Comparisons of Process Automation in Cadastral Digitisation Implementations in Australia - From Fit for Purpose to Digital Rigour in Spatial and Transaction Processes.

Ian HARPER, Australia

Key words: surveying, automation, cadastre, survey database

SUMMARY

Most States in Australia are implementing cadastral digitisation processes with varied levels of machine readable survey content that facilitate survey and land title process automation. This presentation looks at different systems across Australia and specifically compares different systems we have supported in Northern Territory (NT) and New South Wales (NSW).

NSW and the NT are different in every aspect but they have both progressed implementations of digital survey and cadastral processes and provide examples of different levels of automation through validating and examining XML(1) text files representing survey plan data.

As of July 2017 the NT has mandated all survey plan lodgments to be completely digital but with a mixture of formats that is each fit for purpose. The process requires surveyors to lodge digital images of new survey plans and a file of machine readable content of certain parts of the plan for a degree of automation. Surveyors are also required to provide a Plan Examination Report generated by their COTS survey database application. The NT approach is minimalist but scalable if more rigour or cadastral intelligence is required in the future.

NSW has taken a more rigorous approach by mandating to represent every element of a survey plan in a machine readable LandXML(2) structure with the aim to automate as much of the plan examination process as possible. The intuitive input of surveyors into boundary reinstatement in older areas challenges the capacity to apply rigid digital processes to a software based examination solution but Seaconis Inc has provided NSW with a unique rigorous automated examination environment (PlanTest).

This presentation comments on areas of technical complexity and automation, market acceptance and levels of integration into digital land administration between the 2 jurisdictions.

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1. INTRODUCTION

The cadastral digitisation process is part of the transition from measurement based land title systems to the digital position based land title systems of the future. It also facilitates the transition from manual systems to automated processes in survey/title data creation, examination, database management, transactions and facilitation of future transactional applications (Blockchain).

Coordinates are the most efficient way to store measurements and computational outcomes in a digital environment as well as spatially representing a specific location in a reference frame. They underpin the role that spatial databases now play in our society.

The Torrens System is standard across Australia and survey measurement tools and methods are the same but in different states the detail of survey plan cadastral content, statutory survey requirements and methods of examination vary significantly. This has challenged the concept of easily standardising the ePlan data structure as experienced by the Intergovernmental Committee of Survey and Mapping (ICSM) ePlan Project team.

This presentation will focus on what has been achieved in the management and examination of that data based on our Company's involvement in that transition in NSW and the NT over the last 15 years. Consultant engagements or pilot projects allow us to also provide some feedback from other jurisdictions however we are not able to report first hand on the status of Western Australia or more recent developments in Queensland.

Seaconis Inc President Curt Wilkinson provides input from his experiences in developing rigorous automated examination applications for NSW and Singapore and is currently engaged on a Pilot Project with Land Services South Australia (LSSA) with the aim of providing similar applications.

3D cadastre is at the forefront of the cadastral digitisation wish list in most jurisdictions. 3D ownership spaces are currently represented by Strata Survey Plans which provide virtually no measurement details because the Strata property boundaries are designated as the faces or centres of walls, ceilings, floors etc, and are physically evident to all stakeholders. Services (water electricity, etc) are protected by easements but also without any information relating to their accurate location. Trying to mathematically represent these entities in 3D raises the level of digital detail required many times. This takes it to the point that it is currently not economically sustainable unless a BIM model is available and that is only happening in major buildings. Whilst limited in detail, the current Strata Title Legislation and strata survey plan

representation is a very efficient way of simply representing a very complex ownership arrangement. Back capturing existing strata plans will also be a challenge.

Digital transactions through Blockchain are on the horizon and property should be viewed as a tradable commodity in that domain. Blockchain can offer security in transactions at reduced costs but in such unfamiliar territory for most, the security of tenure and spatial certainty become even more critical.

As we move forward in the transition we need to look at the how we use technology to better analyse and manage survey and cadastral data without necessarily automating the manual processes of the past. The digital cadastral future is clear with modern data, but digitisation of the cadastral jigsaw suffers because all the the old pieces don't fit together. This will not change for some time yet.

