ANZLIC
the Spatial Information Council

Principles for Spatially Enabled Digital Twins of the Built and Natural Environment in Australia

December 2019

If you have questions about this report, please contact: Spatial Data Policy Section, Department of Industry, Innovation and Science, Australian Government. Email: spatial@industry.gov.au

Contents

4 Introduction

6 What is a digital twin?

6 The expanding capability of digital twins

7 Spatially enabled digital twins of the built and natural environment

9 Benefits of digital twins

10 Digital twin use cases

12 Digital twin maturity model

13 A digital twin ecosystem for Australia

14 Digital Twin Principles

15 Principle 1 – Public Good

15 Principle 2 – Value

16 Principle 3 – Quality

16 Principle 4 – Adaptation

17 Principle 5 – Openness

18 Principle 6 – Security and Privacy

19 Principle 7 – Curation

20 Principle 8 – Standards

21 Principle 9 – Federated Model

22 Implementing a digital twin ecosystem

23 Engagement

24 Glossary

Introduction

Data and digital transformation is now central to our lives. The development of Australian industry, the functions of government and research all rely on data and insights. This presents a profound opportunity to evolve how we make decisions and deliver outcomes for Australians.

In recent years, digital twins – being highly advanced digital representations of the real world – have emerged as a powerful tool to better harness data to understand our physical environment. Place-based digital twins will drive the need for better access to high-quality data, with advanced visualisation, analytics, modelling and simulation. This will create opportunities across industry, government, the research sector and the community by providing more useful insights for informing decisions and planning.

Digital twins will enable more effective use of data to understand place-based policy and planning issues, test potential interventions, and deliver more sustainable planning and development; thereby improving decision-making efficiency and effectiveness and improving social, economic and environmental outcomes. This is now critically important in the face of emerging challenges such as high population growth and associated housing and infrastructure investment, climate change and sustainable development, and community expectations of improved liveability and equity. Benefits will range from more citizen-centric design and implementation, faster, more robust regulatory approvals and compliance assessments, and opportunities to develop innovative new products and services.

Digital twins will layer data, such as digital engineering models, Internet of Things (IoT) sensor data and environmental data to provide holistic information on the built and natural environment. Spatial (location) data will underpin this, providing the essential elements to position digital twins relative to each other to reflect the real world. Achieving spatially enabled digital twins will require modernised 3D and 4D (temporal) spatial data, particularly land parcel and property (cadastral) data and land use data.

The economic benefits of digital twins, smart cities and emerging digital technologies are considerable.The global digital twin market is projected to be US$29.1 billion (AU$43.3 billion) by 2025.[1] In Australia, emerging digital technologies such as IoT and big data are predicted to increase our annual GDP growth rate by 0.5 to 1.0 percent,[2] and the aggregate direct and indirect value of government data in Australia was AU$25 billion per annum in 2014.[3]

This *Principles for Spatially Enabled Digital Twins of the Built and Natural Environment in Australia* outlines the vision of a federated ecosystem of securely connected digital twins and their value for the Australian economy. These high-level principles will help industry, government, and the research sector generate data and develop digital twins in an aligned and cooperative way. The principles draw on the UK's Centre for Digital Built Britain's *Gemini Principles*[4] while being adapted to Australia's needs and priorities, such as encompassing both the built and natural environments and considering our federated government structure.

Delivery of a digital twin ecosystem in Australia will require a shared vision, clear objectives, guiding principles, appropriate standards, and defined roles and responsibilities. The opportunity is significant, and Australia can realise the value of digital twins through collaboration and coordination across industry, government, the research sector and the community.

Digital twins will enable more effective use of data

The economic benefits of digital twins, smart cities and emerging digital technologies are considerable

Spatial data will position digital twins relative to each other

Delivery of a digital twin ecosystem in Australia will require collaboration across government, industry and the research sector

Achieving spatially enabled digital twins will require modernised 3D and 4D (temporal) spatial data, particularly land parcel and property (cadastral) data and land use data.

[1] Grand View Research (2018) *Digital Twin Market Size, Share & Trends Analysis Report By End Use, By Region, And Segment Forecasts, 2018 – 2025.* https://www.grandviewresearch.com/industry-analysis/digital-twin-market, accessed 03/10/2019.

[2] McKinsey (2017) *Digital Australia: Seizing the opportunity from the Fourth Industrial Revolution.* McKinsey & Company

[3] Lateral Economics (2014) *Open for Business: How Open Data Can Help Achieve the G20 Growth Target,* http://www.omidyar.com/sites/default/files/file_archive/insights/ON%20Report_061114_FNL.pdf, accessed 20/09/2019

[4] Bolton A, Enzer M, Schooling J et al. (2018) The Gemini Principles: Guiding values for the national digital twin and information management framework. Published by the Centre for Digital Built Britain and Digital Framework Task Group. This work is licensed under CC BY 3.0. https://www.repository.cam.ac.uk/handle/1810/284889, accessed 28/10/2019.

What is a digital twin?

A digital twin is a dynamic digital representation of a real world object or system.[5]

Digital twins are dynamic, data driven, multi-dimensional digital replicas of a physical entity. They encompass potential or actual physical assets, processes, people, places, systems, devices and the natural environment. The level of detail and accuracy of a digital twin matches the digital twin's purpose, and is highly dependent on the following:

Data

The underlying information comprising the digital twin

Model

The efficacy of the code and algorithms used to generate the digital twin and simulate processes within the digital twin

Visualisation

The quality of the visual output showing the digital twin

In contrast to traditional digital models, digital twins can connect with the physical 'twin' they model, changing alongside the physical system via real-time sensors and actuators. Artificial intelligence (AI), machine learning technologies and other advanced analytics can then process this data to deliver insights and model future scenarios. Sensors in office buildings for example, can adjust lights, blinds and temperature to balance optimal working environment with energy consumption, with the digital twin managing and adjusting in near real-time.

Traditionally, industry has created digital twins by retrospectively mapping, scanning, surveying, digitising or developing a digital copy of a real world object. Today this process can occur in reverse, with the digital model developed first followed by the physical asset. Irrespective of which comes first, the usefulness of digital twins depends on how accurately they mirror the respective real world object or system and their ability to predict the outcomes of real world actions or interventions through analytics, modelling and simulation.

The expanding capability of digital twins

To date, current uses of digital twin technology are at the micro level, such as in a new building or infrastructure proposal, or for maintenance of facilities and equipment. With new technologies and capabilities, we can now network, nest or combine different digital twins to form a digital representation of an entire precinct, city or ecosystem.

