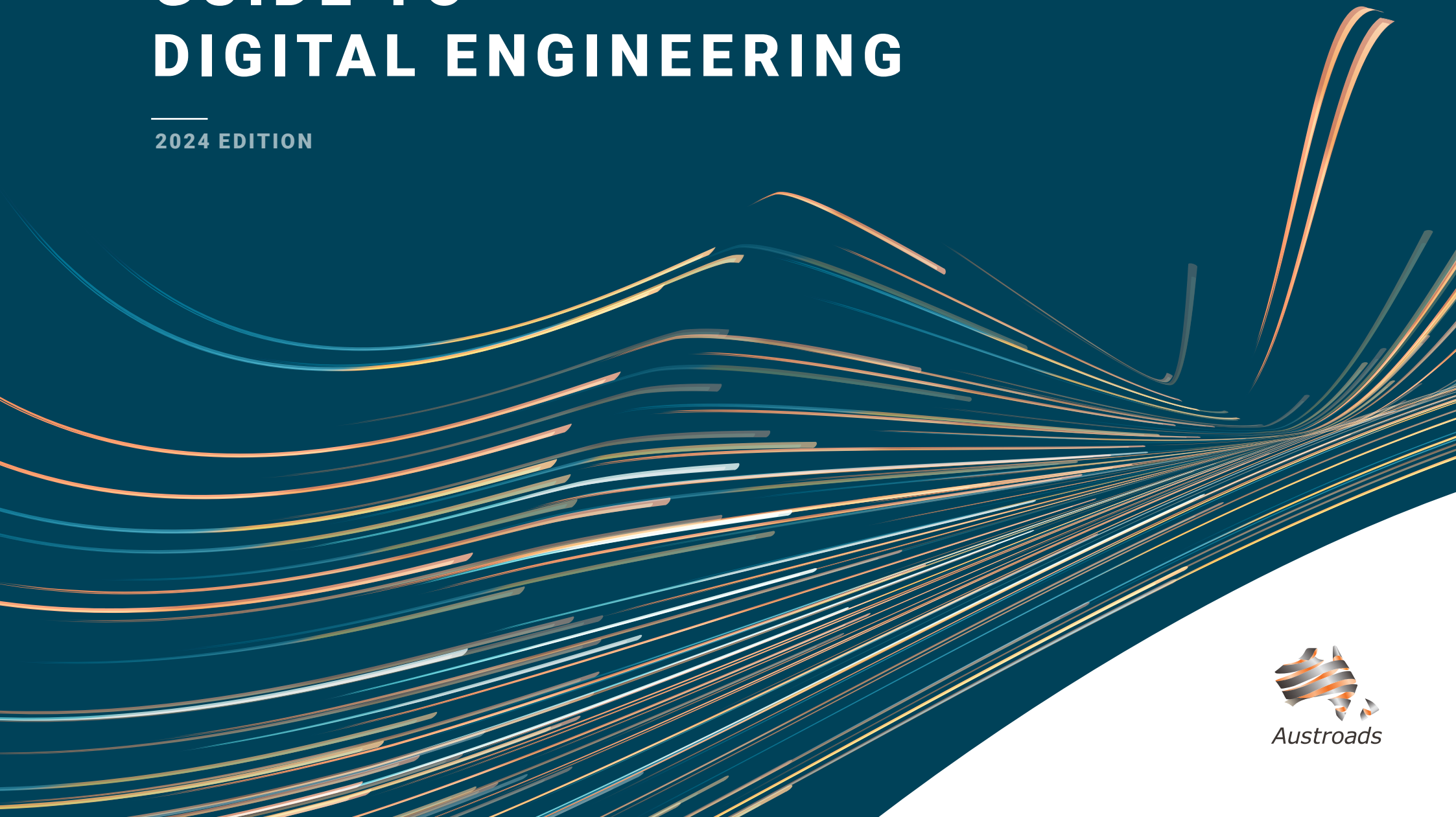
AUSTROADS

GUIDE TO DIGITAL ENGINEERING

2024 EDITION



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Abstract
The *Guide to Digital Engineering* is designed to assist transport agencies in Australia and New Zealand to deliver and operate their assets more effectively by obtaining better value and consistency in the application of digital engineering.

The guide communicates the need for a strategic approach to digital engineering alongside careful consideration and planning, clear engagement and support for its implementation. The guide identifies the importance of establishing a clear business case, governance, a roadmap for phased implementation, metrics and case studies to benchmark outcomes. A learning framework is recommended for continuous improvement and to manage both risk and value when implementing digital engineering.

The guide was developed following extensive engagement with industry and transport agency stakeholders and addresses the needs identified in the broad engagement.

Keywords
Digital engineering, digital strategy, business case, implementation planning, information management, learning and development.

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About Austroads
Austroads is the association of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Transport for NSW
- Department of Transport and Planning Victoria (Transport Victoria)
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department for Infrastructure and Transport South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development, Communications and the Arts
- Australian Local Government Association
- NZ Transport Agency Waka Kotahi.

CONTENTS

ACKNOWLEDGEMENTS

1. The concept of a DE guide originated from Austroads consultation sessions with Australian state and territories and New Zealand representatives held in 2018 and 2019. At these sessions, it was agreed that a guide was to be developed to assist government agencies with a range of DE areas, including justification and implementation. The Austroads Board agreed and approved the DE guide project.
2. A key foundation for the development of the guide was detailed consultation sessions with government, industry and representative specialist groups like building smart. A list of those who generously provided their expertise is given below.
3. Acknowledgement is given to agencies that are advanced in the DE journey, such as Queensland, Victoria, New South Wales, and New Zealand. Their support and feedback will significantly benefit emerging DE agencies. Given their advanced systems, some parts of the guide are valuable for context rather than detailed guidance.

SPONSOR

Austroads – For supporting the development of this guide for the benefit of transport agencies and its stakeholders.

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CASE STUDY PROVIDERS INCLUDING

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Logan City Council	Laing O'Rourke
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INTRODUCTION

SECTION 1:

INTRODUCTION

1.1 Overview

Digital Engineering (DE) enables enhanced precision, efficiency and adaptability across a broad range of industries. It empowers organisations to envisage, analyse, and optimise every aspect of their operations, from design to supply chain logistics and maintenance of built assets. As such, DE is more than just another technological advancement; it is the key to unlocking a new era of innovation, productivity, and economic growth. Investment in DE capability is not just an investment in technology, data and skills; it's an investment in the future of industry and the transport assets that support our communities. Increasing investment in DE capability, both internationally and nationally, seeks to address the significant industry challenges, including the need for improved productivity, asset resilience and increased demand, with the addition of exponential growth of data about these assets. All government agencies in Australia continue to develop clear direction and solutions to support industry transformation, with DE being a key enabler.

The Austroads board recognised the need to develop a DE guidance document to help support the strategic and technical application of DE across Australia and New Zealand (ANZ) transport agencies. Existing DE guidance, while comprehensive, has yet to create a step change in DE adoption in road and transport agencies within ANZ.

The term DE means different things to different stakeholders, and without an international standard definition for DE, this term has caused confusion within the ANZ transport sector.

One internationally recognised description of the process that DE typically seeks to achieve is described as follows with further industry and agency examples also provided in the Glossary of Terms section of this guide:

Use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions – (ISO 19650:1)

DE is often described using other terms, such as Building Information Modelling (BIM), Virtual Design and Construction (VDC), and Asset Information Management. Agencies should be aware that the industry may use several different terms to describe similar concepts, and they should agree on terminology and meaning within their organisation.

The impact of the built environment, the places and spaces created or modified by people, including infrastructure such as road, rail, energy, and water - is felt by everyone in their everyday lives, work, business, and play. It has a pivotal role in supporting sustainable economic growth, boosting competitiveness, and increasing quality of living.

DE has the power to change how organisations procure, design, deliver, hand over and operate assets, representing a significant driver of change. Over the past six years, governments in New South Wales, Victoria and Queensland have championed the use of DE. These individual DE programs have made a significant difference. However, there is a lack of a joined-up national approach and guidance to develop and implement DE strategies on transport projects and assets.

The aim of this guide is to provide a national approach and is primarily for government stakeholders who plan, create, and operate road assets. It provides guidance on planning, implementing, managing, and maintaining an effective DE strategy throughout the lifecycle of an agency's asset base. At the most summarised level, this document focuses on three key questions:

1. ***How to procure and build more effective assets through Digital Engineering?***
2. ***How to operate these assets more effectively through Digital Engineering?***
3. ***How to support agencies' strategic objectives through Digital Engineering?***

1.2 Chapter summary

This chapter presents a clear overview of the guide, including its scope, intended audience, and alignment with broader industry frameworks and standards. It also provides practical information on how to use the guide in real-world settings. By the end of this chapter, readers will gain a good understanding of the guide's purpose, the key concepts of DE and its potential benefits, such as increased efficiency and productivity.

1.3 Purpose of the guide

The purpose of this guide is to assist transport agencies in Australia and New Zealand to deliver and operate their assets more effectively through obtaining better value and consistency in the application of DE.

This guide can be used as a starting point for agencies that are beginning their DE journey and as a guide for the more digitally mature agencies. It provides guidance to executive and senior management to help understand, articulate, and communicate the strategic value in implementing a DE program, as well as to technical staff to help provide a specific (and nationally consistent) approach to obtain better value from implementing DE on projects.

Through extensive engagement with industry and transport agency stakeholders, Figure 1.1 provides an overview of what assistance agencies articulated they need to support them in developing their DE strategy and implementation. This guide is structured to meet this proportionate split of needs.

Figure 1.1 – ANZ agency requirements focus areas for this guide

1.4 About this guide

This guide assists transport agencies in planning and successfully implementing DE, helping them achieve their strategic business objectives. The guide first provides an overview for those seeking to understand what DE means for road and transport assets. It then offers a practical pathfinder on implementing DE, focusing on managing assets throughout the design, construct and operate phases.

This guide offers practical guidance for introducing DE to organisations from the perspective of various stakeholders. It also provides pointers on where to seek further guidance and assistance. The examples provided illustrate the implementation of DE on different types of assets and within various businesses.

Read this guide from the beginning to end to gain an overall understanding, using each chapter to navigate the pillars of a DE journey. Understanding the fundamentals of DE is vital before organisations embark on their journey. Reading this guide is a start and should be combined with building knowledge through discussing DE with other organisations and industry experts.

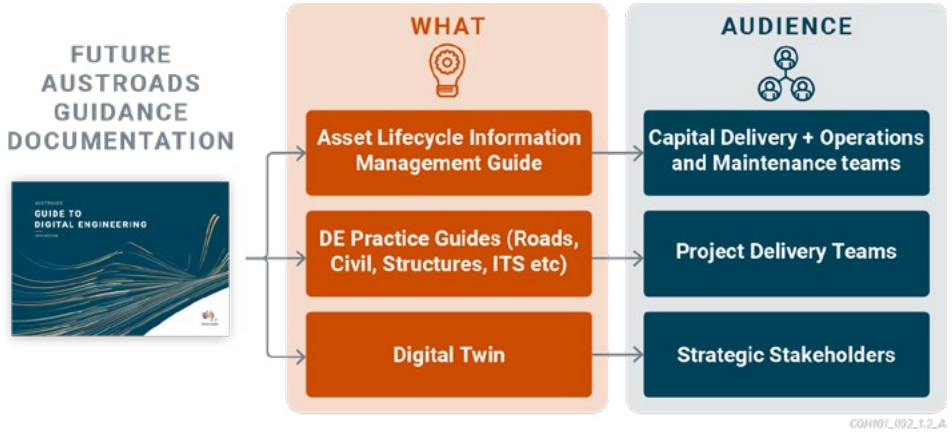
1.4.1 Content scope

This guide responds to the need for DE across the following infrastructure life cycle phases:

- Planning, Investigation and Design
- Construction and Commissioning
- Operations and Service Delivery
- Minor Works and Maintenance.

Figure 1.2 provides an overview of possible future Austroads guidance documentation that will support the ANZ transport industry.

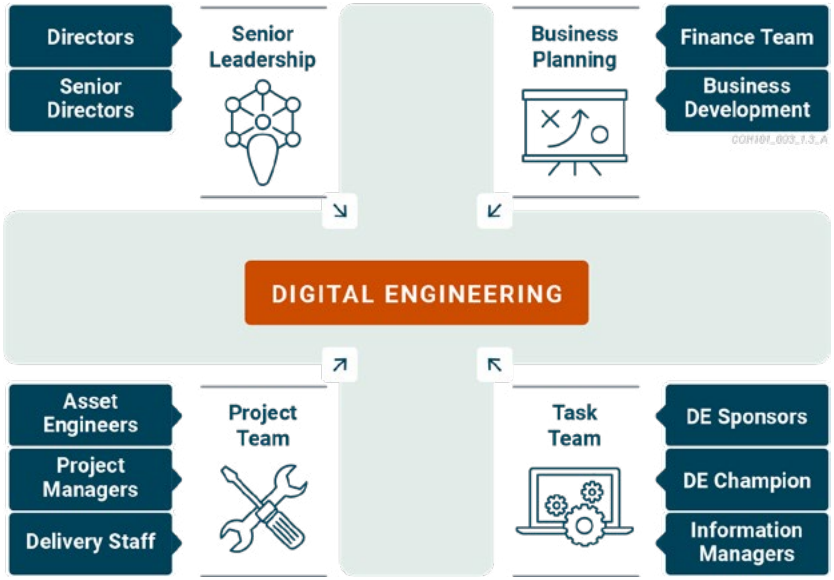
Figure 1.2 – Possible future Austroads guidance documentation



1.4.2 Intended audience

This guide sets out approaches to driving DE adoption across transport agencies. All chapters will be of value to stakeholders involved in DE planning and implementation; Figure 1.3 outlines some of the stakeholder roles.

Figure 1.3 – Intended audience for this guide



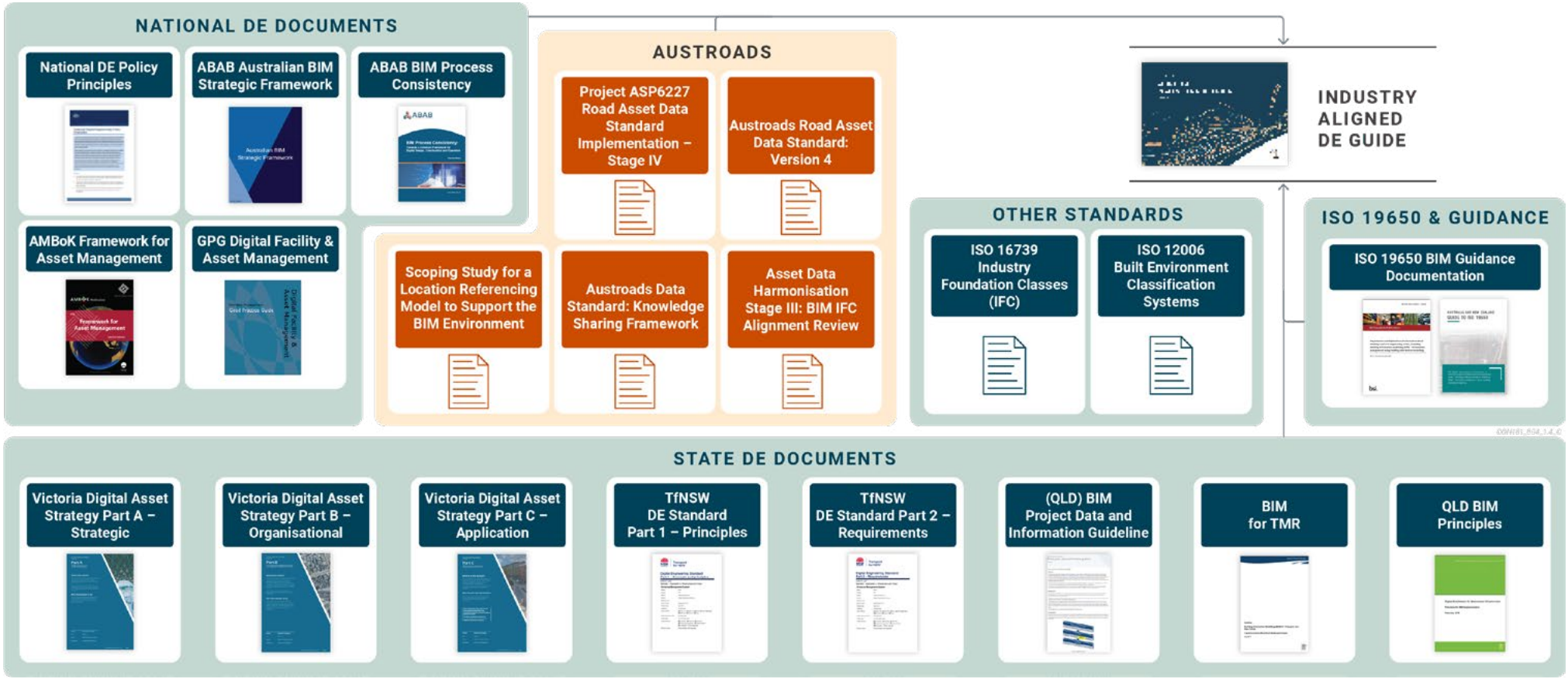
Each chapter includes a summary of the relevance of the content to typical roles as per the example in Table 1.2 provided below:

Relevance to my role (example)		
Reader	Essential	Helpful
Sponsor / key decision maker in the adoption and development of a DE strategy	✓	
Department head / key stakeholder in the adoption of a DE strategy		✓
Leading / supporting the development of a DE strategy	✓	
Leading / supporting the implementation of a DE strategy		✓
Adopting the new digital engineering practices		✓

1.4.3 Industry context

This guide is in the context of the DE policies, principles and frameworks, both global and local, as shown in Figure 1.4. This context is essential to enable future adoption across ANZ. Figure 1.4 provides an overview of the existing national and state government DE policy and guidance material available, ISO 19650 Parts 1-5 and the ANZ guide to ISO 19650, as listed in the references section of this guide. Importantly, this guide recognises the existing Austroads DE work to date and how this will support this guide along with several International documents (provided in the references section).

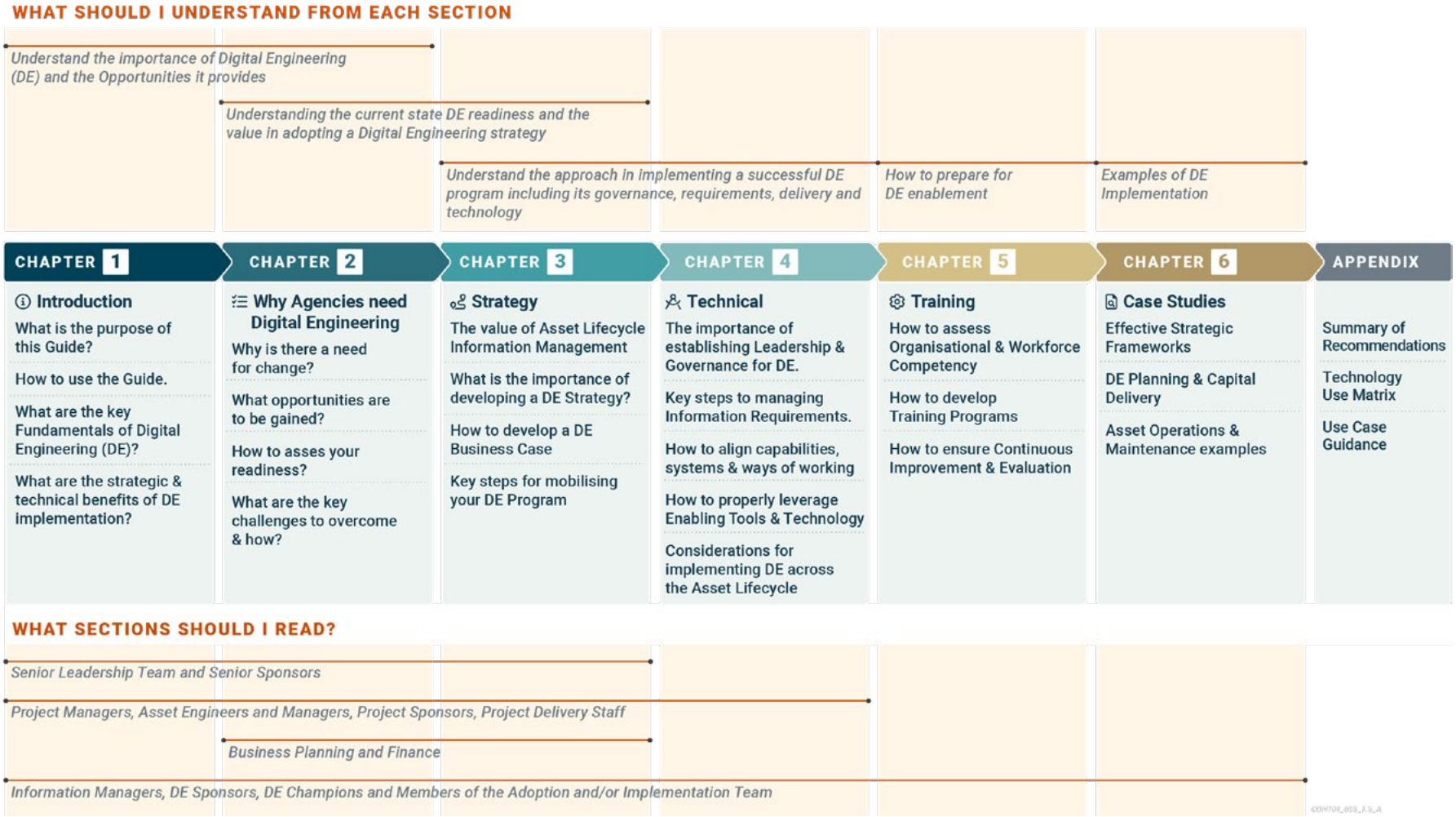
Figure 1.4 – Industry context in relation to existing DE/BIM documentation and the Austroads DE Guide



1.5 How to use the guide

Figure 1.5 shows the structure of this guide and its appendices. The figure also gives some context as to which sections of this guide are more relevant to the stakeholders within an organisation. While this guide is tailored specifically for road and transport agencies/asset owners, the recommendation is that they share and discuss it with their advisors and suppliers before embarking upon their DE journey.

Figure 1.5 – How to use this guide



1.6 Fundamentals of DE

Various sectors can apply the fundamental principles and approaches of DE. This guide is mindful of multi-modal transport and the commonalities in both priorities and disciplines across the different modes, including but not limited to road, rail, light rail and metro. Transport agencies are encouraged to share knowledge and lessons learned to assist in moving industry capability maturity in the application of DE forward, and the content within this guide may be of value to organisations involved in road and rail across Australia and New Zealand.

1.6.1 Key concepts

Key strategic and technical concepts are outlined below and in Figure 1.6, which support the successful implementation of DE in an organisation.

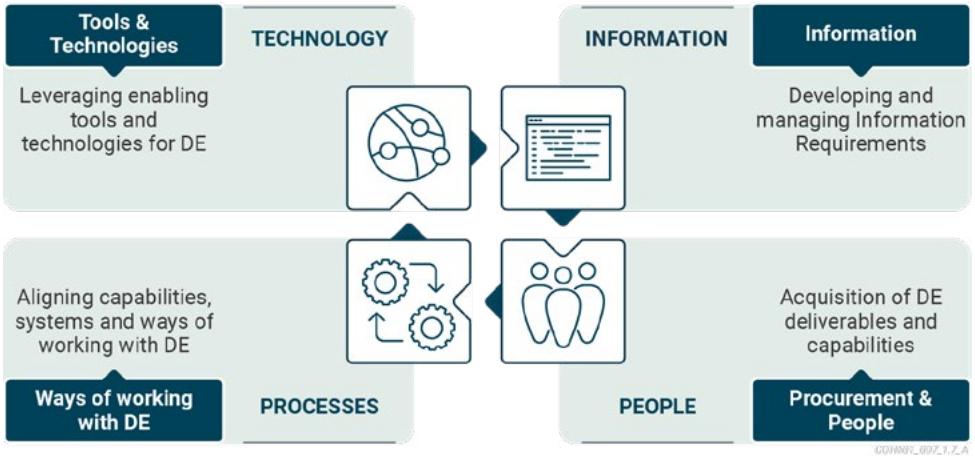
Strategic

- **Strategy –** The organisation needs to develop a clear strategy that defines the desired achievements from DE, along with the required capabilities and targeted benefits.
- **Business Case –** The organisation needs to have a clear understanding of the case for change.
- **Implementation plan –** The organisation needs to detail the key activities required to reach the target state/vision.
- **Transition to Business-as-Usual Process –** The organisation needs to clearly define its benefits realisation plan.

Technical

- **People –** People change, relating to culture and behaviours and specific roles and capabilities that may require attention.
- **Process –** Implementing DE across capital projects requires changes to processes and ways of working.
- **Information –** The information and data needed to enable the DE strategy to deliver benefits.
- **Technology –** Have standardised enabling technology capability in place to support the new ways of working.

Figure 1.6 – Key technical concepts for DE implementation



1.6.2 Benefits of adopting DE

The benefits of adopting DE have been widely published (refer to references section). These documented benefits are from a range of perspectives ranging from articulating risks, barriers and opportunities related to realising DE benefits. Without quantitative data to communicate DE benefits, narratives have limited use beyond raising awareness. These ranges can be dependent on the author's view and or publication. Building a strong case for DE within each organisation and project requires a consistent approach to measuring benefits.

BIM Level 2 Benefits Measurement Methodology (PwC 2018) is an example of a high-level measurement of outputs. The report was developed to help the UK Government, as a client, understand the value and benefit of BIM.

This guide sets a proposed methodology for measuring the overall benefits that result from the application of BIM Level 2. The methodology is focused only on the benefits; it excludes the costs to government construction clients and their supply chains associated with implementing BIM Level 2.

The findings from this work provided the UK Government with a clear indication that they could realise a 2% savings in capital delivery costs by adopting BIM. These savings were accrued from the following benefit categories:

1. time savings
2. cost savings
3. material savings
4. improved health and safety
5. reduced risk
6. improved asset utilisation
7. improved asset quality
8. improved reputation.

One key factor of the UK BIM Level 2 approach was the inclusion of 'openBIM' (see section 1.6.3) to improve interoperability and exchange of information. Adopting DE has clearly shown value and benefit to asset owners, as demonstrated through the global adoption of DE across organisations and major projects. However, you as an organisation need to understand what your individual challenges are before you can understand what benefits you can achieve.

1.6.3 The value of open standards

It is important that agencies consider developing and implementing open standards, openly accessible and usable by anyone, for DE across and between organisations. openBIM® is an approach developed over several decades and implemented successfully internationally and nationally by major projects and transport agencies in ANZ. openBIM is managed by the non-profit organisation buildingSMART International, which has chapters worldwide continuing to drive its adoption and development.

openBIM extends the benefits of DE by improving the accessibility, usability, management and sustainability of digital data in the built asset industry. At its core, openBIM is a collaborative process that is vendor-neutral. openBIM processes are definable as sharable project information that supports seamless collaboration for all project participants. openBIM facilitates interoperability to benefit projects and assets throughout their lifecycle.

openBIM empowers stakeholders to develop new ways of working by transforming traditional peer-to-peer work processes. By breaking down data silos, openBIM can greatly improve project delivery and asset performance. Firms that adopt an openBIM approach develop cross-party collaboration, enhanced communication and industry-standard exchange methodologies. This delivers better project outcomes, greater predictability, improved performance and increased safety with reduced risk.

Throughout the whole lifecycle of an asset, openBIM helps connect people, processes and data to achieve asset delivery, operation and maintenance goals. openBIM, alongside seamless digital workflows, make critical project information accessible to participants on a timely basis to support decision-making through various phases of the asset lifecycle, from inception to handover to refurbishment and even demolition. openBIM removes the traditional problem of BIM data that is typically constrained by proprietary vendor data formats, by discipline or by the phase of a project.

By adhering to international standards, namely ISO 16739, and working procedures, openBIM extends the breadth and depth of the use of BIM by creating common alignment and language. Technical applications developed for openBIM improve the management of data and eliminate disconnected workflows. Independent quality benchmarks ensure reliable open data exchanges.

openBIM permits digital workflows based on vendor-neutral formats such as IFC, BCF, COBie, CityGML, gbXML.

The principles of openBIM recognise that:

- Interoperability is key to the digital transformation in the built asset industry.
- Open and neutral standards should be developed to facilitate interoperability.
- Reliable data exchanges depend on independent quality benchmarks.
- Collaboration workflows are enhanced by open and agile data formats.
- Flexibility of choice of technology creates more value to all stakeholders.
- Sustainability is safeguarded by long-term interoperable data standards.

The benefits from utilising openBIM:

- greatly enhances collaboration for project delivery.
- enables better asset management.
- provides access to BIM data created during design for the whole life cycle of the built asset.

- extends the breadth and depth of BIM deliverables by creating common alignment and language by adhering to international standards and commonly defined work processes.
- facilitates a common data environment that provides opportunities for users to develop new workflows, software applications and technology automation.

1.7 Closing summary

DE offers significant opportunities to improve asset delivery, performance, efficiency and sustainability. It has the potential to maximise value through the life of the asset, deliver better value for operations, and better performance in less time.

DE is essential for the effective management of infrastructure assets. It can facilitate a more efficient use of shared data generated from each phase of the lifecycle. The guidance provided here contributes to developing a comprehensive understanding of digital engineering's lifecycle to maximise the benefits it provides. Given the different approaches needed by different organisations, this guide is a foundation upon which further exploration into the strategic planning and technical implementation of DE can be built.

Transport agencies should consider implementing a clear and impactful digital engineering strategy that will enhance operational effectiveness and efficiency over time while being aligned to an Asset Management Strategy. An increased understanding of DE can greatly assist in the adoption of best practices in a phased manner. Taking affirmative steps towards implementation now will ensure you are well-prepared for the future needs of your organisation.

The DE landscape is driving further improvements in the methods of transport projects and service delivery. From effective planning to implementation, digital engineering enables agencies to do more with less. This guide outlines fundamental considerations, examples and approaches designed to help transport agencies plan, apply and adopt DE. Some of the fundamentals for transport agencies to consider include:

1. Recognising the significant benefits gained from adopting DE and the value in measuring these benefits.
2. Understanding the value in investing in a collaborative and openBIM approach for improved efficiency and potential for long-term re-use of data.
3. Recognising the need for a structured, integrated and holistic approach to strategy and planning for the successful implementation of DE.

The successful implementation of DE has the potential to improve workflows and increase efficiency while reducing overall expenses and lead time on all projects. Although it requires effort and commitment from both government authorities and private transport companies alike, the time spent investing in respective strategies can continue to add value through continuous improvement for many years to come.

It is important to recognise the increasing need for DE and understand how it will shape the evolution of transport alongside the significant benefits gained through a well-planned strategy that can lead to the successful implementation of DE within an organisation and as part of the project and asset delivery cycle.

THE NEED FOR DIGITAL ENGINEERING

SECTION 2:

THE NEED FOR DE

2.1 Chapter summary

This chapter provides a clear overview on the macro challenges that both Australia and New Zealand face and an overview of the infrastructure strategies each country has developed to counter these challenges head-on.

It also provides an overview of agencies' DE programs, including the challenges that agencies and industry currently face while adopting DE. By the end of this chapter, readers will have a good understanding of the main DE challenges agencies face and the key recommendations for agencies to consider assisting them with their DE program.

Table 2.1 Chapter relevance to role summary

Relevance to my role		
Reader	Essential	Helpful
Sponsor / key decision maker in the adoption and development of a DE strategy	✓	
Department head / key stakeholder in the adoption of a DE strategy	✓	
Leading / supporting the development of a DE strategy	✓	
Leading / supporting the implementation of a DE strategy.	✓	
Adopting the new digital engineering practices		✓

2.1.1 Purpose of this chapter

This guide provides an overview of the infrastructure strategic objectives and focus areas for Australia and New Zealand, as well as a summary of the macro challenges and recommendations for agencies to consider for future planning of their DE programs. This chapter also provides information on the discovery process to understand the key challenges agencies and industry face with DE.

2.1.2 Why this chapter is important

Table 2.2 Section content summary

Section headings	What this section addresses:
2.2 The need for change to meet Australia and New Zealand's future infrastructure needs	Provides key information on both Australia's and New Zealand's infrastructure strategic objectives and focus areas.
2.3 Macro challenges for Australia and New Zealand	Provides an overview of the key macro challenges both Australia and New Zealand face.
2.4 Governments and agencies response to DE	Provides an overview of both Australia and New Zealand agencies' strategic plans for DE and how these input to the guide.
2.5 Approach to understanding the current challenges	Provides information on the discovery process to understand the key challenges agencies and industry face with DE.
2.6 Summary of agency challenges and key recommendations	Provides a summary of the challenges and the recommendations for agencies to consider for future planning of their DE programs.
2.7 Key recommendations	Provides key recommendations for Agencies towards establishing the need for DE.

2.2 The need for change to meet Australia and New Zealand's future infrastructure needs

While the Australian and New Zealand economies have fared comparatively well in the aftermath of COVID-19, both countries are now facing a number of macroeconomic challenges.

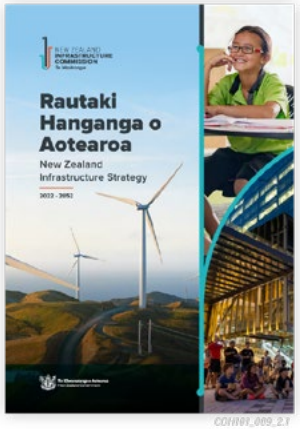
In this section, we take a closer look at some of these challenges and discuss how DE can help support these challenges. Macro challenges, such as rising inflation, weak commodity prices and rising levels of debt, are causing difficulties for policymakers in both countries.

These challenges are likely to persist in the short term. Both Infrastructure Australia and Infrastructure New Zealand have outlined their proposed approach and recommendations in responding to these challenges.

There have been record levels of infrastructure investment across Australia and New Zealand to support economic recovery from the still-unfolding COVID-19 pandemic, as well as natural disasters such as bushfires and floods. In Australia, $17.9 billion has been committed to new and existing infrastructure projects, increasing its 10-year infrastructure investment pipeline from $110 billion to over $120 billion. New Zealand has also committed $9.23 billion to its transport infrastructure investment for the 2023 financial year.

Austroads has sourced two documents from Infrastructure Australia and Infrastructure New Zealand, which outline their respective objectives and focus areas.

2.2.1 New Zealand Infrastructure Strategy (2022 – 2052)



New Zealand's infrastructure faces a historic period of deep and intergenerational change. Historic, because many of the challenges they face are new and uncertain; deep, because it impacts all parts of its society; and intergenerational, because the effort must be sustained, not over months and years, but over decades.

Almost every activity within society relies on infrastructure; the public commutes to work on transport networks that have been constructed and maintained by generations of New Zealanders.

The New Zealand of 2050 will be a very different place to live from the New Zealand of today. Within the next three decades its cities could be home to 1.7 million new people, roughly the size of another Auckland. Its regions will also face considerable change, with some parts of New Zealand growing while others will need to adjust to declining population.

Infrastructure New Zealand developed five strategic objectives based on their case for change (refer to Figure 2.1). These objectives represent the key actions NZ needs to do to achieve the vision of a thriving New Zealand.

1. **Enabling a net-zero carbon emissions Aotearoa** through rapid development of clean energy and reducing the carbon emissions from infrastructure.
2. **Supporting towns and regions to flourish** through better physical and digital connectivity and freight and supply chains.
3. **Building attractive and inclusive cities** that respond to population growth, unaffordable housing and traffic congestion through better long-term planning, pricing and good public transport.
4. **Strengthening resilience to shocks and stresses** by taking a coordinated and planned approach to risks based on good-quality information.
5. **Moving to a circular economy** by setting a national direction for waste, managing pressure on landfills and waste-recovery infrastructure and developing a framework for the operation of waste-to-energy infrastructure.

As part of these objectives we need to strengthen partnerships with and unlock opportunities for Māori

Figure 2.1 - Infrastructure New Zealand's five strategic objectives

2.2.2 Australian Infrastructure Plan (2021)

The 2021 Infrastructure Plan published by Infrastructure Australia recognises long-term infrastructure planning and decision-making are increasingly complicated by the pace of technological change, new consumer expectations and a changing climate.

It details how to build a stronger and more secure economic outlook by prioritising community outcomes, maintaining and enhancing people's standard of living and ensuring every city and region delivers world-class infrastructure for all.

Infrastructure that improves the sustainability of Australia and New Zealand's economic, social, and environmental settings can increase quality of life for all and be resilient to shocks and emerging stresses. This is achievable with a focus on adaptation to climate risk, building resilience, driving economic productivity, and embracing social equity.

The focus areas from the 2021 Infrastructure Plan provide a framework to implement these initiatives (refer to Figure 2.2):

Figure 2.2 - Focus areas from the 2021 Infrastructure Plan

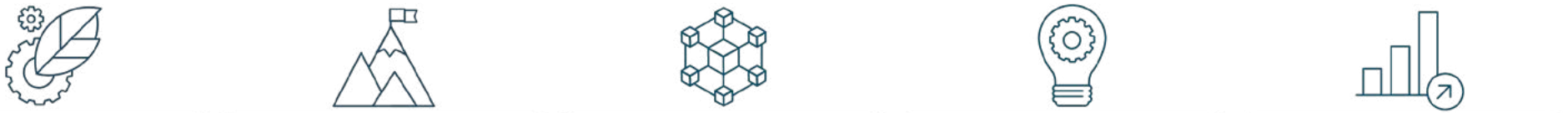
Focus area	Outcome
Place-based outcomes for communities	Unlocking the potential of every place.
Sustainability and resilience	Balancing infrastructure outcomes in an uncertain future.
Industry productivity and innovation	Facilitating a step change in industry productivity.
Transport	Delivering an integrated transport network.
Energy	Enabling an affordable transition to a net zero future.
Water	Prioritising safe and secure water.
Telecommunications and digital	Ensuring equality in an era of accelerating digitalisation.
Social infrastructure	Supporting economic prosperity and quality of life.
Waste	Accelerating Australia's transition to a circular economy.

2.3 Macro challenges for Australia and New Zealand

Australia and New Zealand face many existing and emerging macro-economic challenges. These challenges are well understood and recognised in key strategic artefacts, including the Infrastructure Australia and New Zealand infrastructure strategies.

Summarised from both documents – Figure 2.3 shows the key challenges which are most directly influenced by, and creates requirements of, the built environment. These key challenges set the ultimate objectives of this guide.

Figure 2.3 - Key built environment challenges in relation to the need for DE



Sustainability

Both Australia and New Zealand face challenges in terms of transport, waste management, and energy production. In addition, both countries are heavily reliant on imported goods, which can contribute to environmental degradation. Both countries are among the most urbanised in the world, with over 80% of people living in cities or towns. This can make it difficult to protect natural areas and encourage people to live more sustainably. We also have long coastlines, which makes us vulnerable to rising sea levels and extreme weather events.

Resilience

Australia and New Zealand are two of the most resilience-challenged countries in the world. From natural disasters to pandemics, the region has experienced its share of challenges in recent years. One of the biggest challenges facing the region is transport resilience. With such a large landmass and vast distances between cities, it can be difficult to keep essential goods and services flowing in the event of a disruptions. This was highlighted during the recent COVID-19 pandemic, when many businesses were forced to close due to supply chain disruptions. In order to build a more resilience region, it is essential that transport infrastructure is able to withstand and recover from disruptions.

Infrastructure

The transport infrastructure of Australia and New Zealand is facing a number of challenges including:

- The geographical size of both countries presents a challenge for infrastructure development.
- The transport infrastructure is aging and in need of upgrade and maintenance.
- There is a need to meet the increasing demand for transport services, particularly in urban areas.
- There is a need to improve the efficiency of the transport system, including through the use of technology.
- There is a need to improve safety and security.
- There is a need to address environmental concerns.

Ultimately, addressing these challenges will require significant investment in transport infrastructure.

Productivity & Innovation

Productivity and innovation are challenges for many countries, not just Australia and New Zealand. In a globalised and increasingly competitive world, it is essential for countries to find ways to improve productivity and innovation in order to remain competitive. There are a number of factors that can contribute to productivity and innovation, such as transport infrastructure, education and training, and the availability of capital. Countries that are able to effectively address these challenges will be better placed to compete in the global economy.

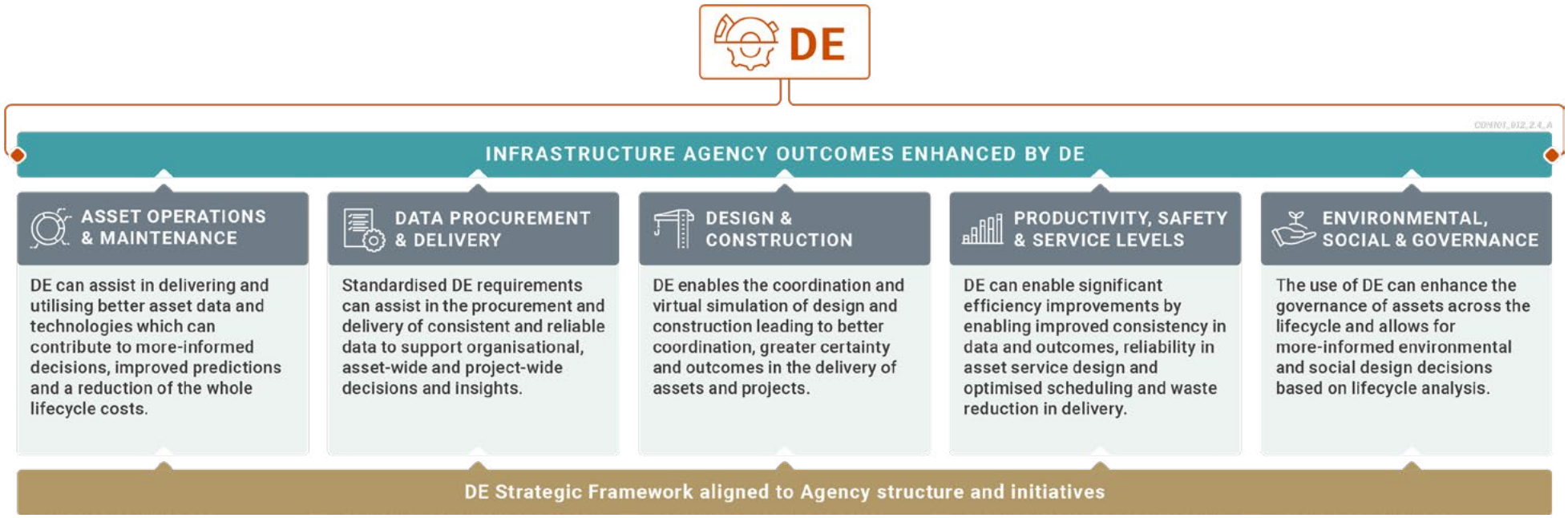
Fiscal Gap

Australia and New Zealand face a number of fiscal challenges in the coming years. One of the most pressing is the fiscal gap, which refers to the difference between government revenue and expenditure. This gap is set to widen in the next decade, as both countries continue to invest in transport infrastructure. Infrastructure costs are also rising, particularly in transport. This is due to the need to upgrade existing infrastructure as well as build new infrastructure to cater for population growth. These fiscal gap challenges need to be addressed in order to ensure the long-term sustainability of the Australian and New Zealand economies.

2.3.1 Opportunities for agencies to meet these challenges head-on

As transport agencies are increasingly focused on making their operations more sustainable and resilient, the need to take a comprehensive approach is becoming more critical than ever. DE can play a significant role in creating stronger, greener transportation networks but must be in conjunction with other initiatives such as operations and maintenance, procurement of materials and services, construction of new infrastructure projects, driving efficiency and cost-effectiveness across systems, as well as incorporating principles related to environmental sustainability into decision-making processes, as summarised in Figure 2.4. A holistic approach that takes all these factors into consideration will help ensure that DE leads to maximum benefit for today's and tomorrow's communities.

Figure 2.4 - DE as a key enabler to meet macro challenges



2.4 Governments and agencies response to DE

Considering the current and future challenges faced by Australian and New Zealand Governments and agencies, a series of artefacts and strategic documents have been developed to help meet these macro challenges head on with strategic plans. We have documented and grouped these strategic plans plus agencies DE strategies to highlight how the guide can support each agency with their respective DE programs as summarised in Figure 2.5.

