INTERNATIONAL FELLOWSHIP:

A STUDY OF CADASTRAL MANAGEMENT AROUND THE WORLD

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Abstract

The New South Wales Surveyor General generously grants an annual International Fellowship award to up to two university graduates annually from Surveying and Spatial Information Systems. The successful applicants of this Fellowship are provided with the opportunity to travel internationally to broaden and develop their personal and professional perspective. The purpose is to investigate international processes by exchanging knowledge and engaging in discussion on the specific topics proposed by the applicant.

In 2009, I was lucky enough to receive this award. I proposed to carry out my research on the use and significance of Geographical Information Systems (GIS) in two different topic areas:

1. *Cadastral Management*
2. *Sustainability*

My reasoning for choosing cadastral management was my belief that the cadastre is the fundamental backbone to all survey and GIS work.

I will be focusing on Cadastral Management in this paper. The purpose of the paper is to provide an informative summary by taking a 'compare and contrast' approach to understand the extensive differences in systems and processes in Germany, United States of America, England and the Netherlands.

Introduction

The Land and Property Management Authority (LPMA) defines cadastral as "records of a cadastre, concerned with keeping a cadastre, an official register of property". Cadastre is defined in the Surveying and Spatial Information Act 2002 No 83 (2010) as "an inventory that records boundaries, dimensions and measurements on, above or below the Earth's surface for the purpose of defining rights, interests, restrictions and responsibilities within the jurisdiction of New South Wales." (LPMA, 2009). The management of cadastral data has evolved over the years especially with the introduction of the Geographical Information Systems (GIS) industry. Cadastral data can now be described in simple terms as a digital, spatial representation of property and its corresponding details such as ownership, address, land use and land taxes.

The need to have a current, well maintained cadastral database is becoming more and more vital and depended upon for a city, state or even country's planning and development. Advanced technology now makes it possible to have high accuracy data. The recording of ownership has always been important for land administration but the process greatly varies around the world.

History

The first, and perhaps most important, difference that needs to be understood is the contrast in history of land administration of each country. History can be considered an explanation to the way in which each system and process is now carried out.

The need to prove ownership has always been a vital part of the British system. However, the system of registration underwent many changes before the current Land Registration Act 2002 was implemented. England's registration history dates back as far as when the Romans introduced a form of land registration to England and Wales. Many Land Registration Acts were introduced but were unsuccessful systems including the Land Registry Act 1862 where the first Chief Land Registrar, Brent Spencer Follett, was appointed. This system was replaced by 1875 Land Transfer Act which remained until compulsory registration was introduced. It was not until the mid 1800s that the registration of title was introduced but was not compulsory in the whole of England and Wales until 1990. Although registration is now compulsory, its history is the reason for the current 25% unregistered titles and therefore missing spatial data. Her Majesty's (HM) Land Registry is working to reduce this figure and now have some 20 million titles registered. (Mayer, Pemberton, 2000).

On the other hand the system in the Netherlands differs greatly from the English system, both in the past and present. In fact, England looked to Holland in the seventeenth century since they had introduced land registration in 1529 and were considered the most successful country in Europe of the day (Mayer, Pemberton, 2000). In England and Australia there is the state title system where the title is guaranteed. It is a legal transaction and registration with the state title office is required. In the Netherlands, the state does not guarantee the title, but merely facilitates the compulsory recording of documents. The key words to understand the difference is 'registration' and 'recording'. The historic reasoning for this is that Holland has adopted the French system which embraces the belief that it is a right of the citizens not the nobility. Therefore property rights and land market are a matter sorted by the citizens, not the state.

The United States of America is a whole other story compared to the two countries just mentioned. Like Holland, the state does not guarantee title but nor is it a right of the citizens. America has what is known as title insurance. This is a private entity which, as the name states, insures your title against any defects or issues. In other words, a title against a property is registered with the state but since it is not guaranteed a big business opportunity began in America to have private insurance on your title like you would your house or car. Each state has its own processes, systems and standards which may or may not be similar to other states. Therefore, there is no one national secure title system. Interestingly, a handful of the states adopted the Torrens Title system as is done in Australia.

United States of America

As stated above, land administration in the United States employ a title insurance system. The state does not guarantee title and nor is a survey plan considered a legal document. It is important to remember that every state has its own system, laws, procedures and even variation in the levels of governmental structure hence the following step by step process may vary and is merely a generalised explanation of USA's land administration.

Surveyors carry out a field survey and prepare a survey plan. The map itself needs to conform to the universal survey requirement that a property's boundaries must have a small and acceptable misclose. However, the property 'illustration' on a survey plan in the USA does not require measurements to the millimetre, or more accurately to the inch. I specifically use the term illustration to highlight that, other than a misclose there are no strict mapping standards for the submission of the plan, unlike in NSW.