2. BACKGROUND

The Torrens Title System developed in South Australia has always been considered one of the more effective title systems. Government maintains a register of land titles with a comprehensive record of ownership and the Restrictions, Rights and Responsibilities (FIG, 2005) related to that land. Government provides a guarantee of title (indefeasibility) but does not guarantee the dimensions or spatial extents based on the fact that older survey plan dimensions may vary slightly from the accurate distance between monuments. Spatially it is based on the premise of "monument over measurement" that dictates any monument or survey mark placed by the original surveyor determines the location of a boundary, irrespective of any measurements on a survey plan defining a Title.

Licensed/Registered surveyors use older plans as a guide to re-establish the original location and where there is some difference they provide a new survey plan and geometric representation of that title that replaces the historical reference on the Title Register. Where uncertainty exists, the surveyor makes an intuitive decision based on survey monuments, measurements and site occupations and prepares a plan with content reflecting the basis of their decision to be Registered at the Titles Office as the Title diagram.

The underlying premise of the survey plan is to satisfy the Land Title examiners that the recorded spatial extents of the land titles surrounding the subject property are not compromised. This reflects how existing adjoining survey plans represent a local cadastral data management solution with legal status. The Digital Cadastral DataBase (DCDB) is a strategic spatial solution or model with no legal status.

In land development areas of modern surveys, high accuracy and the coordinated database storage has overcome the issue of historical uncertainties. As we move into the digital transition, coordinates can become the monuments in the Torrens system. This requires a change to Survey Regulations or Legislation to facilitate this. The NT has done this and South Australia has the Legislation in place but have not utilised it to the best of our knowledge.

Whilst coordinates could be used to spatially define land titles under the Torrens System, there should be discretion applied where a surveyor may be able to prove that a coordinate does not truly represent a corner based on historical survey data. This would be resolved by a Licensed/Registered surveyor providing evidence that this is the case and the Land Titles Office amending their authoritative database to reflect that spatial improvement. This simply reflects current practise where Licensed/Registered surveyors submit survey plans of redefinition to more correctly define a title. Once registered that plan is the defining legal spatial document.

This also highlights how time will become an attribute of a title. As referenced above, government does not guarantee parcel dimensions and that could carry through the transition, but the critical thing is that surveyors particularly, or other stakeholders must access the current database values for property spatial definition. This takes into consideration that the database is dynamic with coordinates being spatially upgraded at various times or the geodetic nework is re-adjusted or subject to a GDA 2020 type shift.

Digital spatial databases are now critical to management of land, utilities and other social infrastructure. Spatial precision adds further value to that management and there is no technical reason that the digital transition to an authoritive digital database cannot occur now in modern land development areas so the automation processes being introduced can be utilised to their maximum. There are however many legal and administrative issues to resolve.

Automated processes can only occur where all elements are digitally defined by a Unique Identifier which should flow on from existing practices. Digital property transactions (e-conveyancing) through the Property Exchange Australia (PEXA) are now the norm, replacing the need for representatives of vendors, purchasers, lawyers, banks or other interested parties to arrange a meeting and exchange documents and cheques. Feedback from many lawyers and conveyancers is positive. Once they have taken the 'leap' and invested the time to undersatnd the process they recognise the positives for all stakeholders.

Underpinning automation is the need to create a data model of all variations of survey plan content that is required to be represented in machine readable language so that a software application can recognise that content and test it against specific standard notations or if it is within a certain spatial accuracy criteria.

Automated plan examination processes developed in Australia for LXML files have been developed at 3 levels:

- LandXML schema validation. This is often a simple XML validation of the standard LandXML schema, or some subset of the standard performed as part of a web portal. It may also include some ICSM LandXML schema elements and attributes, as well as schema structure validation. The main purpose is to ensure that the file has been encoded at the base level of compatibility for submission and further processing.

- Portals may also have additional validation that evaluates the data submitted at a nominal level. This is most often related to administrative aspects needed to accept the plan for

lodgment, but may also include quantitative checks for the number of parcels and even parcel misclose or area calculations.

- Deeper examination of the submitted survey data and its adherence to prior surveys and database records requires a more advanced system and the use of specialised software such as PlanTest (Seaconis). See Diagram 1 for screen shot example. This deeper examination tests adherence to both survey regulation and to the original measurement record. This involves extensive geometric and contextual calculation and rules application to ensure a comprehensive and rigorous validation. The examination usually has specific workflows of tests that are triggered for the plan type, or other conditions. Visual as well as automated tests make up an extensive checklist. Results presentation is integrated with tools and dynamic presentation to allow advanced investigation by cadastral officers.

