Australia's National
Science Agency

Framework for Spatially Enabled Digital Twins:

Summary

February 2021

Queensland Government

ADVANCE QUEENSLAND

Foreword

This Framework has been commissioned by the Queensland Government to help guide the development and operation of spatially enabled digital twins in Queensland. The Framework is intended to support the implementation of the *Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia* released by the Australian and New Zealand Land Information Council (ANZLIC) in December 2019.

It is expected that this Framework will be revised and updated through ongoing collaboration between government, industry, research and community stakeholders in Queensland and across Australia.

This Framework is available for other jurisdictions to use should they wish to do so.

Further information about the issues covered in the Framework are available in an accompanying information paper, *Framework for Spatially Enabled Digital Twins: Information Paper*, Data61, February 2021.

CITATION

Griffith C, Truelove M
Framework for Spatially Enabled Digital Twins: Executive Summary, February 2021.
CSIRO Data61, Australia.

ACKNOWLEDGEMENTS

This study was funded by the Queensland Government's Advance Queensland Big Data Challenge for the Department of Resources.

The authors would like to express gratitude to the experts from industry, government, research, and community organisations who shared their expertise and guided the development of the Framework.

Contents

Framework for Spatially Enabled Digital Twins

Framework Purpose

This is a Framework to guide the development and operation of spatially enabled digital twins that align with the *Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia* released by ANZLIC in December 2019.

The Framework is designed to enable an open and collaborative ecosystem of digital twin platforms, technologies, and services that can interoperate and support each other. It will allow the underlying data services to be discovered, accessed, and used as openly and extensively as possible across multiple digital twin platforms, while sharing private and sensitive data only with authorised users in a secure manner.

The Framework promotes coordinated action across governments, industry, the research sector and the community, to realise the best outcomes for a digital twin ecosystem within Australia.

Context

The concept of 'digital twins', being an advanced digital representation that can model and optimise the management of a real-world object or system, has emerged over the last two decades. Significant public good and other benefits can be realised through connecting digital twin initiatives so they can share data and interoperate with each other. This has the potential to significantly improve urban and environmental planning and operations, through digitally-connected and efficient use of resources.

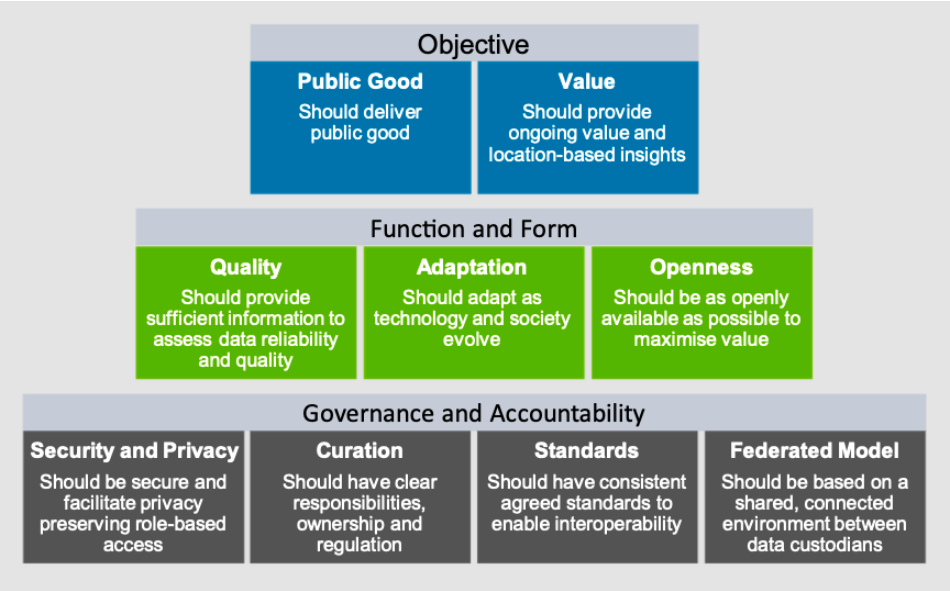

Diagram 1: The nine principles from The Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia

There is, however, a considerable journey required to realise a vision of interconnected digital twins sharing data and capabilities. A digital twin maturity model has been adopted to help define where digital twin systems are on their development path. The ability to locate their data in the real-world and visualise it in three dimensions (3D) and over time (4D) are foundation stages of this maturity model which can realise immediate benefits.

