number
OCS Block Parcel
OCS Block Number
OCS Block Parcel Designation
Survey System Third Division
Survey System Third Division ID
Survey System Second Division ID
Third Division Type
Third Division Designator
Third Division Description
Parcel Legal Area
Parcel Legal Area ID
Legal Area Description ID
Parcel ID
Parcel Legal Area Status
Legal Area Record Boundary
Legal Area Record Boundary ID
Legal Area Description ID
Record Boundary ID
Legal Area Record Boundary Status
Legal Area Corner
Legal Area Corner ID
Legal Area Description ID
Corner ID
Controlling
Placement
Sequence
Corner Number
Page 1 of 4



Cadastral Standard ERD
Version 1.3 - May 2003
Boundaries and Corners
Legal Area Record Boundary
Legal Area Record Boundary ID
Legal Area Description ID
Record Boundary ID
Legal Area Record Boundary Status
Parcel Record Boundary
Parcel Record Boundary ID
Record Boundary ID
Parcel ID
Parcel Record Boundary Status
Angle
AngleID
From Record Boundary ID
To Record Boundary ID
Reference Direction
Angle Value
Angle Reliability
Record Boundary Offset
Record Boundary Offset ID
Record Boundary ID
Offset Direction
Offset Plane
Offset Point
Offset Distance
Record Boundary
Record Boundary ID
Record Boundary ID Assigner
Records Bounds
Record Boundary Legal Status
Record Boundary Comment
Direction Type
Direction Unit
Distance Unit
Distance Type
Distance Reliability
Direction Reliability
Measurement Method
Source ID
Record Boundary Type
Straight Line
Distance Value
Direction Value
Direction Quadrant
Circular Curve
Radius
Central Angle
Direction of Curve
Degree of Curve
Long Chord Length
Length of Curve
Degree of CurveType
Other Curve
Other Curve Type
Other Curve Parameters
Legal Area Corner
Legal Area Corner ID
Legal Area Description ID
Corner ID
Controlling
Placement
Sequence
Corner Number
Corner Classification
Corner Qualifier
Corner Type
Corner Aliasas
Corner
Corner ID
Corner ID Assigner
Corner Label
Record Boundary Corner Point
Record Boundary Corner Point ID
Record Boundary ID
Corner Point ID
Record Boundary Corner Point Sequence
Record Boundary Curve Corner Type
Corner Point
Corner Point ID
Corner Point ID Assigner
Corner ID
Monument Type
Monument Set Date
Corner Point Status
Source ID
Source *
Source ID
Source ID Assigner
Source Agent
Source Index
Source Type
Source Date
Source Comment
Originating Agent
* Note - The source entity is repeated on other pages
Coordinate Value
Coordinate ID
Coordinate ID Assigner
Corner Point ID
X Coordinate
Y Coordinate
Z Coordinate
Coordinate Value Status
X Accuracy
Y Accuracy
Z Accuracy
Reliability
Accuracy Comments
Coordinate Method
Coordinate Procedure
Source ID
Coordinate Reference ID
Coordinate Reference
Coordinate Reference ID
Horizontal Datum
Coordinate System
Coordinate System Units
Vertical Datum
Vertical Units

