ACIL ALLEN CONSULTING

REPORT TO
3D QLD TASKFORCE

FEBRUARY 2017

3D QLD ROAD MAP PRELIMINARY FINDINGS

INTERIM REPORT ADDRESSING PART A

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GLOSSARY OF TERMS

Term	Definition
3D Data	Data representing the physical attributes of the natural and built environment in 3 dimensions, as well as all RRR boundaries.
3D Qld	'Three Dimensional Queensland' is a project that aims to build on successful centuries old land surveying practice and law, transitioning to a modernised and efficient system suitable to meet the needs of the 21st century. It will be realised in part by land surveying professionals incorporating survey accurate, three dimensional measurements on the earth into their everyday practice and presenting this in a digital format. Ultimately, a potential outcome envisioned by 3D Qld is 'An authorised, federated, secure, digital 3D model (of the natural and built environment, including all RRR) with high positional certainty'.
3D Qld Taskforce	Comprising representatives from the Surveying and Spatial Sciences Institute QLD division, Spatial Industries Business Association, Australian Institute of Mine Surveyors, the Surveyors Board of QLD, Queensland Spatial and Surveying Association (QSSA) and the Qld Department of Natural Resources and Mines. The purpose of the Taskforce is to realise the 3D Qld vision through the preparation of a Road Map.
ABS	Australian Bureau of Statistics.
ADAC	Asset Design and As Constructed, local government focused data specification, mainly used in Qld.
AEC	Architecture, Engineering and Construction.
Agile Development	An umbrella term for several iterative and incremental software development methodologies. The most popular agile methodologies include Extreme Programming (XP), Scrum, Crystal, Dynamic Systems Development Method (DSDM), Lean Development, and Feature-Driven Development (FDD).
AI	Artificial Intelligence, is a branch of computer science dealing with the simulation of intelligent behaviour in computers, with the capability to imitate intelligent human behaviour to some degree. A General AI is defined to have an intelligence similar to (or better than) a human.
AIMS	Australian Institute of Mine Surveyors.
AMCA	Air Conditioning and Mechanical Contractors' Association.
AMCA	Air Conditioning and Mechanical Contractors' Association.
A-Spec	Standardised approach to specifying roads, drainage, open space, water, sewerage and buildings. It is used across many jurisdictions in Australia (mainly Victoria and Western Australia), as well as Wellington in New Zealand.
BIM	Building Information Modelling, a process involving the generation and management of digital representations of physical and functional characteristics of places.
BIM-MEP^{AUS}	Building Information Modelling-Mechanical and Electrical Australia, and initiative of AMCA to develop specifications that define plant, equipment and fittings for essential building services (mechanical, electrical and plumbing).

Term	Definition
Blockchain	An electronic public ledger of all transactions that have ever been executed. It is constantly growing as 'completed' blocks are added to it with a new set of recordings. It was first used to create a digital currency (Bitcoin) but is now being modified for other uses to decentralise document processing – enabling the process to be sped up at much reduced cost and without the need for a 'trusted third party' to hold the official record.
BMS	Building Management System.
Cadastre	Provides the most fundamental information on land tenure, establishing unique boundaries for the principal Rights, Responsibilities and Restrictions (RRR) that apply to it.
CGSSR	Cadastral & Geodetic Services Systems Review project to determine DNRM's future approach to how land information e.g. property, surveying and addressing data, is created and used by different people and organisations. The project aims to develop a system that enables the industry to use and contribute spatial information, which will build a resource that will have benefits for everyone.
CityGML	Standard for delivering city-scale 3D models through the Web.
CORS	Continuously Operating Reference Stations (together with GNSS satellites and new receivers and algorithms) enable precise point positioning over the whole country.
CRCSI	Cooperative Research Centre for Spatial Information.
CSG	Coal Seam Gas.
DBE	Digital Built Environment is a 3D Computer Model of the Natural and Built Environment (inside and out, above and below ground) that includes all RRR boundaries - on all scales required for decision-making. It is a potential outcome envisioned by 3D Qld.
DCDB	Digital Cadastral Data Base. It is created and maintained by the DNRM and currently exists only in 2D. It represents the compilation of all lots into a single seamless 'fabric', without gaps or overlaps and includes some restrictions.
Discount Rate	Rate of Return used to discount future cash flows to current dollars.
DNRM	Queensland Department of Natural Resources and Mines.
DNRM Project	Cadastral and Geodetic Services Systems Review Project (CGSSR).
EARL	Former name for standard and system for the electronic lodgement of survey plans in Qld, now called eSurvey.
eConveyancing	Private practices set up to manage electronic property transactions.
eGeodesy	A project of the Permanent Committee on Geodesy (PCG) of the Australian and New Zealand Intergovernmental Committee on Surveying and Mapping (ICSM) to develop a standards based approach for the exchange of geodetic data and metadata within Australia and New Zealand.
ePlan	Standard and system for the electronic lodgement of plans and planning enquiries.
eSurvey	Standard and system for the electronic lodgement of plans in Qld.
Federated	Made up of many different linked data sets under the control of many of different entities (public and private) who have a vested interest in maintaining their own source data.

Term	Definition
Flagstone	The Greater Flagstone Priority Development area covers a total area of 7188 hectares to the west of the Jimboomba and the Mount Lindesay Highways, along the Brisbane-Sydney rail line. When fully developed it is anticipated that it will provide approximately 50,000 dwellings to house a population of up to 120,000 people.
GDA2020	Geocentric Datum of Australia 2020, a new dynamic reference frame that can account for mm shifts of the whole continent of Australia, as well as local ground movement, over time. This permits improved dynamic positioning of boundaries and elevations relative to an agreed datum (a coordinate reference frame) that has a known relationship to the whole Earth. (http://www.icsm.gov.au/geodesy/modern.html)
GE	General Electric Company.
Geo-referencing	The process of assigning spatial coordinates to data that is spatial in nature. In Australia, the coordinates proposed to be used are those within the new GDA2020 Dynamic Datum.
Geoscape	A new initiative from PSMA that captures the observed built environment and anchors it in a reliable geospatial base. The dataset includes 3D building attributes, land cover and tree heights. Geoscape also captures features such as roof materials, swimming pools and solar panels.
GIS	Geographic Information System, a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface.
GNSS	Global Navigation Satellite System that triangulates signals from satellites and ground stations to deliver real-time precise point positioning.
Hackathons	An event in which computer programmers and others involved in software development, including graphic designers, interface designers and project managers, collaborate intensively on software projects. Occasionally, there is a hardware component as well.
IaaS	Infrastructure as a Service is a form of cloud computing that provides virtualized computing resources over the Internet.
ICSM	Inter-governmental Committee on Surveying and Mapping.
IFC	Industry Foundation Class is an object-based file format with a data model developed by buildingSMART International to facilitate interoperability in the architecture, engineering and construction (AEC) industry.
IndoorGML	A new standard that supports way-finding and emergency egress in buildings.
InfraGML	A possible replacement for LandXML, designed specifically to address the modelling of broader infrastructure elements of the environment.
IoT	Internet of Things, a proposed development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data.
Landgate	Comprehensive electronic Land Administration system, including standards and system for the electronic lodgement of plans in WA.
LandXML	XML stands for Extensible Markup Language. It is a file format used to create common information formats and share both the format and the data on the World Wide Web, intranets, and elsewhere using standard ASCII text. XML is similar to HTML. LandXML provides the standards that relate specifically to data files relating to land and buildings.
Lidar	Light Detection And Ranging is a detection system which works on the principle of radar, but uses light from a laser to measure distances to points on the surface of objects that reflect the laser light.

Term	Definition
MOOC	Massive Open On-line Courses, some of which provide world class STEM training, with the option to pay for assessment to gain a recognised qualification.
Moore's Law	Moore's Law is the observation that the number of transistors in a dense integrated circuit doubles approximately every two years.
MOU	Memorandum of Understanding is a formal agreement between two or more parties that are not legally binding, but set out the parties joint intent.
National Map	A website for map-based access to spatial data from Australian government agencies. It is an initiative of the Department of Communications and the Arts now currently managed by the Department of the Prime Minister and Cabinet and the software has been developed by Data61 working closely with the Department of Communications and the Arts, Geoscience Australia and other government agencies.
NIEIR	National Institute of Economic and Industry Research.
NPV	Net Present Value.
OGC	Open Geospatial Consortium.
PaaS	Platform as a service is a category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app.
PCG	Permanent Committee on Geodesy of the Australian and New Zealand Intergovernmental Committee on Surveying and Mapping (ICSM) to develop a standards based approach for the exchange of geodetic data and metadata within Australia and New Zealand.
PEXA	Property Exchange Australia is Australia's online property exchange network. It assists members – such as lawyers, conveyancers and financial institutions – to lodge documents with Land Registries and complete financial settlements electronically.
Photogrammetry	The science of making measurements from photographs, especially for recovering the exact positions of surface points. A special case, called stereophotogrammetry, involves estimating the three-dimensional coordinates of points on an object employing measurements made in two or more photographic images taken from different positions to construct 3D images from 2D photos.
Point Cloud	A point cloud is a set of data points in some coordinate system. In a three-dimensional coordinate system, these points are usually defined by X, Y, and Z coordinates, and often are intended to represent the external surface of an object. Point clouds may be created by 3D scanners.
PPK	Post Processing Kinematic is a position location process whereby GNSS signals received by a mobile location device stores position data that can be adjusted using corrections from a reference station after the data has been collected.
PSMA	PSMA Australia Limited is a company owned by state, territory and Australian governments, established to coordinate the collection of fundamental national geospatial datasets and to facilitate access to this data.
QSSA	Queensland Spatial and Surveying Association.
Queensland Globe	The Queensland Globe is an interactive online tool that can be opened inside the Google Earth™ application. Queensland Globe allows you to view and explore Queensland spatial data and imagery. You can also download a cadastral SmartMap or purchase and download a current titles search.

Term	Definition
RPAS	Remotely Piloted Aircraft Systems, aircraft that can be remote controlled aircraft (e.g. flown by a pilot at a ground control station.
RRR	All Rights, Responsibilities and Restrictions (RRR) boundaries applying to real property, including easements, water rights, native title, mining tenements, etc., as well as National, State and Local rights.
RTK	Real-time Kinematic – a technology used to augment the accuracy of position data derived from GNSS.
SaaS	Software as a Service is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted. It is sometimes referred to as "on-demand software". SaaS is typically accessed by users using a thin client via a web browser.
SIBA	Spatial Industries Business Association.
SIX	Spatial Information eXchange, recently replaced by Spatial Services portal that provides the spatial and cadastral products and services, also the LPI Online Portal that supplies titling and registry products and services, and the Property NSW Valuation Portal that supplies valuation products and services.
SPEAR	Surveying and Planning through Electronic Applications and Referrals, a standard and system for the electronic lodgement of survey plans in Victoria.
SPP	Queensland State Planning and Policy division within the Department of Infrastructure, Local Government and Planning.
SSSI	Surveying and Spatial Sciences Institute, QLD division.
STEM	Science, Technology, English and Maths.
UAS	Unmanned Aircraft Systems, also Drones and Unmanned Aerial Vehicles (UAV), which is an aircraft with no pilot on board that can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems.
UAV	Unmanned Aerial Vehicle (see UAS).
VANZI	Virtual Australia and New Zealand Initiative, a stakeholder led initiative to create the legal framework, web services architecture and business processes to create the Digital Built Environment.
Virtual Brisbane	A computer-generated 3D model which is helping Brisbane City Council plan for the city's future growth. It enables the visualisation and analysis of development in relation to the existing urban environment in a level of detail not previously possible.

DOCUMENT NAVIGATION

To navigate links: Hold Ctrl Key and Click:

1. on entry in Contents to move directly to selected section
2. on blue highlighted link to go to source, if connected to the internet
3. on red superscript number (E.1 or 1) to go to reference.

EXECUTIVE SUMMARY

Introduction

This report has been prepared for the 3D Qld Taskforce comprising the Surveying and Spatial Sciences Institute (SSSI) QLD division, Spatial Industries Business Association (SIBA), Australian Institute of Mine Surveyors (AIMS), the Surveyors Board of QLD (SBQ), Queensland Spatial and Surveying Association (QSSA) and the Qld Department of Natural Resources and Mines (DNRM).

This report addresses Phase A of a three-stage project to develop a Road Map to implement the 3D Queensland Vision. The purpose of the Road Map is to guide government and the spatial/surveying sector in understanding and implementing the reforms required within both sectors.

It completes the Preliminary Phase of the 3D Qld Road Map and is based on feedback from a wide range of stakeholders within Queensland and Nationally.

The 3D Qld Vision

The Cadastre sets out the legal boundaries of most Rights Responsibilities and Restrictions (RRR) relating to land and buildings.

3D Qld (Three Dimensional Queensland) aims to build on successful centuries old land surveying practice and law to create a modernised and efficient Cadastral System suitable to meet the changing needs of the 21st century.

3D Qld will be realised in part by land surveying professionals incorporating survey accurate, three dimensional measurements on the earth into their everyday practice and presenting them in a digital format. This will create a 21st century digital cadastre capable of supporting the changing needs of the community for generations to come.

An accurate 3D Digital Cadastre will create options for the community to build on new tools (such as Building Information Modelling (BIM) and Digital Engineering) to develop more integrated approaches to 3D design, construction and management of the built environment.

A potential outcome could be an authorised, federated, secure, digital 3D model (of the natural and built environment) with high positional certainty and dimensional accuracy.

Its purpose would be to facilitate:

- enhanced spatial data analysis, and
- more efficient and accurate public and private decision-making.

Findings

Pressures on government and industry

There is an emerging need to progress the 3D Qld Road Map driven by many factors including:

- demand for greater 3D positional and dimensional accuracy in the Cadastre
- changes in technology, including increasing access to precise positioning
- increasing demand for government data (such as the Cadastre) to be in digital form
- the impending modernisation of the Australian Datum
- development of 3D data bases in the private sector and by major cities
- development of open data policies

- the need to increase collaboration between government and industry in the use and exchange of digital cadastral and other land related data
- the potential for further major productivity improvement in the construction and infrastructure sectors in particular
- the use of spatial data in support of data analytics in many areas including insurance and hazard risk management.

The Cadastral and Geodetic Services Systems Review (CGSSR)

The Department of Natural Resources and Mines is currently undertaking a Cadastral and Geodetic Services Systems Review project. The project will implement aspects of the 3D Qld vision. It aims to develop a cadastral system and a collaborative environment that will enable industry to use and contribute spatial information, creating a cadastral resource that will benefit everyone.

The project is focussed on modernising business processes for cadastral and geodetic data to implement fully digital processes speed up the delivery of, an accurate 2D and 3D Cadastre through automation, to provide more access to 2D and 3D data, and to facilitate a two way exchange of information through a collaborative environment.

The ultimate goal is twofold:

- to develop a 'single point of truth' for the data being captured to underpin the legal cadastral framework, and
- provide a 'positionally accurate' digital expression of this legal framework.

As shown in Chapter 8, investment in modernising the cadastral system has the potential to deliver significant productivity benefits for government and the surveying, building and construction sectors in the near term.

The DNRM project will implement aspects of the 3D Qld vision. It is the intention of the Task Force that the 3D Qld Road Map will assist in the development of the business case for the expenditure necessary to implement the modernisation program.

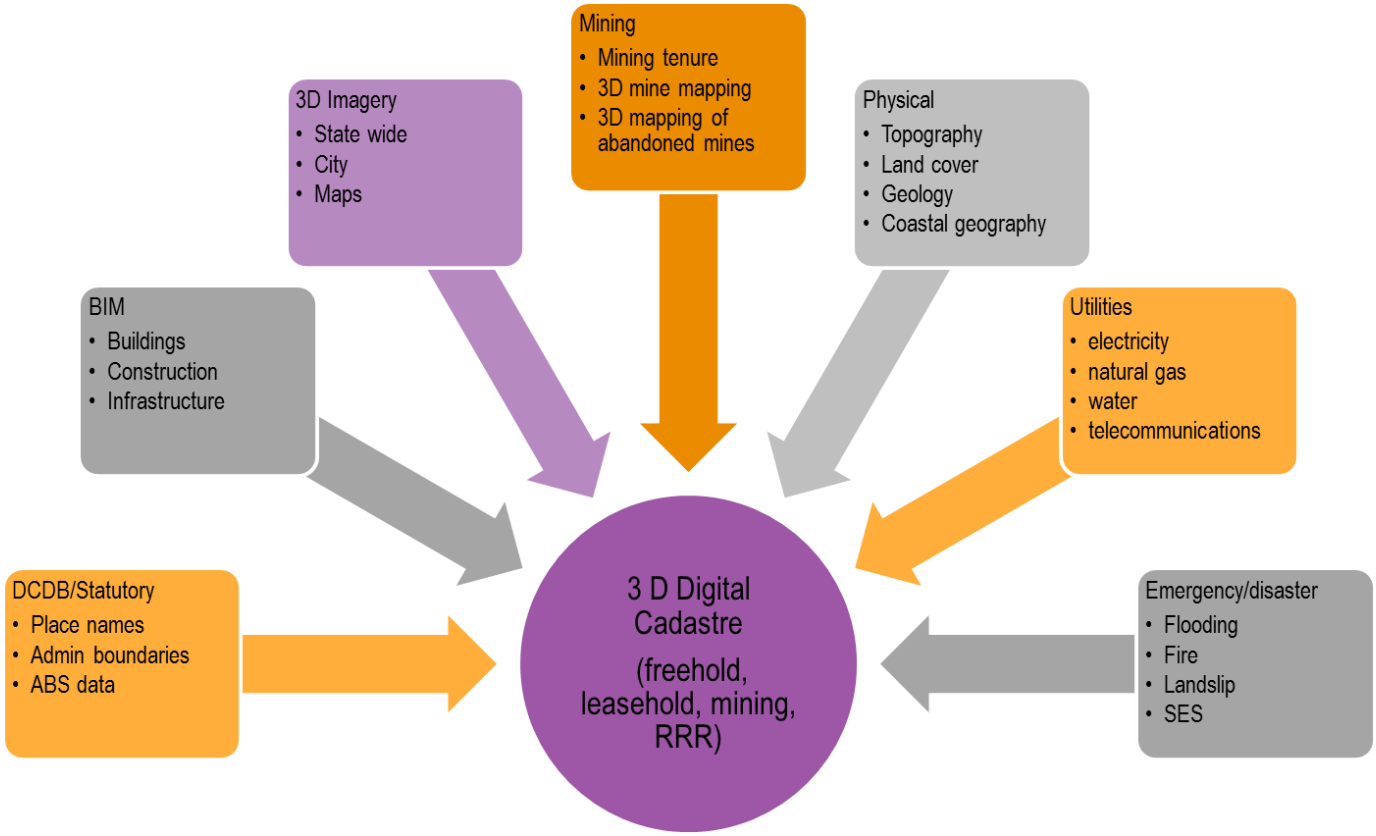
Potential longer term developments

Consultations undertaken for this report also identified additional potential longer term benefits for the private sector and government that could ultimately be delivered through the development of authenticated registers of 3D as-built data. The potential benefits accruing in the building, construction, utilities and mining sectors are significant.

To fully realise these benefits, collaboration on standards, protocols and data verification will be required. Such collaboration is envisaged to be part of the of the 3D Qld strategy over the longer term.

The areas of activity where collaboration and integration are likely to change the operating environment and deliver benefits over time are shown in Figure ES 1.

FIGURE ES 1 AREAS OF POTENTIAL FOR GREATER INTEGRATION AND COLLABORATION FROM THE 3D QLD VISION



SOURCE: ACIL ALLEN

Value of land and property administration

There are currently around $1.6 trillion of mortgages secured against land titles in Australia, of which an estimated $277 billion are in Queensland.[1] At the same time, the total value of all the residential property held in Queensland is $924 billion and $5.9 trillion Australia-wide.[2] As noted in ICSM (2014)[3], the land administration systems allow people, businesses and governments to leverage and manage these huge national and state asset bases. Indeed, given that the size of the Queensland and Australian economies (as at 2014-15) was $314 billion and $1.6 trillion respectively[4], the value of the land administration systems and the opportunity that 3D Qld offers to substantially enhance this value are evident.

TABLE ES 1 SOME KEY ECONOMIC VALUES UNDERPINNED BY LAND ADMINISTRATION

	Queensland	Australia
	A$ billion	A$ billion
Total value of residential dwelling stock (March 2016)	$924	$5,931
Gross State Product/GDP (2014-15) [a]	$314	$1,605
Total residential housing loans (March 2016)	$277 [b]	$1,603

[1] Australian data sourced from Australian Bureau of Statistics (ABS) (2016), *Housing Finance, Australia*, Catalogue number 5609, June. Queensland figures were estimated by ACIL Allen.
[2] ABS 2016, *Residential Dwellings: Values, Mean Price and Number by State and Territories Dataset*, http://stat.abs.gov.au/Index.aspx?DataSetCode=RES_DWEL_ST, accessed August 2016.
[3] Intergovernmental Committee on Surveying and Mapping (ICSM) 2014, *Cadastre 2034: Powering Land and Real Property, Cadastral Reform and Innovation for Australia – National Strategy*, Consultation document, April.
[4] ABS 2015, *Australian National Accounts: State Accounts, 2014-15,* Catalogue number 5220.0, November.

	Queensland	Australia

[a] Chain volume measures.

[b] Estimated by ACIL Allen.

SOURCE: ACIL ALLEN CONSULTING BASED ON ABS DATA.

Demand for accurate 3D mapping of the legal environment for property in digital form

Stakeholder consultations have identified that demand for an accurate 3D Cadastre is coming from two directions:

First, accurate 3D mapping in digital form of all Rights, Responsibilities and Restrictions (RRR) boundaries relating to land and buildings has the potential to deliver significant productivity improvements in key sectors of the economy, particularly in the surveying, engineering, construction and infrastructure sectors. This opportunity is being addressed directly by the Department of Natural Resources and Mines via their CGSSR project, and forms the foundation of the 3D Qld vision.

The second source of demand is the emerging need to coordinate the growing number of 3D models of the natural and built environment that are being created for design and construction, asset and facility management, and sales and marketing. There is longer term potential for these to be federated into integrated 3D model of the Digital Built Environment (DBE) that can be used for decision making throughout the property cycle.

Stakeholder consultations confirmed that an accurate and comprehensive 3D cadastre is fundamental to a DBE. It is required to provide the boundaries for access to private parts of the federated model (most internal spaces), and for reliable and legally enforceable decisions to be made directly in the DBE (based on real-world RRR boundaries being accurately delineated in the model). While this is a longer term project, it offers the potential to deliver significantly bigger benefits on top of the CGSSR project.

Ultimately, the RRR boundaries will need to include all legislative and administrative boundaries with direct reference to the laws and regulations that apply to land and buildings within each boundary (for example, environmental or historical overlays, or specific health regulations, etc.). In the longer term, this could require local, state and federal bodies to geo-reference their applicable legislation and make it available in digital form.

Imagery, maps and models provide an intuitive contextual interface for customers and staff. Already, instead of making text based queries, users can simply point to (or select) boundaries, areas or objects within a model (also linked to the real-world using augmented (2) and merged (3) reality displays), and use natural language and gestures to access all relevant data relating to the selected elements. New data may also be ingested via the model directly from the source; as simply as sending a geo-referenced photo of a pothole to the council via an app, to automatically show its location in the model (already available (4)).

Over the next decade, RRR boundaries in 3D imagery, maps and models will also increasingly provide legal spatial context for all operational data generated by the Internet of Things (IoT) - smoothing the flow of energy, water and waste, as well as people, vehicles and goods throughout our cities.

The emerging use and application of location data analytics is also growing rapidly with the evolution of robotics and autonomous control systems throughout the supply chain (from agriculture and mining to manufacturing and logistics), as well as in health and education, for insurance, finance and tourism, and emergency services and disaster recovery. This data too will need to be understood in its legal spatial context.

For a 'federated system' system to work efficiently at least cost across all these sectors, a way will need to be found to securely store, locate and share 'authenticated' data that is under the control of millions of different entities, each having different RRR.

An accurate 3D Cadastre covering all RRR and tied to a modernised datum was seen by stakeholders as fundamental to the rights of access to any federated model - to maintain security and protect privacy - as well as for decision making in the model.

The majority of stakeholders felt that whatever the approach, it should be nationally consistent.

It was also recognised that, just as we protect our physical environment and buildings from arbitrary modification and destruction, so we may need to protect their digital twins, as the DBE becomes an increasingly valuable community resource.

Many stakeholders saw the day when it would be standard business process for no changes to be made to the real world before they had been approved in the digital world, and for any model to be updated once the changes had been made (before payment for work done) – to ensure both worlds remain in lock step.

3D Qld has the potential to provide the foundation on which this new digital infrastructure could be built.

Ultimately, it could enable users to deliver better outcomes, more quickly, at lower cost, and with much less risk (financial, safety and property) across all sectors of the economy.

At an even more basic level, in the words of Rony Abovitz, CEO Magic Leap: new 3D technologies have the potential to "make us better, happier and smarter by putting the world's knowledge literally in front of our eyes and at our finger tips (1), wherever we are, whenever we need it" - all in its legal spatial context, without the need to search, or gain approval, or check terms of use - depending only on our real-world RRR. But only if we get the framework right.