The key aspect of a survey plan in the USA is the written legal description which describes the property. According to C. Lodge (2009) these can be one of three descriptions and they are:

1. Metes and Bounds: Describes a parcel of land with direction and distance measurements and establishes its boundaries using markers such as monuments or natural objects.
2. Government Survey: It also describes a parcel of land by establishing boundaries however the description is not as specific as the direction and distance measurements on a metes and bounds description. The basis begins with a reference of section, township and range.
   (Metes and bounds and Government Survey can be categorised as unplatted land which is property defined by survey measurements rather than a lot and block identification.)
3. Platting: When an area is subdivided, a survey plan is recorded at the county which identifies each lot within a block with a unique identification number. The legal description of any further survey plan on platted land is simply a reference to the lot and block number along with the volume and page of the recorded plat.

The legal description from a plan is recorded at the county level. This written description is the most important section of a survey plan, also known as a survey map, as far as the county is concerned. A basic check of the survey measurements is often carried out and any major changes, such as consolidation or division of lots, will be updated to the spatial data using a simple coordinate geometry (COGO) method. Taxation, including property tax, is also collected at this level.

Following the legal recording at the county, the plan is passed on to the municipality, most commonly known as city level. At this stage each department has their own accuracy standards dependent on a number of contributing factors such as revenue, intended usage and resource. The city's separate cadastral database is updated accordingly.

Environmental Systems Research Institute, known simply as ESRI, provides the most commonly used advanced GIS software package worldwide known as ArcGIS. I was fortunate enough to visit ESRI's head office in Redlands, California. In the latest version of the software, ArcGIS version 10, ESRI's intention in terms of cadastral editing was to improve and make readily accessible a previously existing editing tool. The parcel editor, originally known as cadastral editor, aims to break down the barriers between the departments and various levels of land administration. The product has also been further developed in order to embrace the requirements of tax mapping in USA. It aims to encourage the upkeep of a spatially accurate cadastral database by providing simple, efficient, user friendly tools.

The counties are interested in legal description and attribute information. The cities are interested in accurate GIS mapping. It seems there is a future possibility for a merge to a single database. For this to be option, obviously there are many factors that need to be

considered but ESRI products will be a starting platform to consistency in software, data, methods and standards.

England

England's system or even United Kingdom in general, is fairly unique. It was quite a contrast in research compared with cadastral administration and spatial information systems in the United States and also Europe.

Ordnance Survey (OS) is Great Britain's (England, Scotland and Wales) national mapping agency. The key aspect of their work is managing the nation's topographic data and mapping. In terms of cadastral management, OS does not map the legal boundaries of property nor does it handle deeds, titles, registration or other such legal operations. Ordnance Survey's topographic mapping is used by Her Majesty's (HM) Land Registry for land administration therefore can be considered a support of cadastre. HM Land Registry is responsible for registration of title and recording dealings of registered land in England and Wales.

As previously mentioned land registration in England has quite a colourful history. The fact that registration was not compulsory until 1990 is an explanation to the 25% of unregistered titles and therefore absent sections of national spatial cadastre. Over the years this figure is gradually diminishing.

In the past England had a 'fixed' boundary system but later adopted what is known as "general boundaries". This was due to the decision to use OS topographic data as a base for their cadastral work since they already possessed full mapping coverage of all of UK. The term "general boundaries" was implemented to allow a buffer for the fact that OS data does not capture legal property boundaries.

For the cadastral database itself HM Land Registry uses OS MasterMap among other in-house systems such as Land Registry Property Gate (LRPG). OS MasterMap is a continually updated database containing data and a unique reference (TOID) for every feature on the British landscape. This information is available through OS MasterMap products and online services provided by Ordnance Survey.

It is difficult to know the level of accuracy of the cadastre due to the use of general boundaries but it seems that high accuracy is not vital in this case. The accuracy of OS data however is said to be:

- 1:1250 Map accuracy = +/-1m for every 100m
- 1:2500 Map accuracy = +/-2m for every 100m

Ordnance Survey has built a national network of continuously operating reference stations (CORS) across Great Britain called OSNet. CORS networks such as this continuously collect data from satellites which creates a solid survey framework for the area covered. Real time information can be downloaded to receive positioning to centimetre level accuracy in most areas of Great Britain. Without the OSNet system GPS signals alone can only produce horizontal positional accuracy to approximately 5–10m. There are approximately 90 stations collecting GPS (American system) signals and has the potential to work with Galileo signals (Europe system) in the future.

England clearly has a very different approach to land administration and is heavily based on the data of the national mapping agency. It is quite unlike the processes and systems used in Europe, America or even Australia.