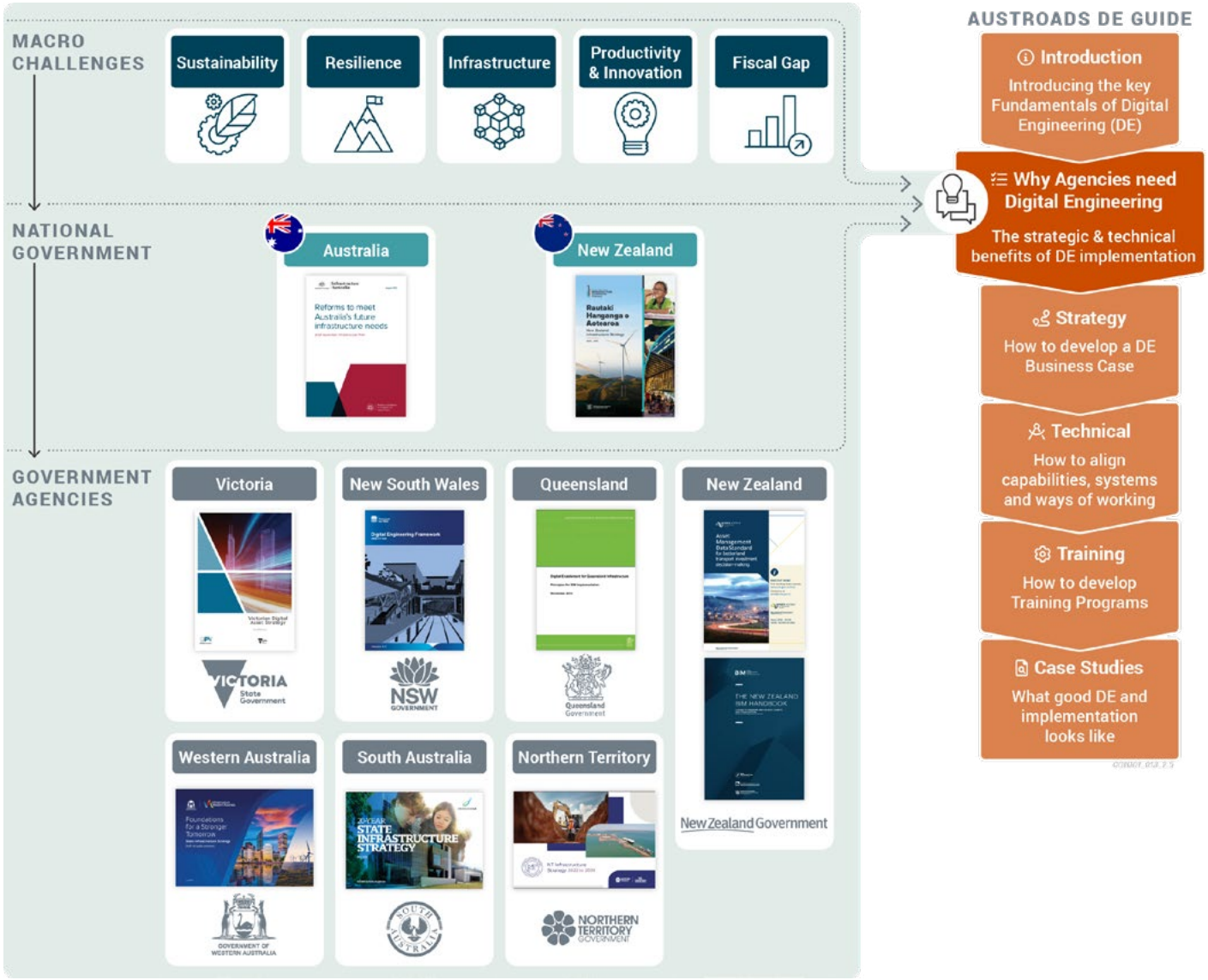


Figure 2.5 - How the guide suports agency DE programs

2.5 Approach to understanding the current challenges

Section 2.5 provides an overview of the various agencies that have developed DE strategies. To help develop this guide, Austroads needed to understand how these strategies are performing, what challenges agencies face in implementing them and how the supply chain responds to these new requirements.

2.5.1 Overview

The purpose of the discovery process is to establish an agreed record of a cross section of stakeholders as to the current assessment/position of DE maturity across all ANZ road agencies, clearly identifying opportunities, challenges and root causes. To ensure that this guide provides solutions to the current challenges that ANZ transport agencies face with DE, Austroads engaged with both agencies and the supply chain. The engagement took three forms of consultation as outlined in Table 2.3:

Table 2.3 - Engagement approach for agencies and supply chain in developing this guide

No.	Form of consultation	Description
1	Transport agency key personnel consultation – Strategic stakeholders	Business and strategic leads were consulted in a session to gain an understanding of where are they on their DE journey, why are they adopting DE and understanding how this guide can help them solve some of their issues.
	Transport agency key personnel consultation – DE Leads	• DE leads from each ANZ transport agency were consulted during two sessions. • The first session was an initial introduction to the Cohesive team and to the project. • The second session was a more targeted session to gain an understanding of where are they on their DE journey, how they are implementing DE on their projects and understanding how this guide can help them solve some of their issues.
2	ANZ Transport agency survey	• A survey was distributed to ANZ transport agency stakeholders putting open-ended questions to them to help understand the current challenges they face in developing DE strategies and implementing DE on their projects. • The survey was distributed via the DE leads within each ANZ agency. • The purpose of the information capture, from this method of consultation, was to ensure all members were provided with the opportunity to influence the guides content.
3	Industry workshops (engineering consultants, contractors and Industry groups)	Austroads hosted three industry workshops that had representation from (engineering consultants, contractors and Industry groups). These workshops focused on three key areas in understanding the current strategic challenges of DE, technical challenges of DE and the strengths and weaknesses of current DE standards from NSW, QLD, TfNSW and ISO 19650.

2.5.2 Agency key consultation meetings

Austroads conducted targeted stakeholder meetings with the DE leads from different jurisdictions across Australia and New Zealand as part of the discovery phase, as depicted in Table 2.4 opposite.

The purpose of meeting key stakeholders was twofold:

- To understand the current strategic and technical challenges that each transport agency is facing in implementing DE on their projects.
- To seek advice on how the guide could support them in their DE journey.

Figure 2.6 provides an overview of how each department, agency, delivery authority and company saw the guide could support their respective DE journey.

Figure 2.6 – ANZ agency requirements focus areas for this guide

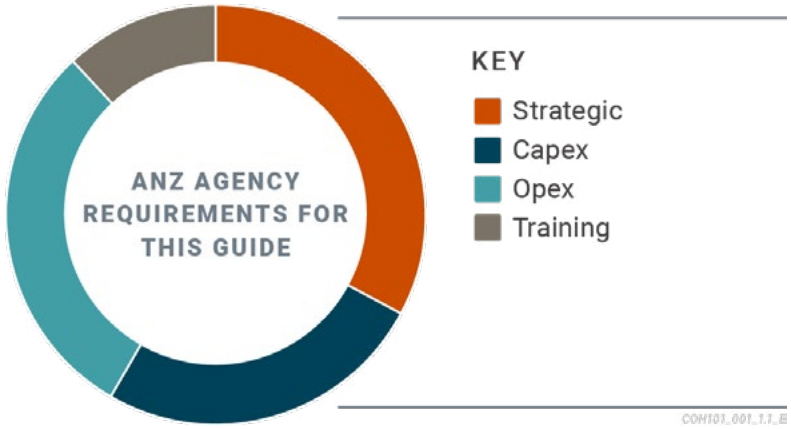


Table 2.4 - DE Lead stakeholder engagement coverage

Department, agency, delivery authority and company
Transport for New South Wales
Department of Transport Victoria
North East Link Victoria
Office of Project Victoria
Queensland Department of Transport and Main Roads
Main Roads Western Australia
Department for Infrastructure and Transport South Australia
Department of Infrastructure, Planning and Logistics Northern Territory
Transport Canberra and City Services Directorate, Australian Capital Territory
New Zealand Transport Agency
Kiwi Rail
Inland Rail
Transurban

2.5.3 Agency survey - key findings

The purpose of the survey was to capture current strategic and technical challenges in implementing DE on projects and to assess current capability around people, process, information and technology. Austroads invited each agency to send out the survey to anyone involved in DE projects (i.e., project director, project managers, engineers, technicians, designers) within their organisation. 30 responses were received and completed by stakeholders within the following agencies:

- Department of Transport and Main Road - QLD
- Department of Transport Victoria
- Transport for NSW
- Kiwi Rail
- Rail Projects of Victoria.

Figures 2.7, 2.8 and 2.9, provide an overview of the agency survey results.

Figure 2.7 – Agency survey results for DE capability

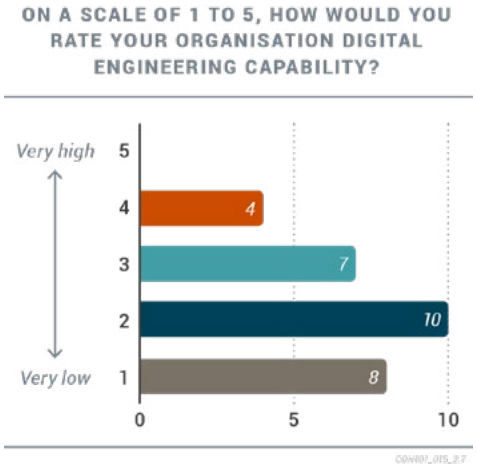


Figure 2.8 – Agency survey results for Value of Information. **Average: 2.2 (Low)**

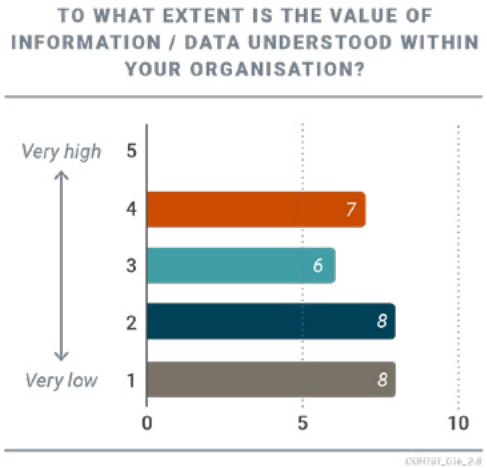
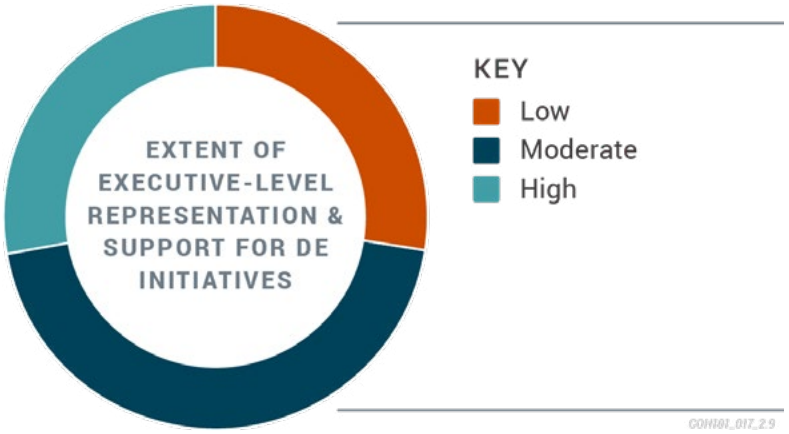


Figure 2.9 – Agency survey results for DE support from executives. **Average: 2.4 (Moderate)**



2.5.4 Industry engagement – key findings

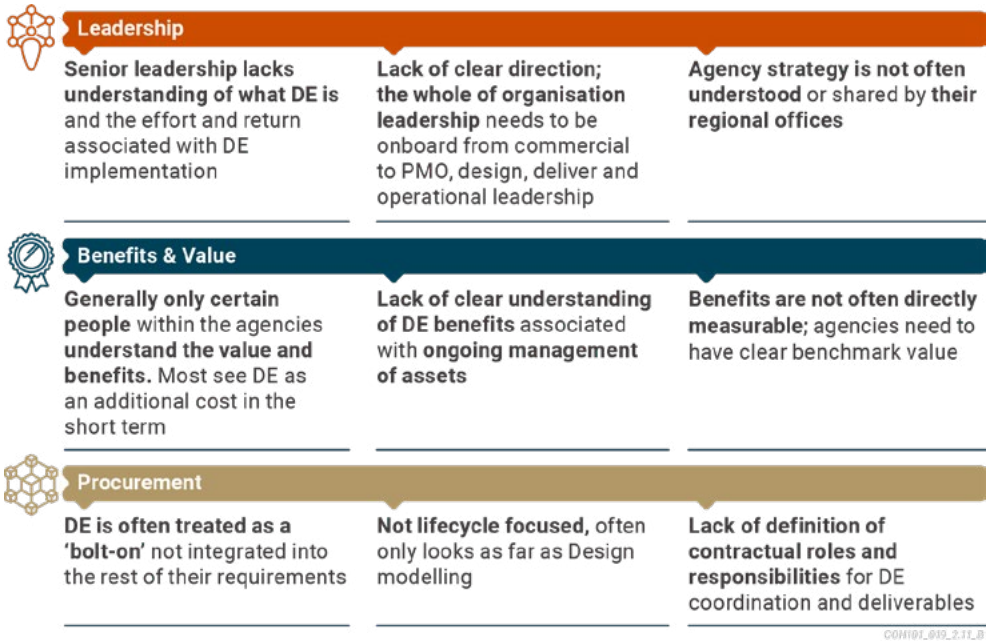
Figure 2.10 – Stakeholder groups consulted as part of Industry engagement

To realise the full benefits and to ensure this guide will help meet industry needs, stakeholders were invited from across the transport industry to share their experiences around the adoption of digital processes for the delivery of transport projects and maintenance of assets, and to capture current strategic and technical challenges. There were three interactive online sessions (1.5 hours) with engineering and consulting firms, contractors and broader industry associations and software vendors as identified in Figure 2.10.

A summary of strategic and technical implementation challenges from these sessions are shown in Figures 2.11, 2.12 and 2.13.

Strategic

Figure 2.11 – Summary of strategic implementation challenges



Technical – DE implementation

Figure 2.12 – Summary of technical implementation challenges (people and process)

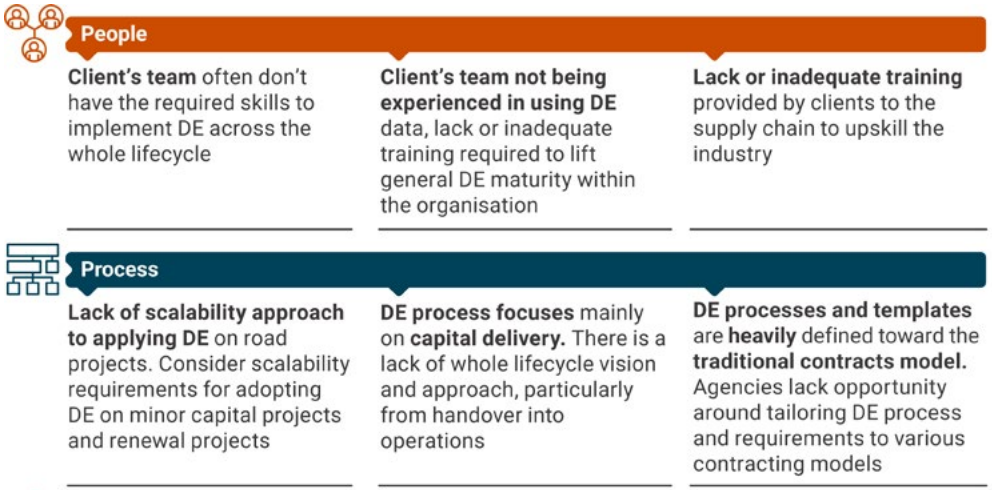
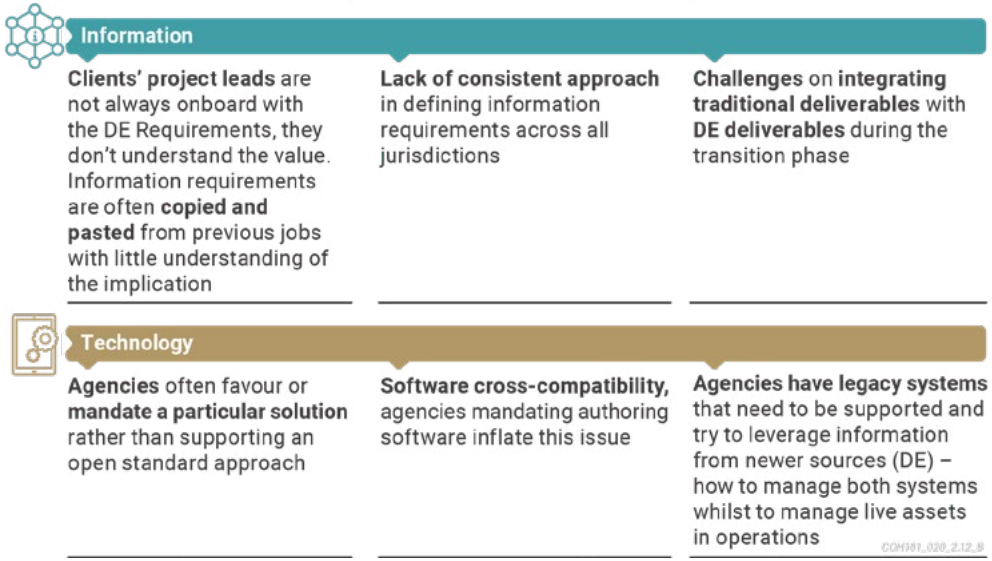


Figure 2.13 – Summary of technical implementation challenges (information and technology)



2.6 Summary of agency DE challenges and key recommendations

2.6.1 Agency DE challenges

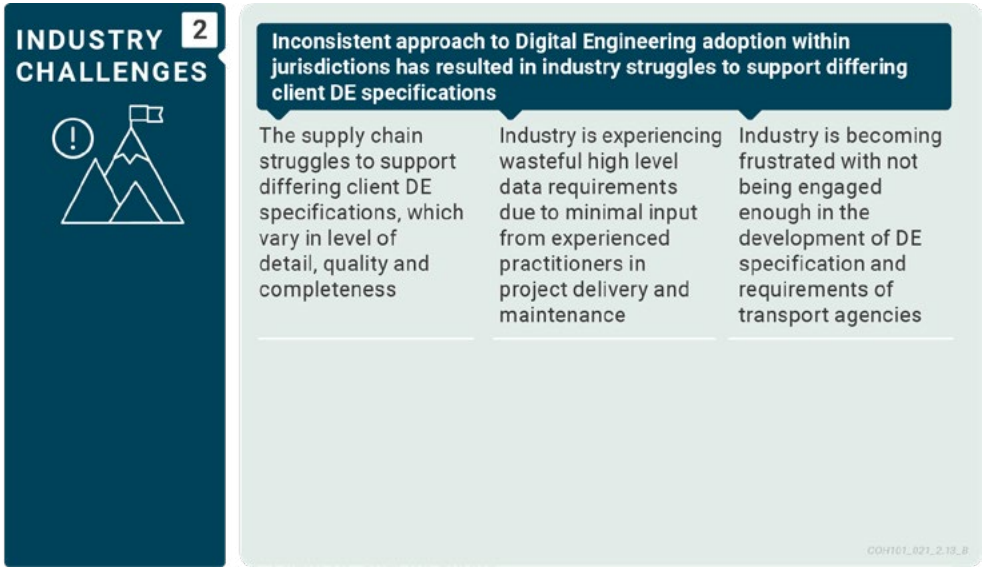
Transport agencies around Australia and New Zealand have started to recognise the challenges and opportunities related to digitisation, and a few have initiated programs linked with unlocking its potential. The summary of the findings from the discovery process of developing this guide focuses on the perspective of an agency (pull) and the supply chain (push) and are further identified in Figures 2.14 and 2.15:

Figure 2.14 – Agency challenges identified through engagement

As transport agencies around the world continue to embrace digitisation, they face both challenges and opportunities. Technology advancements have greatly impacted how transportation is thought about and managed. As a result, transportation agencies are constantly looking for ways to improve their operations and services. However, the implementation of digitisation is not without its challenges.

One of the main challenges transport agencies encounter when implementing digitisation is gaining buy-in from stakeholders. This includes both internal and external stakeholders such as employees, government bodies, and customers. The idea of implementing new technology can be daunting for some, especially if it means changing established processes and routines. To overcome this challenge, agency leaders must communicate the benefits of digitisation and address any concerns or resistance from stakeholders. They must also ensure that all stakeholders have the necessary knowledge and skills to effectively utilise new digital tools.

Figure 2.15 – Industry challenges identified through engagement



One of the main challenges that many industries face with digitisation is implementing a consistent approach. With so many different technologies, platforms, approaches and standards available, it can be overwhelming for companies to choose the right combination that suits their needs. This leads to inconsistency in how some processes are digitised and in different ways while others remain traditional, resulting in disjointed workflows and inefficiencies.

2.7 Key recommendations

With the current macro challenges Australia and New Zealand face in delivering infrastructure to support growth, plus the challenges identified during the discovery process in developing this guide, the key recommendations are as follows:

Recommendation 1 – **Ensure that agency DE program has executive buy-in and aligns to business strategy**

The success of any agency DE program is dependent on executive buy-in. Without it, programs will find themselves with limited resources and insufficient support from key decision makers, potentially resulting in the abandonment or complete disregard of the program; furthermore, the DE program must help and bring to life the agency's business strategy for the DE program to be successful.

Recommendation 2 – **Have a strategy and business case – not just a plan**

Too often, organisations embark on a DE initiative with little more than a plan. They may have a vague idea of what they want to achieve and how they want to use DE, but they lack a clear strategy and business case. As a result, they can quickly become bogged down in the details of technical implementation, losing sight of the bigger picture.

For a DE initiative to be successful, it must start with a sound strategy that considers the unique business needs of the organisation. Once the strategy is in place, the organization should utilise it to develop a detailed business case that outlines the costs, benefits, and risks associated with the project. Only then can an organisation create a plan that will guide the implementation of its DE initiative.

Recommendation 3 – **Influence standards adoption through policy and procurement**

Agencies have two key levers to invoke change within their projects and supply chain. Agencies need high quality information from their supply chain, and without a consistent and standardised approach, agencies will struggle to procure the high-quality information they need to manage their assets. Agencies can mandate the use of standards (ISO 19650) to help ensure that the products and services meet their requirements, and the information is compatible with agencies' systems.

Recommendation 4 – **Ensure that your operations and maintenance teams are part of your DE strategy**

For as much progress as organisations have made over the past decade about DE, even the most ardent DE adopters have neglected what is perhaps the most vital component of any project—operations and maintenance processes and procedures.

It is vitally important that your operations and maintenance teams input into the development of asset information requirements to ensure there is a seamless transfer of information at the handover stage.

Recommendation 5 – **Have a clear plan for the trailing edge of industry**

It is clear from a healthy open market that there is innovation and opportunity in the sector. From investments already being made by key suppliers, the leading edge of the industry is busy understanding and implementing DE. It is the trailing edge that needs help and clear targets.

The recommended approach is to work collaboratively with the Tier 2s and 3s to help build capacity and capability to ensure delivery of information to agencies and also ensure that no suppliers are unduly penalised.

Recommendation 6 – **Help the supply chain by understanding your DE program**

When engaging with your supply chain about DE, it is important to understand your supply chain's DE capacity and capability. Furthermore, consider assisting your supply chain in understanding why your DE program is important, what your DE program is and finally, how your DE program will impact future contracts.

The government, as a client, has a responsibility to assist the supply chain, where possible, to help build industry DE capacity and capability. This engagement will help to identify/mitigate any potential risks or challenges that could impact the successful delivery of DE projects from your supply chain.

Recommendation 7 – **Be very specific with what you ask for from the supply chain**

The supply chain has become very adept at producing information for the delivery of specific parts of an asset. Issues arise not generally in the individual businesses but where they interface with others or have to deliver a composite set of information from across the supply chain. The contract requirements must be specific regarding deliverables and responsibility for delivery to include clear roles and responsibilities, assurance requirements including consistent ways of working, information and data requirements and clarity about the administration, access and configuration of enabling technologies.

Recommendation 8 – **Measure and report benefits**

Measuring and reporting benefits is an important part of your DE program. Benefits can take many different forms, including improved efficiency, or reduced costs etc.

In measuring and reporting benefits to maximise the benefits of a project, it is essential to first identify the DE goals and objectives that are most important to the organisation. Once identified, a plan can be put in place to track and measure progress against these goals. Organisations can utilise this data to generate

reports that show the benefits of the project. By taking the time to measure and report benefits, organisations can ensure that they are getting the most out of their DE program. Furthermore, agencies should consider their approach to, and need for, incentivisation and penalties, i.e., commercial drivers to support consistent results across various projects and suppliers.

2.8 Closing summary

The Australian and New Zealand governments and agencies have identified the need for change to meet future infrastructure needs. Austroads guide to DE can support these objectives. To date, there are several challenges that agencies and industry face when it comes to implementing DE; the key recommendations put forward in this report will help overcome some of these challenges.

In addition to these recommendations, Chapter 3 – Strategy, provides agencies with key advice to:

- **Develop a DE strategy and roadmap** – Provides key information on why a strategy is required, what the strategy entails and how you can develop a strategy.
- **Develop a business case for DE** – Provides key information on why a business case is required, what the business case entails and how you can develop a business case.
- **Mobilise your DE program** – Provides key information on how an agency can plan and prepare to mobilise its DE program.
- **Deploy pilot programs** – Multiple pilot projects prior to full adoption. Risk based approach to which projects should be DE projects and those not required to leverage DE and measured.
- **Assess scale of adoption and procurement approaches** – Consider the scale of DE adoption including the contracts/commercial and procurement models and aligning this with current and emerging DE adoption.

DEVELOPING A STRATEGY FOR DIGITAL ENGINEERING

SECTION 3:

STRATEGY

3.1 Chapter summary

This section of the guide covers the development of a DE strategy and supporting business case. As noted in section 2, many agencies have started their DE journey; take this into context while reading this section.

Table 3.1 Chapter relevance to role summary

Should I read this section to help in my role?		
Reader	Essential	Helpful
Sponsor / key decision maker in the adoption and development of a DE strategy	✓	
Department head / key stakeholder in the adoption of a DE strategy		✓
Leading / supporting the development of a DE strategy	✓	
Leading / supporting the implementation of a DE strategy		✓
Adopting the new DE practices		✓

3.1.1 Purpose of this chapter

This chapter explores the purpose of the strategy to create a vision and rich picture of how DE will look and feel to various teams within an agency as an intelligent client and operator and the supply chain, exploiting the latest technologies, digitalised ways of working, and data-driven decision-making across multiple activities and asset types to deliver the efficiencies needed to be successful.

The strategy will present the current business state and future state, with a clear articulation of why they are needed. In turn the strategy supports an agency's wider strategic objectives and pillars.

A roadmap will present how an agency can move from the current ways of working to the new ways of working in a series of achievable stages with clear business benefits associated with each stage.

Without a DE strategy, agencies risk making reactive decisions based on current circumstances rather than long-term planning. This can lead to missed opportunities and a failure to capitalise on strengths.

Additionally, without a strategy, it can be difficult to measure progress and assess whether goals are being met. Without a clear strategy, agencies also risk the duplication of effort and resources as different departments, or divisions pursue conflicting objectives. To be successful, an agency needs to have a clear plan that

takes into account their unique circumstances and sets out a path for achieving their goals.

Figure 3.1 below illustrates the typical steps towards establishing the case and roadmap for DE implementation, which includes understanding the drivers and current state, developing a vision, strategy and business case, and to ultimately mobilise your DE program.

Figure 3.1 Key steps to developing a strategic approach to implement DE.

3.1.2 Why this chapter is important

Table 3.2 Section content summary

Section headings	What this section addresses:
3.2 Why is a program and strategy required?	Provides key information on why a DE program and strategy is required and the challenges this will address
3.3 Developing a DE strategy and roadmap	Provides key information on what developing a DE strategy entails and how you can develop a strategy
3.4 Developing a business case for DE	Provides key information on why a business case is required, what the business case entails and how you can develop a business case
3.5 Mobilising your DE program	Provides key information on how an agency mobilises its DE program
3.6 Key recommendations	Provides key recommendations for agencies in developing a DE strategy

3.2 Why is a program and strategy required?

Several agencies and supply chain organisations actively engaged in developing this guide to understand their current DE practices and the challenges they face in implementing DE. Refer to Figure 3.2 for the overarching challenges identified with some specifics provided below:

- Lack executive buy-in to DE – the link between DE and strategic business objectives is unclear.
- Lack of long term (10 -20 years) digital vision and mission.
- Typically, a lengthy payback period for investment in DE.
- Lack of budget to resource a DE program.
- Project Directors lack awareness and knowledge of DE; risk of change appears to outweigh near term benefits.
- Change associated with DE applies to a broad and complex set of stakeholders with differing readiness for adoption.
- Insufficient, compelling road-orientated use cases to highlight real DE benefits.
- Lack of authority and support to discontinue legacy processes, resulting in a duplication between DE and traditional project processes.

A DE strategy and supporting business case will address all these challenges by articulating – **WHY** change is required; **WHAT** are the new ways of working and digital capabilities, what will it cost and what are the benefits; and **HOW** will the new ways of working and capabilities be delivered? This approach supports the establishment of connections between the business objectives of the agency and DE, resulting in increased executive support and accelerated DE adoption.

Figure 3.2 – Key challenges identified implementing DE.

DE programs typically tend to focus on technological changes. The suggested methodology outlined in this section ensures that the strategy, with a supporting roadmap, is created, considering the development of digital capabilities for an agency across the full range of organisational requirements – Process, Organisation (people), Technology and Information (standards and actionable insight from data), typically known as the POTI model.

Additionally, the strategy and roadmap should consider the changes in commercial practices required to support the digital capabilities and new ways of working.

Agencies should not focus solely on developing a DE strategy but try to develop a plan and gain approval for an effective DE implementation. The process involves understanding the problem or problems, including any parent problems, seeking to be solved and how DE can enable or outright solve these with consideration of key outcomes. The following areas were identified by the stakeholders engaged in the development of this guide as key areas of focus for an agency's DE strategy and planning to address:

- **Enhancing the delivery of work:** execute the work more safely and efficiently.
- **Specifying asset data:** asset data specified that responds to a system and not the other way around. Ie part of the strategy is to keep working on designing the asset management system along with the Asset Information Requirements (AIR).
- **Utilising common language:** common language for government, industry for delivery, asset and other stages of the lifecycle.
- **Ensuring quality of data:** Include an overarching checking process. Ensure there is an approach to assurance where those who are disciples of this imposed approach are also responsible and actively engaged in addressing all the problems as early as possible.
- **Meeting legislative requirements:** Including safety e.g. we need to specify and be able to rely on the data e.g. safety handrails and fall arrest systems on tunnel projects.
- **Integration of systems:** This is significant in rail, tunnels but increasing in roads e.g. the integration of up to 100 digital systems on the UK crossrail project.

Note: that this is sentiment derived from the industry stakeholder engagement outlined in Chapter 2.

3.3 Developing a DE strategy and roadmap

This section explains methods for developing a DE strategy, the supporting business case and benefits management strategy, see Figure 3.1 above.

The recommended methods align with four key steps, see Figure 3.3 below, that establish where an agency is currently and where an agency wants to be. The remainder of this section is structured to follow the stages illustrated in Figure 3.3.

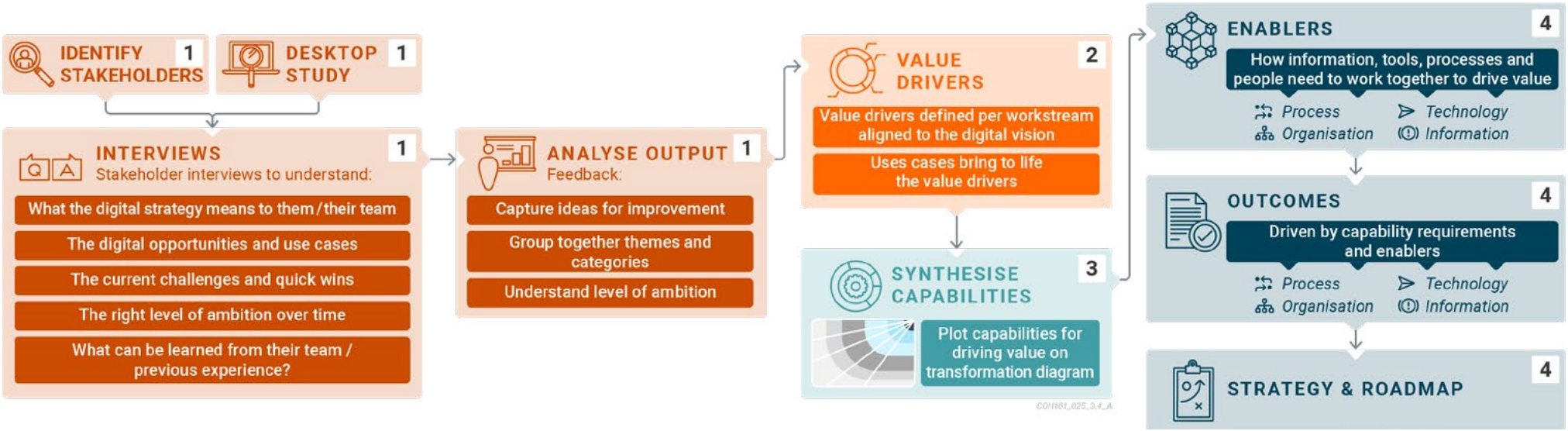
Figure 3.3 – Key stages in making the case for DE

The methods for making the case can be split across four key stages, as shown in Figure 3.3, to ensure that there is clarity on where an agency is currently and where they want to be.

Figure 3.4 below illustrates how the four key stages can be broken down into several linked activities ensuring that there is clear connection between the current state through to the digital strategy and the supporting roadmap. For clarity the stage numbers have been added to the activities.

The analysis of the discovery findings, as part of a state assessment, helps to identify use cases by going through section 3.3.2 and articulating them to value drivers for an initial set (or roadmap). Capabilities from these roadmaps can be developed and fine-tuned during each phase until they achieve maturity at a point in this process. However, it is important that you explain what needs these phases serve, mitigating confusion as to what was included or left out once everything is complete.

Figure 3.4 – Suggested methodology to deliver the four stages



Note: It is important to capture and leverage data from projects and departments for key insights and to conduct thorough root cause analysis to support the development, approval and execution of a DE strategy.

The development of a strategy is not just through consultation with managers and analysing their personal views. It includes looking at data on projects and across departments within an agency. It is important to measure and understand what is causing cost and time overruns, how is safety in design done and why some projects that apply DE still experience overruns. Root cause analysis and the careful and consistent measurement to identify the real trends and correlation are important to the initiation and ongoing success of an agency's DE strategy and roadmap. Chapter 6 of this guide shares some case studies on DE implementation and Appendix C explores how an agency might approach capturing benefits. Some common themes that may be strongly correlated to the success or failure of DE implementation include:

- significant lack of expertise and experience in procuring and managing consistent data including scope, execution and assessment
- lack of data-driven and objective decisions with thorough assessment of issues
- insufficient expertise and development of staging of projects for construction staging and traffic staging
- lack of experienced client representative with site experience and presence during the design and construction stages
- identification of risk areas that will cause time and cost impacts and how to mitigate
- identification of sources of water and continued management and the impact of weather conditions
- the need for consistently detailed investigation and staging design of utilities
- pre-planning and investigation of available materials for road, bridge and rail
- inconsistent quality of overseas imported materials and the cost impact of this.

Ultimately, developing a DE strategy and roadmap should include a baseline of current state and a collaboratively established shared vision to bring focus to the DE strategy and program. Furthermore, a clear plan of action to identify and close the gaps identified will help establish a progressive roadmap to help shape a DE program for capability uplift and to assist agencies in keeping on track towards realising the shared vision. These are all important considerations which are explored further in this chapter.

3.3.1 Establishing current state

The establishment of the current state relates to step 1 in Figure 3.3 above. The key activities to understand the current state comprise of:

- Desktop study – review of internal information and data to understand current ways of working along with agreeing on the scope of the discovery and supporting the preparation for workshops/meetings. In this stage the material delivered is used as the basis for agreeing the Discovery Scope, which in turn assists the development of an evidence base.
- Identify stakeholders from across the agency and suppliers as appropriate, representing the leadership, management, and technical levels.
- Conduct interviews and workshops to understand challenges in current ways of working and start to discuss individual/team's digital ambitions.
- Analyse outputs – capture ideas for improvement, group together themes and categories and understand the level of digital ambition.

Note: Executive approval to commit resources to undertake a current state assessment may need to be obtained.

The establishment of a true, current state is of the utmost importance, as findings emanating from the discovery activities provide documented evidence and/or justification for further intervention. Therefore, planned and structured discovery activities should align with methods used to carry out an element of academic research. This will ensure that the discovery activities are well documented and the interpretation of the results can withstand scrutiny, forming a golden thread of information between the current state and the proposed strategy and roadmap. A poorly planned and executed discovery is likely to result in a formed strategy which does not present a sufficiently strong case to justify a change program to adopt DE practices.

The discovery process is required to establish the shared ambition and understand the current challenges:

- Confirm the current 'as-is' position from a cross-section of stakeholders, clearly identifying opportunities and challenges and root causes of challenges.
- What is the desired end state and what are the logical interim steps?
- What are the specific steps/actions needed to get to the desired end state?
- What can the agency learn from others?

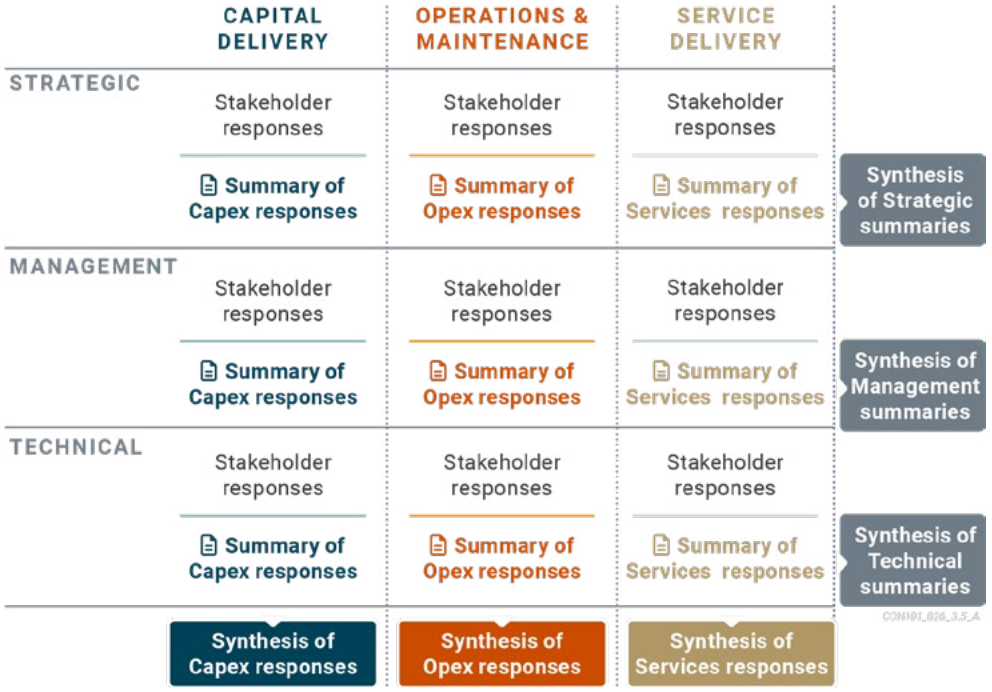
Information may be gathered by any combination of research, through carrying out a desktop study, along with questionnaires, interviews and workshops. To establish the current state and proposed to-be position, there is a need to understand the business needs against the current and future maturity levels. The discovery process, and in particular, the desktop study activity, requires knowledge and experience across several facets, and, as such, needs to be carried out by suitably experienced people who have a good understanding of the infrastructure sector.

The discovery approach should engage stakeholders across an agency comprising strategic leadership level, management level and technical level across the asset lifecycle i.e., operations, maintenance, project planning, and delivery along with internal business functions. The purpose of engaging across these three levels is to identify alignment and misalignment across the ambition, challenges, and root causes, all of which are important to understand.

In identifying stakeholders, it is important to consider the likely level of knowledge of the stakeholder in terms of what is DE. A level of background briefing may need to be provided to stakeholders in advance of any planned interviews so that they have sufficient awareness of DE and how it fits with the stakeholders' role.

Austroads have learnt that the discovery interviews are most successful when conducted as a conversation as opposed to asking a series of questions. This ensures that stakeholders remain engaged during the interview and allow the conversation to address key issues.

Figure 3.5 – Example of how to synthesise the findings both vertical and horizontally across and agency



However, to support the synthesis activity, a series of questions will need answering from strategic, management and technical levels. The team undertaking the interview, therefore, need to be well rehearsed to plan the 'conversation'.

The discovery process could also include assessing the digital maturity of an agency and key suppliers. Appendix A provides 22 maturity questions using the POTI model, which can inform the development of program specific maturity tools. An organisation with good digital DE will score above 80 points.

The discovery activity does need to confirm the digital capabilities and ambition of an agency's supply chain as it informs the design of the roadmap, including the commercial and training activities required to implement sustained change. As such, the discovery process may need to include interviews with suppliers, ensuring that representation covers the full asset lifecycle.

The process of synthesising the results of an information-gathering exercise identifies the root causes of challenges. A defined structure, often based on some initial research, is used to carry out this exercise. The analysis activity in Figure 3.4 represents this process. An example of synthesising the findings both vertically and horizontally across an agency is provided in Figure 3.5.

As noted previously the findings in the discovery phase set the foundation for the whole strategy. Therefore, it is important to fully document the findings from the discovery activities. Firstly, to ensure that the synthesis of the results and business needs reflects all stakeholders. Secondly, to substantiate their observations and recommendations to the business leaders, investment committees and stakeholders, the team should expect to be challenged.

Outcomes from completing these activities

The deliverables and outcomes from completing these activities are:

- Established understanding of how the agency currently operates.
- Establish the current state of digital maturity, challenges, needs and aspirations.
- Commence business change activities through providing context on the initiative to stakeholders.
- Findings will have been documented as part of maintaining a golden thread of data and information through the development of the digital strategy, ensuring not to miss points in subsequent steps and being able to substantiate recommendations.

3.3.2 Setting the vision

Establishing the vision state relates to step 2 in Figure 3.3 above. The key activities to understand the vision state comprise:

- develop a vision/strategy statement
- establish the value drivers
- understand the required capabilities
- develop a set of high-level use cases
- document how the agency will operate at key stages of the digital program to inform the next stage of developing the roadmap.

Note: Executive approval to commit resources to develop a vision may need to be obtained.

Developing a vision/strategy statement

The purpose of defining a vision is to provide an agreed focal point to the change program, setting a future horizon end state which the roadmap works towards. Not establishing a vision is likely lead to several challenges, including:

- The position of the strategy is unclear, and the leadership team are more likely not to understand why a strategy is required, leading to delays/problems in gaining approval of the strategy and the supporting business case.
- Increase likelihood of significant abortive work as key stakeholders have not provided timely input/missed the opportunity to form a consensus before the roadmap and strategy are developed.

Figure 3.6 – Example vision / strategy statements

Establishing the current state and the documenting of the digital ambitions of the stakeholders provides the necessary insights to be able to define a vision. Figure 3.6 provides several vision statements for client asset owner/operator organisations adopting digital working practices. Agencies may not create vision statements as they are not normally business practice. In these circumstances, a strategy statement, which has a more fixed end date compared to a longer-term vision statement, could be prepared.

The vision statement/strategy statement can be developed by the team developing the digital strategy and tested with stakeholders or developed as part of a workshop with key stakeholders / the program sponsor, where there are discussions about the outputs from the current state and the digital ambitions of the stakeholders before workshopping a program vision / strategy statement.

Value drivers

Alongside developing a vision, it is useful to develop a set of value drivers/guiding digital principles that enable both internal and external stakeholders to understand why an agency wants to adopt DE practices.

For this guide, the VDAS principals provide a foundation for an agency to develop their own value drivers/digital principles as shown in Figure 3.7.