Many existing assets, products and services generate and collect 3D modelling and advanced digital engineering data. Emerging technologies now provide opportunities to harness this data for a range of new purposes, delivering broader value for the economy. Digital twins are an important element of the 'Fourth Industrial Revolution', where technological integration is increasingly prevalent and cyber-physical systems more common. A range of technologies is enabling this, including AI, the IoT, autonomous vehicles and fifth-generation wireless technologies (5G). These technologies will continue to develop and evolve over time, providing new data, communications and analytical capabilities and re-shape how we manage, monitor and optimise the built and natural environment.

Industry, government and researchers are already generating and using digital twins, and this will continue to increase. With capabilities to connect digital twins between different organisations, sectors or geographies, we now have the opportunity to realise their full value.

---

[5] Adapted from Gartner (2017) *Prepare for the Impact of Digital Twins,* https://www.gartner.com/smarterwithgartner/prepare-for-the-impact-of-digital-twins/, accessed 15/07/2019

Spatially enabled digital twins of the built and natural environment

A spatially enabled digital twin combines a digital twin with spatial and positioning information, covering a defined geographic space above and below ground.

Digital twins have clear value, but their potential to improve how we manage the built and natural environment is enhanced if we relate them to one another and position them as they are in the real world. Achieving this requires integration of digital twins with accurate location information (e.g. satellite positioning data, elevation data, land parcel and property data (cadastre[6])) overlayed with 3D reality mesh data to generate *spatially enabled* digital twins. This might be for a specific factory or industrial area, or even entire towns, cities, regions or countries. Spatially enabled digital twins:

- cover both the built and natural environments (above and below ground)
- are underpinned by a precise positioning framework
- incorporate current and emerging 3D and 4D (temporal) data (e.g. positioning, elevation, cadastral data), 3D reality mesh data, spatial systems and digital engineering models (e.g. Building Information Models (BIMs))
- are spatially enabled at appropriate scale, with the appropriate level of accuracy.

Spatially enabled digital twins provide high value information, particularly for managing the interconnected challenges of urbanisation. Location-based, systematic insights combined with social, economic, environmental and built environment information can inform place-based policy design, planning and implementation, and improve service delivery (Figure 1).

[6] Digital 3D/4D cadastre is a digital model of cadastral boundaries and properties that defines, records and delivers land parcel information in support of tenure (ownership), land use and land value. The 3D element comprises transformation of the current 2D cadastre with elevation data such that the cadastre includes a height dimension. The 4D element involves creating temporal cadastral parcels that include historical and future data.

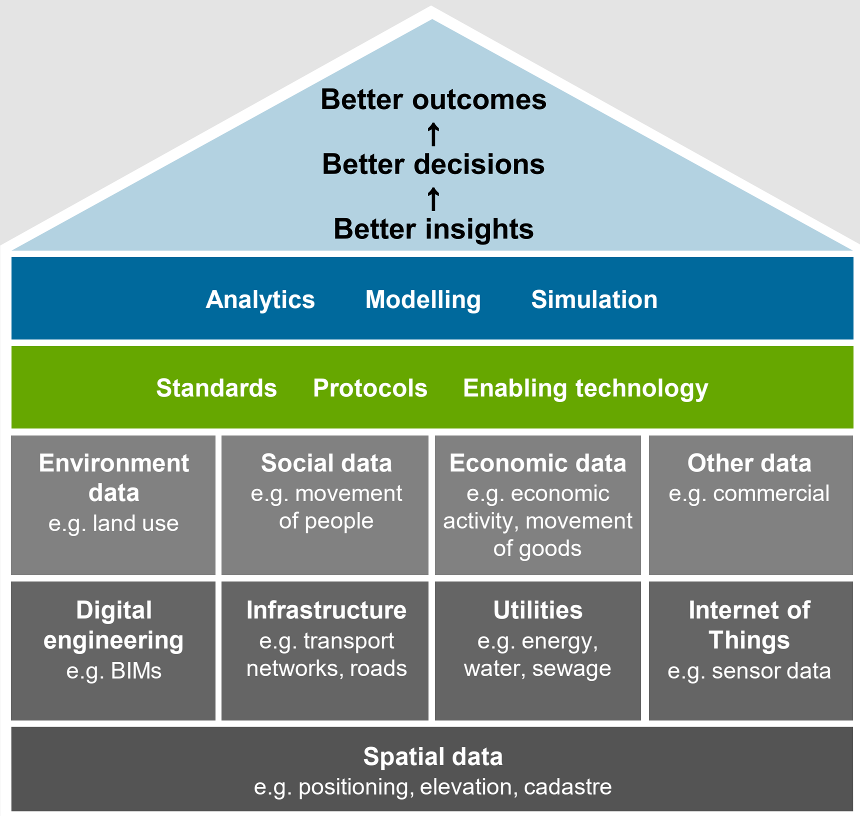

Figure 1: Spatially enabled digital twins integrate multiple data types and sources to enable advanced analytics for improved insight.

This highlights the importance of spatial data in realising the value of digital twins for the Australian economy, and the need for collaboration between relevant stakeholders and *ANZLIC – the Spatial Information Council*, the peak intergovernmental body providing leadership in the collection, management and use of spatial information in Australia and New Zealand.[7] Open access to national, standardised, spatial data represented under ANZLIC's Foundation Spatial Data Framework will assist users to spatially enable digital twins (Figure 2).

[7] http://www.anzlic.gov.au and https://link.fsdf.org.au/

Figure 2: ANZLIC's Foundation Spatial Data Framework provides a common reference for the assembly and maintenance of foundation level spatial data within these 10 themes.