The Netherlands

The Netherlands, also commonly referred to as Holland, is made up of twelve provinces and some 400 municipalities. Historically each province maintained separate databases for the cadastre. Errors along the boundaries of each province soon highlighted the fault of having divided systems. A great deal of time, money and effort was committed to repairing the alignment issues once the technology was available. This also called for the development of a centralised database which is now managed at the Dutch Kadaster: Land Registry and Mapping Agency which politically stands under the Minister of Environment, Spatial Planning and Housing although they are more correctly known as an independent public body.

Prior to this, over the years, nationwide cadastral maps were produced to a scale of 1:1000 as well as separate 1:1000 topographic maps. The formation of seamless cadastral data across Holland uncovered the fact that the cadastral and topographic maps did not match, often by substantial differences. This became a further necessary extension to the original project as Holland always had a reputation for "accurate data".

Ten years later in 2007, a seamless, nationwide cadastral and topographic fabric was available.

Many may question the need for a national cadastral fabric. A cadastral fabric is "a continuous surface of connected parcels" as defined by ESRI (2009). What are the benefits? Is it worth the time and money?

While there is no doubt that it is a costly and timely process to establish seamless data the outcome allows for the following:

- Highly accurate cadastral and other spatial data
- Highly efficient and simple maintenance
- Controlled management with little room for error
- Minimises the amount of legal disputes due to the accuracy of the data
- Cost effective once the system is in place

Updating accurate cadastral data used to be a time consuming, manual process. Unfortunately this still is the case in NSW. There are many steps from when a surveyor carries out a field survey to the final step consisting of a manual COGO update in the office by a GIS professional. All in all it is a slow operation. The Netherlands have eliminated most of the manual labour with the implementation of this cadastral fabric. The steps taken to update Holland's cadastral data are as follows:

1. A surveyor takes a copy of the required survey area from the cadastral database into the field on a field laptop (usually Panasonic Toughbook)
2. The toughbook is connected to the total station or GPS while the survey is carried out therefore instantly loading and automatically updating the data on the spot. This allows a surveyor to be aware of any survey errors they may make and instantly re-survey as required.
3. When the surveyor returns to the office, the newly surveyed data is imported into the national database and an automatic adjustment is carried out accordingly by performing a least squares adjustment on the nationwide fabric.

With advanced GPS technology it is now possible to achieve accuracies of 20cm standard ellipse plus the accuracy of the physical monument in urban areas and 40cm in rural areas.

The use of such technology together with rigorous calculations achieved from least squares, results in sub-metre, reliable cadastral data. M. Elfick (2009) states that using accurate cadastre as a base layer can "serve as the control for GIS data" which is "created and maintained in context with the cadastre". The most beneficial point to mention is that a shift in the 'base' layer will automatically adjust all other dependent GIS data due to established spatial relationships.

Land registration is a system based upon the rights and control of the citizens instead of the involvement of the state. The Netherlands employs a compulsory 'recording' system rather than a 'registration' overseen by a notary which is part of a private law. Basically private law is the law that regulates the relation between the citizens. Any legal recordings or cadastral updates are made accordingly. A document outlining the full details of the transaction must be recorded at the Land Registry.

Germany

The precision, progression of technology and forward-thinking of the Germans regarding geodesy, surveying and spatial information was undoubtedly remarkable.

Like the Netherlands, Germany has a national cadastral fabric therefore maintaining the data is a similar process. The accuracy however is at a higher standard with a dense, nationwide coverage of about 270 GNSS reference stations approximately 25-60km apart (Jahn, 2008). The German CORS network system is called SAPOS and produces accuracies to +/- 2cm using RTK. This effectively means that cadastral data is also to +/- 2cm accuracy which was the highest level of accuracy found from this research.

Since GPS was so effective, SAPOS was introduced with the cooperation of all 16 states. The main reason to set up this system was for the purpose of improved cadastral surveying. As mentioned the cadastral database can be updated directly from the survey due to the presence of a cadastral fabric. The key to time and cost efficiency in the field was to provide a strong and precise GNSS network for establishing one's spatial location to tie the local survey into the national framework. SAPOS can produce such required, accurate results within a couple of minutes using both GPS and GLONASS signals.

There is one sole topic which virtually became the focal point of the German sector of research. The topic is the national geodatabase model called AFIS-ALKIS-ATKIS (AAA).

According to AdV, Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany, (2006) the following define the three A's in the AAA model:

- AFIS - Official Control Station Information System
- ALKIS - Official Real Estate Cadastre Information System
- ATKIS - Official Topographic and Cartographic Information System

In 2000 the 'AAA project' commenced to integrate the three systems mentioned above nationwide. Previously all 16 states in Germany had their own database and structure with no apparent national standardisation. The realisation is that the spatial data infrastructure needs to be restructured in order to provide reliable data and allow the opportunity to use it to its full capacity. With the launch of the AAA scheme all systems are being made compatible and therefore allowing for consistent, seamless data nationally. "The AAA basic scheme becomes a core data model that can easily be combined or extended with other data from various administrations in order to build up a spatial data infrastructure in Germany". (Seifert, 2006)

Historically the foundation of state survey authority was to produce maps for the purpose of war. In the 19th century the state began to collect taxes from citizens which lead to the need for a cadastre at the municipality level. This is done in two parts: legal section and cadastral section.

