MERCURY
PROJECT SOLUTIONS

Implications of a Dynamic Datum on the Cadastre

Phase 1 Report

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Executive Summary

This document presents the outcomes of phase-1 of CRCSI Project 3.20: Implications of a Dynamic Datum on the Cadastre, conducted in partnership with NSW Spatial Services and ICSM.

The project's objectives are to document how the cadastre in NSW will be affected by adoption of a dynamic datum, establish and prioritise what tasks need to be undertaken to transition the cadastre in NSW to the dynamic datum (technically known as 'ATRF'), and to identify what new procedures and tools will be required for the on-going management of the cadastre once the dynamic datum has been adopted.

While the project scope is focussed on the NSW Cadastre, there are two underlying assumptions. Firstly, that the findings for Cadastre can be extended into other Foundation Datasets, and secondly that the findings for NSW can be largely aligned with findings from other jurisdictions.

Phase 1 of the project focused on establishing the impact of the dynamic datum. The impact assessment was conducted through a combination of literature review, and stratified stakeholder engagement by means of interviews, workshops and online user questionnaire.

The findings of the literature review and stakeholder engagement are summarised in Table 1. The findings are classified by strategic components: Data, Technology, Standards, People and Governance; and by impacts, barriers and future expectation.

The main conclusions from the findings is that while there will potentially be a positive impact of ATRF implementation on the NSW Cadastre, it will be subject to a nationally coordinated implementation that considers many technical, as well as non-technical aspects such as legal and governance issues, user awareness and training, and managing the risk of confusion and complication that might lead cadastral users to managing their own cadastral data, rather than the NSW DCDB.

The phase-1 findings will be further socialised and reviewed by other parties and jurisdictions and may evolve during the remainder of the project. In the meantime, they will form the basis for development of phase-2: the definition, prioritisation and resourcing estimates of the tasks needed to transition the NSW cadastre to ATRF.

Table 1 Summary of Findings

	ATRF Impacts	Barriers to implementation	Future State with ATRF
Data Cadastral workflow Related data Quality Accessibility	• Positive: GNSS field data will better match Cadastre • Impact on land development: 9% (of respondents) positive, 35% negative • Limited impact on survey plans lodged with NSW LRS (previously LPI) - regulatory requirement to connect to control network • Greater impact on related data when Cadastre moves • High impact in urban centres • Risk of reduced confidence	• NSW DCDB may have to be available in ATRF before user adoption • Variations in, and uncertainty about Cadastral accuracy • DCDB Cadastral update process 'not ready for ATRF' • No topological links with related data	• Sufficiently accurate NSW Cadastre, matching other datasets • Coordinates with known accuracy and reliability • DCDB, SCIMS, usable in both GDA2020 & ATRF • Default for source storage is plate-fixed (GDA2020) • Greater level of topological relationships with downstream/coincident datasets
Technology Architecture Interoperability Software Tools	• Up to 100 different software platforms to be updated • Users with legacy systems will need to upgrade	• 1st-mover disadvantage, software updates delayed • Current COTS can't handle ATRF & time-tagged data • Can we transforming bulk imagery 'on the fly'? • Slow user upgrades of legacy software • SCIMS & DCDB won't support multiple coordinates • Risk: solution looking for a problem (or making it worse)	• Technology deals with transformation, "it just works" • Transformations at point of supply, fully automated • Most COTS software tools are ATRF enabled (conform global standards)
Standards Data & Metadata Business Processes	• Increased reliance on proper metadata (with time tags)	• Confusion re. WGS84 • Some data formats (e.g. DXF) don't enable time-dependency • Legacy processes & (meta-) data standards • Dependence on international standards still under development	• Internationally mandated (meta-) data standards (time-enabled) • Standardised, automated, federated Cadastral supply chain
People Education Behaviours Communication	• "Short-term pain for long-time gain" • Increased effort & possible confusion • Risk: users will abandon NSW Cadastre and manage their own	• Highly variable understanding • Broader benefits variable, not well understood, or hard to articulate • Uncoordinated communication & messaging • No access to knowledge or best-practice examples • No consistent metadata management practice • Risk of confusion	• Change in human knowledge, behaviours and practices • "If you don't make it easy for people to do the right thing, you're wasting money on datum modernisation" • Education & best-practice materials available • End-users shielded
Organisational Legal/ Governance Funding Business Cases Policies	• "Do Nothing" is not an option • Impact & benefits will affect users differently between application domains and over time • Risk of Inconsistency in planning instruments, e.g. between ePlanning portal and 'paper' certificates • Other legislative dependencies: e.g. biodiversity legislation • May be expensive to implement • Little or no impact on legal status of cadastre	• 1st-mover disadvantage (globally) • Legacy datums prescribed in high-level legislation (e.g. NSW surveying Act) • Cadastre: plan is the legal basis vs. Planning act: DB is the legal basis • No jurisdictional implementation plans yet • Legislation and Regulation slow to catch-up • Unknown/prohibitive cost of adoption • Implementation of GDA2020 will impact ATRF timing	• Public awareness drives adoption & investment • User assistance easily accessible • Focus on user domains & applications with highest value proposition & positive ROI • Opening the door to co-ordinated Cadastre (DB is the legal basis)

Glossary & Definition of Terms

Term	Definition
AGD66	Australian Geodetic Datum 1966 (AGD66), since replaced with GDA94. http://www.icsm.gov.au/gda/agd.html
ATRF	Australian Terrestrial Reference Frame. Earth fixed, and therefore time dependent coordinate, reference frame
Cadastre NSW	Cadastre NSW is a Spatial Services program to address key barriers to the adoption of a single land cadastre for NSW.
COTS	Commercial Off The Shelf – mostly referring to software products
CRCSI	Cooperative Research Centre for Spatial Information. http://www.crcsi.com.au/
DCDB	The NSW Spatial Services' Digital Cadastral Database (DCDB) is a digital representation of the cadastre of New South Wales (NSW). http://spatialservices.finance.nsw.gov.au/mapping_and_imagery/cadastral_data
Downstream Data	Datasets that are derived from, or have a fixed spatial relationship with the Cadastre, such as transportation, planning or utilities. (see also Impacted Data).
Dynamic Datum	A dynamic datum (alternative term often used instead of Earth Fixed Reference Frame) allows the changes in coordinates of points on the Earth's "dynamic" surface to be referenced and represented. ATRF is an Australian example of a dynamic datum. http://www.ga.gov.au/scientific-topics/positioning-navigation/datum-modernisation
Earth-fixed	As an alternative to a "plate-fixed" datum, a national geodetic datum may be defined like the ITRF so that its axes appear to co-rotate with Earth in its motion in space and are "fixed" to the whole solid Earth, rather than a tectonic plate.
Epoch	Timestamp of a reference frame
GDA2020	The Geocentric Datum of Australia 2020 (GDA2020) is a new Australian plate fixed national datum that will replace the current GDA94 by 1 January 2020. http://www.ga.gov.au/scientific-topics/positioning-navigation/datum-modernisation
GDA94	Geocentric Datum of Australia 1994 (plate fixed). http://www.icsm.gov.au/gda/gda94.html
ICSM	Intergovernmental Committee on Surveying and Mapping. ICSM's role is to provide leadership through coordination and cooperation in surveying, mapping and charting. http://www.icsm.gov.au/

Term	Definition
ICSM PCC	Permanent Committee on Cadastre. Subcommittee of ICSM
ISO TC211	A standard technical committee formed within ISO, tasked with covering the areas of digital geographic information and geomatics. http://www.isotc211.org/
Impacted Data	Datasets that are often used in analysis of their relationship to the Cadastre, for instance bushfire zones or imagery (see also Downstream Data).
ITRF	International Terrestrial Reference Frame. International realisation of an Earth fixed geocentric system of coordinates. http://itrf.ensg.ign.fr/
LandXML	LandXML is a specialized XML (eXtensible Mark-up Language) data file format containing civil engineering and survey measurement data commonly used in the Land Development and Transportation Industries.
OGC	Open Geospatial Consortium. An international not-for-profit organization committed to making quality open standards for the global geospatial community. http://www.opengeospatial.org/
Plate-fixed	A national geodetic datum may be defined by reference points that are said to be “fixed” to one of the Earth’s tectonic plates. The reference points move along with the tectonic plate and the coordinates appear to be unchanging with time.
SCIMS	The NSW Survey Control Information Management System (SCIMS) is a database that contains all of the coordinates, heights and related information for NSW survey marks that form the official State Survey Control Network (SCIMS). http://spatialservices.finance.nsw.gov.au/surveying/scims_online
Positional Accuracy	Also known as absolute or spatial accuracy, spatial accuracy refers to the quality of a coordinate with respect to the coordinate reference system
Relative Accuracy	The quality of a coordinate with respect to nearby features
WGS84	WGS84 is an Earth-centred, Earth-fixed terrestrial reference system and geodetic datum used by the US Military for its GPS navigation satellite system. https://en.wikipedia.org/wiki/World_Geodetic_System

1 Introduction

1.1 Project Background and Objectives

A datum is a system that allows locations on the Earth's surface to be identified. It includes a reference surface, a coordinate system, and a set of defined reference points. Every country has its own datum and Australia's current national datum is called the Geocentric Datum of Australia 1994 (GDA94). All the latitude and longitude coordinates of features on our maps are based on GDA94.

Australia is scheduled to adopt a dynamic datum by the end of the decade, and this will have implications for all people who use and rely upon accurate location information. It will be increasingly important to understand that latitude and longitude coordinates do not define a unique location unless the related datum is also identified. At best, a coordinate without datum is ambiguous and may even be meaningless. In 2020, the dynamic datum will establish a different kind of location reference system that will continually model the movement of the Australian continent.