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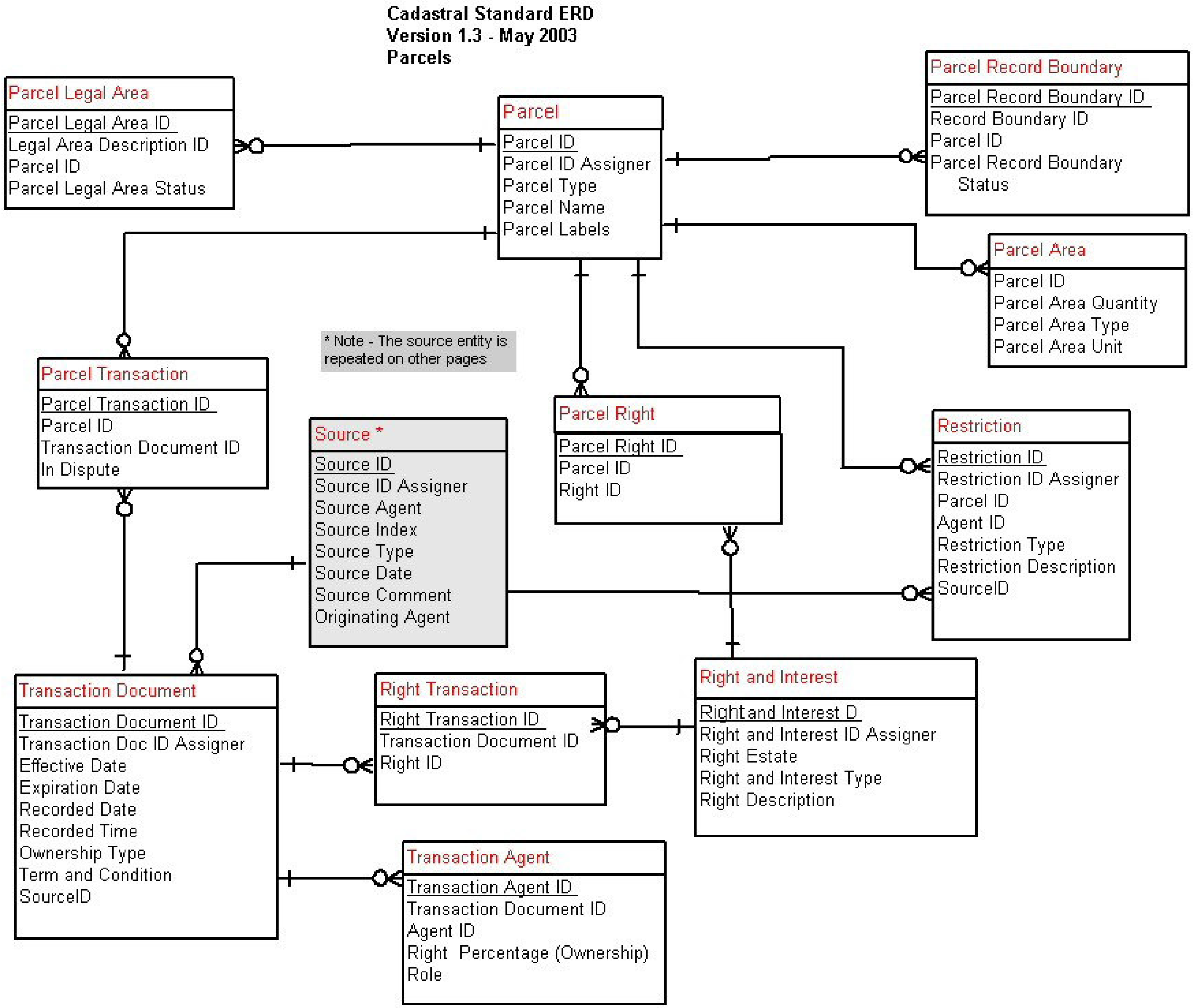
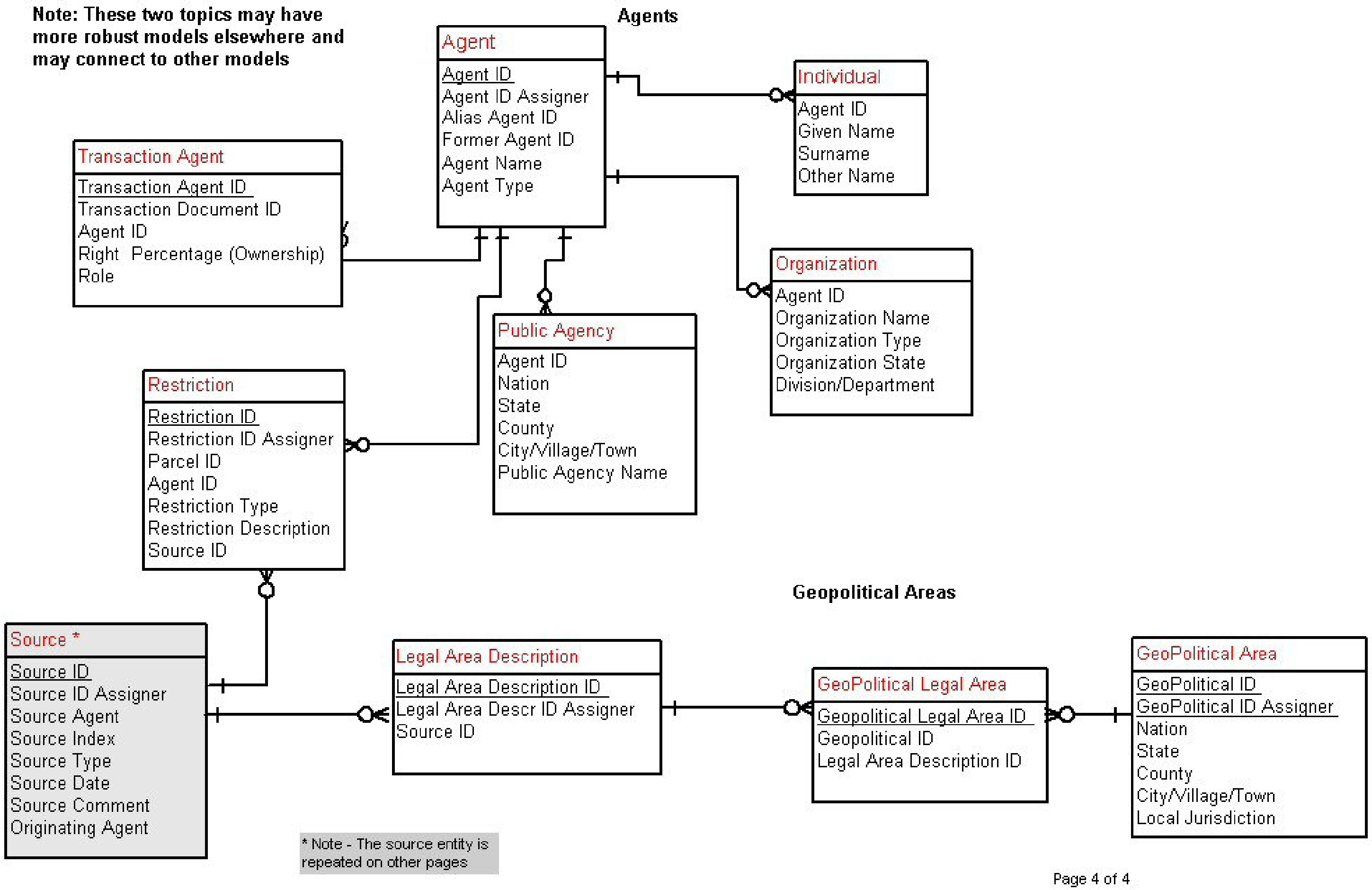