Figure 3.7 – Victorian Digital Asset Strategy (VDAS) principles

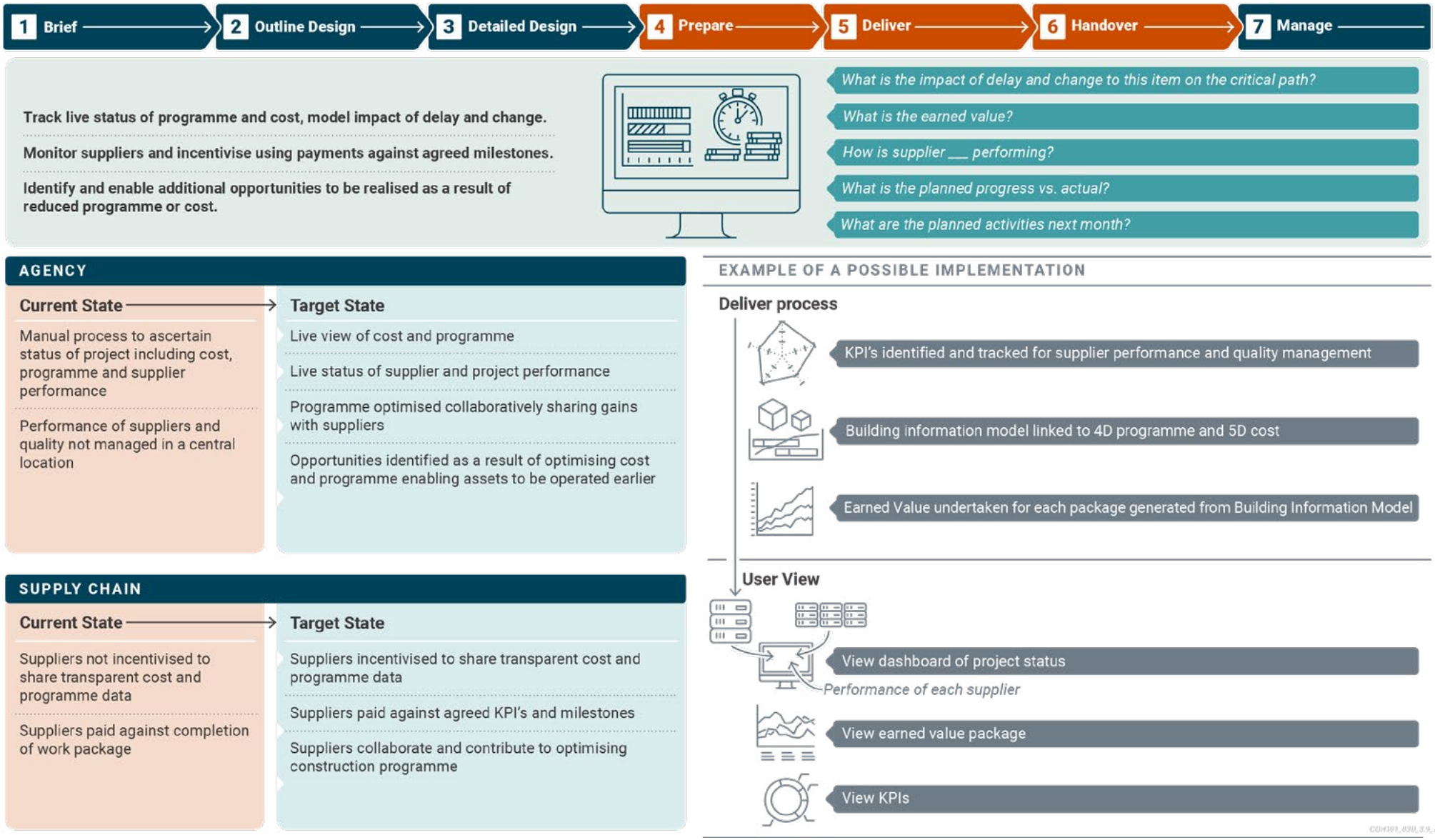
Use cases

Use cases provide a method to bring to life proposed new digital working practices across different teams within an agency and are useful in providing context to the value drivers. There are a variety of ways to develop use cases. Two examples, provided in Figures 3.8 and 3.9, illustrate approaches that demonstrate how to adopt and develop simple use cases. These use cases support the development and communication of the meaning of new capabilities to different stakeholder communities.

Use cases should be representative of the stakeholders engaged in the discovery process. The testing of the use cases with the stakeholders provides a useful feedback loop to check that points raised during the discovery process are correctly recorded and interpreted, providing an opportunity to re-confirm the level of ambition along with challenges.

Figure 3.8 – Example use case reflecting the voice of a stakeholder

Figure 3.9 – Example use case reflection a capability requirement in terms of manage cost and program on of project/program.



Outcomes from completing these activities

The deliverables and outcomes from completing these activities are:

- A vision/strategy statement agreed with agency senior leadership team.
- As set of value drivers agreed upon with agency senior leadership team, which, combined with the vision/strategy statement, act as ‘anchors’ to the digital strategy.
- Document how the agency will operate at the key stages of the digital program, which will inform the development of the high-level roadmap and the setting of the horizons used in the roadmaps, which are required in order to start the detailed gap analysis.
- The project team will have documented the key capabilities that need to be in place to adopt DE practices with a supporting set of high-level use cases.

3.3.3 Undertaking a detailed gap analysis

The purpose of the detailed gaps analysis activities, represented in step 3 in Figure 3.3, is to confirm what is needed to move from the current state to the vision state. The key activities comprise:

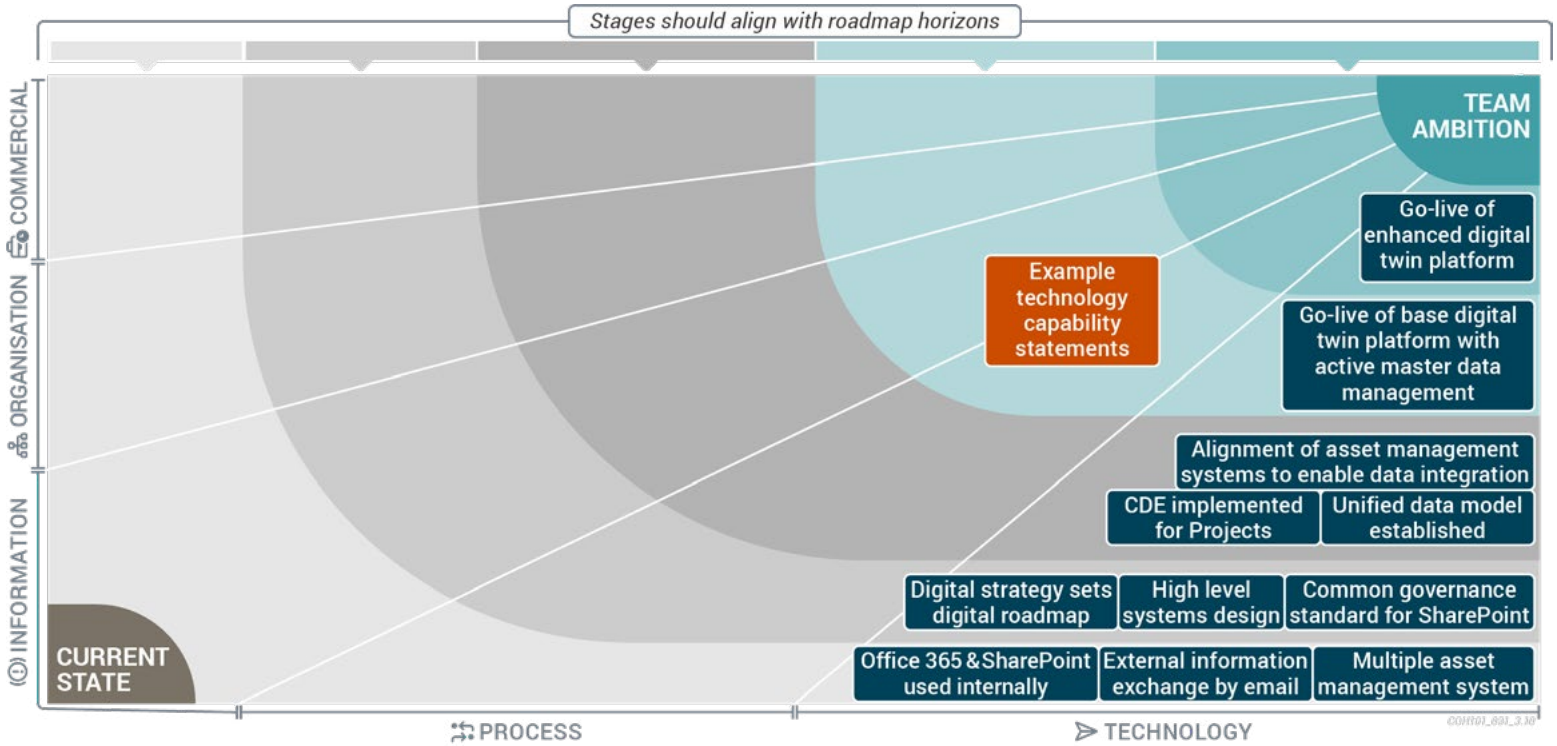
- Mapping the capabilities for teams within the agency using the POTI model and aligned to high level roadmap horizons.
- Establishing an integrated set of DE capabilities using the POTI model and aligned to high level roadmap horizons.

Transformation diagrams are a useful tool to carry out this activity by mapping out the phasing of the digital capabilities, which then helps to identify the enablers that need to be put in place to adopt the new working practices.

Figure 3.10 provides an example of how a transformation diagram can be configured and aligned with the POTI model, with the addition of a separate section for commercial capabilities, which are best kept separate to the organisational capabilities. It should be noted that the other sections are essential and should be prioritised over the technology as key enablers. For example, the Information section would cover asset classification and data hierarchies and standards etc. or the organisation section to address activities relating to governance and leadership.

The stages across the top of the transformation diagram should align with the horizons used within the roadmap (see section 3.3.4 for further guidance on roadmap horizons).

Figure 3.10 – Example structure of a transformation diagram using the POTI model.



Section 3.3.1 highlights the importance of stakeholders being able to identify their needs and challenges and points of concern, when asked to comment on the strategy, roadmap and supporting business case, which were taken into account. Austroads has found that it is useful to create a transformation diagram for each stakeholder group as well as an overall transformation diagram. The diagrams explain to each stakeholder group how the strategy is responding to their needs by delivering several capabilities across several different roadmap horizons.

In developing the transformation diagrams, it is important to ensure that the capabilities within each horizon are aligned and will deliver defined benefits to the agency. Implementing change over several horizons, taking cognisance of the existing/previous horizon capabilities, enables the roadmap to be ambitious while considering the sustainability of the impact of business change while still operating, maintaining and enhancing the transport network.

Outcomes from completing these activities

The deliverables and outcomes from completing these activities are:

- A capability map for each relevant team within agency using the POTI model, aligned to high-level roadmap horizons.
- An integrated set of DE capabilities using the POTI model, aligned to high level-roadmap horizons.

3.3.4 Building a roadmap

The establishment of the digital strategy roadmap relates to step 4 in Figure 3.3. Within this section Austroads advocate developing three levels of the roadmap developed in the following sequence:

- Develop/complete the high-level roadmap using the horizons established as part of the detailed gap analysis.
- Consult with key stakeholders to review the high-level roadmap and update leading to approval of this level of the roadmap.
- Develop the mid-level roadmap – this may lead to refinement of the high-level roadmap. Once developed test with key stakeholders.
- Develop the detailed roadmap and consult with stakeholders to gain feedback across the roadmaps and update to address comments.

Establishing the roadmap and interim states — what do we need to do to get there?

A roadmap is a high-level document that articulates the program of work required to adopt DE practices. The roadmap provides a blueprint for aligning the initiatives with the short/long term business objectives/DE vision. It is recommended to develop a series of roadmaps; high-level, mid-level and detailed-level as illustrated in Figure 3.11. This approach is built on learning from other DE change programs and Austroads recommend that teams break the change down into several stages (horizons) that progressively deliver the new digital capabilities and is cognisant on the level of change that the agency and supply chain can undertake at any given time.

The high-level roadmap identifies the key phases/horizons, shows interdependencies with other ongoing or planned change programs and provides a summary of the capabilities at each phase/horizon. This level of the roadmap can show the journey to the vision/long term strategy as it only identifies/describes the key steps. It was noted in section 3.3.3, that the phases on the transformation diagrams should align with the roadmap horizons, which emanate from the high-level roadmap.

The mid-level roadmap identifies the key activities/capabilities for a defined period. The top-level roadmap typically covers a five-to-ten-year period. The mid-level roadmap is more likely to cover a period of two to three years addressing the first two or three phases/horizons.

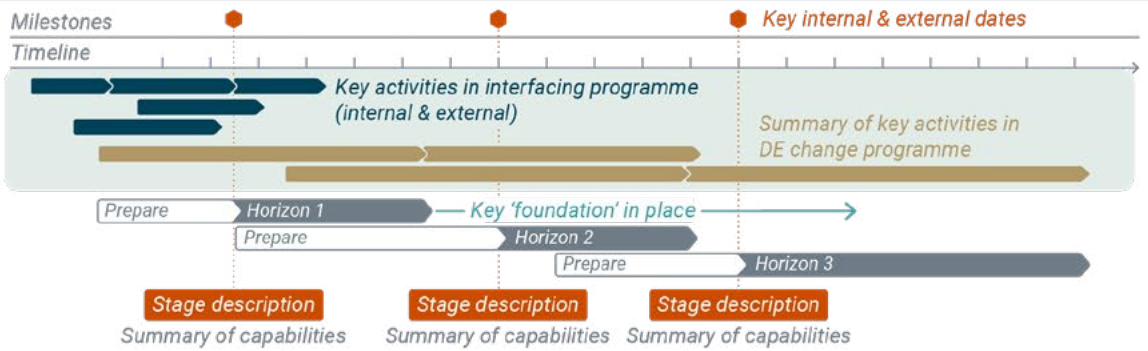
The detailed-level roadmap identifies the core activities to be undertaken to deliver the change. Typically, the low-level roadmap focusses on the first one to two years. It would not be appropriate to extend this level of roadmap beyond this initial period as there would be too many unknowns. As the agency implements the roadmap, a continual improvement program will be required, which is likely to lead to changes in the later phases of the roadmap. The overseeing project board may also only release funding for the first phase and potentially the second phase with funding of future phases being dependent on demonstrating realisation of the benefits in the business case (refer to section 3.3).

Figure 3.11 – Illustration of the suggested 3 levels of roadmap

HIGH LEVEL ROADMAP

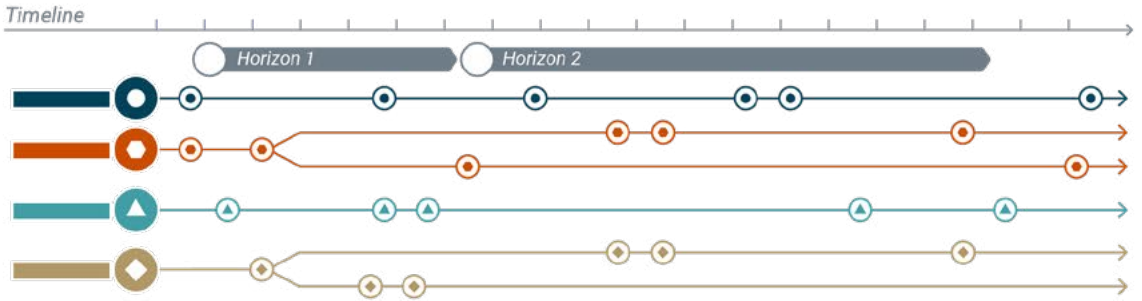
Plan-on-a-page, the high level roadmap identifies key milestones, key interfaces, key stages and the capabilities per stage.

Presents long term plan, not all stages may be implemented



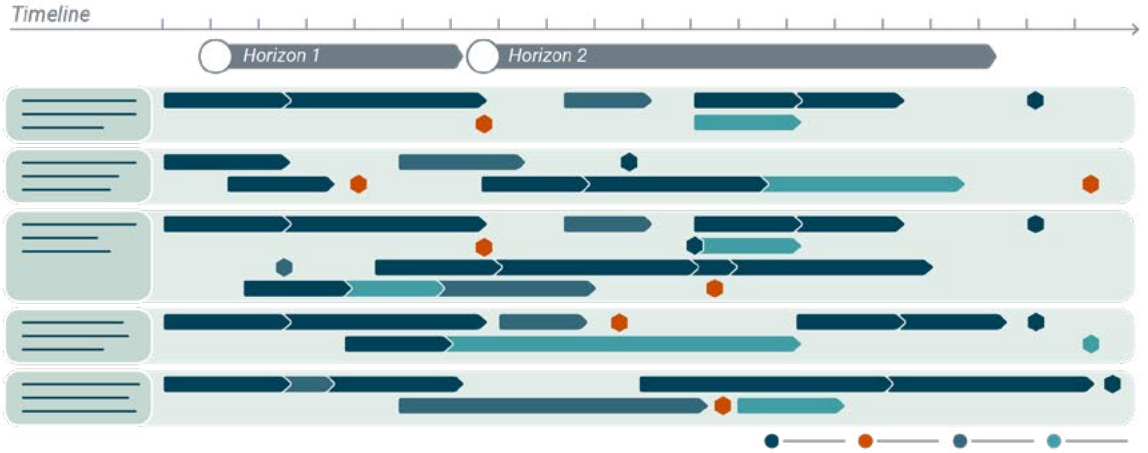
MID LEVEL ROADMAP

Shorter duration 2–5 years maximum. Identify key capabilities using the POTI model and also consider commercial capabilities



DETAILED ROADMAP

Shorter duration 12–48 months. Identify key activities to delivery capabilities using POTI model and also consider commercial activities

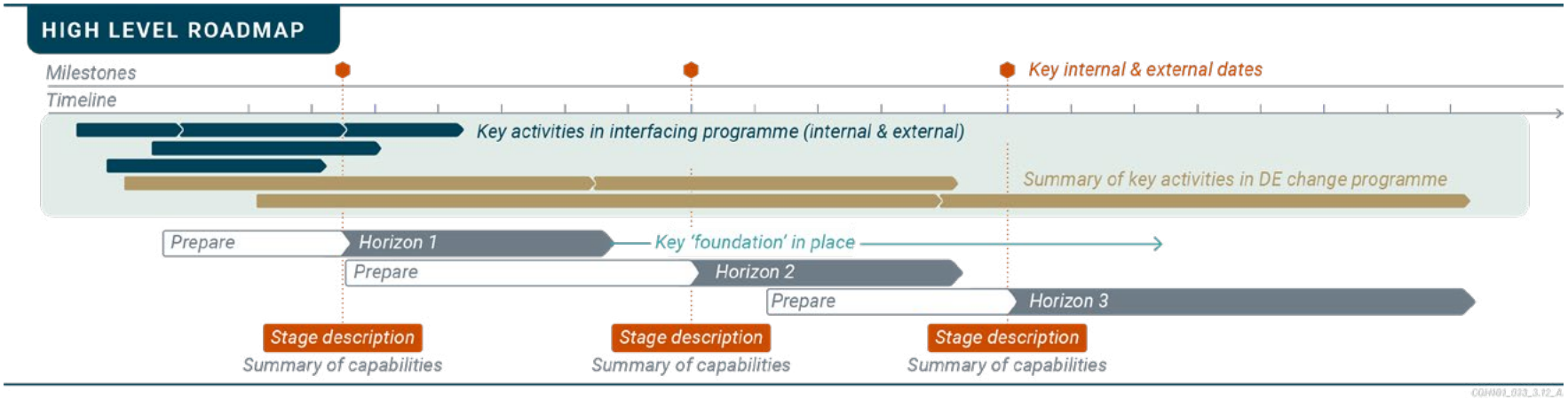


Note: Further detail in developing a roadmap is provided in Section 3.5 Mobilising your DE program.

High level roadmap and guidance on structuring the setting of the horizons

The high-level roadmap should be developed during the detailed gap analysis as the phasing of the horizons needs to align with the transformation diagrams. This ensures alignment but also allows early testing of the roadmap with stakeholders to gain feedback on the pace of change, and hence several horizons. The high-level roadmap should also consider alignment to other internal and external influencing factors such as a federal/state government mandate or other internal change programs. Teams should expect to create multiple iterations of the high-level roadmap, but once agreed it should lead to only a small number of interactions of the mid- and detailed-level roadmaps, as the underlying principles would have been agreed. Figure 3.12 provides an overview of the typical components of a high-level roadmap.

Figure 3.12 – Typical component of a high-level roadmap



Within the high-level roadmap, it is helpful to define several goals to push the adoption of DE. The definition of the horizons allows aggressive goals to be set yet agency retains control on when the start work on the next horizon.

Outcomes from completing these activities

The deliverables and outcomes from completing these activities are an integrated set of roadmaps which are agreed by the key project stakeholders.

3.3.5 Documenting the DE strategy

The DE strategy is typically completed through the development of a document to articulate the overall digital vision and goals for adopting DE practices, the plan to achieve them and the alignment to an agency's goals and objectives. The target audience ranges from the CEO/COO through to department heads.

Content from the strategy will likely be used to create new documents for briefing staff and suppliers. Table 3.3 provides an outline of the type of content which is typically expected.

Table 3.3 – Example content of a digital strategy for adopting DE practices

Section	Topics to be considered	
Executive summary	• Two to three-page minimum summary, the target audience is the agency's senior leadership team.	
Introduction	• What does DE mean to the agency?	• What is the digital vision, ambition and value drivers?
Context of the digital strategy	• What problems are being addressed/why does the agency need to adopt DE practices?	• What are the insights from industry within Australian/New Zealand and other similar countries?
The digital strategy	• Purpose – what is the digital strategy seeking to deliver? • What are the overarching objectives? • Governance model for delivering the strategy and sustaining the new ways of working. • Alignment to other internal initiatives.	• Overview of the capabilities. • Current maturity and how digital maturity will be measured and reported. • Overview of the use cases. • What is the data architecture/high level system architecture required to support the strategy?
The roadmap	• Introduce the high-level roadmap, introduce the concept of the horizons.	• Describe each horizon focusing on the business capabilities that will be delivered.
Digital target operating model	• Outline the proposed target operating model for at least the first two horizons by addressing how the new practices, standards, processes, competencies, governance and technology are to be managed aligned to the governance model.	
Supporting appendices	• Use cases. • Transformation diagrams.	• Roadmaps. • Stakeholder engagement and communication strategy.

3.4 Developing a business case for DE

A tried and tested approach to developing a business case is outlined in the sections below but some key steps that agencies may typically follow include:

1. **Identify** the problem and define it. Define the scope of DE. Consider the impacts to an organisation to implement DE to fix the problem
2. **Investigate:** What are others doing (This is essential when briefing the executive)
3. **Develop** a solution hypothesis
4. **Consult** senior managers including those executing the work.
5. **Prepare** a briefing if the problem is significant and presents current impact and expected risk, prepare a briefing for the executive
6. **Brief** the Executives - part 1 to include questions and actions
7. **Follow up** the questions and actions from Executives and investigate further benefits, cost, value. Update solution
8. **Consult** the Executives - part 2 to progress business case
9. **Develop** business case
10. **Consult** the Executives - part 3 to include refinement
11. **Develop** implementation plan and costing
12. **Consult** the Executives - part 4-to include approval in principle
13. **Secure** funding
14. **Mobilise** and implement.

3.4.1 Planning the approach for a business case

The adoption of digital working practices requires both executive sponsorship and funding approval.

This section provides guidance on building the case to justify the implementation of a DE roadmap within an agency and secure funding for the program. The development of the business case is typically part of the digital strategy and roadmap, as discussed in section 3.3 above, represented in Step 4 of Figure 3.13.

An agency is likely to have their own business case process that must be followed. This section, therefore, provides several general suggestions for developing a business case to adopt DE practices which can be incorporated into a typical agency format or approach.

The building of the case typically starts following the development of the initial roadmaps, which identify the activities to implement the change. The business case should be developed in parallel with the maturing of the roadmaps as illustrated in Figure 3.13, as the two elements need to be mutually supportive; the roadmaps articulate ‘What’ is required, while the business case explains the ‘Why’ and the ‘How’.

An agency may elect not to develop a business case and instead implement the change as part of the day-to-day activities of the team with a supplier using existing funding.

While it is a credible option, the approach is less likely to be successful as it is driven from the technical/management levels of the organisation and may, therefore, lack senior leadership support leading to a narrow program of work which only has limited value and benefits.

Figure 3.13 – The methods for making the case can be split across five key stages to ensure that there is clarity on where an agency is currently and where they want to be.

3.4.2 Key elements of a business case

The business case articulates the justification for investment in a project to implement the DE roadmap. It evaluates the benefits, costs and risks of the various project options and provides a recommendation of and rationale for the preferred solution. The purpose of the business case is to obtain approval and gain management commitment for the project and the investment.

Alongside the justification and the strategic rationale for the project, the business case provides a framework for informed decision-making. It enables improved planning and management of the project and the subsequent Benefits Management strategy. The business case is an evidence-based evaluation of the benefits, costs and risks of a solution to a need, problem or opportunity identified by the sponsor and approved by the funding agency.

Depending on an agency's business rules, it is likely that a business case will need to be developed to secure approval to implement a change program to adopt digital working practices. As well as understanding an agency's own rules along with the state and territory's requirements, further guidance on development business cases can be found within Infrastructure Australia's Assessment Framework. At each stage, the business plan should demonstrate an understanding of the end client (asset owner) in the benefits and adoption of DE. An agency is required to understand the small increase in cost at earlier developed and complete stages, which are outweighed later with improved program and cost benefits.

The following provides general guidance in developing the business case for DE. In general, a business case needs to address five key themes, which are discussed further below and as per Figure 3.13:

- **Strategic case** – What is the case for the proposed change and demonstrate the strategic fit.
- **Economic case** – Demonstrate that the spending proposal optimises value by identifying and appraising a wide range of realistic and achievable options.
- **Management case** – How will the program of work be delivered, and the new ways of working sustained?
- **Commercial case** – Demonstrate the viability of the procurement approach for external provided professional services and technology.
- **Financial case** – Demonstrate that the preferred option will result in a fundable and affordable solution.

The strategic case

The strategic case demonstrates that the spending proposal provides business synergy and strategic fit and is predicated upon a robust evidence case for change. This includes the rationale of why intervention is required, as well as a clear definition of outcomes and the potential scope for what is to be achieved.

The documenting of the current business challenges digital ambition as part of the discovery process, see Section 3.3 above, should provide key inputs to developing the strategic case and provide the required evidence base.

The economic case

The economic case should demonstrate that the spending proposal optimises value. It should explain how this is to be achieved by identifying and appraising a wide range of realistic and achievable options, in terms of how well they meet the spending objectives and critical success factors agreed for the activity.

The strategic case should consider many options from which a preferred option is identified. Table 3.7 illustrates different categories that could be used to develop a matrix of options.

Table 3.7 – Illustration of several different categories that could be used to develop a matrix of options.

Horizon based	Lifecycle based	Asset based	Delivery of change (See further details below)
Only include first horizon outline potential follow-on projects	Operations and maintenance only	Structures	Self-deliver with limited external support
Only include first two horizons outline potential follow-on projects	Major projects only	Highways	Outsource packages
Include horizons for defined investment period	Capital projects	Technology assets	Hybrid approach – joint team
Include all horizons	Whole asset lifecycle	All assets	Fully outsourced

Several factors will influence the level of external support likely to be required to help develop the roadmap and business case as well as deliver some packages of work comprising both professional services and technology. Factors will include the availability of staff within an agency to carry out these activities through to limited in-house knowhow in terms of the application of DE working practices to transport networks.

Further to the earlier discussion on implementation plan, see Table 3.4 in Section 3.3.4, depending on the level of work that needs to be outsourced there are several options an agency could consider:

1. **Light touch** – the agency appoints an internal hire or a supplier(s) to act as a critical friend with subject matter expertise that can be called upon as required to provide guidance that assists in the agency's self-delivery of the DE roadmap.
2. **Outsource packages of work** – the agency appoints a supplier(s) to deliver specific packages of work, such as establishing the core information and data requirements along with information exchange processes as part of the early activities of the information and process workstreams.
3. **Hybrid approach** – agency establishes a joint delivery team comprising members from both the agency and one or more supplier.
4. **Fully-managed implementation** – agency appoints a supplier to fully deliver the implementation of the DE roadmap for one or more of the horizons within the roadmap.

There are advantages and disadvantages of each option, and the right solution will be dependent on the complexity of the roadmap and the level of capability and capacity to self-deliver the work.

The management case

The roadmap implementation plan, see Section 3.3.4 and Section 3.5.1, forms the basis of a project execution plan. The implementation plan should identify where activities are to be completed by the agency's people/teams along with which activities are to be completed and/or supported by supply chain partners (professional services and technology).

The management case should describe how to organise, lead and govern the project team, taking cognisance of how the project team will work with supply chain partners and whether the management team have sufficient subject matter expertise to lead and manage the program of work. Where an agency has an internal program/project management function, its task could be to manage the program. However, care is needed to ensure that the resourcing levels are commensurate with the size of the team.

The management case should be clear on which project management methodologies to be adopted to deliver the program. A waterfall approach should be suitable for most of the roadmap activities. However, some elements of the technology roadmap could use an agile methodology in their delivery. In adopting an agile methodology, it is important to set out what the agency wants to achieve to deliver the required change for each horizon, i.e., are they a key critical success factor versus what is not essential for the outcome of a horizon. A good practice is to establish a set of functional and non-functional technology requirements for each horizon and categorise each one as being either 'must have' or 'should have' or 'could have'.

The project management methodology should detail the robust arrangements for change, contract management, delivery of benefits, and the management and mitigation of risk.

The commercial case

The economic and management cases will define the procurement of the work/technology capabilities packages from the supply chain. The commercial case demonstrates that the 'preferred option' will result in a viable procurement and well-structured solution. The business case includes the planning and management of the procurement, specifying the competitive procurement process for the 'preferred option' for spend.

An agency's procurement procedures will ultimately control the procurement methodology. Alongside cost, key considerations are:

- **Technical fit –** does the supplier have the rights skills and experience generally and specifically within the highways sector? A supplier who has limited highways sector knowledge is likely to require more time with stakeholders to create outputs such as information and data requirements.
- **Cultural fit –** has the supplier shown how their culture and approach, particularly relating to business change activities, align with the agency's? This is a key assessment where the hybrid or fully managed implementation approach is adopted.
- **Technology fit –** has the supplier provided confidence that the functional and non-functional requirements can be met at the required stages of the program? How well will the product integrate with the current technology stack? Does the vendor's product roadmap align with the agency's digital ambition?

The commercial case should also cover the contracting strategy and risk allocation. As noted above, the breaking down of the program into horizons, with each providing positive business outcomes, enables an agency to control the program, i.e., potentially choose to delay or not implement the next horizon. It also helps in the appropriate transfer of risk to the supply chain as there is a reduction in the scope of work and potential unknowns. Where an agile project management methodology is adopted, the commercial case needs to be particularly clear in terms of risk management and the level of risk transfer, providing confidence that all the 'must have' outputs are delivered.

The financial case

The financial case demonstrates that the 'preferred option' will result in a fundable and affordable solution. It sets out the capital and revenue requirements for the spending proposal over the expected lifespan of the service, alongside its impact upon the balance sheet, income and expenditure account of the agency. The financial case would also include the valuation of benefits, which are discussed in Section 3.4.3. Section 3.4.4 provides further recommendations in terms of developing the financial case.

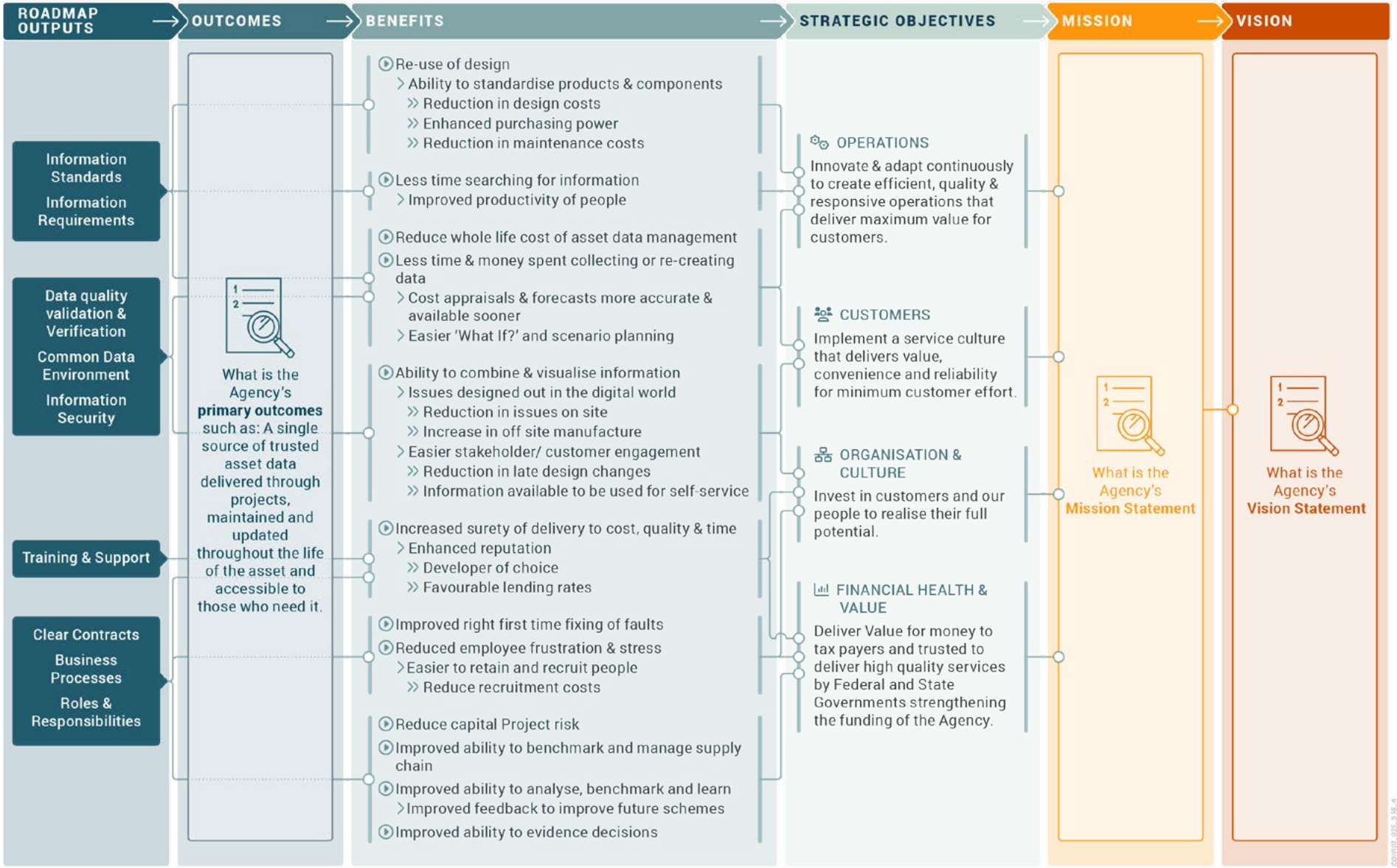
3.4.3 Getting executive buy-in (benefits and ROI)

A business case will typically require a benefits case and a supporting benefits realisation plan. Benefits can typically be grouped into one of the four categories:

- **Cash releasing** – the benefit delivers a net saving such a decreasing the contingency funding of projects.
- **Cash avoidance** – the benefit avoids unnecessary expenditures such as health and safety issues identified and addressed early in the design phase, compared to identifying issues during the detailed design or construction stage when the cost to implement change is very high.
- **Quantifiable non-financial** – the benefit can be measured but does not generate a cash saving or reduce the need to spend cash.
- **Non quantifiable and non-financial** – such as increased situational awareness and understanding of the assets in operations.

An early assessment of the likely costs, see Section 3.4.4, will help provide a rough order of magnitude of the required benefits to demonstrate a sufficiently robust return on investment.

Figure 3.14 – Example of a benefits map linking the roadmap outputs to the strategic objectives, mission and vision.



There is limited publicly available material in terms of benefits methodology for DE practices. One example methodology is the PwC BIM Level 2 BIM benefits methodology, which includes benefit themes and how to evaluate the benefits. Two important points are, firstly, the availability of baseline data to assess the benefit and, secondly, the need to consider the cost of measuring and reporting benefits, i.e., it is easy to spend more on reporting of low-value benefits than the actual financial benefit.

Before starting to develop a complex benefits case, the project team should first understand the agency's requirements and secondly critically assess the availability of baseline data in terms of the availability of the data and the level of provenance that the data has. Benefit maps are a useful tool in identifying benefits and being able to connect the benefits to either the roadmap outputs, as illustrated in Figure 3.14 above, or new capabilities on the left-hand side through to strategic objectives, mission and value of the agency.

It is not un-typical to find that sufficient base data is not available. In these circumstances, teams can develop benefits hypothesises from a benefits map. One example is the hypotheses that DE practices will reduce the risk of projects being unsuccessful/issues identified during the construction phase when the cost to rectify is high. The benefit measure would be a percentage saving on the contingency funding of capital projects and capital renewal programs, with different savings applied to the different types. The percentage would be progressively increased over several years recognising that the full benefit will not be fully realised until the new ways of working become business as usual. An agency is likely to have a 5 and possibly 10-year investment plan which identifies capital projects and budgets for capital renewals. Understanding the business rules for the application of contingency funding to different types of projects enables benefits to be evaluated on an annual basis and may singularly be sufficient to demonstrate a return on investment over 5 years.

3.4.4 Securing funding for your DE program (costs and risks)

To provide the required information to understand cost and risks, it is recommended to include information in the following areas:

- background
- key issues
- financial impact
- human resources impact
- recommendations.

Furthermore, more detailed information may be of benefit in supporting the understanding and ultimately approval of funding such as:

- high priority actions and justification tables
- summary of actions from procurement board direction
- executive summary from case studies report
- details on products, services, activities or approaches considered to be high risk
- preliminary risk summary
- preliminary cost estimate of the cost impact from the risk
- other supporting material, metrics or evidence.

Strategy is important yet agencies putting forward an initiative to address a major issue will ultimately have to engage with the executive board. The process generally follows about four steps. There are often more sub-steps within the 4 main steps required depending on the agency in order to secure the required funding for a DE program as follows.

1. **Initial executive briefing and problem definition** including the fundamentals of DE and what it means in the agency.
2. **Executive briefings in developing business case**
    a. Executive briefing part 2 - respond to the initial questions and update on actions
    b. Executive briefing part 3 - draft business plan and obtain advice on changes
    c. Executive briefing part 4 - present the business case with costings and confirm these to go ahead promptly within principal agreement for timing and funding.
3. Secure the funding approval based on the agreement at executive briefing part 4.
4. Implement and mobilise the agency's DE program.

3.5 Mobilising your DE program

This Chapter of the guide provides recommendations on how to define and establish your DE program. Guidance on mobilising and implementing your DE program is provided in Chapter 4 of this guide and the importance of a learning and development framework is covered in Chapter 5.

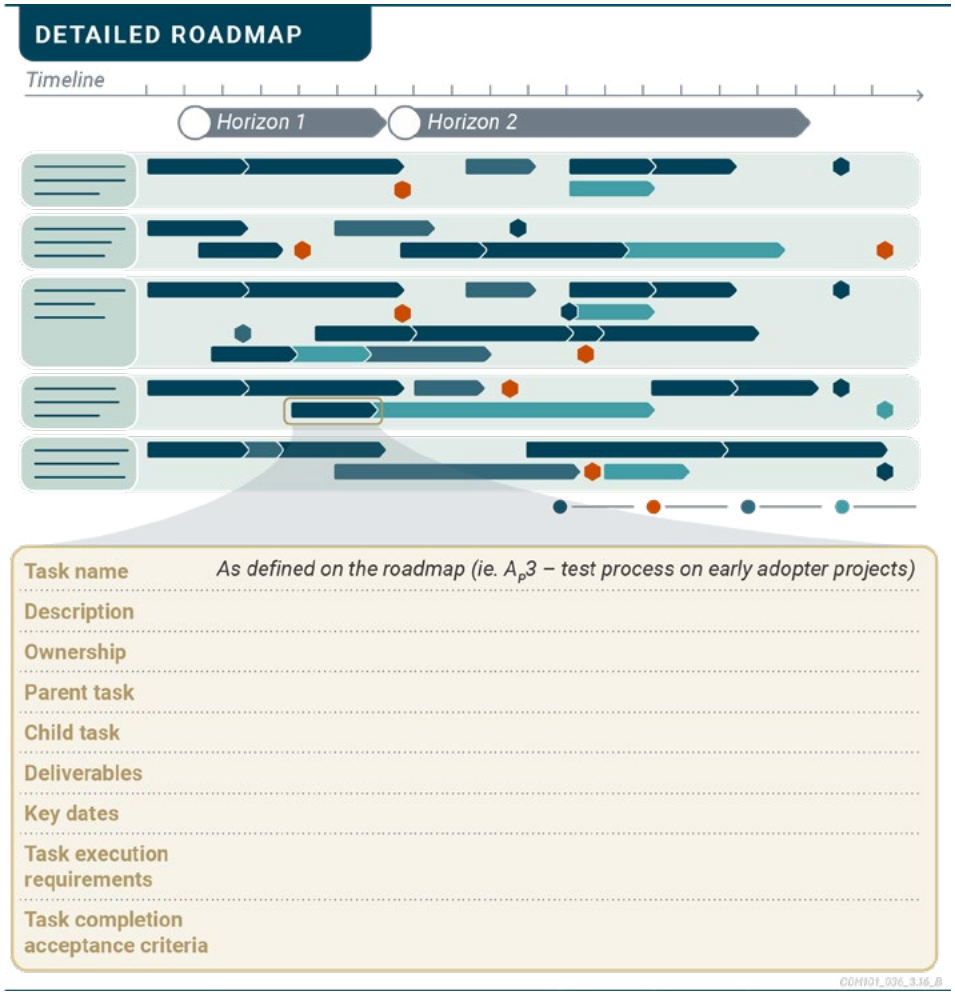
The roadmap will identify the activities to be implemented to provide an agency with a new set of digital capabilities in terms of process, organisation, technology, information along with legal and commercial. This section covers:

- **3.5.1 Developing the implementation plan**
- **3.5.2 Develop the change management strategy**
- **3.5.3 Create early adopter and proof of value**
- **3.5.4 Wider business implementation.**

3.5.1 Developing the implementation plan

The mid-level and low-level roadmaps are a graphical representation of the program of work required to implement the change program. As a next step, an agency should develop an implementation plan detailing the process for each activity. Aligned with the POTI model, a tabular approach helps provide a clear articulation of how to perform each task (see Figure 3.15). These tasks can then be presented sequentially, i.e., all the process activities, or can be grouped by other criteria, such as by a responsible team. Grouping activities within, for example, process into the different teams makes it easier to, first, establish a clear scope of work per team along with tracking and reporting the progress of the roadmap. As such, the implementation plan forms a key element of a Project Execution Plan.

Figure 3.15 – Example of a table used to define the implementation requirements for one of the detailed roadmap activities. Colour coding can be used to link the table with the breakdown of activities in the roadmap.



The development of the implementation plan will enable the agency to determine the current level of capability within the agency to deliver the change program and consider options to address gaps in capability through the choice of how the program should be delivered, which are presented in Table 3.4.

The table includes a non-exhaustive list of advantages/disadvantages of the options. The agency can adopt different delivery approaches for each horizon. For example, the 'hybrid model' could be used for the first horizon, and as the agency's capability increases, it can adopt the 'self-deliver' option could be adopted for later horizons.

Table 3.4 – Implementation options

Option	Advantage/benefits	Disadvantage/risk
Self-deliver – The agency utilises existing staff and or recruits new colleagues to address capability gaps. The agency could have an external advisor who acts as critical friend and peer reviews the outputs for key activities	• Lower cost if activities are delivered efficiently. • Builds internal capability from the outset to drive and sustain the change. • Timely engagement of the advisor should help to address challenges/help delivery team deal with/respond to change.	• Likely to take longer to deliver/start could be constrained by recruitment/availability of suitably experienced resources to start and continue work. • Potential to miss wider industry insights and knowhow. • Internal teams may find it difficult to change teams to adopt the new ways of working.
Hybrid model – The agency addresses gaps in capability by creating an integrated project team with external support provided via professional advisory contracts/ secondment. The agency could also consider secondments/joint working with other agencies where there is alignment with their roadmaps etc.	• Could represent the lowest cost option if the works are well planned and executed particularly when phased to fit with the horizons with ability to pause/stop at the end of each horizon. • Ability to form a high performing team that has the know-how of the agency/sector with wider experience of the external advisor(s).	• Delays/increased cost as internal resources are not available or do not have the right skills and experience. • the agency selects an advisor with the wrong level of skills and experience/right suppliers are not available – subject matter knowhow should be prioritised over change management specialists.
Outsource – The agency lets a contract for some or all the change program activities for the first/first two phases as appropriate.	• Should be the fastest delivery approach. • Access to the right skills and experience sharing insights from similar work/reducing risk of regret work. • Can challenge current ways of working.	• Seen as being the highest cost but may delver better value. • Agency staff do not have sufficient time to engage with the supplier which delays progress. • The agency selects an advisor with the wrong level of skills and experience and/or supplier does not take cognisance of the needs of the agency and uses language and terminology that does not fit with the agency business norms. • The agency allocates significant internal project management resource to manage the supplier which further drives up the cost.

3.5.2 Developing the change management strategy

This section proposes an approach to develop a change management strategy that helps to address the people side of the change, enabling people to engage, adopt and implement DE within the agency.

Although change happens one person at a time, it is important to use processes and tools that facilitate change across projects, groups and organisations.

There are many tried and tested change management frameworks available to support organisational change efforts. However, for this guide, the **'Prosci 3-Phase Process'** is referenced as the proposed structured, adaptable and repeatable approach for managing the people side of change for the adoption of the new ways of working.

This approach is as a critical link between individual change management and organisational change, enabling the change team to scale change management activities as needed to agency stakeholders impacted by the new ways of working move through the required stages and transitions smoothly and successfully.