The new datum will bring with it the need to create and work with time-tagged coordinates. New processes and tools to collect, manage, integrate and disseminate spatial information will therefore be required. The associated technical and procedural challenges represent a major barrier to efficient and wholesale adoption of the new datum. The broader spatial sector has expressed concern about the potential cost of adopting a new datum and the lack of commercial off the shelf software that can support a dynamic datum. There are also highly varying levels of understanding across industry regarding the technical elements of datum and reference system implementation (Stakeholder Requirements for Modernising Australia's Geocentric Datum – CRCSI July 2015).

The digital representation of the cadastre is inarguably one of the most critical layers of spatial information held and managed by any jurisdiction. Not only does it represent state-wide land assets of major economic importance, there are also large volumes of other spatial and non-spatial information that are directly linked to and affected by, changes to the cadastral fabric.

The DCDB's positional accuracy is being improved. Managing the cadastre in the context of this improving accuracy, and the impact of a new dynamic datum, poses a substantial and pressing priority not only for NSW, but for land agencies across Australia.

This project postulates that if these issues can be resolved for the cadastre, the findings and outputs can be translated to the management of other layers of spatial information. The project will focus on NSW initially in each phase, and then expand its investigation and findings through engagement points with other jurisdictions.

Information about Australia's datum modernisation, including a simple explainer animation, frequently asked questions, fact sheets and progress updates, is available on the ICSM website, www.icsm.gov.au.

1.1.1 Project Objectives

1. Document how the cadastre in NSW will be affected by adoption of a dynamic datum.
2. Establish and prioritise what tasks need to be undertaken to transition the cadastre in NSW to the dynamic datum.
3. Identify what new procedures and tools will be required for the on-going management of the cadastre once the dynamic datum has been adopted.

1.2 Project Timeline & Deliverables

The high-level timeline for delivery of the project is:

1. Impact Assessment: August – October 2017
2. Transition Tasks: November 2017 – February 2018
3. New Tools and Procedures: March 2018 – June 2018

1.3 Related Initiatives

This project does not stand in isolation. Several initiatives and research projects are currently underway that have relevance to this project.

- CRCSI project 3.19: "Functions & Benefits of the Spatial Cadastre" (April 2017- June 2018)

This project will explore the actual and potential uses of a more accurate spatial record of cadastral boundaries in Australia & New Zealand and the resulting benefits. Across all jurisdictions it will develop and apply a framework to assess the principal components of evidence for locating and representing cadastral boundaries that contribute to spatial accuracy; the functions that a more accurate spatial cadastre can contribute to; the dependencies of those functions on spatial accuracy; and qualitative identification of costs that can be avoided through enhanced spatial accuracy.

- CRCSI project "Upgrading the spatial accuracy of the digital cadastre – a pilot study" (March 2017 – Feb 2018)

  This project will explore the extent to which high-resolution airborne and space borne imagery, in cases complemented by LiDAR data, can be used to upgrade the spatial accuracy of the digital cadastre.

- CRCSI Program 3 – Spatial Knowledge Infrastructures (SKI) initiative

  The Cooperative Research Centre for Spatial Information (CRCSI) conceptualised a Spatial Knowledge Infrastructure (SKI) that moves the agenda from more traditional Spatial Data Infrastructure (SDI) concepts, to automatically creating, sharing, curating, delivering and using knowledge (and not just data and information) in support of the digital economy and the rise of spatially aware and equipped citizens. Just how the SKI will be delivered and why it is necessary, is explored in a white paper that sets out the research agenda required to make the transition from a SDI to SKI. The digital cadastre is used to case study the need for change and explain the necessary research and development required to streamline data supply, improve information value and increase knowledge utility.

- Cadastre NSW (Ongoing)

  Cadastre NSW is a Spatial Services program to address the key barriers to adoption of a single land cadastre in NSW. More specifically Cadastre NSW is addressing three key issues highlighted by all major stakeholder groups:
  - Proposed plan data is not consistently distributed
  - Users are uncertain about the cadastre's accuracy
  - Lack of a co-ordinated minimum NSW Cadastre

1.4 About this document

This document is an interim report for phase1 of the CRCSI 3.20 project. Its content will be included, and may be modified, in the final project outcomes report.

It is organised as follows:

- Section 2 presents the project approach and methodology, with a focus on phase-1, and presents the relevant research questions;
- Section 3 presents the findings from the literature and stakeholder engagements;
- Section 4 addresses each of the phase-1 research questions;
- The appendices provide more detail on stakeholders, participants in the engagement, user questionnaire outcomes and a register of documents consulted.

2 Approach & Methodology

2.1 Research Questions

The Project scope defines several research questions to be addressed. These are allocated to the respective project phases in the tables below.

Table 2 Research Questions for 3 phases

Phase 1 – Impact Assessment
• What legislative barriers exist and what changes might be necessary to support the cadastre in the context of a dynamic reference frame?
• How can the integrity of the cadastre be maintained in the context of a dynamic datum?
• What impact will a dynamic datum have on the legal definition and re-identification of property boundaries?
• What impact will a dynamic datum have on the cadastral data supply chain (eg plan preparation by surveyors, data validation, approvals by councils and others etc)?
• What differences exist between jurisdictions in terms of starting point, capability, technology etc?
• How are other spatial and a-spatial datasets linked to the cadastre and will those links still be valid in the context of a dynamic datum?

Phase 2 – Transition Tasks
• What other information (eg Remote Sensing data) could supplement existing data resources to address issues related to moving to a dynamic datum? (link to related research project)
• How can the integrity of the cadastre be maintained in the context of a dynamic datum?

Phase 3 – New Tools & Procedures
• What maintenance systems and processes will be essential to support the digital cadastre and how can current systems be migrated to a dynamic datum?
• What additional tools and services will be required to maintain relationships to other spatial and a-spatial datasets?
• How can the integrity of the cadastre be maintained in the context of a dynamic datum?

During phase 1, several ancillary research questions have been formulated for phases 1 and 2:

Table 3 Ancillary Research Questions

Ancillary Phase 1 Research Questions
• How does the impact of ATRF differ from that of Datum Modernisation & GDA2020 in general?
• How can the findings for the Cadastre be extended to other spatial (foundation) datasets?
• How universal are the findings for NSW, and how can they be enhanced from, or extended to, other jurisdictions?

Ancillary Phase 2 Research Questions
• What sectors and applications will be affected by ATRF, by when, and what is their value proposition for adoption?
• What are the 'gaps' between the GDA2020 implementation plan, and specific ATRF transition needs? (functional, application domains)

2.2 Statement of Intent

The Statement of Intent is a one page summary of the project's objectives, drivers, current- and future states and principles, approach and constraints to arrive at the future state.

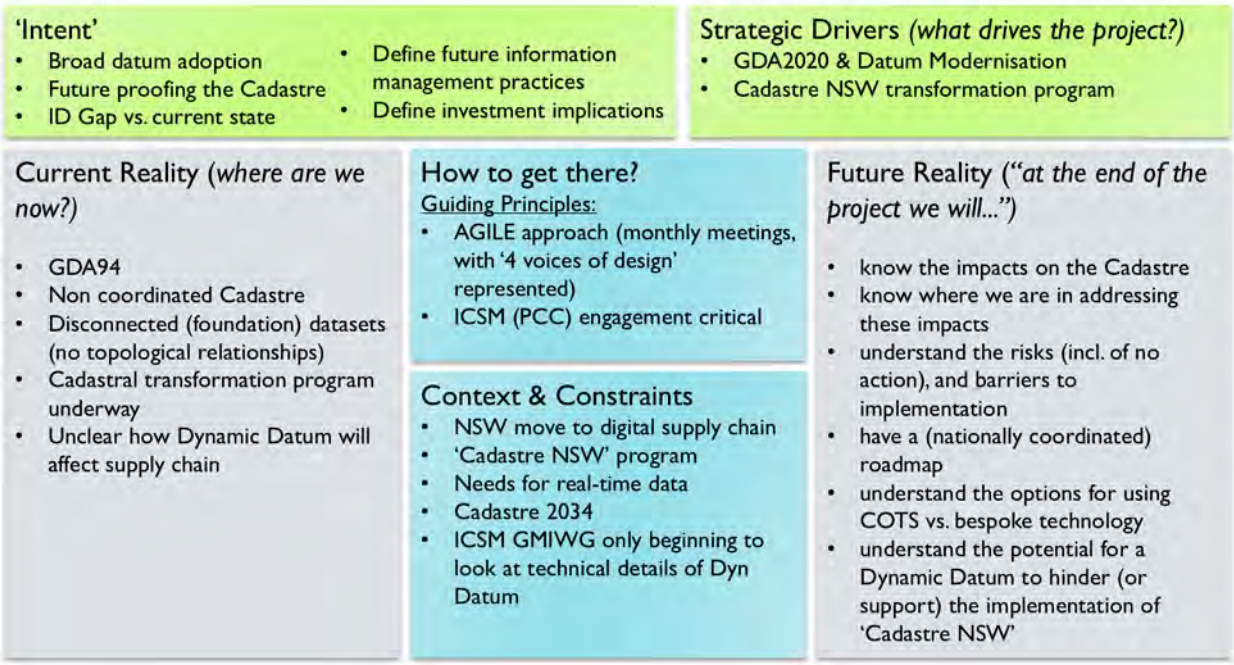

Figure 1 Statement of Intent for CRCSI Project 3.20

2.3 Scope & Approach

The Project will have three distinct phases:

1. Impact Assessment
2. Transition Tasks
3. New Tools and Procedures

Phase 1: Impact Assessment

Scope of works:

- Literature review of research into managing the dynamic cadastre
- Document the impact of a dynamic datum on managing and disseminating the cadastre in NSW
- Present findings to other jurisdictions in Australia and New Zealand with a view to extending the impact assessment where necessary
- Coordinate with related research projects to conduct interviews with other jurisdictions
- Prepare a report on Phase 1

Phase 2: Transition Tasks

Scope of works:

- Document the tasks (manual and automated) that need to be done in NSW to transition the digital cadastre from a static to a dynamic datum
- Identify the magnitude, nature, priority and resources required to complete each task
- Present findings to other jurisdictions with a view to extending the list of required tasks where necessary
- Coordinate with related research projects to undertake a workshop of initial results, feedback and response.
- Prepare a report on Phase 2

Phase 3: New Tools and Procedures

Scope of works:

- Scope what tools and procedures will be needed to maintain and disseminate the cadastre in NSW once it has been transitioned to the new datum
- Establish a work plan and budget to develop, validate and implement these new tools and procedures
- Validate the outcomes with other jurisdictions with a view to refinements where necessary
- Prepare a report on Phase 3

2.4 Phase-1 Detailed Timeline and Deliverables

This section presents the detailed plan and deliverables for phase 1. At the end of each phase, a detailed project plan for subsequent phases will be developed.

Table 4 Phase-1 Planned Timeline & Deliverables

Week of	Activity	Deliverables
7-Aug	Kick-off & Planning	Draft PID Stakeholder Segmentation
14-Aug	Start literature review Contact stakeholders & plan engagement	Final PID Stakeholder Engagement Schedule Draft Table of Contents (ToC) for Phase-1 report Draft engagement questions
18-Sep	Information Gathering & Stakeholder Engagement	Draft Current State, Pain Points, Opportunities
16-Oct	Write draft Phase-1 report	Draft Phase-1 report: Impact of DD on the cadastre
23-Oct	CRC Project Board Review; Phase 2 Planning	Phase-2 Project Plan
30-Oct	Finalise Phase1 report	Final Phase-1 report

Several factors have delayed the completion of phase 1:

- Delays in availability of key stakeholders, e.g. NSW Spatial Services ICT (to be interviewed 7 December)
- Opportunity for jurisdictional review with ICSM/PCC, following presentation at their bi-annual meeting on 13 November;
- Opportunity to get input from the international standards community at the ISO TC211 meeting in Wellington (27-November – 1 December)
- Minor delays in the writing of phase 1 report;

The actual finalisation will be:

Week of	Activity	Deliverables
20 Nov	Phase 2 Planning	Detailed Phase 2 project plan
27 Nov	Final draft ISO TC211 engagement Commence Phase 2	Final draft for jurisdictional review
4 Dec	NSW Spatial Services ICT – Engagement	
11 Dec	Incorporate Phase 1 comments and additional input	Final Phase-1 report

2.5 Stakeholders & Stakeholder Engagement

Figure 2 shows the identified stakeholders, classified into four categories by the level by which they are likely to be impacted by the project, and the level of influence they have:

- Group 1: Key Players – from who strong buy-in is required;
- Group 2: Engage – Active Engagement and Consultation is required;
- Group 3: Regular Consultation;
- Group 4: Maintain Interest and Keep Informed.

The stakeholders are also colour-coded by the general role: Governance (Blue), NSW Spatial Services (Red), R&D (Yellow), User Representatives (Green), and Suppliers (Grey).

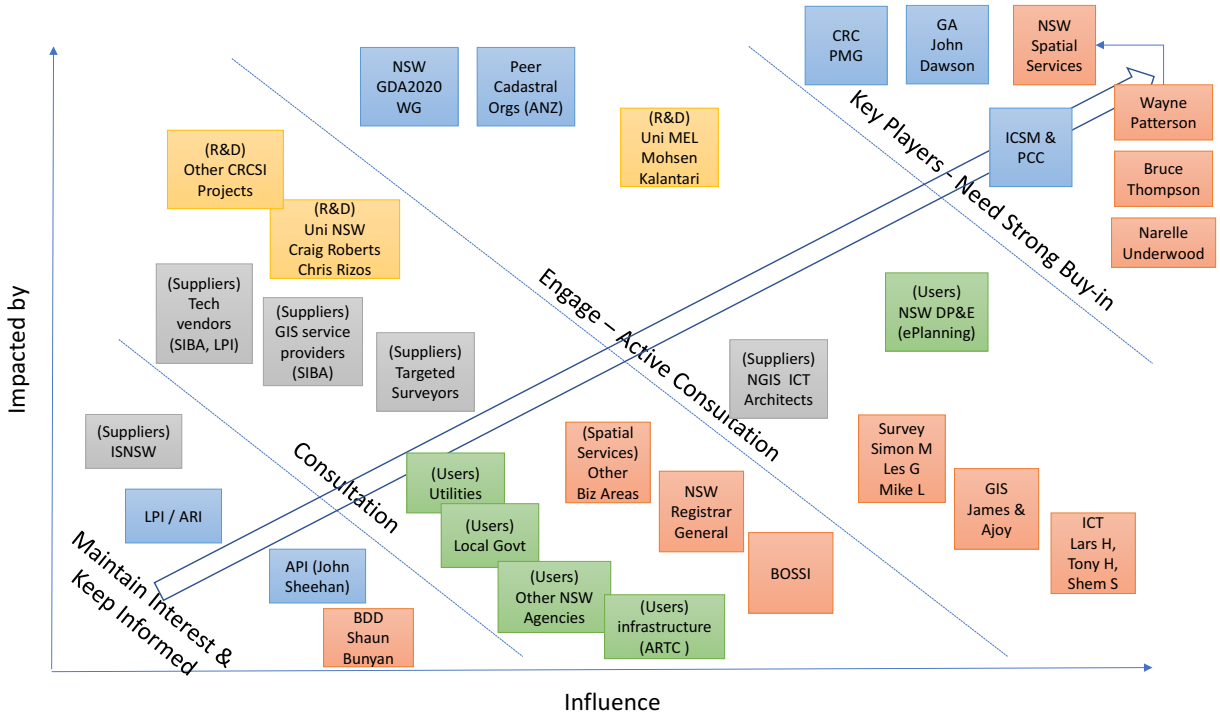

Figure 2: Stakeholder Map

The full list of stakeholders that were engaged in phase 1 is available in Appendix 1.

Each of the stakeholder segments has a separate engagement objective, each requiring its own engagement approach, as illustrated in Table 5. Note that these engagement approaches are for the purpose of conducting this research. They are likely to differ significantly for the transition implementation.

Table 5 Stakeholder Engagement Objectives & Approach

Segment	Objective	Engagement Approach
1. Key Players	Strong buy-in	**Build ongoing relationships**: Regular one-on-one briefings and other engagement as required.
2. Engage	Active consultation: solicit key requirements. Develop	**Start a conversation**: One-on-one interviews (in person or virtual; where possible on the back of industry events).

Segment	Objective	Engagement Approach
	relationships and possible collaboration opportunities	
3. Consult	Consultation: understand impacts, issues & opportunities	**Listen**: Workshop(s), Online survey (optional)
4. Inform	Maintain Interest & Keep Informed	**Notify**: Regular updates through e.g. blogposts, industry publications (Spatial Source, Position), industry events (e.g. SIBA breakfast), and conference presentations (Locate – April '18, SSSI NSW conference, Dec '17).

3 Findings

This chapter lists the findings from the Impact Assessment, broken down into the three main assessment streams: “Literature Review”, “Stakeholder Engagement” and “Jurisdictional Review”.

Within each stream, the findings are grouped into three categories: “Impacts”, “Barriers to Implementation” and “Future Expectations”.

While the scope of this research is the implementation of a Dynamic Datum or ATRF, in many cases this cannot be seen in isolation from the overall Datum Modernisation program (i.e. GDA2020). In this chapter, where relevant, we indicate which findings apply primarily for ATRF, and which for Datum Modernisation in general.

3.1 Literature Review

The literature review consulted a total of 24 sources, as summarized in the table below. The full list is available in Appendix 3.

Table 6 Literature Review Sources (Summary)

Document Type	Number of documents
Research reports	8
Presentations	8
General publications	4
Trade publications	2
Academic papers	1
Other	1
TOTAL	**24**

The findings from the literature review are classified in Impacts of ATRF, Barriers to Implementation and Future Expectations

3.1.1 Impacts

The geodetic datum is the reference system and fundamental layer for all survey, mapping, spatial datasets and activities as it supports geospatial information through accurate horizontal and vertical positioning of datasets. Infrastructure and services such as GNSS and CORS now provide the basic framework to enable downstream centimetre level accuracy, navigation and positioning applications. As a result, with minimal training, users are now able to position themselves to an unprecedented level of accuracy with the simple push of a button on a smart device such as a hand-held tablet or phone. These are expected to have sub-decimeter accuracy within the next 5 years.

The consensus in the literature is that ‘do nothing’ is not an option. Increasing user expectations regarding cadastral accuracy, combined with this improved accuracy of consumer GNSS devices and a gap between GDA2020 and ATRF that will increase over time all mean that while the impact of ATRF will be small initially, it will grow steadily from 2020 onwards.

On the demand side, the user expectation is that as a key fundamental dataset and crucial decision support tool, the Cadastre is expected to be of the same accuracy as its related (or ‘downstream’) datasets, such as transportation, planning or utilities. The accuracy of these datasets is improving, as is the spatial accuracy of the Cadastre under the Cadastre NSW program.

The impact of ATRF will therefore grow with increasing downstream data accuracy and evolving user expectations. Different user applications have different requirements regarding data accuracy, and different levels of business impact of reduced data accuracy. Therefore, different user domains will be impacted at different times. and identifying the sectors and domains that will be impacted most (and earliest) will be an important element in implementation planning.

3.1.2 Barriers

The literature review identified several practical barriers to implementing ATRF for the NSW Cadastre.

First and foremost, highly variable levels of understanding of datum modernisation in general, and ATRF in particular, will, if unaddressed, prevent broad implementation. An ICSM survey conducted in 2016 showed that a quarter of the surveying and spatial information industry doesn't understand GDA2020, let alone ATRF. These numbers are likely to have improved since then for GSA2020; for ATRF there has been very little communication and the situation will likely be unchanged.

There is a risk that ATRF adoption levels will be reduced if users perceive the implementation to be separate from GDA2020 and involving significant extra disruption and extra cost and effort. Coordination of messaging and implementation will be crucial, as a review of the GDA94 implementation has shown[1].

From a technical perspective, over 100 separate pieces of (COTS) software from over 80 vendors are in use to conduct coordinate transformation. Also, digital coordinate storage systems are currently rarely able to include time-tagged (meta-) data. Each of these would need to be upgraded or replaced with tools that are ATRF enabled, to facilitate a smooth implementation.

In that context, Australia is likely to suffer from a 'first-mover-disadvantage'. As the first country world-wide to implement an earth-fixed, dynamic datum, it may find international technology vendors struggling to upgrade their tools in time for ATRF implementation.

From a NSW Cadastre perspective, barriers identified include the lack of a coordinated and mandated cadastral update process, users' uncertainly about cadastral accuracy, and the lack of a single, co-ordinated minimum cadastre.

Finally, as a legal barrier to datum modernisation in NSW, the NSW Surveying and Spatial Information Act prescribes that surveys in NSW must be carried out by reference the "Geocentric Datum of Australia" (as adopted by ICSM in 1990; i.e. GDA94) as the coordinate reference system to be used[2]. Any formal change to GDA2020 or ATRF would therefore require a legislative change.

3.1.3 Future Expectations

There is optimism that the ambition of achieving a highly accurate digital cadastre is technically achievable in NSW. Implementing the ATRF will therefore be critical to maintain alignment with global positioning systems and with new global spatial datasets – especially those derived from satellite data.

There is also a strong consensus in the literature that a change in stakeholders' behaviours, knowledge and practices is needed to avoid the risk of getting very low user take-up of ATRF, and thus wasted investment.

Technology has advanced to a point where it has the capability to acquire data more accurately and with more metadata than is currently required in Government databases. Therefore, there is a critical need not to lose this intelligence. The first step is to capture and manage this information with the data as soon as possible so it can be used into the future when systems evolve.

Ideally, coordinate transformation will occur at the point of supply to users (be they GIS specialists or mainstream consumers), and will need to be easy. To quote: "If you don't make it easy for people to do the right thing, you're wasting money on datum modernisation"[3]. Close involvement from software vendors and developers will be essential.

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[1] "Stakeholder Requirements for Modernising Australia's Geocentric Datum", CRCSI Project 1.02 report. July 2015.

[2] http://www8.austlii.edu.au/cgi-bin/viewdoc/au/legis/nsw/consol_act/sasia2002362/s4.html

[3] Locate 17 Panel discussion - Impacts of Datum – National and International Perspectives

Also, with an increasing need to communicate the trustworthiness of (derived) information in machine-to-machine data exchange, knowledge and provenance of coordinate accuracy will play an important role, supported by associated metadata standards.

Finally, we note that several jurisdictions, including the Commonwealth, have well developed plans for the introduction of GDA2020, at the time of writing, none have published plans for ATRF implementation (possibly because the technical details of ATRF are still being finalised, and the difference between ATRF and GDA2020 will be minimal initially).

3.2 Stakeholder Engagement

The stakeholder engagement process followed a three-pronged approach as introduced in section 2.5: interviews with key players and influencers, active engagement through workshops with suppliers and an online questionnaire for end-users of the Cadastre.

3.3 Interviews & Workshops

As part of the stakeholder engagement, 15 people were interviewed from 6 different organisations.

Also, two workshops were conducted with NSW cadastral surveyors (9 participants) and suppliers of spatial data, technology and services (9 participants) respectively.

Details of Interviewees and workshop participants can be found in Appendix 2.

3.3.1 Impacts

There is limited impact on NSW survey plans lodged with NSW LRS (previously LPI). There is a regulatory requirement to connect the surveys to the control network. This is done by listing the relevant permanent survey mark IDs on the plan, as well as the survey date. The coordinates of these marks are obtained from the SCIMS database, which can be made time dependent when ATRF is implemented.

Data collected using satellite positioning on the other hand, will be more easily aligned with the DCDB when it is ATRF enabled.

There will be possible issues with downstream data products such as planning data, utilities or building footprints, which often coincide, or have a fixed relative spatial relationship with the Cadastre. In the vast majority of cases, similar or related spatial features are not topologically linked between datasets (and often shouldn't be, e.g. when legal and physical boundaries are different), so when the DCDB moves over time in an ATRF context, other datasets that are not aligned to the same datum, will increasingly shift away from the Cadastre. This impact will be highest where the DCDB accuracy is highest, i.e. in urban centres (sub decimetre). For other areas, DCDB accuracy will need improvement before the difference between GDA2020 and ATRF will become relevant.

It is yet to be decided if the future default for DCDB supply should be ATRF or GDA2020 (which is in-effect ATRF for the 2020 epoch). However, it is expected for an extended period, the DCDB may have to be available in both GDA2020 and ATRF. A significant contingent of users with lower data accuracy requirements will not need the complexity of an ATRF. Others may require ATRF base-data while their software won't yet support ATRF to GDA2020 (other plate-fixed datum) transformations.

ATRF will potentially impact providers of large data stores, such as imagery, as 'on the fly' coordinate conversions in many cases may become too computationally burdensome[4]. These providers would be limited in their ability to deliver data in ATRF. GDA2020 may well prove to be the best default datum for (imagery) data supply

3.3.2 Barriers

Barriers to implementation that were emphasised in the Interviews and Workshops include the lack of education and awareness about datum modernisation and ATRF. This could contribute to possible

[4] In some cases, a transformation of an image's corner coordinates ('block shift') may be all that is required. However, for high resolution and high accuracy data sets covering larger areas, or datasets in distortion areas, more complex image transformation and adjustments would be needed.

confusion in the marketplace about the why, when and how of ATRF implementation. Understanding the arguments for adoption for each user domain, and communicating these, will be critical.

For any implementation to be successful, there will be an increased reliance on accurate and complete metadata to indicate the reference framework and epoch (timestamp) of any set of coordinates. Given the current practices in this regard, a significant behavioural change would be required to achieve the required levels of metadata completeness.

The costs of ATRF adoption are currently unknown and are often perceived as prohibitive. Stakeholders who have just adopted GDA2020, may be reluctant to invest further time and money in an ATRF upgrade.

ATRF implementation will depend heavily on the ubiquitous availability of modern, up-to-date software to manage the required coordinate transformations. This applies to survey- and GIS software, as well as coding libraries used for e.g. mobile app development.

Industry inertia will mean that for a considerable period, people will continue to use legacy software, forget or be unwilling to pay for software upgrades, or use outdated (meta-) data formats. All of which will delay ATRF adoption.

3.3.3 Future Expectations

The community expectation is that in an ATRF implementation (or any datum modernisation for that matter), coordinate transformation 'just works'. Data sources such as DCDB, SCIMS, and other (downstream) data will be available in multiple reference frameworks, and different datums are aligned 'on the fly', invisible to the end-user: software and applications 'just deal with it'.

For this to become a reality, the DCDB accuracy needs to become more consistent, and (meta-) data standards and practices need to be set and complied with.

Data custodians, providers and professional users will need education and awareness raising so that they become conscious of the issues and possibilities. This can be done through the development of training materials and best-practice examples, and this may provide business opportunities for the industry.

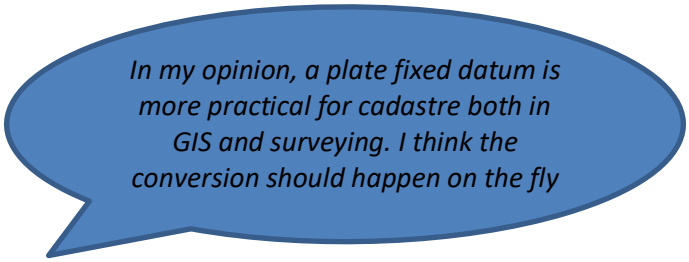
Awareness raising is also required to alert relevant authorities to possible risks and negative impacts over time of a 'do nothing' approach, and the urgency of a sustained and coordinated approach to mitigate these. Some stakeholders drew parallels to the 'Y2K' campaigns in the late 1990s that generated an industry-wide response to avert possible impacts.

Several stakeholders also raised the opportunity that with improved accuracy and ATRF, the DCDB could become the de-facto authoritative source of parcel information, which over time could open the door to the establishment of a legal co-ordinated Cadastre.

3.4 User Questionnaire

The User Questionnaire was conducted online in September 2017, and sent out to 190 users of the NSW Cadastre. The response rate was approximately 40%, predominantly from local government. Appendix 3 provides full details of the questionnaire and outcomes analysis.

3.4.1 Impacts



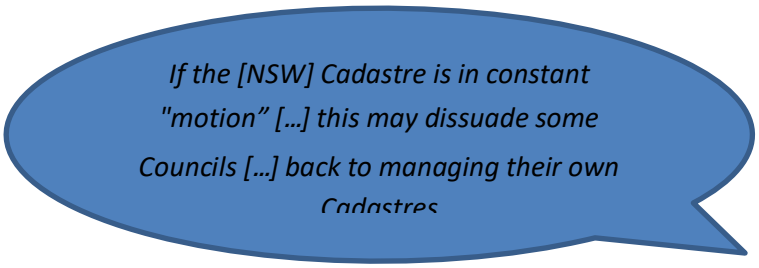
Among the surveyed users, there was a high awareness that datum modernisation is under way. Yet 80 percent responded that they are currently not experiencing any issues with the (up to 1.8m) difference between GDA94 and GPS/GNSS coordinates, and many indicate they are uncertain of the timing of implementation and how it will work in practice.

In the future, when an ATRF is implemented, users are particularly concerned about the impact on the legislative and regulatory aspect of their business, notably the planning regulations and e-planning implementation. There was concern about confusion and possibly being open to legal action when, due to differences is coordinates, discrepancies occur between e.g. the zoning constraints of a property on the e-planning portal, vs. a section-149 certificate council has issued.

Of concern is that only 9% of users expect ATRF to have a positive impact on the land development process, while 55% expected a neutral impact or were unsure.

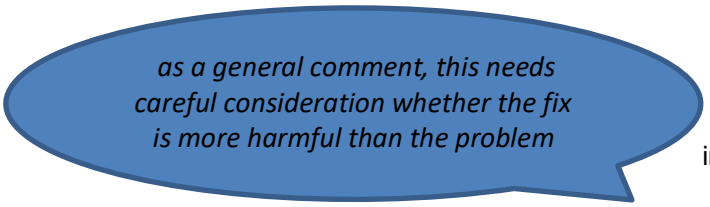
3.4.2 Barriers

A major risk that respondents raised was that if the cost and complexity of ATRF implementation becomes prohibitive, or if the implementation leads to reduced confidence in the (digital) Cadastre, even more users may decide to maintain their own Cadastre, rather than use the NSW DCDB.



3.4.3 Future Expectations

A thorough understanding of the impact and mitigation strategies would be needed to prevent ATRF being perceived as a 'solution looking for a problem'.



Many respondents raised the point that education, training, automation, and other assistance will be critical for successful implementation.

3.5 Jurisdictional Review

The jurisdictional review looks at how the NSW situation compares to other jurisdictions in Australia and New Zealand, and how experience in other jurisdictions can enhance ATRF implementation for the NSW Cadastre or vice versa.

The Jurisdictional review was conducted through informal conversations with representatives from WA, Victoria and Tasmania, a review of jurisdictional implementation plans, and formal engagement with the ICSM Permanent Committee for the Cadastre (PCC) and Land Information New Zealand (LINZ).

The main inputs from other jurisdictions are that:

- Many jurisdictions have plans for GDA2020, but none were found for ATRF (possibly because the technical details of ATRF are still being finalised, and the difference between ATRF and GDA2020 will be minimal initially);
- Material differences between jurisdictions in legislation/regulation and cadastral accuracy determine differences in the expected impact of ATRF implementation;
- Relative position is almost always more important than absolute position. Therefore, the direction of transformations (convert ATRF coordinates to GDA2020 or GDA2020 to ATRF) is likely to be a moot point;
- Over 1 million spatial apps are developed each year, eventually these will be using tools and software libraries that will recognise the datum for each data source and manage these automatically;
- Geospatial software will need to work world-wide, and software vendors and – developers will strive to use global standards and reference frameworks over having to manage and comply with many local ones. This might delay the support of country specific datums such as ATRF, in global software solutions.

3.6 Findings Summary

To summarise the findings, they have been classified using the dimensions of the 'SDI Strategy Components Model illustrated below; namely: Data, Technology, People, Standards and Organisational.

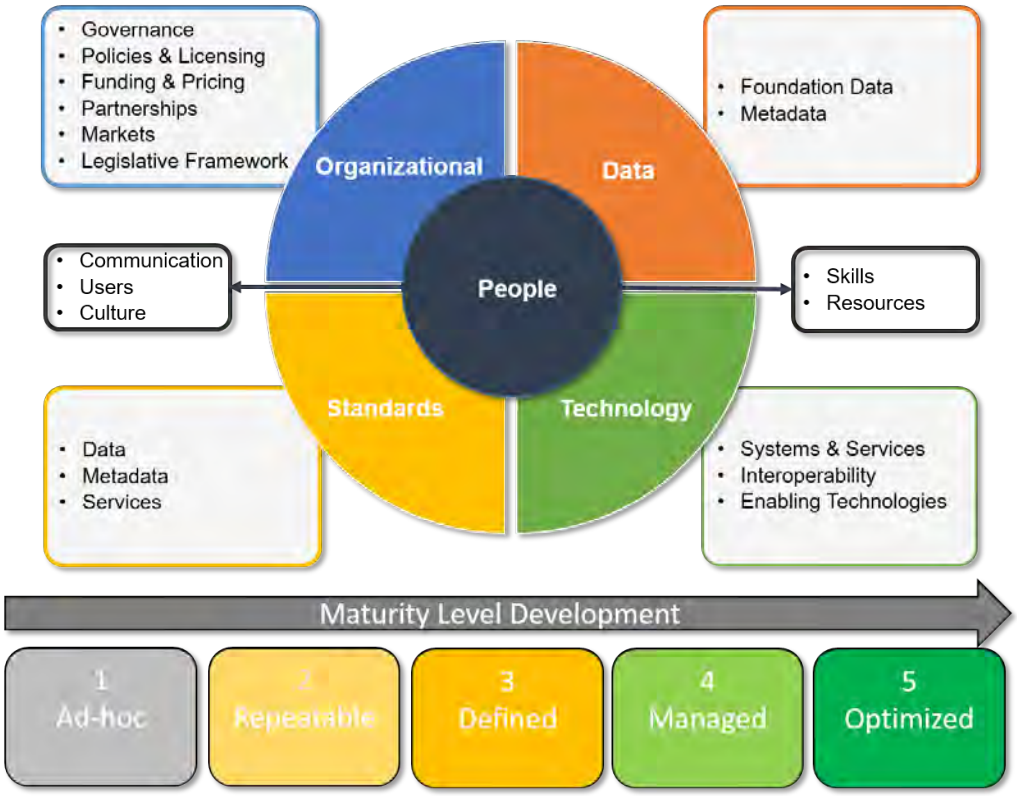


Figure 3: Strategy Components Model (© Dr. Vanessa Lawrence CB, Gilles Albaredes, John Schonegevel, Maurits van der Vlugt)

The Impacts, Barriers and Future Expectations have been summarised against these dimensions in Table 7.

Table 7 Summary of Findings

	ATRF Impacts	Barriers to implementation	Future State with ATRF
Data Cadastral workflow Related data Quality Accessibility	• Positive: GNSS field data will better match Cadastre • Impact on land development: 9% (of respondents) positive, 35% negative • Limited impact on survey plans lodged with NSW LRS (previously LPI) - regulatory requirement to connect to control network • Greater impact on related data when Cadastre moves • High impact in urban centres • Risk of reduced confidence	• NSW DCDB may have to be available in ATRF before user adoption • Variations in, and uncertainty about Cadastral accuracy • DCDB Cadastral update process 'not ready for ATRF' • No topological links with related data	• Sufficiently accurate NSW Cadastre, matching other datasets • Coordinates with known accuracy and reliability • DCDB, SCIMS, usable in both GDA2020 & ATRF • Default for source storage is plate-fixed (GDA2020) • Greater level of topological relationships with downstream/coincident datasets
Technology Architecture Interoperability Software Tools	• Up to 100 different software platforms to be updated • Users with legacy systems will need to upgrade	• 1st-mover disadvantage, software updates delayed • Current COTS can't handle ATRF & time-tagged data • Can we transforming bulk imagery 'on the fly'? • Slow user upgrades of legacy software • SCIMS & DCDB won't support multiple coordinates • Risk: solution looking for a problem (or making it worse)	• Technology deals with transformation, "it just works" • Transformations at point of supply, fully automated • Most COTS software tools are ATRF enabled (conform global standards)
Standards Data & Metadata Business Processes	• Increased reliance on proper metadata (with time tags)	• Confusion re. WGS84 • Some data formats (e.g. DXF) don't enable time-dependency • Legacy processes & (meta-) data standards • Dependence on international standards still under development	• Internationally mandated (meta-) data standards (time-enabled) • Standardised, automated, federated Cadastral supply chain
People Education Behaviours Communication	• "Short-term pain for long-time gain" • Increased effort & possible confusion • Risk: users will abandon NSW Cadastre and manage their own	• Highly variable understanding • Broader benefits variable, not well understood, or hard to articulate • Uncoordinated communication & messaging • No access to knowledge or best-practice examples • No consistent metadata management practice • Risk of confusion	• Change in human knowledge, behaviours and practices • "If you don't make it easy for people to do the right thing, you're wasting money on datum modernisation" • Education & best-practice materials available • End-users shielded
Organisational Legal/ Governance Funding Business Cases Policies	• "Do Nothing" is not an option • Impact & benefits will affect users differently between application domains and over time • Risk of Inconsistency in planning instruments, e.g. between ePlanning portal and 'paper' certificates • Other legislative dependencies: e.g. biodiversity legislation • May be expensive to implement • Little or no impact on legal status of cadastre	• 1st-mover disadvantage (globally) • Legacy datums prescribed in high-level legislation (e.g. NSW surveying Act) • Cadastre: plan is the legal basis vs. Planning act: DB is the legal basis • No jurisdictional implementation plans yet • Legislation and Regulation slow to catch-up • Unknown/prohibitive cost of adoption • Implementation of GDA2020 will impact ATRF timing	• Public awareness drives adoption & investment • User assistance easily accessible • Focus on user domains & applications with highest value proposition & positive ROI • Opening the door to co-ordinated Cadastre (DB is the legal basis)

4 Response to Research Questions

The tables below addresses the research questions relevant for phase-1, as identified in section 2.1.

Table 8 Response to Research Questions for Phase 1

Phase 1 – Impact Assessment	Response
• What legislative barriers exist and what changes might be necessary to support the cadastre in the context of a dynamic reference frame?	As a legal barrier to datum modernisation in NSW, the NSW Surveying and Spatial Information Act prescribes that surveys in NSW must be carried out by reference the "Geocentric Datum of Australia" (as adopted by ICSM in 1990; i.e. GDA94) as the coordinate reference system to be used[5]. Any formal change to GDA2020 or ATRF would therefore require a legislative change. Councils are concerned about confusion and possibly being open to legal action when due to differences in coordinates, discrepancies occur between e.g. the zoning constraints of a property on the e-planning portal, vs. a section-149 certificate council has issued.
• How can the integrity of the cadastre be maintained in the context of a dynamic datum?	The main challenge won't be technical or legal, but instead managing the people-factor. A major risk that respondents raised was that if the cost and complexity of ATRF implementation becomes prohibitive, or it the implementation leads to reduced confidence in the (digital) Cadastre, even more users may decide to maintain their own Cadastre, rather than use the NSW DCDB. Any implementation must focus on the required change in human knowledge, behaviours and practices. It must be easy for people to 'do the right thing'. Stakeholders expect the digital Cadastre to continue to be maintained and supplied in a plate fixed reference frame (GDA2020) for the foreseeable future. At the same time, the data and technology providers must shield end-users from coordinate transformation details. It 'should just work', and will be enabled by rich metadata, mandated standards and a broad availability of ATRF-enabled COTS software.
• What impact will a dynamic datum have on the legal definition and re-identification of property boundaries?	Several stakeholders identified as key barriers the lack of a coordinated and mandated cadastral update process, user uncertainty about cadastral accuracy, and the lack of a single, co-ordinated minimum cadastre. They raised the possibility that with improved accuracy and ATRF, the DCDB could further evolve into the de-facto authoritative source of parcel information, which over time could open the door to the establishment of a co-ordinated Cadastre, where the DCDB becomes the (de-facto) authoritative source and legal basis for property boundaries.
• What impact will a dynamic datum have on the cadastral data supply chain (eg plan preparation by	9% of users expect ATRF to have a positive impact on the land development process.

