Cadastral Modelling and the Role of the Government Surveyor

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ABSTRACT

Industry must adapt to changes in technology to be successful and digital database technology together with cadastral modelling will challenge the future of surveyors. While governance in survey and titling roles is weighed down by variables beyond commercial existence, such as statutory requirements, there is significant scope for improvement in these areas. In the past, survey plans modelled the cadastre and surveyors were necessary to locate boundaries. That historical cadastre will be modelled more effectively in a digital database, and accurate measurement tools are more freely available. Already there is a perception that anyone will be able to identify their boundaries with a Global Positioning System (GPS) device. This is not an unreasonable assumption based on the technology. However, under our current Torrens system of governance, a Registered Surveyor will always be required for boundary definition and validation. Understanding the status and opportunities presented by cadastral modelling will be vital to the role of the government surveyor in order to be relevant in integrated data management systems. This paper discusses how the digital environment can provide considerable efficiencies in survey and land administration and how it is critical that the survey profession is foremost in the transition from measurement-based systems of the past to the position-based systems of the future. Accuracy and data integrity in the database will be the key to those efficiencies and that will be provided by integrating as much historical measurement data as economically possible to model the real-world cadastre. The authors have been involved in modelling survey data for cadastral databases for government and infrastructure projects across Australia and pursue the agenda that surveyors must be an integral part of the process. This includes long-time survey data modelling in the Northern Territory, the NSW ePlan pilot and a 'whole of state' integration project in Tasmania.

KEYWORDS: *Survey data modelling, cadastral databases.*

1 INTRODUCTION

In the earliest times in Australia's history, the Surveyor General was considered the leading public servant based on the importance of their technical skills and contribution to the society. That relative status has changed over time and, similarly, the survey profession is facing many challenges. Surveyors have always embraced measurement and computing technology but the extent of change in wider technology now threatens aspects of the surveyor's role and challenges them to remain relevant to our property-based economy that is now being managed in a digital database environment.

This paper discusses how the digital environment can provide considerable efficiencies in survey and land administration, how it is critical that the survey profession is foremost in the transition from measurement-based systems of the past to the position-based systems of the future, and the role of the government surveyor in regards to these developments.

2 EXISTING SPATIAL DATABASE STRUCTURE

Geographic Information System (GIS) property layers in land administration databases have grown in relevance since their introduction. Their first use was a pictorial representation of spatial information in the same way early survey plans provided measurements as a guide to locate monuments or survey marks. Measurements on modern survey plans are now relied on to accurately represent property boundaries. This is a realistic premise which is underpinned by technology. In the past there was no option as to how those measurements were represented, but digital technology and coordinates do provide an alternative way to represent measurements.

The role of the cadastral database is now taking over the role of supplying freely available boundary information and the available technology generates the perception that this information is accurate because it has 3 decimal places and is supplied by the government. Original GIS cadastres were generated by mapping solutions such as digitising 'charting' maps. They represented the spatial relationships of properties for land administration purposes. The effectiveness of that role grew as the capacity of GIS technology grew. The accuracy could vary considerably but initially this was not relevant as computing technology limited the accuracy of GIS coordinates. The introduction of computers using 64 bit integers has overcome that limitation but existing databases generally retain that lesser spatial accuracy with the extent of the accuracy variations being unknown. The application of GIS grew from general land administration into infrastructure management and accuracy became important to its effectiveness, particularly at a local level.

3 THE DIGITAL SPATIAL DATABASE FUTURE

Technology is providing new and better tools that include:
- Distance measurement.
- Position measurement, e.g. using GPS/GNSS or mobile telephones.
- Imagery, e.g. via satellite, aircraft, drone or toys.
- LiDAR.

Whilst technology is changing, the rate of change in that technology is also a big challenge. It is considered that a significant amount of information has a spatial component and technology is providing powerful tools to represent that information in a spatial context. The importance of this is recognised at the highest levels with a federal Office of Spatial Policy (OSP). The federal budget is now spatially enabled to provide evidence of how and where funds are being distributed.

Another trend is that the digital possibilities provided by GIS technology is seeing a focus on larger and more complex systems to meet the e-government agenda and considerable resources are being pushed in this direction. The focus on the expenditure is moving to management and delivery systems as well as the data component.

For many years, surveyors were never challenged in their role as map makers. GIS systems then provided a rapid means to generate colourful and informative maps that management soon recognised as an effective way to manage and inform, so GIS has grown rapidly. Technical capability has allowed GIS to expand into 3D visualisation, which raises the bar on effective management and representation of information. At all levels of government and marketing, interactive 3D modelling and visualisation is seen as a powerful tool of influence and decision making.