The current landscape

At present, the Cadastre is recorded in 2D format and has variable positional and dimensional accuracy due to historical shortcomings in the equipment and practices of the past. Accuracy has improved greatly over time as technology and processes have been refined. However, many old titles remain to be updated.

Even though the future value of 3D data is clear, most organisations across the stakeholder group do not yet incorporate 3D mapping or modelling as part of their core business processes. Those that do incorporate mapping into their processes, mainly use 2D GIS.

As a result, much of the 3D data that is now being generated for specific projects is simply 'lost' over time, as it ceases to be tracked once the project is completed.

Despite the general lack of 3D business systems, the message from all sectors is the same, and is supported by a review of the literature and international experience, namely that integration between LIDAR (including Mobile Laser Scanning) (14) and photogrammetry (150), and Geographic Information Systems (GIS) (16) and Building Information Modelling (BIM) (17) is already happening on a project by project, and user by user basis, sector by sector.

Furthermore, development of precise GNSS positioning systems, together with new sensors and control systems and the emergence of cloud computing, is creating a demand for core data to apply new approaches to data management, analysis and integration for design, construction and asset and facility management purposes.

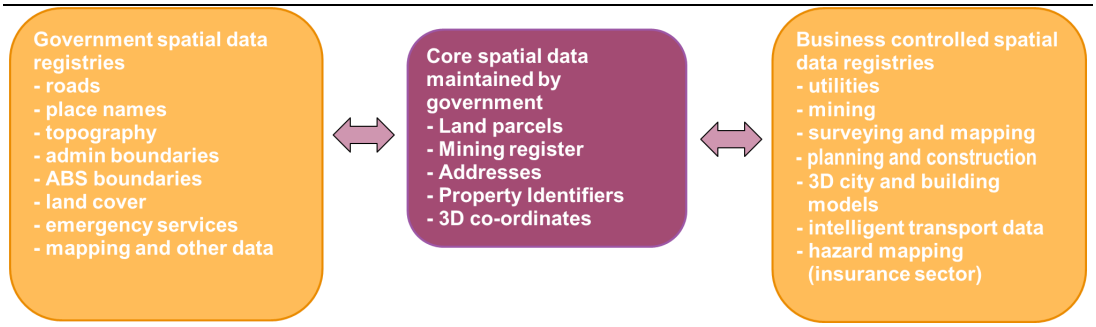
Future needs

There will be a need for greater collaboration between government and industry (in particular utilities, local government, infrastructure providers and miners) in the development of an accurate representation of the 3D Cadastre.

Collaboration will also be required in the federation of the 3D data sets that represent the natural and built environment, and potentially an evolution in the legislative and regulatory arrangements that apply to authoritative data sets, if the economic potential of the 3D world is to be fully realised.

The relationship between core data and data registries held by governments and spatial data registries held by the private sector is illustrated in Figure ES 2.

FIGURE ES 2 POSSIBLE SPATIAL DATA REGISTRIES AND LINKAGES TO CORE SPATIAL DATA



Note: the spatial data registries included above are not exclusive

SOURCE: ACIL ALLEN CONSULTING/VANZI:

Demand for certified data sets is likely to arise from the need for productivity improvement in the surveying, engineering and infrastructure sectors in the first instance. Many of the benefits will accrue to local government and the community in general from improved coordination between land, infrastructure, utilities, transport activities and local government.

As noted in the preceding sections, increasing use of 3D sensors, precise positioning, web-based services and control systems are likely to increase the demand from industry and the community in general for more accurate and federated 3D data.

The accurate display of all Rights, Responsibilities and Restrictions (RRR) boundaries within the federated model will be central to:

- decision-making
- all contractual dealings in the federated model; and
- managing access, use and trade in the data itself to protect privacy and commercial interests and importantly, to mitigate cyber threats.

An accurate 3D Cadastre is a key foundation in the core data base.

Consideration will also need to be given to establishing a framework for maintaining and managing data sets held outside of government. Important issues are likely to include approaches to establishing and managing federated data registries, certifying certain data as authoritative, managing access to data and managing security risks.

Stakeholders expressed a strong preference for national arrangements including the possible need for nationally consistent legislation in the medium term.

The availability of technology will not be an impediment to development of 3D systems. However, implementation of the 3D Qld vision will require new skills particularly in the surveying and spatial disciplines. This will create demand for ongoing professional and technical training and development.

Appetite for change

Stakeholder consultations identified three important observations.

Firstly there is a recognition across most sectors of the planning, construction, mining and infrastructure sectors that initial investment in developing an accurate 3D digital cadastre offers potential for significant productivity and efficiency benefits for industry and government.

Secondly, much wider benefits are possible in the longer term if a way can be found to securely federate authoritative 3D data, with access based on each entity's RRR. One possibility is to use authoritative public and private registries (or a variant using 'blockchain' technology) to hold the data on behalf of individual entities and the community (with private registries charging a fee for service, and in some cases, perhaps public registries also) – assuming the quality of data is much improved, and that overall costs and time to gather data are significantly reduced.

Thirdly, concerns about employment and professional opportunities are not considered to be insurmountable obstacles to change. However, change would require a recognition of an ongoing need for education, training and professional development in the surveying and spatial professions, as well as more broadly as the use of 3D models extends throughout the community.

Economic benefits

The potential economic benefits are significant as shown in Table ES 2. The table provides present values of benefits calculated over a 15 year and a 20 year period. The benefits are also split into three parts: benefits accruing to the surveying sector which accrue from 2020, benefits to the engineering and construction sector that accrue from 2026 and benefits to building facilities management sector that also that accrue from 2026 in line with adoption levels assumed in **Table 8.2** in the main body of the report.

TABLE ES 2 INDICATIVE ECONOMIC VALUE

		NPV (7% discount rate)
	Real A$2017 million	Real A$2017 million
Cash flow period	15 years	20 years
Lower bound		
Net productive gain for surveyors [a]	47	58
Savings from federated 3D models:		
Engineering & infrastructure (1%)	179	388
Facility management (1%)	27	78
Total	**253**	**524**
Upper bound		
Net productive gain for surveyors	47	$58
Savings from federated 3D models:		
Engineering & infrastructure (5%)	894	1940
Facility management (2%)	55	156
Total	**996**	**2,154**

[a] These benefits are calculated on the basis of net productivity gains for registered surveyors in Queensland of 15 per cent per annum after a three year implementation period (2016/17 to 2019/20) where no gains are realised.

b Engineering benefits are calculated on the basis of cost savings of between 1 per cent and 5 per cent for levels of adoption commencing at 10 per cent in 2016 rising to 70 per cent by 2033. Forecasts of the value of engineering construction were based on construction activity forecasts by NIEIR ('Queensland regional construction supply and demand analysis: 1994-2025 and quarterly indicators to June 2017', 2015) and ACIL Allen Consulting estimates.

c These benefits are calculated on the basis of cost savings of between 1 per cent and 2 per cent of annual operating costs for levels of adoption commencing at 10 per cent in 2016 rising to 70 per cent by 2033 for all new non-residential buildings and an assumption that annual building operating costs are 3 per cent of construction cost. Forecasts of the value of non-residential construction were based on construction activity forecasts by NIEIR ('Queensland regional construction supply and demand analysis: 1994-2025 and quarterly indicators to June 2017', 2015) and ACIL Allen Consulting estimates.

SOURCE: ACIL ALLEN CONSULTING.

Medium term Benefits to the surveying sector

It is estimated that the present value of benefits to the surveying sector would be around $47 million if calculated over 15 years and $58 million if calculated over 20 years.

These benefits would accrue from 2020 assuming that the full implementation of eSurvey (one component of the CGSSR Project that covers the electronic transfer and submission of cadastral and geodetic data). The economic benefits are derived from consultations with industry stakeholders undertaken in the course of this project.

Longer term benefits for the engineering and construction sector

It is estimated that the present value of benefits to the engineering construction sector could range between:

- $179 million (lower bound) to $894 million (upper bound) if calculated over 15 years
- $388 million (lower bound) to $1,940 million (upper bound) if calculated over 20 years.

These are potential long term benefits for engineering and construction from the efficiencies achievable through federated 3D models.

Longer term benefits for facilities management of buildings

It is estimated that the present value of benefits to operation and maintenance of non-residential buildings could range between:

- $27 million (lower bound) to $55 million (upper bound) if calculated over 15 years
- $78 million (lower bound) to $156 million (upper bound) if calculated over 20 years.

In summary the total benefits that could potentially arise range from

- **$253 million to $996 million if calculated over 15 years**
- **$524 million to $2,154 million if calculated over 20 years.**

These benefits do not take into account the costs or savings flowing from the original creation of the data, as the cost of creating it must covered by the project for which it is first required. The benefits flow only from federating pre-existing private and public data.

The longer benefits additional to this accrue after 10 years and are dependent on the development of federated 3D models as discussed in the report. However if realised they deliver significantly greater benefits in the longer term.

Given the federated system does not have to cover the cost of data generation, and the fact that it should be entirely digital (so its operating costs could be much less than the cost of acquiring the data under current conditions), the assessed federated benefits are considered to represent net savings.

The benefits are also considered to be a conservative, principally because they capture only the federated benefits to construction, and asset and facility management, and because those making the estimates state they are conservative.

As well, many other likely benefits identified by stakeholders have not been quantified due to the lack of comparative cost data for current conditions. Nor is it possible to quantify as-yet unidentified uses. As with all new technologies, its full value will become apparent only years, or even decades, after it is in full use.

The long time frame for realisation of the benefits reflects the fact that the value of the stored data will accumulate over time. The first few 3D data sets captured for posterity will provide little benefit. In time, it will be like the telephone network. As more and more data is retained, its usefulness will escalate.

Once the framework is in place to securely retain and share the data, it is likely that the federated authorised 3D Digital Built Environment (from which most of the benefits flow) could be built over 20 years, an order of magnitude faster than the development of the real world.

Data security

An important issue that arose in discussions with Stakeholders was data security. The net can provide access to data in the 'public domain'. However, most of the built environment consists of private spaces, including spaces and assets controlled by utilities and government bodies that are not open to the public, many of which also pose major security risks.

Cyber warfare, terrorism and crime are becoming an existential threat, the more integrated and automated our cities and economies become. The Australian Cyber Security Strategy (5) recognises that industry alone cannot mitigate these risks. It requires national leadership and a holistic approach.

In the not too distant future, the emerging Digital Built Environment (as envisaged by 3D Qld) may need to be seen as a new piece of 'digital infrastructure' (at least as important as our telecommunications and banking networks), requiring a high level strategic security focus. This will be especially so, the more the DBE becomes embedded with operational data from water and energy networks linked to machines, buildings, and the movement of goods, vehicles and people.

Implementation

Stakeholders were unanimous that the vision is technically achievable, with 3D imaging, mapping and modelling already used to some degree across all sectors of the economy. As well, there are exemplars of secure private data sharing already in existence within the industrial and mining sectors, and on a project by project basis within architecture, engineering and construction (AEC).

The challenge is to find a pathway to extend this sharing capability to all 3D data across all sectors. Given the magnitude of such a task it will be necessary to identify needs and set priorities in the short to medium term.

While this may appear daunting, it may be no more difficult than using a cloud service (like Dropbox™), if the framework and data model standards are in place to support the system. Geo-referencing and good meta-data will be the key.

Unlike in the past, there is no need to provide a detailed specification for the whole system. The aim should be to provide the framework and a statement of the outcomes required (including interoperability and security) and leave the technology sector to deliver it (based on emerging open standards).

With the framework in place, it is expected that industry will be in a position provide the platforms and software as cloud services, at a net saving to users compared with how they get their data currently.

The main concern amongst stakeholders is that any federated system must be national and must protect their rights in the data. In particular, private data owners want to retain control over access and monetisation.

3D Qld can provide these assurances to data owners and government authorities if the RRR in the data are aligned with RRR in the property that the data models. As well, this would greatly simplify contractual arrangements and regulations – another key requirement of stakeholders.

Stakeholders also recognised that having the same RRR in the model as in the real world meant that local, state and federal government responsibilities remained aligned in the real world and the DBE.

Also, as the federated model becomes increasingly integrated into economic and social activity, cyber security becomes of paramount concern.

The risks cannot be overstated. A national framework and platform may be necessary in the medium to long term to provide the necessary level of security.

Conclusion and recommendation

There is a clear need for, and the technical capability to deliver, an accurate 3D Cadastre tied to a new dynamic datum.

Having established the 3D digital framework of RRR boundaries with appropriate positional certainty, the massively growing volume of government and private 2D & 3D digital datasets can be confidently integrated into a federated system that securely holds and shares the data for sound decision making.

The integration of private data with government data promises to deliver benefits of around $520 million to $2.2 billion of value to the Qld economy, and $2.6-11 billion nationally.

Based on these findings, it is recommended that the Task Force proceed with the Road Map to achieve the full potential of 3D Qld.

INTRODUCTION 1

1.2 Background

This report has been prepared for the 3D Qld Taskforce which comprises the Surveying and Spatial Sciences Institute (SSSI) QLD division, Spatial Industries Business Association (SIBA), Australian Institute of Mine Surveyors (AIMS), the Surveyors Board of QLD (SBQ), Queensland Spatial and Surveying Association (QSSA) and the Qld Department of Natural Resources and Mines (DNRM).

The Taskforce was formed by the organisations that represent the people who create and maintain the Cadastre, along with other spatial data, technologies and services: SSSI, SIBA, AIMS, SBQ, QSSA and DNRM. The purpose of the Taskforce is to realise the vision through the preparation of a Road Map for 3D Qld.

ACIL Allen Consulting (7) has been appointed to prepare the Road Map, together with VANZI (8) and a team of domain experts (refer appendix D).

This report is an interim report addressing the economic case for pursuing the 3D Qld Vision, developed by the Taskforce under the umbrella of Cadastre 2034 (9), as well as issues related to needs, appetite and implementation of the strategy. The report is based on feedback from a wide range of stakeholders within Queensland and nationally and draws on research and case studies for the economic analysis.

In establishing the terms of reference for the project, the 3D Qld Taskforce recognised that industry and the broader community are driving greater demand for a 3D representation of the increasingly complex tenure arrangements, to meet consumer need.

1.3 Terms of Reference

The purpose to the 3D Qld project (9) is to develop a Road Map that will guide the spatial / surveying sector in understanding and implementing the reforms required within the private and government sectors.

A priority action is the need to develop a roadmap that would provide clarity on the underpinning drivers for realisation of the vision from economic to public good imperatives.

It is critical that we accelerate migration of current land administration cadastral systems towards an authorised, federated, secure, digital 3D model with high positional certainty to facilitate a revolution of enhanced spatial data analysis and more efficient and accurate public and private decision making.

This concept of the roadmap is consistent with the vision by the Intergovernmental Committee on Surveying and Mapping (ICSM) Cadastre 2034: Powering Land and Real Property (9), which is a national strategy for cadastral reform and innovation for Australia. The vision of 3DQld is further supported by and has substantial synergies with VANZI (8) (Virtual Australia and New Zealand Initiative) in their vision for a Digital Built Environment, and aligns with similar aspirations of the

international standards bodies such as buildingSMART (11) and Open Geospatial Consortium (12) (OGC).

The purpose of this roadmap is to enhance the realisation of the 3DQLD vision and in turn set underpinning frameworks for realisation of an outcome that would support a foundation for title information outlined under the VANZI concept (for a secure federated 3D model including all RRR boundaries). The roadmap would aim to match short term and long term goals with specific technology and supporting process, standards and regulation through enhanced private sector and government collaboration.

The Cadastral and Geodetic Services Systems Review project currently being undertaken by the Department of Natural Resources and Mines (DNRM) is being conducted as a separate (though complementary project). Since its inception, the Taskforce has endeavoured to ensure that both projects have clear responsibilities to deliver a coherent vision, recognising that the outcomes of the DNRM project will implement aspects of the 3D Qld vision.

The DNRM is managing all aspects related to the actual processes of Land Administration, while the 3D Qld project is considering the economic benefits and Road Map to achieve the overall vision.

1.4 The 3D Queensland Vision

The Cadastre sets out the legal boundaries of most Rights Responsibilities and Restrictions (RRR) relating to land and buildings.

3D Qld (Three Dimensional Queensland) aims to build on successful centuries old land surveying practice and law to create a modernised and efficient Cadastral System suitable to meet the changing needs of the 21st century.

3D Qld will be realised in part by land surveying professionals incorporating survey accurate, three dimensional measurements on the earth into their everyday practice and presenting them in a digital format. This will create a 21st century digital cadastre capable of supporting the changing needs of the community for generations to come.

An accurate 3D Digital Cadastre will create options for the community to build on new tools (such as Building Information Modelling (BIM) and Digital Engineering) to develop more integrated approaches to 3D design, construction and management of the built environment.

A potential outcome could be an authorised, federated[5], secure, digital 3D model (of the natural and built environment) with high positional certainty and dimensional accuracy.

Its purpose would be to facilitate:

- enhanced spatial data analysis, and
- more efficient and accurate public and private decision-making.

1.5 Phase A – setting the framework, vision and justification of the 3D QLD Vision

The initial phase includes the steps to satisfy essential conditions, provide leadership and sponsorship and define the scope and boundaries for the roadmap. It answers the questions:

a) What if any pressures are government and private industry experiencing in administering the current system under technology, standards and current practice?

b) What is the estimated value of current land administration practice and systems to the economy of Queensland and Australia?

[5] Federated simply means that, ultimately, it will be made up of many different *linked* data sets under the control of many different entities (public and private) who have a vested interest in maintaining their own source data.

c) Provide a clearer understanding of the present and future demand for accurate mapping of the legal environment for property in a standard digital form.

d) What is current landscape in terms of industry expertise and practice, technology, standards, government systems and community engagement to meet a future demand?

e) Provide a clearer understanding of the future needs for accurate land and property information to support a range of economic pillars and industry sectors, social and community expectation, government institutions and industry professionals.

f) What is the appetite or demand for change in the short, medium and long term? What will be the demand for a simple and accessible central register for land and property interests?

g) Targeted economic opinion on the benefit of an accelerated realisation of 3DQLD, VANZI and Cadastre 2034 to government and private industry both in Queensland and Nationally.

1.6 Stakeholder consultations, review of the literature and international exemplars

Key stakeholders have been consulted in Queensland and nationally from within state and local government, utilities, mining, agriculture, surveying, architecture, engineering, building and construction, property, insurance, emergency services, spatial and other sectors. The people consulted are listed in Appendix A.

The consulting team has also used its extensive experience and reference material related to national and international developments, as a guide for the project. Appendix E provides a list of the main references.

1.7 Layout of this report

Many of the questions raised in the terms of reference are interlinked. Each Chapter addresses different components of the questions in the following sequence:

— Chapter 2 addresses question a) which is what if any pressures are government and private industry experiencing in administering the current system under current technology standards and practice. It also addresses part of question d) which is what is the current landscape in terms of industry expertise and practice, technology, standards and government systems to meet a future demand for 3D data including all Rights, Responsibilities and Restrictions (RRR) boundaries.

— Chapter 3 focuses on the business process and technology aspects of question d) in the terms of reference, concerning the current landscape for industry expertise and practice, technology, government systems and community engagement to meet a future demand (for 3D data, including all RRR boundaries).

— Chapter 4 addresses the present and future needs for accurate mapping of the legal environment for property in a standard digital form, the future needs for accurate land and property information to support a range of economic pillars and industry sectors, social and community expectations, government institutions and industry professionals and the demand for a simple and accessible central register for land and property interests.

— Chapter 5 discusses the appetite or demand for change in the short, medium and long term.

— Chapter 6 discusses the current landscape in terms of industry expertise and practice, technology, standards, government systems and community engagement to meet a future demand (for 3D data). It also identifies impediments to achieving the 3D Qld vision and looks at the possible approaches to addressing these impediments that were suggested by stakeholders.

— Chapter 7 examines the changes in roles and data storage that might be expected from implementation of the 3D Queensland vision. It explores the potential changes in the role of the surveyor and the data bases that would be required to support the 3D vision.

— Chapter 8 addresses question g) of the terms of reference: a targeted economic opinion on the benefit of an accelerated realisation of 3DQLD, VANZI and Cadastre 2034 to government and private industry both in Queensland and Nationally.

— Chapter 9 outlines key findings and conclusions.

- Appendix A lists all of the Stakeholders consulted.
- Appendix B discusses the relevant Issues relating to Land Administration in Queensland.
- Appendix C reviews matters specifically relating to the Mineral, coal, oil and gas industries.
- Appendix D lists the members of the 3D Qld Taskforce and Consulting Team.
- Appendix E lists all References.

2 PRESSURES ON GOVERNMENT AND INDUSTRY

This Chapter answers question a) in the terms of reference: what if any pressures are government and private industry experiencing in administering the current system under technology, standards and current practice? It also addresses part of question d): what is current landscape in terms of industry expertise and practice, technology, standards and government systems to meet a future demand (for 3D Data, including all RRR boundaries)?

2.1 Pressures on land and mining administration

Information on current issues and deficiencies was gathered from a series of workshops with government and industry conducted over the March to June 2016 period. A Mind Map was also prepared by a range of surveyors for the DNRM and 3D Qld projects, succinctly capturing the constraints and shortcomings of the current process. The main observations on the current situation from these consultations were:

1. Input and output to and from the Land Administration system is paper and plan based, and requires original signatures from many parties.
2. The system cannot handle electronic signatures or the 3D model data generated by surveyors, resulting in delays (and potentially errors) caused by manual processing and conversion of data between surveyors, the DNRM and Local Councils.
3. Inefficiencies result in high cost and consequential avoidance of re-survey and, in some cases, non-compliance to reduce costs.
4. Survey plans are not easily understood by non-cadastral surveyors.
5. Surveys cover only small local areas based on a series of abuttals. This has led to 'shortages and excesses' (see section B.17 for explanation), as national coordinates for boundaries have not been used to locate them. Currently, geo-references are still only required for subdivisions of 10 lots or more. Accurate geo-references are fundamental for accurate positioning of boundaries within imagery, maps and models tied to the national datum.
6. The official map of all surveys, the Digital Cadastral Data Base (DCDB), is restricted to 2D, does not include all RRR, and has inherent inaccuracies from old surveys that are reflected in derived (rather than actual) geo-references. This has led to different parties developing their own DCDB relating to their own municipality, or utility and road network, etc. This has resulted in additional cost, and has also meant that there is currently no 'single point of truth' for any boundary representation. Also, in cases where users have relied on the State DCDB, errors have resulted in incorrect decisions being made regarding property rights, resulting in project delays and additional costs.
7. The mining industry is largely using 3D models to plan and develop existing and new projects. However, this 3D data is converted into 2D data in the mining cadastre administered by DNRM. This limits the potential to utilise 3D modelling of possible interactions between mine planning and records

and locational data held in the land cadastre, as well as data held by other parties including local government and infrastructure and utilities.

8. There are many abandoned mines where the plans and records of these mines have been either lost or are difficult to locate given changes in ownership and different archiving policies of past mining company practices.
9. Utilities are increasingly moving to 3D mapping of underground infrastructure. The potential to collectively document this data in 3D is being explored at the state as well as the national level. However, there is as yet, no authoritative registry of this 3D Digital infrastructure which limits the potential for improved planning and maintenance of services, and the use of such data by third parties for improved planning of construction and mining activities based on the exact 3D location of utilities' infrastructure.

2.2 Broader pressures across all sectors

In the current economic climate, businesses and governments are under pressure to reduce costs while at the same time improving services. This is creating pressure for improvements in productivity in all sectors which in turn is creating the demand for innovation in policies, practices and technologies. This message was repeated by many stakeholders, who quoted it as both a driver for change, and as a constraint (no money to spend on improvements).

It is also well recognised that a lack of timely, quality data that is easily accessible is a key source of inefficiency and a constraint on innovation and productivity improvement. It is why so much effort is now being devoted to data management both domestically and internationally which is creating an emerging demand for data analytics and data analysts and scientists.

However, to meet the challenge of innovation and productivity improvement, data analysts need good data to work with. The more often data is handled manually and re-generated, the more likely that mistakes, misunderstandings and inefficiencies arise.

Federated authoritative data registries (or some variant using 'blockchain' technology) have great potential to smooth the data flow, reduce and remove errors, speeding operations, reduce reworking of data acquisition and analysis which, in turn, facilitates greater innovation in processes and improved productivity across the board.

This sentiment is expressed in the recent 2026 Spatial Industry Transformation and Growth Agenda (13). This document notes at p8: "One of the keys to innovation will be to identify, share and store knowledge".

The challenge is to update legacy technology, processes and skills when budgets are also under pressure.

2.3 Current developments

The rate of evolution in the use and application of surveying and spatial systems has been accelerating over the past decade. There are many factors that are contributing to this development.

- Adoption of open data policies by most jurisdictions in Australia has complemented work by the Australian Land Information Council (ANZLIC) to develop ten nationally consistent foundation spatial data sets.
- Agreement to proceed with the vision of Cadastre 2034 will lead to a cadastral system that enables people to readily and confidently identify the location and extent of all rights, restrictions and responsibilities related to land and real property.
- The move to a Geocentric Datum of Australia for 2020 (GDA 2020).
- A subsequent move to an Australian Terrestrial Reference Framework (ATRF) as the point of reference for position.
- Innovation in the use and application of spatial technologies, control systems, IT and web based applications has seen rapid take up of 3D data and models in a growing range of applications across many sectors of the Australian economy.