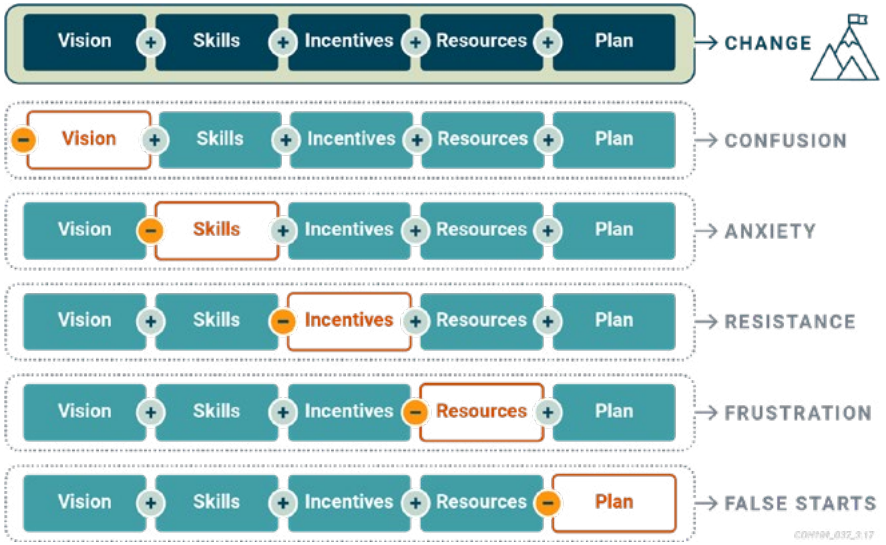
Challenges

Successful change management requires many different facets to come together. If any one of them is missing, then the result is a failure to implement change for varying reasons.

The diagram below highlights that if staff see no vision, then they are confused as to why the change is needed. If the skills are not present, then there is anxiety as to whether the outcome will be successful. If there are no incentives (not necessarily financial – this includes reassurance that jobs will be secure or new posts created) then resistance arises. If the resources to implement change are not provided, then there is frustration.

And finally, if there is no plan then there will be false starts probably leading to the change being abandoned.

Figure 3.16 – Commitment to change management



Change management toolkit

Change management is the application of a structured process and set of tools that supports moving an organisation from a current state (how things are done today) through a transition state to a desired future state. Change management tools by help individuals impacted by a change make successful personal transitions that enable them to engage, adopt and use a change.

The toolkit methodology is based on the 'Prosci' change management process and tools, designed to outline the current state, the transition state and the future state.

Agencies should leverage existing frameworks for change management where available.

This process is built in three areas, as described in the diagram below:

Figure 3.17 - Change Management Toolkit

Benefits of this toolkit

By implementing a change management program - risk is minimised, cost is reduced (and predicted), time shortened, and implementation maximised.

Opportunities for an agency in adopting a measured change program are:

1. Ensures that change is planned and managed.
2. Benefits are known before implementation and serve as motivators and assessments of progress.
3. Helps to align existing resources within the agency.
4. Assesses the overall impact of change and lowers risk associated with change.
5. The time needed to implement change is reduced.
6. Managed costs of change.
7. Increased return on investment (ROI).

Prepare for the change

The first step in the toolkit helps change teams and project teams prepare for designing their change management plans. It answers these three key questions:

1. How much change management does this project need?
2. Who is impacted by this initiative and in what ways?
3. Who are the sponsors we need to be involved to make this initiative successful?

Manage the change

The second phase of the toolkit will ensure that the right activities are occurring at the right time and that agency staff are receiving the right information they need to move through their process of change. This phase will help to answer the following questions:

1. What will we do to prepare, equip and support people?
2. How are we doing?
3. What adjustments do we need to make?

Reinforce the change

Equally critical but often overlooked, the third phase helps create specific action plans to sustain the change.

In this phase, measures and mechanisms are developed to measure how well the change is taking hold, to see if employees are doing their jobs the new way, to identify and correct gaps and to celebrate success.

The goal is to answer these questions:

1. Now where are we?
2. What is needed to ensure the change sticks?
3. Who will assume ownership and sustain outcomes?

3.5.3 The role of early adopters and proof of value

The mid and detailed roadmaps should include testing the new ways of working on early adopters to gain feedback to incorporate lessons learnt before rolling out the new ways of working on a horizon-by-horizon basis. The early adopters should be representative of standard business activities, and they would likely comprise of medium and small capital projects used to test changes in ways of working.

The adopter project(s) need to start applying the new ways of working at the start of the phase of the project, such as detailed design or at the appointment of the contractor. Projects should also be selected based on the duration of each phase, i.e., will be completed in 3 to 6 months otherwise there will be a long delay in receiving feedback which either delays the wider role out of the new ways of working or roll out commences before receiving and taking due consideration of the feedback. Aspects to be considered in selecting suitable early adopter projects are presented in Table 3.7.

Table 3.7 – Aspects to be considered in selecting early adopter projects.

Theme		Points to consider by the DE project team
1	What is the selection criteria?	Establish a set of criteria for use to create a short list of projects: • Timeline, i.e., when does testing need to start and when is feedback/lessons learnt required? Plus, is the approach to be based on project type and/or target specific departments/ asset types. • What project stage(s) are to be tested, taking cognisance of the timeline for completing early adopters, plus the size of, and type of, contract(s) to be tested?
2	What needs testing?	Establish what capabilities/new ways of working need to be tested: • Process, including information exchange, and information/ data requirements. Plus, supporting technology such as the common data environment. • Organisation change/building new digital skills activities, plus DE benefits realisation methodologies and tools.
3	Ability to implement	Establish a list of criteria to assess the capability of the early adopter and DE project team to implement the new ways of working on the project: • Size of the team – both the agency and the supply chain. Plus, the level of engagement in the program. • Level of DE knowledge across the internal and external teams, plus program fit and level of confidence in milestones; is there a risk that the project could be delayed/paused?
4	Program assumptions	The short listing of projects will be conducted while new capabilities are being established. The DE project team should set assumptions of what will/needs to be available to support the early adopter projects such as the CDE having been implemented and ready for testing by the early adopter projects by a defined date.

To accelerate the testing of the new ways of working, it is helpful for the technical resources delivering the roadmap activities to lead or provide close support to the project team in the application of the new ways of working, which also provides more time to develop training materials.

3.5.4 Scaling for wider business implementation

The wider implementation of DE builds upon the work undertaken on the early adopter projects. Depending upon the size of an agency and complexity of the supply chain, the implementation is likely to be undertaken in a phased approach, for example, by discipline, such as highways or structures.

For a smaller agency, it may be feasible to require all new projects to follow the new ways of working from a set date. When these projects are complete, and the asset a hand-over to operation and maintenance is complete, DE may then be implemented in broader organisational activities.

Before commencing implementation, all the enabling technology must be fully available so that there is a single training program and that staff, along with suppliers, can quickly see the benefits of the new ways of working. This will reinforce the adoption of DE. Where an external organisation has provided support to the delivery of the program, it is key that there is a team of individuals who will take over the ownership of the standards, templates and training materials, and who are capable of providing support during the implementation stage. This ensures governance is applied, safeguarding compliance with the new ways of working along with providing support and driving a program of continual improvement.

There is a need to establish suitable governance within an agency for DE, which will likely align to existing governance structures which may typically include internal steering committees, working groups, specialist interest groups including groups including external specialists and supply chain. This should be considered and included as part of developing the implementation plan (see Section 3.5.1) and developing the change management strategy (see Section 3.5.2).

3.6 Key recommendations

Key recommendations when developing a learning framework for DE include:

- **Establish a clear vision:** understand your organisational objectives and requirements and where DE fits as a key enabler.
- **Establish a roadmap:** identify and sequence key activities required to support capability uplift over multiple horizons.
- **Understand the resources required:** assess available options to secure the internal and/or external resources and expertise required.
- **Seek senior sponsorship and support:** secure buy-in and commitment from key decision-makers to ensure sustained success.
- **Establish a benefits measurement system:** establish a measurement system of benefits and a companion justification of ROI and value for money.
- **Baseline current state capability maturity**: to assist in measuring continuous improvement.
- **Understand the actual challenges**: in the organisation and projects, how can DE support or address these challenges?
- **Capture and define specific use cases**: and align this to the funding and resources allocated to ensure focus is maintained and outcomes and benefits can be realised.

- **Feedback loop and cumulative learning:** be a learning and listening organisation – continue to feedback and understand the real challenges and solutions within your organisation and collaborate and share with other industry organisations.
- **Long-term funding and vision for learning and development:** make DE a business activity and not a specialist activity, integrating it into the organisation to serve the parent problems and objectives.

3.7 Closing summary

A DE strategy and roadmap is required to enable an agency to realise the full potential of DE. The current state, vision state, gap analysis and roadmap are key components of a successful DE program. Executive buy-in is essential for benefits realisation and change management should be planned early in the program. Adopting a phased approach will help ensure wider business adoption and proof of value can demonstrate tangible benefits.

To be successful, agencies must consider a DE strategy that efficiently incorporates their current state alongside the latest best-practice and technologies. A robust DE strategy that includes a roadmap driven by goals and clear benefits is essential to achieving an agency's wider strategic objectives. Furthermore, without embracing DE opportunities and understanding the advantages of long-term planning, agencies run the risk of lacking longevity in their operations. It is paramount for agencies to take proactive steps and leverage their strengths through establishing a clear DE strategy and plan for the future which also assists in mobilisation and activation in the short-term.

The next chapter (Chapter 4) focuses on providing details about implementing DE within an agency and/or projects, applying DE across the asset lifecycle alongside the required capabilities and considerations.

IMPLEMENTATION OF DIGITAL ENGINEERING WITHIN AN AGENCY

SECTION 4:

IMPLEMENTATION

4.1 Chapter summary

This section of the guide covers key technical areas that agencies should consider when executing their DE strategy and roadmap in relation to continuous improvement where capability has already been established.

The technical areas explored in this section of the guide are framed around leadership, information requirements, ways of working, enabling technologies and implementation.

The technical areas outlined in this guide are all essential components to enabling the consistent implementation of DE by an agency across the asset lifecycle while considering the need to align to both the capabilities and setup of both agency and supply-side organisations. Many large infrastructure projects are in fact like hybrid organisations involving stakeholders across many organisations needing to come together to work collaboratively to achieve the project or agency outcomes while realising mutual social and economic benefit.

Table 4.1 Chapter relevance to role summary

Should I read this section to help in my role?		
Reader	Essential	Helpful
Sponsor / key decision maker in the adoption and development of a DE strategy		✓
Department head / key stakeholder in the adoption of a DE strategy		✓
Leading / supporting the development of a DE strategy	✓	
Leading / supporting the implementation of a DE strategy.	✓	
Adopting the new digital engineering practices	✓	

4.1.1 Purpose of this chapter

This guide provides an overview of the infrastructure strategic objectives and focus areas for Australia and New Zealand, as well as a summary of the challenges and recommendations for agencies to consider for future planning of their digital enablement programs.

It outlines how agencies have a key role to play in successfully and consistently implementing DE capabilities across the entire asset lifecycle by planning, participating actively, dealing with legacy data and systems, and measuring progress. Furthermore, how an agency's direct management of information requirements across the asset lifecycle can help them procure DE deliverables and outcomes while maintaining access and control of data collaboratively and aligned to industry standards such as ISO 19650 and emerging ways of working and new technologies.

4.1.2 Why this chapter is important

Table 4.2 Section content summary

Section headings	What this section addresses:
4.2 Implementing across the asset lifecycle	Provides key information on how an agency is the driving force for successfully and consistently implementing DE capability across the entire asset lifecycle including departments and projects. Agencies have a key role to play in not only how they plan out their DE programs but also in taking active steps to implement these plans by being willing to participate actively at every level along the way. Key considerations for an agency are explored concerning dealing with legacy data and systems, the implementation of a CDE for enterprise and project applications and measuring and monitoring progress and impacts that new DE capabilities are making.
4.3 Managing DE capability and outcomes	Provides key information relating to roles and responsibilities within the agency which need to be considered or consulted when leading and driving digital transformation for DE capability improvement.
4.4 Developing and managing information requirements	Provides key information in relation to approaches for defining and procuring what information and DE capabilities are required to support asset lifecycle activities.
4.5 Procurement of DE deliverables and outcomes	Provides key information on how departments can work together and with external partners through collaborative working to produce, manage and leverage DE across the asset lifecycle, the role of standards in enabling this and the concept of a CDE, as per ISO 19650, in terms of a consistent and governed workflow to be enabled by a suite of enabling technologies and aligned with other stakeholders and systems.
4.6 Aligning capabilities, systems and ways of working	Provides key information on how technology can enable strategic, management and technical outcomes. Key methodologies are also considered which agencies may adopt or procure in terms of DE outcomes or data deliverables for various purposes in a quality-controlled manner supported by a CDE solution aligned to specific agency requirements.
4.7 Leveraging enabling tools and technologies	Provides key information on how technology can enable strategic, management and technical outcomes. Key methodologies are also considered which agencies may adopt or procure in terms of DE outcomes or data deliverables for various purposes in a quality-controlled manner supported by a CDE solution aligned to specific agency requirements.
4.8 Key recommendations	Provides key recommendations for Agencies in preparing for the implementation of a DE strategy

This chapter builds on the topics explored in Chapter 3 – Strategy as per Figure 4.1:

Figure 4.1 – Synergies between Chapter 3 Strategy and Chapter 4 Implementation

4.1.3 Impact of new information paradigms on the procurement of built assets

Successful digitalisation of the design, construction and operation of built assets requires the clients and other project stakeholders to adopt into their thinking the fact that digital information produced about the physical asset is also an asset – as important as the physical asset itself. This digital asset has value, is paid for by the client and must be produced by the service providers according to the client's requirements and in compliance with the best practices in the industry.

This new way of thinking about information is a profound paradigm change, which requires shifting minds and deeply rooted cultural habits of construction professionals on all levels. It has an impact on almost all areas of the industry, procurement being one of the key ones. New contracts should therefore reflect these changes in their principles and clauses to ensure that digital assets become contractual deliverables and methodologies to produce and manage them.

One of the fundamental problems of the construction industry nowadays is waste – of resources and of information. Both types of waste are related and wasted resources are often results of ineffective production and use of information. Resources are also wasted for reproducing the same information multiple times at various project stages due to inefficiencies in digital standards and systems used. Information is wasted by:

- Producing unnecessary information due to the lack of clear specifications at the beginning of the project.
- Not using the necessary and available information due to communication problems, format incompatibility, insufficient training, etc.

To eliminate the waste of information and resources to produce it, it is therefore fundamental that new contracts contain information requirements, which are clearly and unambiguously specified by agencies and on every level of contracting through a well-managed process, e.g., based on ISO 19650. The management process of information produced because of such information requirements should be contractually required and cover all the project stages to ensure that the information can be digitally planned, procured, and prepared. For this to happen, existing key roles such as project managers, design/engineering managers and asset managers should be equipped with new digital skills and enhanced responsibilities to ensure the procurement and delivery of information across the asset lifecycle.

4.2 Implementing DE across the asset lifecycle

To manage the impact of new information paradigms to have a positive and lasting impact on the procurement of built assets, there are several critical factors to be addressed by agencies which include:

- Properly evaluate how information is currently and could be better procured, delivered and managed across the asset lifecycle.
- Understand the DE readiness of the organisation including the supply chain service providers (See Section 4.3.2).
- Evaluate the value and actions needed to be taken in relation to addressing legacy data and systems (See Section 4.2.2).
- Consider the scale and complexity of projects to determine the right pace and interventions for introducing DE capabilities and outcomes (See Section 4.2.3).
- Consider the roles necessary to support successful DE capabilities (See Section 4.3.1).
- Exploring the role technology can play in enabling the consistent and collaborative approach to managing and leveraging built asset information (See Section 4.7.1).
- Establishing a governance model and embedding controls and measures to ensure continuous improvement can be achieved across departments, project portfolios and asset networks (See Section 4.3.2).

By fully addressing these key elements, agencies can better position themselves with their suppliers towards successfully achieving the desired strategic outcomes by introducing and maintaining DE capabilities and new ways of working.

4.2.1 Evaluating the information delivery cycle

Figure 4.2 – Information delivery cycle as per ISO 19650 and ISO 55000

1. Delivery Phase (PIM): Progressive development of the PIM

2. Operational Phase (AIM): Utilising the AIM for Operational purposes

3. Maintenance Phase (AIM): Utilising and updating the AIM for Operational purposes

4. Planning Phase (AIM): Utilising the AIM and PIM's for planning purposes. Including provision of relevant information from AIM to support PIM development

ISO 19650: Standard for managing information over the whole life cycle of a built asset using Building Information Modelling (BIM)

ISO 21500: Standard and guidance on Project Management

ISO 55000: Standard and principles of Asset Management

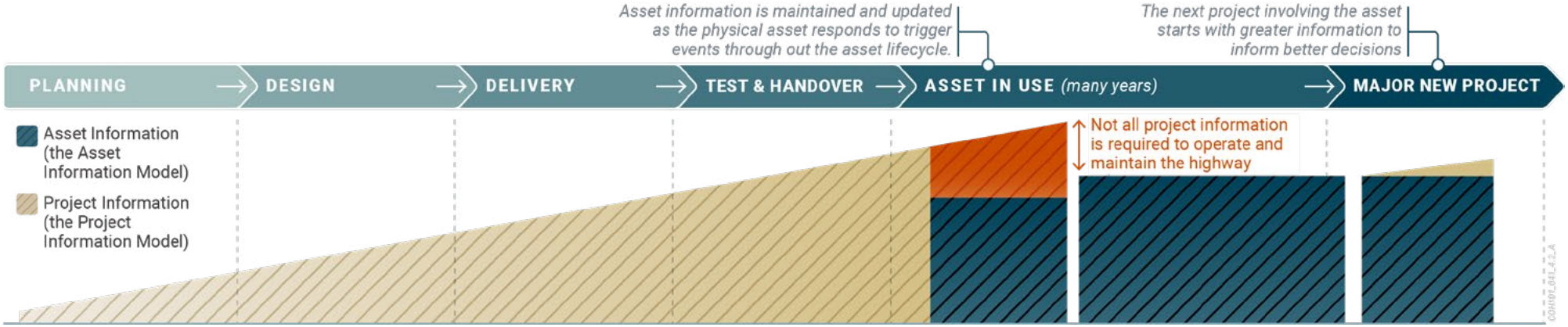
ISO 9001: Guidance for a quality management system within an organisation

ISO 8000: Standard for Data Quality and Enterprise Master Data

Following the assessment of the DE readiness of an agency and its workforce and before preparing for implementing a DE Framework, careful evaluation of the information delivery lifecycle within an agency should be undertaken. The following should be explored and included in the planning considerations when mobilising a DE framework:

- Evaluate the current processes and systems that support the procurement, management and use of data across the asset lifecycle. Identify potential risks, issues and opportunities to assist in assessing where DE capability can have a positive impact.
- Introduce a model for the whole life cycle which brings together ISO 55000 with other standards such as ISO 9001. Acknowledgement that the agencies are operating an established transport network where the focus is on operating and maintaining assets, asset renewal projects and some capital projects to enhance the network.
- Identify and discuss the role of suppliers of data and information around the whole life cycle in relation to the agency's structure and priorities.
- Identify and discuss typical challenges and how DE practices may help to address these.
- Identify and describe the information delivery cycle starting with asset management, i.e., Opex, and then move to Capex.
- In identifying and describing the information delivery cycle within an agency, present the connection between ISO 55000 (Asset Management) and ISO 19650 (Information Management), ISO 21500 (Project Management), ISO 8000 (Data Quality) and ISO 9001 (Quality Management) and seek engagement from key stakeholders across these areas.
- Identify and explore the difference and relationship between the project information model and the asset information model noting that not all project information forms part of the actively managed asset information for operations and maintenance purposes. The following image is an example from Cohesive to illustrate the step between PIM and AIM.

Figure 4.3 - Transitioning between a Project Information Model (PIM) and the Asset Information Model (AIM) across the information delivery lifecycle



4.2.2 Addressing legacy data and systems

The challenges and considerations when dealing with legacy data and systems can be significant, particularly when introducing new ways of working. In some cases, it may be necessary to migrate data and systems to new platforms or architectures to take advantage of new capabilities or to improve performance. This can be a complex and time-consuming process, requiring careful planning and execution.

There are several factors to consider whether or when an agency might migrate or uplift its existing data and systems, including:

- The age and condition of the existing data and systems.
- The format of the data (e.g., structured, or unstructured).
- The volume of data to be migrated.
- The dependencies of the data and systems on other parts of the organisation.
- The availability of skilled staff to carry out the migration.

The decision to migrate data and systems should be based on a careful assessment of the costs and benefits. In some cases, it may be more cost-effective to maintain the existing data and systems, rather than undertaking a complex and costly migration. It is also important for agencies to address any process improvements before embarking on any data cleansing activities. In addressing the underlying processes and ways of working first, legacy data can be brought into alignment with new standards and requirements as it is utilised.

Agencies will need to consider any data migration between CDEs supporting project delivery and the systems that support information and data used for operations and maintenance, particularly in ensuring access to archived information is maintained over the life of assets.

In some circumstances, new systems will need to be introduced alongside legacy systems for some time to allow for both data migration and transition of users, who may require upskilling in the new systems or ways of working.

When migrating data and systems, it is important to consider the impact on users. The migration process should be designed to minimise disruption and downtime and to ensure that data is accurately transferred. Users should be given the necessary individual training and support on the new system, to help them transition smoothly.

In summary, the challenges and considerations when dealing with legacy data and systems can be significant. Careful planning and execution are essential to successfully migrate data and systems to new platforms or architectures. Key challenges and mitigations that agencies may need to consider include:

Table 4.3 Key challenges and mitigations for agencies

Key Challenge	Mitigation Considerations
Data migrations from old systems to new systems.	Data is to be migrated using new approaches as and when it is needed and prioritised to avoid significant upfront costs.
Digitising paper-based data.	
Reconfiguring existing systems for new ways of working.	Access to data and data quality procedures must be maintained and staff adequately prepared and supported to ensure continuity.
Supplementing existing data with new metadata for provenance and identification.	Defining standard metadata and how to associate this with legacy data is a key element.
Procuring and managing 2D and 3D deliverables.	Consistency and phased delivery of both 2D and 3D deliverables ensure access to reliable data.
Managing approvals using 3D deliverables alongside traditional workflows.	Piloting approaches to capturing approvals using 3D should be undertaken and communicated with all stakeholders before transitioning to a new approach to approvals.
Transitioning workflows of deliverables alongside ongoing project and operations activities.	Reconciliation of data generated by capital projects into existing asset information is challenging but consistent breakdown and classification are of significant help.
Managing the evolving capabilities and shift in technology.	Learning and development, and knowledge management will support effective continuous improvement.
Shifting from proprietary data sets to more interoperable and open data for compatibility and longevity.	Greater levels of data literacy are required but longer-term value from data is more easily achieved.

4.2.3 Implementation for scale and complexity of projects

The following table outlines a typical initial phased roll-out of key elements in relation to the scale of projects where DE may be deployed and respective timeframes, resourcing and capabilities typically available. The amount and complexity of content will typically vary based on the scale and complexity of particular projects:

- Small projects typically have limited timeframes, resources and DE capabilities.
- Mid-size projects typically have moderate timeframes, resources and DE capabilities.
- Large projects typically have extensive timeframes, resources and DE capabilities.

Agencies typically have their own framework for classifying projects in terms of risk, value and complexity, which should be considered when determining the priority for roll-out of DE capability.

Table 4.4 Information planning and requirements

LEGEND:
1 – Highly recommended
2 – Recommended
3 – Where feasible

Key elements	Small projects	Mid-size projects	Large projects
Project Information Requirements (PIR)	1	1	1
Exchange Information Requirements (DE and PIR)	2	1	1
Exchange Information Requirements (DE, PIR, and AIR)	3	2	1
Exchange Information Requirements (DE, PIR, AIR, and OIR)	3	3	1
Supplier capability assessments	3	2	1
Master Information Delivery Plans (including task/discipline input)	3	2	1
Roles and responsibilities matrix	3	2	1
DE Execution Plan	1	1	1

Table 4.5 DE model production and use

LEGEND:
1 – Highly recommended
2 – Recommended
3 – Where feasible

Key elements	Small projects	Mid-size projects	Large projects
3D model authoring (2D in alignment with 3D)	3	2*	2*
3D model authoring (2D derived from 3D)	3	2	1
Coordination management (clash detection, reporting and resolution)	3	2	1
3D visualisation	3	2	1
Virtual construction simulation	3	2	1
Virtual estimating	3	2	1

**If part of a pilot shadowing traditional delivery*

Table 4.6 DE technology

LEGEND:
1 – Highly recommended
2 – Recommended
3 – Where feasible

Key elements	Small projects	Mid-size projects	Large projects
Model authoring tools	2	1	1
Model review and mark-up	3	2	1
Model data quality checking tools	3	2	1
3D model viewers	1	1	1
Common Data Environment (CDE)	1	1	1
Digital surveying equipment (LIDAR scanners, drones etc.)	3	2	1

It is ultimately best for agencies to address things more holistically and plan implementation across their project portfolio in line with their DE strategy and roadmap supported by a DE capability improvement team.

4.2.4 Common data environments across CAPEX and OPEX

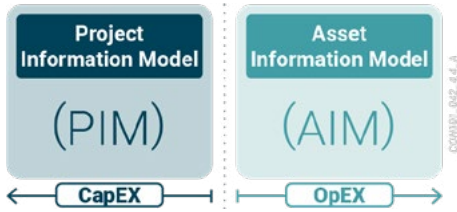
A key enabling technology for supporting a collaborative and consistent way of working, which is an essential component of DE, is the establishment of a CDE. The concept of a CDE, as defined by ISO 19650, is further described in Sections 4.2.4 and 4.6.3. Agencies should invest appropriate time and investment to establish a clear CDE strategy, ensuring linkage across CAPEX and OPEX while ensuring consistent management and use of information, including DE deliverables, can be achieved. (See Section 4.6.3 and Section 4.7.4 for further detail regarding a CDE).

Establishing a CDE for managing information models across both CAPEX and OPEX

To comprehensively support the management of asset information across the asset lifecycle, a CDE strategy needs to cater for two key sets of information and environments:

- **The Asset Information Model (AIM)** which provides information relating to assets (OPEX stage).
- **The Project Information Model (PIM)** which provides information relating to projects (CAPEX stage).

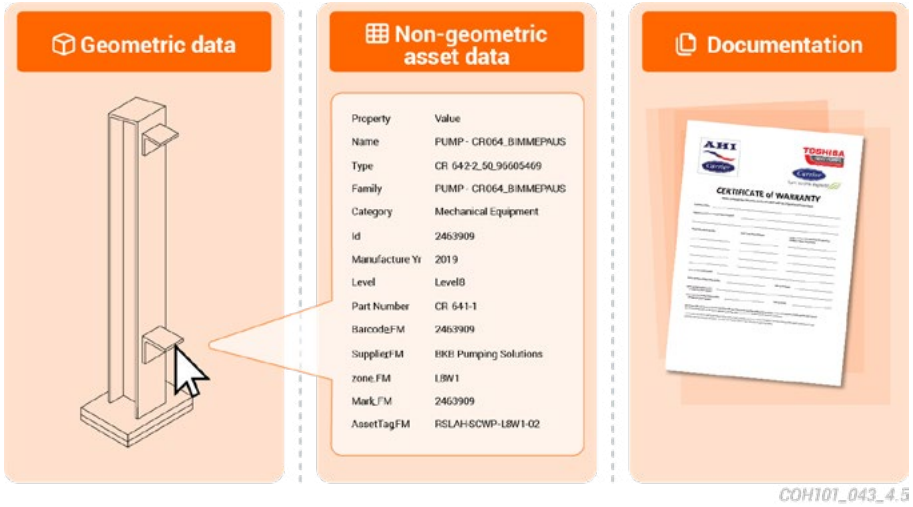
Figure 4.4 – The concept of an information model as per ISO 19650 across Capex and Opex.



Both models need to inform each other and exchange information through the CDE based on the AIR and PIR in the relevant stages of asset delivery and operation.

Information models are referred to by ISO 19650 in the context of both what is required to deliver the project, i.e., a PIM, and what is required to support activities in the operations and management of the assets, i.e., an AIM.

Figure 4.5 – The elements of an information model as per ISO 19650.



An information model, as per ISO 19650, is defined by three distinct but connected elements shown in Figure 4.5; these are the graphical models, asset data and documentation.

Asset management specific requirements for CDE

The CDE for asset management has the following key objectives:

- To allow all the stakeholders access to high-quality information about assets necessary for operating them through various stages, i.e., survey, inspect, use, maintain, and repair.
- To support and enable optimisation of business processes related to operating assets.

Requirements include:

- Support operation specific and agency specific classification of assets.
- Implement operation specific and agency specific standards, actions, workflows and business procedures, e.g., workflows for foreseen, unforeseen trigger events and acquisition of assets based on ISO 19650-3.
- Integrate on a system level (automatically) with the Asset Management System (AMS) used or planned to be used by an agency or its suppliers.
- If integration on a system level is not feasible or desirable, exchange information with other digital systems, e.g., AMS, Enterprise Management Systems (EMS), etc., using a specific common data exchange format.
- Deliver relevant information for specialised analytical applications, providing advanced asset management techniques, e.g., predictive maintenance.
- Integrate with and process data from real-time asset monitoring systems to ensure access to information in case of a failure of a physical asset and to enable the implementation of a Digital Twin concept.
- Exchange information with systems used by the agency's supplier(s), preferably using open data format.
- Provide a secure and controlled means of storing and retrieving information about built assets.

CAPEX specific requirements for CDE

- Support delivery specific and agency specific classification of objects and assets.
- Implement delivery specific and agency specific standards, actions, workflows and business procedures, e.g., WIP, SHARED, PUBLISHED and ARCHIVED states of the information lifecycle, file and object naming standards based on ISO 19650-2, etc.
- Integrate on a system level (automatically) with design authoring and design review platforms used or planned to be used by the agency or its suppliers.
- Integrate on a system level (automatically) with contract and construction management platforms used or planned to be used by the agency or its suppliers.
- If integration on a system level is not feasible or desirable, exchange information with other digital platforms, using a common data exchange format, e.g., IFC.
- Deliver relevant information for specialised analytical applications, providing advanced design/construction review and monitoring techniques, e.g., automatic clash analysis, statutory code checking, as-built construction verification, etc.
- Exchange information with other systems used by the agency's supplier(s), preferably using open data format.
- Provide a secure and controlled means of storing and retrieving information about built assets.

4.3 Managing DE capability and outcomes

4.3.1 Roles and responsibilities within an agency

Several key roles and responsibilities within the agency need to be considered or consulted when leading and driving digital transformation for DE capability improvement. This includes:

- **Strategic leadership roles:** to sponsor investment and provision resources to deliver strategic outcomes over multiple horizons and timeframes.
- **Capability improvement roles:** to help plan and drive the required digital capabilities across the agency and its supply chain.
- **Operational roles:** to ensure that business continuity is achieved, and the implementation of DE is established and maintained.
- **Delivery roles:** to ensure that requirements are implemented, and the supply chain is enabled to respond to any new requirements and are managed accordingly.

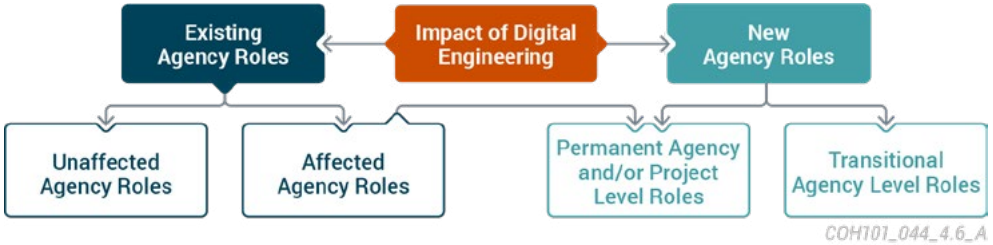
Key role types for enabling DE at an agency level

Defining new roles and related skills and responsibilities is an essential aspect of managing the digital capabilities of an agency. The first step of this process is to analyse the existing organisational structure and roles within the agency and adjust subsequent steps accordingly. In doing this the principle of minimum possible disruption should be adopted, so that the new roles and their responsibilities are introduced while preserving as much as possible (but no more) of discipline specific, and familiar naming, scope and structure.

The size of the agency and its digital maturity also matter, as this will determine, in some organisations, if specific people will perform more than one role. Such options for consolidating roles by the same person are indicated below and on the diagram in Figure 4.6.

Note that the guidelines below and the names of the roles are based on a generic model without considering the specifics of a particular agency. Practical implementation of these guidelines may vary, e.g., the names of the roles can be different if they reflect their nature, are used consistently and are associated with the right sets of skills and responsibilities.

Figure 4.6. Changes in roles in the organisation structure of an agency because of digital transformation.



Key agency roles that will need to be actively engaged in the introduction, development and implementation of DE capabilities across strategic leadership, capability improvement, operational and delivery roles include strategic leadership, capability improvement, operational and delivery roles which are further outlined on the following pages:

Strategic leadership (agency roles)

- **Board member / executive director / CEO** is responsible for ensuring the DE transformation is in line with the business model and objectives and remains part of the long-term strategy and to ensure that focus and investment are sustained over many years.
- **The agency's Chief Information Officer (CIO)** is responsible for the development and implementation of the agency's information technology strategy. This includes ensuring that the right systems and processes are in place to support the digital transformation of the agency's operations.
- **The agency's Chief Engineer** is responsible for leading the engineering team and ensuring that the agency's engineering processes are fit for purpose. This includes working with the CIO to ensure that the right systems and processes are in place to support the digital transformation of the agency's operations.
- **The agency's Head of Digital Transformation** is responsible for leading the digital transformation of the agency's operations. This includes working with the CIO and Chief Engineer to ensure that the right systems and processes are in place to support the digital transformation.
- **The agency's Head of Communications/Training** is responsible for ensuring that the agency's communications strategy is fit for purpose. This includes working with the Head of Digital Transformation to ensure that the right communications channels are in place to support the digital transformation of the agency's operations.
- **The agency's Department Heads** are responsible for ensuring their teams are briefed and aligned to support the requirements for DE across their respective roles and remit across the asset lifecycle.

These are some of the key roles and responsibilities to be considered within the organisation when leading and driving digital transformation. It is important to ensure all stakeholders are aware of their roles and responsibilities in this process so that everyone can contribute to the success of the transformation.

Capability improvement (agency roles)

The purpose of these roles is to support the digital transformation of the agency across the organisation. Such roles may be permanent to support continuous improvement or be temporary, with duties handed over and embedded across various departments, e.g., quality management, asset management and capital delivery teams. Examples of such roles include:

- **Digital Engineering (DE) Transformation Leader**

  Senior executive, in charge of the entire digital transformation process of the organisation (objectives, planning, budget, process, KPIs, and measurement). This role is maintained until the end of the digital transformation project. The DE Transformation Lead may be the same person as or may later become the Chief/ Lead Digital Engineer.

- **Digital Engineering (DE) Standards Manager**

  Senior Manager and subject matter expert, accountable for formulating information management and data governance standards. This role is maintained until the data governance standards are ready and tested on a pilot project. The maintenance of data governance standards is taken over by the CIO or Information Owner.

- **Digital Engineering (DE) Process Manager**

  Senior Manager and subject matter expert, accountable for analysing the existing business processes and formulating implementation strategies and methodologies of digitalising these processes including developing responsibility assignment matrices. This role is maintained until the digital processes are ready and tested on a pilot project with the use of data governance standards. The maintenance of digital processes is taken over by the Chief Digital Engineer.

- **Change Management Expert**

  Change Managers are accountable for the user satisfaction and logistics of digital transformation, i.e., communicating digital transformation objectives, engaging stakeholders, assessing digital skills, formulating training needs, training the trainers and dealing with resistance. This role is maintained until the end of the digital transformation project.

Operational (agency roles)

The purpose of these roles is to develop, maintain and enhance the digital capabilities of the agency across the organisation. Examples of such roles include:

- **Network Operations Manager/Asset Manager**

  The Infrastructure Assets Manager is responsible for the asset management functions for existing assets including maintaining asset registers, asset modelling, asset revaluations, and asset renewal works programming.

- **Chief/Lead Engineer**

  Senior executive, in charge of strategy, implementation and the development of DE systems, workflows and procedures for information management of the assets during their entire lifecycle.

- **Information Owners**

  Senior manager, accountable for the use and protection of one or more types of information, either related to one or more business processes or digital systems. In the latter case, the Information Owner may be the same person as the System Owner.

- **System Owners**

  Manager and subject matter expert, in charge of a specific digital system (e.g., CDE), accountable for its configuration and administration.

- **Digital Engineering Lead/Champion**

  Manage information and deliverables throughout the project lifecycle. Implementation and technical support of DE technologies to enable improved project deliverables. Provides technical review and assurance of project deliverables, ensuring compliance with project and asset information requirements.

- **Digital Engineering Training Manager**

  Digital subject or system expert, accountable for planning, preparing and conducting training for the agency's staff and their supply chain, based on their roles in the organisation or project/work package.

Delivery (agency and supply chain roles)

The purpose of these roles is to implement, use (for intended purposes) and supervise information management in terms of requirements, standards and procedures of the agency being established and met for specific projects/work packages. Examples of such roles include:

- **Project Manager**

  A project manager is responsible for planning and overseeing projects within an agency, from the initial ideation through to completion. They coordinate people and processes to deliver projects on time, within budget and with the desired outcomes aligned with objectives.

- **Design/Engineering Manager**

  Engineering managers plan, coordinate and oversee the technical and engineering activities of an agency. They are responsible for planning engineering projects and overseeing the efficient running of projects, including providing supervision and guidance to other engineers.

- **Information Manager**

  Senior manager, accountable for digital management, compliance and quality of information for the project in line with the data governance standards. Additional responsibilities may be assigned to individuals or teams, which include:

  - Systems Administrator (including DE tools and project CDEs)
  - Discipline Author (only if applicable, i.e., where an agency's in-house team produces information for work packages).
  - Discipline Reviewer (may include both informal and formal reviews aligned to stage gates and decision points).
  - Discipline Approver (may include the acceptance of DE deliverables to be transferred into the agency's Systems).

4.3.2 Measuring and monitoring DE readiness

It takes time to successfully implement the required DE capabilities within an organisation and consistently across projects. To realise the benefits of digitalisation, agencies need to continuously evolve their operating models, processes and technology. This necessitates a shift in organisational culture, with a focus on innovation, collaboration and continuous improvement.

As such, measuring and monitoring readiness for DE adoption is critical to ensure the required capabilities are introduced and adopted. The following key factors should be considered:

1. **Organisational readiness**

Ensure the right structures and processes are in place to support the introduction of new ways of working and systems. This includes having clear governance arrangements and the necessary skills and capabilities within the agency.

2. **Workforce readiness**

Assess how prepared the workforce is for the changes that the agency intends to introduce. This includes ensuring that its supply chain has the right skills and knowledge to work to new requirements, and the right mindset to embrace change.

3. **Technology readiness**

Understand, to what extent the project or agency's systems and infrastructure are ready to support DE adoption. This includes having robust and appropriately resourced mobilisation planning.

Agencies should consider their workforce in relation to the resources and capability needed to support their specific DE capability improvement. Other relevant sections in relation to workforce readiness include section 4.3.1 for typical roles and responsibilities, 4.5.2 Planning for procurement of DE delivery,

4.6.1 Digital ways of working for asset lifecycle collaboration and section 5.3.1 for guidance on learning and development frameworks.

Assessing agency DE readiness

Assessing the agency's DE readiness can be done using a maturity model approach. This involves assessing the agency against a set of criteria, and then mapping it to a scale of readiness (e.g., early, emerging, advanced). This gives a clear indication of where the agency is in its journey, and what areas need to be addressed to move forward. Agencies can choose to assess readiness in terms of specific DE capabilities and/or how they intend to adopt new ways of working in terms of people (roles), processes, information or technology.

Assessing supply chain and partner DE readiness

Awareness of the capabilities of the workforce in the given business environment/ construction field is required in order to be able to formulate realistic digital requirements for the tender documents and to assess the training needs of suppliers.

Such assessment can be obtained by:

- Stakeholder engagement sessions with invited market players focused on the mutual sharing of achievements in the application of DE methods and solutions.
- Market surveys of a broader pool of past and potential service providers and their supply chains.
- Utilising the existing stakeholder networks and expertise within the organisation to derive insights and trends.

Assessment of the digital capabilities of the tenderers for specific projects/ work packages

In the project/work package context, such assessment is an essential process at the tender stage to ensure that the awarded service provider can meet the DE requirements as determined by the agency's information requirements (see Section 4.4 managing information requirements). To ensure an easy to evaluate outcome and to enable an audit trail, the process should be formalised and documented. As a minimum, it should consist of the following elements:

- Tender assessment criteria specifying how the results of the assessment of the digital capabilities of the tenderers will weigh on the decision of contract award, i.e., how the agency should use the results of this assessment.
- Use of the following documents (based on the ISO 19650 information management process) in the tender stage evaluation of the digital capabilities of the prospective service providers (tenderers). The tenderers should include these documents in their tender response packages:
  - Supply Chain Capability Assessment (SCCA) – an organisation specific questionnaire in which the tenderers declare their organisation's digital and information management capabilities by answering a series of questions. A SCCS form template should be a part of the organisation's digital standard and be included in every tender package.
  - DE Execution Plan – a project specific document being a response to the client's information requirements and specifying how these requirements will be met on this project. A DE Execution Plan template could be a part of the organisation's digital standard and be included in every tender package or establish an evaluation and assessment approach that accommodates the supplier's planning documentation.

Early adopters, proof of concepts and proof of value

As more and more organisations begin to realise the potential of DE, they continue to explore ways to integrate it into their business models. One way to do this is through proof of concept (PoC) or proof of value (PoV) projects. (See Chapter 3 - Strategy for further guidance on the strategy relevance of PoCs)

PoCs and PoVs are typically used by early adopters of new technology or ways of working to test their feasibility and potential value. By implementing a PoC or PoV, organisations can gain a better understanding of how DE capabilities can work and how they could be used to solve specific business or project challenges. PoCs and PoVs also have the potential to generate valuable data that can help organisations make informed decisions about whether to invest in further development of DE.

Key considerations for agencies or supply chain organisations when implementing a PoC or PoV:

1. **Define objectives,** which should be aligned to the agency's DE strategy and roadmap.
2. **Select the right team,** which may include external suppliers and specialists.
3. **Define success criteria,** which should align with the intended benefits to be realised.
4. **Communicate results,** which should be used to seek engagement, feedback and lessons learnt to support next steps and continuous improvement.

Following successful PoCs or PoVs, early adopters are key projects or stakeholders that support introducing new DE capabilities by being amongst the first to implement new ways of working or new systems.

Capability maturity models

There are many ways to measure the progress and impact of DE initiatives. One approach is to use capability maturity models (CMMs). CMMs are frameworks that help organisations assess their current capabilities and identify areas for improvement. There are several different CMMs available, each with its focus and strengths. However, all CMMs share a common goal: to help organisations improve their performance by systematically addressing areas of weakness.

When selecting a CMM, it is important to choose one that is aligned with organisational goals and objectives and avoid selecting a generic industry CMM without adjustment where possible. Additionally, ensure that the CMM selected is compatible with the organisation's existing processes and systems. Once a CMM has been selected, it will need to be implemented across the organisation. This process typically involves training staff on the use of the CMM and developing processes and procedures for applying the CMM to meet the organisation's specific needs.

Once the CMM is implemented, it can be used to assess the organisation's DE initiatives. By tracking the progress and impact of the initiatives, using a CMM, areas of improvement can be identified and steps taken to address them. This helps ensure that the organisation's DE initiatives are successful and have a positive impact. A phased approach to implementation and adoption is often the most successful over the long term to ensure solid traction and continuous improvement can be achieved.

Another approach to measure the progress and impact of the organisation's DE initiatives is to use performance metrics. Performance metrics are quantitative measures that can be used to assess the success of particular initiatives rather than broader outcomes and capabilities.

There are a variety of performance metrics that can be used, depending on the type of initiative being assessed. Metrics should be aligned to use cases to ensure they are both meaningful and relate to the wider strategy. (See Chapter 3, Section 3.3.2 of this guide for further information on defining use cases)

Some examples of metrics that may be useful to consider are outlined in Appendix C – Case Study benefits Capture Guidance.

4.3.3 Driving continuous improvement at an agency and project level

Agencies need to be able to maintain and improve on any new DE capabilities by establishing an approach to continuous improvement. This is essential not only for ensuring the investment in DE contributes to progress but also that the progress is sustained and has a positive impact across their business, asset and project portfolio.

There are several ways in which agencies can drive continuous improvement including:

- **Set clear goals and objectives:** Identify what the agency wants to achieve put in place a plan, and describe how it will be achieved.
- **Identify and allocate the right resources:** Ensure the required resources, skills and expertise are identified and sourced, either internally or externally. Evaluating current in-house and market capabilities can provide valuable insights when assessing the support needed.
- **Engage with employees and stakeholders:** Communicate effectively and involve key stakeholders in the decision-making process.
- **Review progress regularly and make changes where necessary:** Establish a method of measure to track and monitor key priorities and outcomes to help determine the impact, and where additional focus, resources and interventions may be required.