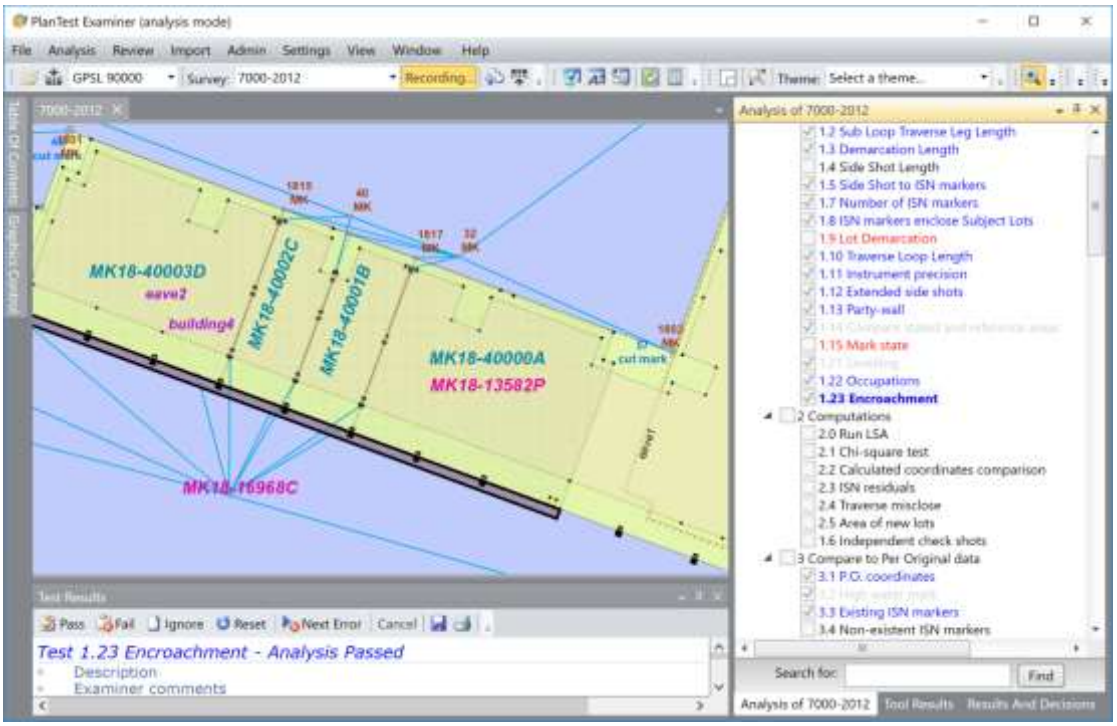

Diagram 1 – Screen Shot from PlanTest

The first two categories are generally employed in a portal to filter poorly prepared submissions, rapidly returning reports and instructions to lodging parties to help them rectify errors and omissions. This reduces cadastral examination staff effort, which can be directed to more difficult situations needing experienced judgment.

Different jurisdictions have applied variations of the above examination levels as part of their digitisation introduction as outlined below.

3. AN OVERVIEW OF LEVELS OF DIGITISATION IN SURVEY AND CADASTRAL MANAGEMENT IN AUSTRALIAN JURISDICTIONS

Around 2003 the ICSM ePlan Committee was formed with representatives from all States and Territories. That committee would later include New Zealand & Singapore. The intent was to initially progress a National Standard that would represent the original measurement and administration information of a survey plan in a machine readable (text) form that will lead to the capacity for fully automated lodgement and examination to replace manual processing.

The technical agenda was initially driven by Queensland and then with NSW and Victoria, development continued while the remaining States and Territories stepped back to assess the outcomes. The LandXML survey schema developed by New Zealand was adopted with the aim to represent every component of a survey plan in a machine readable text structure and be able to reproduce or render an image of that complete plan content from that text file.

The ICSM data model standard grew as different jurisdictions required consideration of data and processes that was specific to their jurisdiction. Each jurisdiction needed all their varied measurement types, notations etc to be included in the data model so their examination tools could automatically recognise and validate the content.

As referenced in the introduction, survey measurement tools and underlying geometry is the same but the detail of survey plan cadastral content, statutory survey requirements and methods of examination vary significantly. Whilst the ICSM LandXML data model could be standardised, each jurisdiction faces a separate challenge in progressing the automation of the examination process.