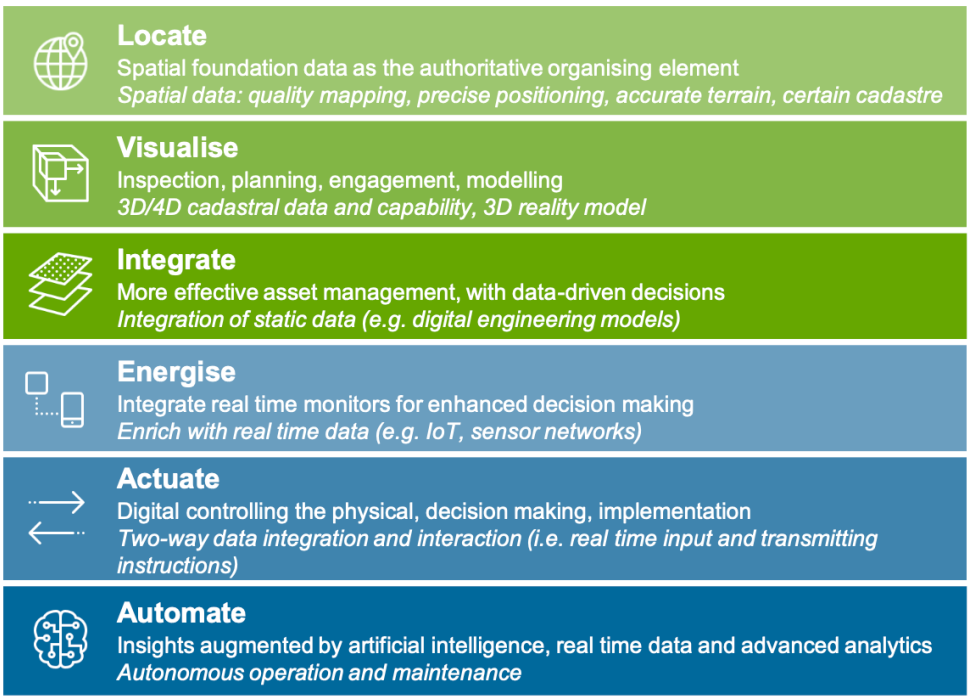

Diagram 2: Spatially enabled digital twin maturity model illustrating the evolution in complexity, connectivity and capability. Integration of dynamic, real time data moves digital twins beyond static data platforms. Maturity levels are not necessarily linear; there are benefits in data upgrades and analytics at any stage.

Currently, most digital twins are islands of varying capability, not easily discovered, not connected, or able to securely share their underlying data easily with each other. Additionally, most of these digital twins do not accurately reflect their real-world location, so a digital twin model of an individual building cannot be easily integrated into a city-wide digital twin.

Spatially enabling digital twins requires open access to authoritative national, standardised, spatial data, known as foundation spatial data. A critical enabling foundation dataset for the digital twin ecosystem in Australia is a true digital cadastral environment in which property boundaries are dynamic, automatically recalculating and improving as new boundaries are registered and as land survey and positioning technologies continue to improve. This supports an enhanced land development process through fully immersive digital twins that are precisely spatially positioned and experienced at a grounded, human scale, appropriate for their purpose.

The development of a national ecosystem of digital twins can also be supported by automating the open release and sharing of government data. While most Australian governments have released and shared many datasets, these activities have generally been ad-hoc and slow despite examples of good practice in several sectors.

Other challenges to be addressed include:

- Ensuring trust in the use of private and confidential data with processes and protocols to ensure it is protected and only shared with authorised users
- Data custodians adopting the use of common, and preferably open standards, protocols and quality controls for the ongoing maintenance of fit-for-purpose data
- Greater awareness, understanding and engagement about the role of spatially enabled digital twins outside of the spatial community.
- Sustainable resourcing to enable coordination, shared infrastructure, and data services for digital twins as well as for developing capability in less mature and resourced organisations.

Information and Technology Components of the Framework

An ecosystem of spatially enabled digital twins requires a federated data sharing model, where data and shared resources held by different data custodians can be easily discovered and accessed. This must be supported by the use of common standards and processes, and methods to protect private and sensitive information. Under this model, data remains under the control of data custodians as the 'authoritative source of truth' with a minimum amount of persistent data stored on shared platforms or with an intermediary.

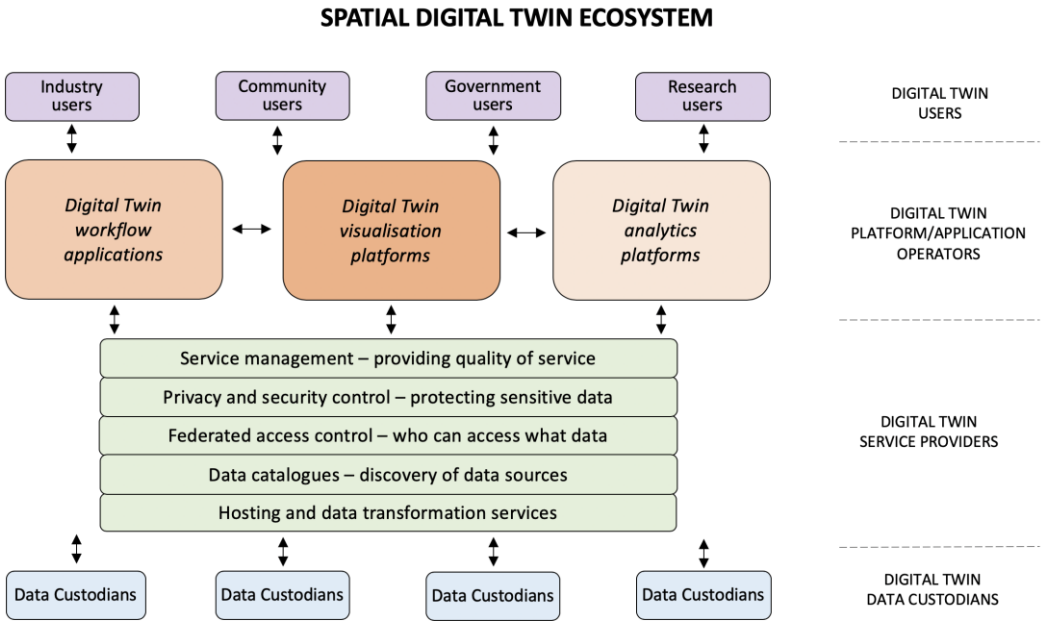

Diagram 3: Spatial Digital Twin Ecosystem
This shows the functional architecture of digital twin ecosystem from Data Custodians (blue), Service Providers (green) both external and internal to organisations that provide enabling services, Digital Twin Platform/Application operators (brown) of Visualisation and/or Analytics Platforms and/or Workflow Applications, and Digital Twin Users (purple).

The key information and technology components of this digital twin framework include:

- *Data Catalogues – the discovery of data sources*
  Data catalogues that provide a directory to available data sources are critical to enable the easy discovery of data, describe access conditions, data formats, and quality.
- *Data Standards and Quality Control*
  The adoption of common and preferably open standards along with defined levels of quality to support relevant applications is necessary to make data easy to integrate and use appropriately.
- *Federated Access Control*
  Federated Access Control that incorporates role and group based authentication enables users of one organisation to access data or services of another organisation seamlessly and securely without the need for additional centralised or duplicated administration.
- *Privacy and Security Control*
  Digital twin operators need to identify and protect private and sensitive data and ensure it is shared securely only with authorised users. This also includes the adoption of tools and services to assess disclosure risks and appropriate mitigation actions, especially with the integration of different datasets.
- *Hosting and data transformation services*
  Hosting and data transformation services may be required, especially for less capable organisations, to enable data to be made available in appropriate formats and quality for use in digital twins. This may

involve transforming legacy spatial and statistical data into different formats and made available as APIs.

- *Service management*
  Service management functions that monitor, manage and audit access to data services and resources to ensure quality of service, tracking of use for stakeholders and reporting on performance, are also needed.
- *Digital twin platforms/applications*
  Digital twin platforms/applications ingest and process data to provide services to users such as visualisation, analytics services and/or workflow applications (supporting decisions and control systems). These functions can be done by either specialist services or integrated into a single platform.

Social Components of the Framework

The social components of an ecosystem of spatially enabled digital twins also require action to address institutional and cultural barriers and enablers. The key social components include:

- *Commons: shared language, concepts and standards*
  A critical enabler for the digital twin ecosystem is the adoption of a shared language to describe and understand what digital twins are, how they operate and what impact they can have. This needs to be accompanied by a shared understanding and support for common processes, specifications and standards.
- *Align and complement relevant policies and initiatives*
  The development of the digital twin ecosystem should engage with other relevant policies and initiatives, especially in built and natural environment sectors, to demonstrate and deliver benefits to a broader set of stakeholders.
- *Data sharing arrangements and licences*
  The digital twin ecosystem requires more consistent data sharing arrangements, including agreements and licences, that make it easier to access and use data. There is also an important role in promoting an efficient and fair marketplace for the exchange of commercially licensed data relevant to digital twins.
- *Privacy and access arrangements*
  Spatially enabled digital twins pose important privacy issues that need to be addressed as they can represent physical objects in the real world, potentially at a level of detail beyond existing services.
- *Data custodianship and curation*
  The role of data custodianship needs support for investment in curating data, making it available with appropriate protections, and providing transparency about the use and value of data in digital twins.
- *Governance models*
  Federated digital twins require governance models that engage relevant data custodians to help create standards-based data services of an appropriate quality and reliability to meet the needs of users. Governance of digital twins also needs to help promote collaboration, adoption of common standards and sharing of resources and capability across the national ecosystem.
- *Stakeholder and community engagement*
  There is also a need to engage with a broader set of stakeholders and the community about the development and operation off digital twins, communicating the benefits and addressing risks and issues of concern.

Change and Implementation

The implementation of the *Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia's* will be a many-tiered journey, requiring a major transformation in how data is released, shared and used safely to create value through an ecosystem of digital twins.

The best approach for the development of both individual and associated ecosystem of digital twins is through a staged and iterative development process. This will deliver tangible short-to-medium term benefits by addressing priority needs and problems such as building assurance or emergency management while remaining aligned to the longer-term vision.

Approaches for implementation could include:

1 Leadership and governance

Governance groups could be established within different government jurisdictions as well as industry sectors, to provide: leadership and coordinate digital twin investments; to identify, release and maintain the supply of high-value quality-assured data; to promote digital twin standards and common processes; to protect private and sensitive data; and to communicate benefits to stakeholders.

At a state/territory level, digital twin governance arrangements could be established to coordinate collaboration within and between government jurisdictions, especially with local government.	At a national level, ANZLIC could assist guide the enhancement of foundation spatial datasets to spatially enabled digital twins, as well as promote collaboration between jurisdictions to develop relevant standards, common practices and shared infrastructure. Leadership from a range of cross-jurisdictional government agencies and ministerial groups responsible for data and digital initiatives will be important to progress a digital twin ecosystem in Australia.
Additionally, leadership from industry peak bodies and the research sector will also be important, as a collaborative approach across governments, industry, the research sector and the community will help realise the full benefits and best possible outcomes of a digital twin ecosystem in Australia.	

2 Digital twins Commons and standards

The development of an ecosystem of digital twins requires the promotion of common concepts, standards and processes with stakeholders, supported by formal governance arrangements and communities of practice.

At a state/territory level, existing processes could be expanded to identify and promote the open release and sharing of priority data, as well as promote the adoption of data standards and standard data sharing agreements, to support the development of digital twins.	At a national level, ANZLIC and ICSM could assist develop and implement relevant standards for spatially enabled digital twins particular relating to foundation spatial data. At the same time, industry peak bodies, standards entities, cross-jurisdictional government agencies and ministerial groups can play a key role in promoting wider cross-sectoral standards and common practices relating to data release and sharing

3 Communities of Practice

The promotion of best practice, knowledge sharing and collaboration related to digital twins could be supported through Community of Practice initiatives. These could leverage grass-roots interest and existing peer-to-peer activities in knowledge sharing, providing templates/guidance documents and related resources. These Communities of Practice could support both early adopters of spatially enabled digital twins and the needs of less capable organisations over time.

At a state/territory level, digital twin communities of practice could be established and resourced involving staff from relevant agencies, local governments, industry and research/education community.	At the national level, the current collaboration between state government digital twin programs could be leveraged and expanded to support a national cross-jurisdictional community of practice. Other Communities of Practice could be supported in key industry sectors covering the built and natural environments.

4 Enabling Initiatives

A range of enabling initiatives need to be resourced and implemented to drive the change required to realise the vision and benefits of an ecosystem of spatially enabled digital twins.

a) Supply of Foundation Data Services

An ecosystem of digital twins will require foundation data services at increasing levels of details and quality to support the needs of priority use cases. This includes upgrades to Australia's cadastral data and other foundational spatial data, as well as making data available increasingly through APIs.

At a state/territory level, digital twin governance arrangements could be established to coordinate collaboration within and between government jurisdictions, especially with local government.	At a national level, ANZLIC could guide the enhancement of foundation spatial datasets to spatially enabled digital twins, as well as promote collaboration between jurisdictions to develop relevant standards, common practices and shared infrastructure. Cross-jurisdictional government agencies and ministerial groups could sponsor coordinated actions across jurisdictions and between sectors, particularly to integrate building and environment data into digital twin services.

b) Shared Digital Services to support Federated Digital Twins

Federated digital twin ecosystems need to resource and operate shared services including data catalogues for the discovery of data, federated access controls, data linkage services, data transformation and hosting services, service management tools such as API gateways, and data security controls.

At a state/territory level, the Queensland Government's Spatial Catalogue provides the foundation for some of these services supported by Land and Spatial Information and Queensland Government federated authentication service. Further work is required to define both role and group based categories.	At a national level, implementation of these shared services could be coordinated through for example, cross-jurisdictional groups, jointly owned entities (provided funding contributions were agreed across the different levels of governments) and peak industry bodies, leveraging existing Australian Government initiatives such as data.gov.au, National Map, VANguard and the Trusted Digital Identity Framework (TDIF).

c) Capability Development

The different levels of maturity of data custodians and data users require support to guide and assist them in developing their capabilities to contribute to and use digital twin services.

At a state/territory level, Queensland's 77 local government authorities vary widely in capability to contribute, manage and use digital twin datasets and services and some will require support through guidance and enabling digital infrastructure.	At the state/territory and national levels, support could be provided for local government to contribute to, use and manage digital twin datasets and services.

d) Procurement Policies

Australian governments can play a leading role in leveraging their procurement capabilities to support the development of a national ecosystem of digital twins.

- Mandating the supply of Building Information Modelling (BIM) data in open formats in the required level of detail and with spatial positioning data for all significant infrastructure, building and related capital works.
- Ensuring that the purchase and major upgrades of all geospatial and related data management platforms should support open geospatial data standards, interoperability and provide data access through APIs.
- Requiring that data and modelling created through environmental impact, planning, transport and related studies be made available where possible as either open or shared data for use in digital twins.
- Adopting open licensing formats or using standard commercial licences when providing data services (either created or procured by governments) to users to remove friction in the use of this data.
- Resolving intellectual property (IP) issues related to the acquisition of certain data such as BIM so that an appropriate balance is stuck between rewarding the creators of this data and providing a greater level of access and use.

At a state/territory level, the Queensland Government is leading with the requirement for BIM data to be supplied for major infrastructure projects. Further steps can be taken to address other procurement and data acquisition activities across the Queensland Government.	At the national level, these procurement initiatives could be achieved through specific priority initiatives such as the cross-jurisdictional response to the Building Confidence Report and co-ordination of common procurement policies.

Definitions

ANZLIC

Australian and New Zealand Land Information Council (also known as the Spatial Information Council) is the peak intergovernmental organisation providing leadership in the collection, management and use of spatial information in Australia and New Zealand.

APIs

Application Programming Interfaces (APIs) are data services that allow for automated access between computer applications/systems (including access from a database to a web browser/application).

BIM

Building Information Modelling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of the built environment. BIM may also be referred to as Asset Information Modelling (AIM), Virtual Design and Construction (VDC), Digital Engineering (DE) and the terms Building Information Modelling or Management are variously used.

Data sharing

Data that is shared securely between organisations (not open data) for access by authorised users.

Digital twin

A digital representation *that models* a real-world object or system. Digital twin platforms could be visualisation, analytic or workflow application functions.

Digital Twin assured data service

Digital Twin assured data service is real-time feed from a data source that is made available via an API (application programming interface) and has been assured as fit-for-purpose for use in a digital twin.