4.4 Developing and managing information requirements

4.4.1 Value for clients in owning and driving their information requirements

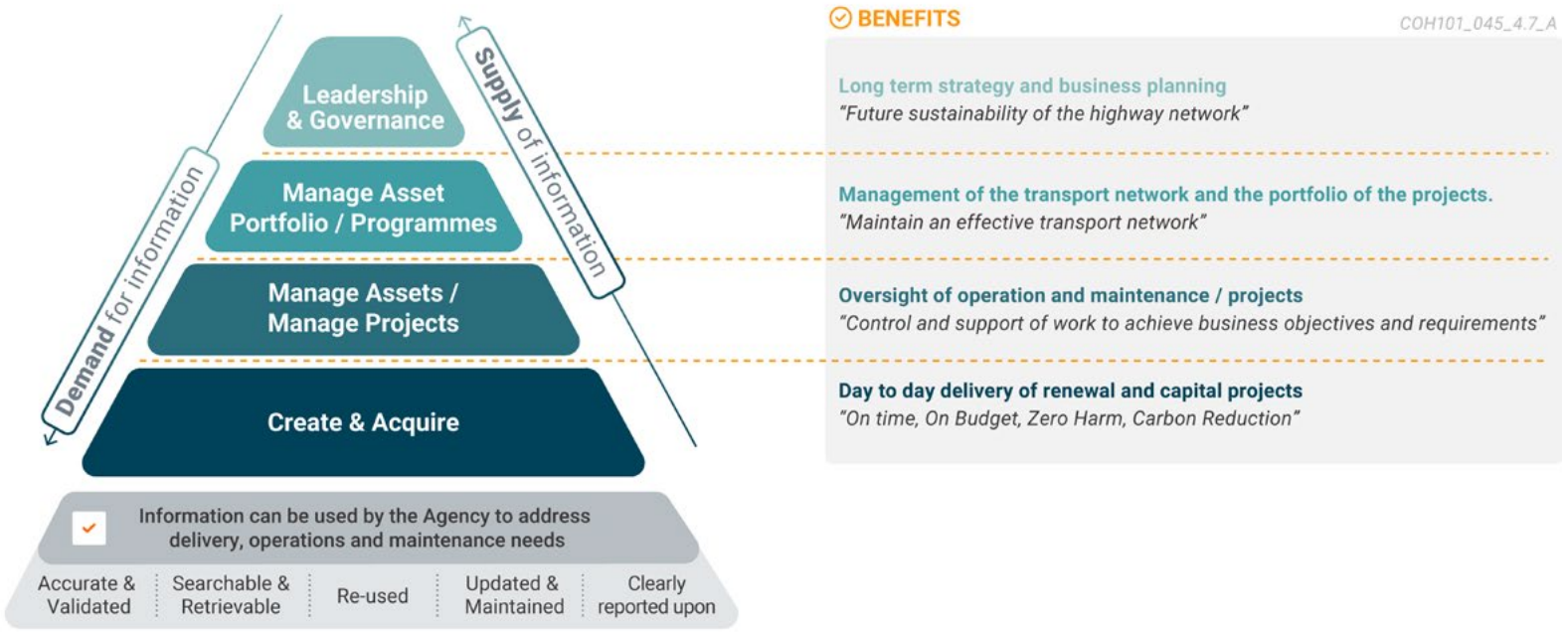
An agency that directly manages its information requirements can have a positive impact on business and project outcomes. By doing so, an agency can improve communication and collaboration among project stakeholders, reduce risks associated with changes in requirements, and ensure that the right information is captured and made available to the appropriate people at the right time.

In addition, an agency that manages its information requirements can easily identify and track issues and risks associated with the project, and opportunities for improvement. By taking this proactive approach, an agency can avoid potential issues before they arise and ultimately improve the quality of the deliverables, including asset and project outcomes.

Some key benefits derived from agencies managing their information requirements include:

- **Improving communication and collaboration:** When an agency directly manages its information requirements, it can improve communication and collaboration among project stakeholders. By doing so, an agency can ensure that everyone is on the same page about the project's objectives and goals. In addition, by managing information requirements directly, an agency can reduce the likelihood of miscommunication and misunderstanding among project stakeholders.
- **Reduce risks associated with changes in requirements:** When an agency is proactive about managing its requirements, it can avoid last-minute changes that could have a negative impact on the project. In addition, by having a clear and up-to-date view of the project's information requirements, an agency can make informed decisions about changes that need to be made, and when those changes should be made.
- **The right information is made available to the right people at the right time** When an agency is proactive about managing its requirements, it can ensure that project information is captured accurately and is complete. In addition, by having a clear and up-to-date view of the project's information requirements, an agency can disseminate that information to the appropriate people promptly.
- **More easily track issues and risks associated with projects:** By having a clear and up-to-date view of the project's information requirements, an agency can quickly identify and resolve issues that could impact the project negatively and ensure the delivery of asset information. In addition, by tracking risks associated with the project, an agency can take steps to mitigate those risks and avoid potential problems down the road.

Figure 4.7 - Benefits from managing the flows and demands for information throughout a transport agency.



4.4.2 Agencies' role in data governance

An agency's role in data governance is critical to ensuring better outcomes for its programs and projects. By establishing and maintaining clear control over access to data, an agency can ensure that only authorised personnel can view and modify sensitive information. Additionally, by implementing change control procedures, an agency can protect against unauthorised changes to data that could jeopardise the accuracy and completeness of its records.

When it comes to data governance, an agency has several responsibilities. First and foremost, an agency must ensure that only authorised personnel have access to sensitive data. This can be accomplished through the use of security measures such as user authentication and permission levels. Additionally, an agency must put procedures in place to control how data is changed. Change control procedures can help to prevent unauthorised changes from being made to data, as well as ensuring that all changes are properly documented.

By taking on a role in data governance, an agency can help to ensure better outcomes for its programs and projects. By establishing clear controls over access to data and implementing change control procedures, an agency can

protect the accuracy and completeness of its records. Additionally, by ensuring that only authorised personnel have access to sensitive data, an agency can help prevent unauthorised changes from being made to its records. In this way, an agency's role in data governance is critical to ensuring better outcomes for its programs and projects.

Master Data Management (MDM) is a critical aspect of modern transport systems. It involves managing and maintaining large sets of data related to transportation operations, assets, customers and suppliers. MDM plays a crucial role in ensuring the efficiency, reliability and safety of transportation processes.

Aligning DE data governance with MDM

Data governance is a critical function for all agencies, large and small. It ensures that mission-critical data is accurate, complete, and accessible to authorised personnel while protecting against unauthorised access or changes. MDM is a key component of data governance, and agencies need to have an MDM strategy in place to ensure better outcomes for their programs and projects.

MDM is the process of managing an agency's master data, which includes all of the unique, mission-critical data elements that an agency uses to run its operations. This data may include customer or client information, financial data, supplier information, employee records, and more. MDM ensures that this data is consistently accurate and complete across all agency systems, applications, and databases.

An agency's MDM strategy should be designed to meet the specific needs of the agency and its mission. However, there are some key elements that all MDM strategies should include:

- **Data quality management:** To ensure that master data is accurate and complete, agencies must put procedures in place to regularly review and update their data. This may include establishing thresholds for data quality, setting up processes for monitoring data quality, and implementing corrective action plans for addressing data quality issues.
- **Data security:** Given the sensitive nature of many types of master data, agencies need to put security measures in place to protect this data. This may include encryption, access control measures, and activity logging.
- **Data integration:** For master data to be used effectively across all agency systems, it must be properly integrated. This may require the use of data quality management and security measures, as well as ETL (extract, transform, and load) processes.
- **Data lifecycle management:** To ensure that master data remains accurate and complete over time, agencies must put processes in place to manage the data throughout its lifecycle. This may include establishing policies for when and how data should be updated, archiving old or outdated data, and deleting data that is no longer needed.

By putting an MDM strategy in place, agencies can ensure better outcomes for their programs and projects. By managing their master data effectively, agencies can ensure that this data is accurate, complete, and accessible to authorised personnel while protecting against unauthorised access or changes. In this way, MDM is a critical part of data governance and is essential for all agencies.

Agencies should seek to engage with their CIO/IT department to understand current data governance and current master data management practices which may identify current or emerging standards, processes and potentially technology that can be adopted/built upon.

4.4.3 Establishing and controlling information requirements

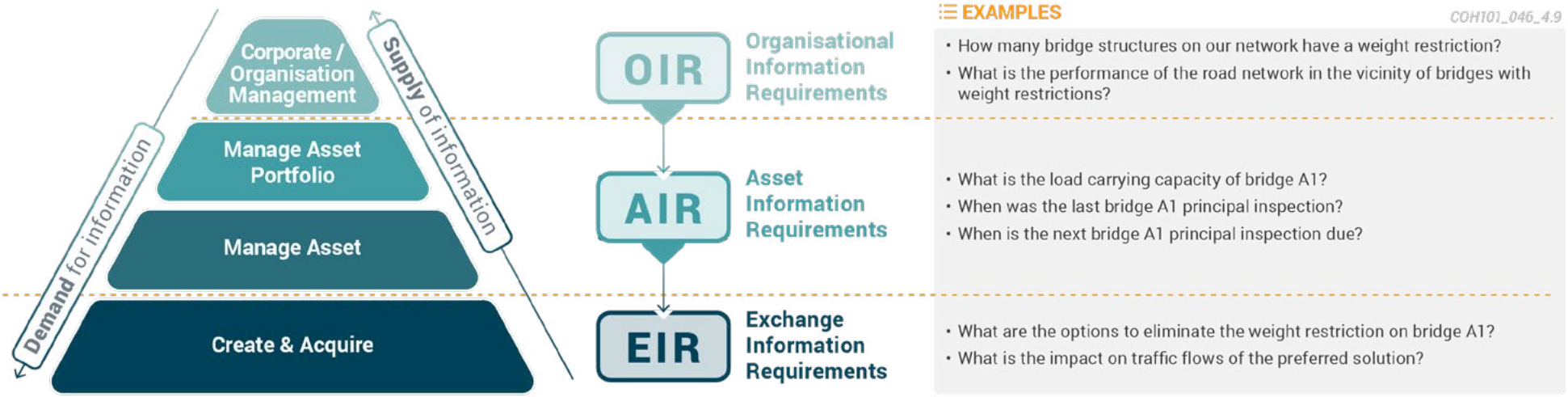
Organisations need to establish a framework and build on existing approaches for capturing and managing information requirements at an organisational, asset and project level. This will ensure that the right information is captured and controlled throughout the organisation and suppliers and that it remains fit for purpose.

ISO 19650 represents a suite of standards that frame what good practice currently looks like for managing information when using DE. ISO 19650 describes different types of information requirements as below:

- **Organisational Information Requirements (OIR):** OIRs are essential for supporting regulatory or strategic business decisions and reporting and are related to organisational objectives.
- **Asset Information Requirements (AIR):** The objective of capturing AIRs is to provide a clear statement of the requirements that will enable the project to deliver asset information deliverables and are related to the operation and maintenance of an asset.
- **Project Information Requirements (PIR)**: The PIRs capture the specific information to inform and manage a project and are in relation to the purpose, design and construction of an asset.
- **Exchange Information Requirements (EIR)**: The EIR specifies the project and asset information requirements, for a particular scope of work or contract.

Figure 4.8 shows the fundamental relationship between different types or tiers of information requirements. Starting with those which are needed to inform decisions at an organisational level or for regulatory compliance. Then followed by those information requirements relevant to the asset portfolio. These are often supported by resolving information requirements relating to projects within an agency. Finally, information requirements specific to each project contract need to encompass all relevant organisational, asset and project information requirements relevant to the contracted scope of works. It should also be noted that a set of EIRs could be applied to both project delivery and operations and maintenance contracts where appropriate.

Figure 4.8 - The relationship of Information Requirements managed across operations, maintenance and within projects.



There are three main methods of capturing and communicating information requirements at various levels of granularity and relevance:

- **Descriptive:** A descriptive method of capturing information requirements is often in plain language and very broad, which does not include specifics, such as certain scenarios or variances in project stage gates across different jurisdictions or organisations or asset types within broad disciplines. Examples include Natspec guidance and BIMForum specifications.
- **Industry specification:** Industry specifications can provide a framework for the level of information requirements for suppliers to interpret in response to particular contracts, which are often broad in context and do not always reflect project or asset specific nuances such as varying the level of information to be produced for assurances for particularly complex locations or activities. Examples include information requirement templates included as part of the VDAS guidance and TfNSW DEF, ABAB AIR guidance etc.
- **Asset or task specific:** The most specific and relevant approach to defining information requirements is typically conducted by the asset owner/operators. Because the requirements are captured and specified based on each asset type and purpose, this can often be the most time-consuming approach but provides the most clarity and granularity for agencies and their suppliers. A suitable management system to manage the detailed information requirements and compliance against them is recommended. Examples include the Asset Data Dictionary developed by Crossrail UK.

Managing information requirements within a template

There are several ways in which this can be achieved, but one approach is to use a standardised template. This can be used to record the information required, who is responsible for capturing it, and when it needs to be updated. The template should be populated with information from a variety of sources, including asset registers, project plans, and business processes. It is important to ensure that all stakeholders are involved in this process, as they will be able to provide valuable input on what information is required.

Once the template is complete, it should be reviewed regularly to ensure that it remains relevant and up-to-date. This will ensure that the organisation has the most accurate and current information available that can be used to inform decision-making.

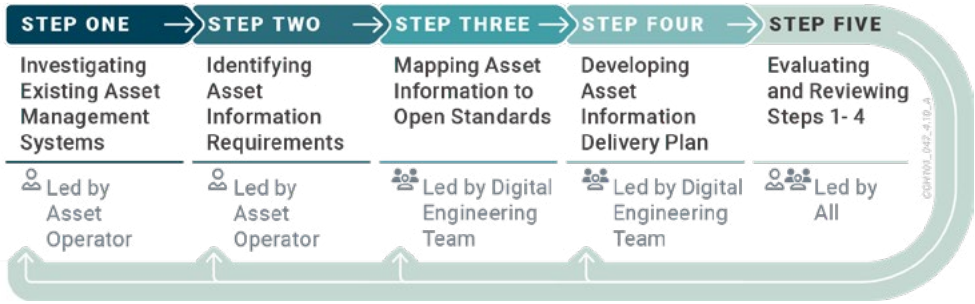
Managing information requirements within a database

Organisations can also manage information requirements using a database. This will allow them to store and track information in a central location, and to update it as required. This approach has the added benefit of allowing organisations to share information across different departments and projects. Databases can be used to record information such as asset registers, project plans, and business processes. This will ensure that all stakeholders have access to the most up-to-date information.

It is important to review information requirements regularly to ensure that they remain accurate and up-to-date. This will ensure that the organisation has the most accurate and up-to-date information available and that it can be used to inform decision-making and specify requirements for other departments or suppliers. Information delivered by departments, projects and suppliers can be managed via a CDE and checked against the information and data requirements when in the form of a managed database, which can offer a significant improvement in efficiency and consistency in managing compliant information exchanges.

Below is an outline approach to capturing and managing an agency's information requirements as developed by SBEnrc Project 2.51 Digital Asset Information Manual for Infrastructure:

Figure 4.9 - From SBEnrc Project 2.51



Agencies should consider the type of information and data they need and how this can be managed as it changes and evolves. Typically, geometric information rarely changes in operations and maintenance, but the asset data may evolve regularly based on maintenance activities.

4.5 Procurement of DE deliverables and outcomes

4.5.1 Challenges and opportunities of the traditional procurement process

Specific complexities and challenges in procurement in construction

Due to its specifics and complexity construction procurement is significantly different from procurement in other production industries (e.g., automotive) for the following main reasons:

- Location-based factors such as ground conditions and weather can represent a key variable in the planning and delivery of built assets.
- The project team consists of a number of separate and equally important organisations with interests, which do not always align.
- The procurement process consists of a number of sequential stages, so contracts are strictly separated in time and scope.

General challenges of the traditional procurement process

Major procurement challenges, which are largely still present in the contracts and on construction sites today include:

- Unclear responsibilities.
- Miscommunication.
- Lack of collaborative working procedures.
- Wasted resources.

Information specific challenges of the current procurement process

Apart from the above problems, there are also contractual issues related specifically to information including:

- Current procurement methods are not ready for adopting the key new information paradigm, i.e., treating information as a commodity equally valuable as physical products and assets.
- Only recently have some of the modern forms of contract, like NEC 4 ECC or Alliance Contract, included provisions for ‘information modelling’.
- The inclusion and fidelity of information requirements depends strongly on the client’s circumstances, i.e., the type of work, responsibilities and information the agency intends to outsource to its supply chain vs what is to be done in-house.
- Early involvement of all key project parties may prevent errors, which otherwise could be detected much later in the process and be more costly to rectify.

Figure 4.10. Typical risks for outsourced operation and maintenance model.

Table 4.7 – Data acceptance points and considerations for outsourced operation and maintenance model.

Data acceptance point	Data management considerations
1 – Planning	• Has the agency provided any relevant existing asset data to assist in planning activities? • Are any specialist consultants aware of the required deliverables to support planning, e.g., business case, environmental or feasibility reports etc? • Has the relevance, accuracy, completeness and provenance of the data been assessed and understood? • Has the agency provided all necessary agency tender documents including design standards, guides and provided delivery templates? • Has the agency defined all project specific tender documents including their exchange information requirements and Scope of works? • Does the agency supplied tender documents take into consideration the handover model's suitability for construction and operational use?
2 – Design	• Is the Level of Information needed for each asset type defined against each milestone? • What model files and accompanying delivery documentation/tables are required at each design review? • How is evidence of the level of information shown at each design review? • Have considerations been made to the level of completeness of the 'issued for construction' model for construction purposes?

Data acceptance point	Data management considerations
3 – Construction and Handover	• What is the model format required for 'issued for construction' to best suit construction costing and scheduling needs? • What is the procedure when updates to the 'issued for construction' model are required to meet 'as-built' model changes? • Have considerations been made to the level of completeness of the 'as-built' model for operations and maintenance purposes?
4 – Maintenance framework/ event following handover including defects management period	• What is the model format required for 'as-built' to best suit design changes due to future renovations? • What is the model format required for 'as-built' to best suit operations and maintenance needs? • Have considerations been made to the level of completeness required at handover for acceptance into the AIM? • How will the asset's Level of Information data feed into the AIM for use later in Operations and Maintenance?
5 – Maintenance framework/event into long-term service delivery or with a change in operator	• What is the model format required for 'as-built' to best suit operations and maintenance needs? • What is the procedure when updates to the 'as-built' model are required to meet renovations?

Some common challenges and risks associated with the typical resourcing model are shown in Figure 4.10 and Table 4.7 in relation to managing information requirements across the asset procurement and delivery lifecycle:

- Contractual information requirements do not define standards of digital deliverables.
- The main contractor does not provide all the specified digital deliverables.
- The operation and maintenance contract does not stipulate that the contractor shall provide data back to the client and/or does not specify data standards.
- Contracts do not have requirements to provide data as contractual deliverables.
- Data is not maintained/updated against the corresponding trigger events during operation and maintenance.
- Data is not structured and/or provided in proprietary formats that do not allow for easy transition of the information into operational systems.
- Information is available, but not used by operation/maintenance teams.

Recommendations for more information-oriented contracts

To minimise the above risks and issues, the following recommendations should be considered by agencies when preparing project/operation contracts for the needs of DE and information delivery:

- Adopt the 'alliancing' approach to contracts either by amending typical contracts or using new standard forms of contracts, e.g., the NEC4 Alliance Contract.
- Make it clear that delivering information is part of the Scope of Service and is equally important as services, physical assets and traditional design deliverables.

- Consider adopting a standard for information management (e.g., ISO 19650), which clearly defines actions and resources necessary to manage information.
- Understand the agency's project information needs – WHY the specific information should be produced.
- Based on the needs specify information requirements – WHAT information should be produced.
- Specify precise information standards in the contract – HOW the information should be structured and formatted to be useful for the client and his systems.
- Define information management procedures to be followed – HOW the information should flow, be managed and accepted throughout the contract.
- Include a schedule of information deliverables in the contract – WHEN information should be provided.
- Request the supplier to prepare detailed a responsibility matrix specifying WHO in the supply chain is responsible for delivering which information.
- Require that all project information must be present in and managed through the project CDE, otherwise, it will not be considered acceptable project information.
- Require information to be provided in an open format, to be transferred easily and with high fidelity between systems and to support futureproofing and accessibility of data.

If suppliers use or deliver specific digital systems for an agency, they are required to provide documented workflows and training for relevant agency staff.

Introducing DE requirements into contracts

To ensure that the new digital processes are implemented on projects and the risks identified above are avoided or mitigated, a number of new requirements should become contractual in the new digitally oriented procurement processes. Managing information flow for the entire project lifecycle in the context of the agency.

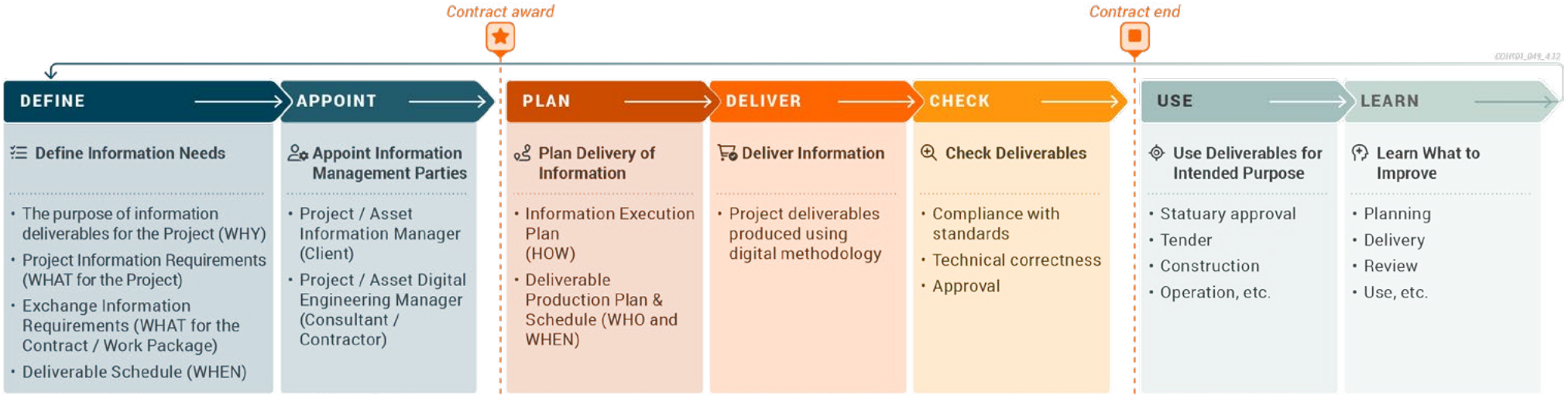
- Managing the process of planning information delivery for a contract (Define, Appoint, Plan).
- Managing the process of executing information delivery for a contract, i.e., authoring (production), submission, review and approval of contract deliverables and administration documents using CDE (Deliver, Check).

Changes in contract management

Digital management of project information refers to:

- Managing information flow for the entire project lifecycle in the context of the agency.
- Managing the process of planning information delivery for a contract (Define, Appoint, Plan).
- Managing the process of executing information delivery for a contract, i.e., authoring (production), submission, review and approval of contract deliverables and administration documents using CDE (Deliver, Check).

Figure 4.11 - DE information management cycle for projects.

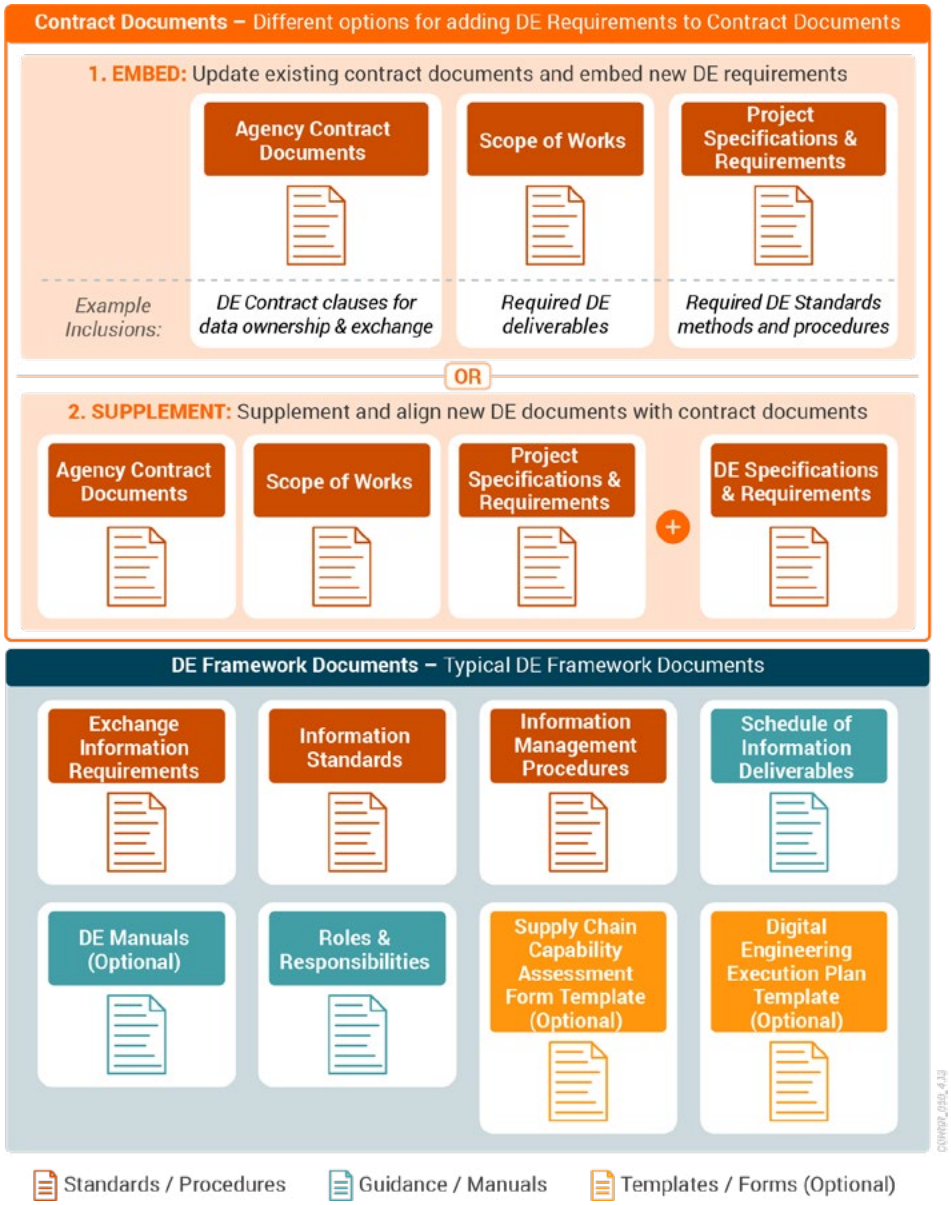


Key interventions and impacts of introducing DE

The current construction procurement process still relies on, and will mostly rely on, drawings in the foreseeable future due to several challenges and interventions that are necessary to enable the paradigm shift to a data-centric approach to built asset procurement and delivery. Drawings continue to be the primary artefacts as both legal documents (in most jurisdictions) and technical documentation informing the construction, operation and maintenance of physical assets. Some of the main impacts and interventions necessary for agencies to begin to shift to a more data-driven approach are as follows:

- **Shifting the type and volume of information and data that is delivered** to be more data-driven and less drawing and document centric.
- **Including all information deliverables** into the project deliverable schedule.
- **Introducing 3D models** as equally important components of construction documentation.
- **Reducing the number of drawings** produced and delivered in the traditional procurement process as models will take over and improve the functions of some types of drawings.
- **Automating the revision and approval management of deliverables** through CDE to make it clear for every party which revision is the latest and allow access to past revisions.
- **Ensuring contracts contain provisions for information management and information requirements** while implementing a more collaborative approach to the whole procurement process.
- **Supplementing or appending contracts with IP and legal clauses relating** to the production, delivery and ownership of specific information and data at certain stages in the asset lifecycle. This could also be in the form of a separate information protocol.

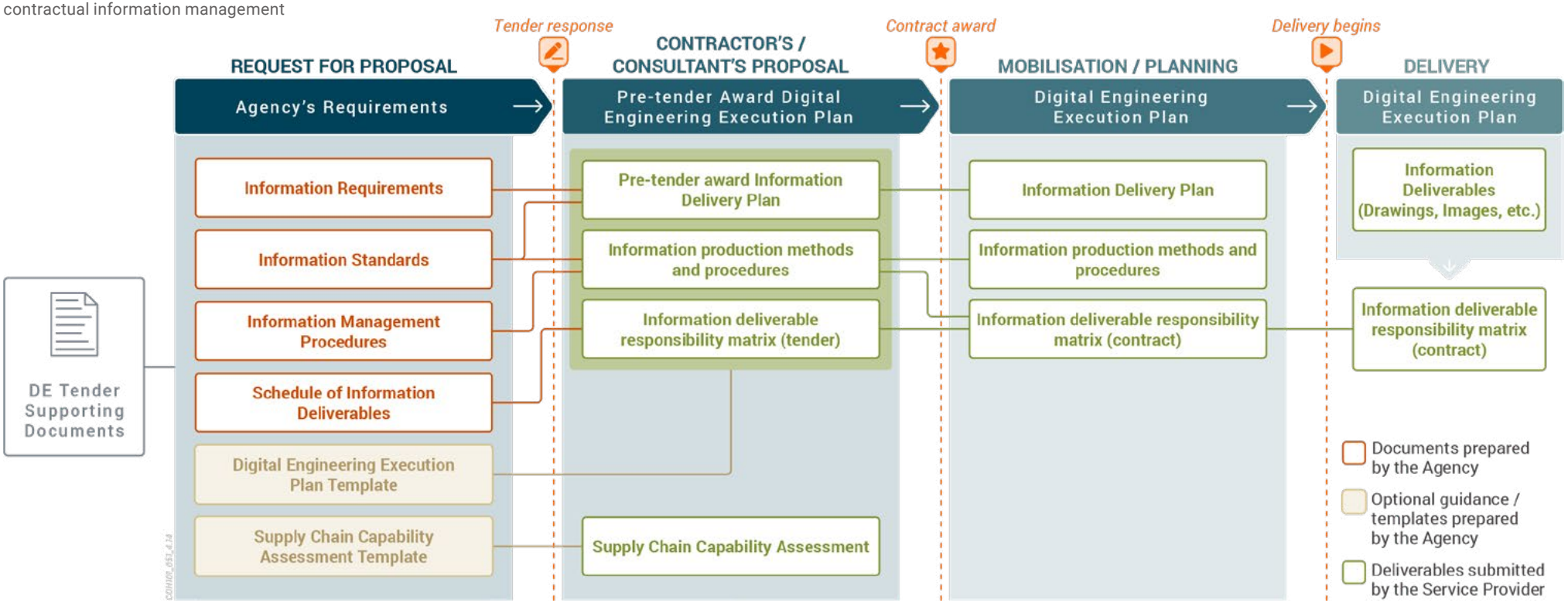
Figure 4.12 – Two options for adding DE requirements to contracts.



- **Adding predefined templates as appendices to contracts** to help the service providers in submitting their tender proposals and ensure that their methods are appropriate for the requirements, the agency may prepare templates for information management documents to be filled by the service providers.

An example of the information management workflow and docs combining the three first methods of enabling information-oriented procurement process is shown in Figure 4.12.

Figure 4.13 – Example of an information management workflow combining three first methods of contractual information management



- **Using digital online platforms for building a contract**
  Some of the most innovative methods of preparing information centred construction contracts include the use of dedicated digital platforms. Such platforms semi-automatically support the process of collating and managing a contract by providing a number of predefined standards, templates and requirements content to choose from.

Examples of standard industry documents supporting contractual digital requirements:

- Australian National Alliance Contracting Guidelines
  https://www.infrastructure.gov.au/sites/default/files/migrated/infrastructure/ngpd/files/National_Guide_to_Alliance_Contracting.pdf
- UK Information protocol to support BS EN ISO 19650-2 the delivery phase of assets
  https://ukbimframework.org/wp-content/uploads/2020/06/Information-Protocol-to-support-BS-EN-ISO19650-2.pdf

- UK Information protocol to support BS EN ISO 19650-3 the operational phase of assets
  https://www.ukbimframework.org/wp-content/uploads/2021/11/Information-Protocol-Template-to-support-BS-EN-ISO-19650-3.pdf
- NEC4 ECC - standard form
  https://www.neccontract.com/products/contracts/nec4/engineering-and-construction-contract
- NEC4 Alliance Contract - standard form
  https://www.neccontract.com/products/contracts/nec4/alliance-contract
- ISO 19650-1 standard (concepts and principles)
  https://www.iso.org/obp/ui/#iso:std:iso:19650:-1:ed-1:v1:en

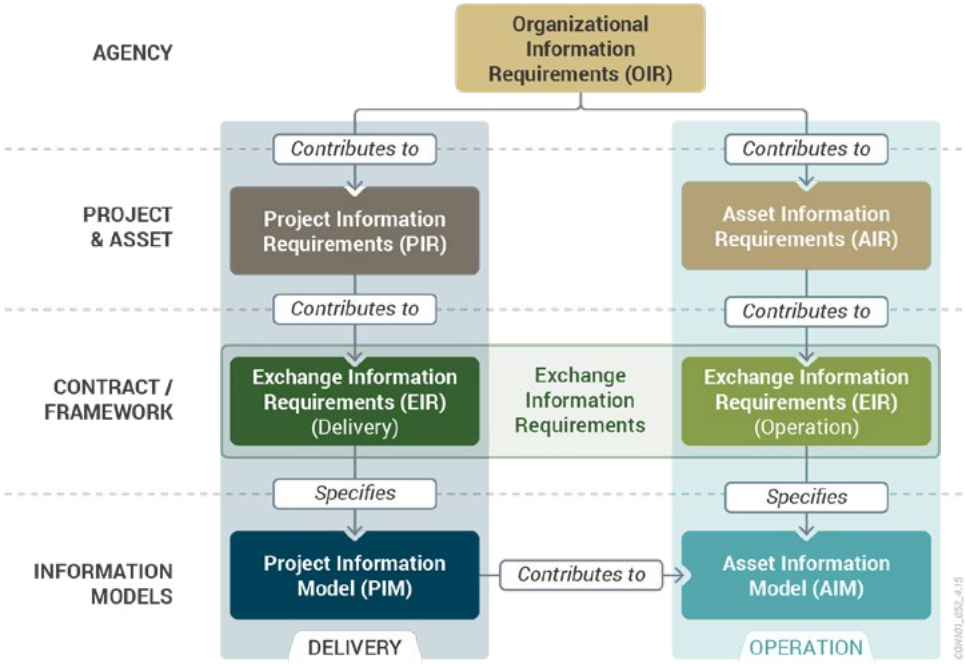
4.5.2 Planning for procurement of DE delivery

Delivery of information for a project can only be a success if it is well planned, i.e., the organisation has clear data governance policies (standards and management procedures), understands well why it needs information and prepares clear specifications of what information is needed. Ultimately the information must satisfy the objectives of the organisation.

Information standards and management procedures

Standards define the organisation, structure, naming formats, attributes and other parameters of data to be understandable by machines and/or humans as information. Management procedures specify how the standard compliant information packages (regardless of their content) are managed with digital systems. Standards and procedures are parts of Data Governance and should be in place before any digitalised project enters its procurement phase.

Figure 4.14 – Hierarchy of information requirement resources for delivery and operation of assets



Organisation information requirements (OIR)

This is the top-level internal resource defining the information needs of an organisation. It depends on the agency's model, i.e., the type, scope and proportion of work that the agency outsources and does in-house. Also, the high level architecture of digital systems like ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management), etc. will define the type and standards of information required at the enterprise level from the delivery and operation of assets. In the assessment and need phase of the project, the OIR is used to inform the content of the PIR.

Project/asset information requirements (PIR/AIR)

PIR/AIR is an internal document, which specifies information necessary to be delivered to complete a project – a set of activities undertaken to produce a new asset or to operate an asset – a set of activities undertaken to use an existing asset for its intended purpose. Although the nature of asset delivery and asset operation is quite different, the information requirements should in both cases contain the following main parts:

- Project scope and key information objectives, like CDE mandate, principles of defining the Level of Information Need, equivalence of 2D and 3D, etc.
- Intended purposes (uses) of the PIM/AIM.
- Method of procurement (to understand the information needed at various procurement stages).
- Plan of work (to understand the information needed at various work stages).
- Key decision points (to understand the information needed to make key decisions).
- Plain language questions are essential for the works (to understand the information needed for KPIs and define success).

Exchange information requirements (EIR delivery/operations)

EIR specifies information and information deliverables required by a contract or work package, which can be a part of a project. EIR should be as specific and as detailed as possible and practicable and is best produced as a database, which includes requirements for delivering:

- **unstructured information** (human readable only), like drawings, bitmap images, text documents, etc.
- **structured information** (machine readable), like databases, tabular spreadsheets, objective asset models, etc., structured information can be further broken down into objects, which contain geometrical, alphanumerical and documentation information and metadata (information about information).

The following activities should be undertaken by an agency before and during the procurement of DE delivery:

- Assign a Project Information Manager for the project.
- With assistance from the Project Information Manager, prepare the EIR to go out during tender evaluation.
- Review and comment on DE Execution Plans (DEXPs).
- Lead in the evaluation of the DEXPs received from contractors during the tender evaluation.
- Establish DE KPIs.
- Establish the agency CDE for the project for receipt of information from suppliers (depending on the solution adopted and as defined in the EIR).
- Manage and maintain the exchange of information between stakeholders.

Contract documents for DE delivery

The procurement phase of the contract contains stages of prequalification, tender invitation, and response to the tender invitation and is concluded with an appointment, which officially marks the start of the contract. Information management resources prepared in the planning phase are essential for procurement. Additionally, an agency may choose to prepare a number of templates, which can assist the prospective service providers in delivering only useful and meaningful information to the client for review. Key information management resources and templates can be included in the tender package to

the prospective service providers and should be requested to be completed and included as part of their tender response submissions, noting that they will need to be updated and re-confirmed before mobilisation following contract award. The key information management resources are outlined below:

Prequalification – to be undertaken before or during tendering:

- **Supply chain capability assessment** – attached by the agency to the invitation to Expression of Interest (EOI). It is a survey containing questions about the organisation structure, digital capability, capacity and experience of a prospective service provider and its supply chain.

Tender invitation – to be issued by the agency during tendering;

- **Information management activities responsibility matrix** – a RACI table listing actions required by the client concerning information management and contract parties involved in these actions. ISO 19650 Part 2 Annex A provides a useful template for a responsibility matrix.
- **Project information standards** – a document containing the agency's information standards and management procedures (described in the planning phase above) adjusted for the needs of a specific project.
- **Shared resources** – any information that may be useful for tendering, including existing asset and site information, templates, configuration files and even example DE deliverables to help align expectations.
- **Project information production methods and procedures** – a document with the agency's requirements as to how the required information should be produced. It is only necessary if the client has very specific reasons dictating how the information should be produced. In other cases, it will be produced at the tender stage by the prospective service providers as they are the specialists, whose job is to produce information and who have their internal best methods and procedures for doing it.
- **Exchange information requirements (EIR)** – the key resource specifying what information is contractually required. It is described in the planning phase above. For tender invitation, may also contain a Schedule of Information Deliverables (SID) – a chronological list of specific information packages with approximate times of delivery (usually in weeks) relative to the commencement of the contract.
- **DE execution plan (DEXP) template** – an optional template to be used by a prospective service provider in preparation for their DEXP included in the response to the tender invitation. It is a preliminary response to the client's EIR. The document confirms that the service provider understands the client's requirements and should outline his proposed and justified changes to these requirements (if any).
- **High-level responsibility matrix template** – an optional template used by the service provider to develop a structured list of information deliverables (from the client's schedule of information deliverables) with added information about the organisation(s) to produce specific deliverables.

Response to tender invitation to be issued with the tender submission:

- **DE execution plan (DEXP)** – preliminary response from the service provider to the client's EIR. A DEXP as part of a tender response may be general, limited in detail only to the information required in the DEXP template or as stipulated in the EIR and not too time consuming for the service provider to prepare and for the agency to review. Suppliers may become more familiar with agency requirements as they are better defined and assist them in becoming more efficient in responding. The pre-tender DEXP submitted will need to be reviewed and updated to include further detail before mobilisation of the works.

- **High-level responsibility matrix** – schedule of the contractual information deliverables developed from the client's SID with added information about the organisation(s) which will produce specific deliverables based on the supply chain proposed by the service provider.

4.5.3 Mobilisation and production for DE delivery

The mobilisation and production phase of information delivery for the contract begins just after the tender award. In this stage, the parties sign the contract, and the client passes to the service provider additional, more detailed information and document templates related to the contract necessary for detailed information delivery planning, which is completed by the service provider. The mobilisation stage finishes when all the information planning resources are approved by the client and the service provider can begin information production and delivery.

Key mobilisation requirements include delivery of the following as a minimum:

- **DE execution plan (DEXP)** – the key contractual resource produced by the service provider to specify project Information standards and project information production methods and procedures. Provided to the client.
- **Detailed responsibility matrix –** Information about the task teams scheduled to produce specific information deliverables. Typically, it will still contain the submission times of information deliverables relative to the commencement day of the contract rather than the absolute dates.
- **Task or discipline information delivery plan –** planning of information deliverables production for a single task team.
- **Master information delivery plan –** planning of information deliverables production for the entire delivery team. It is consolidated from multiple task or discipline information delivery plans and has added information about dependencies between the task teams. Therefore, it may be useful for the MIDP to have a gantt chart format.

Production of DE deliverables

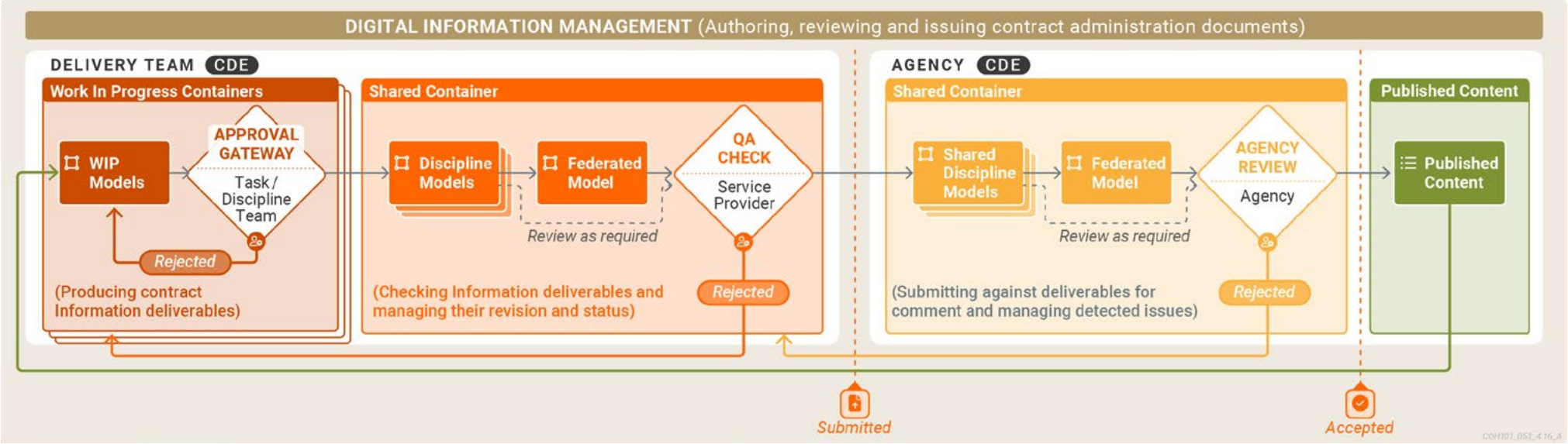
Production of information begins after all the information planning is completed by the awarded service provider and accepted by the client. In this stage, the service provider will produce information and information deliverables based on its agreed and accepted delivery plans and submit them to the client's CDE system at the times specified in the MIDP. The client, notified by the system about the submissions, will review the information deliverables for compliance with standards and technical correctness and raise issues (if any) through the issue management system. After resolving all the issues with the service provider and their supply chain, the information deliverables will be accepted by the client for their intended use. Throughout the contract, the CDE system will allow the agency to track the history of information deliverables and their management including, their status, revisions, actions, time, team members involved, etc.

Control and exchange of DE deliverables

The consistent control and exchange of information across the asset lifecycle is paramount and requires all parties to undertake their roles in relation to managing information which can include the production, planning, review, approval and acceptance of information deliverables.

Figure 4.15. shows the conceptual workflow aligned to ISO 19650 to facilitate the control and exchange of project and asset information between projects and agencies.

Figure 4.15 – Key workflows and states of information lifecycle in the production stage of information delivery.



4.6 Aligning capabilities, systems and ways of working for DE

4.6.1 Digital ways of working for asset lifecycle collaboration

Large asset-owning organisations are already using DE to transform their businesses. For example, they are using digital twins – virtual representations of physical assets – to simulate how their assets will perform over time. This helps them to make better decisions about design, construction and maintenance, and to avoid potential problems before they occur. Therefore, DE is an important capability for organisations that want to improve their asset management. It can help organisations to save time and money and to avoid potential risks.