4 THE DIGITAL CADASTRAL FUTURE

The future will see a transition from a measurement-based title system to a position-based system, driven by technology. Accurate measurement technology is no longer restricted to the domain of the surveyor but boundary definition and creation and legally validating measurements still requires statutory recognition and surveyor registration.

There are various terminologies in use that can have different meanings, but for a homogeneous future it is important those definition nuances are understood. They include:

- Survey Accurate Cadastre (SAC) – A true SAC would require every boundary to be defined on the ground by a Registered Surveyor and accurately coordinated. The level of precision would be high but the method of compilation would not be economically realistic.
- Coordinated Cadastre (CC) – All databases are coordinated and as such this is a generic term that refers to any cadastral database. The status of any CC is subject to the method of creation and any governance.
- Survey Data Model (SDM) – The SDM technology is based on the process where survey measurement data from all sources (current and historical) are input to generate a geometry model. The process applies a Least Squares Adjustment (LSA) to the measurement data based on the age or quality of the data. Thus, modern measurements would generally carry a higher weighting in the LSA than older measurements using lesser technology.
- Survey Accurate Cadastral Model (SACM) – Based on the SDM above.
- Numerical Cadastral Database (NCDB) – A term that is considered an outcome of the SDM as the input to the cadastral model are numerical survey measurements.
- Parcel Fabric (PF) – The Esri Corporation has licensed an SDM process as the cadastral management engine within the ArcGIS technology, in use by governments and the private sector around the world. The terminology is based on the premise that the outcome is a seamless ‘fabric’ of property, replicating the real-world cadastre.

5 THE SURVEY DATA MODEL (SDM)

GIS representations of the cadastre have always been coordinate based, as coordinates are the most efficient way to digitally record the outcomes of geometry computations. Survey coordinate geometry software has also always been coordinate based. Measurements are input and computations completed with all outcomes stored as coordinates. Survey plan measurement outcomes are then computed from that coordinate database and produced as spatial records to meet current statutory titling requirements. Thus coordinates are already at the core of our survey systems with office and field digital systems.

Our current property governance is based on the Torrens title system where registered survey plans represent monuments placed or adopted on the ground. Redefining the location of those existing boundaries is an intuitive process that considers various factors. The highest weighting in that evidence is the location of original survey marks or monuments. Other factors to consider include measurements on survey plans and occupations. It is an intuitive process and the outcomes are recorded on registered survey plans. Being an intuitive process makes it difficult to replicate in a digital workflow.

The legal survey boundary definition process is rigorous and surveyors have workflows that validate their work. Surveyors recognise that to provide a legal outcome that they will endorse, this must be the case. While the SDM process does not generally provide a legal outcome, it has several levels of validation to get the most accurate outcome in the database. Measurements shown on registered survey plans have a legal status and a unique aspect of the SDM process is that those original measurements are stored inside the system and contribute to the adjustment outcome. This reflects the fact that all historical survey plans have remained accessible and often are utilised in a boundary definition.

The GIS world has always been focussed on the speedy delivery of information and this is reflected in the way cadastral databases have been created. The rigour in the SDM process has meant that a speedy delivery was not always possible and the SDM process was initially not readily accepted in the database environment. Now there is recognition that accuracy of the database is a critical component for efficiency of management and operations and as such there has been an acceptance that the extra up-front cost of developing an NCDB is justified. The true business case is that those costs are amortised very quickly by efficiencies in operations. There is also the case that many problems caused by inaccurate cadastral databases are not correctly attributed. The case where such inaccuracies could contribute to the severing of an optical fibre cable is not unrealistic. The cost ramifications for this type of incident are substantial. A validated accurate cadastral database can mean that liability for such an incident can be apportioned more directly. Thus, an accurate SDM should be seen as a powerful risk management tool.

The technical level and legal status of any database needs to be recognised. Many people unknowingly use them for various spatial identification without knowledge of the quality of the information.

6 CADASTRAL MODELLING PROJECTS

Implementation of the SDM technology has occurred at various levels in Australia and the U.S. The range of projects considered in this paper includes:

1. Northern Territory – A territory-wide SDM has been generated by entering the measurement data from most of the survey plans. This has included survey traverses that define boundaries of pastoral leases of up to 80 km. Whilst the traverse generally follows a line defined by a specific latitude, traverse pegs defining the boundary have been placed which gives them a monument status. The boundary traverse is replicated in the model such that these pegs are effectively coordinated and the slight angle variations between them are represented in the model. The NCDB will support NT legislation enacted in the 1990s, enabling land titles to be legally defined by coordinates in the future.