Digital Twin assured data set

A collection of data that is managed by a data custodian that is formatted so it complies with appropriate standards and quality levels set by a digital twin.

Digital twin ecosystem

A federated ecosystem of digital twins connected by open and shared data using visualisation, analytical, modelling and simulation tools. The ecosystem has common authentication and authorisation rules to enable role-based access to securely shared data.

Federated digital twin

A digital twin that is supported by multiple data services usually from multiple organisations, and orchestrated so they can be integrated within a digital twin environment (either visualisation, analytic system or workflow application) and that minimises the need for centralised data replication and storage.

Framework for Spatially Enabled Digital Twins

A framework to support the development and operation of spatially enabled digital twins that are aligned with the *Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia*. This version has been sponsored by the Queensland Government in collaboration with Data61.

National Foundation Spatial Data

A set of datasets that are assembled and maintained under the Foundation Spatial Data Framework (FSDF) that provide national coverage of the best available, most current, authoritative source of foundation spatial data which is standardised and quality controlled.

Open data

Data that is released to the public for their use at no charge and supported by an open licence that permits reuse.

The Principles for Spatially Enabled Digital Twins in Australia

The Principles for Spatially Enabled Digital Twins of the built and natural environment in Australia is a set of principles to guide digital twin development and delivery of Australia's digital twin ecosystem. These have been developed by the Spatial Information Council (ANZLIC) in collaboration with governments, industry and research organisations and was released in December 2019.

Spatially enabled digital twin

A digital representation that combines a digital twin with accurate spatial information, such that the digital twin covers a defined geographic space above and below ground and enables digital twins to relate to each, providing real-world context.

References

ANZLIC, Principles for Spatially Enabled Digital Twins of the Built and Natural Environment in Australia, December 2019.
https://www.anzlic.gov.au/resources/principles-spatially-enabled-digital-twins-built-and-natural-environment-australia

ANZLIC, The Australian and New Zealand Foundation Spatial Data Framework, April 2014.
https://link.fsdf.org.au/sites/default/files/FSDF_Resources/One_ANZ_Foundation_Spatial_Data_Framework_Booklet.pdf

Australian Government, Physical Environment Analysis Network (PEAN),
https://www.pean.gov.au/

CSIRO, A Data Specification Framework for the Foundation Spatial Data Framework, 2015
https://www.anzlic.gov.au/sites/default/files/files/FSDF-Data_Specification_Framework.pdf

Centre for Digital Built Britain, The Gemini Principles, 2018,
https://www.cdbb.cam.ac.uk/system/files/documents/TheGeminiPrinciples.pdf

Department of Agriculture, Water & the Environment, Environmental Resources Information Network (ERIN),
https://www.environment.gov.au/about-us/environmental-information-data/erin

Digital Transformation Agency, Trusted Digital Identity Framework,
https://www.dta.gov.au/our-projects/digital-identity/join-identity-federation/accreditation-and-onboarding/trusted-digital-identity-framework

Department of Prime Minister and Cabinet, Data Sharing and Release: Legislative Reforms Discussion paper, September 2019.
https://www.datacommissioner.gov.au/resources/discussion-paper

Queensland Department of Resources, Queensland Foundation Spatial Data Framework, February 2018,
https://www.dnrme.qld.gov.au/?a=109113:policy_registry/queensland-foundation-spatial-data-framework.pdf&ver=3.00

Queensland Government Department of State Development, Manufacturing, Infrastructure & Planning, Digital Enablement for Queensland Infrastructure: Principles for BIM Implementation, November 2018,
https://www.statedevelopment.qld.gov.au/resources/guideline/infrastructure/bim-principles.pdf

The Australasian BIM Advisory Board,
http://www.abab.net.au/

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

Contact us

1300 363 400
+61 3 9545 2176
csiroenquiries@csiro.au
csiro.au

For further information

Data61 CSIRO
Colin Griffith
Business Development & Commercialisation
+61 2 9490 5656
colin.griffith@data61.csiro.au
data61.csiro.au

Data61 CSIRO
Marie Truelove
Engineering & Design
marie.truelove@data61.csiro.au
data61.csiro.au

Queensland Government
Department of Resources
Spatial Information
CadastreQLD@resources.qld.gov.au
resources.qld.gov.au