[5] http://www8.austlii.edu.au/cgi-bin/viewdoc/au/legis/nsw/consol_act/sasia2002362/s4.html

Phase 1 – Impact Assessment	Response
surveyors, data validation, approvals by councils and others etc)?	There will be limited impact on survey plans lodged with NSW LRS (previously LPI). There is a regulatory requirement to connect these to the control network. This is done by listing the relevant permanent survey mark IDs on the plan, as well as the survey date. The coordinates of these marks are obtained from the SCIMS database, which can be made time dependent when ATRF is implemented. Stakeholders expect the digital Cadastre to continue to be maintained in a plate fixed reference frame (GDA2020) for the foreseeable future. Councils are concerned about confusion and possibly being open to legal action when due to differences in coordinates, discrepancies occur between e.g. the zoning constraints of a property on the e-planning portal, vs. a section-149 certificate council has issued.
• What differences exist between jurisdictions in terms of starting point, capability, technology etc?	Currently, no jurisdictions have any published plans for ATRF implementation. In that light, it is difficult and possibly premature to draw definitive conclusions regarding their capabilities or technical readiness. Material differences between jurisdictions in legislation/regulation and cadastral accuracy determine differences in expected impact of ATRF implementation. Further input from jurisdictions will be sought during the remainder of this project.
• How are other spatial and a-spatial datasets linked to the cadastre and will those links still be valid in the context of a dynamic datum?	The user expectation is that as a key fundamental dataset and crucial decision support tool, the Cadastre is expected to be of the same accuracy as its related (or 'downstream') datasets, such as transportation, planning or utilities, which often coincide, or have a fixed relative spatial relationship with the Cadastre. The accuracy of these datasets is improving, as is the spatial accuracy of the Cadastre under the Cadastre NSW program. The impact of ATRF will therefore grow with increasing downstream data accuracy and evolving user expectations. There are, however, possible issues with downstream data products. In the majority of cases, similar or related spatial features are not topologically linked between datasets, so when the DCDB moves over time in an ATRF context, other datasets that are not ATRF enabled, will increasingly shift away from the Cadastre. This impact will be highest where the DCDB accuracy is highest, i.e. in urban centres (sub decimetre). For other areas, DCDB accuracy will need improvement before the difference between GDA2020 and ATRF will become relevant.

Table 9 Response to Ancillary Research Questions

Ancillary Phase 1 Research Questions	Response
• How does the impact of ATRF differ from that of Datum Modernisation & GDA2020 in general?	The main differences identified so far are: • Where GDA2020 implementation planning is well advanced, there are no published ATRF implementation plans;

	• While GDA2020 is fundamentally a 're-set' of a plate-fixed reference system, ATRF represents a paradigm shift to an earth-fixed, time dependent system; • ATRF will require substantial upgrades to software, databases and (meta-) data formats to include time-enabled coordinates and coordinate transformations; • Existing NSW infrastructure (such as SCIMS and the DCDB) does not (yet) support the delivery of data in multiple reference systems (both GDA2020 and ATRF).
• How can the findings for the Cadastre be extended to other spatial (foundation) datasets?	Findings for the cadastre regarding technology, standards and people impacts are largely equally relevant for other datasets. The main exceptions are findings that are specific for the (NSW) cadastre, such as the legal barriers, and the risk of stakeholders (e.g. councils) abandoning the DCDB and maintaining their own. Different spatial (foundation) datasets have different requirements re data accuracy, and different levels of business impact of reduced data accuracy. Therefore, different data- and user domains will be impacted at different times, and identifying the ones that will be impacted earliest will be crucial for transition planning. ATRF will potentially impact providers of larger datastores, such as imagery, as 'on the fly' coordinate conversions in many cases may become too computationally complex. These providers would be limited in their ability to deliver data in ATRF.
• How universal are the findings for NSW, and how can be enhanced from other jurisdictions?	Currently, no jurisdictions have any published plans for ATRF implementation. In that light, it is difficult and possibly premature to draw definitive conclusions regarding ability to enhance NSW findings. Material differences between jurisdictions in legislation/regulation and cadastral accuracy determine differences in expected impact of ATRF implementation. Further input from jurisdictions will be sought during the remainder of this project.

Appendix 1. Stakeholders

Segment 1: Key Players

Stakeholder	Role	Key Contact(s)
CRC-SI Project Management Group (PMG)	Oversees the project and approves project deliverables as well as quarterly reports	Chair: Phil Collier Ph: 0413 514 210 Email: pcollier@crcsi.com.au
Geoscience Australia	Major national role in Geodesy space, including ICSM, CRCSI Positioning Program	John Dawson Ph: 02 6249 9028 / 0478 318 816 Email: John.Dawson@ga.gov.au
ICSM / ICSM Permanent Committee on the Cadastre (PCC)	Drives specifications & strategy for Cadastre2034, GDA2020 & ATRF	Russell Priebbenow Ph: 07 3330 4779 / 0417 615 965 Email: Russell.Priebbenow@dnrm.qld.gov.au
NSW DFSI Spatial Services	Custodian of the NSW DCDB Office of the Surveyor General Chair of BOSSI	Bruce Thompson Ph: 0413 483 721 Email: Bruce.Thompson@finance.nsw.gov.au Wayne Patterson Ph: 0400 660 114 Email: wayne.patterson@finance.nsw.gov.au Narelle Underwood Ph: 0428 834 081 Email: Narelle.Underwood@finance.nsw.gov.au

Segment 2: Active Engagement and Consultation

Stakeholder	Role	Key Contact(s)
NSW GDA2020 Working Group	Responsible for implementation of GDA2020 for the cadastre. Coordination between GDA2020 roll-out and Dynamic Datum roll-out.	Chair: Narelle Underwood (see above)
Peer Cadastral Organisations (other jurisdictions in Australia & NZ)	Compare issues, approaches and possible solutions. Consider collaborative projects & technological solutions	QLD: Russell Priebbenow (see above) ACT: Jeff Brown, Surveyor General (Jeffrey.Brown@act.gov.au) VIC: Craig Sandy, Surveyor General (Craig.Sandy@delwp.vic.gov.au) TAS: Michael Giudici, Surveyor General (Michael.giudici@dpipwe.tas.gov.au) SA: Michael Burdett, Surveyor General (Michael.burdett@sa.gov.au) WA: Murray Dolling (murray.dolling@landgate.wa.gov.au) NT: Robert Sarib (Robert.Sarib@nt.gov.au)

Stakeholder	Role	Key Contact(s)
		LINZ: Mark Dyer (markdyer@linz.govt.nz)
University of Melbourne	Leading R&D in Cadastral systems	Mohsen Kalantari Ph: +61 3 8344 0274 Email: mohsen.kalantari@unimelb.edu.au
NSW DP&E (ePlanning)	User: ePlanning Portal, interaction with councils.	Peter Bowen, Manager Spatial Delivery, Business and Information Services Ph: 02 9585 6834 Email: peter.bowen@environment.nsw.gov.au
NGIS – ICT Architects	Supplier: providing technology & ICT architecture advice to Spatial Services	Shem Semple (Spatial Services contact point) Ph: 02 6332 8197 Email: Shem.Semple@finance.nsw.gov.au
NSW Spatial Services	Subject Matter Experts	Survey: Simon McElroy, Les Gardner, Mike London GIS: James Leversha, Ajoy Saha ICT: Lars Hansen, Tony Hope, Shem Semple

Segment 3: Consultation

Stakeholder	Role	Key Contact(s)
Other CRCSI Projects	R&D	Project Leads (as required)
UNSW – School of Surveying and Spatial Information	R&D / Subject Matter Experts	Craig Roberts Ph: 02 9385 4464 Email: C.Roberts@unsw.edu.au Chris Rizos Email: C.Rizos@unsw.edu.au
Technology Vendors	Suppliers	SIBA|GITA/LIIAC : Francisco Urbina (NSW Branch Chair Ph: 0412 311 439 Email: FUrbina@esriaustralia.com.au
GIS Service Providers	Supplier – user consultation	SIBA|GITA : Francisco Urbina (NSW Branch Chair Ph: 0412 311 439 Email: FUrbina@esriaustralia.com.au
Targeted Surveyors – 'friendly' firms	Supplier – user consultation, subject matter experts	ACS NSW Mark Andrew Ph: 02 9212 4655 Email: mark@linkersurveying.com.au

Stakeholder	Role	Key Contact(s)
Utilities	Users – user consultation	Survey via Spatial Services (Bathhurst)
Local Government	Users – user consultation	Survey via Spatial Services (Bathhurst)
Other NSW Agencies	Users – user consultation	Survey via Spatial Services (Bathhurst)
Infrastructure	Users – user consultation	TBD
Spatial Services – other business areas	Users – user consultation	Survey via Spatial Services (Bathhurst)
NSW Registrar General	Governance, Subject Matter Expert	TBD
BOSSI	Governance, Subject Matter Expert	Chair: Narelle Underwood Ph: 0428 834 081 Email: Narelle.Underwood@finance.nsw.gov.au