The Cadastral and Geodetic Services Systems Review (CGSSR)

The Department of Natural Resources and Mines is currently undertaking a Cadastral and Geodetic Services Systems Review project. The project aims to develop a cadastral system that enables industry to use and contribute spatial information to the cadastre, which will build a resource that will have benefits for everyone.

The outcome will be to replace the current information management systems that support the delivery of land information, which are not able to meet growing industry requirements, are not easily integrated with technology advancement, and require significant manual interventions.

The project is focussed on modernising business processes for cadastral and geodetic data. The aim is to implement fully digital processes: to speed up the delivery of an accurate Cadastre through automation, to provide improved access to 2D and 3D data, and to facilitate a two way exchange of information through a collaborative environment.

A key requirement is to develop a Land, Property, Addressing and Positioning Environment able to incorporate new features, standards, connections, modules and 3D+ time representations, as new opportunities arise.

The ultimate aim is twofold:

- to develop a 'single point of truth' for the data being captured to underpin the legal cadastral framework, and
- develop a positionally accurate digital expression of this legal framework.

The outcomes of the DNRM project will implement aspects of the 3D Qld vision.

It is anticipated that the 3D Qld Road Map will help the Government develop the business case to support the expenditure necessary to implement its modernisation program.

As shown in Chapter 8 of this report, based upon the value identified by key stakeholders, investment in modernising the Cadastral system has the potential to deliver significant productivity benefits for government and the surveying and building and construction sectors in the near term.

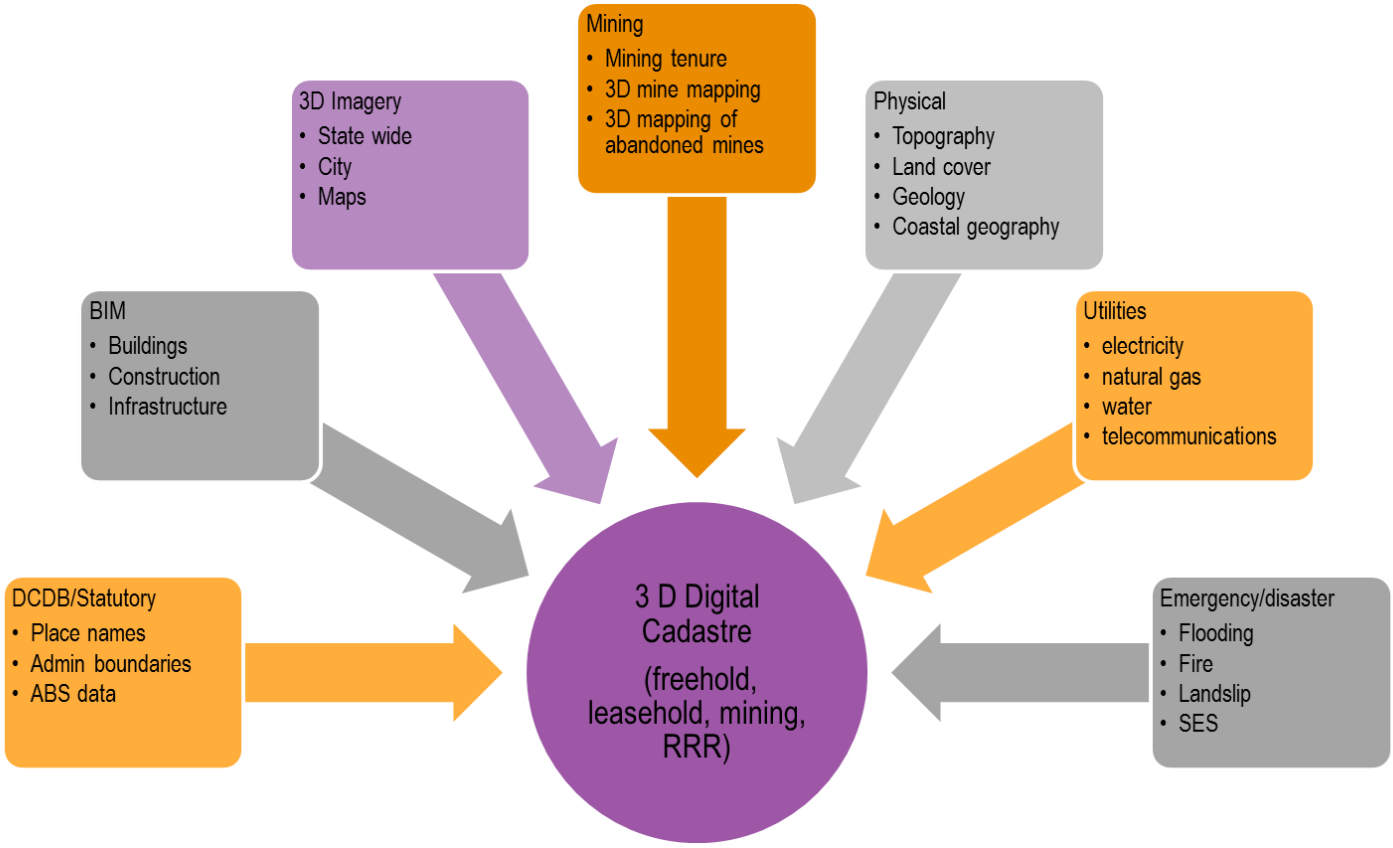
2.3.2 Potential longer term developments

Our consultations have also identified further potential benefits to the private sector and government (including within planning, construction, utilities, roads and infrastructure) that could ultimately be delivered through the development of registers of authenticated 3D as-built data.

Discussions with a selection of the mining industry also indicated the potential for greater federation of current mine models that, in most cases, are now 3D representations. However, this potential will only be realised via greater coordination of standards and verification based on the economic value to be realised. The industry also noted that many abandoned mines were no longer documented. Better 3D documentation of all mines and maintenance of a suitable registry would ensure that in future all existing and abandoned mines were held in proper records. More detail of the issues associated with the use and application of 3D data in the mining sector is provided in Appendix C

The areas of activity potentially involved are illustrated in Figure 2.1.

FIGURE 2.1 AREAS OF POTENTIAL FOR GREATER INTEGRATION AND COLLABORATION FROM THE 3D QLD VISION



SOURCE: ACIL ALLEN CONSULTING

As will be discussed in Chapter 8, the realisation of benefits from investment in the vision of the 3D strategy will vary in timing and size.

Some benefits, such as those accruing to industry from an improved 3D cadastre, will be realised directly from the investment undertaken by the DNRM to deliver the CGSSR project.

Other benefits, such as those that potentially could accrue for the construction and asset and facility management sectors will require further collaboration in standards, protocols and verification for the benefits to be realised. However, they are significant, and if realised, will readily justify investment in improved collaboration and development of authoritative 3D registries (or a variant using 'blockchain' technology).

2.4 Key findings

While there are many drivers for change in the surveying and spatial disciplines, underlying pressures for development of 3D technologies in both Government and the private sector are derived from the need for ongoing improvement in productivity across all sectors, better management of natural resources and safer and more effective management of natural disasters and emergency services.

This comes at a time when greater access to spatial data, innovation in the application of 3D technologies in the surveying and spatial sciences and concurrent development of open data policies, particularly with respect to foundation spatial data, is occurring.

The 3D Qld Strategy provides a framework for future investment and action that has the potential to meet the challenges created by these pressures through strategic investment in 3D Systems,

harnessing the potential of innovation and providing a framework for collaboration on implementation between government and industry.

Before examining the economic potential of these investments, it is necessary to first consider the nature and scope of potential for 3D technologies for Queensland. The following Chapters 3 to 7 discuss this potential and in doing so address the questions raised in the scope of work.

The potential economic value is then discussed in Chapter 8.

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3 CURRENT LANDSCAPE

This Chapter focuses on the business process and technology aspects of question d) in the terms of reference, which asks: what is current landscape in terms of industry expertise and practice, technology, government systems and community engagement to meet a future demand (for 3D data, including all RRR boundaries)? The balance of the question is addressed in Chapter 6.

3.1 Historical Inaccuracies in the Cadastre

Some of the data recorded by the Titles office is not accurate to modern tolerances, particularly measurements relating to very old titles which may be out by tens of metres or more. This leads to disputes and additional cost and time in having the record corrected. This is not a 'system failure' as such. It simply reflects the reality of the technical capabilities and practices and standards in force at the time of original survey. This problem is dealt with more fully in appendix B 'Land Administration in Queensland'.

It is the aim of the Cadastral and Geodetic Services Systems Review Project (CGSSR) now being undertaken by the Queensland Department of Natural Resources and Mines (DNRM) to correct these deficiencies to underpin the broader 3D Qld project.

3.2 Lack of 3D business processes

Even though the future value of 3D data is clear, most organisations across the stakeholder group do not yet incorporate 3D mapping or modelling as part of their core business processes. Those that do incorporate mapping into their processes, mainly use 2D GIS.

Not surprisingly, there is a 'chicken and egg' problem holding back development in the early stages. Until there is sufficient 3D data in the system, the value of adapting business processes to handle 3D data cannot be cost justified. But without the ability to handle 3D data, there is not the imperative to generate and use it.

As a result, much of the 3D data that is being generated for specific projects is simply 'lost' over time, as it ceases to be tracked once the project is completed. This includes highly valuable 3D models of buildings and underground services created for construction projects.

3.3 Uptake of 3D imaging, mapping and modelling across many sectors

Despite the general lack of 3D business systems, the message from all sectors is the same, and is supported by a review of the literature and international experience, namely: integration between LIDAR (14) and photogrammetry (15), and Geographic Information Systems (16) (GIS) and Building Information Modelling (17) (BIM) is already happening on a project by project, and user by user basis, sector by sector.

Furthermore, development of precise GNSS positioning systems, development of sensors and control systems is creating a demand for core data on which new approaches to design, construction, asset management are emerging.

GIS mostly provides 2D area mapping, BIM provides the 3D detail and information for new structures, and imagery/scans captures the natural form and as-built condition in 3D (for cities, buildings and equipment).

The imagery/scans, maps and models (in some cases with embedded boundaries) are now being used to some degree by different organisations that span the entire property cycle from building and infrastructure planning to decommission, including finance and insurance, as well as within mining and agriculture, and for transport and logistics, to emergency services and disaster recovery. They are used to speed decision-making and reduce costs and risks.

The following examples are drawn from both local and international experience:

- The Queensland Globe (18) provides 2D imagery overlaid with a wide range of government spatial data sets, including the DCDB, for use by the community. It has proven that there is huge demand for spatial data, with 8 billion map requests in just three years. Emergency services, insurance, and utilities also use the service to identify the data sets that may be of use to them.
- As well, the State Planning Policy (SPP) Mapping division (19) (part of Qld Department of Infrastructure, Local Government and Planning) maintains a repository for all GIS 2D mapping that relates to matters of State interest under the SPP. It has also recently become integrated with the Queensland Globe.
- Some councils are using 3D imagery and block models (e.g. Virtual Brisbane (20) and other cities (21) for planning and to a lesser extent at present, for building approval. The models are mainly used as a communication and decision tool, rather than being central to service delivery. They have limited value where they are held in proprietary formats and do not include up to date internals or engineering elements (useful for emergency services and asset and facility management).
- There is growing recognition that 3D BIM will become the norm for all new buildings in due course, requiring new processes to manage them in the planning and building approval process.
- The Singapore Land Authority led an SGD 8 million government initiative to create and maintain a high-resolution 3D map of the country (22). The project encompassed all of Singapore, an area of more than 700 square kilometres. The project involved capturing large amounts of data, creating 2D and 3D datasets in several data formats, and supporting the interoperability of the data and management of datasets in a single repository. See more at: Mapping Singapore (23).
- The cadastre is fundamental to the development of new lots. For councils, it underpins rating, where lots are aggregated into properties which are linked to addresses that are key for deliveries and locating people and businesses. 2D GIS is the norm within most councils for managing these functions, with paper still used as the main medium for exchanging information.
- More recently, 2D/3D imagery has been used as the context for subdivision approval in Qld (e.g. Flagstone (24) with the new boundaries geo-referenced in the imagery to speed up the process and reduce cost. 3D models have also been used for cut and fill, and to plan and construct roads and services.
- 3D Models are becoming important for use in emergency services to help locate people and equipment more quickly within the built environment. Maintaining the data remains a major problem, as it is still based on manual processes to capture the data and provide updates.
- More recently, 3D imagery has also being used for major event planning (25), where route designation, line of sight amongst multi-storey buildings, and the simulation of the movement of crowds within a City or Precinct (26) become important.
- Insurers are also looking to 3D imagery (27) (including the cadastre marked within the imagery) for risk management, premium assessment and to speed up claims processing after a major event (storm, fire, flood or earthquake).
- 3D BIM are increasingly used for design and construction (28), and are just beginning to be used for asset (29) and facility management (30). In all cases, accurate representation of the cadastre (and other rights boundaries) within the model is important where property rights are relevant to decision-making.

The Scottish Futures Trust has produced a recent comparative study (Scotland Global BIM Study (31), which disappointingly ranks Australia at the bottom of a global league table. The UK is leading the uptake of BIM (32).

- Many organisations are now working to integrate not only the data, but also the workflows (33).
- BIM is also facilitating modular construction (34) where modules (such as bathrooms and kitchens) are prefabricated and transported to site ready to 'plug and play' into the main building. This leaves only localised finishes and vertical and horizontal service reticulation through the communal areas to complete, simplifying the need for on-site trades and significantly shortening construction time and lowering cost.
- As well, there is increasing use of scanned and photogrammetric 3D models (often generated using Unmanned Aircraft Systems (UAS)) to capture current conditions prior to re-development (35), in one recent case saving 90% of the project cost of $10 million (36). They are also being used to monitor construction progress (37) and for asset management (38), including for plant, building and infrastructure maintenance.
- Scanned 3D models, integrated with BIM and Building Management Systems (BMS) and the Internet of Things (IoT), are just now being considered for asset and facility management, with the Sydney Opera House taking a leading approach (39).
- 3D models (BIM and scanned) are also being used to track equipment, goods and people in real-time within large industrial and commercial sites to provide major productivity and safety benefits. Again, accurate representation of the cadastre and other boundaries in the models is important for ensuring activities are constrained within contractual and statutory limits.
- Underground services are also being captured in 3D using ground penetrating radar (39) at depths of up to 10 metres, with decimetre accuracy at shallower depths. However, most utilities still use 2D GIS. In Australia, companies are already offering augmented reality views of underground services (41) with field data capture and viewing, but the quality of visualisation is restricted by the quality of data. There is a global trend to model underground services as more and more cities recognise the value (42).
- Above-ground, Ergon Energy is using 3D laser scans to help manage its network (43) resulting in a reduction of $40 million pa in a budget of $100 million. Knowing the correct position of boundaries in the model is key to protecting property rights in regard to the placement of assets and access to other property owner's land.
- Transport & Logistics (44) is one sector where 3D mapping and modelling is becoming essential to the operation of the business; increasingly so with the impending adoption of driverless technology. Key is knowing dock heights, turning circles, road gradient and camber, overhangs, etc., as well as internal roads and signage. Addressing, rather than cadastral boundaries, is key in this context.
- Mineral deposits, as well as current open cut and underground mines and bores and stockpiles are also now being modelled in 3D (45) with varying degrees of accuracy. Access to such models will be critical in areas where new developments and roads are planned. Unfortunately, data relating to many old mines is lost, or is in a form that is not easily accessible. This sector is considered in more detail in Appendix C.
- 2D and 3D models are already being used in agriculture, including for modelling run-off, with imaging used to monitor everything from weeds to plant health. As well as for natural resources management.
- 3D models (46) are also beginning to be used for the sale and marketing of properties (47), as well as for property valuation and lease condition reports.
- 3D Models are even being used for retail (48) and crime scene re-construction (49).

3.4 New technological developments

The following sections provide an overview of the rapid developments occurring across the technology spectrum that together underpin 3D Qld.

3.4.1 New positioning & measuring technologies enable geo-referencing

In recent decades, it has become possible to record the position of boundary markers using geo-references (longitude and latitude) using Global Navigational Satellite Systems (GNSS) (50) that triangulates signals from satellites and ground stations to deliver real-time positioning. GNSS signals can be augmented to provide high levels of accuracy and integrity. Simultaneously, cost has been falling and ease of use has been dramatically improving. Together with other positioning technologies (51), it is likely that cm accuracy may be achieved 52 using consumer grade receivers in the not too distant future.

Directly related to this, Geoscience Australia has been working with international bodies to develop a new dynamic reference frame that can account for mm shifts of the whole continent of Australia, as well as local ground movement, over time. This permits improved dynamic positioning of boundaries and elevations relative to an agreed datum (a coordinate reference frame) that has a known relationship to the whole Earth.

The goal of the Cadastre 2034 project is to achieve a cadastral system that provides a digital representation of the real world that is survey accurate, 3-dimensional and dynamic.

Use of geo-references to pinpoint pegs further reduces time, cost and errors in the process. In Queensland, geo-references of boundaries are now required for all subdivisions over 9 lots.

3.4.2 Photogrammetry, Lidar and remote sensing enable more 2D and 3D detail to be captured

Until the recent past, it has been economic to capture only the xyz co-ordinates of the vertices of each lot. Today, with the use of Photogrammetry (53), Lidar (54) and other Remote Sensing (55) (including from space (56) many millions or billions of points can be economically captured to fully define the land and each object in and on it at all scales required for decision making.

The point clouds generated by these technologies are becoming the lingua franca of the 3D world. All software companies that provide services across the built environment are moving to incorporate the capacity to model the point clouds as 3D surfaces, and to automate the identification of objects within the imagery (57).

Importantly for 3D Qld, modern technological advances in data capture (particularly photogrammetry) enables integration of different data sets created at different times at different resolutions, to create an integrated model that allows the user to seamlessly zoom from national scale down to the image of a nameplate on a piece of equipment (53) so it can be directly read by the user.

As well, advances in LIDAR are now being driven across many sectors including for metrology (58) in manufacturing, and sensing for driverless cars (59).

As with everything, equipment is getting smaller and cheaper. The Massachusetts Institute of Technology has recently announced LIDAR on a chip (60) that can sense up to 2 metres and potentially 100 metres at an estimated cost of $10 if made in commercial quantities.

3.4.3 Remotely Piloted and Unmanned Aircraft Systems (RPAS and UAS) and Terrestrial and Mobile Scanners enable more areas to be captured

Advances in RPAS/UAS, combined with new cameras and sensor systems, together with new control algorithms and other types of scanners have resulted in new platforms for data gathering that are highly efficient, and able to generate vast amounts of 3D data at relatively low cost.

Uses include: capturing initial site data for planning purposes, monitoring construction, volume calculations, asset inspections, as-built surveys and conformance reporting and monitoring for geotechnical/stabilisation works (61). See US experience here (62).

Australian company Propeller has just introduced AeroPoints (63): smart ground control points that make it easy for anyone to capture survey-accurate mapping using drones. AeroPoints are designed to be visible from the air and capable of quickly determining its own position down to 2cm absolute accuracy using Post Processed Kinematic (PPK) GNSS positioning.

Peter Kinne (Digital Globe) has suggested a similar approach to aid registration of Satellite, Aerial and UAS imagery by having surveyors place their remote control points within a square metre of high contrast concrete.

Soon it is expected that UAS will be able to scan the inside of a building without the need for any human intervention (64) and to do it safely in all environments (65). This will pave the way for direct capture of all as-built structural elements and enclosed services while they are still exposed during construction, providing a permanent record for later use during repairs, renovation or re-development – *if the data can be located and accessed with appropriate permissions*.

UAS are also coming into their own for condition monitoring, comparing current condition with previous data sets, and using change detection software to highlight potential problems in structures, as well as changes in the natural and agricultural environments.

In addition to cost and time savings, the use of UAS greatly reduces risk to personnel, as it reduces the need for people to work at heights and amongst machinery to gather the data.

They are also being used to capture 360° video for entertainment and virtual tourism (66), creating an immersive experience when combined with a VR headset.

On the downside, as the number of UAS proliferate, safety, security and privacy concerns will inevitably lead to regulation (62) that go beyond 'air safety' (e.g. CASA rules) (67), with flying over built-up areas largely restricted to specific business and government tasks, such as surveying of the built environment, or capturing 3D models for sales and marketing, as well as for policing and emergencies – with real-time broadcast of purpose and name and contact for controller.

3.4.4 3D Modelling and simulation software enable the creation of dynamic 3D virtual worlds

Both GIS and BIM providers are moving from different ends of the scale to provide an integrated view of the world at all scales, as detailed in the BuildingSMART/SIBA position paper (68) that makes a strong case for the convergence.

Software is also going beyond static modelling, to dynamic simulation (69) and process control, including for asset and facility management through the whole life cycle of any structure - all within its full 3D spatial context.

Significantly, the use of 3D simulation and reality capture for entertainment (70) is also driving improvements so that finer and finer details can be modelled dynamically.

It is also being used in manufacturing and medicine to dynamically test everything from car crash safety (72) to the effects of drugs on the human body (74).

With widespread demand for better algorithms to reflect reality, it is now predicted that the rate of improvement is expected to continue until it may become difficult to distinguish between what is real, and what is not.

3.4.5 3D Data Capture

While the platforms and sensors required to capture 3D data are getter smaller and cheaper, portable storage is expanding, with SanDisk announcing a 1Tb SD card (71).This enables much more data to be captured in a single run, further improving efficiency

3.4.6 3D Data Storage using Objects rather than Files

Traditional file systems are designed to store content in a hierarchical manner, often in a tree of files and folders. In these systems, users access a file by following a path to a specific location. While this method can be intuitive for storing a few files, when content storage explodes to billions or even trillions of files, a hierarchical access method can create too much complexity and in some cases overwhelm traditional file system storage architecture.

Object systems are designed using an alternative approach with a single and massively scalable flat address space where file access is provided via a unique identifier (72). An analogy that can help describe this difference is that accessing a specific file in a file system is like following a set of directions to find a location. For example, "take the first left, then the second right, etc." Object

storage, on the other hand, is like using GPS coordinates. This more efficient manner of identifying specific content helps enable object storage to scale to higher capacities than can be achieved by traditional file systems.

Object storage systems exactly reflect how we may want to access data within the natural and built environment, including the need to retain data indefinitely without permitting any change or deletion.

3.4.7 3D data management

While the software that generates BIM now includes much better management protocols to securely manage data within any individual system, a significant problem remains in locating and/or capturing *reliable* data that is under the control of third parties, and then feeding back changes to those third parties to ensure the data remains current, without it being corrupted or accessed without authority. This is especially so where the parties are not in a contractual relationship.

Facilitating the data capture, certification and sharing processes is an essential requirement for the 3D virtual world to operate effectively and securely, while also protecting privacy and commercial interests.

Importantly, we need to manage the geometry of the natural and built environment separately to the data and meta-data relating to each object, as the data relating to an object will change independent of the geometry. It also means that we will need to be able to identify who owns or controls the object, separate to the operating data, etc.

3.4.8 3D visualisation hardware enables viewing of 3D virtual worlds

In conjunction with advances in data capture and modelling, the hardware to display it is also now improving at an exponential rate, becoming smaller, cheaper and far higher quality - to the stage where it is projected that within 5 years, it will be common for people to use 3D Virtual Reality viewers (like Occulus Rift (75) and Augmented Reality glasses (like Magic Leap (76) and Hololens (77) for business, entertainment and socialising, with the latest, Merged Reality chips (Intel (78)) that let you do it without wires.

3.4.9 Artificial Intelligence (AI) enables automation of higher order tasks

While general AI remains on the 'far horizon', there is no doubt that AI is now a reality for image and natural language processing; first demonstrated with IBM Watson (79) decisively beating the world Jeopardy champions just 5 years ago. Google has taken this a step further besting the Go World Champion in a game of strategy in May 2016 (80). The advances in these areas mean that it is now much easier to automate object recognition within images, to test for compliance against all regulations (81) and to interface with the system in a much more natural way, reducing misunderstanding and speeding processes.

It is conceivable that in the coming decade, using this technology, a great deal of legislation can be automatically interpreted and applied to digital models to speed the processing of planning, engineering and building applications, as well as a great many other government services

This is being further advanced with IBM now offering cloud based AI (82) and also Google (83), opening the technology to the world – further speeding application development.

3.4.10 Global and national data networks enable ubiquitous communications

The 3D Virtual world would be impossible without the leap in communications technology including satellite communications (84), optical fibre (85) and even free Wi-Fi in India (86), as well as new hardware and software to provide highly (though not absolutely) secure cloud services for multi-media.

All these elements are now being put in place. They will enable more secure data management and high-speed data sharing to provide real-time imaging of the real-world, integrated with virtual images and data, for real-time decision making in virtual, augmented and merged space… *subject to the data being accessible*.

3.4.11 Cloud services enable ubiquitous data processing

While there has been some hesitancy in the past, the clear trend is to adopt cloud services to provide high quality, highly secure processes. These include Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS) (87), and now IT as a Service (ITaaS) (88)
These services allow users to access the benefits of the service without the need to carry the hardware cost or technical expertise internally. Users pay only for what they want, when they want it. More importantly, the scale of the cloud enables much greater support for the service, with much better security than individuals can provide for themselves.