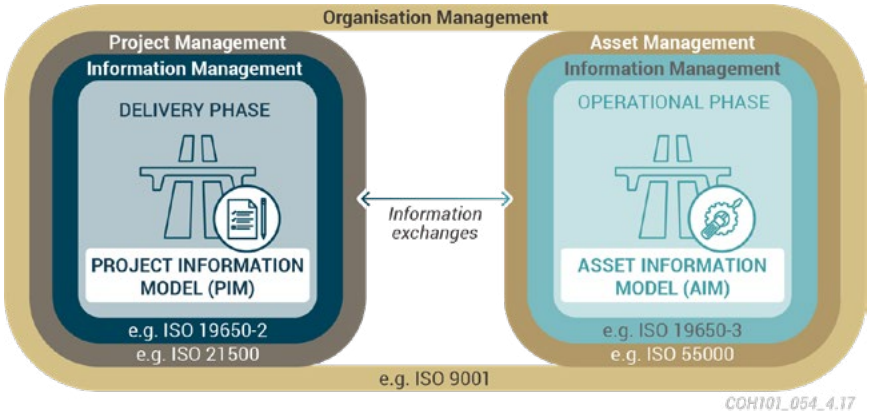
For agencies to realise the benefits through the implementation of DE within their organisation, asset network and projects, there are a number of key areas which will need to be aligned including:

- How information about assets is defined.
- How information about assets is procured.
- How information about assets is exchanged.
- How information about assets is controlled and governed.
- How information about assets is stored and interacted with.
- How information about assets is collaboratively and iteratively produced or updated.

4.6.2 The role of standards and best practice

The 'process' discussed in this chapter is a process of Information Management for asset delivery or asset maintenance projects. It is based on the principles of the international standard ISO 19650 and therefore also includes a wider context of the organisation (agency), that commissions the said projects. It is essential to consider such context as information is a critically important asset for every organisation and therefore should fulfil the high-level organisational objectives and be protected at every level. Information is delivered during projects together with assets and services and the process to do this has been traditionally known as 'project management' (CAPEX phase) and "asset management" (OPEX phase). It is therefore essential to treat Information Management as an integral part of project/asset management rather than a parallel activity. Specifically, for the design part of an asset delivery project, all and only project deliverables are information deliverables as the asset itself is not built yet. The diagram below outlines these dependencies using the relevant ISO standards for various levels of management and CDE as the single digital system for information management for the whole asset lifecycle.

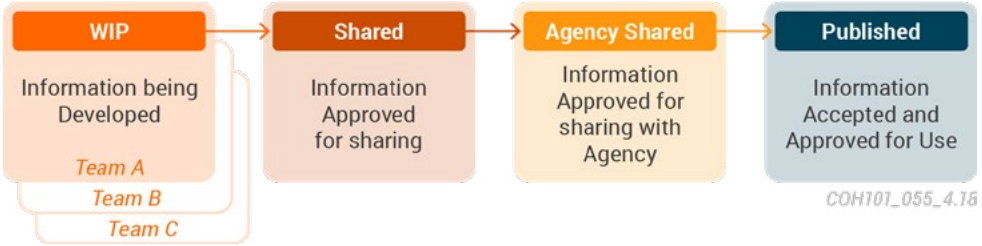
Figure 4.16 – Information management (ISO 19650) in the context of project, asset and organisational management.



4.6.3 A common data environment (CDE) process and solution as a key enabler

ISO 19650 describes managing the collaborative production of information as a well-defined workflow for the approval of information contained within electronic files. The workflow introduces the notion of data being controlled and assigned with particular statuses via a container-based approach, i.e., electronic files with metadata to track status and to identify individual information containers within a common data environment (CDE).

Figure 4.17 – The CDE workflow as outlined in the ISO 19650-1 and its use of containers.

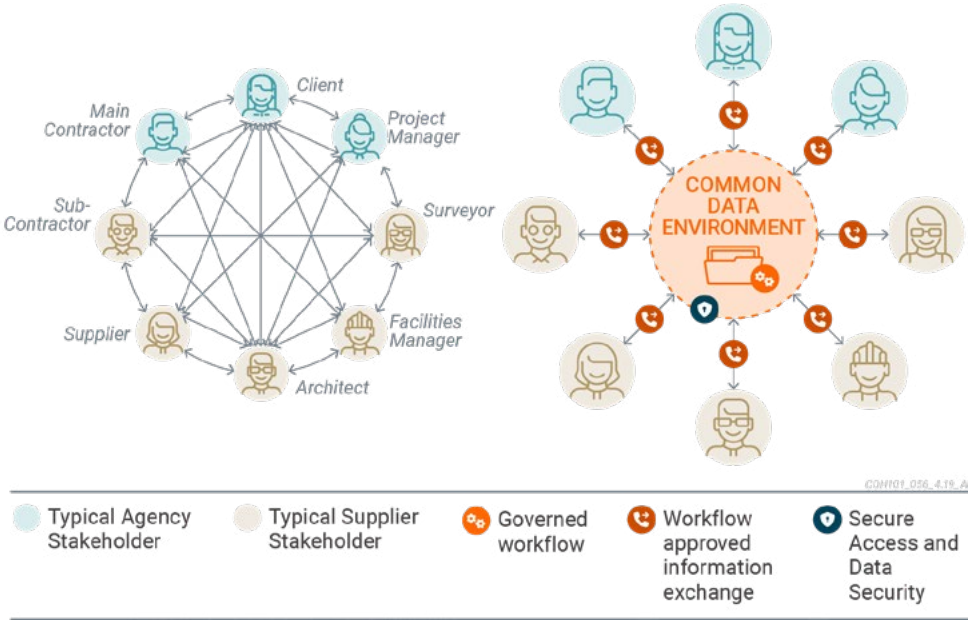


A thorough explanation of the CDE workflow and its potential technology solution can be found in Section 4.7.4.

What is a CDE

CDE is a central digital system for collaboratively managing and accessing all information about projects and assets by all the project and asset stakeholders (single source of truth). The fundamental benefit of CDE for the agency is that it replaces traditional multiple non-synchronised channels of transferring information using often multiple versions of the same information with a single, verified and up-to-date version of information centrally accessible to all stakeholders who need to use and have the right to use this. information.

Figure 4.18 – Traditional model of sharing information (left) vs the CDE model (right).



A CDE to support planning and capital delivery has the following key objectives:

- To support and enable optimisation of business processes related to collaboratively producing, coordinating, managing and analysing information generated during major design and construction works.
- To allow all the stakeholders access to high-quality information about the current state and history of a design and construction project.

Implementation of CDE results in the following key benefits for an organisation:

- Reducing the number of human errors in design, construction and asset management through fully automatising certain tasks and supporting tasks for which human interaction is necessary.
- Reducing time for finding an updated version of the information at any stage of the asset lifecycle.
- Access to track record of revisions of information and deliverables submitted by external service providers and/or in-house work package teams.
- Access to track record of actions executed on Project / Work Package deliverables including their timing, authors and relationship with other actions.
- Access to information about assets in case of asset failure.
- Reducing design errors in the design stage results in reducing the high costs of design rectification in the construction stage (build it right for the first time) through well managed design review and approval process.
- Availability of reliable and properly structured data for specialised analytical software supporting/automating, e.g., design review, clash analysis, statutory code checking, real-time monitoring of assets, predictive maintenance, etc.
- Availability of well organised and structured information for exchange with other digital systems used by the agency or external service providers through implementation and automatic enforcement of data governance protocols by the CDE.

4.7 Leveraging enabling tools and technologies for DE

4.7.1 Technology as an enabler

Digital technology is what enables the existing business processes to be optimised and new business processes to be implemented. Digital technology needs software applications and platforms, with which the end users interact and the underlying hardware infrastructure, which enables software to run. Hardware is delivered and installed by external suppliers/service providers and configured by in-house and/or contracted IT professionals.

The fundamental objective of using digital technology is to optimise the generation of outputs, insights and decision-making processes in the organisation, i.e., to provide the RIGHT INFORMATION at the RIGHT TIME for the RIGHT PEOPLE to make the RIGHT DECISIONS.

Figure 4.19 – Fundamental objective of using digital technology.

For this top-level objective to be achieved the information delivered by digital technology must be:

- **Available** in the digital system when it is needed.
- **Accessible** at any time and from any location by the people it is intended for.
- **Secure**, i.e., protected from unauthorised access, copying and deletion, both accidental and malicious.
- **Relevant** to the decision it needs to support.
- **Correct** by presenting a verified and unbiased picture according to the available knowledge and data inputs.
- **Trackable** by enabling identification of the latest version of information and providing access to all the past versions (history).
- **Understandable** for the people it is intended for.
- **Efficient** by being delivered in a technically optimal way and using as few resources as possible.

People, process, information and technology

When implementing any digital change program there are key elements, people, process and technology. Of these three elements, it is often reflected that it is the people who are both the most important and challenging. This becomes more important when discussing or focusing on the implementation of DE technologies. As the design and construction industry continues to grapple with how best to bring about sustainable technological change it is the impact on the people who work within that industry that must be kept at the forefront of any change program. It is the essential 'so what' question that is required to be addressed for all facets of the organisation and industry.

Defining the value of change

Change is essentially a variation in the common way of doing things. Bringing about change that is both seen as valuable and produces greater value because of that change would seem straightforward in principle. It is however the ability to effectively communicate the potential value that is often where historically the construction industry has struggled with technology adoption.

Improved outcomes through change

Ensuring we have the right drivers for any proposed change is paramount. The application of DE throughout the lifecycle of an asset is fundamentally about improving the overall outcome while balancing the cost to deliver and operate the asset. There are for that reason many areas and factors through the lifecycle where the adoption or utilisation of both new and existing technologies can be of significant benefit to the overall outcome.

4.7.2 Utilising technology across the asset lifecycle

Deriving where opportunities exist to adopt or utilise change that can be supported through new technology can be complex and challenging to understand. This will involve understanding current industry capability and its applicability to the delivery of road assets and infrastructure, as well as exploration into new areas and deliverables which can all ultimately aid the overall delivery of the asset with improved outcomes.

The asset lifecycle technology utilisation matrix in the appendices provides an overview of the perceived current industry capability and adoption of technology as an enabler for DE.

Looking first at the assessment, need and design phase, Table 4.8 shows how across the lifecycle both agencies and supply chains are currently leveraging technology and where potential opportunities may lie. What this tells us is that early on in an asset's lifecycle adoption and use of digital technology is particularly strong on the supply chain side with strong use in both feasibility, planning and design. However, it also clearly shows how much influence the traditional approach to contracts and deliverables is stifling onward development and use outside of the originally intended domain or use.

For example, in the feasibility stage, an agency will likely engage a design consultant to develop a report or business case to aid in the decision-making process around an asset. It is also normal however that the output of this work would likely be an electronic written report which the agency would then use to support the evaluation.

While a report may still be a perfectly acceptable requirement there are significant opportunities that could be extracted and built upon should the decision to proceed to the next stage be positive as is shown below.

Table 4.8 – Leveraging technology across the lifecycle

Lifecycle DE use cases				**BAU shown in** light blue
	Capture	Create	Analyse	Review
Feasibility	• Feature survey • Context capture • Existing utilities	• Solution optioneering • Site analysis	• Initial costings/budgets • Buildability • Stakeholder impact	• Alignment options • Environmental and heritage impacts
Design	• Existing utilities	• 3D focused design	• Safety in design • Risk management • Requirements management • Model based QTO	• Design coordination • Change measurement • Progressive assurance

As demonstrated in this example work undertaken at the feasibility stage such as the capture of existing utilities can have both a significant benefit from a more in-depth digitally enabled workflow and procurement process as well as a flow through effect into the design and later stages of the asset's lifecycle.

Moving through the lifecycle we can start to see how the use of technology drops off however the potential benefits start to grow. As we move from design into the procurement and construction stages the value proposition starts to centre around how the digital process and data are transferred and maintained such that it provides continuity.

What the above example shows, however, is there is room for significant benefit in both the procurement and construction stages of the lifecycle. The greater expectation around the use of digital datasets and workflows would provide greater certainty in the pricing and understanding of procurement of construction packages during the tendering process. This would facilitate consistency in returnable' as well as an ability for clients to understand more consistently how competing offers marry up. The change in procurement would in addition provide far reaching benefits in driving greater application in the actual construction stage through clear digital contractual requirements as well as greater involvement and expectations client side.

The change required here is not just centred around the potential of technology, it is very much underpinned by the need to drive industry change that flows through from clients into tier one and two contractors into the broader supply chain. By recognising that through small additions, amendments and even the removal of requirements agencies can make a powerful statement of intent to the industry which in turn requires a direct response. Both factors will be hugely beneficial to the industry and in turn to the overall success in the delivery of all future assets.

Looking at the varying applications of DE technology across these two stages, we can quickly see the areas of opportunity that sit outside those that are currently used as a business-as-usual approach.

Table 4.9 – Lifecycle DE use cases for procurement and construction

Lifecycle DE use cases				**BAU shown in** light blue
	Capture	**Create**	**Analyse**	**Review**
Procurement	• Model based QTO • Point cloud survey	• Digital fabrication • Estimate • High-level staging • Visualisations	• Client requirements • Buildability • Traffic disruption	• Estimate (5D) • Program (4D) • Staging
Construction	• Existing utilities • Feature survey • As-built point cloud survey	• Existing conditions • Program (4D) • Temporary works • Equipment logistics • Digital work packs • Digital method statements	• Interface management • Construction safety • Cranage strategies • Logistics • Cost control • Environmental tracking	• Construction progress • Materials tracking • Component tracking • Quality due process

As the asset's lifecycle moves into the construction phase the number of systems required ultimately grows thus creating a greater risk of information silos. Project Controls is another significant digital area of focus in construction delivery and thus creating greater linkages with accurate digital models and geospatial data provides multiple benefits. Integration of systems either through Application programming Interfaces (APIs) or via a central data lake provides further room for improvements.

As we move toward the latter end of the lifecycle this is where the importance of good data and information requirements comes to the fore. The quality of that data captured through the earlier stages and how those transfers from one stage to another help provide a robust fit for purpose handover dataset. Of course, the aim of digital in an asset's lifecycle does not end at the handover stage and for that reason, we have explored the operational phase as well.

As we have seen elsewhere there is a disconnect between the 'project' phase of the lifecycle and the operational phase with respect to the information that is required and how this is captured and delivered. This can be taken as a positive however as it can be shown that through minimal changes to current project methods and project requirements, there is an opportunity for improving the quality of a project close-out as well as the handover.

Table 4.10 – Lifecycle DE use cases for handover and operations

Lifecycle DE use cases				BAU shown in light blue
	Capture	Create	Analyse	Review
Handover	• As-built point cloud survey • As-built survey	• WAE models and data • As-built models and data • As-built 2D drawings • Models linkto as-built drawings	• Systems testing • Progressive completions • Progressive assurance • As-built tolerance validation	• Digital asset data validation • Project requirements
Operations	• Digital asset data validation • Project requirements	• Model and asset data integrations • Operation safety testing and scenarios • CAFM model integration	• Systems fault testing	• Operational safety • Systems fault diagnosis • Asset virtual location

There are clear opportunities in improving the types and quality of asset information and more importantly how they are delivered and integrated, all of which serve to create greater possibilities within operations itself. It is worth noting that many if not all modern assets are largely managed digitally and what we are referring to is focused on how the data within the project aspect of the lifecycle can be captured and handed over to facilitate a more streamlined start to operational procedures. In addition, however, there are several areas which then become possible because of this approach. For example, the use of a model by an operations team before installation and testing to check the operation safety of an asset or parts of an asset in a virtual environment. Another example could be the use of an intelligently integrated virtual model and data set with a Computer Aided Facilities Management (CAFM) platform to provide more robust visibility of a piece of equipment within an asset. This can also be used to visually simulate and show actual live performance and occupancy of systems or locations within an asset.

To complete this section the following table expands on all the DE use cases identified as both BAU and opportunities above to provide greater context as to the value of adoption within an asset lifecycle.

For further examples of DE implementation, see Section 6 for Case Studies and the Glossary of Terms: References for further reading.

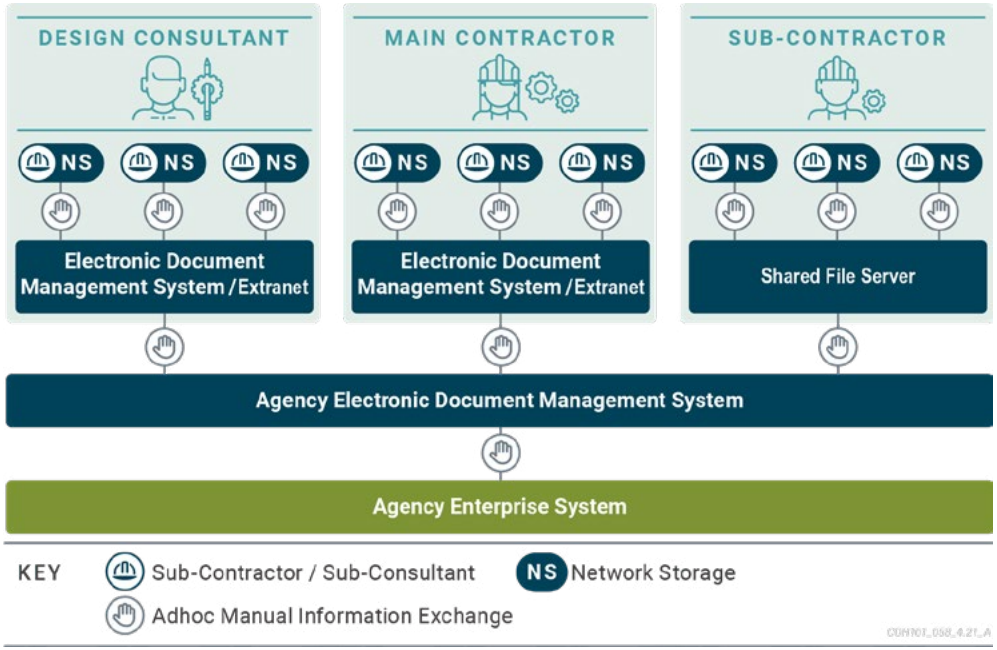
4.7.3 Enabling better information management

In all aspects of the opportunities, we have explored in Section 4.5.2 the management, quality and access to the assets information is critical in enabling or enhancing workflows and processes across the lifecycle.

How information is created, reviewed, validated, shared and managed across all participants requires a significant shift in thinking, implementation and the type of underlying technology used from what is currently adopted in most road or infrastructure projects.

To do this we first understand and evaluate what is currently implemented most.

Figure 4.20 – Example pre-CDE structure of a distributed system lacking automatic workflows and approvals or common configuration across systems (image courtesy of Cohesive).



Looking at the above diagram we can see that in most cases the agency will procure an Electronic Document Management System (EDMS) to capture and manage all correspondence and deliverables required to successfully deliver the asset. In addition, it is common for design participants and contractors to have their own systems and information environments to manage the information they both create and receive throughout the project lifecycle.

As a part of the configuration of the project EDMS by the agency, it is normal for document control procedures to be written to help standardise the creation of document types and their use in the project.

This however is insufficient when looking at information beyond that stored and used just within documentation.

Through the development of industry standards such as BS 1192 and later PAS 1192, an information standard ISO 19650 is now available for use by the industry. This standard focuses on the implementation of an information management approach which is underpinned by two key concepts:

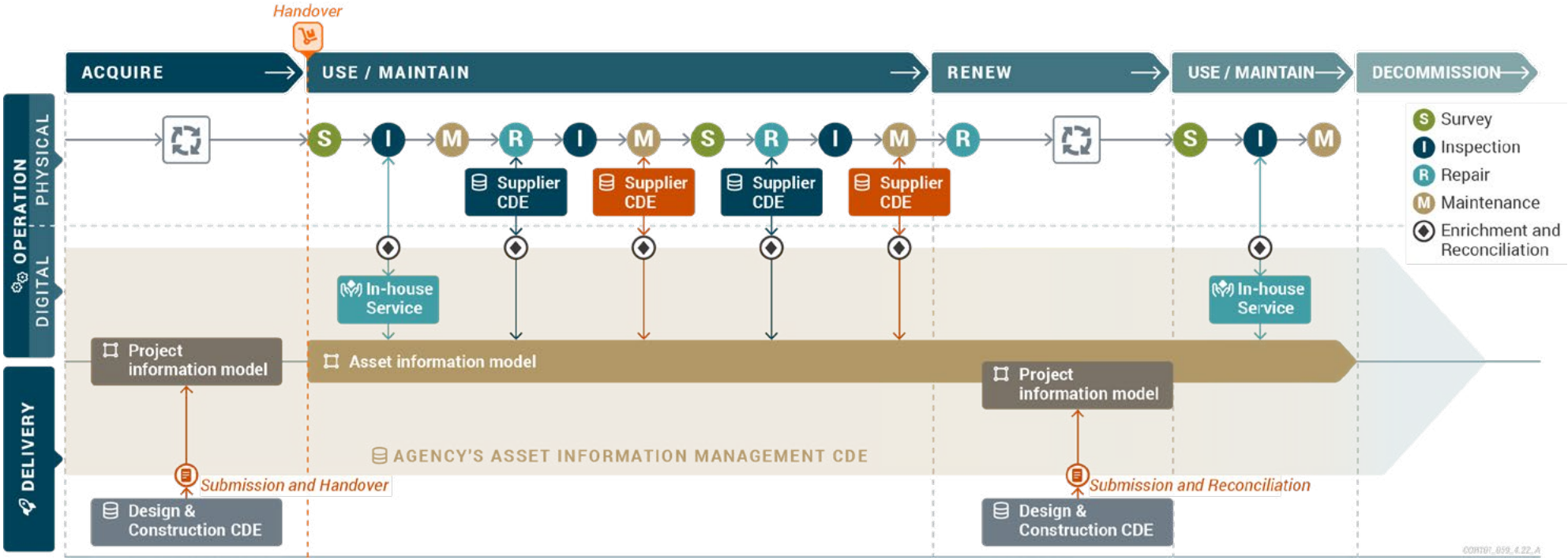
1. Implementation of an information workflow for all project data.
2. Implementation of a CDE to support the creation, sharing and use of all relevant project data.

This approach differs from what is currently adopted on projects primarily in that it focuses very much on how information is created, shared, and then subsequently updated using said CDE. While the definition of the standard holds up theoretically industry has struggled more so due to the lack of understanding around how best to stand up the underlying technology to enable the standard.

4.7.4 Establishing a common data environment (CDE)

A CDE is a fundamental digital technology concept which supports achieving the above qualities of information. In simple terms, a CDE is a digital environment, which can be comprised of several aligned systems, used to process, store and deliver information produced by specialised authoring applications which communicate with the CDE through direct integration on a software level or through specific data exchange formats (e.g., IFC). For a CDE to be functional and effective it must use the right technology (software) to digitally implement the workflows simulating and supporting the real business processes required by the organisation. Therefore, technology and workflow are two essential and tightly related components of the CDE. CDE can be considered to provide a single source of truth for information, which means that all the information about an asset is available in the CDE and that this information cannot be edited anywhere outside the CDE. A CDE solution describes the capabilities of a technology enabled solution which facilitates the exchange and approval of information based on that agreed workflow.

Figure 4.21. An example of the interaction and use of the CDEs used by an agency and their supply chain aligned to typical asset lifecycle activities.



CDE is a fundamental digital technology concept which supports achieving the above qualities of information. In simple terms, CDE is a single digital platform used to process, store and deliver information produced by specialised authoring applications which communicate with the CDE through direct integration on a software level or through specific data exchange formats (e.g., IFC). For a CDE to be functional and effective it must use the right technology (software) to digitally implement the workflows simulating and supporting the real business processes required by the organisation. Therefore, technology and workflow are two essential and tightly related components of the CDE. CDE is considered a single source of truth for information, which means that all the information about an asset is available in the CDE and that this information cannot be edited anywhere outside the CDE.

Identifying the requirements and establishing a CDE

Moving from a traditional project set up straight to the adoption of a new information standard and complementary technology stack is no small feat and for that reason, it would be prudent to think about taking incremental steps towards and end goal of having a fully functioning CDE.

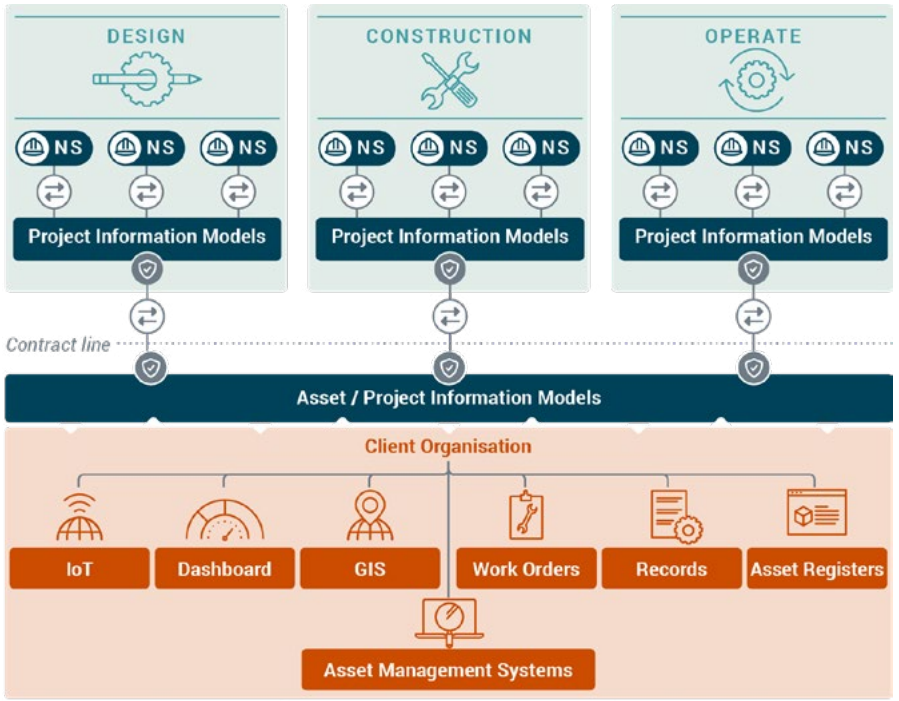
Traditional EDS platforms such as extranet solutions which are most commonly used on large infrastructure projects by government authorities and agencies have many of the elements of functionality required for a CDE.

However, a CDE typically comprises of many varying systems all of which are chosen because they are deemed most appropriate or serve a very specific need. For that reason, it is highly unlikely that a CDE will ever deliver the full value and benefits when trying to utilise just a single platform.

That does not mean that there is a need for radical change straight away but more a recognition of some of the core ingredients that may be missing and potential incremental steps to addressing those gaps. Figure 4.22 highlights a typical conceptual arrangement of a distributed CDE between the agency and its supply chain.

When defining requirements for and procuring a CDE, it is crucial to consider how it fits into the overall organisational strategy as well as the DE strategy. This includes an articulation of the options that an agency has in terms of technologies to be provided by the supply chain versus technologies provided by an agency.

Figure 4.22 – Structure of a distributed CDE (image courtesy of Cohesive).



OPEX and CAPEX stages will drive specific requirements for the CDE system, which should be considered by the agency apart from the general requirements listed below. (See Section 4.2.4).

Developing a CDE strategy

The table below outlines the recommended approach towards developing a CDE strategy for an agency and why this is important for implementation:

Table 4.11 – Key CDE strategy development activities

Key CDE strategy development activity	Why this is important for CDE implementation
Define the scope and capabilities required of CDE	Typically, there are a number of systems that can form a distributed CDE and can support various functions from basic information exchanges, transmittals, automated workflows, contract management, and model viewing among others, so a clear scope is very useful when selecting, procuring and configuring a CDE.
Describe the role of CDE in the context of known use cases	Having clarity around how the CDE is intended to be used helps to ensure the right expertise, planning and mobilisation for the required solutions meet the intended outcomes.
Describe CDE 'footprint' and architecture and its impact on the business	Understanding and communicating the systems that will form a commonly configured data environment will help interface with or adapt existing systems with any new systems that may need to be introduced.
Develop data flows/journeys, functional requirements and non-functional requirements	To configure the systems that form the CDE, it is important to plan and agree on ways of working and workflows that will support this before mobilising systems for use to ensure consistent governance of data within the CDE.
Undertake market engagement/research and develop a CDE procurement plan/approach	Understanding what capability and capacity is available in the market at any given point in time is valuable in informing whether to leverage existing systems and services or acquire new ones.
Develop a CDE implementation plan	Implementing new systems and ways of working requires careful consideration, planning and communications as well as support and training for administrators and users so a formalised plan will help enable successful deployment and uptake of the CDE solution.

Known challenges in implementing a CDE

Below are several known challenges that an agency is likely to face when implementing a CDE and the recommended mitigations:

Table 4.12 – CDE implementation challenges

CDE implementation challenge	Recommended mitigations
Scope of the responsible party for hosting CDE	Providing adequate storage and levels of support and service should be agreed upon with dedicated resources.
Data integration across differing organisations	Verification of information requirements and validation of data may require additional effort and skills, which should be put in place, particularly to monitor and manage information exchanges between different teams and systems.
Hardware capacity and IT firewalls for client agencies	IT departments will need to be closely aligned to ensure controlled access to systems that are designated as part of the CDE to ensure secure yet efficient information exchanges while adhering to IT policies.
The inability of one vendor to provide a robust overall solution	Defining the scope and capabilities of the CDE will help understand where and how the required solutions and support can be established. Managing the deployment of various systems will need to be carefully coordinated.
Reluctance from supply to chain a different approach	Agencies are in a position to provide clarity and leadership about how information should be delivered and controlled and the more clarity that can be provided to suppliers, the better the outcomes.

Recommended features of a CDE

To fulfil the DE objectives of an agency and to assist in realising the potential benefits of better information management, a CDE should meet the following general requirements based on the requirements for high-quality information.

Table 4.13 – Requirement for high-quality information and a CDE solution

Requirement for high-quality information	Requirement for CDE
Available	Ability to define in the CDE the time when information is needed and ensure that this information is provided at this time. For this to happen the CDE needs to enable the configuration of workflows containing states through which information flows in a controlled way, i.e., is distributed to the right people, who are notified about the nature and time of the action that they need to take.
Accessible	CDE should be implemented with technology allowing access from multiple locations using multiple digital devices, e.g., using public or private cloud servers or web-based access to the agency's intranet.
Relevant	The CDE system must ensure that the users have access only to the information which they need (is relevant to them). For this to happen the CDE should allow defining groups of users and roles assigned to these groups or users. Roles in the CDE should be related to the business roles of the individuals in the agency/project/work package organisation structure. Roles are collections of permissions, each of which allows the execution of a specific action within the CDE. On top of this, a powerful searching system using attributes/metadata of the entities maintained in the CDE is required for the Users to access information specific to their current job.
Secure	The CDE system must ensure that the users have access only to the information which they have the right to access. This requires the functionality of defining detailed access rights for the users or groups of them based on the roles they have in the process. CDE should implement and control different types of access rights, i.e., read, modify, download, delete.
Correct	To support this requirement the CDE needs to ensure that the information has been reviewed and approved by the people with the relevant roles in the work package team. The workflow of information should contain the actions, 'review' and 'approve', which must be completed before the information becomes ready for its intended use. The agency information policy must also require that all the information is available in the CDE for a given project/work package and it cannot be edited outside CDE.
Trackable	CDE should implement a revision control system allowing the users to identify the latest version of information as well as all the past versions (history). Actions executed by the users on information should also be recorded by the CDE system enabling a comprehensive audit trail of the project/work package.
Understandable	CDE must have the ability to present information in a way which is understandable and relevant for specific users and other systems, e.g., as 3D views (models) or 2D views of the assets (drawings) for engineers and graphs or tables for financial controllers. The CDE should enable configuration enforcement of naming standards of assets, entities and actions managed by the system to support the searching of information by human users and automatic processing of information by digital systems.

4.8 Key recommendations

Key recommendations for agencies explored in this chapter include:

- **Implement DE across the asset lifecycle –** an agency is the driving force for successfully and consistently implementing DE capability across the entire asset lifecycle including departments and projects. Agencies have a key role to play in not only how they plan out their DE programs but also in taking active steps to implement these plans by being willing to participate actively at every level along the way.
- **Manage information requirements –** implementing a framework for capturing information requirements. The key opportunities and outcomes when an agency directly drives the management of their information requirements, described in relation to procuring DE deliverables and outcomes while maintaining access and control of data across the asset lifecycle.
- **Align capabilities systems and ways of working –** An agency should seek to understand how departments can work together and with external partners through collaborative working to produce, manage and leverage DE across the asset lifecycle, the role of standards in enabling this and the concept of a CDE, as per ISO 19650, in terms of a consistent and governed workflow to be enabled by a suite of enabling technologies and aligned with other stakeholders and systems.
- **Leverage enabling tools and technologies –** An agency should continuously explore, with industry, how technology can enable strategic, management and technical outcomes. Key methodologies are also considered which agencies may adopt or procure in terms of DE outcomes or data deliverables for various purposes in a quality-controlled manner supported by a CDE solution aligned to specific agency requirements.
- **Implement with a phased and measured approach –** An agency should take a phased and pragmatic approach to dealing with legacy data and systems, the implementation of a CDE for enterprise and project applications and measuring and monitoring progress and impacts that new DE capabilities are making.

4.9 Closing summary

To continue current progress, it will be necessary for agencies to collaborate and continue to share best practices. By working together, agencies can make sure that they are taking advantage of the latest technologies and tools while continuing to improve their capabilities systems and ways of working.

In the ever-demanding provision of reliable transport services, it is crucial for agencies to constantly evolve and improve their capabilities. The ever-changing landscape demands a proactive approach towards capability improvement to keep up with emerging technologies and changing customer expectations.

One of the key considerations for agencies in this process is implementing DE across the asset lifecycle. By utilising DE, agencies can streamline their processes and improve efficiency by digitising workflows and data management. This not only saves time and reduces costs but also allows for better collaboration among stakeholders throughout the entire lifecycle of an asset.

Another crucial aspect is managing information requirements. With the increasing amount of data being generated by assets, agencies need to have a robust information management system in place. This includes ensuring data accuracy, accessibility and security, as well as implementing protocols for efficient sharing and utilisation of information.

Furthermore, agencies need to align their capabilities, systems and ways of working to fully leverage the benefits of DE. This requires a holistic approach towards capability improvement, where all aspects including people, processes, information and technology are integrated seamlessly to achieve common goals.

For agencies to make the most of DE, they must continue to develop DE capabilities within their supply chain and across their organisations. Furthermore, to continue to collaborate with wider Industry and other agencies to enable DE to become an integral part of how road agencies operate.

LEARNING & DEVELOPMENT DIGITAL ENGINEERING FRAMEWORK

SECTION 5:

LEARNING AND DEVELOPMENT DE FRAMEWORK

5.1 Chapter summary

As an agency's DE program evolves, there will be increasing reliance on new processes and technology to enable and support its strategic objectives. To succeed, agencies need an effective framework for learning and development (L&D) in DE. The framework will support individuals and teams to keep up with today's rapidly changing technologies and to future-proof the agency.

An L&D framework is applied systemically across an agency to ensure all employees can participate in developing products and services that are updated through technological innovation. This chapter will respond to essential questions of why an L&D framework for DE is required, what it looks like and how a DE training program is delivered.

Table 5.1 Chapter relevance to role summary

Should I read this section to help in my role?		
Reader	Essential	Helpful
Sponsor/key decision maker in the adoption and development of a DE strategy	✓	
Department head/key stakeholder in the adoption of a DE strategy		✓
Leading/supporting the development of a DE strategy	✓	
Leading/supporting the implementation of a DE strategy.	✓	
Adopting the new digital engineering practices		✓

5.1.1 Purpose of this chapter

Industry is amid a technological revolution that is fundamentally altering the way we live, work and relate to one another.

Formal learning through workshops and eLearning is no longer enough to provide the level of responsiveness and adaptation needed in the environment of constant change post COVID-19.

To drive an agency's performance, they must leverage the abundant opportunity to learn from the work of others. Encouraging a culture of continuous individual and organisational investment in learning, sharing learning resources, and partnering across agencies will be crucial. Agency staff will need to develop new DE skills while staying open to new ideas and new ways of working.

Supporting people to learn at the current pace of change requires agencies to consider new approaches to learning and development. The design of the L&D framework should provide agencies with a foundation to help build DE capability and to develop, share and distribute learning experiences for a highly capable and future-ready agency staff.

5.1.2 Why this chapter is important

Table 5.2 Section content summary

Section headings	What this section addresses:
5.2. Why is a L&D framework for DE required?	Provides an overview of the key challenges that agencies face in developing a DE L&D framework.
5.3. What is a L&D framework for DE and what are its benefits?	Provides details on the key aspect that agencies should consider in developing a DE L&D framework and its benefits.
5.4. Key recommendations	Provides key recommendations to consider in developing a DE L&D framework.

5.2 Why is an L&D framework for DE required?

Without an L&D framework, there is a risk that projects will be chaotic, and team members will not be able to work together effectively. This can lead to uncoordinated ways of working, reduced quality and efficiency, project delays, additional costs and inefficient maintenance of assets. Furthermore, an L&D framework can help to ensure that DE teams can continuously improve their skills and knowledge. By investing in an L&D framework, agencies can make sure they reap the full benefits of DE.

It is essential to have an L&D framework in place to ensure the success of DE projects. This framework can help to ensure projects are well organised and team members are properly trained in the use of DE tools and techniques.

In an increasingly complex and competitive industry, the need to identify and nurture talent has never been greater. Planning and delivering education and skills training as a managed program helps meet standards and allows everyone to develop to their full potential.

By managing the delivery of training, agencies can be sure they have the capacity and capability to meet future demands. In addition, by collecting data and information about performance, agencies can continually review and improve their training programs. As a result, managed education and skills training programs can provide significant benefits for both individuals and agencies.

5.2.1 Key components of a L&D for DE

When developing an L&D framework for DE, there are several essential components to consider:

- **Goals and objectives** – The L&D framework should align with the overall goals and objectives of the agency. It should focus on developing skills that are relevant to the company's DE strategy. This ensures that the L&D framework is in line with the agency's vision and mission. This approach should also be applied to project objectives and goals.
- **Competency framework** – A competency framework defines the skills, knowledge, and behaviours required for successful performance in a particular role. It helps identify skill gaps and provides a clear direction for employees' development. The competency framework for DE should include technical skills, such as 3D modelling, information management, model coordination, federation and review, as well as soft skills like collaboration and communication.
- **Learning methods** – The L&D framework should incorporate a variety of learning methods to cater to different learning styles and preferences. This could include classroom training, e-learning, on-the-job training, workshops, and mentoring. A blended approach that combines different learning methods is often the most effective as is one that leverages a combination of in-house and externally provided training including accreditation and certification.
- **Continuous evaluation** – It is essential to regularly evaluate the effectiveness of the learning framework and make necessary adjustments. This could be in the form of assessments, surveys, or feedback sessions with employees. Continuous evaluation ensures that the learning framework remains relevant and impactful.

5.3 What is a L&D framework for DE and what are its benefits?

An L&D framework is a guide that helps agencies to plan, implement, and assess their learning and development initiatives. The framework provides a structure for identifying an agency's learning needs, designing appropriate interventions, and evaluating the results. It can be used to benchmark progress and compare results against other agencies.

Typically, an L&D framework will include the following four key steps:

- Current state competency assessment
- Planning and strategy
- Delivery and uptake
- Continuous improvement and evaluation.

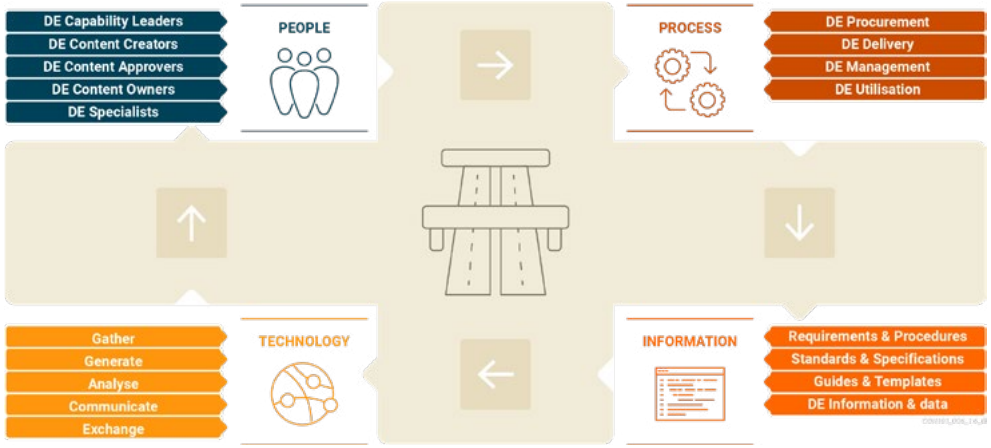
5.3.1 Current state – assessing agency and workforce competency

There are a variety of ways to identify key gaps in current agency capabilities. One common approach is to conduct a needs assessment, which can involve surveys, interviews, focus groups, or other research methods.

Before commencing any detailed design of training strategies and materials, current competencies within an agency should be assessed to provide a clear understanding of the ability to undertake the implementation of an Agency's DE Roadmap to realise the desired future DE state as described in Chapter 4 of this guide.

Perform a current state assessment to understand the current digital capacity within an agency encompassing people, process, information and technology capability.

Figure 5.1 – Areas for current state assessment of digital engineering maturity



The digital maturity assessment can be extended to an agency's supply chain – this has several purposes.

- **Clear assessment of current capability** – Firstly, the agency has a clear assessment of the current capability of their supply chain, this needs to be understood to plan interventions to ensure the supply chain can respond to changes in working practices.
- **Engage with the supply chain** – Secondly, it engages the supply chain in the business change conversation where they assess their capabilities and gain a level of insight (limited view) on the capability of their peers. This should encourage the supply chain to look at addressing gaps in their digital capabilities to ensure they remain competitive.
- **Understand the level of support required** – Thirdly, it provides insight on the level of support that the agency may need to provide to their supply chain, i.e. to what extent the supply chain can enhance their capabilities using industry wide resources (free and paid for) versus being able to identify training needs that are best fulfilled by the agency.

Extending the assessment to the supply chain will allow for the development of a targeted and appropriate training program that meets the specific needs of the agency. It will also allow for the creation of a baseline, which enables the agency, through subsequent assessments, to track the progress of developing DE capability and, importantly, monitor the success of the training program.

The results from the digital maturity assessment will allow the agency to get a better understanding of the training and support required to implement DE. Once the processes have been designed and the roles and responsibilities agreed upon, the competency assessment should be designed to provide a role-level granularity to ensure all the critical DE roles have the required competencies to deliver.

5.3.2 Develop a strategy

When developing a training strategy, it is important to consider the teams needs and the agency's goals. What skills do employees need to be successful in their DE roles? What is the agency's objectives? An effective training strategy will take both factors into account.

Some key areas to consider are as follows:

- Conducting a training needs analysis is your first step to developing a successful training program.
- Conducting a training needs analysis before you start putting together your training program is a crucial step in developing effective training material aligned with your digital maturity assessments.
- In all DE training programs, the strategy should focus on the delivery of three key elements:
    1. Building a cross-organisational understanding and buy-in to DE.
    2. Developing the organisational skills required to deliver DE effectively and work within the new processes, protocols and technology environment, as defined by the skills framework.
    3. Providing the supply chain with the knowledge and capability to deliver their required DE activities.
- The training program should range from awareness to role-specific to technical training, depending on the audience and their level of involvement in DE. It should also reflect where the agency is with its DE maturity and where it wants to go.

- Except for awareness training, the training delivery should be at the appropriate level depending upon the individual's role. For example, a project manager should be able to create and apply an EIR, while a client manager needs to be aware of what an EIR is and its use. Typically, the levels will range from awareness (I know of it) to user (I know how to use it) to creator (I know how to create it and can train other people). It is important to develop training around these levels for people to get the right level of know-how and skills to do their jobs using DE.
- Example of an outline training program, adaptable to an agency's needs in line with its maturity levels:
  - Awareness training: for everybody in the agency to provide a basic DE foundation for all future training modules to build upon.
  - Strategic training: for the executive and leadership team to understand the why, what and how of DE.
  - Project training: for the project team to provide training that introduces the DE application of the project and how this relates to individuals' day-to-day activities.
  - Role-specific or persona-based training: delivered to each role separately, or group of roles where the depth of training is consistent. Provide training to all individuals across the project team to the necessary depth for each aspect of DE to enable them to fulfil their role in the creation, validation, maturation and maintenance of data and information.
  - Supplier training: delivered to a supplier to develop the capability needed to work with the agency. The training also informs the suppliers on the agency's way of working.

5.3.3 How can an agency deliver a DE training program?

There are many ways that an agency can deliver a DE training program. Whichever the delivery method, the important thing is to make sure that the content is engaging and relevant to the audience. The options for agencies to consider are:

Online courses or tutorials

- One common approach is to use online courses or tutorials. These can be self-paced or instructor-led, and they can provide a comprehensive overview of the topic.

Live online events

- Another option is to use webinars or other live online events. These can be a great way to get interactive feedback and answer questions in real-time.