- Legal section – Books held at local county court which states the owner of a certain parcel and any other legal detail. No map or spatial information managed.
- Cadastre section - Geometry and description of the parcel purchased is recorded. This involves updating a cadastre map as well as a cadastre 'book'. Until the early 80s this was actually a book with hand written parcel descriptions.

The beginning of the digital era allowed for vast improvements in surveying and cadastral management as evident from the discussion above regarding the current update procedure. However, there is still a certain amount of manual work involved to ensure all systems are up to date and correlating. With the implementation of AAA, all systems will be connected.

In basic terms… Corner points are related to the boundaries. Boundaries related to parcels. Parcels related to attributes. A change to one parcel will automatically adjust everything relating to that parcel as well as any changes required to surrounding parcels.

Compared to the tedious, error-prone historical method of cadastral maintenance, it is clear that in the long term the AAA model will prove its worth. Once the system is up and running very little manual labour, time or money will be necessary for the cadastre database. There is no escaping the necessity of a cadastre which can be quite time consuming and repetitious work. However taking on a challenge such as the AAA model or a national cadastral fabric means more resources available in the future to concentrate on further important, advanced systems.

Summary

If there is one thing I have discovered from this Fellowship, it is that despite the fact that the spatial industry can be considered reasonably new compared to others, there is an incredibly vast amount of knowledge available around the world. The speed in which this industry has developed is overwhelming.

Cadastral Management is the key to maintaining land records and providing a platform to all spatial data. As a general statement in terms of cadastral management there is no right or wrong method of management. All in all, it came down to 'what is appropriate and most effective for each country'. Germany's system was by far the most advanced and accurate. Their SAPOS system of continuously operating GNSS stations provides a solid network nationwide therefore achieving astonishing levels of accuracy in positioning.

A national cadastral fabric in Germany and the Netherlands allows for efficient and cost effective methods of maintain the cadastral database. A tedious manual coordinate geometry procedure was turned into an on-the-spot updating process.

The spatial management of the cadastre in England is quite unique. The database is based on Ordnance Survey mapping which is unlike any other system I came across. An adoption of general boundaries in the country made this possible. The major difference in the registration system between England and Europe is the property title. A title is in England and Wales is guaranteed by HM Land Registry whereas Europe's registration system operates on a public law where title is not guaranteed by state.

Further to these differences, the United States of America has title insurance. My understanding is that this is a system solely implemented in America. The state does not guarantee title nor is it a formally recorded agreement between the buyer and seller as is done under the public law therefore title insurance was developed.

Based on the knowledge gained and seeing the functioning systems first hand, it is my opinion that NSW should look to the benefits of an accurate cadastre based upon a single state-wide cadastral fabric similar to that of Germany and the Netherlands. An incredible amount of work is being placed on the NSW GNSS CORS network which is an important and creditable step in the right direction.

References

AdV (2006) *Documentation on the Modelling of Geoinformation of Official Surveying and mapping in Germany* GeoInfo Doc Version 5.1, The AdV working group Information and Communication Technology, Germany

ESRI (2009) *What is a cadastral fabric?* ArcGIS Desktop 9.3 Help, Environmental Systems Research Institute, Redlands, California, United States of America http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=What%20is%20a%20cadastral%20fabric%3F

Jahn, C.H (2008) *SAPOS – Part of a Geosensor Network* International GNSS Symposium 2008, Amtliches Deutsches Vermessungswesen (AdV), Germany

Lodge, C (2009) *Why is this lot "unplatted"?* The Talon Group http://talonnw.typepad.com/talon_northwest_neighborh/2009/12/what-exactly-is-a-legal-description.html

LPMA (2009) *Glossary* Land and Property Management Authority, New South Wales, Australia http://rgdirections.lands.nsw.gov.au/glossary?107691_result_page=C

Mayer, P., Pemberton, A. (2000) *A Short History of Land Registration in England and Wales* HM Land Registry, London, England

NSW Government (2010) *Surveying and Spatial Information Act 2002 No 83* New South Wales Government, Australia http://www.legislation.nsw.gov.au/view/inforce/act+83+2002+pt.1+0+N/

Seifert, M (2006) *AAA – The Contribution of the AdV in an Increasing European Spatial Data Infrastructure – The German Way* Shaping the Change, XXIII FIG Congress, Munich, Germany