Cloud services also benefit from a wide customer base to generate ideas for improvement that benefit everyone, with higher quality resources employed to develop them.

These are major selling points for 3D Qld as a cloud service.

As an example, in Victoria after a shaky start CenITex (89) now provides IaaS to a growing list of State Government Departments and Agencies who are now seeking out the service, where once they had to be pushed to take it on.

Internal expertise is still required to interpret the data and to ensure internal processes support the cloud services, which support the external customer. However, most of the drudgery and risk is removed from these roles.

3.4.12 Computer power and the end of Moore's Law… or maybe not

Many of the advances now being made rely on increased processing speed packed into smaller and cheaper computers.

While we are now reaching the limits on how many components can be placed on a chip (90), there are still strategies being developed to expand capacity through parallel processing and new algorithms and perhaps even carbon nanotubes (91) to keep Moore going for a few more iterations.

As well, 'quantum computing' is starting to be taken seriously (92), with IBM, Google and many physics labs now working on the idea. Where just a few years ago it was considered science fiction, reputable scientists suggest that it could become a reality in as little as 10 years.

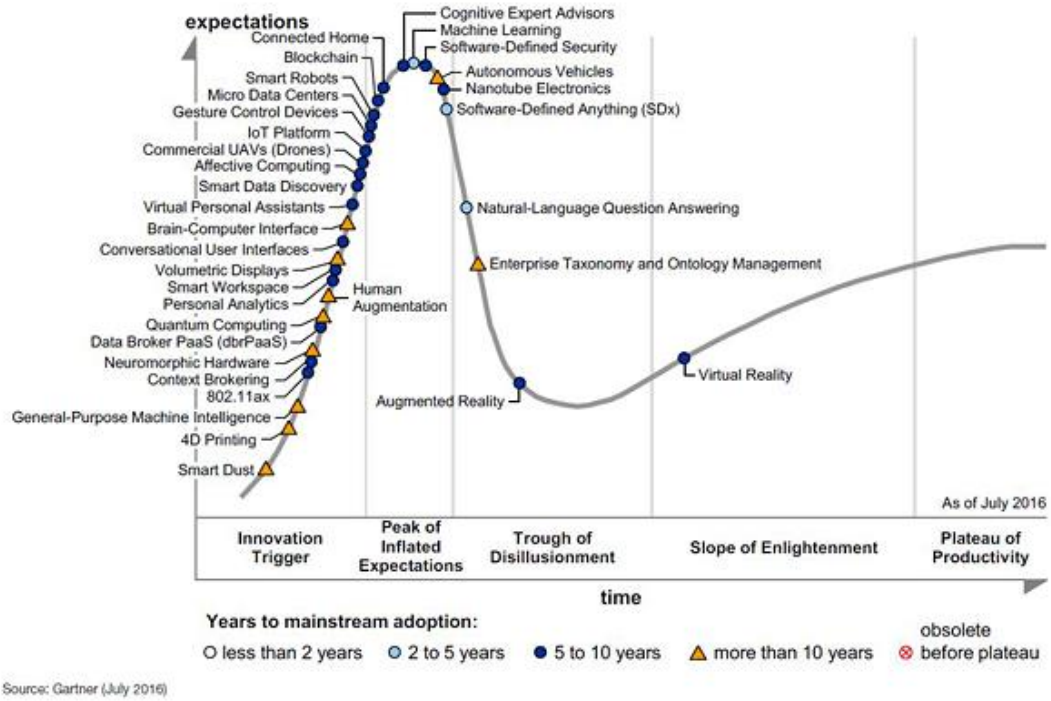
Regardless, there is already sufficient power to undertake the modelling required for 3D Qld.

3.5 Gartner 'Hype Cycle'

The Gartner 'hype cycle' (93) is a now well-recognised tool for understanding the evolution of new technology,

Gartner's 2016 technology review graphically illustrates the new developments that are delivering a tsunami of change, ready or not. As it shows, the two key technologies that will underpin the use of 3D spatial data (Virtual and Augmented Reality) are well on the way to delivering massive productivity benefits… *if the data is available*.

FIGURE 3.1 GARTNER 'HYPE CYCLE'



SOURCE: GARTNER (JULY 2016)

3.6 Key Findings

Massive changes are mounting across the technology spectrum that are transforming how we gather, store and use 3D data throughout all sectors of the economy and society. These changes are not confined to Queensland; they are now becoming universal in the developed world.

The 3D Qld Strategy provides the opportunity to lay the groundwork to enable Queensland government and industry to prepare for these emerging developments and meet future demand for these services.

FUTURE NEEDS 4

This Chapter answers several questions from the terms of reference:
(c) what is the present and future demand for accurate mapping of the legal environment for property in a standard digital form?
(e) what are the future needs for accurate land and property information to support a range of economic pillars and industry sectors, social and community expectations, government institutions and industry professionals?
(f) what will be demand for a simple and accessible central register for land and property interests?

4.1 Future needs for 3D data

The uptake of 3D content across many different sectors as detailed in section 3.3, together with the exponential growth in the use of 2D spatial data in recent years, provide a very clear pointer to present and future needs.

Combined, the new imaging, mapping, modelling and positioning technologies are delivering an explosion in geo-referenced 2D and 3D content, at all levels of accuracy required for decision-making, as well as for use with automated equipment.

4.2 Demand for a 'central register' (in a standard digital form) of all property Rights, Responsibilities and Restrictions (RRR)

There is strong support amongst stakeholders for a federated system underpinned by a single authoritative data set that represents the cadastre.

It is also expected that, in time, authoritative data sets for all other RRR (including mining and other statutory rights such as native title and water rights, as well as rights under leases, etc.) should be accessible under this federated system, with each authority/private actor responsible for maintaining their own source data.

To be useful for decision-making, it is seen as essential by stakeholders that the boundaries of each of the data sets (including the boundaries of all laws and regulations) be geo-referenced by the data owner, so they can be displayed in the context of certified orthographically accurate geo-referenced 3D imagery, maps and models.

In the case of strata titles and related interests in multi-storey buildings, it is expected that the boundaries be related to the authorised 3D model of the building to which they apply, for both access to the data, and for decision-making within the model.

These issues were canvassed at a Smart Future Cities Conference Conducted by Melbourne University in 2015, which looked at the Role of Land, Property and Cadastre Information (94).

The following abstracts and related papers from that conference are just a selection of the work now being undertaken across the globe to tackle the question of how to integrate RRR within the virtual domain. As yet, no jurisdiction has developed a definitive approach.

— **Four Key Statements on 3D Technology Development in Land Administration and the Compliance Between Spatial and Legal Data**

(Professor Stig Enemark, FIG, Aalborg University)

The focus is on the need for compliance between spatial and legal data. In this regard the presentation offered some theoretical reflections and a few examples from Denmark. It is argued that the 3D technology opportunities in land administration require careful consideration of the "legal geography" to make the legal concepts fit better into a modern interactive digital environment.

— **Korea 3D Cadastral & Land Registration System** (95)

(Mr. Byungyong Kwak, Korea Cadastral Survey Corporation)

Land administration based on the cadastral system has been rapidly changing with technical development in the geospatial area. In addition, traditional cadastral map and surveying methods have also changed and improved from paper base to digital base. In Korea in 2012, a cadastral resurvey project was implemented to transform analogue to digital format.

A purpose of this project is to give a solution for mismatching between the real boundary and the cadastral boundary, and integration of geospatial information for the next generation. In this project, the 3D cadastre is also considered to present 3D rights and objects such as apartments, tunnels, complex buildings, underground shopping malls, subway stations, subway line, and utilities in relation to the cadastral map. Because those objects are deeply related to ownership.

— **New Zealand Experience: The Role of a 3D Cadastre** (96)

Mr. Mark Dyer (Land Information New Zealand)

While New Zealand has a 3D cadastre in that rights are defined in three dimensions, it has yet to develop a 3D digital cadastre. The NZ government is currently in the business case approval stage to build the second version of our integrated digital survey and title system and the intention is to build 3D capability into the design requirements. This is in accordance with a cadastral strategy - a strategy that recognises the benefit of accommodating a wider set of rights, restrictions and responsibilities, as well as a broader application of cadastral data such as in city scale models. Critical success factors are meeting anticipated societal demand, the ability to support engineering level precision to allow the integration with built-environment related survey data, the need for a precise vertical reference frame, and the need to recognise the constantly changing earth crust by developing a dynamic geodetic datum. Given that we are in the earliest stages of implementing Cadastre 2034, the focus is on designing a system that enables interoperability and future integration of business systems such as with those of city administrators and asset managers.

— **Smart Property Information for Smart Cities**

Assoc. Professor Donald Grant (RMIT)

One of the layers needed for smart cities will be land-based property rights. The spatial representation of this layer is the spatial cadastre. The cadastral system exists in the real 3-dimensional world but we currently choose to view it only in plan-view and to model only 2 of the 3 dimensions in digital databases. Surveyors discard a significant component of the measurements and information they gather to flatten it out onto the ellipsoid or a projection. The techniques they use are clever – but that does not mean they are smart.

To fully integrate property rights information with the other 3 dimensional spatial datasets for smart cities, the cadastral system will need a redesign. It needs to be 3 dimensional (actually 4 dimensional to reflect changes over time). It will also need to be strongly linked to the geodetic system to be fit for purpose right across neighbourhoods and cities.

4.3 Experience in Europe and Asia

ACIL Allen and VANZI have not undertaken an exhaustive study of activity on development of 3D systems overseas. However, a brief review revealed that the two countries developing 3D strategies in Europe are Denmark and The Netherlands.

Denmark is the more advanced in terms of developing a national 3D cadastre and is understood to have undertaken an economic study of the benefits. This study has not been published. We understand that a business case has been developed and implementation is underway.

The Netherlands is also understood to have developed a design framework for a 3D cadastre. The Netherlands has well developed registers of cadastre, buildings and addresses that are linked.

A key feature of the development of 3D cadastre in these countries is a move to establishment of authoritative registries that can be linked for wider use. The National Mapping and Cadastral agencies are understood to play leading roles in this endeavour which to some extent facilitates the sharing of data contained in these registries and managing access to these data.

Key drivers for developing these systems are understood to be more transparent valuation processes, more efficient taxation systems, legal systems and better coordination of infrastructure.

The team also has experience in working with the Singapore Government on aspects of their 3D City Model. As noted in Chapter 3, the Singapore Land Authority led an SGD 8 million government initiative to create and maintain a high-resolution 3D map of the country. The project involved capturing large amounts of data, creating 2D and 3D datasets in several data formats, and supporting the interoperability of the data and management of datasets in a single repository for use across all sections of government in support of private sector activity.

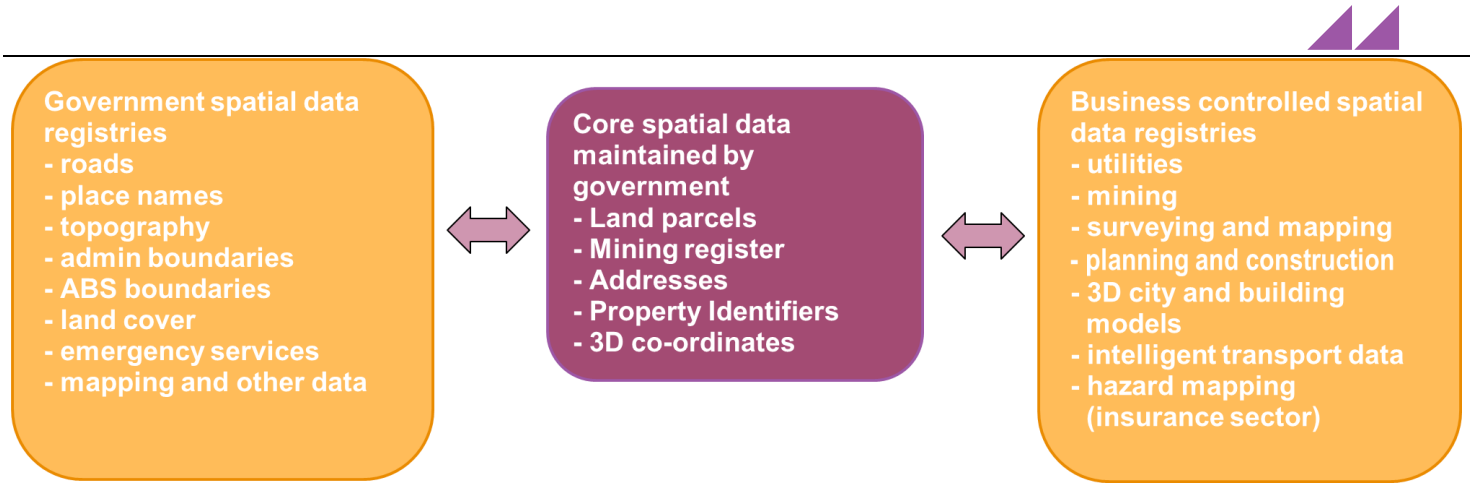
4.4 Future possibilities

Core data held maintained by Government is the foundation upon which other spatial data registries and indexes held in both government and industry registries are established. This is illustrated (in an oversimplified way) in Figure 4.1. The central core data which comprises the land and mining cadastres along with property identifiers for valuation purposes will be enhanced with updated coordinates with the implementation of the dynamic datum which is currently planned for 2020.

On this base governments also add other data including roads and topography, place names and points of interest, administrative boundaries, ABS boundaries, land cover and data held for emergency services and other activities.

The private sector is in parallel developing its own spatial data which is increasingly moving to 3D. Some of this data is captured in core spatial data. Currently cadastral information is published in 2D plans. However, proposals to digitise the land cadastre will open opportunities for exchange of 3D data between Government and the private sector.

FIGURE 4.1 SPATIAL DATA REGISTRIES



Note: the spatial data registries included above are not exclusive

SOURCE: ACIL ALLEN CONSULTING/VANZI

The vision of 3D Queensland provides the framework for greater integration and collaboration in the longer term between these three data groups. Our consultations indicated that many of the benefits to the private sector, and hence to the productivity of Queensland industry, lies in linking these data sets to the core data held by government and providing scope for sharing the data between registries.

The potential for data analytics around such data collections is one that carries significant potential for productivity improvements across a number of industries from agriculture, finance, insurance, mining, planning and construction, as well as asset and facilities management, and even retail activities. Similarly, location based analytics around government policy and programs also have the potential to significantly improve and lower costs and improve the effectiveness of policy formulation and program implementation.

This raises many questions as to how the privately held data sets might be better utilised, updated and certified and securely shared particularly for planning, design, construction and operation and maintenance purposes.

These issues are explored in subsequent chapters.

4.5 Key findings

Our consultations revealed considerable support from stakeholders to development of a framework for sharing and controlling the mapping of all RRR for property in Queensland, and for that matter Australia generally.

Most stakeholders (including utilities, miners, engineers and construction companies) have said that it could be very valuable to have access to the 3D data captured by other organisations, to save the cost, time and errors involved in regenerating the data for their own purposes project by project.

This means of course, that each organisation must be willing to share their own data. However, when pressed, there were considerable reservations about sharing their own data in the absence of a robust legislative and regulatory framework to protect the interests of the data owners.

These matters are discussed further in Chapter 6.

5 APPETITE FOR CHANGE AND NEW AND OLD ROLES

This Chapter answers the first part of question f) of the terms of reference: what is the appetite or demand for change in the short, medium and long term?

5.1 Appetite for change

No one disputes the inevitability of the changes that are coming. However, as would be expected, amongst stakeholders there is the usual spread of keen leaders, fast followers and the late adopters, including some who are quite fearful of what it may mean for their organisations and even their own jobs, especially amongst some in the surveying profession. Such concerns should not be unexpected. History has shown that most structural adjustments raise concerns about future roles and activities of the industry participants and fear of change is not uncommon in some circles.

A key difference in this case is the likely need for coordinated action on behalf of a number of industry and government players over a long time frame. This means that change could affect a wide number of industry participants.

Having said that, the majority of stakeholders consulted agreed that the 3D strategy offered significant benefits for the Queensland economy and society in general and was worth pursuing in a measured and coordinated way, having regard to the speed of technological change.

5.2 New roles

Stakeholders who supported the need for change suggested that concerns over future roles could be addressed by demonstrating the growing need for new roles that have the potential to provide new opportunities as traditional processes are made faster and cheaper.

It is possible for example that the role of the surveyor could be broadened to embrace the wider spectrum of authorised 3D models. While still having a role to locate points on the ground and record surveys, a new role of 'spatial surveyor' is not inconceivable. Such a role might be more focussed on generating models from photogrammetry and LIDAR and locating the boundaries in the models which are then used as platforms for design and decision-making by architects, engineers and planners.

For third parties (e.g. architects and engineers) to rely on the stored federated data, they will require third party professional certification on each re-use to ensure:

- the orthographic and dimensional accuracy of the model and all embedded boundaries, and
- its position and elevation in relation to the national grid is correct (having regard to current conditions on the ground and all relevant legal requirements).

Where changes have taken place, they will also need the models and boundaries updated and re-certified.

This may mean for example, that the certifier's role would change from generating new data for each new project, to change detection, data update and re-certification. This process of building on pre-existing data is vital to sustain continuous improvement in the data.

Similarly, in government, the role of custodians of foundation spatial data could broaden to include wider collaboration with industry in the integration and aggregation of foundation data to support the broader landscape of registries of 3D models.

This is just one new opportunity. As the scan of the current landscape should illustrate, the demand for new skills is likely to widen and deepen as new systems and processes evolve. This is likely to generate demand for ongoing professional development, as well as tertiary courses to support the wider skills.

On balance our consultations indicated that concerns about future technical and professional roles are not likely to be a permanent obstacle to implementation of the 3D Qld strategy over the longer term.

5.3 Retention of traditional surveying role

There is also a need to explain both in professional circles (particularly construction and property) and the community that geo-referencing of surveying marks enables accurate location of the boundaries in imagery and models. It does not change the requirement for surveyors to place a boundary peg in the correct location on the ground in accord with well-defined practices. The rationale for the retention of pegs and surveyor placement is discussed in detail in Appendix B - Land Administration in Queensland.

5.4 Key findings

Stakeholder consultations demonstrated three important points:

- There is a recognition across most sectors of the planning, construction, mining and infrastructure sectors that the 3D Qld vision offers potential for significant productivity and efficiency benefits for industry and government activities.
- While significant benefits can be expected to accrue from initial investment in the 3D cadastre, much wider benefits are possible in the longer term if a way can be found to establish registries of authoritative 3D data (or using 'blockchain' technology) where access can be properly managed in a federated system of 3D data.
- Concerns about employment and professional opportunities would not be insurmountable obstacles to change but would require a recognition of the ongoing need for education, training and professional development.

6 POSSIBLE IMPEDIMENTS AND APPROACHES

This Chapter answers the remainder of question d) of the terms of reference: what is the current landscape in terms of industry expertise and practice, technology, standards, government systems and community engagement to meet a future demand (for 3D data)? It also identifies impediments to achieving the 3D Qld vision and looks at the possible approaches to addressing these impediments that were suggested by stakeholders.

6.1 Technical capability to deliver the Vision

As should be evident from the scan of the current landscape in Chapter 3, technology is no longer an impediment to implementing the vision of the 3D Qld strategy.

There is unanimous agreement that the technical capability now exists to economically capture, share and use 3D cadastral and other 3D data at all scales required for decision-making to deliver better, quicker outcomes at much less cost, and with much less risk (financial, safety and property), across all sectors of the economy.

This will require considerable collaboration between organisations in the private and government sectors and an innovative approach to the application and development of the new technologies.

6.2 Shift to GDA2020 and a common datum

A recent survey (97) of the surveying profession indicated that 25 per cent of respondents were not aware that all GNSS systems operate in an 'Earth-fixed' reference frame that shows coordinates of features on the Earth's surface changing over time, unlike GDA94 which is a static or 'plate-fixed' datum where coordinates don't change. This lack of understanding is now being addressed by the profession.

Significantly for 3D Qld, a large proportion of respondents (68 per cent) also indicated that they would require the property boundary layer to be available on GDA 2020 before they could operate on the new datum. Also, over 100 different software platforms from over 80 suppliers were listed as requiring added support for the new datum.

A further problem with data sharing is the fact that many councils, utilities and private organisations use their own grid references for situating their assets within the natural and built environment, even on a site to site basis. This is essentially a translation problem between one grid reference and another. Traditionally, this has required manual processing that has sometimes made the task time and cost prohibitive. Fortunately, there are products coming on stream that are claimed to automate this task (98).

Nevertheless, this change alone will require considerable time and effort on the part of government and industry to resolve these issues.

6.3 Skills to meet future demand

Stakeholders raised two concerns in developing the technical and professional skills to implement a transition to a 3D spatial data model across the economy:

- the aging workforce of cadastral surveyors (99)
- the growing requirement for technicians capable of using the new hardware and software

While the aging workforce is of concern, four mitigating factors have been identified.

Changes in surveying practice

The likely changes in surveying practice driven by the DNRM and 3D Qld projects have the potential to reduce the professional workload, enabling more projects to be managed by each professional.

Improvements in software and hardware and cloud based processing

Software and hardware are becoming easier and faster to use, with the added potential for cloud based processing to take pressure off in-house resources. This will be facilitated by the use of Artificial Intelligence (AI) to embed implicit rules into the system to support less skilled people.

Attracting new recruits

The new spatial/UAS technologies are potentially more attractive to young people than traditional surveying practice, not to mention the on-going demand and higher starting salaries (100) that together should see a lift in supply over the next few years (subject to active marketing).

Global skill base, global contracting and virtual services

While there may be local skill shortages to advance all these new technologies, we have to recognise that as the world becomes even more inter-connected, the availability of people globally with the required STEM training is continuing to advance at unparalleled rates.

Massive Open On-line Courses (MOOC) (101) have not yet reached anywhere near full potential but are already delivering new highly effective Science, Technology, English and Maths (STEM) training to all sectors of the globe.

Combined with new virtual market places (102), free access to You Tube training videos (103) and all the other resources of the internet, these advances are providing smart people from around the world the skills they need, not only to participate in service delivery, but also to further advance new developments… escalating the pace of change ever more quickly (104).

Last, but not least, the expansion of cloud services and global contracting (with improved video conferencing and virtual meetings) will help fill any skill gaps locally.

Organisations will need to gear their business around these resources to keep up to date.

As an example, in Australia, Landgate (105) provides staff with the one thing that eludes many in the quest to innovate – time. Landgate Chief Executive Mike Bradford says (106),

"We recognise that the success of Landgate's innovation program relies on the diverse skills, expertise and engagement of our people. That's why all employees are encouraged to spend five per cent of their time on innovation activities, and more than that when a project is underway".

In addition to having time to innovate, staff at Landgate are also given up to five hours paid study leave every week, to encourage people to be lifelong learners – an important skill for innovators.

6.4 Lack of 3D business processes

As noted in section 3.2, despite the recognized future value; most organisations across the stakeholder group do not yet incorporate 3D mapping or modelling as part of their core business processes. Those that incorporate mapping, mainly use 2D GIS.

As a result, much of the 3D data that is being generated for specific projects is simply left unmanaged on computer hard drives, once the project is completed. It can be lost forever, if/when servers are updated and the data is regarded as of no value to the firm. This includes 3D models of buildings and underground services created for the construction of major projects. These have great potential value to third parties for 'existing conditions' relating to a new project in the same vicinity.

It is considered that competitive pressures will push organisations to adopt 3D processes over the next few years, while cloud services will pull them in that direction, underpinned by the proposed 3D Qld framework.

6.5 Standards and protocols

Part of the requirement for 3D Qld will be to specify open international standards for use within any new federated system.

In July 2015, the Spatial Industry Business Association and buildingSMART Australasia provided an overview of the need for standards in their joint report: Integration of Geospatial and Built Environment National Data Policy (68). It states:

"buildingSMART Australasia is part of a worldwide industry organisation that has developed open standards for exchanging BIM data (known as IFC) and the processes needed to support collaborative design. The traditional focus of this work has been on buildings, but over the past few years that has shifted significantly towards supporting BIM processes for transport infrastructure projects (roads and railways) and civil structures such as bridges and tunnels. This shift is in response to the need for a broader view of built environment modelling and recognition by the infrastructure sector of the value of BIM technology to improve efficiency, quality and cost of project delivery as well as improved asset management.

The Open Geospatial Consortium (OGC) is a global standards organisation, serving the spatial sector by developing publicly available standards for the delivery and management of spatial data across the Internet.

Of particular note is the CityGML standard for delivering city-scale 3D models through the Web, and the more recent extension known as IndoorGML that supports way-finding and emergency egress in buildings. Currently, OGC is developing a new standard known as InfraGML that is seen as possible replacement for LandXML (currently used in Australia for electronic submissions of the cadastre under the ePlan initiative) and designed specifically to address the modelling of broader infrastructure elements of the environment.