In-person training sessions

- Use of offline methods, such as in-person training sessions or workshops.

Linking with continuous professional development

Continuous improvement is the ongoing process of identifying and implementing small, incremental changes to improve processes, systems, and skills. It is an essential aspect of professional development as it allows individuals to continually enhance their knowledge, skills, and abilities.

Continuous improvement involves regularly assessing current knowledge and skills, identifying any gaps or areas for improvement, and then taking steps to bridge those gaps. This process allows individuals to stay updated with the latest trends, technologies, and best practices with DE. By continuously learning and improving, individuals can develop a well-rounded skillset that makes them more valuable to employers.

Case studies are another mechanism for capturing and sharing knowledge about what has delivered value and how challenges have been overcome, which can help guide individuals and teams towards learning new ways of working including the use of new enabling technologies. Several DE case studies are provided in Chapter 6 of this guide.

Industry training, guidance and certification

As industries evolve and technology advances, it is crucial for agencies to continuously invest in training and development. This not only keeps their employees updated with the latest skills and knowledge but also helps businesses stay competitive in the market. Industry training is a key component in achieving this goal, as it provides agencies with the opportunity to upskill their workforce and prepare them for current and future challenges.

Industry training can take different forms, such as workshops, seminars, on-the-job training, or even online courses. Depending on the specific needs of an agency and its workforce, industry training can be tailored to provide guidance and support for employees at all levels. This ensures that every individual receives education and development opportunities that are relevant and valuable to their role within the agency.

In addition to providing knowledge and skills, industry training can also lead to certifications. This is particularly beneficial for employees as it not only demonstrates their expertise in a particular field but also enhances their career prospects. Moreover, agencies can use certified employees as a competitive advantage, showcasing their commitment towards continuous improvement and quality excellence. As an agency, this can provide a clear message about the level of commitment to DE to their supply chain.

5.3.4 Organisational and project level implementation

DE should be considered at both an agency and project level in terms of implementation to maximise the impact to both. Governance and support at both levels will be essential in ensuring good and consistent uptake and delivering of results in line with the strategic and project goals.

Macro size projects may have DE Academy's, similar to the UK Crossrail approach. A significant number of systems, organisations and solutions across a vast and diverse workforce require a combination of organisational and project-specific learning and development. Projects often develop new and innovative ways to solve problems and this should be captured and shared across and beyond the project to benefit other projects and agencies.

Some key areas for a project academy to tackle include:

- engineering and interfaces
- systems and solutions interfaces
- process and data alignment
- mobilisation and uptake
- testing and configuration
- physical and digital mock-ups
- demilitarised learning zones off project sites to assist in learning
- the need to be software and vendor agnostic i.e. include an openBIM approach as described in Chapter 1.

Measure training ROI and mapping value chains:

Establish a measurement system to track the learning outcomes from investment in learning and development and how this is applied within an agency and across projects. There will of course be differing priorities within each agency but project focus at design and construction phases needs to maintain sight of the return on investment of both training and implementation of DE in the operations and maintenance phase.

This would include outcomes from audits and how much it costs to fix errors, emissions and inefficiencies from traditional ways of working when compared to DE approaches implemented. This is also explored in Chapters 2 and 3 when measuring DE maturity capability and in making the case for DE.

5.3.5 Continuous improvement and evaluation

Continuous improvement and evaluation are essential components of any agencies DE program success. By constantly assessing operations and making necessary changes, agencies can ensure that they are always operating at the highest level. Additionally, regular evaluation allows agencies to identify areas of improvement for the DE training program and make the necessary changes to become more efficient and effective.

While some businesses may view continuous improvement and evaluation as two separate processes, they are closely linked. Evaluation provides the data and insights needed to identify areas of improvement, while continuous improvement ensures that those changes are implemented effectively. By working together, these two processes help agencies to continuously improve their performance and achieve their DE goals.

5.3.6 Benefits of having a well-defined L&D framework

A well-defined L&D framework can bring several benefits to an agency. Perhaps most importantly, it can help to ensure that employees have the skills and knowledge they need to do their jobs effectively. This, in turn, can lead to improved productivity and better-quality work.

In addition, a well-defined framework can help to create a more positive and engaged workforce. When employees feel that they can continuously develop and grow within their role, they are more likely to be satisfied with their job and committed to the agency.

Finally, an L&D framework can also help to attract and retain talent. In today's competitive labour market, agencies need to offer more than just a good salary and benefits package. Employees are looking for opportunities to develop their skills and grow their careers.

By having a well-defined framework in place, agencies can show that they are committed to employee development and offer a clear path for career progression. As a result, they are more likely to attract and retain the best talent.

5.4 Key recommendations

Here are some key recommendations when developing a learning framework for DE:

- **Involve multiple stakeholders:** When designing a learning framework, it is crucial to involve multiple stakeholders such as subject matter experts, HR professionals, and employees. This ensures that the learning framework meets the needs of all parties involved and is aligned with the agency's goals.
- **Stay up-to-date with industry trends:** DE is a rapidly evolving field, and it is crucial to stay informed about the latest trends and technologies. This will help ensure that the learning framework remains relevant and current.
- **Encourage continuous learning:** In the fast-paced world of DE, continuous learning is essential. The learning framework should encourage employees to continue developing their skills and knowledge even after completing formal training programs. This could include providing access to online resources or organising regular workshops and seminars.
- **Promote a learning culture:** A learning framework is only effective in a company that promotes a culture of learning and growth. Leaders should lead by example and actively participate in the learning process. This will help create an environment where continuous learning is valued and encouraged.
- **Shared learning and in-person collaboration:** Capturing lessons learnt and case studies is essential for continuous improvement. In-person collaboration also often enhances these outcomes and the clarity of which key findings are captured and understood.
- **Develop a capability framework that has mandatory and desirable skills and capabilities:** Ensure this includes measurable competencies while considering the need for diversity within teams.
- **Measure training ROI and map value chains:** Establish a measurement system to track the learning outcomes from investment in learning and development and how this is applied within an agency and across projects.
- **Implement DE approaches via shadowing and tailor them to project needs where necessary:** Measuring two similar projects to compare the impact of traditional vs DE approaches to provide clear metrics about the ROI.

5.5 Closing summary

- Developing a learning framework for DE is a crucial step towards building a successful and sustainable DE team. It involves creating a structured approach to learning that aligns with the goals, objectives, and values of the agency. A well-designed learning framework can help facilitate the development of skills and knowledge required for DE, ensuring that employees are equipped to meet the challenges of this ever-evolving field.
- Developing a learning framework for DE requires careful consideration of an agency's goals, competencies, and learning methods. It is an ongoing process that requires continuous evaluation and adaptation to keep up with the ever-changing landscape of DE.
- By following these key recommendations, agencies can create a robust learning framework that equips their employees with the necessary skills and knowledge to thrive in managing new ways of digital working. DE is the future, and with a well-designed learning framework, agencies can be ready to tackle the ever-demanding challenges they face in delivering reliable and safe transportation.
- Organisational leaders and project leaders want to see a return on investment in learning and development and a clear demonstration of value for money. They also want to avoid time and cost overruns, meet compliance requirements and enhance the delivery of projects and asset performance. This requires doing DE to the defined requirements, and specifications and ensuring quality and rigour are built in. Training has a significant role in achieving this.

CASE STUDIES

SECTION 6:

CASE STUDIES

6.1 Chapter summary

This concluding chapter delves into several infrastructure sector projects, exploring their varying levels of benefits and results gained from the implementation of DE processes and enabling technologies.

It's important to highlight that not all projects have specific measurement efforts in place from the outset, and often, those that do can be of low maturity. The case studies in this chapter provide, where available, quantifiable benefits and examples of DE uses. In areas where this hasn't been possible and has been provided as a qualitative measure, the same benefit has been shown over multiple cases, helping to strengthen the case of the qualitative measure and its added value.

Table 6.1 Chapter relevance to role summary

Should I read this section to help in my role?		
Reader	Essential	Helpful
Sponsor/key decision maker in the adoption and development of a DE strategy	✓	
Department head/key stakeholder in the adoption of a DE strategy	✓	
Leading/supporting the development of a DE strategy	✓	
Leading/supporting the implementation of a DE strategy.	✓	
Adopting the new DE practices	✓	

6.1.1 Purpose of this Chapter

This Chapter provides a number of real industry case studies to help demonstrate the development, planning and implementation of DE strategies and solutions within an agency and project level.

6.1.2 Why this Chapter is important

Table 6.2 Section content summary

Section Headings	What this section addresses:
6.3 DE Focus Areas	Provides key information on what the DE focus areas are and why these are the focus areas.
6.4 Case Studies	A summary of the content submitted Context, Drivers for change, Process, challenges and constraints and finally key learnings.
6.5 Closing Summary	Provides key findings and recommendations based on insights and trends identified across the sample of case studies.

Case studies are pivotal tools in business and technological development, playing a critical role in elucidating the real-world implementation and impact of a product, service, or process. A use case provides a detailed, technical roadmap of how a system interacts with users, highlighting potential challenges and solutions, and serving as a guide for developers, stakeholders, and end users. Conversely, case studies offer valuable empirical evidence of a product or service's performance and effectiveness in real-life scenarios, contributing to credibility and trust. Together, they form a comprehensive picture of practical utility and value, streamlining decision-making and optimising customer satisfaction.

Quantitative and qualitative measures serve as integral components in case studies, each contributing distinct yet complementary insights. Quantitative measures offer a numerical understanding of the case, utilising statistical, mathematical, and computational techniques. This ensures an objective evaluation of the product or service under analysis, offering quantifiable evidence of its efficacy or shortcomings. On the other hand, qualitative measures deepen the narrative, providing detailed descriptions, individual perspectives, and a nuanced understanding of the real-world context. They delve into aspects such as user experiences and subjective interpretations, adding depth and richness to the case study. Together, these measures create a holistic understanding of the case under scrutiny, encapsulating both hard data and human experience.

6.2 DE focus areas

To ensure the case studies are valuable resources and align with the messaging of this DE Guide, the following DE focus areas have been identified:

- **Benefits**
- **Asset Lifecycle**
- **Procurements & Culture**

Table 6.3 – Mapping of case studies to focus areas

Case Study	Benefits		Asset Lifecycle				Procurement & Culture	
	Quantified DE Value	Business Case	Planning	Design	Construction	O&M	Contract and Procurement	Culture & Training
6.4.1. Brisbane City Council – Brisbane Metro Project	■	■	□	■	■	■	■	■
6.4.2. RMS & TfNSW – Woolgoolga to Ballina Pacific Highway Upgrade	■	■	■	■	■	□	■	■
6.4.3. TfNSW – Sydney Gateway	■	□	□	■	□	□	■	□
6.4.4. TfNSW – M4-M5 Link Rozelle Interchange	■	□	□	■	■	■	□	■
6.4.5. MRWA – Northlink Central Section	■	□	□	■	■	□	□	■
6.4.6. Network Rail – High-Speed Rail 2	■	□	■	■	■	■	■	■
6.4.7. Logan City Council – Arch Culvert Asset Rehabilitation	□	■	■	□	■	■	□	■
6.4.8. Logan City Council – Red Bridge Repainting Project	□	■	■	■	□	■	□	■
6.4.9 NZTA – DE Roadmap Development	□	■	□	□	□	□	□	■

6.3 Case studies

To assist the industry in its DE transformation journey, Austroads reached out to notable industry clients who have either successfully transitioned to or are currently in the process of transitioning to a digitally empowered approach to asset lifecycle management. Austroads requested these clients to share their valuable project case studies, providing the project overview, their desired DE goals and objectives, any challenges and constraints they faced, the results and benefits achieved, and finally, their key learnings. Acknowledgement and gratitude go to:

- Brisbane City Council
- Roads and Maritime Services
- Transport for New South Wales
- Main Roads Western Australia
- Network Rail
- Logan City Council
- New Zealand Transport Agency

The case studies included in this section serve as a valuable resource for supporting others in embracing DE solutions. The contribution of these case studies has been made possible through the efforts and support of several prominent industry leaders. Austroads expresses gratitude to the following organisations for their valuable contributions:

- **Laing O'Rourke:** renowned for their expertise in construction and engineering, has played a pivotal role in sharing their project experiences and insights. Their case study serves as an illuminating example for others in the industry.
- **Arcadis:** a leading global design, and consultancy firm, showcases their project progress and achievements. Their valuable project insights offer valuable guidance to organisations embarking on their digital transformation journey.
- **DBM Vircon:** are very experienced in providing both technical and advisory services to industrial, general contractor and government clients on multiple continents. Their support has enabled digital innovation across all dimensions examined in this document and the use case demonstrates this integrated approach.

This section is a summary of the content submitted.

6.3.1 Case study 1

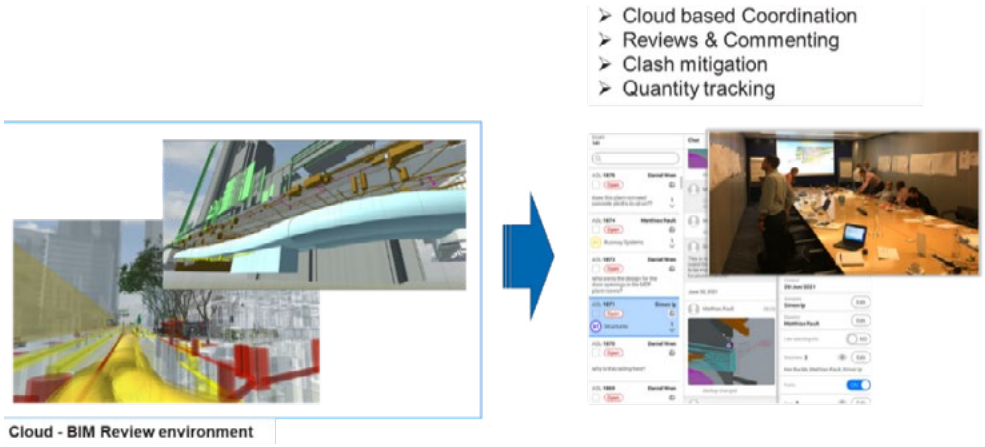
BRISBANE METRO PROJECT

Client: Brisbane City Council
Project cost: $1.4 Billion
Duration: 2016 (business case) – ongoing
Case study provided by: DBM Vircon on behalf of Brisbane City Council

Project overview

To ensure Brisbane's bus network is flexible and future ready, Brisbane City Council is delivering the turn-up-and-go Brisbane Metro project. By providing high-frequency and high-capacity services, Brisbane Metro will better connect suburbs and the city with key destinations.

Figure 6.1 – Cloud - BIM review environment



The metros will operate along dedicated busways from Eight Mile Plains to Roma Street, and Royal Brisbane and Women's Hospital to University of Queensland, connecting 18 stations.

Council is working with world-leading vehicle manufacturer HESS and electric infrastructure experts Hitachi Energy to deliver the electric metro fleet and supporting charging infrastructure.

As part of Brisbane Metro works, Council is also delivering new and improved infrastructure in preparation for the introduction of the electric metro fleet.

In 2020, Council awarded the Collaborative Partnership contract (CP) to Brisbane Move Consortium, comprising of ACCIONA and Arup to design and build major infrastructure works for the project.

Infrastructure works are well underway and include delivering a new tunnel beneath Adelaide Street providing a dedicated connection to our busways for bus and metro services. Council is also increasing station capacity to support with the growth of the bus network including works at Cultural Centre station, Buranda station and UQ Lakes station. End of route charging infrastructure is also being delivered at key stations to power the electric metro fleet.

This includes building a new metro depot at Rochedale to house and maintain the metro fleet and provide fast and slow charging facilities. The 10-hectare depot will be one of the largest and most technologically advanced facilities of its kind in Australia.

DE goals and objectives:

- Increase value, for both the physical infrastructure works program and the asset management functions, relating to time, cost, and quality, through the implementation of DE.
- Further develop the DE framework and create a suite of reference documents, based on Council and project needs, to support and drive Council's DE capabilities, processes, and enable efficient project delivery of future infrastructure projects.
- Conform to the principles for BIM as part of the Digital Enablement for Queensland Infrastructure - Open, Managed, Effective and Supported.
- Maintain flexibility to allow for the inclusion of input and feedback from relevant authorities who have a stake in geo-spatial mapping, 3D modelling, city models, and BIM.
- Develop and maintain a shared 3D digital model that serves as a foundation for managing, planning, coordinating, designing, communicating, delivering, and operating assets across both the digital and physical realms.
- Increasing asset management capability and facilitating the transfer to Returned Works Owners once work on individual assets is completed.
- Identify and evaluate software-independent solutions for data exchange that safeguards all asset data, guaranteeing long term compatibility and adaptability to DE advancements.
- Utilise digital visualisation techniques to communicate outcomes to non-technical stakeholders and community members.
- Manage and deliver the project in accordance with the international BIM level 2 maturity.
- Enhance design integration and coordination, and collaboration and communication between all stakeholders.
- Minimise data loss between project phases.
- Manage the social impacts of project activities.
- Mitigate incomplete, inconsistent, and uncoordinated design and construction data.
- Maximise the performance of the designed and constructed assets.

Process:

Brisbane City Council developed a detailed DE Framework, closely following the intent of ISO 19650, which defined their Organisational Information Requirements (OIR), Asset Information Requirements (AIR), and Project Information Requirements (PIR). This live document was adopted by the Collaborative Partnership (CP) and further developed to meet Council and project needs.

BIM requirements were included, as a specific annexure to the performance specification for the CP. The requirements prescribed adherence to BIM level 2 maturity, which encompasses the development, management, and delivery of structured information models that can be utilised throughout the lifecycle of the built asset.

In response to the BIM requirements and the DE Framework, the CP developed and maintained a Digital Management Plan (DMP), which communicated the details relating to how the information models were to be constructed; the parties responsible for the different components; how much detail and information was required at each stage of the project lifecycle; when and how data and information was shared; agreed file exchange formats; and the agreed uses of the information

models (coordination, design review, stakeholder engagement, scheduling (time), cost, asset and facilities management).

The information models, consisting of both object-oriented 3D geometrical and non-graphical data, were prepared by the contracted parties throughout the project life cycle using various software solutions and managed and shared within the context of a Common Data Environment (CDE), in accordance with the DMP. A suite of connected systems and platforms was created that facilitated the sharing of information among partners and stakeholders.

3D visualisations, animation, and VR were used to communicate project vision, design intent, and construction sequencing, to the various stakeholders.

The information models, in their native file format, were synced with 'dRofus', which is used by Brisbane City Council to facilitate the capture of loose furniture and equipment into a structured and accessible database, enabling the seamless update of element data within the models directly to the database. This mitigated the need for siloed Excel workbooks and Room Data Sheets.

Challenges and constraints:

- Establishing new systems and processes within Council and managing the complexities of diversified asset, systems and data ownership.
- Obtaining appropriate levels of approvals for software procurement, training, and process development and implementation.
- Differing approaches to project delivery and the assumptions shaped by previous experiences delivering smaller scale projects.

Implementation of DE, at an organisational level is currently limited by the capacity for uptake. However, it is relatively easy to implement DE processes within specific, individual projects.

Results and benefits:

The process of developing design and construction data within the context of an information model provided the following benefits:

- **Visualisation:** this increased the team's ability to communicate complex interfaces and design considerations to stakeholders.
- **Design analysis:** data from the information models was synced with specific analysis software, creating a bi-directional link. This mitigated the need to recreate the data multiple times in multiple systems for different uses.
- **Design coordination:** model federation enabled the team to design dynamically, within designated spaces, where they could quickly identify and pre-empt coordination issues, reducing the cost of rework.
- **Clash detection:** enabled the team to systematically check the overall design for coordination issues, reducing time spent manually reviewing drawings.
- **Stakeholder engagement:** using the approved and verified information models to facilitate stakeholder engagement simplified and expediated the communication of the project vision, design intent, and construction sequencing to both technical and non-technical people.
- **Efficient and effective communication:** the information models provided a holistic and comprehensive overview of the design and construction progress. It enabled the teams to communicate more information in a shorter time.
- **Interface management:** the information models provided the opportunity of early-stage issue detection, leading to cost and time savings. In addition, using visualisation techniques increased the ability for the teams to communicate complex, human scale, spatial interfaces, and design considerations, resulting in better informed decisions, allowing time to resolve stakeholder interface issues.

- **Constructability and health and safety:** the information models enabled constructability and health and safety reviews, allowing informed decisions and changes to be made earlier in the project lifecycle, resulting in reduced time and cost of site changes, reduced injury/accidents per full time equivalent (FTE) site resource impacts and increased quality of work.
- **4D modelling:** the information models enabled the development of 4D models, which provided a detailed overview of construction sequencing and a view of possible operational issues and obstructions. It also helped with the bid program by providing a thorough analysis thereby reducing the likelihood of a rebase line of the contract program during delivery.
- **Asset and facility management:** the DE processes provide greater confidence in the completeness of the delivered as built information models. This provides potential cost savings in asset maintenance and refurbishment. The inclusion of commissioning data, attached directly to asset information model elements, ensures that the model reflects current commissioned status and install dates, thereby reducing the cost of completion tracking activities.

Key learnings:

- Alliance and collaborative contracting approaches are very well suited to Integrated DE processes.
- Specific process implementation should be chosen to allow maximum learning and integrated with as many complimentary organisational initiatives as possible.
- The client organisation is best placed to provide ultimate leadership, contractual integration and technical support where required, to reduce overall cost and quality risk where DE is implemented.
- The client is best placed to ensure that delivered data is compliant with asset owner requirements.
- The client is best placed to ensure that pre-existing client owned digital datasets are vetted and made available to support contractor delivery.

6.3.2 Case study 2

WOOLGOOLGA TO BALLINA PACIFIC HIGHWAY UPGRADE

Client: Roads and Maritime Services (RMS) and Transport for New South Wales (TfNSW)

Project cost: $4.4 Billion

Duration: 5 Years

Case study provided by: Laing O'Rourke (LOR)

Project overview:

The Woolgoolga to Ballina Pacific Highway upgrade, to a safer, four-lane divided road, was the final link in the Pacific Highway upgrade, between Hexham and the Queensland border.

Partnering in a joint venture (Pacific Complete JV), TfSNW, Laing O'Rourke, and WSP assumed the role of delivery partner and managed the delivery of the 129-kilometer section between Glenugie and Ballina. The joint venture had overall responsibility for providing planning, programming, design management, procurement, and construction management. The JV oversaw more than 3,000 people to deliver part of Australia's largest regional road infrastructure project.

The project was delivered under a delivery partner model which was based largely on the delivery approach used for the construction of the London Olympics infrastructure. This was the first time the Delivery Partner Model was used for a major Australian infrastructure project.

Despite disruptive bushfires and a global pandemic, the final link of the Pacific Highway was opened to traffic in December 2020. This was achieved through a staged approach focused on keeping communities moving.

DE goals and objectives:

- Seamless exchange of design, construction, and as constructed data and information, that is compatible with asset owners' systems for use in the asset's operational lifecycle stages.
- Provide integrated, data-driven project controls that allow for the communication of performance information to all stakeholders.
- Using DE technologies provides the capability to create and manage the delivery of the project effectively and streamline future maintenance of the physical assets.
- Connect multiple datasets across various functional systems and deliverables.
- Facilitate integration with Pacific Complete systems (quantification and 4D, for example).

Process:

As part of the RMS initiative to leverage building information modelling (BIM) technologies, the project brief mandated the inclusion of DE processes starting from the detailed design stage.

The Pacific Complete JV developed a project delivery methodology that seamlessly integrated data-driven project controls with a cutting-edge DE application specifically designed for road projects. Using web-enabled GIS the JV provided instant access to current, real-time data and information, in one accessible system. Sophisticated user-friendly digital systems provided performance information to the team and project partners to make informed decisions and deliver the project at an unprecedented scale and pace.

The information model content was developed to a high level of definition which included accurate 3D representations of pavement layers, earthworks, kerbs, line markings and safety barriers, all divided into 100-metre intervals to facilitate integration with Pacific Complete systems (quantification and 4D, for example).

A project-wide code library was provided which enabled a logical method for connecting the multiple datasets which sat across the different functional systems and contracted deliverables. All elements within the information models, the model containers, along with drawing content and containers were named and tagged following the Pacific Complete Integration naming protocols, which extended across all design packages.

Challenges and constraints:

- Implementation of DE was challenging in some areas due to the uptake capacity.
- Added pressure was placed on the digital team by a lack of common understanding of a data-centric approach to project delivery, including the domain and ownership of the systems, processes, data, outcomes, and deliverables.

Results and benefits:

The implementation of a well thought through code library and tagging philosophy enabled benefits across many facets of the project design and delivery:

- **4D modelling:** the consistent tagging of data across the different datasets (progame, cost, project information models), enabled direct linking of the data. to efficiently produce 4D models and the ability to automatically update them to test different scenarios.
- **Project controls and reporting:** with the data tagged consistently, across all information models, the Pacific Complete JV were able to directly link reporting dashboards to the contained data and extracted outputs. This provided the ability to generate on-demand, real-time progress reporting.

Integrating the project information models with GIS-enabled quick and efficient navigation and interrogation of over 5000 models that made up the entire dataset for the overall 155-kilometer Woolgoolga to Ballina Pacific Highway upgrade, within one system. Teams were able to quickly access data, while on site, and identify and resolve any design, construction, community, or environmental compliance issues, providing significant cost and time savings.

Planning and the implementation of DE systems and processes, along with a robust project delivery methodology enabled the JV to deliver compatible data, seamlessly, to the client's systems for operational use as a by-product, as opposed to a separate, disconnected activity to meet a deliverable.

The ROI for the set-up and configuration of the systems and processes required to support the digital strategy, outweighed, many times over, the planning and resources (6 people, full-time for 12 months) costs.

Figure 6.2 – Project information model example

Benefits

Tangible (43 documented use cases)

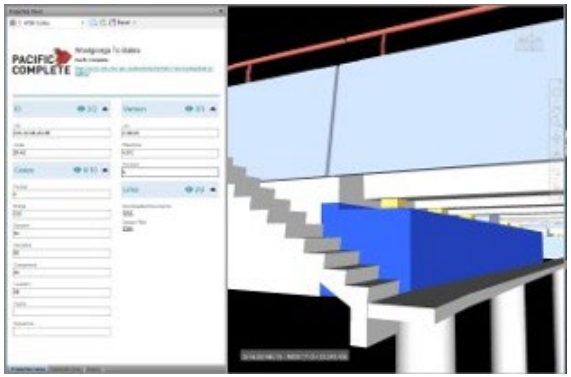
- Design quality
- Cost certainty
- Increased information quality
- Informed Project Team (5 vs 99%)
- Increased value of information
- De-risking
- Community engagement
- Environemental approval
- Less or earlier RFI
- Audit trail
- Rapid automated check
- Optioneering
- Productivity/data processing

Intangible

- Full 3D model, named and structured
- Design coordination, clash detection
- Change management
- Qualification checks
- Augmented reality, virtual reality
- Progress reporting
- 4D (planning) sequencing
- 5D (costing) reporting
- Compliance
- Commercial
- Geotechnical dashboard
- Production dashboard
- LiDAR
- Precast tracking
- Model links to design drawings and schedules
- Model links to WAE drawings
- Model RFI, NCR and comment register
- Environmental agencies communication

Figure 6.3 – Handover / asset management

Handover /asset management



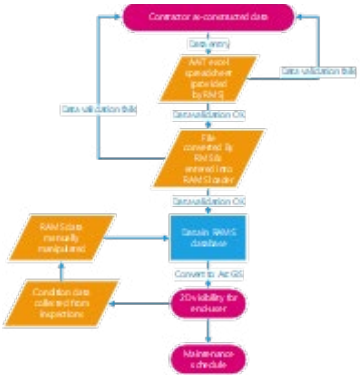
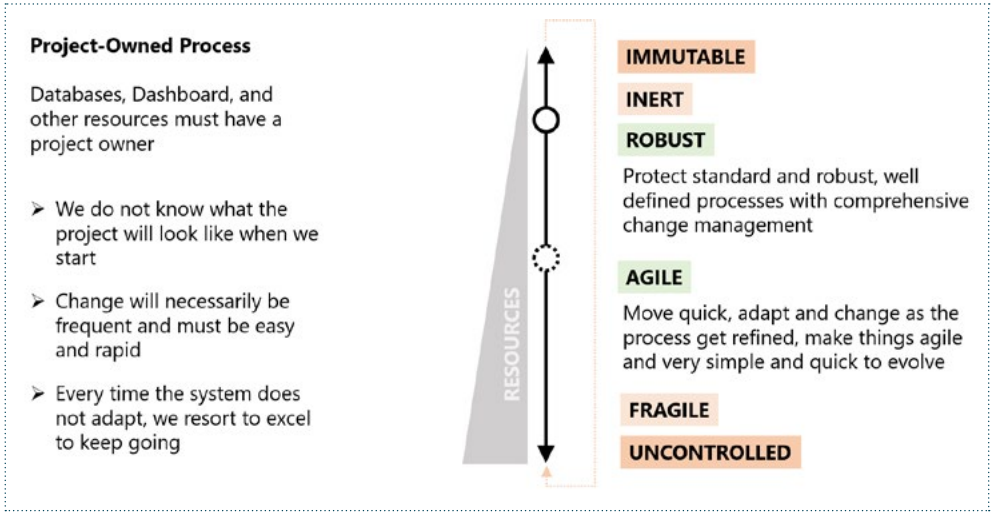


Figure 6.4 – Project-owned process



Key learnings:

- With full support and commitment from all parties, project objectives and goals are achievable.
- Connected up various DE technologies and datasets to reduce risk and improve productivity in construction.
- DE was applied holistically across various use cases with a focus on risk mitigation, which included resource management, cost control, design coordination, construction sequencing and data-driven progress capture and reporting. A unified and well-planned approach assisted with seamless data exchange and insights.
- The set-up and configuration of the systems and processes to support the digital strategy required a team of 6 people, full-time, and was carried out over 12 months. The cost and planning need to be understood and the relevant investment agreed.

Figure 6.5 – Project leaders and functional leads are setting the right behaviour

Project Leaders and Functional leads are setting the right behaviour

Focus on fixing the source not the result: get the *data* right, not just the *number*

Define explicit, shared, business rules

6.3.3 Case study 3

SYDNEY GATEWAY

Client: Transport for New South Wales (TfNSW)
Project cost: $2.6 Billion
Duration: 1 year for Detailed Design
Case study provided by: Arcadis

Project overview:

Sydney Gateway is a critical piece of infrastructure that will greatly improve travel to Sydney Airport and Port Botany. It will deliver new toll-free connections from Sydney's motorway network to Sydney Airport's international and domestic terminals.

The $2.6b project will strengthen Sydney's position as a global city, return local roads to local communities, and slash travel times to and from Sydney Airport's domestic and international terminals, and Port Botany.

Made up of a collection of roads, bridges, pedestrian and cyclist connections, the project will benefit road users and local communities. Importantly, Sydney Gateway will provide a new route for around 10,000 trucks a day. This will divert trucks from local streets in Mascot by providing an alternative route, which in turn will reduce travel times and congestion, and return local streets to the community.

The brownfield site is heavily congested with critical airport utilities, and compact and compressed existing infrastructure.

DE goals and objectives:

- Manage and mitigate risks associated with a heavily congested brownfield site before construction.
- Facilitate the coordination of the design process across multiple, dispersed stakeholders.
- Design optimisation to enable a reduction in construction time.
- Manage stakeholder engagement.

Process:

The project was developed and delivered following the TfNSW DE Framework (DEF).

As part of the project delivery plan, the following items were agreed with all parties, implemented, and governed throughout the project:

- DE uses
- Information exchange requirements and frequency
- Definition of scope, roles, and responsibilities
- Lines of communication and frequency of DE specific meetings.

The project established systems and processes that enabled collaboration and communication across a multitude of stakeholders.

Information models, comprising of 3D graphical objects and associated non-graphical data, were developed by the individual design teams. These were regularly federated and used to facilitate all design coordination activities and meetings and were key for decision-making and design optimisation.

A DE culture was embedded within the project, across all stakeholders.

Challenges and constraints:

- Managing information was a challenge due to the large number of information models across a multitude of stakeholders.
- Challenges were encountered in achieving data interoperability due to the number of different applications used.
- Multiple information repositories were used, but not integrated, this in effect siloed different datasets.

Results and benefits:

The process of developing design data within the context of an information model, following the TfNSW DEF, provided the following benefits:

- **Communication:** the information models provided a holistic and comprehensive overview of the design. This improved design clarity across all stakeholders and enabled the teams to communicate more information in a shorter time.
- **Design:** working in a 3D environment enabled better coordination between the design teams and provided a greater understanding of the design's integration in a heavily congested site.
- **Design review:** model federation enabled the teams to design dynamically, within designated spaces, where they could quickly identify and pre-empt design and coordination issues, reducing the need for rework and the subsequent cost involved in the additional effort.
- **Cost:** working in a 3D environment enabled the design teams to mitigate risks, associated with the heavily congested brownfield site before construction.
- **Time:** utilising the federated models to facilitate design coordination activities and meetings enabled greater design optimisation, improving the overall construction process.
- **Quality:** the implemented DE systems and processes, configured to meet the DEF, ensured the verification of completeness of the detailed design data and information.
- **Safety:** the development of the information models enabled the process of 4D modelling. This helped to identify and resolve health and safety issues by simulating construction, site compound logistics, and the installation of large bridge superstructures, before construction.

Key learnings:

- Aligning and fostering a unified team culture is essential for maintaining client and stakeholder relationships, with a focus on collaboration rather than a culture of blame.
- Collaborate with a singular objective to enhance the project and guarantee its successful delivery.
- Understand, agree, and communicate all DE requirements at the outset of the project, especially the level of detail and level of information, required at each milestone, for each discipline.
- At the beginning of the project, it is crucial to understand, agree, and effectively communicate all DE requirements. This includes specifying the required level of detail (LOD) and level of information (LOI) for each discipline at every milestone.

6.3.4 Case study 4

M4–M5 LINK ROZELLE INTERCHANGE

Client: Transport for New South Wales (TfNSW)
Project cost: $3.9 Billion
Duration: 2 years for Detailed Design
Case study provided by: Arcadis

Project overview:

The Rozelle Interchange and Iron Cove Link will provide a new underground motorway interchange to City West Link and provide an underground bypass of Victoria Road between the Iron Cove Bridge and the ANZAC Bridge, with links to the approved Western Harbour Tunnel. The interchange in Rozelle will be mostly underground and located at the site of the old Rozelle Rail Yards. By building the interchange mostly underground, the project will deliver new active transport options in Rozelle and up to 10 hectares of new open space.

This project is Stage 2 of the M4-M5 Link, construction of the Rozelle Interchange and Iron Cove Link. The contractor at this stage is John Holland and CPB Contractors Joint Venture. This stage is being managed by Transport for NSW.

DE goals and objectives:

- Reduce time wasted searching and retrieving information.
- Better design coordination to mitigate surprises during construction.

Figure 6.6 – Artist impression of future Rozelle Parklands

Figure 6.7 – Artist impression of future Rozelle Parklands

Process:

Although the TfNSW DE Framework (DEF) was not a direct requirement of the project, a DE Management Plan (DEMP) was developed considering the TfNSW emerging DEF. The DEMP was developed by the main contractor and formed part of the design consultant's contract.

Each design consultant produced DE Execution Plans (DEXP), communicating their scope and their processes for delivering against the contracted requirements.

The Design Joint Venture (DJV) produced a Standards, Methods, and Procedures (SMP) document, detailing how each team would develop, share, and exchange their information models (systems, processes, and exchange formats), and compile drawings.

A CDE environment was set up, consisting of ProjectWise (main hub) and two satellite systems, BIM360 (to manage Revit) and Synergy (to manage 12D). The folder structure and file naming were agreed upon and made consistent across all systems. The client mandated all information models were to be shared weekly. These shared models were compiled into a federated model which was subsequently used to aid the design coordination process and for identifying and quickly resolving design issues.

At schedule design gates the information models and associated design information went through a check and approval process before submission. As part of this process, the information models' graphical content went through a clash check process and was reviewed as part of a joint model review workshop. Where spatial coordination issues were identified, resolutions were agreed upon, and model updates were made before submission.

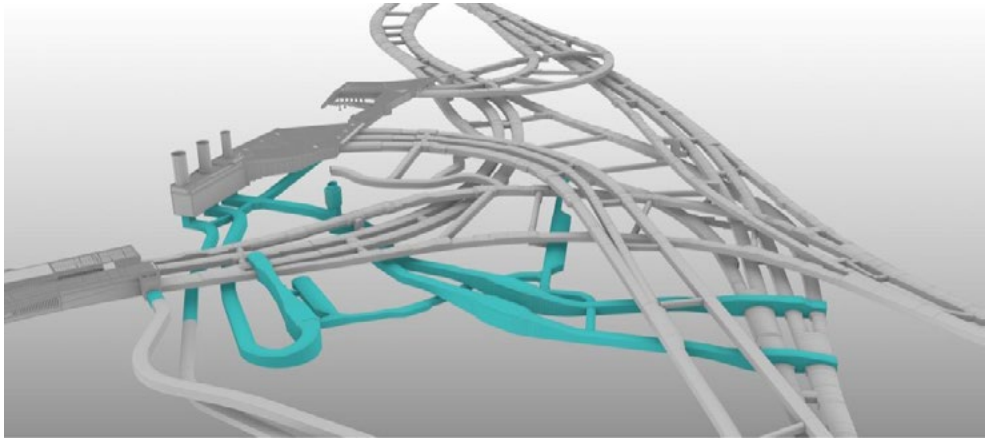
Challenges and constraints:

- Challenges were encountered in achieving data interoperability due to the number of different applications used. Iterations of exchange models required multiple formats and variations to allow consumption across platforms of data across teams. In most cases, the common denominator was the '.dwg' file format – this was reliable, trustworthy, and practical in terms of file size.
- Insufficient BIM configuration management. Although the CDE environment was in place and information could be located, there was limited metadata to define the status of the information. There was no documentation as to the status and provenance of the reference information, except for the road alignment.
- Designs were based on reference information that had been cut off at a past point in time, with no indication as to their completeness and currency.
- Long processes for the procurement, implementation, and training of new systems.
- Information model acceptance criteria missing.

Results and benefits:

- Several of the established, tried, and tested processes have become business-as-usual and have evolved to meet the more prescriptive requirements found in TfNSW DEF.
- The CDE environment provided added data security and enabled robust, safe remote working.
- Cross-discipline coordinated design.
- The QA process and information model reviews were invaluable and focused attention on the overall, integrated design communicated within the federated model.

Figure 6.8 – 3D visualisation of the federated subsurface structure and tunnels model



Key learnings:

- The DEMP and DEXPs need to outline more than processes at a high level. They should include details on how each discipline needs to operate.
- Greater focus and attention to the DEMP and DEXPs, ensure they are effectively communicated and consumed by all project participants and stakeholders.
- Agree, implement, and communicate data and information configuration management, giving focus and attention to status and validity.
- To mitigate wasteful activities, ensure all required data and information have an owner and a purpose.

Figure 6.9 – Aerial photograph of the project location

6.3.5 Case study 5

NORTHLINK CENTRAL SECTION

Client: Main Roads Western Australia
Project cost: $400 Million
Duration: 2 years
Case study provided by: Laing O'Rourke (LOR)

Project overview:

The NorthLink WA central section was the second package of a program of works to upgrade Tonkin Highway to freeway standard and extend this link north to Ellenbrook, connecting with Great Northern Highway and Brand Highway at Muchea. The project consisted of the design and construction of more than 20km of highway, four interchanges, including 14 road bridges, three footbridges and new cycling and pedestrian facilities.

DE goals and objectives:

- Mitigate the risk of incomplete, inconsistent, and uncoordinated design and construction data.
- Reduce time spent reviewing individual drawing design content.
- Streamline the design delivery process.

Process:

The DE team scoped the data provided by designers, consultants, surveyors, and utility providers. They set up workflows to integrate the data provided into a single information model, all the while maintaining the integrity of the information.

The information model was issued to the engineers for their review and analysis of the proposed design. Having the data in one place, they were able to quickly identify coordination issues within their areas of work and influence the design at an early stage to improve staging, constructability, and coordination of the works.

Processes were established with the survey team and implemented to ensure the information model included all the latest existing, proposed, as-built, and in-progress service information. This added a layer of safety controls.

The information model was used as a communications tool in client meetings, for stakeholder engagement, and to facilitate the review of design changes and design options.

The information model was routinely used to deliver enhanced community engagement.

Challenges and constraints:

- Managers and engineers with limited knowledge of the functionality of the digital tools and requirements of the digital information they need to produce and deliver.
- Digital maturity of the supply chain.

Results and benefits:

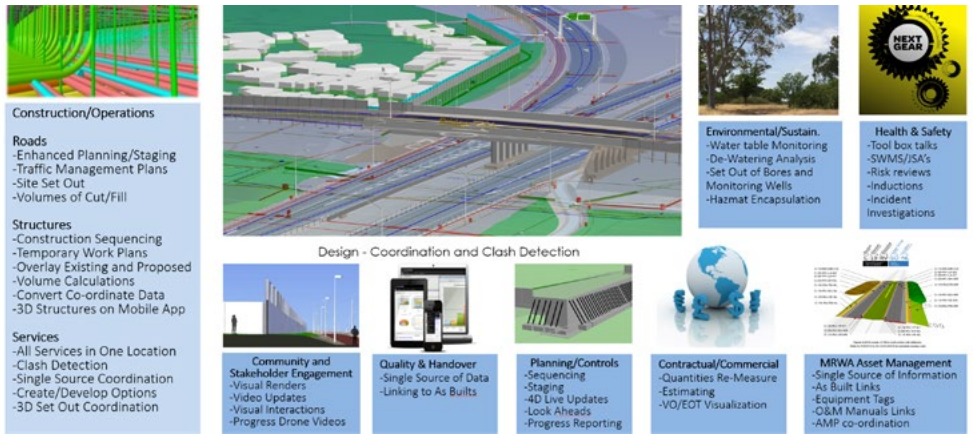
The process of developing design and construction data within the context of an information model provided the following benefits:

- Enabled efficient design coordination in one place.
- Provided the ability to influence the design early in the process to improve staging and constructability.
- Enabled engineers to track the subcontractors' progress and quality against the program.
- Stakeholder approvals were agreed on the spot, rather than the normal six weeks.
- Enhanced community engagement by being able to communicate the project vision to non-technical people.
- Reduced reliance on traditional 2D drawings and time spent reviewing them.

Key learnings:

- To maximise the efficiencies and benefits of DE, projects require ongoing support from digital engineers embedded within the project.
- Set out a digital strategy for the project against the project requirements.
- Coach designers and engineers on the requirements of the digital information they produce.
- Coordinate with project functional teams to develop awareness and implement the available digital tools.
- Work collaboratively with the supply chain.
- A highly detailed information model, underpinned with validated data has greater benefits and use far beyond the design stages of the asset's lifecycle.
- The implementation of DE holds greater value when used to inform all areas of the project delivery lifecycle.
- Greater buy-in from stakeholders is achieved when DE is applied and provides greater clarity or removes risk from construction.

Figure 6.10 – Areas of the project delivery lifecycle informed by implementing DE



6.3.6 Case study 6

HIGH-SPEED RAIL 2

Client: Network Rail
Project cost: undisclosed
Duration: undisclosed
Case study provided by: Laing O'Rourke (LOR)

Project overview:

The Digital Bridge philosophy has been a 5-year ongoing development and more recently collaboration between Laing O'Rourke Cambridge University, Ramboll WSP and Highways England as the owner participant.

The 12-month project aimed to collaborate on an entirely new standardisation of design construction and handover of road bridges across England's main road network with a view to best utilising current technology and digital off-site manufacturing techniques.

The products developed as part of the project were used by the HS2 enabling works contractor LMJV (Laing O'Rourke and J Murphy & Sons Joint Venture) in the construction of the M42 bridge installed over the weekend of 8-9 August 2020.

Figure 6.11 – M42 bridge installation

DE goals and objectives:

- Reduce cost and time associated with bridge design development and assembling and installation of new road bridges.
- Efficient generation of analytical design data and outputs and constructible components.
- Reduce waste, improve quality assurance, and reduce defects.
- Reduce construction time and improve site safety.
- Automate model and drawing creation.
- Reduce disruption for road users.

Process:

Establishing DE processes and a digital configuration toolset, that can be implemented from feasibility studies through to manufacture, construction, and handover, was core to enable a new, streamlined approach to bridge design and construction.

A comprehensive detailed information model, suitable for both design and construction purposes, was created by developing parametric components that could be adjusted to accommodate different alignments and existing site conditions.

A detailed, data-driven SolidWorks model was developed which enabled the rapid generation of analytical design data, its related outputs, and constructable components.