Whilst this presentation is focused on the comparison of the directions taken by NSW and the Northern Territory a brief outline of the status of other stakeholders is included:

1.1 Victoria

Victoria progressed the ePlan process for many years as part of the Surveying and Planning process through Electronic Applications and Referrals (SPEAR) process. This links the LandXML file into the planning and approvals process as the name suggests. For many years the LXML file contained the basic parcel geometry and cadastral intelligence needed for that purpose. SPEAR is highly regarded as effective on-line lodgement, management and tracking tool in the land development process.

In recent times the focus has returned to the automated validation of the LXML survey plan content and Victorian Department of Environment, Land, Water and Planning (DELWP) has introduced the automated lodgement validation of geometry and content (including 130 validation rules) with a pilot project of selected surveyors submitting LXML plan files. This is in line with stages 1 & 2 of ePlan automation.

In 2018 DELWP announced it had secured funding for a major Digital Cadastre Modernisation (DCM) project, as outlined in the Advance Tender notice:

DELWP is upgrading the spatial accuracy of the state's digital representation of property boundaries (the authoritative digital cadastre) for the state's 3.3 million properties. An upgraded digital cadastre will deliver significant quality and efficiency improvements for sectors including land development,surveying, planning, utilities, emergency services and infrastructure development. The DCM willdeliver spatial accuracy of up to 0.1 metre for urban and 0.5 metres for rural land.

The project is broken down into 4 inter-related stages:
STAGE 1 - Back capture: *This stage will accurately capture specified data from PDF copies of registered plans and cadastral surveys into digital format LandXML files. This stage will also include the capture of particular features from aerial imagery. The Tender will seek proposals to deliver back capture services for the entire state.*

STAGE 2 - Adjustment: *Initially, the analysis and validation of the back captured data obtained from stage 1 will be required. This will be followed by calculation and validation of the coordinates and uncertainties for all land parcel corners from back captured files and Victoria's Survey ControlNetwork. DELWP has bespoke software that may assist with the adjustment process, which can be licensed free of charge to the service provider.*

STAGE 3 - Integration: *Integrating the upgraded digital cadastre from STAGE 2 into the state's authoritative map base (Vicmap™). Note that the DCM upgrade coincides with the next re-tender of the ongoing maintenance contract for Vicmap™, and it is possible there will be an opportunity for vendors to bid for both the integration stage and ongoing maintenance.*

STAGE 4 *- Automation: Enhancing DELWP's existing corporate systems to fully automate the process of updating Victoria's digital cadastre with new data (such as new sub-divisions) lodged in a digital format through SPEAR.*

Currently the Stage 1 Back capture has been awarded and is under way. Proposals for the following stages have been received at the time of writing.

DELWP is also moving forward with plan rendering from the LXML file, generating an image of the parcel and other geometry. They have developed on-line applications for surveyors to edit the content to improve legibility and remove ovelapping text etc.

1.2 South Australia

South Australia had until recently not been actively involved in ICSM ePlan development. In 2017 the private entity Land Services South Australia (LSSA) was the successful bidder to take over the processing of land transaction services for the next 40 years. **Land Services SA chairwoman Dr Annabelle Bennett said the consortium aimed to "enhance customers'**

experience, improve registration processing times and invest in electronically-delivered services". (The Advertiser-August 10, 2017)

Part of that investment in electronically delivered services has seen the engagement of Seaconis Inc to undertake a Pilot Project implementing the Plan Test application for rigorous automated digital spatial examination of survey plans represented as CEXML [(4)] files.

A comment from Curt Wilkinson about the pilot project - *"Initial attempts to apply concepts models and analytic approaches developed for NSW to the SA cadastre showed the SA and NSW to actually be quite different. The survey and base fabric geometry are very much similar, but the approach to applying a new survey over the existing fabric and the selection of what aspects are important to the regulations are interestingly varied"* .

Once the plan is Registered the CEXML file is joined to the departmental ESRI Parcel Fabric cadastral database where spatial upgrading can follow by adjusting a relevant section of the Parcel Fabric with the new survey.

1.3 Tasmania

Tasmania is still considering digital formats and processes to adopt.

1.4 The Australian Capital Territory (ACT)

The **ACT** is similar to Tasmania but has less historical cadastral 'baggage'. Canberra is a new City and as most surveys are modern, the spatial precision of the authoritative cadastral data base is high. The office of the Surveyor General and Land Information takes advantage of that precision by requiring new developments to adopt the coordinates of the extents of their development as supplied by the Department.