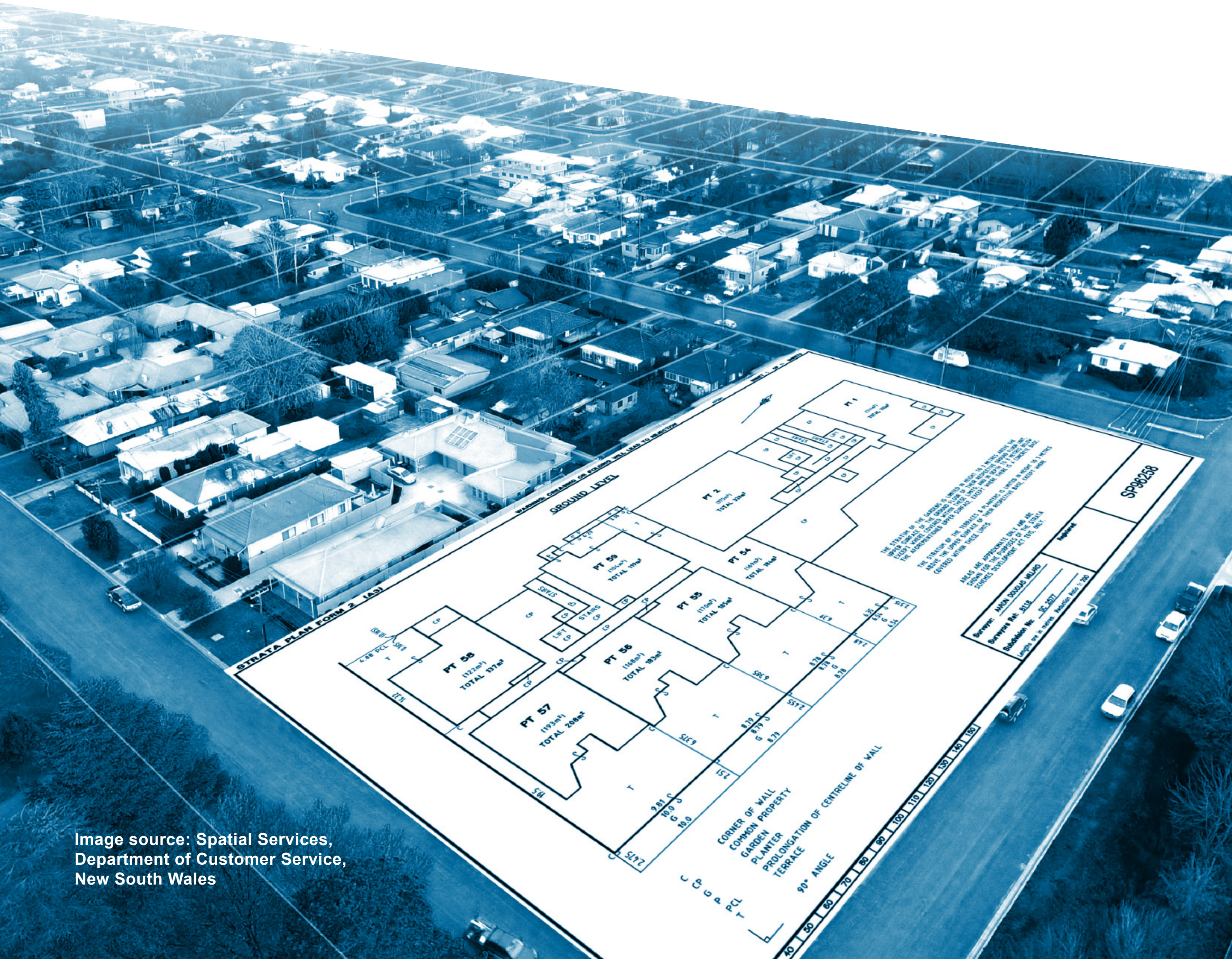

Image source: Spatial Services, Department of Customer Service, New South Wales

Benefits of digital twins

Fundamentally, digital twins provide access to historical and current data and analytical capability to enable improved insights and better and more efficient decisions, which can ultimately improve outcomes for all Australians.

They also promote trust, transparency and accountability, the foundations of government. Digital twins have a wide variety of potential benefits for both cities and regions in the built and natural environment; ranging from:

- **improved and more sustainable planning and development** for social, economic and environmental outcomes
- **better management** of assets, processes and systems, including better understanding of their interdependencies to maximise productivity and efficiency
- **real time monitoring** through IoT sensor data to inform on use, faults, upgrades, movement, environmental attributes, efficiencies and emergency management
- **simulation and modelling** (such as machine learning and predictive analytics) of an event or future intervention, such as natural disasters, investments, or policy interventions
- **driving innovation** through the development and use of new technologies.

Collectively, these benefits will assist with time and cost savings, better government services and quality of life improvements for all Australians.

The global digital twin market was valued at US$3.2 billion (AU$4.7 billion) in 2018, and has a projected value of US$29.1 billion (AU$43.3 billion) by 2025.[8] The global smart-cities market is expected to reach US$717.2 billion (AU$1020.4 billion) by 2023, expanding at a compound annual growth rate of 18.4 per cent from 2018.[9] In Australia, emerging digital technologies such as IoT, big data and automation are predicted to contribute AU$100-$210 billion to the Australian GDP, an increase to Australia's annual GDP growth rate of 0.5 to 1.0 percent.[10]

The benefits and value of digital twins are similar to those of open data generally. In 2014, Lateral Economics estimated that the aggregate direct and indirect value of government data in Australia is up to AU$25 billion per annum.[11] In the UK, a 2017 study[12] found that data currently contributes approximately £50 billion (AU$90 billion) in direct, indirect and induced impacts to the UK economy each year. Additionally, big data is predicted to contribute more to economic growth in the period from 2012-2025 than the typical contributions from R&D.[13]

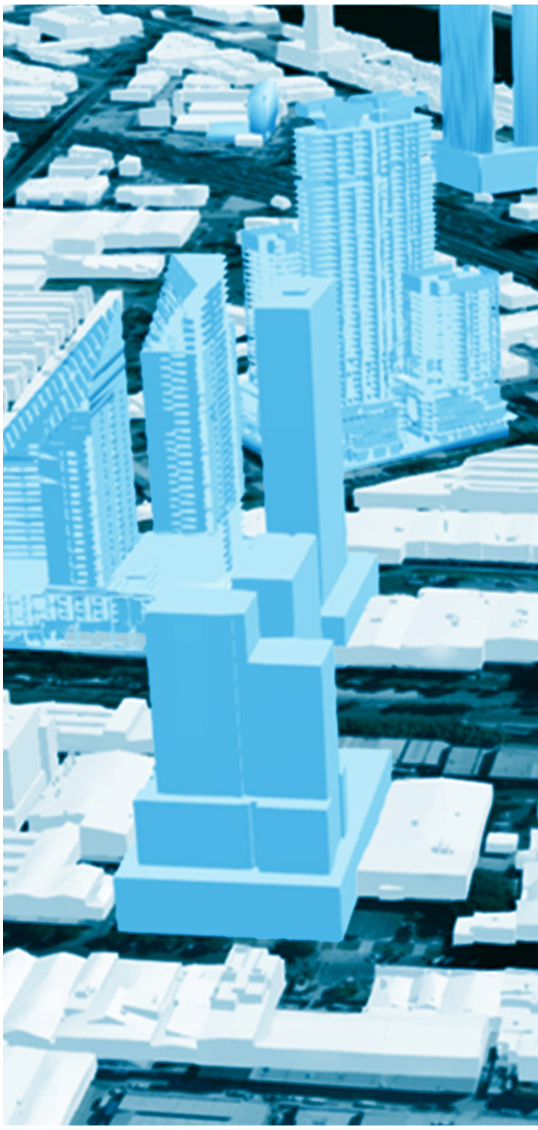

Image source: Department of Environment, Land, Water and Planning, Victoria

[8] Grand View Research (2018) Digital Twin Market Size, Share & Trends Analysis Report By End Use, By Region, And Segment Forecasts, 2018 – 2025. https://www.grandviewresearch.com/industry-analysis/digital-twin-market, accessed 03/10/2019.