OGC are also engaging in a broader discussion on the requirements of a digital framework for Smart Cities. It is clear that both these industry standards bodies are beginning to expand into the other's domain in various ways, again demonstrating the convergence of thinking in both sectors. This has been recognised in a recent landmark MOU, where buildingSMART International and OGC agreed to work together in the development of data exchange standards that are of mutual interest. This marks a significant first step in bringing together these two domains and demonstrates both the need and the opportunity for Australia.

As that work proceeds, we must contribute to ensure that what is agreed in the international arena is appropriate for use in Australia, but more importantly, there is an opportunity for Australia to take leadership in this work as it builds capacity in the formation of the Digital Built Environment (DBE). Within the Australian context, there are many examples of standards and guidelines across both industry sectors.

A couple of examples are provided from the land surveying domain.

State jurisdictions have established standards for the electronic lodgement of survey plans and subdivisions: EARL in Queensland (through the DRNM); SPEAR in Victoria; SIX in NSW; Landgate in Western Australia, etc. Similarly, Local Government jurisdictions have established requirements for the lodgement of project data following the construction of assets: ADAC is used mainly in Queensland and covers roads, drainage, open space, water, sewerage and cadastre; the A-SPEC (107) standardised approach covers roads, drainage, open space, water, sewerage and buildings and is used across many jurisdictions in Australia (mainly Victoria and Western Australia), as well as Wellington in New Zealand. These have been adopted at different times and address very specific data delivery processes as part of

established practices, demonstrating the great need for standards. Without undermining those processes, there is a long-term need to rationalise and, where appropriate, amalgamate standards across the construction and spatial sectors in Australia, and across jurisdictional boundaries.

As noted [in the Integration of Geospatial and Built Environment National Data Policy paper from which this quote is extracted], as well as information exchange standards, there will be a need to establish robust, legally-enforceable mechanisms to manage access rights to the information held in the DBE. Over the past few years, there has been much discussion around the Virtual Australia and New Zealand initiative (VANZI), initially supported by the CRC for Spatial Innovation [now via the Spatial Industry Business Association] and promoted through National Conferences in 2013 and 2014 (the second, in collaboration with buildingSMART Australasia). The two core concepts proposed in this initiative are that access rights to information held in the DBE should align with legal property ownership rights in the real world and that access should be brokered through a network of "data banks" (analogous to financial banks) where people can securely lodge built environment information and gain access to information regulated by those access privileges. These ideas are fully-documented on the VANZI web site.

This brief section has highlighted the need for consistent standards and rigorous protocols as a foundation for the evolution of the DBE".

Also in Australia, the Air Conditioning and Mechanical Contractors' Association (AMCA) is leading development of standards for fabricators who provide building services. The Association's approach is expressed by the Executive Director:

"Major savings are predicated on the idea that a building should be constructed twice: digitally first, using a data-rich three-dimensional model; and physically second, using the model to better plan, coordinate, and execute construction works, with the detail then available for facility and asset management.

A lack of standardisation with respect to data and digital object libraries has so far inhibited greater adoption of BIM. Without standardisation, there is no guarantee that the investment made by firms in the creation of digital assets and capabilities can be applied from project to project, or over the life-cycle of the building, diminishing the economies of scale that would justify such investment.

To address these barriers, AMCA has established an industry initiative BIM-MEP^{AUS} that aims to develop a common set of protocols that improves information capture and communication across the supply chain; thus allowing industry to focus on value add activities. The AMCA is currently developing 300 specifications which will define plant, equipment and fittings for essential building services (mechanical, electrical and plumbing). Further details on the AMCA standardisation process is available at: http://www.bimmepaus.com.au/initiative/specifications/".

It is recognised that standard setting is an international and national imperative that goes beyond State borders, and even individual initiatives.

3D QLD can help drive the development of standards by providing the framework for platform(s) that encourage secure data sharing on a national scale.

6.6 Other national & Queensland initiatives

The Federal and State Governments have long recognised the need to standardise many aspects of Land Administration through the formation of Australia and New Zealand Land Information Council (ANZLIC) and the Inter-governmental Committee on Surveying and Mapping (ICSM). These groups have set out strategies to achieve integration of spatial data on a National basis across 10 Foundation Data Themes (108). These are reflected in the Queensland Foundation Data Themes.

Additional projects aimed at creating fully integrated and automated Land Administration include:

- eGeodesy (109) (under the umbrella of ANZLIC and ICSM)
- eSurvey (110) (via DNRM under the umbrella of ANZLIC and ICSM)
- ePlan (111) (Brisbane City)
- Virtual Brisbane (112) (Brisbane City)
- eConveyancing (113)
- Property Exchange Australia Ltd (PEXA - National) (114)

Independently, governments in Australia also been developing a 'viewing' platform to visualise key data sets in their spatial context, e.g.:

- National Map (115) (National)
- Queensland Globe (116) (DNRM)
- Geoscape (117) (PSMA – National in development)

These initiatives all show an evolving expertise in the electronic collection and use of 2D and 3D digital data, as well as a willingness to share the data.

The Main Shortcomings identified by stakeholders included:

- None of the government visualisation tools provide guarantees that the imagery and data displayed is accurate. Verification is currently carried out by the user going to the source (or via an independent third party, such as a surveyor). This is unlikely to change in the near future.
- At present, none of the visualisation tools provide a 'single point of truth' for any feature or attribute, nor can they do so until there is a single point of truth in the data itself.
- This requires, for example, that the same data set used by a Council to model its local area feeds the State model, with all State Planning features feeding the Council model, with the same data set used by the design team feeding the Council's planning and building approval process, which feeds emergency services, etc.
- This requires a framework, platform and business processes to share the data simply and efficiently. While these already exist to some degree, stakeholders have indicated there is room for improvement. The potential is for 3D Qld to provide the improved framework.
- The data on underground mines is of variable quality, or non-existent, and/or not able to be displayed. Resolution of this impediment to the 3D Qld vision is discussed in detail in Appendix C .
- The data on underground services is of variable quality, or non-existent, and/or not able to be displayed, and is often held in private hands.
- The data that is held in the private sector (which makes up the bulk of the internal and underground spaces of the built environment), cannot be readily integrated with the public data sets.

Data verification is discussed in more detail in Chapter 7.

6.7 Sharing 'private' 3D data

The Queensland government has already proven the value of federating public data through its Queensland Globe initiative. This has made it much easier to discover and access data that was previously accessible only via specific approaches to specific departments under specific terms and conditions.

The same problem still exists within the private sector, only more so, given the millions of different entities, data sets and registries involved.

Even if the data could be found, there is a question on its reliability. And even if it was reliable, it would not be feasible to approach a firm and say 'I'm building next to a project you did ten years ago', and expect them to provide all of the data on foundations, footings and utilities that you would need to design and execute your project. Even if they could find it and wanted to share, there is no straightforward framework or platform within which the data could be shared. It would require a whole separate contract.

In some cases, the reluctance to share is based on the tyranny of the commons: any single stakeholder only benefits if all other stakeholders share their data.

In these circumstances, most private sector and utility stakeholders considered that the best way to encourage participation in any federated system would be if it were covered by legislation. They also see this as a way to minimise complexity and costs, protect privacy and commercial interests, and to maintain security.

Their principal concerns related to any federated system were:

- that these systems retained the means for them to manage 'permissions' for access to their data, and

— that they should not be forced to change their systems to use 3D data until they see a value in doing so.

It was generally acknowledged that full value would not emerge immediately. The value is expected to grow as more and more 3D data is accumulated in a federated system. At some point, the value of the stored data would be sufficient for each organisation to change its business processes to utilise the data.

6.8 Approaches to managing private federated data

Development of a framework of processes and standards for managing and sharing private spatial data will take time. The issues that will need to be considered include:

— The needs of the data users
  – This report has confirmed the need on the part of users and addresses the benefits that could be expected to accrue from implementation of the 3D Qld strategy.
— Priorities
  – These will need to be prioritised as the time and work required to find solutions are likely to be significant.
— Technologies
  – The technologies that will be drawing on the data are evolving rapidly as sensors, positioning and simulation models evolve to meet the demand for things like autonomous vehicles, route optimisation and BIM systems evolve.
— Standards
  – development of standards for meta data, data sharing and data exchange protocols etc.
— Legislation and regulation
  – It is likely that an evolution in regulation and legislation will be required as the program of implementing a 3D strategy is progressed.

Developing recommendations on these issues is not within the scope of this preliminary report. It will be necessary to identify actions that can be taken as part of implementing the road map. However, it is possible to speculate on what the future might look like as far as legislation and regulation is concerned.

6.8.1 Possible need for legal framework

Full consideration of the need for a legal framework for a federated system is beyond the scope of this project. However, most stakeholders felt that with a legal framework in place, it could be expected that cloud services would emerge to provide the business processes and software to securely hold, share and make use of the stored data; making it much easier for users to convert to 3D sooner than if they have to develop all processes in-house.

As an exemplar, within the industrial domain, General Electric (GE) has already developed a platform (118) to manage access to the 'digital twin' of each piece of equipment, wherever it is located around the globe. The digital twin is used to monitor performance (in real-time in some cases), to conduct programmed maintenance, and to identify improvements in design.

Ultimately, it is seen that the digital twin of each piece of equipment will sit within its built-form twin (providing spatial context for the operation of the equipment). GE sees the integration of equipment and building models as the norm for building management in the future. In this case, the equipment model would be situated in the model of the plant room, which is inside the model of the building, connected to the model services that are linked to the utilities model networks. In time, all these models are expected to be dynamic, allowing simulation and operational control of the energy, water and waste flows involved.

As an example of the efficiencies to be gained, ThyssenKrupp has claimed they are now repairing elevators 4 times faster than previously (119) using Augmented Reality to access 3D models, data and online help.

Managing rights of access is seen as crucial for security and to protect commercial interests.

The mining sector is another exemplar which already shares huge spatial data sets (45). One company in Queensland provides a service that essentially acts like a Dropbox™ for mining operators. The data owner determines who gets access on what terms. In this case, the data owner pays for the hosting which is set up to handle the many different data types and to provide a translation service. Sharing is determined by the direct commercial interests of the parties involved.

In the case of 3D Qld, the sharing of private data is not so clear cut. In many cases, the data does not have immediate benefit to the current owner (or data holder) who may be a surveyor, an engineering consultant, construction company, or even the property owner who lacks the systems to hold and manage 3D data. Without an immediate need, there is little incentive to spend money on managing the data, or making it available to third parties.

One way to solve this problem is to simply establish 'repositories' for them to 'bank' the data until it is needed. This could be a registry managed by the government, an industry body or a third party. The possibility also exists that blockchain technology could facilitate 'registration' of 3D spatial and building data without the need for a 'trusted third party'. These are matters for subsequent consideration. The main point is that if the framework were right, the digital world could operate in parallel to the real world.

When people or organisations buy or sell a property, what they buy or sell is a 'property right' that has been defined in law. The property stays where it is, regardless of who owns it. Similarly, a single authorised digital model of each object could be held permanently in a federated repository (that could be a trusted third party or perhaps a blockchain network), with each person having an interest in it 'for the time being' - based on their real-world interests in the object that it models. Then, when they sell their interest in the real property, they would also transfer their interest in its digital model which remains in the 'repository'.

Just as we expect the geometry of the federated models to match the geometry of the real world, so too the simplest requirement is for the legal environment in 3D Qld to match the legal environment in the real world.

As with real property rights, to be recognised in law, these digital property rights may need to be explicitly defined in legislation or regulation.

Many stakeholders (utilities, architects, engineers, financiers, insurers, property owners and lessees) believe that a legislative framework would be required and would need to be national or at least nationally consistent. This raises many constitutional and legal questions. However, putting these concerns aside for the time being, the simplest framework is one where the rights, responsibilities and restrictions in the models reflect the rights, responsibilities and restrictions of each jurisdiction.

A nationally consistent legal framework, could identify the entities/ registries established to hold the 'authorised models'. For example, city councils could hold the official city model, each utility could hold the official model of their network, property owners may hold the official models of their properties, and so on. For small owners and councils and even some utilities, this 'holding function' could be provided on a commercial basis via an authorised organisation within a 'cloud' of approved model holding organisations or registries - to ensure security and quality of service and adherence to the requirements of the federated system.

For this to work, the 3D model (including all property and rights boundaries, along with all administrative and statutory boundaries) would need to be:

- lodged with an authorised organisation or registry
- accompanied by good quality meta data (who created it, when, using what tools, etc.)
- certified and locked against deletion or change, and held indefinitely on Australian soil (to avoid data being frozen in an offshore data base under foreign laws (120))
- geo-referenced to the National Datum
- accessible based on the permissions that people have under statute, contract and common law in the real property that is the subject of the model.

- In this case, a member of the public may see the external image of a building, but only the owner and those permitted by the owner may see inside with, for example, a lessee being able to see the model of their leased premises, but not able to change it, unless they are allowed to make modifications under their lease.

As well, the system must be able to identify each user and their rights of access as they change. This raises the whole issue of cyber-security which is considered in detail in the next section.

With such systems in future, there may be potential for blockchains (121) & (122) to manage/automate some or all of these contractual relations.

The models could then be integrated via the federated system from 3D state and city level models to building to plant and equipment 3D models, down to the legible image of a nameplate on an individual piece of equipment (as long as it has been photographed at sufficient resolution).

The platform does not have to do this integration, it simply has to make the data available to anyone who is authorised to access it through a web based application. The portal selected to access the data, and the software used to model/visualise it, would be a matter for each user to determine.

A National framework would greatly simplify operation of the system, as it would avoid the need for each party to agree terms of access, use and trade with every other party, and with jurisdictions or local government.

Importantly, such a framework would mean that every person and government officer who knows their rights, responsibilities and restrictions in the real world, would also know them in the digital world, without the need to employ a 'spatial lawyer'.

It was felt by stakeholders that this approach should not be a major problem for the States. By ensuring that rights in the models reflect State rights (i.e. each person's and organisations rights in the property), this leaves the States and Councils with same control over the models as over the related real property.

Another factor in favour of a uniform national approach is that there is little legislation specifically governing the 3D digital world that needs to be harmonised. This is very different to most harmonisation proposals, where there is already a great deal of legacy legislation that differs State to State and Council to Council.

Federation of certified private imagery, maps and models with other authorised data, including all RRR boundaries and Geo-coded Addressing (123) linked to the source data sets, would represent realisation of 3D Qld, VANZI and Cadastre 2034, and could potentially be an exemplar for the nation, and the global community.

The embedded RRR boundaries would play two roles.

- First, they could be used to limit access to parts of the federated model, to protect privacy and commercial interests, and importantly in the case of services and infrastructure, to maintain security (addressing the two key concerns of stakeholders).
- Second, they would enable users to make reliable decisions regarding ownership and other RRR, directly in the model.

There is more research required to establish the most appropriate path to achieve the vision of 3D Qld and VANZI and the above possibility is only one approach. However, the model discussed above should provide some confidence that a framework for realising the vision over the longer term would not be impossible to develop.

6.9 Cyber security

While the prospect of federated registries of spatial data offer prospects of greater efficiency and productivity there are nevertheless considerable security issues to consider. The US Department of Homeland Security has stated:

> "The growing number of serious attacks on essential cyber networks is one of the most serious economic and national security threats our nation faces" (124).

Similarly, The UK's National Crime Agency in its July 2016 Cyber Crime Assessment 2016 (125), stated:

> "…the speed of criminal capability development is currently outpacing our response as a community and that only by working together across law enforcement and the private sector can we successfully reduce the threat to the UK from cyber-crime".

In the preamble to Australia's Cyber Security Strategy (5), it states:

"The Australian Government has a duty to protect our nation from cyber-attack and to ensure that we can defend our interests in cyberspace. We must safeguard against criminality, espionage, sabotage and unfair competition online"…

"Many of our larger businesses, particularly banks and telecommunications companies, have strong cyber security capabilities. Our future work will build on this platform. We must also do more. If an organisation is connected to the Internet, it is vulnerable to compromise.

As people and systems become ever more interconnected, the quantity and value of information held online has increased. So have efforts to steal and exploit that information, harming our economy, privacy and safety. Cyberspace, and the dynamic opportunities it offers, is under persistent threat.

Malicious cyber activity is a security challenge for all Australians. Australian organisations across the public and private sectors have been compromised by state-sponsored or non-state actors. Overseas, large multinational companies and government organisations have been targeted, losing substantial amounts of sensitive commercial and personal information or incurring major damage to their business and reputation…

Ultimately, to deal with all these challenges we must elevate cyber security as an issue of national importance. Leadership will be critical to achieving this goal".

As we connect 3D models of the natural and built environment and link them into the Internet of Things, we are beginning to generate ever more dynamic data flows that represent the movement of vehicles, goods, people, electricity, gas, water, chemicals, and waste throughout our cities - all within their spatial context. As we do so, the level of risk escalates enormously.

Australian governments and institutions are putting a great deal of focus on banking and telecommunications security for good reason: they are fundamental to the operation of our economy and society in general. In the coming years, the Digital Built Environment (DBE) could well be as important as it becomes embedded in everything we do.

The DBE is going to evolve regardless. If Australia is to capitalise on the benefits of faster, cheaper, better decision-making, it is imperative protocols are in place to securely manage it, to mitigate the security risks.

This security can be federated, just like the data, as long as the framework is established.

A step along the way is the imminent establishment of the federated identity hub by Australia's Digital Transformation Office (126). It offers the possibility that the identity used for government could also be used to access the DBE.

National security of 3D data will require careful consideration at all levels of government, given 3D data is set to proliferate. Leaving it to 'the market' and individuals to manage their own data does not limit risk. It heightens it. Simply because the whole 'system' is exposed to its weakest link.

6.10 Roadmap to address impediments

The 3D Qld Strategy is much more than a strategy focused on the geometry that comprises the physical attributes of objects in the real world, it is even more than the information attached to each object in 3D models. Ultimately, to mirror the real-world for decision-making, the DBE must also mirror all the boundaries that govern our Rights, Responsibilities, and Restrictions (RRR). It is these that govern all contractual relationships.

The boundaries in the digital models must also act just like the walls, doors and locks in the real world to restrict access to those who have permission to enter. This is vital if we are to maintain any possibility of security and privacy, and respect for property rights in the digital world.

The Road Map will address the impediments and proposed countermeasures identified by stakeholders in more detail in the Final Report.

At the very least, it would seem from stakeholder feedback we need a system to begin capturing and holding the data that is now being generated (ideally in an agreed standardised form) – so it can be used in future.

Added services and applications can be developed by the market over time to utilise the 3D data - once the volume of data warrants the investment.

6.11 Key findings

Stakeholder consultations and research undertaken for this report suggested that technology both current and emerging will not be an impediment to meet the demand for 3D data. The key areas of concern were found to be:

- raising the awareness among industry professionals and technicians in both government and industry of the implications of the GDA 2020 datum for their operations
- developing the new skills to use the new hardware and software to implement a 3D spatial model across the Queensland economy
- lack of 3D business processes particularly with respect to sharing and protecting authoritative 3D data between private organisations
- lack of standards and protocols for sharing of and access to authoritative data in 3D registries. Many stakeholders felt that there would be a need for a legislative framework to manage and facilitate the management and sharing of authoritative 3D data and that this should be nationally consistent. Consideration of a legislation framework is beyond the scope of this report however a possible approach to a nationally consistent legislative framework was discussed to illustrate the issues that would arise in such a case.
- Finally, this chapter outlined the cyber security issues that would arise from the growing integration of 3D data (with or without the development of authoritative registers of 3D data) and emphasised the need to address these issues in parallel with development of legislative, regulatory or other protocols to facilitate the sharing and protection of such data.

7 A CHANGING PARADIGM

This chapter examines the changes in roles and data storage that might be expected from implementation of the 3D Queensland vision. It explores the potential changes in the role of the surveyor and the data bases that would be required to support the 3D vision.

7.1 Traditional role

Traditionally, surveyors have been charged with locating points in space, placing monuments (pegs) to represent the points, and documenting evidence on paper in the form of 2D plans so the point can be reliably relocated if any peg is moved.

For hundreds of years, surveyors have also drawn plans to scale for decision-making. They have been drawn in 2D on paper (because that has been the only medium available), with the third dimension shown as numbers on contour lines, or possibly as sections and elevations (for complex 3D boundaries in the urban environment). In this era, all maps were abstract representations. The map was never the territory.

Over-time, the accuracy of these maps has improved, as the technology has improved. However, the decision-making process has not changed significantly. The person making any decision has used the plan appropriate to the scale for the decision they have to make. Decisions regarding localities have been made on small scale maps, decisions made in regard to subdivisions have been made on larger scale maps, and for lots and parts of lots, still larger scales have been used.

As it is not possible to reliably scale off the plan, it has meant that every measurement required for decision-making has had to be captured on site and separately recorded. The more points required, the greater the cost, time and potential for error.

7.2 The model is now the territory

Lidar and photogrammetry now enable millions and even billions of points to be captured economically. More importantly, together they make it possible to capture features from sub-mm to national scale within a single model (127) (both inside and outside structures), with the accuracy only limited by the resolution of the photography or scan (128).

With photogrammetry, the resolution can be increased by simply taking more photos closer up (129).

It means that for the first time, it is possible to take measurements directly from 3D imagery/models, at all scales required for decision-making (region, city, precinct, building, room, equipment, part).

This is because the model is no longer a scale representation, it is the (virtual) territory - within the limits of accuracy specified.

7.3 New role to certify 3D data sets together with all RRR in the model

Most stakeholders considered that certification is as important in the digital world as in the real world if the full economic value of digital models is to be realised.

Once a wall is built in the real world, it generally stays put. But in a model, it can be moved with the drag of a mouse. Doubtless, if it can be done to advantage one party over another, it will be done. Certified locked models are seen by stakeholders as the best protection against fraud in the digital world, and as the preferred option to minimise the cost of re-generating data on every project.

As the State does not guarantee the accuracy of any representation of the DCDB, or any imagery or model, stakeholders within the engineering, construction and property sectors have noted that, for the data to be useful to third parties in commercial transactions, it will need to be certified as accurate by a suitably qualified independent professional on each new use.

In this case, both the physical attributes and all RRR boundaries would need to be certified in the model for orthographic, dimensional, positional and elevation accuracy relative to the national datum.

It is generally accepted by stakeholders that any professional would have to conduct appropriate investigations of any existing model and related data in order to provide certification for any new use (and for any new user) - to ensure it is up to date and fit for purpose. However, it is expected that as the tools and quality of the data and ease of access improve, so the time and cost to provide each certification will fall over the next 5-10-20 years.

It means that as well as locating boundary vertices on the ground and placing pegs, there appears to be a new business opportunity for surveyors (and perhaps others) to locate and certify boundaries against the new national datum within each authorised image and model, for each new use.

This approach has already been demonstrated in developing a new subdivision within Flagstone (24) where the lots were first specified and certified by the surveyor by reference to the National Datum, with pegs only being placed in accord with the geo-references upon completion of the subdivision.

As well, architects are beginning to demand that cadastral surveyors provide them with comprehensive scanned certified 3D 'as-built' models of existing land, buildings and surrounds (with the boundaries accurately marked); in lieu of 2D drawings.

The 3D scanned imagery provides a much richer environment for the Architect and can be uploaded directly into their modelling software. Importantly, it reduces delays that now occur as a result of missed measurements, as every measurement can be made direct from the imagery/model once it has been orthographically certified and dimensioned. Importantly, by including geo-references in the model, it can also be situated within its authorised City and State 3D imagery/model (where available), allowing users to see the property in its full spatial context.

There may well be several approaches to certification and techniques and processes for such certification may well differ from the current approaches. In Denmark and the Netherlands for example the trend appears to be for the mapping authorities to take a role in certification of 3D models. However, institutional arrangements in these countries differ from those in Australia.

Without pre-judging possible approaches to certification options that might be suitable for Australia, it would appear that the Cadastral Surveyor is well positioned to provide certification services due to their intimate understanding of all the factors involved, including all relevant property and planning laws. Key to surveyors' value is that users can rely on their certification in law.

This need for third party certification is likely to continue because the basic requirement is to certify how closely the imagery/model represents reality *at the time it is to be used for decision-making*. In fact, as noted, certification becomes even more critical in the case of digital data due to the ease with which it can be changed (by accident or design).

Even so, the data for locating boundaries on the ground would not be scaled from the model. It would still need to be derived directly from the survey plan, though stakeholders felt it would be ideal if this data could be downloaded via a federated model portal.

While it is not within the scope of the current DNRM project, it is possible that in future, in addition to lodging ePlans with a few points marked and measured, surveyors could provide a full 3D 'scan'

(LIDAR or photogrammetry, or both) of the lot (or site), at each scale necessary to capture all relevant features for decision-making.

It is recognised that these rich 3D data sets may or may not be held by the government. They could be held by the surveyor undertaking the survey (subject to the new legal framework) or in authenticated registries established for this purpose. In this case, local government could be given access to approve, and the DNRM to endorse, the RRR boundaries in the certified model, via the federated system. This would avoid the need for duplicate copies that could get out of sync.

This is one possible approach that could be considered in subsequent investigation.

7.4 Surveyor's value and liability

This section summarizes the expansion of professional liability in the context of the emerging role of 'spatial surveyor'. Table 7.1 sets out our understanding of the current value and liability of the Cadastral surveyor.