Final Survey Plan examination then becomes a process of confirming that the outer boundary of the development matches the database supplied and the internal geometry meets all required planning and survey integrity. As all the survey data can be transferred digitally, automation of the examination will be a straight forward process.

1.5 New South Wales (NSW)

NSW has progressed the ICSM LXML ePlan structure to implementation of all 3 levels of automated examination as outlined in the "background" above and pursued rendering a plan image from the LXML file.

Diagram 2 below shows the level of content in a modern NSW survey plan. It should be noted that great foresight was shown by NSW 20 – 30 years ago when they began mandating that where reasonble, all surveys should include surveyed connections to coordinated survey control marks in the vicinity of the survey. This is paying dividends today in providing a significant resource in building an accurate strategic survey database.

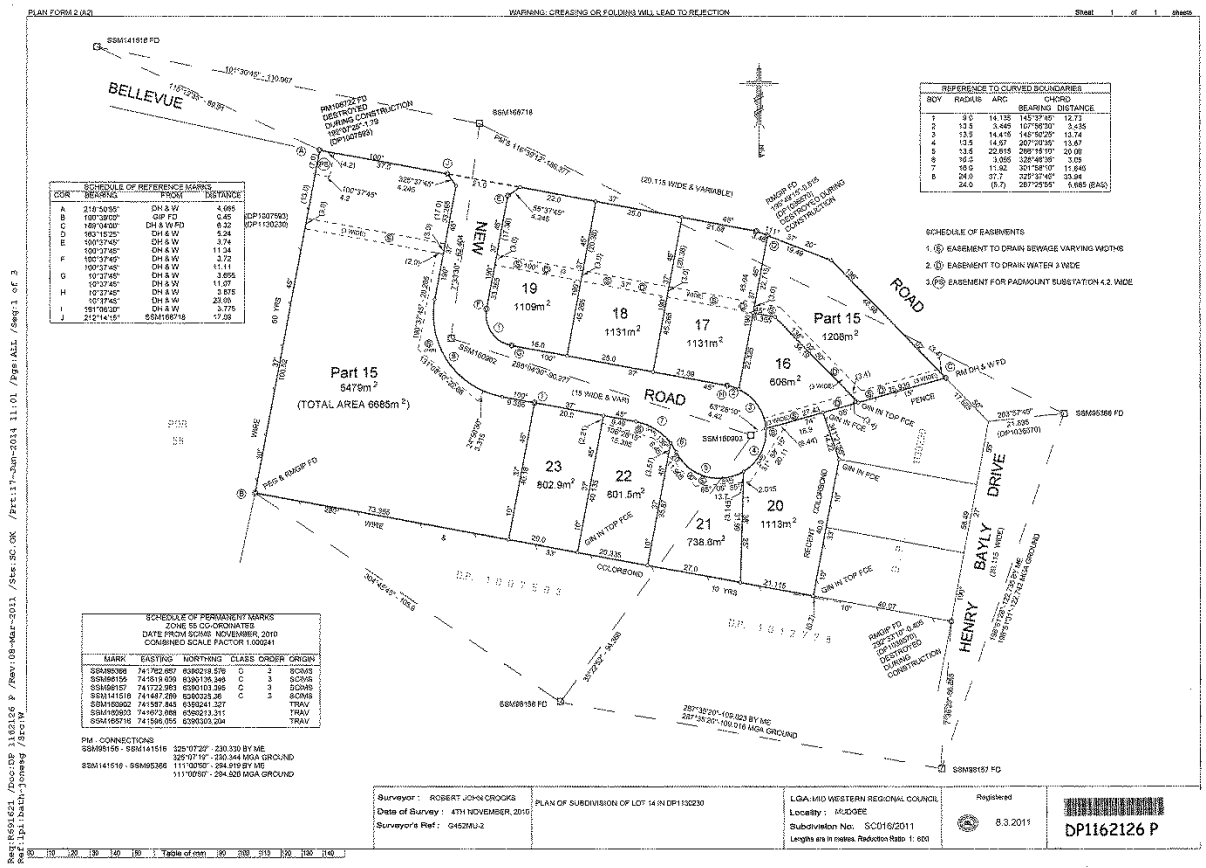

Diagram 2 - Example of content required to be represented in a LXML file

The ePlan challenge was originally embraced by the then NSW Land and Property Information (LPI) and they developed it through to implementation until recent times when that role moved to being managed by NSW Land Registry Services (LRS) which is the private operator of land titling and registry operations in NSW.