[9] MarketsandMarkets (2019) Smart Cities Market by Smart Transportation, Smart Buildings, Smart Utilities, Smart Citizen Services, and Region - Global Forecast to 2023, MarketsandMarkets, TC 3071

[10] McKinsey (2017) Digital Australia: Seizing the opportunity from the Fourth Industrial Revolution. McKinsey & Company

[11] Lateral Economics (2014) Open for Business: How Open Data Can Help Achieve the G20 Growth Target, http://www.omidyar.com/sites/default/files/file_archive/insights/ON%20Report_061114_FNL.pdf, accessed 20/09/2019

[12] IDC and Open Evidence for the European Commission (2017) European Data Market Study, http://datalandscape.eu/study-reports/european-data-market-study-final-report, accessed 25/06/2019

[13] Goodridge, P. and Haskel, J., (2015), How does big data affect GDP? Theory and evidence for the UK. Imperial College Business School, UK. http://spiral.imperial.ac.uk/bitstream/10044/1/25156/2/Goodridge_2015_06.pdf, accessed 04/09/2019

Gartner predict half of all large industrial companies will be using digital twins by 2021, delivering a 10 per cent improvement in operating effectiveness.[14] In part, this stems from using digital twins of assets, processes and systems to optimise use and maximise whole-of-life outputs. Digital twins will also create opportunities for firms to build new products and services. For example, Australia has the potential to deliver enhanced 'data-driven urban management' services (a AU$5 to AU$10 billion export market)[15] and commercialise new smart-city technology products. Together, this illustrates how digital twins and a common digital twin ecosystem, particularly if the data comprising them is accessible to a broad range of users across the economy, could increase efficiency, productivity and innovation.

The benefits related to infrastructure are particularly prominent in the face of high population growth and major city development pressures, as improved infrastructure data would extract more value per unit of infrastructure output. The National Infrastructure *Data Collection and Dissemination Plan*[16] prioritises better collection, sharing and use of infrastructure data for investment decisions and monitoring of infrastructure networks. Addressing the challenges of population growth and city development will also require more efficient land use, estimated to deliver benefits of approximately AU$10 billion per year for the Australian economy.[17]

Digital twin use cases

Digital twin use cases for the built and natural environment can include, but are not limited to:

- **Integrate and prioritise maintenance needs of transport networks** (e.g. road and rail), buildings (e.g. commercial, residential, mixed use) and supply chains from in a specific area to minimise community disruption
- **Overlay planned infrastructure** on existing infrastructure to show interdependencies and need, evaluate the optimal timing of investments and clearly communicate planned developments to stakeholders and the community
- **Identify efficiencies in utility (e.g. water, electricity, gas, sewage) use** to optimise demand, assist with heat mitigation and adaption, bring more cost efficiency to energy networks and lower costs for consumers and businesses
- **Optimise transport network planning and use** by integrating public transport location, speed and carrying capacity data with other data
- **Transform building and construction** by improving approval processes, enabling automated progress monitoring, assessing as-built to as-designed, improving resource planning and logistics, monitoring safety and quality assurance and compliance
- **Assess the effectiveness of development and infrastructure approval processes**, to ensure alignment with strategic development objectives
- **Model population dynamics and movements synthetically** in high-density development areas or planned developments to optimise accessibility and efficiency, leading to improved living standards and public health
- **Improve agricultural efficiency and sustainability with precision agriculture** (e.g. real time monitoring of the environment, livestock, soil, crops, equipment, pests, disease)
- **Anticipate and predict the impact of natural disasters on the community and infrastructure, improving emergency management** by monitoring infrastructure and populations in real time, and better planning response, recovery and reconstruction efforts.

[14] Gartner (2017) Prepare for the Impact of Digital Twins, https://www.gartner.com/smarterwithgartner/prepare-for-the-impact-of-digital-twins/, accessed 8/05/2019

[15] AlphaBeta Advisors (2018) Digital Innovation: Australia's $315B opportunity, commissioned by CSIRO's Data61, https://www.data61.csiro.au/en/Our-Work/Future-Cities/Planning-sustainable-infrastructure/Digital-Innovation, accessed 08/08/2019.

[16] Commonwealth of Australia (2018) National Infrastructure Data Collection and Dissemination Plan, https://www.bitre.gov.au/data_dissemination/files/National_Infrastructure_Data_Collection_and_Dissemination_Plan.pdf

[17] Productivity Commission (2017) Shifting the Dial: 5 year Productivity Review, Supporting Paper No. 10: Realising the Productive Potential of Land, Canberra. https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting10.pdf, accessed 25/07/2019.

Australia's governments can also use digital twins to answer challenging policy questions or better assess safety and compliance for built assets. Examples include:

Challenging policy questions

- What is the natural disaster risk for residential buildings in a particular location, and what changes or investments would reduce or mitigate this risk?
- If the population of our major cities and regional centres grows by five per cent per year to 2025, where can government target infrastructure and residential development to maximise efficiency, reduce congestion and raise living standards?
- How can we reduce energy consumption by 15 per cent per person by 2040?
- What is the required healthcare investment in a particular city/region/precinct to service projected population growth effectively?
- How will service needs (such as health, utilities, infrastructure, emergency response) change as the climate changes over the next decade and beyond?
- Where should community and other infrastructure development occur to realise the vision of a 30 minute city?

Safety and compliance

- What critical assets or utilities are located underneath a new planned public transport or road infrastructure project? How can we minimise risks of compromising these assets?
- Which buildings have significant safety risks and compliance issues requiring attention?
- How has the structural integrity of specific high-rise developments changed over time, and are these developments compliant with applicable standards, safety requirements and community expectations?
- How does the distribution of disease and natural hazards change over time, and what can we do to manage this change?

Being able to use digital twins to answer policy questions such as these would be a major step-change for how decision-makers in government design and implement policy across Australia, and represents a profound opportunity to move beyond what is currently possible.

Image source: Department of Environment, Land, Water and Planning, Victoria

Digital twin maturity model

Our ability to realise the benefits of spatially enabled digital twins and use them effectively will depend on their evolving maturity (Figure 3),[18] each maturity stage can provide significant and distinct value. These include visualisation capabilities from aligning spatial data for design and coordination purposes; planning capabilities from integrating static data such as digital engineering models; analytical capabilities from real time data; and management capabilities that arise from being able to control physical elements through the digital twin. As such, individual digital twins may only evolve to meet their respective need.

Governance will be required for a standards-based approach, data integration and role based access. Each stage will likely involve unique challenges, including data modernisation, changes to business processes and more technical capability. For example, an essential element to deliver a spatially enabled digital twin will be collection and availability of appropriately accurate and precise high-quality spatial data, including related metadata.

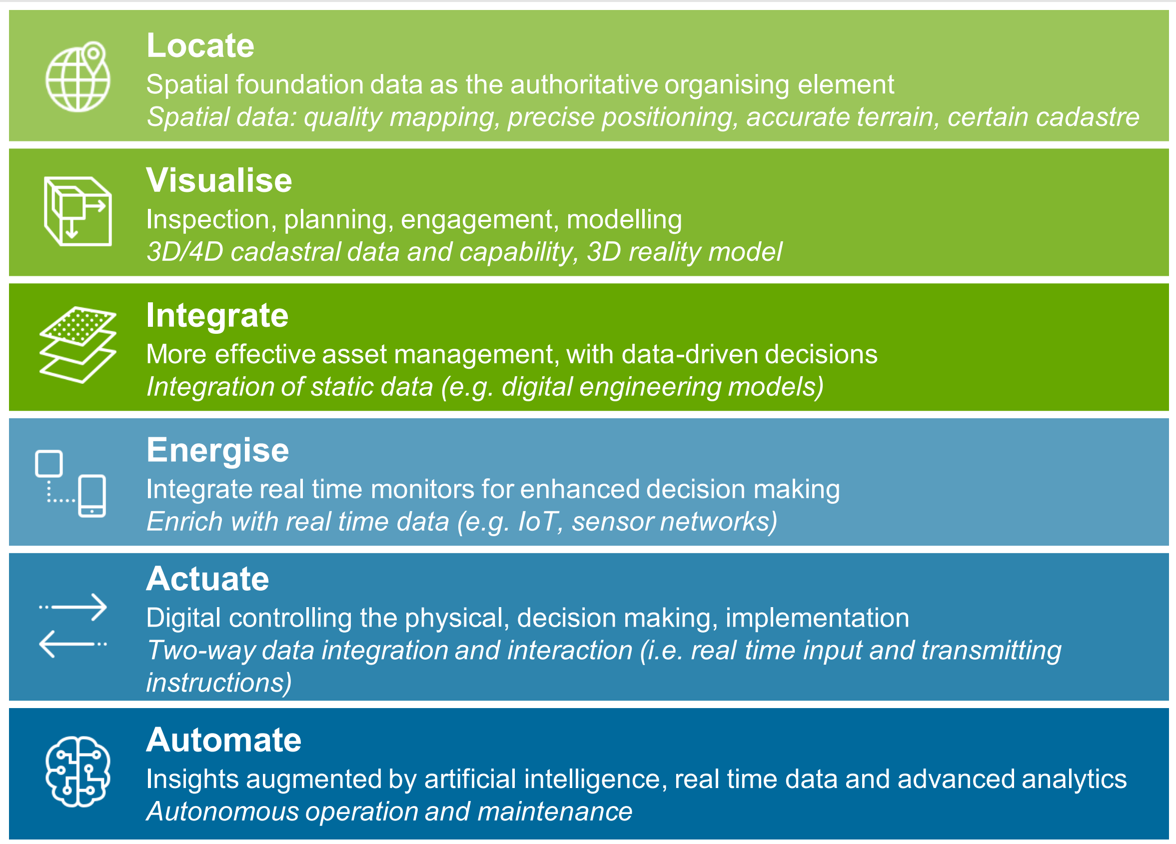

Figure 3: Spatially enabled digital twin maturity model illustrating the evolution in complexity, connectivity and capability. Integration of dynamic, real time data moves digital twins beyond static data platforms. Maturity stages are not necessarily linear; there are benefits in data upgrades and analytics at any stage.

[18] Adapted from SNC-Lavalin, Beyond Buzzwords: Digital Twin Maturity Spectrum (online) https://www.snclavalin.com/en/beyond-engineering/beyond-buzzwords-digital-twin-maturity-spectrum, accessed 02/10/2019

A digital twin ecosystem for Australia

A digital twin ecosystem for Australia would comprise interoperable data and connected digital twins governed by authentication and authorisation rules to enable role-based access to securely shared data.

A federated ecosystem of digital twins would cut across a broad range of government (i.e. Commonwealth, state, territory and local) and industry (e.g. construction, manufacturing, transport infrastructure, utilities) sectors, with no single owner or contributor (Figure 4). An ecosystem could include a combination of data that is open or shared with approved users.

To maximise value, the key challenge is to allow data to flow across an ecosystem while maintaining clear data custodianship for contributors, appropriate protections for private, confidential and sensitive information and consideration of commercial impacts, such as intellectual property. Spatial data is a key enabler for integrating data within a digital twin ecosystem, providing the common location information to link and position different data and digital twins relative to each other.

Key elements of a digital twin ecosystem in Australia include:

- **Agreed rules, protocols and standards to discover, share and access data, services and capability** including agreed approaches for authentication of user identity and role, authorisation to access particular data (or levels of detail/granularity of data), and access conditions (such as access costs, licence and use restrictions).
- **Ensuring data custodianship and authority remains with the contributing organisation** so that custodians can maintain control over shared data, monitor access to and use of their data through role-based access, and maintain authority for their respective functions and data.
- **Defining digital twin-compatible data** (i.e. interoperable, compatible, cross-platform and platform-agnostic) that will allow for digital twins in different sectors and government jurisdictions to mature at different rates and levels of complexity.
- **Seamless integration of government and non-government data** to realise the benefits of combining industry, government, research and community sector data.
- **Maintaining data over time** so that it accurately reflects the current environment and changes in the environment, where responsibility for ensuring data is up-to-date, accurate, quality assured and compatible would reside with data or digital twin custodians.
- **Customisable, user-driven access to data** in a form that can leverage new technologies and adapt to user needs, such as connecting digital twins in a particular region or city for localised insights.

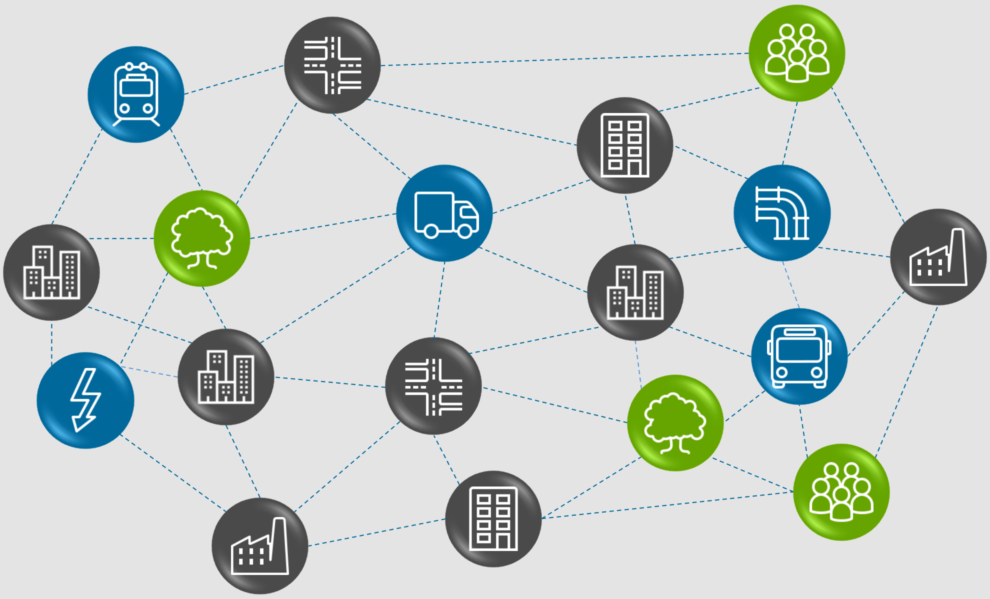

Figure 4: A federated, spatially enabled digital twin ecosystem of the built and natural environment in Australia will enable industry, research, government and the community to share data and collaborate in new ways to deliver better collective outcomes.

Digital Twin Principles

Given the complexity of digital twins and a digital twin ecosystem for Australia, there is a clear case for a common set of principles to guide digital twin development and delivery of a digital twin ecosystem in Australia (Figure 5).

The intent of these principles is to help industry, government, and the research sector develop digital twins in an aligned way that can feed into an ecosystem. The principles are intentionally simple, and purposefully describe overall intent rather than point to specific solutions.

The principles draw on the UK's Centre for Digital Built Britain's *Gemini Principles*;[20] while being adapted to Australia's needs and priorities. The principles also draw on F.A.I.R. Principles (Findable, Accessible, Interoperable, Reusable)[21] to ensure users can find, read, use and reuse the data comprising digital twins, and Data Sharing Principles[22] for safe and effective sharing of data. Application of common, open standards (such as those developed by Standards Australia, the Open Geospatial Consortium (OGC), International Organization for Standardization (ISO), and World Wide Web Consortium (W3C)) will enhance useability of the data and digital twins and maximise benefit to all users.

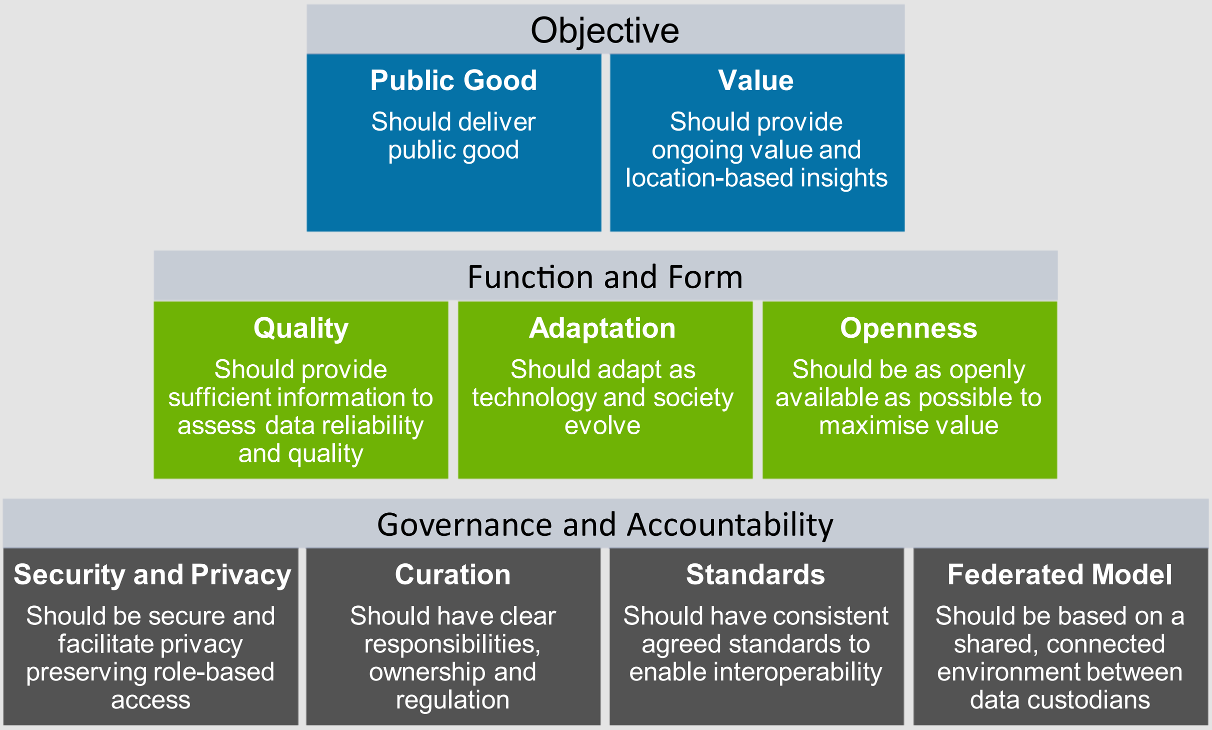

Figure 5: Principles for spatially enabled digital twins for the built and natural environment in Australia.[23]

[20] Bolton A, Enzer M, Schooling J et al. (2018) The Gemini Principles: Guiding values for the national digital twin and information management framework. Published by the Centre for Digital Built Britain and Digital Framework Task Group. This work is licensed under CC BY 3.0. https://www.repository.cam.ac.uk/handle/1810/284889, accessed 28/10/2019.

[21] Wilkinson, M. D. et al. (2016) The F.A.I.R. Guiding Principles for scientific data management and stewardship. Sci. Data 3:160018 doi: 10.1038/sdata.2016.18, https://www.fair-access.net.au/

[22] Commonwealth of Australia, Department of the Prime Minister and Cabinet (2019) Best Practice Guide to Applying Data Sharing Principles, https://www.pmc.gov.au/sites/default/files/publications/data-sharing-principles-best-practice-guide-15-mar-2019.pdf, accessed 01/10/2019

[23] Adapted from Bolton A, Enzer M, Schooling J et al. (2018) The Gemini Principles: Guiding values for the national digital twin and information management framework. Published by the Centre for Digital Built Britain and Digital Framework Task Group. This work is licensed under CC BY 3.0. https://www.repository.cam.ac.uk/handle/1810/284889, accessed 28/10/2019.

Principle 1 – Public Good

Key objective:

Digital twins should deliver public good, including by facilitating open access to non-sensitive data across the Australian economy and shared access with approved users.

Key benefit:

Digital twins are an important resource for the Australian economy that should be openly available (to the appropriate extent) or shared with approved users, and maintained to retain currency and value. This will enable Australia's industry and governments to use digital twins to develop new and improved products and deliver better services for Australians.

Key elements:

Digital twins and a digital twin ecosystem for Australia should be structured and shared to promote collaboration and innovation across the economy, consistent with the principle of public good.

Principle 2 – Value

Key objective:

Digital twins should provide ongoing value to the Australian economy, by enabling industry, governments, the research sector and the community to use them to better understand and manage the built and natural environment.

Key benefit:

Through location-based insights provided by spatially enabled digital twins, industry, governments and the research sector can better manage planning, development and use of the built and natural environment, while also optimising maintenance of existing assets, processes and systems. Realising these benefits will yield increased national productivity, particularly in large cities and regional centres.

Key elements:

Digital twins have particular benefits for planning, management and use of infrastructure, and can facilitate improved infrastructure performance, both as a system and as a service. The value of digital twins and a digital twin ecosystem for Australia will be maximised by integrating data, including spatial data, from different sectors to provide holistic insights.

Principle 3 – Quality

Key objective:

Users can assess data reliability and quality, including aspects such as the collection environment, relevance, timeliness, accuracy, coherence and consistency, interpretability, and accessibility, in relation to its intended use.

Key benefit:

Provision of sufficient metadata, including provenance of the data, will support the appropriate use of data in digital twins and a digital twin ecosystem, enabling effective data integration to create value. Contributors to a digital twin ecosystem should assess appropriate data quality based on the functionality, longevity and security required to fulfil the purpose for which the data is (or will be) used.

Key elements:

Digital twins should have agreed minimum data quality standards, in conjunction with case-by-case data quality standards or assessments as needed. This is particularly important for instances where the appropriate quality standard is difficult to determine.

Levels of quality should be transparent, defined, measurable and supported across a digital twin ecosystem.

Principle 4 – Adaptation

Key objective:

Digital twins and a digital twin ecosystem need to be able to adapt and develop as the world evolves (e.g. society, technology, requirements, information management, data science, cyber security).

Key benefit:

Continual adaptation of digital twins will ensure they remain useable over time and evolve to meet the changing needs of end users, ensuring data-informed decision making continues to be possible for both industry and government.

Key elements:

Digital twins will continue to adapt and evolve. Technical solutions, platforms and software in particular, should be agnostic to enable continual adaptation and evolution of digital twins and a digital twin ecosystem over the long term.

Principle 5 – Openness

Key objective:

Digital twins and a digital twin ecosystem should be as openly available as possible, that is, comprise open or shared data supported by open standards, to ensure they create the most value possible across the economy.

Key benefit:

A digital twin ecosystem will benefit from network effects – the more people or organisations that use, contribute to and maintain an ecosystem, the more valuable and useful it becomes.

Key elements:

Openness is a critical element to realising the vision of a digital twin ecosystem for Australia and maximising its value for the economy. An open, collaborative approach will help to ensure a digital twin ecosystem remains current and relevant for a broad range of contributors and users, thereby reducing the likelihood of siloed, inefficient approaches. Openness also requires digital twins to be discoverable and accessible, so users can find and connect to relevant data based on their level of access.

While openness is critical to maximising the value of digital twins and a digital twin ecosystem, it needs to be considered alongside security and governance. A digital twin ecosystem in particular needs to achieve the appropriate balance of openness and role-based access, which in part relates to the system or governance mechanisms agreed between relevant stakeholders.

Image source: Department of Natural Resources, Mines and Energy, Queensland

Principle 6 – Security and Privacy

Key objective:

Digital twins and a digital twin ecosystem for Australia must be 'secure by design', enabling data security, privacy protection and a role-based access approach.

Key benefit:

Data security, and associated personal, physical and cyber security, are essential to ensuring the integrity of digital twins. A 'secure by design' and 'privacy-preserving' approach will ensure the community has trust in the integrity of digital twins and a digital twin ecosystem, enabling realisation of the benefits for the economy.

Key elements:

A digital twin ecosystem's design should promote a risk-based approach based on holistic security and privacy-preserving principles. This includes having a standard approach for authorisation to access data in the ecosystem and authentication of user identity and role.

Data custodians should determine the agreed rules for role based access to different levels or granularity of data within the ecosystem.

Specifically, digital twins in an ecosystem must address:

- protection of sensitive data as per the *Privacy Act 1988*
- protection of sensitive national infrastructure assets
- mitigation of risks associated with data aggregation and de-identification
- protection of commercial-in-confidence, intellectual property and commercial data and models.

The Five Safes Framework provides a useful model for taking a multi-dimensional approach to managing disclosure risk from the perspective of data custodians providing sensitive data to authorised users within a digital twin ecosystem and agreeing authorisation and data access rules and procedures. Key elements of the Five Safes Framework include:

- Safe people – Is the data user appropriately authorised to access and use the data?
- Safe projects – Is the data to be used for an appropriate purpose?
- Safe settings – Does the access environment prevent unauthorised access?
- Safe data – Has appropriate and sufficient protection been applied to the data?
- Safe outputs – Do the statistical results achieve non-disclosure? (considered after the previous four elements).

Principle 7 – Curation

Key objective:

All parts of digital twins and a digital twin ecosystem should have clear and transparent ownership, governance, responsibilities and regulation to support the creation, maintenance and responsible use of relevant data.

Key benefit:

Clear ownership and responsibilities will enable effective data management and issues resolution for individual digital twins within a digital twin ecosystem and for a digital twin ecosystem as a whole. Government could use regulation to drive the desired behaviours in an ecosystem when this is not possible through industry, research and community approaches.

Key elements:

Data ownership is a central element of this principle, providing accountability for curating appropriate quality data for integration into a digital twin ecosystem. Data custodians should work with stakeholders to identify high-value datasets that are required to support digital twins. Data custodians should also engage the appropriate skills and competencies required to enable digital twins. Particular digital twins could be governed by government, industry, research or the community.

Image source: Spatial Services,
Department of Customer Service,
New South Wales

Principle 8 – Standards

Key objective:

Agreed open standards and industry best practice for data and digital twins should be adopted, with agreed cross-platform and platform-agnostic architecture models to ensure overall interoperability, compatibility and functionality.

Key benefit:

Open standards that adopt industry best practice will build trust, set the right culture, reduce costs and ensure digital twins and a digital twin ecosystem create the most value possible.

Key elements:

Use of open standards will help ensure digital twins and a digital twin ecosystem are vendor neutral. Provision of open Application Programming Interfaces (APIs) will enable broad accessibility and use of data across the economy. This principle also aligns with the collaborative approach required to develop a digital twin ecosystem for Australia due to Australia’s federated government structure.

Image source: Spatial Services, Department of Customer Service, New South Wales

Principle 9 – Federated Model

Key objective:

Digital twin operators and data custodians should support a federated model where data and services can be connected and shared in a flexible and responsive manner.

Key benefit:

Adopting a federated model for a digital twin ecosystem in Australia will ensure industry and all levels of Australian governments maintain authority for their respective functions and associated data that can feed into a digital twin ecosystem.

Key elements:

This model requires and incentivises industry and Australia's governments that contribute data to digital twins to develop and manage the data in consistent, interoperable, cross-platform and platform-agnostic ways. Achieving this will drive scale and enable end users across the economy to use digital twins (and a digital twin ecosystem) within and between industry sectors and jurisdictions.

Governance is a vital element of this principle. The proposed federated model requires a level of consistent governance across different sectors, as well as between industry and government. In particular, governance needs to ensure a digital twin ecosystem is able to work with different types of data and information within and across:

- different infrastructure sectors (e.g. transport infrastructure, communications and utilities)
- both the built and natural environment
- various spatial and temporal scales
- different modelling approaches

Governance should also provide mechanisms for overall management of a digital twin ecosystem, ensuring fair value and consistent adherence to standards.

Implementing a digital twin ecosystem

The key elements to deliver the full value proposition of a digital twin ecosystem are spatial enablement; connectivity (including appropriate standards); and collaborative agreements on, for instance, governance mechanisms, data sharing and access, and roles and responsibilities. Secondary implementation aspects also requiring shared agreement and guidance include, but are not limited to, capability building, communication and engagement activities.

Consideration of these elements may necessitate development of a framework and/or roadmap to ensure an ecosystem meets the needs of all stakeholders.

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.

Align

with Digital Twin Principles for spatially enabled digital twins of the built and natural environment.

Collaborate

to deliver appropriately connected and useful digital twins.

Implement

appropriate information and data management practices including adopting common standards and approaches.

Engagement

The following government agencies and peak bodies were consulted during the development of the principles.

Government entities

- Australian Bureau of Statistics (ABS)
- Australian Capital Territory Directorate for Environment, Planning and Sustainable Development
- Australian Geospatial Intelligence Organisation
- Australian Space Agency
- Commissioner for Environmental Sustainability Victoria
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- CSIRO's Data61
- Commonwealth Department of Communications and the Arts
- Commonwealth Department of Environment and Energy
- Commonwealth Department of Industry, Innovation and Science
- Commonwealth Department of Infrastructure, Transport, Cities and Regional Development
- Digital Transformation Agency
- Geoscience Australia
- Infrastructure Australia
- Land Information New Zealand (LINZ)
- National Indigenous Australians Agency
- New South Wales Department of Customer Service
- Northern Territory Department of Infrastructure, Planning and Logistics
- Office of the National Data Commissioner
- Queensland Department of Natural Resources, Mines and Energy
- Victorian Department of Environment, Land, Water and Planning
- Services Australia
- South Australian Department of the Premier and Cabinet
- Tasmanian Department of Primary Industries, Parks, Water and Environment
- Western Australian Land Information Authority (Landgate)

Academia

- Centre for Spatial Data Infrastructure and Land Administration, Melbourne School of Engineering, The University of Melbourne
- City Futures Research Centre, University of New South Wales
- SmartSat Cooperative Research Centre

Industry groups, peak bodies and organisations

- Australasian BIM Advisory Board (ABAB)
- Australian Construction Industry Forum (ACIF)
- Australian Institute of Architects
- Australian Local Government Association (ALGA)
- Australian Urban Research Infrastructure Network (AURIN)
- Consulting Surveyors National
- Engineers Australia
- FrontierSI
- Planning Institute of Australia
- PSMA Australia Limited (PSMA)
- Smart Cities Council Australia and New Zealand
- Space Industry Association of Australia
- Spatial Industries Business Association and Geospatial Information and Technology Association Australia and New Zealand (SIBA/GITA)
- Surveying and Spatial Sciences Institute (SSSI)
- The Property Council of Australia

Glossary

The Australian and New Zealand Land Information Council (ANZLIC): Also referred to as the Spatial Information Council, ANZLIC is the peak intergovernmental body providing leadership in the collection, management and use of spatial information.[24]

ANZLIC's Foundation Spatial Data Framework (FSDF): Provides a common reference for the assembly and maintenance of foundation level spatial data across 10 themes: geocoded addressing, administrative boundaries, positioning, place names, land parcel and property, imagery, transport, water, elevation and depth, and land cover and land use.[24]

Built environment: All types of buildings (e.g. residential, industrial, commercial, hospitals, schools), all built infrastructure (e.g. roads, rail, utilities) and the urban space and landscape between and around buildings and infrastructure (e.g. precinct).

Data Sharing Principles: Risk management safeguards applied when sharing public sector data.[25]

Digital 3D/4D cadastre: A digital model of cadastral boundaries and properties that defines, records and delivers land parcel information in support of tenure (ownership), land use and land value. The 3D element comprises transformation of the current 2D cadastre with elevation data such that the cadastre includes a height dimension. The 4D element involves creating temporal cadastral parcels that include historical and future data.

Digital twin: A dynamic digital representation of a real world object or system.

Digital twin ecosystem: Interoperable data and connected digital twins governed by authentication and authorisation rules to enable role-based access to securely shared data.

F.A.I.R. (Findable, Accessible, Interoperable, Reusable) Principles: Designed to ensure users can find, read, use and reuse data.[26]

Federated model: A group of systems operating in a standard, collective and connected environment.

Natural environment: All living and non-living things that occur naturally, meaning not because of humans. This includes ecological units such as vegetation, microorganisms, soil, rocks, atmosphere and natural events, which are natural systems without much human interference, as well as universal natural resources, such as climate, air and water, which lack clear-cut boundaries.

Open data: Data that is freely available, easily discoverable and accessible, and published in ways and under licences that allows use without restriction from copyright, patents or other control mechanisms.

Public good: A service that is provided to all members of society, either by the government, research or a private sector organisation, without exclusion or detracting from others using it.

Sensitive information: As defined in the *Privacy Act 1988*, is a subset of personal information and includes information about an individual's health, racial or ethnic origin, political opinions, religious beliefs, criminal record, or biometric templates. Sensitive data means information within the definition of 'sensitive information' as well as other types of data that are of a legally privileged, commercial-in-confidence, security classified, or environmental nature.[27]

Shared data: Data made available to another agency, organisation or person under agreed conditions.

Spatially enabled digital twin: A digital twin integrated with spatial and positioning data, covering a defined geographic space above and below ground.

---

[24] http://www.anzlic.gov.au and https://link.fsdf.org.au/

[25] https://www.pmc.gov.au/sites/default/files/publications/data-sharing-principles-best-practice-guide-15-mar-2019_0.pdf

[26] https://www.fair-access.net.au/

[27] Commonwealth of Australia, *Data Sharing and Release Legislative Reforms Discussion Paper,* 2019, https://www.datacommissioner.gov.au/sites/default/files/2019-09/Data%20Sharing%20and%20Release%20Legislative%20Reforms%20Discussion%20Paper%20-%20Accessibility.pdf, accessed 01/10/2019