Table 7.1 **Current value and liability**

Value	Liability
Interpret Evidence to Locate Corners of Boundaries in Space	Misinterpretation
Place Pegs on Identified Points (and place related pins)	Misplacement
Prepare Plan to correctly reflect Placements and Measurements	Miss-description
SOURCE: ACIL ALLEN CONSULTING/VANZI	

The Surveyor only has liability to the client contracting for the service. They have no liability for how the client uses the peg or the plan, or to any third party.

Table 7.2 sets out possible additional emerging value and liability for a future cadastral surveyor in a 3D operating environment.

Table 7.2 **Additional Emerging Value and Liability**

Value	Liability
Determine Ortho Accuracy of 3D Imagery/Model	Misinterpretation
Determine Registration of Image/Model vs National Datum	Miss-orientation
Determine Boundary Peg Positions in Image to Specified Accuracy vs Features	Miss-description
SOURCE: ACIL ALLEN CONSULTING/ VANZI	

The Surveyor still only has liability to the client contracting for the service. They have no liability for how the client uses the model/imagery, beyond the purposes specified, nor any liability to third parties.

The benefit to the client is that the detail in and the quality of the imagery/model (with marked boundaries) is much more meaningful and useful than a 2D plan which is only a scale drawing. The model is the territory, so there can be no misinterpretation. Also, all measurements (at the required scale) can be taken directly from the imagery/model. In the case of a 2D plan, if the feature is not marked and measured, a further survey is required, increasing cost and delaying work which is why more and more architects are demanding 3D imagery/models instead of 2D paper plans.

7.5 Changing data bases

This section compares the current and emerging data sets 'spatial surveyors' will be required to work with. Table 7.3 shows current data and emerging data sets that are expected to be required under a 3D model.

Table 7.3 Comparison of current and emerging data sets-

Current	Emerging
2D Surveyor's Paper Plans showing Boundaries and Measurements	3D Surveyor's Digital Imagery and Model, including complete 'point cloud' of the site showing Boundaries and Measurements, and ultimately, all the improvements on and under it. The survey models would need to be geo-referenced to align with any 3D City imagery and model
2D Building Plans	3D Building Models and As-built scans. The authorised model would be the only data set used for all decisions at the building level.
2D City GIS	3D Certified City Imagery and Maps (GIS), including surveyor's 3D Digital models (where available), with all other boundaries reflecting the existing DCDB (including the level of uncertainty applying to each boundary). These data sets would comprise the only authorised Imagery/models for all decisions at the City Level relating to property.
2D Digital Cadastral Data Base, 2D SPP GIS and other Government GIS data.	3D Certified State Imagery and 2D Maps (GIS) showing the boundaries as per the surveyor's 3D Digital model (where available), with all other boundaries reflecting the existing DCDB (including the level of uncertainty applying to each boundary) and all other rights and planning boundaries. Each data set managed and controlled by the responsible authority contributing the data. Together these data sets would comprise the only authorised Imagery/models for all decisions at the State Level relating to property, where no City model exists. All parties would have access to these data for their own decision-making.
2D Imagery (and some 3D) – Non-certified	Other 2D and 3D imagery and models may be created by any party for any reason, but it would have no legal standing beyond contractual rights between the parties generating and using the imagery and models.

SOURCE: ACIL ALLEN CONSULTING/VANZI

The table shows how the maintenance of possibly federated 3D registries will be important as data under a 3D Qld model.

7.6 Key findings

This Chapter noted the changes in data sourcing and the integration of an increasing array of sources of 3D data that are being captured today and which form a potential platform for a different paradigm that comes with the use of 3D models.

This by default establishes the need for certification of 3D data sets together with all RRR in the models. The manner and methods that might be developed in future to certify 3D data sets are still be explored and there are different approaches being considered around the world. That said, the cadastral surveyor is well positioned to provide certification services to this end. There will be a need for greater collaboration between industry and Government to ensure that authenticated registries established to store these data are properly managed and maintained in a manner consistent with the use of the data by others.

These developments would also have implications for the value and liability for cadastral surveyors in certifying 3D models for use by others for planning and construction purposes. The surveyor would still only carry liability to the client contracting the service. However, the detail and quality of the imagery/model will be richer and more useful than a 2D plan. Measurements would be able to be taken directly from the imagery/model.

Data sets in a 3D world would be more comprehensive than in a 2D world. Survey models would show boundaries and measurements including improvements and features above and below ground. The data would include certified city imagery and maps and all boundaries reflecting the existing DCDB and would comprise the authorised imagery/models for all decisions at city level planning relating to property. The data sets themselves would need to be managed and controlled by a responsible organisation. The custodians of the data could vary according their purpose and sensitivity. Registries could be federated depending on the uses and needs of the users.

8 ECONOMIC VALUE OF 3D QLD VISION

This Chapter addresses question g) of the terms of reference: a targeted economic opinion on the benefit of an accelerated realisation of 3DQLD, VANZI and Cadastre 2034 to government and private industry both in Queensland and Nationally?

8.1 Estimated value of land and property administration systems

The property sector is a vital part of the Australian economy. Indeed, the industries within the property sector are significant contributors to the national economy in terms of output and employment. Furthermore, through its activities, the property sector (including infrastructure) also has a major impact on the efficiency and productivity of other sectors of the economy. The land administration practice and systems play a significant ongoing role towards the contribution of the property sector today and in the future.

Table 8.1 outlines key indicators that provide context to the importance of the cadastre and the land administration systems in Queensland and Australia.

There are currently around $1.6 trillion of mortgages secured against land titles in Australia, of which an estimated $277 billion are in Queensland.[6] At the same time, the total value of all the residential property held in Queensland is $924 billion and $5.9 trillion Australia-wide.[7] As noted in ICSM (2014)[8], the land administration systems allow people, businesses and governments to leverage and manage these huge national and state asset bases. Indeed, given that the size of the Queensland and Australian economies (as at 2014-15) was $314 billion and $1.6 trillion respectively[9], the value of the land administration systems (and the opportunity that 3D Qld offers to substantially enhance this value) is evident.

[6] Australian data sourced from Australian Bureau of Statistics (ABS) (2016), *Housing Finance, Australia*, Catalogue number 5609, June. Queensland figures were estimated by ACIL Allen.
[7] ABS 2016, *Residential Dwellings: Values, Mean Price and Number by State and Territories Dataset*, http://stat.abs.gov.au/Index.aspx?DataSetCode=RES_DWEL_ST, accessed August 2016.
[8] Intergovernmental Committee on Surveying and Mapping (ICSM) 2014, *Cadastre 2034: Powering Land and Real Property, Cadastral Reform and Innovation for Australia – National Strategy*, Consultation document, April.
[9] ABS 2015, *Australian National Accounts: State Accounts, 2014-15,* Catalogue number 5220.0, November.

TABLE 8.1 SOME KEY ECONOMIC VALUES UNDERPINNED BY LAND ADMINISTRATION

	Queensland	Australia
	A$ billion	A$ billion
Total value of residential dwelling stock (March 2016)	$924	$5,931
Gross State Product/GDP (2014-15) [a]	$314	$1,605
Total residential housing loans (March 2016)	$277 [b]	$1,603

[a] Chain volume measures.

[b] Estimated by ACIL Allen.

SOURCE: ACIL ALLEN CONSULTING BASED ON ABS DATA.

[a] Chain volume measures.

[b] Estimated by ACIL Allen.

SOURCE: ACIL ALLEN CONSULTING BASED ON ABS DATA.

8.2 The DNRM project

Of immediate concern to surveyors and the property development sector, are the delays and costs incurred due to the use of paper-based Land Administration systems within State and Local Government. Also, there is concern due to inaccuracies inherent in the DCDB. The reason for the inaccuracies is discussed in section B.18.

A parallel project (being planned and implemented by the DNRM, as outlined in Section 2.3) aims to address stakeholder concerns by utilising surveyors' 3D digital cadastral data. DNRM is also investigating ways to access improved data developed by utilities, councils and road authorities to more quickly rectify the DCDB.

All the operating efficiencies and costs (of both the DRNM and Local Councils) to be derived from the DNRM project, as well as the benefits to be derived from an improved DCDB, will be assessed as part of that project.

Only the direct savings to surveyors from using their 3D digital cadastral models have been included in the costed benefits for the 3D Qld project.

8.3 3D Qld project

Overall, the benefits of 3D Qld to the Queensland economy are expected to be substantial as shown below.

The benefits flow only from sharing pre-existing private imagery/models, data and RRR, federated with existing public data (including RRR). The benefits do not take into account savings flowing from the original creation of the data (e.g. BIM models for a particular project [which savings are in the order of 20% of benefits (68)], or from the use of scanned models to facilitate asset management [which can generate up to 40% or more savings (43)], or any other 'first use' case for 3D models.

Under current conditions, the cost to acquire data involves searching many different data sets across many organisations, with most output in 2D paper form that then has to be collated and input into separate models.

As the cost to operate the digital federated system should be less than the current paper-based processes the federated benefits should also be net.

8.4 Quantifiable Benefits

The benefits have been costed on the basis of hard dollar savings resulting from three main areas discussed below.

8.4.1 Saving in data processing time.

Reduced time for processing data as a result of using Surveyors 3D digital models avoids the need for transcription to and from a 2D format. The amounts have been calculated using detailed operational timings developed by a team of surveyors. The benefits are calculated on the basis of net productivity gains for registered surveyors in Queensland of 15 per cent per annum after a three year implementation period (2017 to 2020) where no gains are realised.

It is estimated that the present value of benefits to the surveying sector would be around $47 million if calculated over 15 years and $58 million if calculated over 20 years. These benefits would accrue from 2020 assuming that the full implementation of eSurvey (one component of the CGSSR Project that covers the electronic transfer and submission of cadastral and geodetic data). The economic benefits are derived from consultations with industry stakeholders undertaken in the course of this project.

8.4.2 Reduced time and errors in engineering design and construction

Reduced time and errors in design and construction can be realised through sharing 3D data (including all RRR boundaries) from prior projects. The savings are estimated to be in the range of 1-5% of total project costs for major projects.

The percentages have been identified by a wide range of professionals within the architectural, engineering and construction (AEC) sector. In calculating these savings, it was assumed all the data available at the conclusion of a large project (namely, details on the footings of adjacent buildings, foundations and underground geology and hydrology, the location of all services, the topography of the site and surrounding streets and structures, all in 3D, all tied to the national position and elevation grid, as well as all certifications, etc.), would be available at the *start* - for use in design, tendering (including savings for unsuccessful tenderers), and then for demolition, engineering and construction.

It would not be necessary to model the entire metropolitan area before realising many of the benefits; as it would be possible to use algorithms to estimate the path of services located between separate models. Also, ground penetrating radar and new drones designed to fly, crawl and float through tunnels, pipes and ducts are likely to be able to trace the path of underground services.

Essentially, over time, a 3D Qld (as envisaged under the strategy), would have the potential to provide high-quality (and constantly improving) data for 'existing conditions' for new projects.

It has been assumed that the adoption of these techniques commences in 2026 at 10 per cent rising over time to a maximum of 70 per cent by 2033. The increase in the rate of adoption year on year is anticipated to increase as more models are federated it expected that the adoption level would increase. The rate of adoption is summarised in **Table 8.2**

TABLE 8.2 ASSUMED RATE OF ADOPTION

Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading	Heading
Year	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Level of adoption	0%	10%	15%	25%	35%	45%	60%	70%	70%	70%	70%	70%

Source: ACIL Allen Consulting assumptions

It is estimated that the present value of benefits to the engineering construction sector could range between:

- $179 million (lower bound) to $894 million (upper bound) if calculated over 15 years
- $388 million (lower bound) to $1,940 million (upper bound) if calculated over 20 years.

These are potential long term benefits for engineering and construction from the efficiencies achievable through federated 3D models.

Stakeholders also see that having such good quality data would result in a huge reduction in risk (financial, safety and property) for all parties.

The Sydney Light Rail Project provides an example of the problems encountered in trying to establish existing conditions for a major project (130). The Sydney Light Rail Project is a $2.1 billion project to deliver approximately 12 km of light rail from Circular Quay to Sydney's south eastern suburbs by 2019.

- Prior to commencing award of the main PPP contract, the Department of Transport for NSW undertook approximately 12 months of night works, to map around. 5,000 subsurface utilities along the route.
- To make way for the new infrastructure (e.g. light rail track slab) approximately 500 existing subsurface utilities had to be relocated.
- During the course of construction, an additional 400 unknown services were identified.
- Each service must be treated as live, and requests for information must sent out to all providers to identify the owner and status of the conduit. This process typically takes about a month for responses to be returned and the issue closed-out.
- Of the 400 new services found, only a handful have been claimed. The remaining services are being managed, and are often found to be redundant and no longer in service.
- This issue has created unnecessary costs to the program, with relocation works currently delayed by approximately 5 months. It is noted however these activities currently aren't on the project critical path so the overall project remains on-track.
- As-built information from utility providers has also proved to be problematic and is frequently unreliable (e.g. services out of location, marked as incorrect material etc.). This is also causing disruption and delays with construction.

While the project remains 'on time and on budget', this is only because these sort of delays and costs are included in the pricing and schedule; though with a high degree of risk.

If all the data now being gathered had been available at project planning stage, the project could have been completed at least one and a half years sooner, at less cost with much less risk.

8.4.3 Use of 3D models for asset management

On-going use of 3D models integrated with the building management system for asset and facility management are estimated to generate savings of 1-2% of operating cost over the whole life of any building or piece of infrastructure.

These savings are less certain due to the limited number of examples of 3D models being currently used for asset and facility management.

They are based on industry and research comparisons of current paper-based management practices, with the use of 3D BIM.

The paper: BIM Application on Asset Management (131) provides an excellent overview. It includes this graphic illustration of the opportunities for productivity improvement:

FIGURE 8.1 DOCUMENTATION STORAGE FOR FACILITY MANAGEMENT

SOURCE: HTTPS://WWW.LINKEDIN.COM/PULSE/BIM-APPLICATION-ASSET-MANAGEMENT-AMIR-BADINLOO

In Australia, the Air Conditioning and Mechanical Contractors' Association (AMCA) is leading the use of BIM within both the construction industry and for facilities management. According to AMCA, the software, services and standards that encompass BIM for facilities management has the capacity to cut facilities management costs by 30 percent (132). The Facilities Management Association concurs that savings are likely to be substantial (133).

Despite these aggressive estimates, the quantified benefits have been limited to 1-2% in order to provide a conservative estimate.

As with the construction impacts discussed above, it has been assumed that adoption of facilities management techniques using BIM systems would commence in 2026 at 10 per cent increasing over time to a maximum of 70 per cent by 2033 (see **Table 8.2**)

It is estimated that the present value of benefits to operation and maintenance of non-residential buildings could range between:

- $27 million (lower bound) to $55 million (upper bound) if calculated over 15 years
- $78 million (lower bound) to $156 million (upper bound) if calculated over 20 years.

These are potential long term benefits for engineering and construction from the efficiencies achievable through federated 3D models.

8.4.4 Other benefits

Further support for significant savings is evidenced from the following sampling of on-going global initiatives.

- New Zealand Asset Metadata Standards (134):

In NZ, good management of the Government's physical assets is considered beneficial to New Zealand's long-term fiscal position and the performance of the economy. The Thirty Year New Zealand Infrastructure Plan 2015 identified that raising the standard of infrastructure and asset management is a key part of the Government's economic growth agenda. Improving how the investments are managed and made will also deliver significant social, environmental, health and cultural benefits.

Using local, national and international case studies, the business case developed in mid-2016 supported the initial findings of the strategic assessment that shared asset metadata standards has the potential, in time, to unlock hundreds of millions of dollars, if not billions of dollars of productive benefit within New Zealand – annually. The case study outlines how this can be achieved, the role BIM will take in these initiatives and the programmes and costs required to achieve the outcomes being sought to achieve it. It also highlights, due to the nature of this type of investment, it will take in some cases, many years to secure these benefits.

— The UK BIM Case Studies for Asset and Facilities Management published by the British Institute of Facilities Management September 2015 (135).

— A US perspective is provided by Michael Schley, founder and CEO of FM Systems and an International Facility Management Association Fellow (136).

8.5 Non-quantified benefits

Additional benefits are expected to accrue as a result of having good quality 3D data with high positional accuracy in regard to all services (137). This would include less damage to services and interruption to supply, as well as lower maintenance costs. None of these expected savings have been included in the costed benefits, simply because the current overall cost is not readily quantifiable in many cases, so the potential savings cannot be assessed.

For similar reasons, the likely benefits for transport and logistics, emergency services, agriculture, finance, general insurance, property valuation, home building, renovation and maintenance, landscaping, furnishing, decorating, and leasing, as well as in education and tourism have not been quantified. How these benefits may manifest will be discussed in the Final Report.

It is also important to note that these benefits do not include savings in holding costs for developers from faster development approvals, again because of the difficulty in quantifying the benefit.

Nor have any community benefits been accounted due to the earlier completion of any building or piece of infrastructure as a result of having good quality data for 'existing conditions'. That is, if there are benefits in having the new buildings and infrastructure, there will also be benefit in realising those benefits sooner.

8.6 Summary of benefits

The potential economic benefits are significant as shown in **Table 8.3.** The table provides present values of benefits calculated over a 15 year and a 20 year period. The benefits are also split into three parts: benefits accruing to the surveying sector which accrue from 2020, benefits to the engineering and construction sector that accrue from 2026 and benefits to building facilities management sector that also that accrue from 2026 in line with adoption levels assumed in **Table 8.2** above.

TABLE 8.3 ESTIMATE OF BENEFITS

		NPV (7% discount rate)
	Real A$2017 million	Real A$2017 million
Cash flow period	15 years	20 years
Lower bound		
Net productive gain for surveyors [a]	47	58
Savings from federated 3D models:		
Engineering & infrastructure (1%)	179	388
Facility management (1%)	27	78
Total	**253**	**524**
Upper bound		
Net productive gain for surveyors	47	$58
Savings from federated 3D models:		
Engineering & infrastructure (5%)	894	1940
Facility management (2%)	55	156
Total	**996**	**2,154**

[a] These benefits are calculated on the basis of net productivity gains for registered surveyors in Queensland of 15 per cent per annum after a three year implementation period (2016/17 to 2019/20) where no gains are realised.

b Engineering benefits are calculated on the basis of cost savings of between 1 per cent and 5 per cent for levels of adoption commencing at 10 per cent in 2016 rising to 70 per cent by 2033. Forecasts of the value of engineering construction were based on construction activity forecasts by NIEIR ('Queensland regional construction supply and demand analysis: 1994-2025 and quarterly indicators to June 2017', 2015) and ACIL Allen Consulting estimates.

c These benefits are calculated on the basis of cost savings of between 1 per cent and 2 per cent of annual operating costs for levels of adoption commencing at 10 per cent in 2016 rising to 70 per cent by 2033 for all new non-residential buildings and an assumption that annual building operating costs are 3 per cent of construction cost. Forecasts of the value of non-residential construction were based on construction activity forecasts by NIEIR ('Queensland regional construction supply and demand analysis: 1994-2025 and quarterly indicators to June 2017', 2015) and ACIL Allen Consulting estimates.

SOURCE: ACIL ALLEN CONSULTING.

In summary the total benefits that could potentially arise range from

- **$253 million to $996 million if calculated over 15 years**
- **$524 million to $2,154 million if calculated over 20 years.**

In the medium term the full implementation of the eSurvey program would deliver between $47 million and 58 million if evaluated over 15 and 20 years respectively.

The longer benefits additional to this accrue after 10 years and are dependent on the development of federated 3D models as discussed in the report. However if realised they deliver significantly greater benefits in the longer term.

Given the federated system does not have to cover the cost of data generation, and the fact that it should be entirely digital (so its operating costs could be much less than the cost of acquiring the data under current conditions), the assessed federated benefits are considered to represent net savings.

These benefits are considered to be conservative for a number of reasons:

1. They capture only the federated benefits to construction, and asset and facility management
2. Some stakeholders believe the actual percentages could be much higher, in some cases up to 20%, but are not able to warrant such savings.
3. They do not include the many recognised benefits across other sectors of the economy that have proven difficult to quantify, as per 'non-quantified benefits' above.
4. The benefits assume a gradual rate of adoption of around 8 years from 2026 for long term benefits. However, it is highly possible that the uptake of the technology will soon accelerate because spatial applications are becoming easier to use with immediate benefit at the consumer level.

Also, demand for 3D data will be pushed along by the use of Virtual Reality for real estate, tourism and education, as well as Augmented and Merged Reality for both workplaces and consumer use to display information about any feature in the nearby environment that the person is permitted to access.

5. It is also impossible to quantify the network benefits that will inevitably arise. The $28 billion valuation for LinkedIn gives some indication of the value of a platform to network people. The value of networking millions of property models and data with the Internet of Things to create a dynamic 3D virtual operating environment for decision-making is, quite literally, incalculable – but no doubt substantial.
6. Lastly, as with all new advances (steam, electricity, computing, etc.), many of the benefits are yet to be even thought of, and will only be realised years after use of 3D Qld becomes widespread.

The most significant savings appear to arise in engineering and infrastructure. It should be noted that the realisation of these savings will depend on the ability to develop certified federated registers of 3D data. This issue was discussed in Chapter 6.

Australia wide

Given the relative size of the Queensland economy and based on stakeholder advice that similar conditions prevail in other States, it is estimated that the NPV benefits across Australia would be in the range of $5-15 billion net, as a minimum.

8.7 Key findings

Based on case studies undertaken for this project, we estimate that the potential benefits over the period from 2017 to 2030 associated with implementing the 3D Qld vision could range between

- **$253 million to $996 million if calculated over 15 years**
- **$524 million to $2,154 million if calculated over 20 years.**

This based on the following comments

- Present value of $47 million (15 years) to $58 million (20 years) in savings to the surveying sector from the full implementation of eSurvey
- Present value of benefits to engineering and construction of between
  - $179 million to $894 million calculated over 15 years
  - $388 million to $1,940 million calculated over 20 years
- Present value of benefits to facilities management of
  - $27 million to $55 million calculated over 15 years
  - $78 million to $156 million calculated over 20 years.

Stakeholders consulted believe that the benefits to construction and asset and facility management will depend upon certification of models in federated registries of 3D data developed over the next 10 years.

9 CONCLUSIONS

9.1 Overview of the report

This report covers the initial phase of the 3D Qld Road Map. As per the terms of reference:

- A general assessment of the estimated value of current land administration practice and systems to the economy of Queensland and Australia was provided in Chapter 8.
- Chapter 2 looked at the pressures that government and private industry are experiencing in administering the system under current technology, standards and practice. It identified a range of difficulties within Land Administration that 3D Qld needs to address, as well as more general concerns regarding pressures to innovate – to improve services, while constraining costs. It also discussed the Cadastral and Geodetic Systems Services Review undertaken by DNRM and the benefits to the delivery of modernisation of the Cadastral System to underpin the legal cadastral framework with the aim for a positionally accurate digital expression this legal framework. The outcome of this project will implement aspects of the 3D Qld vision.
- Chapter 3 considered the current landscape in terms of industry expertise and practice, technology, and community engagement to meet a future demand (for 3D data), with a mounting wave of change clearly evident.
- Chapter 4 provided an understanding of the present and future demand for: a) accurate mapping of the legal environment for property in a standard digital form, and b) accurate land and property information to support a range of economic pillars and industry sectors, social and community expectation, government institutions and industry professionals.

  This Chapter also canvassed the demand for a simple and accessible central register for land and property interests. It concluded that there is strong demand for these services, subject to protection of each party's rights in the data.
- Chapter 5 reviewed the appetite or demand for change in the short, medium and long term, indicating a range of responses from eager anticipation to a fear of losing work. In particular, it identified a need for a new role: the 'spatial surveyor'.
- Chapter 6 assessed the current landscape in terms of industry expertise and practice, standards and government systems to meet a future demand (for 3D data), as well as the likely impediments to the 3D Qld vision and possible countermeasures proposed by stakeholders. Security was recognised as a major concern.
- Chapter 7 looked at the changing paradigm and the new role of 'spatial surveyor' in more detail.
- Chapter 8 assessed the targeted economic opinion on the benefit of an accelerated realisation of 3DQLD, VANZI and Cadastre 2034 to government and private industry both in Queensland and Nationally. Given property rights are fundamental to all transactions, we used Total Dwelling Stock (Qld $924 bn. and National $5,931 bn.) and Residential Housing Loans (Qld $277 bn. and National $1,603 bn.), together with Gross State Product ($314 bn.) and Gross National Product ($1,605 bn.) as the context for the benefits expected to flow from 3D Qld.

9.2 Key issues raised by stakeholders

The key issues raised by stakeholders are summarised below.

9.2.1 Technical capability

Stakeholders are unanimous that the 3D Qld vision is technically achievable, with 3D imaging, mapping and modelling already used to some degree across all sectors. As well, there are exemplars of private data sharing already in existence within the industrial and mining sectors, and on a project by project basis within construction, not to mention cloud services in general.

9.2.2 Skills requirement

While this is of some concern, the likelihood is that a combination of some increase in professional recruitment, AI driven software and hardware with simplified interfaces, together with improved interactive training, cloud services and global contracting using virtual meetings will enable us to fill the gaps.

9.2.3 Potential new role

A key issue raised by stakeholders was the need for data held in 3D registries in the private sector to be certified as authoritative. This might be achieved in a number of ways. With the advent of the digital built environment there is a possible need for the role of the surveying profession to extend to certification of data held in such registries. It is possible that a new role of the Spatial Surveyor could emerging. Such a professional would be required to certify the key attributes of any digital imagery and/or model with embedded RRR, for use by third parties.

9.3 Business processes and federating the data

Without a system to retain and share private data, there is a real risk that many extremely valuable 3D data sets will be lost to posterity – this is reported to be happening now to some extent.

The vision is for the federated model to become the link to all data about each object, area and boundary in the real world.

If this were achieved it would be possible for eligible users to log on, see the feature they are looking for in its full spatial context and access information related to it. This might include the regulations that apply to it, ownership, address, valuation, controls, what it is made of, its energy use, its cost. Such access would be subject to defined rights managed by the custodian of the data.

All these features are already being built into 3D software and hardware. The policy challenge for government and industry is to provide the framework to store, access, use and trade in the data between authorised users.

While federation of 3D models may appear daunting, it may be no more difficult to start than using a facility similar to Dropbox™, if the framework were there to support the system. Geo-referencing and good meta-data, standards and protocols will need to be developed.

Addressing these challenges would require collaborative action by both governments and industry. This is a major task and it will be important for needs and priorities to be set in any road map.

The consultations undertaken revealed a preference for any framework for 3D data to be national. It is too early to say what such a framework might comprise. However, with a national framework in place, it is possible that industry would be able provide the platform(s) as a cloud service, at a net saving to users (compared with how they get their data now). Once established, it is expected that the service should pay for itself.

The main concern amongst stakeholders is that any federated system must protect their rights to and security of the data. In particular, private data owners want to retain control over access and monetization.

Aligning RRR in the data with RRR in the property will give this assurance, as well as greatly simplify contractual arrangements and regulations – key stakeholder requirements.

9.4 Cyber security

Whether the data is formally federated or simply becomes federated through a process of organic linkages, security will become an over-riding concern.

This concern will be much easier to address in the context of a national framework.

It requires identification of the data, processes to assure its accuracy and currency, as well as identification of each user and their permissions to access, use and trade in the data. This can be managed without central control using federated security protocols within an open platform(s).

9.5 Benefits

As shown in Chapter 8, the present value of net quantifiable benefits for the Queensland economy of federating 3D data are estimated to be in the range of $520 and $2,200 million, with the likely network and other benefits being an order of magnitude greater in the long term - as the Digital Built Environment is realised for design, communication and decision-making throughout the economy and community.

For the reasons outlined in the report, the savings from federating the imagery, models, data, and RRR boundaries should not only be the absolute minimum, they should also be net.

This finding suggests that developing the road map is justified on the basis of the potential benefits identified.

9.6 Findings and next steps

The expected benefits identified above are sufficient to conclude that there is an economic case for proceeding with the 3D Qld road map development. The issues raised in this report identify the issues and possible approaches that will need to be considered in Phase B and provide a number of possible approaches that will be further developed in Phase B.

STAKEHOLDER CONSULTATIONS

A

While the focus has been Queensland, due to the project's economy-wide implications, we have included a range of stakeholders who also have a national presence, to ensure any recommendations are compatible with the interests of the whole Australian community.

A.1 Queensland Government – land administration

Steve Jacoby, Executive Director - Land & Spatial Information - Queensland Department of Natural Resources & Mines. Chair of the Queensland Spatial Information Council, Queensland's representative on ANZLIC - the Spatial Information Council, as well as a member of the CRC for Spatial Information board, and a member of 2026 Spatial Industry Transformation and Growth Agenda and 3D QLD Taskforce

Russell Priebbenow, Director of Surveys, Queensland Department of Natural Resources & Mines. Queensland's representative on the Intergovernmental Committee for Surveying and Mapping – ICSM and a member of the Surveyors Board of Queensland.

Oskar Kadletz, Queensland Abandoned Mines Coordinator, Department of Natural Resources and Mines

Michael Macartney, Surveyor - Mines Tenure at Department of Natural Resources and Mines

Debbie Moore, Principal Spatial Information Officer, Department of Natural Resources and Mines

A.2 Queensland Government – transport and main roads

Tony Kirchner, Director (Geospatial Technologies) at Department of Transport & Main Roads

Dave Zannes, Principal Advisor (Geospatial Information) | Metropolitan Region / Transport and Main Roads

A.3 New South Wales Government – Transport for NSW

Simon Vaux, A/Principal Manager Engineering with Transport for NSW (TfNSW) and currently leading the long-term strategy to implement Digital Engineering (DE) within Transport. He is also a member of the National Digital Engineering Working Group (NDEWG)

A.4 Regional development

Tracy Scott Rimington, SEQ Coordinator on Regional Development Australia, Brisbane.

Bob Germaine, Executive Officer, Regional Development, Sydney

A.5 Queensland Local Government

Andrew Saad, Senior Research Officer, Brisbane City Council

Wilson Lowe, Leader, Virtual Brisbane, Brisbane City Council

(With the benefits now identified, consultations with other key councils will take place during the next phase of the project to ensure the broader interests of all councils are considered in the Road Map)

A.6 Interstate Local Government

Bernadene Voss, Mayor, Port Phillip City Council, Victoria

Greg Stevens, Manager Property Services, Chief Valuer, City of Melbourne

David Hasset, Team Leader GIS, City of Melbourne

A.7 Agriculture

Wayne Hall, Executive Director, Agri-Science Queensland Department of Agriculture and Fisheries (Queensland)

Liz Alexander, Director Cotton Research and Development Corporation and Plant Health Australia and Principal Consultant Blue Dog Agribusiness

A.8 Emergency services

Peter Timmers, Principal GIS Solutions Officer, Public Safety Business Agency, Qld

A.9 Architecture, Engineering and Construction (AEC)

Andy Wohlsperger, Associate Director – Technology & Data Solution, AECOM

Steve Appleby, BIM Practice Lead, Australia and New Zealand at AECOM

Ralph Croker, Senior Consultant – Survey and Geographic Information, Jacobs

John Andary, General Manager - Client Services Civil Contractors Federation

Kevin Pan, Design and BIM Manger, CPB Contractors (formerly Leighton)

Paul Bidwell, Deputy Executive Director, Master Builders Qld

David Sutherland, Director of Planning and Design at Fender Katsalidis (Aust) Pty Ltd

Rogier Roelvink, Associate Director Turner & Townsend Thinc

Jamie Casas, BIM Consultant, Wood & Grieve Engineers

Belinda Hodkinson, Strategic Consultant, BIM and Digital Technologies, and Chair BIM Collaborate ANZ

Jorge Pautasso, Service Line Leader, Structural, GHD

Dominik Holzer, Owner, AEC Connect Australia and Senior Lecturer in Digital Architectural Design at Melbourne University

Daniel Kalnins, Associate Principal, Head of Virtual Design and Construction at Ridley (previously responsible for helping develop BIM and digital engineering throughout the CIMIC Group's Asia-Pacific operations). Member of the Standards Australia working group developing a new international BIM standard.

Ross Clark, former Chief Operating Officer, Australian Institute of Architects

A.10 Queensland Surveying

Peter Sippel, Consulting Surveyor, Chairman of Qld Surveyor's Board

Lee Hellen, Managing Director, Land Solution Australia

Callum McNaughton, Director McNaughton Mining Services

Chris Swane, Director Bennett and Bennett

A.11 Interstate Surveying

Franco Rea, Director, Alexander Symonds

A.12 Property

Nathan Percy, Policy Advisor Property Council of Australia, Queensland

Henry Pike, Communications and Policy Officer, Property Council of Australia, Queensland

Mark Tait, Head of Commercial Developments, Investa Property Group (Top 3 Nationally)

A.13 Asset and facility management

Sumit Oberoi, Executive Director of the Air Conditioning and Mechanical Contractors' Association

Chris Linning, Manager, Building Information at Sydney Opera House

Nicholas Burt, Chief Executive Officer at FMA Australia

A.14 Spatial Industry

Kellee Ireland, Executive Director, Spatial Industries Business Association

David Sinclair, Chair, 43PL and CSQC

Wal Mayr, PSMA Director, Surveyor, Director of Mapping RPS

Richard Simpson, formerly, Executive Director Spatial Industries Business Association

Jack deLange, formerly, Spatial Industries Business Association Qld

Ben Searle, Spatial Services Consultant

A.15 Mining

Nigel Atkinson, Principal Surveyor (O/C & U/G) – Coal, Anglo American

Ben Paech, Coal Assets Australia, Glencore

A.16 Utilities

James Bangay, Managing Director Fugro Roames (regarding Ergon Energy and Energex)

Matt Fossey, Spatial Analyst, Queensland Urban Utilities

Scott Newman, Property Systems Specialist, Stanwell Corporation Limited

Jawad Youssef, Principal Spatial Systems, SEQ Water Corporation Limited

Tim Mackay, Spatial Data Administrator, Powerlink Queensland

Ian Holmes, Senior GIS Advisor, Sunwater

Chris Ross, GM Access Planning, Telstra

Graham Samuel, Spatial Data Specialist, Strategy & Business Dev., Access Planning, Telstra

Andrew Panagopoulos, Capacity Planner, Telstra

Barbara Kobylinski, Senior IT Domain Specialist, Telstra

Chris Upson, Advanced Capacity Planner, Telstra

Joseph Xavier, Senior IT Business Analyst, Telstra

Frank McCreedy, NITS Inventory Program Manager, Telstra

A.17 Insurance

Hugh Saalmans, Location Engineering Director, IAG Insurance

A.18 Transport and logistics

Michael Kilgariff, Managing Director, Australian Logistics Council.

A.19 Cyber Security

Graham Williamson, Director, KuppingerCole (Asia Pacific) Pte Ltd.

Andrew Ferguson, Co-Founder - ViewDS Identity Solutions

A.20 Legal

Kim Lovegrove FAIB, Principal, Lovegrove Smith Cotton Lawyers and Chairman Centre for Best Practice Building Control.

Michael Fraser, previously Professor of Law (now Adjunct Professor), UTS

A.21 Standards

John Mitchell - Chairman, buildingSMART Australasia.

A.22 Technology and data providers

Mark Sheppard - Chief Commercial Officer, GE Digital Asia Pacific

Brian Middelton, Vice President, ANZ Bentley Systems

Peter Kinne, Regional Director, Digital Globe

Mark Deuter, Managing Director, Aerometrex

Guy Perkins, Strategic Sales Director, Spookfish

Jason Lilienstein, CEO at Zuuse

Christian Larsen, Co-founder at Glass Terra

Simon Cookes, Architect and founder Larki

Grant Lynch, CEO iSeek Developments

Tim Newman, PowerCad Software Pty. Ltd. Electrical Engineering Design Software

A.23 Technology impact

Karen Sanders, Director, Real Serious Games Pty Ltd

Dr Kate Crawford, Director Eviva. (Helping to build self-governing, creative, agile and adaptive communities and organisations).

Deanna Hutchinson, Director simpublica.com (strategist using technology as a level for transformational change)

A.24 Research

Dr Mohsen Kalantari, Senior Lecturer in Geomatics Engineering and Associate Director Centre for SDI's and Landa Administration

Dr. Glenn Geers, Associate Adjunct Professor, UNSW Computer Science and Engineering

Dr Elliot Duff, Research Director Autonomous Systems, Digital Productivity Flagship, CSIRO

A.25 Consulting team

Alan Smart, principal ACIL Allen Consulting expert in the valuation of spatial data infrastructure and services, and Lead Consultant for this project.

Michael Haines, Lead Author of this Report and CEO of VANZI working with stakeholders to articulate a vision for an integrated 3D Digital Built Environment including all RRR, for use in decision making throughout the property cycle.

George Havakis, Managing Director of GISSA International specialising in Information Management and Technology where he combines project management experience with specific knowledge of the intricacies and dependencies of GIS projects with a focus on standards.

Haydn Read, NZ based consultant who has been leading the use of 3D data across the NZ government and local councils by identifying the key value propositions and standards requirements.

Prof, Abbas Rajabifard, Director of the Centre for Spatial Data Infrastructures and Land Administration at the Department of Infrastructure Engineering, the University of Melbourne. Prof. Rajabifard is a global authority on the integration of 3D cadastral data with GIS and BIM models.

Alan Hobson, consultant with expertise in Building Information Modelling and its application to Surveying and Deputy Chair for the Spatial Information and Cartography Commission of the Surveying and Spatial Sciences Institute (SSSI)

Jim Plume, member of the Infrastructure Committee for buildingSMART International, contributing to the development of international standards for information modelling of the built environment, with a specific focus on Precinct Information Modelling.

Peter Murphy, Director Brazzier Motti, which provides consulting services in survey, project management, mapping and GIS.

A.26 Conferences

MelBIM

The vision, outcomes and anticipated benefits were presented at MelBIM on 1 Sept. to a meeting of 280 senior managers, comprising architects, engineers, surveyors and planners from the major AEC firms in Melbourne, as well as researchers from RMIT. The feedback from the presentation has been extremely positive.

Surveyor: Northern and Central Regions
Presentations were given to several hundred Surveyors in Cairns and Brisbane in with generally positive feedback for the project, including the use of Surveyors 3D models of the Cadastre as the data source for Land Administration. Some doubted the ability to deliver.

Smart Future Cities: The Role of Spatial Data and Urban Analytics
Presentation to be provided to this International Symposium being conducted by University of Melbourne on 27-28 September, 2016.

Facility Management Association
Invitation from CEO to make three presentations: 1) to BIM Portfolio Group, 2) to their Knowledge Portfolio Group in October 2016 and also to the FMA Digital Transformation Summit, in early February 2017,

AMCA – BIM-MEP^{AUS}
Invitation from Executive Director to present to their 2017 Conference which is now the major BIM conference in Australia.

Locate 17
Once the Preliminary Report has been accepted by the Taskforce, it is proposed to seek an opportunity to present the project as a Keynote.

LAND ADMINISTRATION IN QUEENSLAND

B

B.1 Cadastral and Geodetic Services Systems Review Project (CGSSR)

Since the 3D Qld Road Map was initiated, DNRM has initiated a project to determine its future approach to how land information e.g. property, surveying and addressing data, is created and used by different people and organisations. The Cadastral & Geodetic Services Systems Review project (CGSSR) aims to develop a system that enables the industry to use and contribute spatial information, which will build a resource that will have benefits for everyone.

The outcome will be to replace the current information management systems that support the delivery of land information, which are not able to meet growing industry requirements, are not easily integrated with technology advancement, and require significant manual interventions. The project is focussed on modernising business processes for cadastral and geodetic data: to implement fully digital processes, to speed up the delivery of an accurate Cadastre via automation, to provide more access to 2D and 3D data, and to facilitate a two way exchange of information through a collaborative environment.

A key requirement is to develop a Land, Property, Addressing and Positioning Environment able to incorporate new features, standards, connections, modules and 3D+ time representations as new opportunities arise. The aim is to develop a 'single point of truth' for the data being captured.

The expectation is that the CGSSR project may require a significant multi-million dollar investment.

As the outcomes of the DNRM project will implement aspects of the 3D Qld vision, it is anticipated that the Road Map should help the Government to justify this expenditure, based upon the value identified by key stakeholders.

B.2 Torrens Title

In the 1850's the Torrens Title system was first introduced in South Australia to simplify the process of land administration; to reduce cost and disputation. It was subsequently adopted by all other States, and in many other countries. Essentially, it has removed the need to re-establish (on each purchase) an unbroken contractual chain of ownership, going back to the original grant of title. It does this by registering each lot together with specific interests in the lot. The entitlements of all registered interests are guaranteed by the State. It is generally accepted as the most secure and reliable land titles system in the world.

B.3 The cadastre

The Cadastre is the entire chain of documentary evidence (from every survey) for each lot of land (and more recently strata title), held by the relevant authority. It includes all registrable interests in land and water that are defined by boundaries, e.g. freehold, leasehold and crown land, and includes easements, profit apendre, licenses, covenants etc.

Initially, only the boundaries were measured, with rights extending indefinitely above ground, and below ground to the centre of the Earth. Over recent decades, the Cadastre has included the third dimension to capture limitations (either above or below ground), including strata title and air rights, as well as underground lots, such as car parks.

However, the data are not held in a form that is directly amenable to computer modelling. Nor is the fundamental cadastre geo-referenced.

Part of the 3D Qld project is to evaluate the benefits of moving to a digital cadastre, where the boundary pegs are geo-referenced to allow accurate registration within imagery and digital models aligned with the Geocentric Datum of Australia (GDA 2020).

B.4 The Department of Natural Resources and Mines (DNRM)

The Director of Spatial Policy DNRM is responsible for surveying standards, with the Registrar of Titles responsible for maintaining the register of all registered interests in land and setting the standards for the preparation of plans.

B.5 Role of the cadastral surveyor

Fundamental to the Torrens system has been the use of Registered Cadastral Surveyors to determine the position of boundaries in a way that has allowed future surveyors to re-instate the original boundaries with a high degree of certainty (relative to the technology at the time).

There are very specific guidelines established at law that set out the steps a surveyor must follow to confirm location, and the hierarchy of evidence for re-instating boundaries.

Surveyors must understand the theory of measurement, configuration and calibration of equipment and the processes to be followed in establishing boundaries, as well as the relevant property and planning laws and other regulations that may impinge upon the creation of a new lot, and the re-instatement of an existing lot.

That is, cadastral surveying is not just about measurement and position finding, it is also about the law.

For all the following reasons, and many others, the role is critical in the process, no matter how accurate GNSS becomes, and regardless of any other technology changes that may take place.

B.6 Surveyors Board of Queensland

The high standards of the profession underpin the system and are overseen by the Surveyors Board which holds cadastral surveyors to account through disciplinary action and ultimately de-registration.

B.7 Chain of evidence

In order for a surveyor to ascertain a boundary, it is necessary for them to consider all prior surveys of the lot and surrounds; as these will refer to control points and monuments (such as pegs, pins, fences, roads and even old trees) as reference points for their measurements. Under surveying law and in practice, a chain of evidence goes from the original issue of title, with a hierarchy of evidence going from highest to lowest quality. At present, an undisturbed peg is regarded at the best evidence, with the buried pin as the next most certain.

With the advent of GNSS, geo-references may become the most reliable and repeatable evidence, once a new survey (or re-survey) has been done using this technique. However, for the reasons discussed below, the geo-reference cannot replace the peg.

B.8 Locating points in space

In regard to 'location', it is important to recognise the difference between navigation to a feature (which we all do), and locating points in space (which is what a surveyor does).

Most people are able to find a recognisable feature on the ground (driveway, door, gate, fence, peg, etc.) using GNSS, or other means (including a map and compass). It is a straightforward exercise given that the technology can get you close enough to see the feature you are looking for.

In the case of a boundary, there may be no feature at the vertex. The vertices must be located as 'points in space' and measurements taken and recorded as angles and distances (and as geo-references) to describe that location.

B.9 Positioning pegs and pins

Once the surveyor has determined the correct position, only then can a 'peg' be placed to represent the 'point in space', which thus becomes primary physical evidence of the corner of the boundary.

Once in place, the peg can be located easily enough (e.g. by using a map and compass or geo-references to navigate to it).

However, if the peg is moved or destroyed, the next surveyor must have the knowhow, combined with sufficient evidence about how the point was established, to be able to replace the peg in exactly the same spot as it was placed originally. The surveyor must give consideration to the tolerances accepted at the time of the prior survey and the associated inaccuracies in the original measurements as they were recorded, while balancing the competing property rights of adjacent owners. In this case, there is no 'feature' to locate. It is the surveyor's job to create the feature in the correct location.

B.10 Using Geo-references based on New Dynamic Datum

Over the last few years, State governments and private sector operators have installed Continuously Operating Reference Stations (CORS) across the nation. These, together with GNSS satellites and new receivers and algorithms enable precise point positioning over the whole country.

As well, the Federal Government, together with the States and international standards bodies, is putting in place a new Geocentric Dynamic Reference frame for both position and elevation that takes account of the many variables that influence accurate location on the surface of the earth (and under water). It is due to come into effect in 2020.

With these advancements, it is now possible for surveyors to use GNSS to provide repeatable measurements that are unique for each point in space (within a very small margin of error). There are extensive guides a surveyor must follow to ensure their equipment is configured, calibrated and functioning properly, is operated correctly, and to take account of many different environmental factors, including atmospheric and multi-path effects, with all these meticulously recorded so that any future surveyor can be certain (within 95% confidence level) of locating the same point in space (within the tolerances accepted at the time of the survey).

Once a point is surveyed based on latest equipment and procedures, the error or 'uncertainty' will be reduced compared to older methods, and the geo-reference in many instances may become the most reliable repeatable evidence in the chain, subject to the GNSS systems remaining 'up'.

Importantly, the use of geo-references will not only speed up identification of boundaries (thereby also reducing cost), they will also lessen the historic problem of 'shortages and excesses' (see below for details).

Currently most rural surveyors and those undertaking new development work all use GNSS equipment. Most working in urban areas do not.

Today, all sub-divisions of 10 lots or more must be geo-referenced. In time, all surveying will need to tie back to the Dynamic Geocentric Datum.

B.11 Maintaining the chain of physical evidence

There are several reasons why surveyors must maintain the chain of physical evidence (and not rely wholly on GNSS):

7. The potential loss of all satellite communications due to the Kessler Syndrome (138) (an avalanche of space debris resulting from cascading impacts within the growing cloud of 'space junk'). This remains a major unresolved threat that is only growing with time.

8. A 'Carrington Event', is another major threat that is statistically overdue (139). This is a solar storm capable of wiping out most electronics. They happen on the sun all the time, but are estimated to impact the earth only once every 150 years. The last such event to impact the earth happened in 1859. In 2012 there was a near miss.

9. As importantly, people can locate the approximate position of a peg using GNSS, and then be certain of its actual position by seeing it in the ground. There is no assurance that any untrained person can use GNSS to correctly locate a point is space in a repeatable manner. This is especially the case as the continent is moving north approximately 7.5 cm pa, resulting in a dynamic GNSS reference for each point on the ground.

B.12 Determining the accuracy of the cadastre & other boundaries in space

Many people (even non-surveying professionals in the property and construction sectors) do not understand that the Cadastre is mapped to a horizontal plane. This means that the measurements that define the Cadastre cannot simply be translated to the ground over longer distances due to the curvature of the earth. Also, on-ground measurements in hilly terrain are not clear cut, as the 'edges' of the Cadastre don't drop down at right angles to the plane, they converge to the centre of the earth (i.e. the length of a boundary is shorter at sea level than it is 100m above sea level).

As well, there are many other factors that impact the accuracy of boundary vertices:

- Horizontal Datum (further complicated by the fact that Australia is moving north at the rate of about 7.5 cm p.a.)
- Vertical Datum (with additional complications caused by gravity making exact measurement less precise than horizontal position)
- Control Points, including Monuments and Marks
- Vertices of Boundaries that make up the Cadastre area by area
- Variable scale factors used to convert map grid coordinates to ground coordinates and measurements
- Representation in the Digital Cadastral Data Base (DCDB)

The cadastral surveyor must understand and take into account the many factors that can impact accuracy when making and recording the relevant measurements (within specified levels of uncertainty), and understand how they inter-relate, to determine the margin of error for each measurement.

If we are to avoid disputes, we need an independent third party (the surveyor) to make these measurements in a way that provides a high degree of confidence that any future qualified person can re-locate the exact same spots, whether any particular pegs or pins or other features are moved or destroyed.

B.13 Surveyor's plans

B.13.1 Copyright

When a surveyor lodges a survey plan, they retain the copyright. Essentially, it is a unique work, based upon the evidence used to create it.

B.13.2 Basis for land ownership and related interests

The original survey plans are lodged with the Local Council for approval and the State for registration and subsequent issue of title. In the case of Queensland, they are held by the Department of Natural Resources and Mines.

These plans, together with title registration, provide the basis for asserting all land ownership and related rights, responsibilities and restrictions.

B.13.3 Old surveys

Due to factors such as the lack of precise positioning equipment, loss of original evidence (survey marks etc.) and the contemporary practices and directions of the day, older surveys may not be accurate in the contemporary sense. In some cases, they could vary by tens of metres, or more. These surveys are not guaranteed suitable for modern use. To be warranted by a surveyor, the survey would usually have to be re-done. This problem is greater in rural areas where there has been less need to update boundaries.

B.14 Guarantee of title and boundaries

The State guarantees title, but does not guarantee the dimensions (or geo-reference/coordinates) of boundaries.

Only the surveyor in their capacity as a proxy for the state (and ultimately the courts) guarantees the location of boundaries; first to the client for whom the survey is prepared, and secondly to the community as being fit for use in modern real estate transactions, etc. The guarantee comes from a combination of: (a) the regulatory system which governs the competence of surveyors and the conduct of surveys; and (b) the government administration of the land boundary system, including setting of standards, examination of survey plans; and provision of expert advice.

Whilst the location of boundaries is generally accepted as defined by the professional opinion of a suitably experienced and registered land surveyor on a day to day basis, ultimately boundaries are a matter of proof before the courts, with surveyors providing the expert evidence.

Ultimately, any client has recourse to the surveyor's professional indemnity insurance for any faulty survey.

While the accuracy of equipment is improving and becoming simpler to use, no equipment manufacturer, nor any software provider, guarantees the measurements taken; nor are they likely to. Any instrument requires configuration and calibration by a qualified person to reduce both error and deliberate falsification, taking into account the environmental and system conditions at the time and place of measurement.

This means that, regardless of the precision of the equipment, it will be important to retain the federated system of certification by Registered Surveyors to 'guarantee' boundaries to maintain public confidence.

When giving advice with respect to overlay of cadastral data with imagery or 3D models, good surveying practice requires a thorough examination of the cadastral data by the surveyor so as to determine how it was derived, and its reliability with respect to existing ground conditions. The benefit for society in having integrated accurate imagery, models and geo-referenced pegs will be in the reduced time and cost to conduct such a check/identification survey.

B.15 Title insurance

The alternative to the current system is every owner needing to have title insurance (as in most States in the US, and elsewhere), increasing cost and putting much more pressure on an already stretched legal system to resolve disputes. This would not seem good public policy, and is unlikely to be the approach adopted in Australia given public confidence in the current system – especially if costs and time can be reduced as a result of the DNRM and 3D Qld projects.

B.16 Boundary disputes and surveyor's professional indemnity

Despite its shortcomings, there are very few disputes over the location of property boundaries. This is testament to the soundness of the system overall. In all cases where there is a dispute that cannot be resolved between the parties, surveyors on opposing sides present their evidence to court, and the courts decide. If the decision is a matter of interpretation, the losing surveyor may not be liable if the interpretation was reasonable in accordance with contemporary practice.

Giving advice that is contrary to facts or practices that the surveyor should have known, and or making mathematical errors and not having reasonable processes in place to eliminate them etc. would probably be causes for the surveyor to be found incompetent by the Surveyor's Board; which would in most cases bring their Professional Indemnity into play.

There are several possible reasons for disputes including:

B.16.1 Encroachments

These arise where one property owner (mistakenly or otherwise) constructs a fence or erects improvements across a boundary or otherwise on land for which they do not have title. This is not a surveying issue per se and as such, the State has no interest in resolving it. In these cases, the party deprived of their land has to decide if the encroachment is worth the cost of a re-survey, and or potentially a claim in the courts, to have it resolved on the facts.

B.16.2 Overlapping Title

This may arise as a result of a faulty survey that incorrectly describes the extent of a parcel of land where the description is in direct conflict with another title. It is remedied by a re-survey, with the surveyor at fault liable for losses arising from the faulty survey.

B.16.3 Confused Boundary Areas

This is a surveying issue. It becomes a problem if and when the precise boundary is determined to be different to the existing fence line or occupation and usually effects a number of land parcels. It may come down to interpretation between surveyors regarding the surviving evidence from old survey plans. Should surveyors not be able to agree on the interpretation of the available evidence, it must ultimately be resolved by the courts. If the resolution benefits one party, it negatively impacts the other. The negative impact may include, not only loss of land (real or perceived), but also the cost to move improvements (or the cost to buy the 'misappropriated' land in some cases), as well as legal costs. The positive impact for the winner is more land (real or perceived) or compensation. At the very least, it may require the expense of moving a fence. At best, the status quo obtains and the parties agree to formalise the existing fence as the boundary.

As this is a matter between the two parties, there is no net economic benefit (unless you count the extra work to move improvements!) in having the boundary clarified. Without net economic benefit, there is no rationale for the State to bring forward a re-survey at its expense just to fix the Cadastre in these circumstances.

B.16.4 Shortages are identified following a re-survey

This is similar to B.16.2 above, but can be more difficult to resolve, as it can affect a number of parties who stand to have their official landholding reduced. The next section discusses the problem in detail.

B.17 Shortages and excesses

Shortages are one of the most difficult issues relating to the Cadastre. Excesses, whilst they tend to be more common are generally not so much of a problem.

Shortages and Excesses are entirely due to the system employed by the State in creating lots in the first instance, as well as (to some extent) to the destruction of evidence by human activity over the years. This is not a 'system failure' as such. It simply reflects the reality of the technical capabilities and practices and standards in force at the time of original survey.

The problem is generally discovered when a surveyor or surveyors undertake surveys based on evidence derived from one or more contiguous original survey plans.

When the dimensions of the earlier original surveys are plotted onto a single reference frame (following a re-survey, or a DCDB compilation); the boundaries as plotted either overlap ('shortage', as distinct from 'Overlapping Title'), or do not meet ('excess'), with the boundaries of adjacent land parcels.

For example, with respect to excess, a surveyor in say the 1800's adding a new lot may note on the plan that the frontage is 100 links, but actually place the boundary pegs 101 links apart (as measured on the ground), just to be sure – so no one can complain that they got less than they bargained for. If this is done over, say, 10 lots; the result is a run of properties that measure more like 1010 links on the ground, rather than 1000 links as per the sum of the titles.

When an accurate re-survey is done, everyone gets a bit more than they thought they had. No problem there.

For clarification, an excess will almost never manifest itself (as some may visualise) as being a gap between the fences of adjoining properties, but more likely with land owners occupying more land than is shown on their title documents. The normal rule for dealing with excess is that where the excess is relatively small and would have minimal implications with respect to improvements erected on individual parcels, it is apportioned between the land parcels in the affected area. Where the amount of excess is significant it is usually allocated on the basis of which properties are actually occupying the additional land based on existing fence lines, etc.

Shortages are usually dealt with in the same fashion as excess. In that way, the person who has been happy with the location of their fence for years would generally need to accept the re-definition of the boundary dimensions to align with it.

As the State does not guarantee boundary dimensions or location, and on the basis that all surveys have been done in accordance with the current practices and directions of the time; no property owner usually has recourse to any other party for any such variations in dimension or location.

The problem will persist while each new survey is added to existing surveys, rather than referenced to the National Datum. With surveys now proposed to be geo-referenced, it is unlikely that this problem will re-occur in the future.

B.18 Digital Cadastral Data Base (DCDB) combined with maps and imagery as a tool for decision-making

B.18.1 State DCDB

The official DCDB is created and maintained by the DNRM and currently exists only in 2D. It represents the compilation of all lots into a single seamless 'fabric', without gaps or overlaps. That is, shortages and excesses are 'massaged out'. This has been done by a variety of means over the years including using imagery, surveying coordinates on selected fencing etc. Once one area is done, it may be years before it is revisited. It remains imprecise in many areas (particularly rural areas) because the inaccuracies from many of the old surveys have only been redistributed rather than re-surveyed. In more recent times more sophisticated methods have been employed. However, the basic problem of assumptions with respect to dealing with excess and shortage etc. still hasn't been totally eliminated.

B.18.2 Multiple other DCDB's

Due to its inherent inaccuracies, the representation of the current DCDB when overlaid on maps or imagery usually cannot be relied on for decision-making at law.

Worse, use of the DCDB in its current form can be misleading causing unnecessary concerns for the affected parties, as well as delays and direct out of pocket costs (e.g. when settlements are made with the wrong people because a powerline tower is shown within a map or imagery as being on a parcel of land that it is not actually on).

To circumvent this problem, many private and government organisations have constructed their own Cadastral reference maps covering their own areas of interest.

As a result, there is currently no 'single point of truth' that everyone relies on. This is despite a requirement of the Survey and Mapping Infrastructure Act that public authorities use coordinates approved by the chief executive.

One of the objectives of the DNRM project to identify efficient processes to create an accurate representation of all lots in 3D that is spatially referenced to the state-wide coordinate framework.

B.18.3 Decision-making using representations of DCDB

Stakeholders have suggested that critical to improvement in the use of the DCDB for decision-making is the need to clearly identify the accuracy of each boundary within the current DCDB.

With the accuracy made clear, any user can determine if the accuracy of a particular boundary is relevant to their decision-making.

It is then up to the parties to determine whether or not they require an identification survey, or even a full re-survey, before proceeding.

While absolute accuracy of the Cadastre is vital for positioning pegs on the ground (within the limits of technology and standard practice); stakeholders have stressed that accuracy for decision-making depends on its materiality, which depends upon the scale of the decision. What is material for mines and agricultural boundaries may be different for building in cities - but not always.

For example, the Master Builders are arguing that if improvements are to be sited well inside the boundary, the actual position of the boundary is irrelevant. They claim that the boundary is critical only if the improvements are to be sited on or within a few centimetres of the limit of where they are allowed.

Materiality also comes into play when financing and insuring property. If all improvements are seen to be well inside the fence lines, the accuracy of the boundary is immaterial to any decision regarding those improvements. It will be material only if there is doubt about the boundary and it is possible that the insured improvements are not inside it.

The degree of accuracy that is material to a prospective purchaser will depend upon their own assessment. If the model shows the boundary a few cm off the fence line they may not worry. A few metres could be a problem!

Recently, the State has made the Digital Cadastral Data Base (DCDB) available as a layer within 2D imagery, as part of the Queensland Globe. This is a good start. However, the degree of accuracy is not specified for each boundary in a way that makes it plain. A casual user cannot determine if the boundary within a cm or 10cm or a metre of tis correct position. Nor is there any way to tell if the uncertainty due to the placement of the boundary in the image, or because the boundary itself is uncertain (being based on an old survey).

As well, neither the imagery nor the DCDB are guaranteed.

This results in, either: a) an unnecessary re-survey (because the boundary was incorrectly shown and there is no actual encroachment, or b) one party taking the risk that it is OK (even though the improvements are shown as encroaching) simply because it appears that the fences have been in place for a long time without dispute. Neither situation is ideal.

The ideal is to have the inaccuracy in each boundary clearly marked so stakeholders can make an informed decision to undertake a re-survey or not. Some stakeholders have suggested that this could be done via colour coding.

B.19 The Queensland Globe

The Queensland Globe has demonstrated how much demand there is for spatial data, while also proving to be a very useful tool for discovering a wide (and expanding) range of spatial data sets owned by government.

The difficulty is that the Globe has limited usefulness for decision-making, as: "the Department of Natural Resources and Mines (DNRM), Queensland, makes no representations about the content and suitability of DNRM materials presented online for any purpose. Specifically, DNRM does not warrant, guarantee or make any representations regarding the correctness, accuracy, reliability, currency, or any other aspect regarding characteristics or use of the information presented in DNRM materials.

The user must accept sole responsibility and risk associated with the use and results of DNRM materials, irrespective of the purpose to which such use or results are applied. Users should confirm information from another site if it is of sufficient importance for them to do so. In no event shall DNRM be liable for any special, indirect or consequential damages or any damages whatsoever resulting from loss of use, data or profits, whether in an action of contract, negligence or tort, rising out of or in connection with the use or performance of DNRM materials".

As a result, third parties who need to rely on the combined DCDB and imagery are acquiring their own imagery, including Lidar scans to achieve high level accuracy (within 15mm in some cases, e.g. Ergon Energy).

B.20 Other Rights Responsibilities and Restrictions

In addition, other property interests are recorded on other registers, or not at all. These include mining tenements, native title, water rights and environmental protections, as well as underground services, and many other Rights, Responsibilities and Restrictions (RRR) enacted by a wide range of Local, State and Federal jurisdictions, or established under contract (e.g. leases).

Each State is now working to achieve an integrated view of all the RRR that relate to any property. This is being done without consolidating the various registers, by providing a single view of all the data.

WA is well advanced utilising a volunteered data approach (140) to build a report of both private and public interests (141) within its Landgate portal. The WA Department of Commerce is currently contemplating the issue of a directive for the disclosure of property interests at the listing stage of selling a property. This will not mandate the use of the Property Interest Report (142) but requires selling agents to disclose interests impacting on property in Western Australia. Utilising the Property Interest Report would be seen as a best practice and the easiest way to comply with this directive.

While such initiatives will provide a 'single point of truth' concerning the RRR applicable to any property, the actual location and 3D extent of the interests and the property remain at issue.

A longer term objective of the DNRM and 3D Qld is to integrate all other RRR within the federated system.

MINERAL, COAL, OIL AND GAS

C

Following the establishment of the project, the Consultant was tasked with investigating the impact of the mineral, coal, oil and gas industries on 3D Qld.

There is a separate register for these interests in Queensland; which by their nature include 3D features such as bores, shafts and tunnels that can sometimes overlap in layers of interests. They also intersect water rights and impact agricultural and environmental interests, as well as roads and even property development in some areas.

Stakeholders report that historical mine data are not good; with integration made more complicated as a result of the use of different datums by different entities, as well as the lack of any standard for data capture and representation; making it impossible to obtain a 'single point of truth'. This is compounded by poor calibration of drilling rigs in some cases, as well as the concern with keeping certain key data confidential for competitive purposes.

Lack of knowledge of the location of underground mines and bores has led to the collapse of roads and sometimes even housing estates (143).

It can also result in costly disputes between parties with different interests that are in conflict where the extent of each party's rights is not clear.

A longer term objective of the DNRM and 3D Qld is to integrate the mining cadastre within the federated system

The following sections discuss the main issues raised by stakeholders, together with their suggested countermeasures.

C.1 Mine plans

Mine Plans are required to comply with legislation e.g. Coal mining Safety and Health Act 1999: Sec 67.1.

C.1.1 Purpose

- To show where mining has taken place and the hazards that are associated with it
- In the case of underground mines, the mine plan displays mining that could affect physical structures that may be built on the surface above the mine
- To indicate possible impacts on water bodies and agriculture
- To show the relationship of the mine workings to cadastral boundaries

C.1.2 Main Features of Plan

- All surface features above and adjacent to a mine: Overland Conveyor, Haul Roads, Mine Office, etc.
- All underground workings: development, longwalls, portals

- Contours of the seam being mined and the over lying topography: for clarity these are not shown on the example
- Lease and other cadastral boundaries: ML 1831
- All boreholes: exploration, in seam gas, engineering
- Coordinate grid and its relationship to GDA
- Geological features found and inferred from boreholes: e.g. basalt intrusion and fault lines
- Watercourses, dams and any potential for inflows into the mine
- Information required to evaluate the effect of the mine on the safety of adjoining mines.

In past, the Statutory Plan was simply an extract of the mine's 2D operating plans. Today, more and more the 'operating plans' are in the form of 3D Models, which now have to be 'dumbed down' into 2D .pdf for submission.

C.2 Industry concerns

C.2.1 General

1. Copies of plans for coal, metalliferous and in seam coal gas holes are stored in three different government locations.
2. There is no geographical search engine to find coal and metalliferous plans. You need to have specific local knowledge of what you are looking for prior to searching.
3. There is no state wide numbering system for mine plans.
4. The plans are filed in different formats e.g. original film plans, AutoCad, .pdf, etc.
5. Multiple and various datums across mining operations and throughout the entire state.
6. Unsure of connection to state control network.
7. 2 codes of practice for mine plans, surveys and data.
8. Combination of data types, sources, transformations and accuracies.
9. Only hard copy/pdf plans available from DNRM…. if available at all.
10. Site buried services compiled and managed referencing AS5488 but no external access to data.
11. Limited historical information available from government records – even last 15 yrs.
12. While some mining companies had very rich accurate 3D Data for their current operations that could be of benefit to the community in the future, there was currently no legal requirement nor any process to make this available.

    It was noted that NSW had recently required adjustment of all survey plans to a common Datum, which was accomplished within 12 months.

C.2.2 Deep underground mines

1. Multiple plans representing multiple levels of the mining operation.
   (as a result, vertical information/differentiation lost).
2. Inability to accurately locate 3D position of any underground working level.
   (3D data is critical to any analysis or design of surface infrastructure).
3. Unknown proximity to surrounding strata, water bodies and future developments.

C.2.3 Coal seam gas

1. 3D position of collar (opening), both current and historical is often uncertain or unknown
2. Flightpath accuracy and location (of bore) is often uncertain or unknown.
3. The quality of the data is often unknown
4. How long the surface positions will be operational is often unknown

This state of affairs has led to scenarios involving 5 different mines, mined at 5 different times, by 5 different companies with 5 different sets of mine plans (that may or may not be available), using 5

different datums. Any new mine in the area must create a new plan incorporating all the old plans. Industry representatives suggested that (given the current situation), this could only be done with very great difficulty, without any assurance that it is accurate, or comprehensive.

C.3 Representations to Government

Concerns were raised by surveyors in 2013 (144) concerning the lack of knowledge about old mine sites.

SSSI also made a presentation to the: *Inquiry into the future and continued relevance of government land tenure across Queensland in 2013*

Recommendation 43 from this inquiry was: *The committee recommends that the Queensland Government integrates all tenure data sets and maps to address surface and subsurface tenure issues as a priority.*

This proposed recommendation means that all cadastral, mining lease, and mine workings plans would be on the same datum and would all have references to each other.

The industry believes that if this recommendation is enacted then it will go a long way to addressing some of the issues mentioned above.

It is suggested that 3D Qld could help to advance the cause.

C.4 Countermeasures proposed by industry (what would success look like)

It is recognised that the proposed countermeasures may have to run in parallel as part of a new federated system that incorporates a combination of traditional 2D Plans and 3D Models.

C.4.1 Short term

1. Create a system similar to the present numbering and filing system used for cadastral plans
2. Initially all mine plans to be submitted to one government authority as a .pdf and must be on GDA.
3. All mine plans electronically tagged and linked to cadastral plans.

This would allow any surveyor to search either geographically or via cadastral plan numbers to find all mining operations carried out in an area.

Benefit
Before approving construction of any work such as a residential subdivision, freeway or shopping centre, it would be a simple matter to electronically search and ascertain if there is any mining activity in the area.

C.4.2 Medium term

1. Mining plans to be submitted as a GIS file on the GDA datum. This is already carried out in NSW. This mine GIS data would be automatically imported into a state wide GIS database of all surface and underground services and be related to standard geo-referenced imagery.

Benefit

This would create a one stop shop for all future hazards to mining and engineering projects.

C.4.3 Longer term

1. 3D information supplied in true datum (GDA 2020) with metadata (attributes) attached.

Benefit

This would create a one stop shop for all future hazards to mining and engineering projects.

C.5 Crowd sourcing historical data

While it will not be possible to recover lost data in many cases, it may be possible to use the 3D Qld project to push for the capability to 'crowd-source' historical data using standard accurate geo-referenced imagery (e.g. Qld Globe).

Under this scenario, anyone could mark in where they have discovered shafts and bores, and areas where they believe Coal Seam Gas (CSG) Extraction and Mining has taken place. This could be enhanced by professional surveyors and those in the mining sector adding their own knowledge, with meta-data indicating the source and quality of the information.

Benefit

This would enable the community to capture the community's knowledge to recover as much historical information as possible.

C.6 Data security

Operational models are useful as they show the current extent of all works.

Any proposal requiring the sharing of operational 3D Data within a federated system would need to ensure that systems were in place to ensure security to protect commercial and private interests. The point was made that one mining company has installed locks to its foyer, on each floor, each door to each office and even on drawers in an effort to maintain security of its files, with similar protections on its electronic data!

C.7 Cost to implement

The industry recognises that there are costs involved in improving the system and has suggested:

When mine plans are deposited each year with a government authority, the mining company would be charged a fee for this service.

Any surveyor electronically searching for information about mine plans would also be charged a fee to be passed onto their client.

It was considered that this proposal should be able to generate enough revenue to make it cost neutral for the government department that administers statutory mine plans.

C.8 Summary of potential benefits of 3D Qld for miners

C.8.1 Current mines and CSG

Stakeholders considered that 3D Qld appeared to offer little immediate benefit for current mines, as every operator had good understanding of the location of their own boundaries, works and assets. They also had access to the surveys for current adjacent mines, on request. As such, they could not see the industry volunteering any 3D data on current sites.

C.8.2 Future

1. Mining Shafts, Tunnels and Bores

   Stakeholders agreed that there is considerable benefit for the sector if it is possible to replace any missing historical data, and in having the legal framework and processes to capture and make available current and future 3D data on mines for future reference.

2. Cadastre

   Having the Cadastre related to accurate geo-referenced imagery could be of benefit for future exploration, or mine or bore extension; where it is necessary to determine which properties would be impacted.

C.9 Potential benefits for whole community in speeding up accuracy of the cadastre through data sharing

The Government recognises that many different organisations (miners among them) now construct their own data sets to model specific locations (including assets and boundaries), possibly with much greater fidelity than exists in the official Digital Cadastral Data Base (DCDB) or the Mining Data Base for those locations.

Stakeholders agreed that there could be benefits (in reduced time, cost and errors) for the whole community in sharing third party data within a federated system that enabled all users to accurately locate boundaries and underground assets - like Dial Before You Dig, but within the context of spatially accurate authorised imagery/models.

This would provide the ability to merge and use information from all sectors for the purposes of

- Public Safety;
- Planning;
- Administration; and
- Risk identification and reduction, so new road works and development can be carried out with complete assurance in regard to the location and 'flight path' of all underground works.

The location of actual shafts, tunnels and bores was seen as far more critical than 'boundaries', though having accurate mine boundaries (where known) marked on common standard imagery linked to a common datum was seen as some benefit.

C.10 Need for government action

The industry representatives considered that to achieve widespread compliance by the mining sector with 3D Qld (as suggested in the countermeasures), it would be necessary for the government to legislate its requirements.

As an example of the need for legislation to encourage data sharing, there is pending legislation with the Federal Government that will require Telecommunication infrastructure providers to give details of infrastructure rollout to any new developments (145).

At this stage, the proposal is based on 2D but the same principle could apply to 3D.

C.11 Cadastre in 21st century

Stakeholders also discussed the nature of the Cadastre in the 21st Century. It was recognised that more and more entities can now economically capture the full 3D landform and structures (using Lidar and photogrammetry), including 3D models of underground shafts, tunnels and bores.

The question was asked, if it is useful to capture full 3D underground models: should the surface Cadastre remain restricted to the simple 2D/3D boundary vertices, or should it be expanded to include a model of the 3D landform in which it sits, and even include a 3D model of all underground assets?

There is general agreement that the more comprehensive the data the better.

The questions remain: where and how would the data be held (as a federated data set under the control of each asset owner, or as a central data set, or a combination)? How would it be accessed, with what controls to protect commercial interests, privacy and security?

TASKFORCE AND CONSULTING TEAM

D

D.1 Taskforce members

- **Peter Sippel (Chair)**, Consulting Surveyor, Chairman of Qld Surveyor's Board
- **Steve Jacoby**, Executive Director - Land & Spatial Information - Queensland Department of Natural Resources & Mines. Chair of the Queensland Spatial Information Council, Queensland's representative on ANZLIC - the Spatial Information Council, as well as a member of the CRC for Spatial Information board, and a member of 2026 Spatial Industry Transformation and Growth Agenda and 3D QLD Taskforce
- **Elizabeth Dann**, Registrar of Titles, Queensland Department of Natural Resources & Mines
- **Russell Priebbenow**, Director of Surveys, Queensland Department of Natural Resources & Mines. Queensland's representative on the Intergovernmental Committee for Surveying and Mapping – ICSM and a member of the Surveyors Board of Queensland
- **Lee Hellen**, Managing Director, Land Solution Australia
- **Callum McNaughton**, Director McNaughton Mining Services
- **Richard Statham**, Senior Surveyor - Advising Registrar of Titles
- **Paul Reid**, Seconded Representative of Land Survey Commission, Surveying Spatial Sciences Institute
- **Alasdair Begley**, Representative Queensland Spatial & Surveying Association
- **Chris Swane**, Land Survey Commission, Surveying Spatial Sciences Institute

D.2 Consulting team

- **Alan Smart**, principal ACIL Allen Consulting expert in the valuation of spatial data infrastructure and services, and Lead Consultant for this project.
- **Michael Haines**, Lead Author of this Report and CEO of VANZI working with stakeholders to articulate a vision for an integrated 3D Digital Built Environment including all RRR, for use in decision making throughout the property cycle. Michael assembled the Consulting Team.
- **George Havakis,** Managing Director of GISSA International specialising in Information Management and Technology where he combines project management experience with specific knowledge of the intricacies and dependencies of GIS projects
- **Haydn Read**, NZ based consultant who has been leading the use of 3D data across the NZ government and local councils by identifying the key value propositions.
- **Peter Murphy**, Director Brazzier Motti, which provides consulting services in survey, project management, mapping and GIS.

- **Prof, Abbas Rajabifard**, Director of the Centre for Spatial Data Infrastructures and Land Administration at the Department of Infrastructure Engineering, the University of Melbourne. Prof. Rajabifard is a global authority on the integration of 3D cadastral data with GIS and BIM models.
- **Alan Hobson**, consultant with expertise in Building Information Modelling and its application to Surveying and Deputy Chair for the Spatial Information and Cartography Commission of the Surveying and Spatial Sciences Institute (SSSI)
- **Jim Plume**, member of the Infrastructure Committee for buildingSMART International, contributing to the development of international standards for information modelling of the built environment, with a specific focus on Precinct Information Modelling.

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WE ADVISE COMPANIES, INSTITUTIONS AND GOVERNMENTS ON ECONOMICS, POLICY AND CORPORATE PUBLIC AFFAIRS MANAGEMENT.

WE PROVIDE SENIOR ADVISORY SERVICES THAT BRING UNPARALLELED STRATEGIC THINKING AND REAL WORLD EXPERIENCE TO BEAR ON PROBLEM SOLVING AND STRATEGY FORMULATION.