Segment 4: Maintain Interest & Keep Informed

Stakeholder	Role	Key Contact(s)
ACS/ISNSW	Supplier	ACS NSW Mark Andrew Ph: 02 9212 4655 Email: mark@linkersurveying.com.au
LPI/ARI	Supplier/User	TBD
Australia Property Institute (API)	User	Prof. John Sheehan Ph: 0418 251 601 Email: sarasan@ihug.com.au

Appendix 2. Stakeholder Engagement Details

Interviewees

Date	Interviewee(s)	Role	Organisation
13/11/17	Joseph Abhayaratna	CIO	PSMA Australia
	Michael Dixon	Group Manager, Products and Services	
	Brian Burbidge	Product Management	
	Luke Caruan	Data sourcing & Partner management	
13/11/17	John Dawson	Section Leader, Positioning. Geodesy and Seismic Monitoring Branch	Geoscience Australia
18/9/17	Craig Roberts	Senior lecturer	UNSW, School of Surveying and Spatial Information
20/9/17	Mohsen Kalantari	Lecturer in Geomatics	University of Melbourne
5/10/17	Mark Strong	Project Manager, GDA2020 implementation	NSW Spatial Services
17/10/17	Peter Bowen	Manager Spatial Delivery, Business and Information Systems	NSW Department of Planning and Environment
29/8/17	Prof. Clive Fraser		University of Melbourne
Various	Wayne Patterson	Director Spatial Operations	NSW Spatial Services
Various	Narelle Underwood	Surveyor General	NSW Spatial Services
Various	Bruce Thompson	Executive Director	NSW Spatial Services
7/12/17 (TBC)	Lars Hansen	Senior Program Development Manager (SDI)	NSW Spatial Services
	Shem Semple	Manager Design and Delivery	
	Tony Hope	Manager Integrated Spatial Systems	

Workshop Participants

Surveyor's Workshop (ACS NSW, 7 September 2017)

Name	Organisation
Narelle Underwood	NSW Spatial Services
Adrian White	NSW Spatial Services
Ben Meyer	Craig & Rhodes
Craig Turner	SDG
Ruiyuan Li	SDG

Name	Organisation
Mitchell Ayres	Linker Surveying
Joseph Monardo	Lockley

Supplier's Workshop (Esri Australia, 13 September 2017)

Name	Organisation
Selin Ozdemir	Esri Australia
Chris Hoar	NGIS Australia
Dan Smith	AAM
Ed Garvin	Omnilink
Richard Ingham	CR Kennedy
Brett Madsen	Map Data Services
Johan Nel	Open Spatial
Richard Lemon	Jacobs

Appendix 3. User Questionnaire Outcomes

About the Survey

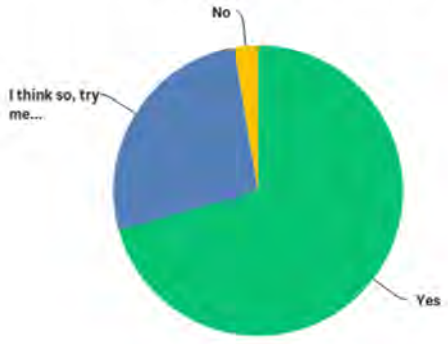
- Audience: Cadastral Users in NSW, approached through Spatial Services – BD
- Conducted: 7-15 September 2017
- High response rate: 75 out of approximately 190 approached (~ 40%)
- Respondents:
  - Largely (83%) Local Government, some State Government & Utilities
  - Majority (81%) GIS professionals, some IT/engineering staff

Q1 What best describes the organization you work for?

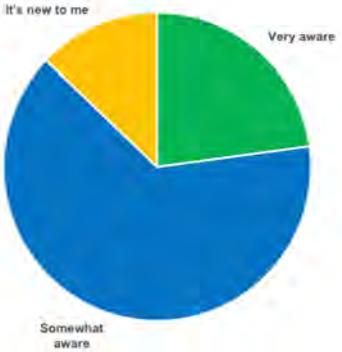
2

Most users know about Datums & Datum Modernisation

Do you know what a 'geodetic datum' or 'geodetic reference frame' is?



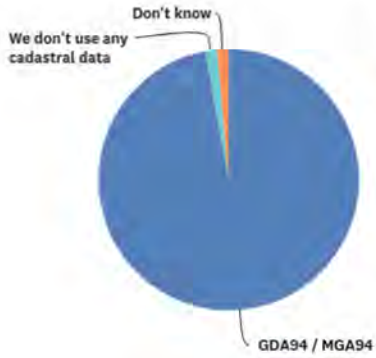
How aware are you of Australia's Datum Modernisation Program?



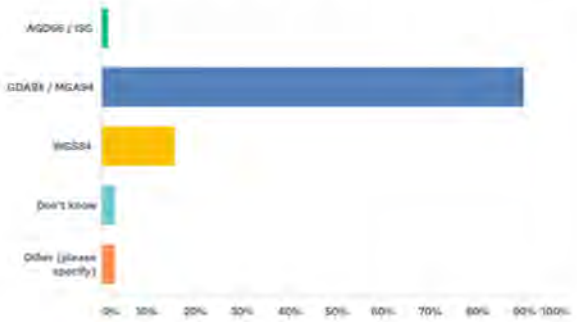
3

GDA94 currently most popular (note 16% WGS84 for other data)

What geodetic datum / coordinate system does your organisation use **for its cadastral data**?



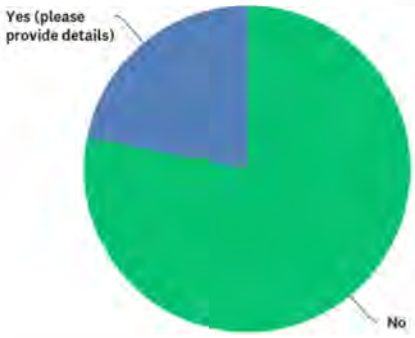
What geodetic datum / coordinate system does your organisation use **for its other spatial data**?



4

Only 20% experience alignment issues GPS vs. GDA94

Have you experienced any data alignment issues as a result of the 1.8m difference between raw GPS coordinates and GDA94?



Misalignment experienced with:

- Assets & utilities (36%)
- GPS data (29%)
- 3rd party data (21%)
- Imagery (21%)
- Cadastral data (14%)

5

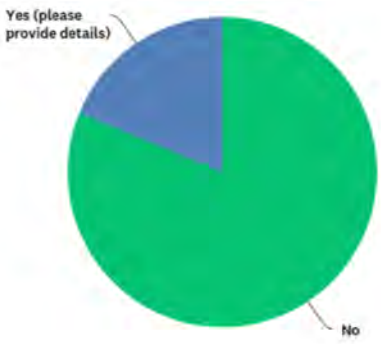
Future Expectations

- Legislative of Regulatory issues?
- Impact on Cadastral Integrity?
- Impact on Land Development Process?
- Impact on Related (Linked) Datasets?

6

Some legislative/regulatory issues identified. Mainly regarding Planning (LEPs, 149 Certificates)

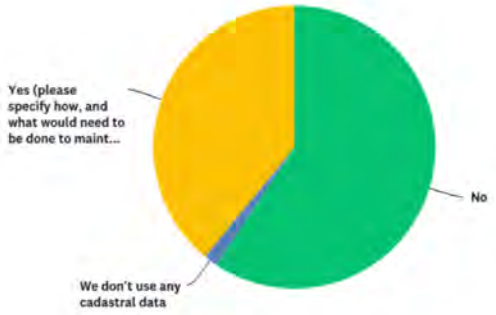
Are you aware of any legislative or regulatory issues that would affect or limit the adoption of the dynamic datum for your organisation?

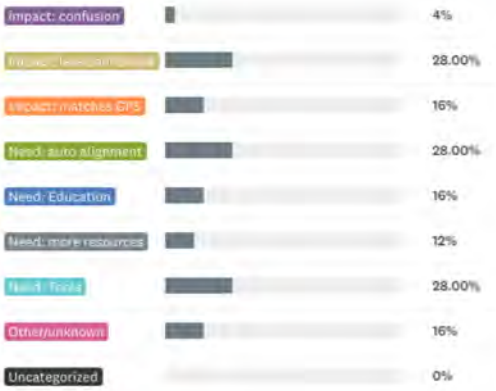


7

40% are concerned about Cadastral Data Integrity being affected: reduced confidence and need for tools to auto-align related data

Would a dynamic datum impact the integrity of your cadastral data, how and what would need to be done?





8

What impact might a dynamic datum have on land development (such as subdivision plan preparation, construction, and approvals)?

- **Only 9% expect positive impact**
- 55% unsure or no impact
- 20% concerned about data misalignment
- Other concerns include:
  - Confusion and reduced confidence in the process
  - Need for tools to manage transformations

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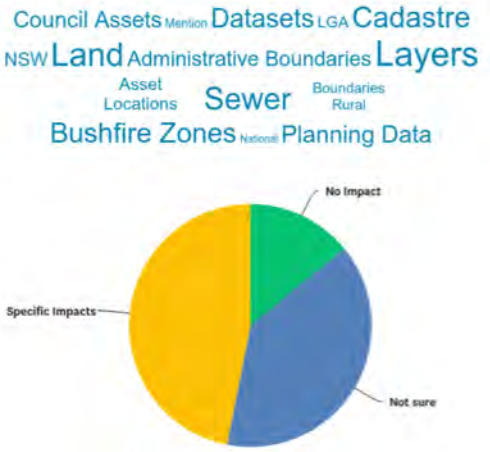
Concerns misalignment with linked data will require extra user efforts. Automation needed.