The NSW ePlan schema/recipe represents every component of the survey plan in machine readable form. LPI & now LRS have been refining the process and promoting it to surveyors to embrace it. The uptake from surveyors has always been disappointing with approx 20% of surveyors having used the LXML ePlan.

This could be put down in part with the cost of the survey software extensions required but more likely the time required to commit to learning how to prepare the LXML file. Like most applications it is not difficult but does require the effort to understand, but once it is done a few times it is usually not a problem.

The measurements and notations shown on a plan must populate the correct fields in line with the data model. The complexity of representing all the annotation noted on a survey plan has challenged the rigid rules of software to match the intuitive decisions made by a draftsperson

and move towards an automated coherent digital representation (rendering), so complete plan rendering from the LXML file is still work in progress.

Whilst a higher level of adoption by surveyors is being sought, the statistics relating to the relative number of number of new parcels registered through LXML ePlan is approaching 30%. This reflects that a high percentage of larger 'green field' subdivision developments are lodged as LXML files. These plans have a minimum of notations outside the required level for statutory requirements of measurement, lot naming, areas, reference marks, jurisdictional, etc protocols.

Property extents and parcel geometry is usually locked down across these large development areas or even suburbs at an early stage so there is spatial certainty within parcels and between plans. The outcome is that these plans can be Registered within 3 days if everything in the LXML file meets Legislative, juridictional and spatial requirements, so informed land developers are requiring LXML ePlan lodgement. Savvy surveyors are able to market this outcome

The Plan Test application was initially developed by Seaconis for the examination of LXML survey plan files in NSW. As the LXML file only represents the plan being examined, the LXML file is converted to an ACS[3] /CEXML parcel fabric structure. A local CEXML parcel fabric database is built from the existing plan/plans and surrounding plans where original parcel ground dimensions are stored and used in the Plan Test examination analysis.

This parcel fabric survey database provides the examiner with powerful digital options in comparing new measurements with original plan measurements in a strategic database environment rather than the historical manual methods using notes written on various plans and using different coloured hi-lighters to provide strategic reference across plans.

Several years ago NSW also commenced a project to back capture all survey plans so there would be a LXML file for every plan to feed into the digital environment of all stakeholders. The LMXL files will be available to improve the spatial quality of the Digital Cadastral DataBase (DCDB) managed by NSW Spatial Services.

A LXML schema for Strata Plans is also undergoing live testing by LRS so LXML Strata Plan files can be examined. As Strata Plans are a spatial subdivision of existing land titles there is no need for rigorous boundary comparisons, so testing will be focussed on the data content as per examination Stages 1 and 2.

NSW Spatial Services is also demonstrating pilot projects of 3D cadastral modelling of Strata Plans.

1.6 Northern Territory (NT)

The underlying comparison with NSW is that the NT has has approximately 85,000 land parcels compared with 4 million parcels in NSW so the issues are different in every respect.

The NT covers over 1.3 million sq kms and is sparsely populated with approximately 250,000 people mainly in several urban areas. Pastoral Leases can cover large expanses and in the past these boundaries (up to 80km) were traversed by survey parties but now GNSS surveys can do in 1 day what may have taken weeks or months in the past. The Surveyor General (SG) and the Department of Infrastructure, Planning and Logistics (DIPL) recognised the benefits of GNSS and a digital survey database over 20 years ago and introduced practises to take advantage of these new technologies.

DIPL has all but completed the back capture of survey plans into an ACS/CEXML parcel fabric survey database (SPICAD) which allows a progression to digital cadastral modelling and in 2004 legislated to allow coordinates to spatially define a title in certain areas (3 to date). The Surveyor General has discretion to declare these areas when he or she is satisfied that the cadastral database model is of suitable precision to represent the surveyed boundaries or a property is suitably defined by SPICAD.

SPICAD recently replaced the mapping based DCDB as the authoritive cadastral database. When new surveys are digitally lodged as an ACS (CEXML) file, a relevant 'packet' of parcels in a Parcel Fabric is extracted from SPICAD. As the original survey measurements are stored in SPICAD, this survey database packet is used for spatial examination in the GeoCadastre application. Comparisons of new survey measurements and existing survey measurements can be made or there are strategic options to compare new and old spatial database locations with relative precision reporting.

The size of the packet is based on the exent of cadastral and control plan measurements beyond the parcel being superceded plus what extents the examiner believes the effect of this new plan will have in spatially improving the surrounding database. Once the plan is registered, the packet is adjusted to include the new measurements and the subdivided parcel remains in the survey database with an 'historical' parcel designation. Historical parcels are not visible as part of a current cadastre but are always accessible. The outside of the packet is held fixed so it can be dropped back into SPICAD seamlessly.

As of July 2017 the SG has mandated all survey plan lodgements to be completely digital but with a mixture of formats that is each fit for purpose. The process requires surveyors to lodge a digital image of their new survey plan and an ACS file of machine readable text of certain content. That content relates to parcel dimensions and other measurements that can benefit the spatial upgrading of SPICAD or statutory jurisdictional content needed for transactions. Surveyors are also required to provide a Plan Examination Report generated by their GeoCadastre COTS survey database application. The NT approach is minimalist but scalable if more rigour or cadastral intelligence is required in the future.

Capture of basic components for 3D cadastre visualisation is now included in the process and those 3D attributes are stored in the survey database for future 3D modelling. See Diagram 3 below.

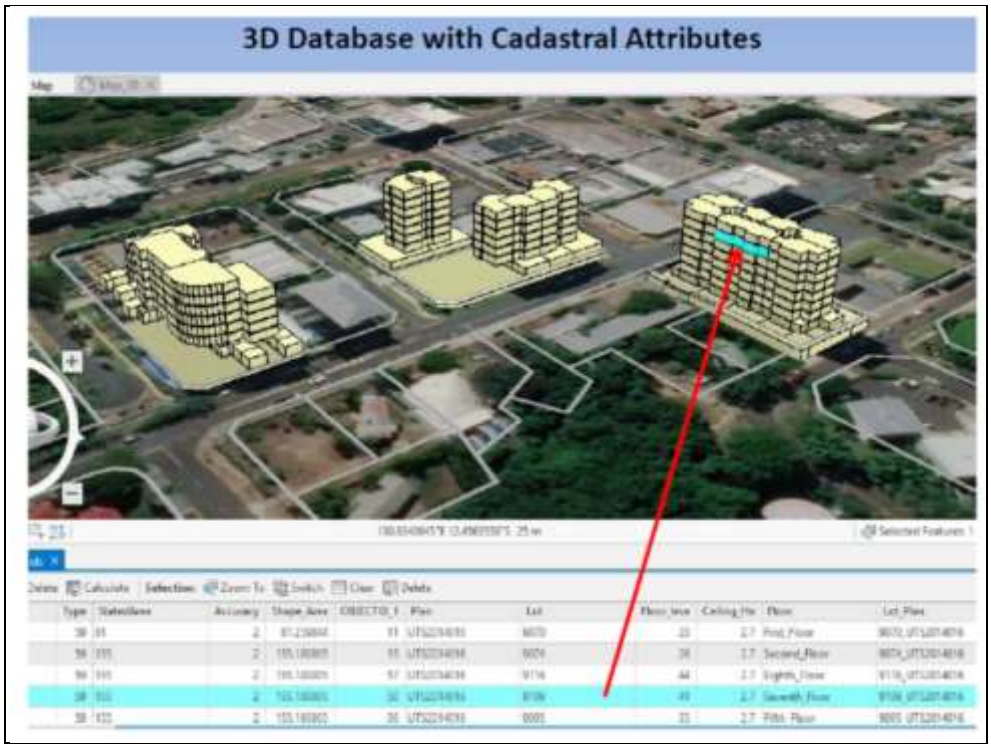

Diagram 3 - basic 3D modelling in Darwin

4. Conclusion

Over 200 years ago Australia began as a group of fiercely independent British self-governing colonies and even with Federation in 1901, the States retained that independance with little interest in working together. We have learnt that cadastres across Australia follow that history in the way they are very different, in spite of being based on the same geometric and practical fundamentals.

We need to look at how technology can manage the manual processes of the past and recognise that those survey practises were designed for line of sight measurement technology that is not relevant to GNSS. It would be ideal to rapidly change the way we do things to maximise the outcomes from technology but that is not going to happen. Whilst the historical survey data is the cadastral foundation, it is best not to be welded to the processes of the past but to look critically at the relevance to the future of all aspects of survey and spatial data, land titling and cadastal database management as part of the transition.

The lesson from the NSW / NT comparison is that technology can supply the simplest of tools for Fit for Purpose or the most rigorous solutions, but how much attention is given to the detail or giving due consideration to what level of detail needs to be digitally managed is the key to the strategic outcome. Digital databases can facilitate a higher level of survey data management and outcomes through rigorous processes like Least Squares Adjustments (LSA) but to function effectively require investment in resolving the detail like:

- **Topology** – no gaps or overlaps

- **Connectivity** between parcels across voids either with or without implied dimensions – e.g. Road widths are nominated on the plan but often no direct dimension is shown. In many jurisdictions this spatial constraint has the highest weighting in boundary reinstatement. In their surveys, surveyors may not provide measurements across a road as it can only raise more problems they must resolve. In a cadastral database environment we must provide that relationship.
- **Line Points** – a point type in the data model that retains a straight line in the adjusted model after side parcels that meet it, split that line. The main parcel retains the total boundary as its dimension attribute in the database. This is reflects a survey solution rather than a mapping solution where every point is a node and an LSA may introduce slight bends at that node and the main parcel boundary may also then be defined by all the split lines rather than one line shown on the plan.

Resolving aspects of the detail is highlighted by Victoria outlining a strategic path of various digitisation stages in their Digital Cadastre Modernisation project.

Overcoming the technical issues relating to data and applications is just the beginning. How Legislation is adapted rather than drastically changed is the only way it can happen. The importance of property assets and transactions to the state economy and personal financial security cannot be interrupted or suffer a loss of confidence in that system, so the transition will not happen quickly across the board.

The issues identified in this paper can relate to any jurisdiction in the world that is looking to digitally manage and examine measurements or spatial data (existing databases, imagery etc) to provide spatial definition and security of title into the future. Those involved in creating new standards and processes for a jurisdiction have to follow a commercially pragmatic path to make progress. Applying one process across a complete State often means it works well in some areas but not in others so flexibility of processes should also be a consideration. Adapting their own survey and title legislation and processes to international data models and data structures give the greatest chance of maximising the benefits of digitisation applications.

The transition is a major technical, commercial and governance challenge but the devil is truly in the detail.

DEFINITIONS

1. **XML - Extensible Markup Language - is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. – (Wikipedia)**
2. **LandXML - A version or schema designed to represent a field engineering and/or cadastral surveys developed in NZ**
3. **ACS – A text file format developed by Mike Fletcher for the Association of Consulting Surveyors (ACS) survey software (circa 1995)**
4. **CEXML – An XML schema replicating the ACS schema adopted by ESRI for the Parcel Editor (previously Cadastral Editor) Parcel Fabric survey database (Circa 2002)**

ACKNOWLEDGEMENTS

Curt WILKINSON – President of SEACONIS INC, USA,
Developer – Plan Test application. (cwilkinson@seaconis.com)
Michael ELFICK – Registered Surveyor & developer of GeoCadastre, Consultant to NT and NSW Survey and Titles Offices - Woodville, Australia, (elfick@bigpond.com)
Mike FLETCHER - Software engineer developer of GeoCadastre, GeoSurvey and Consultant to NT and NSW Survey and Titles Offices, (mike.fletcher@mimaka.com)
Chris WILCOX - Land XML Administrator , NSW Land Registry Services, (Chris.Wilcox@nswlrs.com.au)
Dr Hamed OLFAT | ePlan Coordinator | Electronic Subdivisions Unit | Chairman of Technical Committee | National ePlan Working Group - Land Use Victoria | Department of Environment, Land, Water and Planning (hamed.olfat@delwp.vic.gov.au)

BIOGRAPHICAL NOTES

IAN HARPER - Bachelor of Surveying – UNSW 1977 - Director Geodata Australia
Survey and Cadastral Database Consultant.

2003 - current **Survey & Cadastral Database Management** – Australia
- Creation and management of cadastral databases for local and state government and infrastructure projects across Australia
- Involved in implementation and pilot projects for digitisation of survey and title projects in Australia, India & Malaysia

1988 – 2002 Registered Surveyor and founding Director in a Survey, Planning and Environmental Consultancy – Australia
- Cadastral Surveying
- Land Development Project management

1980 – 1988 Graduate Surveyor, Cadastral and engineering survey experience – Australia, UK and Libya.

CONTACT

Ian Harper
Geodata Australia
148 Marks point road, Marks Point
Lake Macquarie 2280
AUSTRALIA
+61 (0) 412 453 170
harper@geodata.com.au
www.geodata.com.au