Cadastral Standard ERD
Version 1.3 - May 2003
Parcels
Parcel Legal Area
Parcel Legal Area ID
Legal Area Description ID
Parcel ID
Parcel Legal Area Status
Parcel
Parcel ID
Parcel ID Assigner
Parcel Type
Parcel Name
Parcel Labels
Parcel Record Boundary
Parcel Record Boundary ID
Record Boundary ID
Parcel ID
Parcel Record Boundary Status
Parcel Area
Parcel ID
Parcel Area Quantity
Parcel Area Type
Parcel Area Unit
* Note - The source entity is repeated on other pages
Parcel Transaction
Parcel Transaction ID
Parcel ID
Transaction Document ID
In Dispute
Source *
Source ID
Source ID Assigner
Source Agent
Source Index
Source Type
Source Date
Source Comment
Originating Agent
Parcel Right
Parcel Right ID
Parcel ID
Right ID
Restriction
Restriction ID
Restriction ID Assigner
Parcel ID
Agent ID
Restriction Type
Restriction Description
SourceID
Transaction Document
Transaction Document ID
Transaction Doc ID Assigner
Effective Date
Expiration Date
Recorded Date
Recorded Time
Ownership Type
Term and Condition
SourceID
Right Transaction
Right Transaction ID
Transaction Document ID
Right ID
Right and Interest
Right and Interest D
Right and Interest ID Assigner
Right Estate
Right and Interest Type
Right Description
Transaction Agent
Transaction Agent ID
Transaction Document ID
Agent ID
Right Percentage (Ownership)
Role

Cadastral Standard ERD
Version 1.3 - May 2003
Agents and Geopolitcal Places



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