10

Users' capacity to adopt is limited; they need assistance & software tools for automated conversions

Further concerns:

- Cost & effort involved
- Cadastral fabric is often inaccurate to begin with ('bigger fish to fry')
- When is this all happening? (timing)
- Default should be plate-fixed, ATRF coordinates converted 'on the fly'

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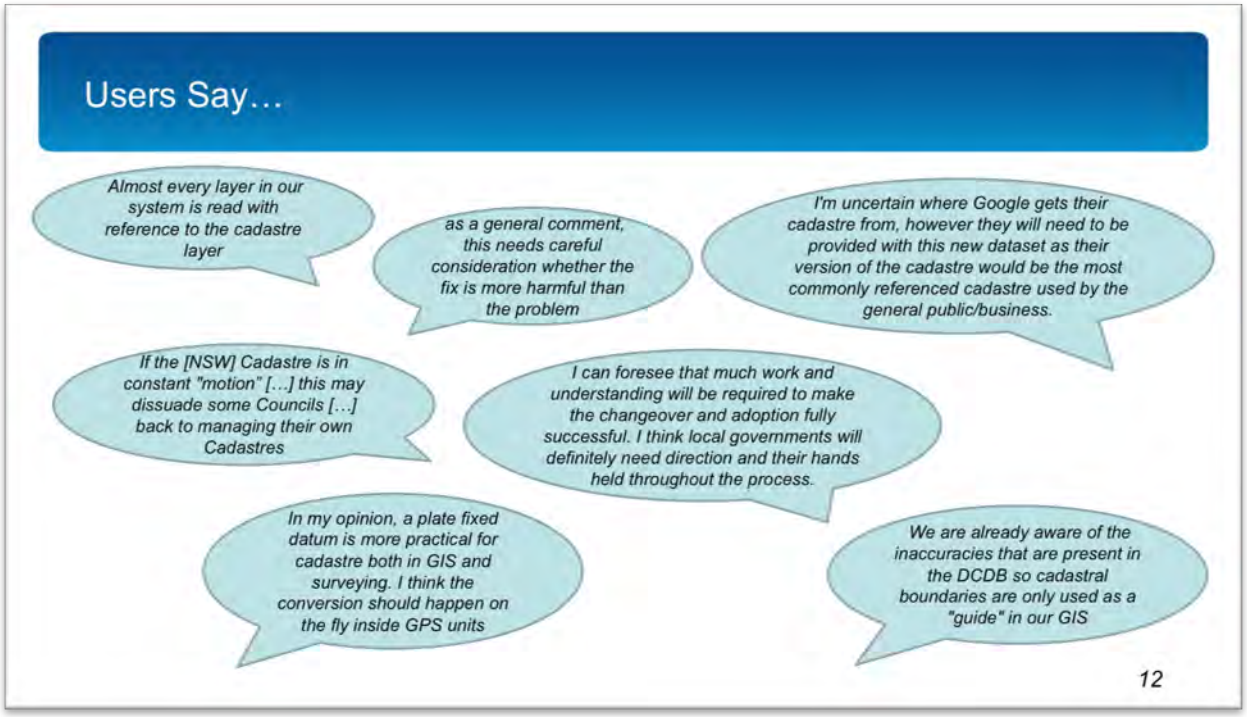
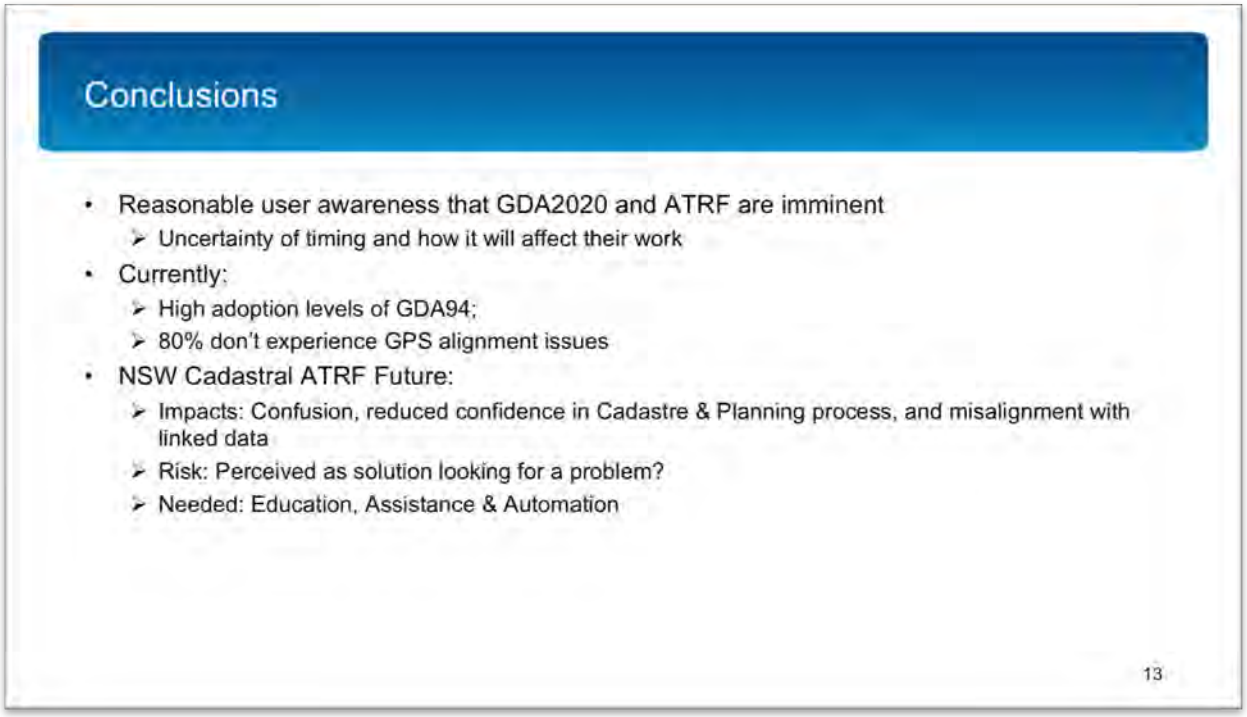

Users Say…
Almost every layer in our system is read with reference to the cadastre layer
as a general comment, this needs careful consideration whether the fix is more harmful than the problem
I'm uncertain where Google gets their cadastre from, however they will need to be provided with this new dataset as their version of the cadastre would be the most commonly referenced cadastre used by the general public/business.
If the [NSW] Cadastre is in constant "motion" […] this may dissuade some Councils […] back to managing their own Cadastres
I can foresee that much work and understanding will be required to make the changeover and adoption fully successful. I think local governments will definitely need direction and their hands held throughout the process.
In my opinion, a plate fixed datum is more practical for cadastre both in GIS and surveying. I think the conversion should happen on the fly inside GPS units
We are already aware of the inaccuracies that are present in the DCDB so cadastral boundaries are only used as a "guide" in our GIS
12


Conclusions
• Reasonable user awareness that GDA2020 and ATRF are imminent
➢ Uncertainty of timing and how it will affect their work
• Currently:
➢ High adoption levels of GDA94;
➢ 80% don't experience GPS alignment issues
• NSW Cadastral ATRF Future:
➢ Impacts: Confusion, reduced confidence in Cadastre & Planning process, and misalignment with linked data
➢ Risk: Perceived as solution looking for a problem?
➢ Needed: Education, Assistance & Automation
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Appendix 4. Document Register

Title	Date	Type	Source
2017-09-01-vic-spatial-summit-gda2020-fraser.pptx	1-Sep-17	Presentation	Roger Fraser (VIC office of Surveyor General)
20170331_Gowans_CSA_conf_GDA2020	14-Aug-17	Presentation	Nic Gowans, through Adrian White
Australia on the move: how GPS keeps up with a continent in constant motion	6-Feb-17	General publication	Chris Rizos (UNSW) & Donald Grant (RMIT), in "The Conversation"
Cadastral Case Study FINAL (002)	26-Oct-17	Research report	Kylie Armstrong (CRCSI)
Cadastre NSW - Stakeholder Analysis Report	6-Apr-16	Research report	Jacobs
Cadastre NSW - Update May 2017.PDF	8-Aug-17	Presentation	Adrian White
Cadastre2034.pdf	7-Jul-05	General publication	ICSM
CORS & Geodesy - Action Plan - 1718 - V1.1	14-Aug-17	Other	Simon McElroy through Adrian White
CRCSI P1.02 Work Package 3 Tasks 2 3 and 4 Consultants Report_July_2017	1-Jul-17	Research report	CRCSI / TAS DPIPWE
Datum Modernisation Implementation Project Plan - Phase 1	1-Apr-16	Trade publication	ICSM
DatumMattersFactSheet1	6-Aug-17	General publication	ICSM
DatumMattersFactSheet2	6-Aug-17	General publication	ICSM
Enabling GDA2020 In the current cadastral and geodetic environment	1-Jul-17	Presentation	Matt Higgins, Geodesy and Positioning Manager. QLD DNRM
GDA2020 Implementation Land Tasmania DRAFT Jurisdictional Plan	1-Aug-16	Research report	TAS DPIPWE Julian Gill | Manager (Spatial Operations) Geodata Services | Land Tasmania
GDA2020, AUSGeoid2020 and ATRF: An Introduction	1-Jan-14	Academic paper	Volker Jansen - NSW Spatial Services, Research@Locate 2014
InterimReleaseNoteV1.0	3-Mar-17	Trade publication	ICSM PCC
Locate 17 Panel discussion - Impacts of Datum – National and International Perspectives	1-Apr-17	Presentation	Michael Giudici, John Dawson, Scott Strong
PCG-SSSC_2013_Canberra	2013	Presentation	ICSM PCC
Report on ACT coordinate datum upgrade (v1.4)	1-Sep-16	Research report	Bill Hirst
Single Land Cadastre for NSW. Co-design workshop, summary of outcomes	2015	Research report	Cofluence
Stakeholder-Requirements-for-Modernising-Australias-Geocentric-Datum	7-Jul-05	Research report	ICSM
SummaryDatumQuestionnaire	1-Jul-16	Research report	ICSM
Utilities and LGA event_GDA2020 100817	10-Aug-17	Presentation	Narelle Underwood
Utilities and LGA event_GDA2020 100817 UPDATED.pptx	10-Aug-17	Presentation	Darren Burns, QLD DNRM