Results and benefits:

- The digital configuration toolset automatically creates models and drawings, rapidly improving the turnaround time to reach sign-off on designs. It also efficiently provides outputs in the form of a 3D model (as an IFC data model), approval in principle documentation, and cost information.
- A set of structured, reusable digital assets
- The toolset and DFMA Bridge component set will contribute towards delivering against three of Highways England's imperatives – Safety, Customer, and Delivery. This will be achieved by reducing time and cost associated with design development, optimisation to hours rather than weeks; enabling greater content of off-site manufacturing; improved efficiency; reduced waste; improved quality assurance; and reduced defects. The construction time on site will be shortened and predictability improved with fewer people on site, for shorter periods and improved safety.
- Installation of a HS2 bridge:
  - The largest bridge, with a 65-metre span, was installed over the M42 motorway over the weekend of 8-9 August 2020. The deck, weighing 2,750 tonnes, was constructed alongside the motorway, and manoeuvred into place on self-propelled modular transporters. Thanks to an immaculately planned operation, the motorway was reopened to traffic a full 22 hours early. This success illustrates the flexibility of the modular bridge system.
  - Reduction in disruption to the transport network
  - Sustainability: 30% reduction in carbon.
  - Productivity and progame: seven-week progame was reduced to one week.
  - Safety: 84 operative weeks, reduced to 6 weeks.

Key learnings:

- Digital design, off-site manufacturing and modular components are enablers of innovative construction methodology. They can provide greater efficiency and safety to infrastructure projects and can save months on delivery schedules.
- This methodology has the potential to reduce bridge construction time by up to 40% compared to traditional methods.

Figure 6.12 – Digital bridges toolset

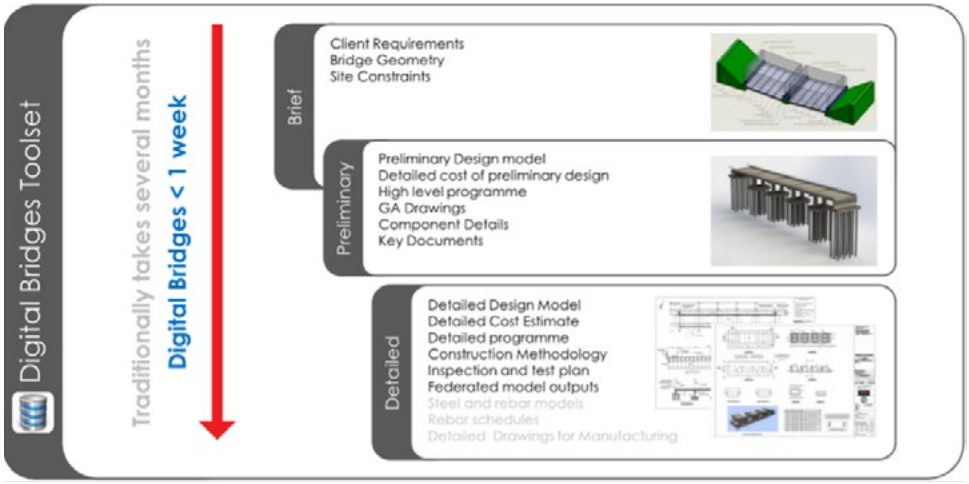
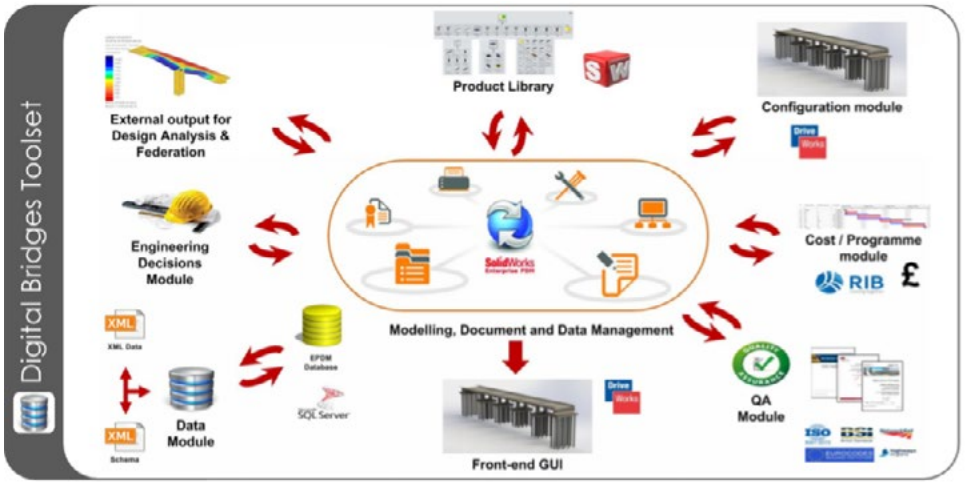


Figure 6.13 – Digital bridges toolset



6.3.7 Case study 7

ARCH CULVERT ASSET REHABILITATION

Client: Logan City Council
Project cost: undisclosed
Duration: 1.5 years
Case study provided by: Logan City Council

Project overview:

The Arch Culvert Asset Rehabilitation is Logan City Council's largest culvert structure which consists of a series of interconnected underground corrugated metal arches and corrugated metal pipe culverts, along with concrete box and pipe culverts. It traverses underneath a commercial district with a drainage length of approximately 1.8 kilometres in total. A terrestrial laser scan and inspection survey was commissioned to develop an accurate 3D BIM model of the culverts including linking defects and related photographs to culvert sections. This model formed the basis for the defect rectification works program along with ongoing structure monitoring.

DE goals and objectives:

- Improve conventional assessment processes.
- Transpose defects and condition information into associated data, linked to sections of assets or specific asset objects.
- Provide the ability to geo-locate and monitor potential issues, to reduce operational and project risk, while allowing for optimisation of the assets lifecycle.

Process:

Logan commissioned the 3D BIM model as an optional service to the traditional level 2 structure inspection.

A control network was established before conducting a terrestrial 3D laser scan survey of the complete pipe alignment. Survey intervals were approximately 50m, allowing for the capture of all features.

The scan data was post-processed and compiled into a single-point cloud data model. This was used to create a geo-reference model of the structural elements.

Challenges and constraints:

- There was an absence of an industry standard requirements specification.
- It was a challenge to establish location accuracy and linear reference positioning of features and defects due to the asset being underground with curved surfaces.
- Limited systems and processes to utilise BIM models for project development and long-term management of a common data environment.

Results and benefits:

- Provision of an accurate 3D Navisworks model, visualising the overall condition of each pipe, the project deliverables, and a custom tool linking inspection photos and defects to model elements.
- The model enables accessible reference to the asset information, supporting improved decision-making for future maintenance and rehabilitation works.
- Unified point cloud data model.
- The project provided greater awareness of BIM and integration opportunities with existing assets and GIS systems for improved information management.

Key learnings:

- Awareness and understanding of the importance of information requirements.
- Environments where GPS is limited create challenges to the collection of accurate data. This needs to be factored into the value proposition for projects implementing DE.
- To enable improved data sharing, limitations of existing systems and processes will need to be addressed. This in turn can also support better integration with existing asset information systems and future condition assessments and analysis.

6.3.8 Case study 8

RED BRIDGE REPAINTING PROJECT

Client: Logan City Council
Project cost: undisclosed
Duration: 6 months
Case study provided by: Logan City Council

Project overview:

The Red Bridge is an iconic Logan steel structure crossing the Logan River, originally built in the 1930's it needed to be structurally repaired as well as repainted due to the coating's fading efficacy. When the chance to design a restoration of Logan's Red Bridge arose in 2017, the project team at Logan chose to investigate BIM principles in a trial project during the 'Asset in Operations' phase.

Based on a drone survey, scanning, as-built drawings, inspection records, and asset renewal requirements, the pilot involved generating an interactive 3D asset information model of the existing bridge.

DE goals and objectives:

- Improve project scoping, design, and coordination methodologies.
- Reduce costs.
- Increase waterway protection.
- Provide officers with awareness, knowledge, and experience on how to leverage DE processes and technologies for the management of existing, local government owned assets.

Process:

An interactive 3D asset information model, of the existing bridge, was developed by the consultant. The model was compiled from various datasets, including, drone surveys, laser scanning, as-built drawings, inspection records, and asset renewals requirements.

The paint deterioration levels were modelled, along with different painting regimes to determine the most cost-effective rehabilitation program for the bridge.

Challenges and constraints:

- Traditional project methodologies come with several environmental challenges – surveying near critical infrastructure and using scaffolding over water and under bridge inspection units. The digital approach overcame these, ensuring the entire structure was surveyed safely.
- A lighting concept for the bridge was explored, which presented several data interoperability issues with more specialised applications. This project did not proceed.

Results and benefits:

- The use of drone technology for bridge inspection mitigated the risk associated with working at heights.
- The information model enabled the project to quickly identify feasible options to manage the upgrade, while assessing the constraints such as using scaffolding over water, potential paint overspray affecting traffic on the adjacent Pacific Motorway, the proximity to overhead powerlines, the water main attached to the bridge, and potential environmental impacts.
- The provision of the information model enabled the team to test integration with other tools used, such as ESRI (GIS), Navisworks, and other 3D model viewing applications.

Key learnings:

- The application of drone technology, for bridge inspections, reduces the need for high-risk activities such as working at heights and rope access which also require specialist skills and certification.
- Continued access to busy transport links can be maintained by removing the human factor typically involved in bridge inspections.

6.3.9 Case study 9

DE ROADMAP DEVELOPMENT

Client: New Zealand Transport Agency Waka Kotahi (NZTA)
Project cost: undisclosed
Duration: 1 year, including:

- 6 months pre-work and stakeholder engagement
- 6 months of planning through to presentation

Case study provided by: New Zealand Transport Agency

Project overview:

NZTA is working with its partners to create a transport system that's safe, accessible, and easy to use – a transport system that connects people, places, and products for a thriving Aotearoa.

NZTA is responsible for operating, maintaining, and improving the State highway system which carries 55% of road vehicle kilometres travelled and 72% of road freight in New Zealand. The State highway system is the largest social asset of the NZ government. NZTA procures planning, design maintenance and capital works investing about 40% of nationwide land transport expenditure each year.

Many of the standards and guidelines developed by NZTA are used for State highways are also used by our local roads partners because they represent good practice, and where required as a condition of funding from the National Land Transport programme.

In early 2021, NZTA began developing a vision, associated strategy and 5-year roadmap for the embedding of DE practices within the agency.

The DE initiative comes from the need to lift collaboration between NZTA and partners, suppliers, and the sector; productivity across the sector, despite the constraints on budgets and resources; the need to optimise the use of assets and the transport system; to deliver safer outcomes; and respond to the challenges that are presented by rising sea levels and natural hazards. There is an immediate need to make decisions with the most reliable and joined up information available.

This case study is about the process of formulating this vision, the strategy that connects the organisation, and the development of a DE roadmap that brings this vision to life.

DE goals and objectives:

- Optimise the use of assets and the transport system.
- Deliver safer outcomes in design and construction of capital and maintenance projects.
- Better long-term collaborative planning and reliable investment decision making.
- Certainty and confidence around project costs and performance.
- Achieve decarbonisation and zero harm targets.
- Maintain stakeholder engagement and support.
- Joined up approach to the implementation of DE across the sector to mitigate duplication of effort and misaligned outcomes.
- Apply internationally recognised best practices.
- Support collaborative processes that reduce rework, variations, and cycle times.
- Reduce the need for material, plant, and labour resources through better design and implementation practices.
- Establish a digital foundation that enables spatial analytics, service level and condition modelling, increased fluent use of third-party spatial data, remote digital sensing devices and survey devices. Which in turn unlocks future advancements in DE practices and allied approaches such as digital twins.
- Provide a common language and consistent approach for the planning, design, construction, maintenance, and operations of our transport assets.

Figure 6.14 provides an overview of the challenges identified by NZTA in collaboration with our industry partners.

Figure 6.14 – Challenges to the sector

Process:

NZTA has adopted a pragmatic approach to DE. The first step was to get BIM and broader DE requirements into a few pilot projects that were underway or about to start and 'try-learn-improve' at each step. This required willingness and enthusiasm from both our teams and our partners and suppliers.

In parallel to 'try-learn-improve', NZTA has built their own internal capability. A key step was identifying use cases and outcomes that could be enabled by DE practices, and how those outcomes would benefit the agency and the wider transport sector. This was a 6-month period of discovery and stakeholder engagement, with specialists from infrastructure delivery, programme management, delivery improvement, network planning, maintenance and operations, sustainability, asset management, transport engineering, technology, and digital. This process identified the value and benefits that could be unlocked if deliberate investments were made into lifting the maturity and capability of the agency. NZTA partner organisation, KiwiRail, shared insights and learnings from the digital transformation of their established design and delivery practices. These insights and learnings enabled NZTA to implement new ways of working in the procurement of projects.

In February 2022, the agency commenced the next step in the development of its DE strategy. The findings from the discovery step were reviewed and synthesised into three clear areas of focus, based on a maturity model that was represented by the concepts of "Stand", "Walk" and "Run".

The "Stand" maturity represented the foundational work that would be required to develop before embarking further and included:

- **Standards and data** – an integrated view of common digital standards and a rich location-enabled national dataset.
- **Operating model** – an operating model across the organisation to keep data current and accessible.
- **Collaborative space** – a collaborative space for third parties to interrogate and add value to shared processes and information.
- **Single source of truth** – a single digital source of the truth for "end to end" delivery, including maintenance and operations.
- **Common platform** – the same digital common operating picture, environment, and datasets are shared across the supply chain.
- **Secure systems** – processes and controls that preserve confidentiality, integrity, and access to the agencies digital information.
- **Benefits realisation** – the capability to automatically track and report achieved benefits (against targets) across all project phases.

The "Walk" maturity builds on the foundations to address specific business problems and opportunities, including:

- **Digitally enabled** – a wide range of digitally enabled interventions that support DE practices.
- **Digital engagement** – communicating digitally and supporting our partners to do so as standard practice.
- **Decision making** – decisions are based on good quality data and a clear digital picture.

- **Options assessment** – the capability to evaluate options and assess the potential impact of decisions in reducing project risks.
- Transport and impacts cost model – a clear transport cost model where investment decisions (including trade-offs) are supported by good quality evidence-based data.

The "Run" maturity delivers more sophisticated, digitally enabled business outcomes, and included:

- **Digital transport twin** – a digital replica of the transport system, accessible from secure virtual environments.
- **National picture** – horizontal and vertical worlds digitally integrated to form a cohesive national picture.
- **Community self-serve** – the public can access data on any road, such as maintenance schedules, investments, road use, etc., in addition to project updates.
- **Digital collaboration** – collaborating digitally with the wider stakeholder community in how the agency works.
- **Deliberate improvement** – deliberately pursuing areas for improvement and measuring the impact of changes.
- **Sector collaboration** – the agency has shared sector goals and are collaborating closely with a common sector view of services and assets that is digitally enabled and informed.

This process of categorising intended areas of focus in a maturity model allowed for the prioritization of work for the next 12 months, with the initial focus being on developing the foundational capabilities under "Stand".

A DE lead and a small team was formed to drive the strategy forward, articulate the vision, and help bring the industry partners (design engineers, transport planners, and contractors) on the journey with the agency.

In a March 2022 industry liaison meeting, the DE team shared the vision statement and engaged with industry partners about the problems to solve to make the vision attainable. The key themes that emerged from this meeting were:

- **Climate and safety** – DE's role in supporting emissions reduction, de-carbonisation and the incidence of death and serious injury on our roads, through the delivery of projects and the development of information related to the road network.
- **Clear requirements** – the need to be clear from the start and define the information requirements that will be appropriate across the entire lifecycle.
- **Commercial benefits** – the understanding that commercial incentives are a powerful driver for change, and it is important to understand the mutual benefits associated with implementing DE practices.
- **Collaboration** – the importance of NZTA having a coordinated approach to DE, and work with the sector to develop a common approach for information requirements and digital ways of working.
- **Standards** – the understanding to leverage international and local data standards (ISO 19650 and ISO 55000), and the Asset Management Data Standard (AMDS), processes, and collaborative digital practices.
- **Learning from others** – the importance of drawing on local and international experience, including the work of KiwiRail, Transport for New South Wales, and Victoria Office of Projects, while leveraging the New Zealand market's ability to be agile and responsive.

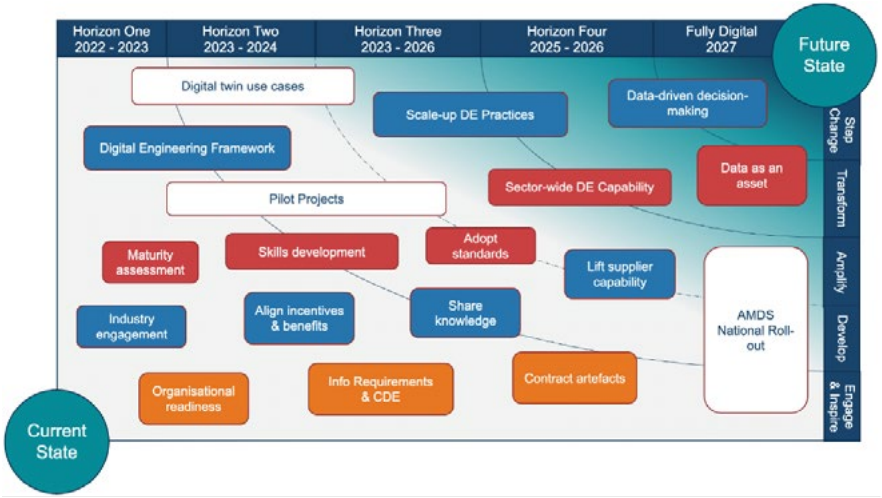
- **Open collaboration** – the strong desire for the sector to be developed with an "open source" mentality, to co-design the solutions that support the digitally enabled vision.
- **Pragmatism** – the understanding that the DE strategy and roadmap can present a range of choices about where to invest resources. Recognising the importance of being pragmatic about what can be achieved over time, while incrementally lifting capability.

Following the feedback from the industry liaison meeting, NZTA developed a proposed 5-year DE Roadmap (Figure 6.11), spanning from 2022 to 2027 covering four themed horizons:

- **Horizon One (2022–23)** – Engage and Inspire – where the focus is on sharing the vision for a digitally enabled future state of the transport system, engaging with industry partners, inspiring new ways of work, and developing the DE Strategy, Policy and Framework.
- **Horizon Two (2023–24)** – Develop – focusing on implementing the DE Strategy, Policy and Framework, developing DE capability and learning from new ways of working. Commercial drivers would also be addressed, and digital twin use cases would be tested.
- **Horizon Three (2023–26)** – Amplify – DE implementation would be scaled up. Connect and leverage initiatives to leap forward. The data creation process will be streamlined to improve the information about the network. NZTA will be driving DE within the sector in New Zealand.
- **Horizon Four (2025–26)** – Transform – the agency would have developed effective ways of working that will need to be nurtured and embedded in the organisation. Data is seen as a valuable asset to increase digital twin maturity and capability. The agency will continue to inspire the next generation of transport professionals to become DE advocates and natives.
- **Fully Digital by 2027** – Step Change – The agencies requirements and investment decisions are enabled by streams of structured digital information.

Figure 6.15 represents the current DE roadmap, as presented at the July Industry Liaison meeting.

Figure 6.15 – DE roadmap: fully digital by 2027



Challenges and constraints:

Despite some progress, there is still some space to improve the way the construction sector uses new technologies and ways of working to create, share and use data and information produced during the lifecycle of an asset.

The challenges and constraints identified can be summarised as:

- **Demonstrating value** – DE initiatives carry a cost that often does not translate into benefits for the asset owner until much later in the asset lifecycle. There is opportunity to demonstrate the more immediate value proposition to the asset owner, such as improved engagement of stakeholders and communities through visualisation; earlier indications of the environmental impact of projects; improved confidence in the outcomes of the time, cost, and scope of capital works projects; reduction in rework on project sites, enhanced health and safety planning. Other significant benefits that are often realised much later include the optimisation of maintenance interventions.
- **Skills shortage** – the construction sector in New Zealand is facing a significant skills shortage, which is also prevalent in the DE space. Expertise in this area is still not widespread across the industry. More investment is required in upskilling construction professionals and attracting and retaining emerging professionals.
- **Manual processes** – there is a significant reliance on manual processes for exchanging information. Even when documents are exchanged in a digital format, the information in such documents is often not in a format that can be easily searched and cross-referenced with other information. This poses significant issues related to analysing and deriving insights from such information.
- **Technology obstacles** – technology can also be a barrier to the adoption of DE. Much information exists today in formats or databases that cannot be easily shared and accessed by other parties. There is still a prevalence of outdated technologies, such as document libraries/repositories, that have not been developed with collaboration and data exchange in mind.
- **Poor data visibility** – NZTA is an asset data-rich agency, however, there are challenges in surfacing this data, and making it available to others that are involved in asset lifecycle activities. Asset data is often unstructured, fragmented, and not easily integrated or shared. This means it is difficult for organisations to take a coordinated approach when sharing information. Furthermore, it is challenging to link technical levels of service to measurable customer outcomes. The development of the Asset Management Data Standard (AMDS) and its adoption at all Road Controlling Authorities is intended to address these asset data shortcomings.
- **Culture** – DE requires an organisational culture change in ways of working today, breaking down the silo's and moving towards open and collaborative practices. This reinforces the need to demonstrate the value DE provides in order that all parties adopt this change.

Results and benefits:

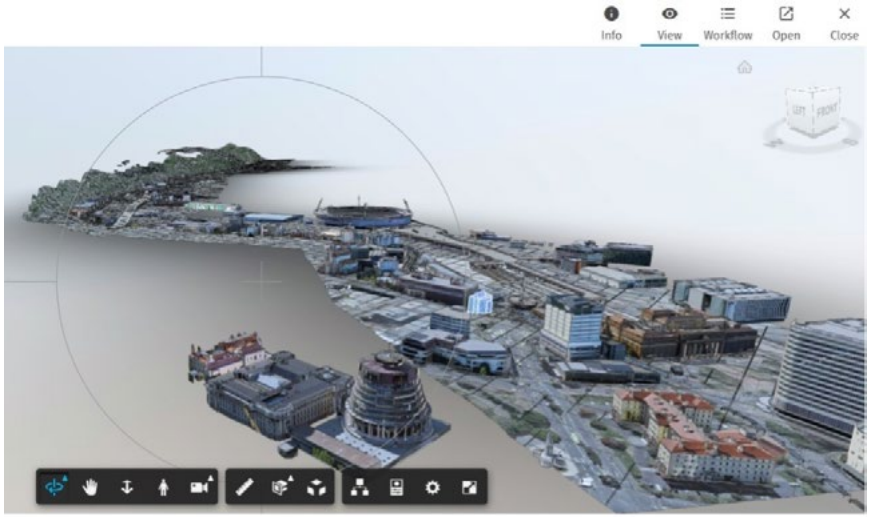
The key benefits of developing the NZTA DE Vision, Strategy, and Roadmap can be summarised as follows:

- **Intent** – signalling the intent for an end to end digitally enabled future, where DE supports decision-making in planning, coordination, maintenance, and operations of assets.
- **Awareness and support** – raise awareness and obtain strong engagement and support from the industry. NZTA plays an important role in promoting and facilitating open and constructive dialogue in the DE space for the transport sector, ensuring everyone's objectives remain aligned – e.g. asset owner, operator, maintainer, builder and designer.
- **Transparency and collaboration** – taking a transparent and collaborative approach will highlight how DE will improve efficiency and productivity in the sector, as well as the challenges and roadblocks to be addressed, such as skills shortages and more process maturity in the way asset information is captured and shared.
- **Innovation** – the clear intent and promotion of a collaborative approach will lead to innovation and skills development within the sector and drive more confidence in the investment in DE initiatives.

Although at the beginning of the DE journey, NZTA message and intent are clear: DE will play a fundamental role in future working practices, both internally and with the supply chain, whether planning for the next road, building the next bridge, maintaining, or operating the next tunnel.

Figure 6.16 shows an example of the types of visually rich web-accessible models that our suppliers are using to set the scene for major transport projects. This example is for a modal shift project in Wellington city, where the emphasis is on stakeholder and community engagement, technical review through the web, de-carbonisation, using models to assess health and safety planning, and the embedment of asset information throughout the design to construction and handover process.

Figure 6.16 – Example of a web-accessible model that can be used by projects



Key learnings:

Although at the start of the DE journey, based on the observations and feedback and observations, the key learnings so far can be summarised as:

- **Culture** – culture is key to driving change, e.g., collaboration, and moving in the same direction.
- **Inspiring stories** – the better stories told about the value and benefits of DE, the easier it is to inspire change. It is important for every person and every team to see "what is in it for me".
- **Clarity of intent** – signalling clear intent, helps the supply chain and partners invest in their people (skills, capability, technology). Promoting DE within educational institutions will help attract new professionals in this area.
- **Link to the organisation's objectives** – it is extremely important to link the DE transformation to the strategic drivers and outcomes of the organisation.
- **Accessible language** – it is important to help demystify terminology: right-sizing for the industry partners and using language that suits the end users, so everyone understands how these concepts apply to people in their roles.
- **Realistic objectives** – be realistic about what can be achieved and how quickly. Focus should be on DE activities that deliver the most value and require the least investment.
- **Being brave** – be brave and not afraid of trying out new things: fail fast, adapt, learn, and try again.
- **Holistic view** – DE approaches have relevance across the full plan, design, build, maintain, and operate lifecycle of assets.
- **Continuous evolution** – DE practices will continue to evolve as the sector gains expertise and new technology enables new approaches.

6.4 Key recommendations

Across the use cases provided as part of this DE Guide, several areas of key recommendations have been identified which include the following:

- culture
- standards
- information management
- interoperability.

Culture

Focus on fostering a culture of unity and collaboration across your project(s). The success of any transformation initiative heavily relies on obtaining buy-in from all of the team and ensuring their active participation in the change process. To achieve this, it is essential to create an environment where everyone feels included and engaged.

Encourage open communication and transparency throughout the project. Establish channels for sharing information, updates, and progress. This can include regular team meetings, town halls, newsletters, or even dedicated communication platforms. By keeping everyone informed and involved, you foster a sense of shared purpose and ensure that no one is left behind.

Emphasise the importance of learning and development as part of the transformation process. Offer training programs, workshops, and resources to help your team members enhance their digital skills and knowledge. This not only equips them with the necessary tools to adapt to the changes but also demonstrates your commitment to their growth and professional development.

Empower collaboration and create opportunities for cross-functional teams to work together on digital initiatives, promoting a sense of camaraderie and shared ownership. Foster a culture where ideas are welcomed from all levels of the organisation, and individuals feel empowered to contribute their unique perspectives and expertise. Recognise and reward collaborative efforts and successes to reinforce the desired cultural shift.

In summary, to nurture a culture that supports digital transformation, focus on fostering unity, collaboration, and a shared sense of purpose. Engage in open communication, provide learning opportunities, encourage cross-functional collaboration, and lead by example. By building a strong cultural foundation, you will pave the way for successful change adoption and reap the full benefits of your digital transformation efforts.

Standards

Establish and adhere to a set of common and consistent standards, methods, and procedures. This includes identifying the applicable regulations, guidelines, and best practices that govern your operations. Where possible, align with international, national, and local standards. By adopting established standards, you not only promote compliance but also benefit from the wealth of expertise and knowledge embedded within these frameworks.

Once the standards are established, clear and continuous communication across the entire team is vital. Ensure that all team members are aware of the standards, their purpose, and the specific requirements associated with them. This can be achieved through regular team meetings, training sessions, and the use of internal communication channels. By fostering a culture of awareness and understanding, you create a shared responsibility for maintaining compliance and upholding the established standards.

To ensure the practicality and achievability of the standards, it is essential to assess their feasibility within the context of your project(s). Carefully evaluate the resources, capabilities, and existing systems to determine if the requirements are realistic and can be effectively implemented. It may be necessary to adapt or customise certain aspects of the standards to fit the unique needs and limitations of your organisation and/or project. Strive for a balance between compliance and operational efficiency.

Assigning ownership and purpose to all data and information is a crucial aspect of effective standardisation. Clearly define who is responsible for each piece of data or information, ensuring accountability and clarity. Additionally, establish a clear understanding of the purpose behind the collection, storage, and usage of the data. This helps align efforts across the organisation and/or project and ensures that data-related activities are driven by defined objectives.

Regularly review and update the standards to accommodate evolving industry practices, technological advancements, and regulatory changes. Standards should be seen as dynamic and adaptable, rather than rigid and static. Encourage feedback and input from team members to continuously improve and refine the standards framework.

Information management

Focus time and effort on effective information management practices to maximise the value and usability of your project's data and information assets.

Develop a clear and consistent approach for how data and information are developed, managed, and shared across your project(s). This includes defining standardised processes, workflows, and best practices that guide the entire information management lifecycle.

Communicate this approach to all stakeholders to ensure a shared understanding and adherence to the established standards.

Prevent the isolation of datasets within different departments or systems. Foster a culture of collaboration and integration by ensuring that systems are interconnected and capable of sharing data seamlessly. Pay close attention to the enablement of data integration throughout your project(s). This involves ensuring that data is adequately prepared and structured for integration purposes. Implement data integration mechanisms, such as standardised naming conventions, metadata management, and tagging systems. These practices enable efficient data discovery, improve data quality, and facilitate cross-functional analysis and decision-making.

Recognise that setting up information management systems and processes requires time, effort, and resources. Allocate sufficient time for planning, designing, and implementing these systems. Identify and allocate the necessary resources, including personnel, tools, and technologies, to support information management throughout the lifecycle of your projects. Adequate resourcing will help ensure the long-term sustainability and effectiveness of your information management initiatives.

Information management is an ongoing process that requires continuous improvement. Regularly review and refine your information management approach, processes, and systems. Stay abreast of emerging technologies, industry standards, and best practices to continuously enhance your information management capabilities. Encourage feedback from users and stakeholders and foster a culture of learning and adaptation to optimise your information management practices over time.

Interoperability

Ensuring data interoperability is essential for seamless information exchange and collaboration across different applications.

Evaluate the compatibility of the different applications being used within your project(s). Consider how these applications reference and link data between each other. Identify any potential interoperability issues that may arise due to differences in data formats, structures, or communication protocols. Understanding these challenges will help you develop effective strategies for achieving data interoperability.

Identify the desired data delivery format(s) for interoperability. This includes specifying the data exchange standards, file formats, and protocols that should be followed. By establishing clear expectations early on, you can avoid issues and delays related to incompatible data formats later in the project lifecycle.

Conduct early testing to verify the applications' ability to export data in the desired format. This will help identify any limitations or technical constraints that need to be addressed. Regular testing and verification throughout the project lifecycle will help maintain data interoperability.

Consider adopting common, interoperable data models such as Industry Foundation Classes (IFC). These standardised data models provide a common framework for representing information across different applications and disciplines. Test the compatibility and interoperability of the different applications' output with these common data models, recognising that there can be discrepancies between the outputs from different applications. Identify any discrepancies or inconsistencies and work with your teams, ensuring seamless data exchange and integration.

Foster collaboration and open communication between stakeholders. Encourage the sharing of information, experiences, and best practices related to achieving data interoperability. Establish cross-functional teams or forums where representatives can discuss and address interoperability challenges. This collaborative approach will help identify innovative solutions and build a collective understanding of the importance of data interoperability.

6.5 Closing summary

Acknowledgement and thanks are given to those who contributed towards the case studies provided within this DE Guide and the efforts made to further their DE capability and outcomes and to share this with the broader industry.

Ultimately, the value of case studies is not to be underestimated. They provide a way to uncover rich insights from past experiences and facilitate guided learning processes of testing. Furthermore, they help organisations better prepare for future challenges and shift their perspective on how tasks and initiatives are handled. The development and sharing of use cases provide the potential to drive creative scenarios, harness new ideas and encourage change, measuring and sharing approaches and outcomes associated with learning interventions, which is important for influencers to make a measured impact. This is why organisations should continue to measure and share approaches and outcomes as they strive forward into an increasingly unpredictable future. Case studies can serve as an invaluable resource, allowing leaders to gain valuable insight, spot trends early on, identify potential problems before they arise, inform decisions, and adjust them based on real-world knowledge generated by case studies.

It is evident from examining case studies that carefully balancing resources can enable even the most diverse operations to achieve exceptional benchmarks in performance.

With this understanding in place, transport agencies should continue to measure and share different approaches and outcomes so others may benefit from their knowledge. Understanding the value of case studies offers a practical way to drive success and ensure companies are well-positioned to capitalise on future opportunities.

Quantitative measures are an invaluable tool for any business, and they should serve as an integral part of every case study. Through the utilisation of numerical data, businesses not only gain insight into the performance and profitability of their operations but can also measure customer satisfaction and business outcomes from strategic initiatives in more meaningful ways. Quantitative metrics serve as a comprehensive window to view all facets of a given project, ensuring that it has the highest potential return on investment.

Two valuable resources available to transport agencies to assist in capturing more quantitative data when developing case studies include SBEnrc's *BIM Value Tool*, hosted by Natspec and the ABAB *Guidance to Case Study Metrics,* which can be found in Appendix B of this guide. Some key metrics to consider include:

- efficiency gain
- quality improvement
- return on investment (ROI)
- innovation drive.

DE case studies primarily revolve around several key metrics. Firstly, the Efficiency Gain quantifies the time and cost savings achieved by implementing DE solutions. Second, Quality Improvement, measures the reduction in errors and rework, thus enhancing the final product's excellence. Third, the Return on Investment (ROI), which assesses the financial viability of the DE initiative. Lastly, the Innovation Drive, gauges how DE spurs creativity and novel solutions within the engineering landscape.

Delving deeper into DE metrics, we encounter four additional key indicators. The first, Adoption, evaluates the extent to which the engineering team has embraced the digital tools and methodologies. It reflects the degree of integration in daily processes and operations. The second, Usability, assesses the intuitiveness and user-friendliness of the digital solutions, ensuring that they enhance rather than obstruct workflows.

The third, Productivity, measures the impact of DE on the output efficiency of the team. It quantifies the potential for increased throughput and reduced project timelines. Lastly, the New Value metric assesses the additional benefits or improvements brought about by DE that could not have been achieved through traditional methods. This entails groundbreaking designs, unprecedented solutions, and innovative processes. Each of these metrics plays a vital role in the comprehensive evaluation of a DE initiative.

Lessons learnt:

- **Digital maturity** – Recognise that individuals and organisations vary in their level of digital maturity. It is crucial to support one another to collectively achieve common goals and desired outcomes.
- **Building foundations** – It is essential to establish solid foundations before progressing further. Just like learning to walk before running, laying the groundwork is necessary to ensure future success.
- **Setting realistic objectives** – Concentrate on digital initiatives and activities that offer the greatest value while requiring the least investment. By focusing on realistic objectives, you can optimise resources and maximise the benefits of your efforts.

GLOSSARY OF TERMS AND REFERENCES

GLOSSARY OF TERMS:

GLOSSARY

Term	Description
Examples of industry and agency definitions of BIM and DE:	"BIM is a digital form of construction and asset operations. It brings together technology process improvements and digital information to radically improve client and project outcomes and asset operations. BIM is a strategic enabler for improving decision-making for both buildings and public infrastructure assets across the whole life cycle. It applies to new build projects and crucially, BIM supports the renovation, refurbishment, and maintenance of the built environment – the largest share of the sector." *Reference ABAB and EU BIM Taskgroup Handbook, 2018*
	"DE is a collaborative way of working, using digital processes that enable more productive methods of planning, constructing, operating and maintaining TfNSW's assets." *Reference Transport for NSW (TfNSW)*
	"Use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions" *Reference ISO 19650:1*
	Note: Transport agencies should refer to other State BIM and DE Guides for definitions where available.

Term	Description
Contract (document)	A formal agreement between the Client and the Supplier specifying the rights and responsibilities of both parties in doing a particular Project/ Work Package.
Contract (job)	A Work Package, which is outsourced to an external Supplier by way of a Contract.
Deliverables	Assets (physical or digital) which must be delivered by the supplier and approved by the Agency under the terms of Contract.
openBIM	An approach to define and support the implementation of open data standards for interoperability for the built environment, developed over several decades and managed by the non-profit organisation building SMART International, which has chapters worldwide continuing to drive its adoption and development.
Permission	A setting in a digital system, which allows a specific person to execute a specific Action. Actions need to be executed to fulfil specific Responsibilities assigned to a role.
Project	A collection of Work Packages.

Term	Description
Role	A collection of Responsibilities and (optionally) Permissions assigned to a person in the context of Project/Work Package or Organisation Permissions need to be assigned if a role is also defined in a digital system (e.g. CDE). Such Permissions are necessary for the system users to execute Actions necessary to fulfil their Responsibilities. The same person may be assigned one or more roles.
Services	Works (physical or digital) which must be executed by the supplier and approved by the Agency under the terms of Contract.
Structured information	Machine readable information, such as databases, tabular spreadsheets, and objective asset models. Structured information can be further broken down into objects, which contain geometrical, alphanumerical and documentation information and metadata (information about information).
Unstructured information	Human readable only, such as drawings, bitmap images and text documents.
Work Package	Defined scope of work, for which a Work Package Team is assembled. The Work Package Team would need to execute a number of Actions to complete a Work Package. These Actions, which should be executed using a digital system require Permissions defined in this system.

GLOSSARY OF TERMS:

ABBREVIATIONS

Term	Description
2D	2 Dimensional (linear)
3D	3 Dimensional (space)
4D	4 Dimensional (time)
5D	5 Dimensional (cost)
AIR	Asset Information Requirements
AMDS	Asset Management Data Standard
AMS	Asset Management System
ANZ	Australia and New Zealand
API	Application Programming Interfaces
BCF	BIM Collaboration Format
BIM	Building Information Modelling
CAFM	Computer Aided Facilities management
CAPEX	Capital Expenditure
CDE	Common Data Environment
CIO	Chief Information Officer
CityGML	City Geography Markup Language
CMM	Capability Maturity Model
COBie	Construction Operations Building information exchange

Term	Description
CP	Colaborative Partnership
CRM	Customer Relationship Management
DE	Digital Engineering
DEF	Digital Engineering Framework
DEMP	Digital Engineering Management Plan
DEXP	Digital Engineering Execution Plan
DJV	Design Joint Venture
DMP	Digital Management Plan
EDMS	Electronic Document Management Systems
EIR	Exchange Information Requirements
EMS	Enterprise Management System
EOI	Expression of Interest
ERP	Enterprise Resource Planning
ETL	Extract, Transform and Load
FTE	Full-time Equivalent
gbXML	Green Building Extensible Markup Language
GIS	Geographic Information System
IA	Infrastructure Australia

Term	Description
IFC	Industry Foundation Classes
IPWEA	Institute of Public Works Engineering Australia
LIDAR	Light detecting and ranging laser imaging
LOD	Level of Detail (Geometric)
LOI	Level of Information (non-geometric)
MDM	Master Data Management
MRWA	Main Roads WA
NSW	New South Wales
NZ	New Zealand
NZTA	New Zealand Transport Agency
OIR	Organisational Information Requirements
OPEX	Operational Expenditure
PIR	Project Information Requirements
PMO	Project Management Office
PoC	Proof of Concept
PoV	Proof of Value
QLD	Queensland
RMS	Roads and Maritime Services
ROI	Return on Investment
SA	South Australia
SCCA	Supply Chain Capability Assessment
SCM	Supply Chain Management

Term	Description
SID	Schedule of Information Deliverables
SMP	Standards, Methods and Procedures
TfNSW	Transport for NSW
TMR	Transport Main Roads, QLD
TNA	Training Needs Analysis
VDAS	Victotian Digital Asset Strategy
VDC	Virtual Design and Construction
VIC	Victoria
WA	Western Australia

GLOSSARY OF TERMS:

REFERENCES

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Standards

ISO 16739 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries

ISO 19650 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling
Part 1: Concepts and principles
Part 2: Delivery phase of the assets
Part 3: Operational phase of the assets

ISO 21500 Project, programme and portfolio management

ISO 55000 Asset Management

ISO 8000 Data Quality

ISO 9001 Quality Management Systems

APPENDIX A: SUMMARY OF RECOMMENDATIONS

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SUMMARY OF RECOMMENDATIONS

Chapter 1: Introduction

The DE landscape is driving further improvements in the methods of transport projects and service delivery. From effective planning to implementation, DE enables agencies to do more with less. This guide outlines fundamental considerations, examples and approaches designed to help transport agencies plan, apply and adopt DE. Some of the fundamentals for transport agencies to consider include:

1. Recognising the significant benefits gained from adopting DE and the value in measuring these benefits.
2. Understanding the value in investing in a collaborative and openBIM approach for improved efficiency and potential for long-term re-use of data.
3. Recognising the need for a structured, integrated and holistic approach to strategy and planning for the successful implementation of DE.

Table A.1 Chapter relevance to role summary

Should I read this section to help in my role?		
Reader	Essential	Helpful
I am sponsoring/key decision maker in the adoption of DE strategy	✓	
I am a department head and hence a key stakeholder		✓
I am leading/supporting the development of a digital strategy	✓	
I am supporting the implementation of a DE strategy		✓
I need to adopt the new digital engineering practices		✓

Chapter 2: The need for DE

With the current macro challenges that both Australia and New Zealand face in delivering infrastructure to support growth, plus the challenges that were identified during the discovery process in developing this guide.

The following recommendations for both agencies are as follows:

Recommendation 1 – **Ensure that agency DE program has executive buy-in and aligns to business strategy**

The success of any agency DE program is dependent on the executive's buy-in. Without it, programs will find themselves with limited resources and insufficient support from key decision makers which could lead to the program being sidelined or ignored altogether; furthermore, the DE program must help and bring to life the agency's business strategy in order for the DE program to be successful.

Recommendation 2 – **Have a strategy and business case – not just a plan**

Too often, organisations embark on a DE initiative with little more than a plan. They may have a vague idea of what they want to achieve and how they want to use DE, but they lack a clear strategy and business case. As a result, they can quickly become bogged down in the details of technical implementation, losing sight of the bigger picture.

To be successful, a DE initiative must start with a sound strategy that considers the unique business needs of the organisation. Once the strategy is in place, it should be used to develop a detailed business case that outlines the costs, benefits, and risks associated with the project. Only then can an organisation create a plan that will guide the implementation of its DE initiative.

Recommendation 3 – **Influence standards adoption through policy and procurement**

Agencies have two key levers to invoke change within their projects and supply chain. Agency's need high quality information from its supply chain and without a consistent and standardised approach agencies will struggle to procure the high-quality information they need to manage their assets. Agencies can mandate the use of standards (ISO 19650x) to help ensure that the products and services meet their requirements, and the information is compatible with agencies systems.

Recommendation 4 – **Ensure that your Operations & Maintenance teams are part of your DE strategy**

For as much progress as organisations have made over the past decade about DE, even the most ardent DE adopters have neglected what is perhaps the most vital component of any project-operations and maintenance processes and procedures.

It is vitally important that your operations and maintenance teams' input into the development of asset information requirements to ensure there is a seamless transfer of information at the handover stage.

Recommendation 5 – **Have a clear plan for the trailing edge of industry**

It is clear from a healthy open market that there is innovation and opportunity in the sector. From investments already being made by key suppliers, the leading edge of the industry is busy understanding and implementing DE. It is the trailing edge that needs help and clear targets.

The recommended approach to work collaboratively with the Tier 2's & 3's to help build capacity and capability to ensure that information is delivered to agencies and also ensure that no suppliers are unduly penalised.

Recommendation 6 – **Help the supply chain by understanding your DE program**

When engaging with your supply chain in relation to DE it is important to understand your supply chains DE capacity and capability. Furthermore, you should also consider assisting your supply by understanding why your DE program is important, what your DE program is and finally how your DE program will impact future contracts.

Government as a client has responsibility to assist the supply where possible to help build industry capacity and capability in relation to DE, this engagement will help to identify/mitigate any potential risks or challenges that could impact the successful delivery of DE projects from your supply chain.

Recommendation 7 – **Be very specific with what you ask for from the supply chain**

The supply chain has become very adept at producing information for the delivery of specific parts of an asset. Issues arise not generally in the individual businesses but where they interface with others or have to deliver a composite set of information from across the supply chain. The contract requirements must be specific regarding deliverables and responsibility for delivery.

Recommendation 8 – **Measure and report benefits**

Measuring and reporting benefits is an important part of your DE program. Benefits can take many different forms, including improved efficiency, or reduced costs etc.

In order to maximize the benefits of a project, it is essential to first identify the DE goals and objectives that are most important to the organization. Once these have been identified, a plan can be put in place to track and measure progress against these goals. This data can then be used to generate reports that show the benefits of the project. By taking the time to measure and report benefits, organizations can ensure that they are getting the most out of their DE program.

Chapter 3: Strategy and planning

Key recommendations when developing a learning framework for DE include:

- **Establish a clear vision –** Understand your organisational objectives and requirements and where.
- **Establish a Roadmap –** Identify and sequence key activities required to support capability uplift over multiple horizons.
- **Understand the resources required –** Assess available options to secure the internal and/or external resources and expertise required .
- **Seek senior sponsorship and support –** Securing buy-in and commitment from key decision-makers to ensure sustained success.
- **Establish a benefits measurement system –** Establish a measurement system of benefits and a companion justification of ROI and value for money.
- **Baseline current state capability maturity –** to assist in measuring continuous improvement.
- **Understand the actual challenges –** in the organisation and projects, how can DE support or address these challenges?
- **Capture and define specific use cases –** and align this to the funding and resources allocated to ensure focus is maintained and outcomes and benefits can be realised.
- **Feedback loop and cumulative learning –** