Unlocking the Value of Data:

Managing New Zealand's Interconnected Infrastructure

Infrastructure
New Zealand

Quake Centre
Delivering Industry Solutions

BUILDING INNOVATION PARTNERSHIP

Executive Summary

New Zealand's physical infrastructure is under increasing pressure from underinvestment, the demands of growth, exposure to natural hazards, climate change, and degradation due to age.

Managing this infrastructure and planning for a post-Covid 19 future requires a change from the current approach. Central to this new approach is the need to understand infrastructure condition, performance and impact on the environment. The information and decision-making required will rely upon on high quality, reliable data in a form that allows sharing, visualisation and analysis. Increasingly around the world companies, industries, cities and even whole countries are developing digital twins to support the planning and decision-making process. Underlying these digital twins are common data standards, shared platforms and clear implementation plans to maximise the benefits.

This paper gives an overview of the benefits for New Zealand in developing a National Digital Infrastructure Model (NDIM) and provides some examples of activities both here and overseas. It is also a 'call to action' to New Zealand's national and local governments, industry leaders and academia to come together and develop the structures that will support the digital future of New Zealand's infrastructure.

> *"A National Digital Infrastructure Model is the key to unlocking something radically new that challenges conventional wisdom and will help meet New Zealand's future requirements. It will put people at heart of infrastructure building, improve access to and consistency of data, promote innovation, and position the centres of New Zealand as smart and resilient cities of the future."*
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> Infrastructure New Zealand Digital Twin Working Group

The Infrastructure New Zealand Digital Twin Working Group

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Introduction

Modern New Zealand is more interconnected, complex and dynamic than at any time in our history.

This has created issues in how we: manage the future of our communities, ensure our people are housed and lessen our environmental footprint. Key to addressing all these issues is how we understand and manage the infrastructure which supports our lives. With an infrastructure-led post-pandemic recovery, with billions of dollars projected to be spent, it is essential that programmes of work are 'shovel worthy'. We must ensure that the money and time invested lead to outcomes that improve New Zealand's collective well-being over the short, medium and long-terms.

The advances in digital technology which have underpinned the transformation of services such as banking, retail or mobility can also be applied to the physical infrastructures such as pipes, rail lines and electricity grids. A transformation in the way we develop and manage the digital dimension of our infrastructure can help New Zealand meet the challenges of population growth, construction pipelines and environmental sustainability and enable the more effective, efficient and strategic management of our infrastructure assets. The use of digital technologies such as sensors, cloud computing, artificial intelligence and machine learning can assist central government to strategically invest and partner with local government and industry to deliver many benefits. The benefits to New Zealand's communities and businesses may include: lower utility costs, improved travel times, enhanced environmental outcomes, and reduced disruption from congestion or maintenance work.

The more information we have about the nation's infrastructure, the better we will understand it and the communities and futures it serves. Therefore, data are crucial. Data can improve how our infrastructure is funded, built, managed, and decommissioned. Real-time data can improve how our infrastructure is operated and allow better responses to disruptions, failures and environmental concerns.

Collecting data alone will not improve the nation's infrastructure and its management. The key is to enable a national, action-oriented and shared approach to meet our challenges using **high-quality data**. Sharing data has been shown to catalyse innovation and improve services. Sharing data multiplies the value of data, not only by increasing the number of people or systems accessing the data but by enabling a digital economy and a coordinated understanding and action across organisations and supply chains.

The opportunity exists to fundamentally change the way that New Zealand's infrastructure is planned, designed, constructed and managed. A shift away from the current silo-ed, inefficient and unsustainable approach to a coordinated, connected and safe system relies upon informed decision-making based on high quality data.

Introduction

It is important that New Zealand moves deliberately, decisively and quickly towards a future state where information on national infrastructure is able to be shared efficiently, effectively and securely.

There is a growing understanding that data are a fundamental infrastructure which need to be managed as much as the physical infrastructure they represent. Standardising data formats and protocols is a demonstrated and necessary path to improving data sharing. Much that we take for granted today is only possible because of agreed standards, such as bar codes on merchandise which have enabled the automation of retail systems.

This paper is a 'call to action' to Central Government; leading infrastructure owners and operators; and the broader industry to come together to develop the data governance, data systems and implementation pathways that will enable the value of New Zealand's infrastructure data to be leveraged for the well-being of all New Zealanders.
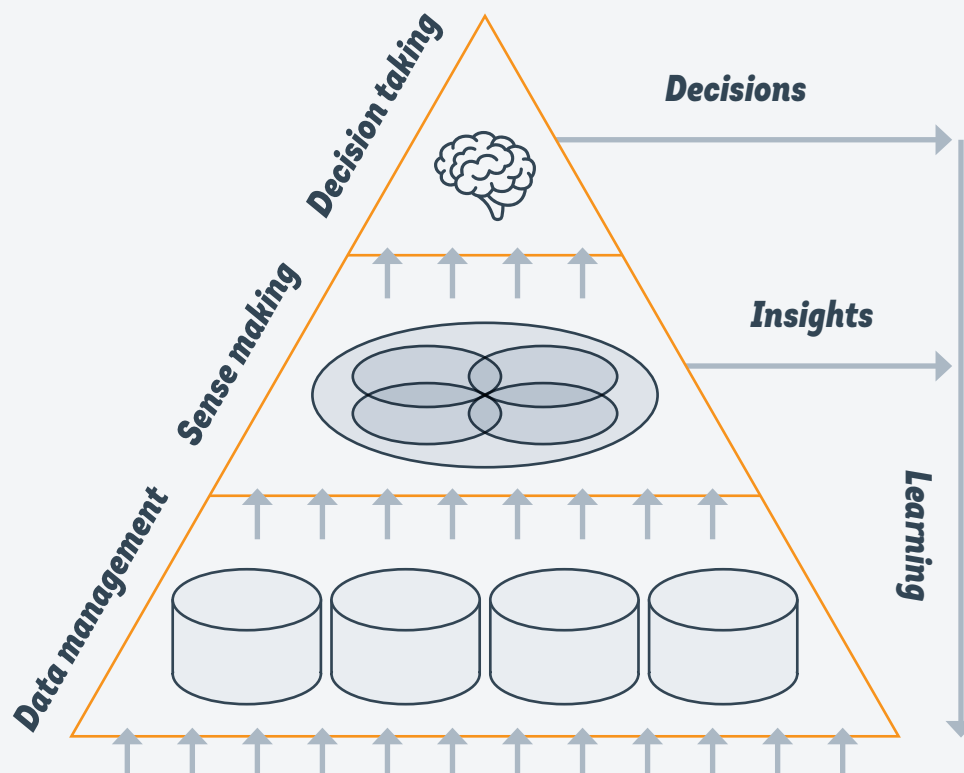
What's the opportunity?

Infrastructure is an essential component in the delivery of services on which the well-being of New Zealanders depend.

Collectively, central Government is responsible for between $116 billion to $250 billion of infrastructure assets, and local government has a further $100 billion of community assets on its balance sheets (see Figure 2).

To maximise the value from our infrastructure we need to enable consistent, high-quality decision making which relies on access to robust data (see figure 1). Simply put **to maximise the value from the physical asset we need to maximise the value we can get from asset data**.

Figure 1: The information value chain

What's the opportunity?

Financial Benefits – Over the next 30 years there is the potential to provide billions of dollars in financial benefits to New Zealand. These benefits include:

- Decreasing the cost of ownership – for example by enabling preventative maintenance, building assets in a way that makes them more cost effective to maintain.

- Increasing the asset utility by understanding capacity – for example if there is excess capacity it can be used through infill housing and brownfields development. Or if the asset is almost fully utilised, using strategies like demand management, such as water metering, to reduce pressure on the asset. There are potential national savings of $816M to $8.16B over 30 years from understanding residential housing capacity, based on Wellington City Council figures.

- Addressing long term infrastructure underfunding – In three waters infrastructure alone there is estimated approximately $8 Billion in underinvestment (however there are not enough reliable data to ascertain if this is an under- or over-estimation). As these networks age, and the communities they serve change the ability to use technology to drive efficiencies and investment is key to the long term fiscal sustainability of network operators, local government and the communities they serve.

- Maximising the value of the asset over its life – for example by not replacing it too soon before all economic life has been extracted from it. There are potential savings to the New Zealand infrastructure spend of $5B-$7.5B over 30 years by reducing repair through more effective maintenance.

- Benchmarking, reducing procurement costs and improving insurance costs.

(New Zealand Treasury, 2017)

Figure 2: NZ's public infrastructure

33% of public assets (by value)

- Local government is estimated to have over $12B of land and building - much of which is social or community infrastructure such as halls, theatres, reserves, sports centres and public libraries
- The Crown's property, plant, and equipment assets in the health, education, justice, social housing, and defence sectors were valued at $44B

Source: Thirty Year New Zealand Infrastructure Plan 2015

Buildings
The main benefits are social and wellbeing

12% of public assets (by value)

Value of water, wastewater and stormwater assets under local government control is estimated to be between $30 to $50B, broken down as follows:

- Potable water $16.2B (36%)
- Wastewater $17.8B (39%)
- Stormwater $11.2B (25%)

Source: Thirty Year New Zealand Infrastructure Plan 2015

3 waters
The main benefit is public health

33% of public assets (by value)

- State highways, valued at $29.2B, 10,886km managed and operated by NZTA
- Local roads, valued at $50B, 83,000km managed and operated by Local Government (half funded by NZTA)

Source: 2015 Infrastructure Evidence Base 2015 - Transport Sector

Roads
The main benefit is economic
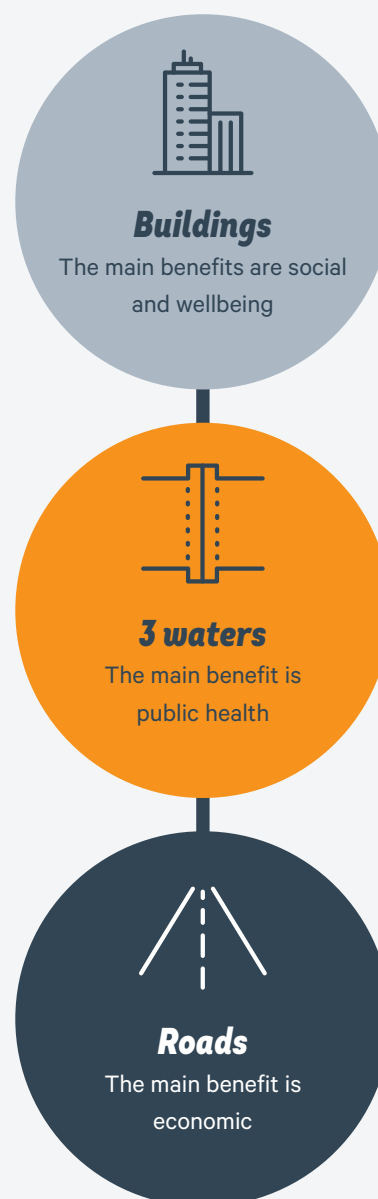
Non-Financial Benefits – Improving data quality and accessibility provides a pathway to stimulate innovation and growth by enabling the continuous improvement of operations and application of new (and still to be invented) digital technologies. This is pathway will help solve complex problems and provide previously unattainable (or unimagined) benefits including;

- Improving the resilience of our communities

- Enabling improved national, regional and local risk management frameworks

- Managing our response and adaptation to climate change

- Managing assets in a proactive rather than reactive manner

- Improving the New Zealand Construction Sector's historically poor productivity and stabilising infrastructure connection costs to new developments

- Improving the appeal of, and growing the capability and talent within, our construction industry

- Enable application of future digital technologies for the realisation of currently unforeseen benefits.

- Allowing the benefits of green technologies to be realised by both infrastructure providers and customers.

- Optimising service delivery through realising the value of re-using data and understanding the inter-connectedness of infrastructure systems.

A National Digital Infrastructure Model (NDIM) for New Zealand

With common data standards, data sets can be combined in informative and transformative ways.

This leads to the ability to leverage the value of infrastructure and other data through the creation of digital twins. Digital twins are having a significant impact on the way organisations, cities and even whole countries are leveraging value from their data. A digital twin is a digital model of a real system which enable analysis, simulation and management of the real system. Whilst digital twins have been around for some time, the technology now available is revolutionising both their scale and impact. A National Digital Infrastructure Model would be a core component in a National Digital Twin, connecting infrastructure information to its cultural, environmental and social contexts. New Zealand would benefit greatly from the insights gained in the development of a National Digital Infrastructure Model. Some of these benefits are outlined in Figure 3.

Figure 3: Why we need a National Digital Infrastructure Model

Inform investment strategies for new and existing infrastructure.

Benchmark performance of infrastructure providers.

Measure and compare infrastructure performance.

Predict the effects of climate change and urban development.

Assess risks associated with infrastructure deterioration and failure.

Aid the transition to a low-carbon economy.

Assess vulnerability to hazards and improve resilience.

Provide a single point of truth for emergency management.

Inform land-use planning.

NDIM

What is happening in New Zealand and internationally?

There are a number of initiatives around the world focused on the benefits of data standardisation, digital twins and data-driven decision-making for national and city-wide infrastructure.

Leading countries such as the UK, Finland, Singapore and Australia are all investing in data and digital infrastructure needed to tackle the challenges of planning, building and managing infrastructure in the future. New Zealand is generally lagging behind in these areas. However there are positive examples from both here and overseas.

New Zealand

There are a number of initiatives underway across New Zealand's infrastructure sector that attempt to realise the benefits of a digital future. Below are examples from the roading, water, and vertical building sectors.

NZTA takes lead

The New Zealand Transport Agency (NZTA) is developing a digital enablement portfolio for transport. This programme builds on the Asset Management Data Standard (AMDS) work already underway and lessons from councils and the NZTA. The new approach includes implementing Building Information Management (BIM) for transport and is expected to increase savings in the build phase of capital projects and across the entire lifecycle of infrastructure assets and the services delivered to customers.

For a total investment of approximately $50m over several years the benefits of this project are in the order $115-224 million per annum. It is estimated that a further $300m per annum of benefits can be realised if the AMDS approach is applied to risk management and investment planning in the land transport sector. (NZTA, 2019). AMDS/BIM will also enable insight into the well-being aspects of good transportation (see Figure 4).

Figure 4: Well-being insights from NZTA

SOCIAL DATA

TRANSPORT DATA

ENVIRONMENTAL DATA

Wellbeing Insights
Integrated Resilience Analysis

- Layering clean, complete data sets
- Leverage multiple data sets
- Environment
- Community
- Infrastructure
- Community Response and Infrastructure Adaptation
- Sea levels vs house and road levels
- National procurement for locally delivered outcomes
- Drainage upgrades, bridge replacements
- Greater insight, improved understanding, smarter investment → better community outcomes

Lind, 2019

What is happening in NZ and Internationally?

Location standards

NZTA, Land Information New Zealand (LINZ) and a number of other utility operators are agreeing on a suite of international location data standards that will form the basis of coordinating utility location information across the country. This is essential to ensure health and safety when digging around underground assets as well as coordinating activities via the use of tools such as Forward Works whereby utilities can coordinate and optimise their programmes of capital works and maintenance.

New Zealand Asset Metadata Standards (NZAMS)

The NZAMS was a project funded by Treasury and delivered by LINZ. This project developed asset data standards for the water sector and residential and light commercial buildings. The outputs were a useful first draft. However there were no ongoing resources, implementation plan, governance structure or support system to carry the benefits through to the industry.

Potable, waste and storm water (Three Waters)

Local government estimates put the replacement value of Three Waters assets at $51.4B. Before the Covid-19 pandemic, Capital works out to 2025 were expected to cost $12.8B. Post-pandemic this needs to be significantly revised upwards. In the meantime, much of this infrastructure is aging, and key parts of it are vulnerable to natural hazards. Increasing urbanisation, population growth, economic growth, climate change and increased service standards add even more pressure. Managing costs and maximising the lifetime value of Three Waters assets requires smarter approaches that embrace data sharing to drive innovation and manage interdependencies with other classes of infrastructure.

The Quake Centre is developing data standards for Three Waters pipe assets for potable, waste and storm water. This Codes of Practice (CoP) is an addendum to the New Zealand Asset Metadata Standards (NZAMS) published by LINZ. The initial focus is on pipes, chambers and fittings which comprise the greatest combined asset value for most councils. The standards will be rolled out via a National Pipe Data Portal and they will provide a common language by which local authorities can federate their data for analysis and benchmarking. Other benefits include standard templates for consultants and contractors. The CoP will, for the first time, provide a national standard and standard tools for delivery of design information and as-built information. This will be vital as regional alliances are formed to tackle the post-Covid recovery.
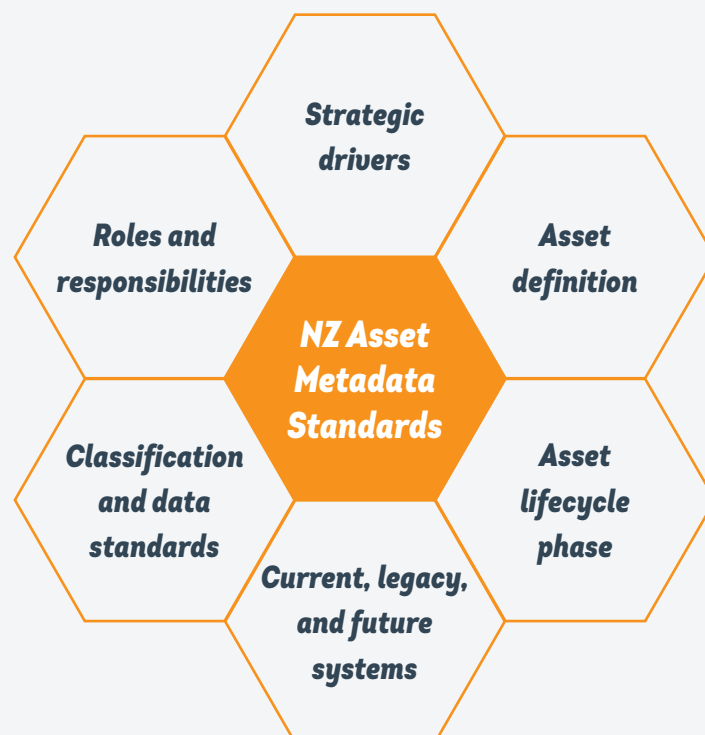
Residential and light commercial buildings

Building asset data is fundamental to managing real estate effectively.

A Building Information Management (BIM) model is fast becoming the essential tool for managing the data needed for the design and construction of buildings. Great advances are also being made in respect to the use of these 'digital twins' for optimising the management and performance of buildings and facilities. To facilitate the creation of such a tools, Masterspec is developing a web-based toolset for industry. The toolset is based on the NZAMS. These standards are being taken-up, tested and further developed by a number of organisations including Christchurch City Council and the University of Canterbury. Figure 5 represents the central role of data standards in managing building information effectively.

Figure 5: Asset management information framework

Strategic drivers

Roles and responsibilities

Asset definition

NZ Asset Metadata Standards

Classification and data standards

Asset lifecycle phase

Current, legacy, and future systems

Wellington City Council

Wellington City Council has invested in a series of projects exploring how the city can harness deeper digital capabilities to improve the way it works and engages. These include:

- **Virtual Wellington** – a digital three-dimensional model which fuses sensor, geospatial, building, health and other data from across government and non-government organisations together to help make better multiagency decisions, understand complex issues like climate change and better engage with communities

- **Machine Consumable Regulation** – converting the city's planning rules to computer legible codebases which allow the rules to be interacted with to understand their effect, their costs and to begin exploring how consenting can be augmented with machine learning tools.

- **Digitalisation** – converting the city from document-based approaches to data based approaches to give greater access to the city's records through online portals and allow their use as machine learning training sets, understanding how BIM-based consenting flows work in practise and how technologies like internet of things (IoT) can work in monitoring workflows

- **Next Generation IoT** – with the conversion of the city streetlights to LED there is now the opportunity for larger scale environmental sensing across the city

These initiatives combine to create the Wellington City Digital Twin – a digital copy and aspect of Wellington which can be used by the council, community, partners and contribute to a national digital twin.

What is happening in NZ and Internationally?

Figure 6: Virtual Wellington

International

Virtual Singapore

Singapore has invested S$73 million in its Virtual Singapore project, a digital three-dimensional city model that can be used as a test-bed by government agencies, businesses and researchers to build a more resilient city. The digital model will allow telecommunications companies to experiment with different wireless network deployment models to optimize coverage, help building owners identify the best places to install solar panels, and allow city planners to analyse pedestrian patterns to improve parks and evacuation routes.

Virtual Singapore offers four major capabilities:

- **Virtual Experimentation**
  Virtual Singapore can be used for virtual experimentation. For example, Virtual Singapore can be used to examine the coverage areas of 3G/4G networks, provide realistic visualisation of poor coverage areas, and highlight areas that can be improved on in the 3D city model.

- **Virtual Test-Bedding**
  Virtual Singapore can be used as a test-bedding platform to validate the provision of services. For example, the 3D model of the new Sports Hub with information within the Virtual Singapore could be used to model and simulate crowd dispersion to establish evacuation procedures during an emergency.

- **Planning and Decision-Making**
  With a rich data environment, Virtual Singapore is a holistic and integrated platform to develop analytical applications (i.e. apps). For instance, an app could be developed to analyse transport flows and pedestrian movement patterns.

- **Research and Development**
  The rich data environment of Virtual Singapore, when made available to the research community with the necessary access rights, can allow researchers to innovate and develop new technologies or capabilities. The 3D city model with semantic information provides ample opportunities for researchers to develop advanced 3D tools.

Figure 7: Virtual Singapore

Prime Ministers Office, Singapore, 2020

UK

With the launch of the Government Construction Strategy in May 2011, the UK Government committed to a digital future for construction. Considering benchmarking, value for money, new methods of procurement and elimination of waste, the Strategy laid the groundwork for the Digital Built Britain Strategy in 2015, updated budgets and strategy papers in 2016, culminating in the National Infrastructure Commission Report: Data for the Public Good and establishment of the Centre for Digital Built Britain (CDBB) in 2017.

Established as a partnership between Government, industry and academia, the CDBB is tasked with delivering a smart digital economy for infrastructure and construction for the future and transform the UK construction industry's approach to the way it plans, builds, maintains and uses its social and economic infrastructure. CDBB vision is depicted in Figure 8.

International

In responding to the multi-billion pound opportunity identified in Data for the Public Good, the National Infrastructure Commission also identified the need for a digital framework for secure sharing of infrastructure data and a Digital Twin of Britain's infrastructure. Work is currently underway on these initiatives, with the information management framework to be completed this year.

The CDBB is open to all and several New Zealand-based individuals and organisations are actively participating in this world-leading initiative.

The Centre has seven core objectives:

1. To act as the custodian of the integrity of the UK BIM and Digital Built Britain Programmes across all the levels and to be recognised both nationally and internationally as that institution.

2. To liaise with national and international standard bodies to create and modify technical standards and protocols which remain relevant to UK needs and which support industry adoption and implementation of all levels of Digital Built Britain.

3. To develop an academic bridgehead to ensure that the Digital Built Britain programme is cognisant of new and emerging research and technological developments that will impact the built environment in the years and decades to come.

4. To track capabilities in the UK and elsewhere to ensure successful commercial exploitation of these new technological developments, identifying where capability investment may be required.

5. To develop and inspire an industrial community who, combined with academics and policy leaders, will provide leadership on adopting and implementing new digital approaches.

6. To co-ordinate and deliver a range of events and activities designed to engage industry in defining and adopting BIM, rethinking their business models and the ways in which they use technologies, data and analytics to deliver social outcomes through the built environment.

7. To ensure that findings and insights from the Centre and its engagement activities inform future policy, industrial practice, standards and research initiatives.

Figure 8: Vision for a Digital Built Britain

Build

Exploit new and emerging digital construction and manufacturing technologies, processes and techniques.

Secure, shared information, enabling clients, design teams, construction teams and the supply chain to work more closely together to improve safety, quality and productivity during construction.

Operate

Use real time information to transform the performance of the built environment and its social and economic infrastucture.

Smart asset management to predict and avoid disruption of services.

Digitisation of existing assets and infrastructure.

Design

Deploy digital techniques to design better performing buildings, homes and infrastructure.

Use good practice, secure by default, information management to get data right from the start.

CDBB, 2020

Integrate

Understand how spaces and services can improve citizen quality of life.

Feed that information in to the design and build of our economic and social infrastructure and the operation and integration of services they deliver.

Australia

Digital twins are being established by several Australian state government departments to better support planning and management of city assets. These are 3D virtual models of new precincts or entire cities hosted on digital platforms that aim to eventually integrate fundamental datasets such as aerial imagery, cadastral parcels with other critical information sources such as flood models, city or district planning zone constraints, 3d models of existing buildings and underground assets. Examples include the recently launched New South Wales spatial digital twin (see Figure 9), Fisherman's Bend precinct in Victoria, and the Virtual Brisbane geospatial platform that supports assessment of development applications through 3D visualisation of proposed buildings and infrastructure.

Figure 9: NSW spatial digital twin

CSIRO, 2020

Several states in Australia have created overarching strategies to move towards a digital future. The State of Victoria has recognised the value of asset information, creating the Victorian Digital Asset Strategy which mandates digital engineering and building information modelling across the entire lifecycle for all infrastructure assets (see Figure 10).

Figure 10: Victorian Digital Asset Strategy

VDAS Goals

The VDAS vision, priorities and key success criteria are underpinned by tangible short, medium, and long-term goals to realise valuable outcomes.

Short-term goals	Medium-term goals	Long-term goals
1-2 years	2-5 years	5+ years
• Release and gain support from the VDAS Strategic Framwork, VDAS guidance, and VDAS technical guides	• Ongoing updates to VDAS technical guides	• Implement the VDAS Competency Framework
• Maintain collaboration consistency across a range of Victorian Government departments	• Continue updates to VDAS Education Map - a comprehensive list of DE providers across Victoria	• Where necessary, refresh VDAS guidance and technical guides with contemporary best practice and lessons learned
• Provide support to the Victorian public service and related stakeholders in the uptake of the VDAS	• Develop the VDAS Competency Framework	• Leverage the VDAS for more effective Victoria-wide planning and decision-making
• Assist with the syllabus definition and rollout of the BIM TAFE courses in Victoria	• Continued sharing and capture of VDAS lessons learned	• Begin integration of innovative technologies, such as real-time sensors, Internet of Things (IoT), augmented reality, virtual reality, and predictive maintenance
• Rolll out Victorian DE Education Map	• Enhanced collaboration with supply chain	
	• Roadmap to intergration with asset management systems	

Victoria State Government - Office of Projects Victoria, 2020

All of these strategies recognise the need to address a range of areas in order to achieve their vision of enabling data driven decision making – collaboration between industries, organisations and government agencies; upskilling; establishment of common data environments and data interoperability standards; broad uptake of technology, and the establishment of innovation frameworks.

How do we get there?

There are a few steps that need to be taken to maximise the value from sharing and utilising the full range of New Zealand's infrastructure data.

These steps are:

Step 1	Recognition at all levels of governance and leadership in the infrastructure sector that realising the value of infrastructure data is essential to the well-being of all New Zealanders. This is done by standardising and re-using data and understanding its interconnected nature.

Step 2	Investment in the digital infrastructure and governance that support data standardisation and sharing.

Step 3	Support for ongoing and future programmes of work that continue to develop data standards and processes of coordination; data quality improvement; data sharing, data analysis and data visualisation.

Step 4	The creation of a partnership model to embed and invest across the public sector, industries and academia to embed data investment, sharing and governance.

Recommendations

Establish governance for this initiative. We recommend that this is driven by the New Zealand Infrastructure Commission and form part of its digital strategy.

Fund a national governance system to support industry sectors to develop, manage and publish their own data standards. This could be expanded over time to other sectors such areas as environmental and social data.

Create a national centre for supporting and coordinating industry testing, implementation, interoperability and research.

Develop a National Digital Infrastructure Model to facilitate planning, investment pipelines, resilience, emergency response and recovery coordination, etc.

Assist local authorities and other infrastructure owners in ways of implementing and fully benefiting from their data as well as the data from other organisations.

Next steps

It is recommended that a Steering Group is formed to investigate, promote and lead the activities required to maximise the value of infrastructure data.

The steering group should comprise representatives from:

Infrastructure Commission

Construction Sector Accord

Key Ministries: Treasury, Ministry of Business, Innovation and Employment, The Department of Internal Affairs, Land Information New Zealand, Ministry of Transport

Local Government New Zealand

New Zealand's largest cities (Auckland, Christchurch, Wellington, Hamilton, Tauranga, Dunedin)

Key utilities: NZTA, Three Waters, electricity, KiwiRail

Infrastructure Consultants and Contractors

Research units

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