2. New South Wales – In the ePlan project undertaken by Land and Property Information (LPI, 2013a), the SDM technology has facilitated the development of a portal lodgement of LandXML survey plans with immediate validation testing followed by automated spatial examination. This is currently in an implementation stage and results in considerable savings in time and resources with respect to the registration of survey plans.
3. Tasmania – A pilot project aimed at testing the outcomes of replacing the Tasmanian Digital Cadastral Database (DCDB) structure with the NCDB structure is being undertaken. The conversion of the DCDB data into the NCDB structure should enable increased efficiency and effectiveness in updating accuracy and land administration processes within the existing Department of Primary Industries, Parks, Water and Environment (DPIPWE) systems and workflows. As part of the process, measurement data from new and old survey plans will be entered into the model and stored where beneficial.
4. Infrastructure projects – accurate SDMs are being generated for the spatial foundation of large and small projects. The initial planning and design of these projects benefit at the earliest times with a minimum of field work required. The model should be managed and upgraded during the life of the construction stage so that an accurate asset management database will be provided to the client at handover.

7 THE ROLE OF THE GOVERNMENT SURVEYOR

Government surveyors at the highest level have played a key role in the development and maintenance of our cadastral system and this continues today. In the light of changes in technology, they regularly review the laws and regulations for cadastral surveys and work with the parliamentary draftsmen to draft changes. Government cadastral surveys also are a solid anchor in the overall plan network. Because they are not subject to the same cost and time constraints as the private sector, they have the ability to do a more thorough and detailed analysis of an area if this is required. In many ways, government surveyors ‘set the standard’ with their work.

Over the years, it has been initiatives from the government sector that have brought in major changes such as survey coordination, integration of surveys, the ePlan process and Continuously Operating Reference Station (CORS) network infrastructure. While the survey profession as a whole readily adapts changes in instrument technology, the government sector has to manage the infrastructure and record systems that underpin the cadastral system.

The complexity of modern Strata, Stratum and Community title plans are a challenge to the current record system. It is likely that our 2D ‘plan-based’ cadastre will have to be replaced with a 3D GIS system. The design of this system and its method of management will be critical to the efficiency of the whole titling system. Cadastral modelling is a proven technology that could be used to build and maintain such a system, but this will need some fundamental re-thinking about the whole cadastral process. If you look at a modern survey plan, how much of the information on that plan is essential to the maintenance of the cadastre and how much is there simply because we have ‘always done it that way’? Now that the CORSnet-NSW infrastructure (Janssen et al., 2011; LPI, 2013b) is established, is there any point in placing more PMs and SSMs?

Existing GIS cadastral systems such as the DCDB are really ‘passive’ in that the fabric is updated some time after plan examination has been completed. However, there is no reason why the checking and charting process should not update the DCDB in real time and post the results on the web. In other words, the titles office would generate and maintain a cadastral model of the state as part of the checking and charting process for new plans. Then we would have one 'point of truth' for the DCDB and it would be 'up to date' and of known accuracy. At present, there are over a hundred versions of the DCDB in NSW, each different and each maintained by a local organisation. They have been built and developed to satisfy local needs in regards to accuracy and timeliness of the data. The need to maintain all these different versions would disappear if this reform were carried out.

Such a change would mean a complete reassessment of workflows and job tasks but that will have to happen eventually anyway. The government surveyors are in a unique position to direct change, but to do so they will need to really grasp the full implications of developments in technology in order to take full opportunity from these changes.

An SDM database will benefit the State and will entrench the role of the survey in managing the database, but the ability to output a survey database to stakeholders means that surveyors will receive much more intelligent information to use in their surveys and they will just as efficiently be able to feed more intelligent data back, for the benefit of the database. At a time where there are fewer resources across all jurisdictions, these efficiencies are needed.

At local or service authority level, the field survey role is similarly diminishing. Where location information of local government or service infrastructure was required, the surveyor was the 'go-to' person for maps and plans. This is not the case anymore as the GIS manager is the 'go-to' person now. If they are an informed operator, they would seek the counsel of a surveyor where there are issues of boundary location, but often they do not. The only way to overcome this is an awareness of seeking the counsel of a surveyor wherever possible problems exist. Many government surveyors are now data or database managers. It must be ensured that authorities look to surveyors for validation of the database environment.

How the survey database and cadastral modelling process is introduced will determine the role of the cadastral surveyor. The surveyor's role under the Torrens title system is not under threat unless changes are made to the legislation to 'dumb down' the level of spatial validation. If that happens, it will be a progression towards title insurance, which was introduced to support systems that do not have the legal strength and spatial indefeasibility of the Torrens system.

8 CONCLUDING REMARKS

This paper has discussed how the digital environment can provide considerable efficiencies in survey and land administration and how it is critical that the survey profession is foremost in the transition from measurement-based systems of the past to the position-based systems of the future. The important role of the government surveyor in regards to these developments has also been outlined.

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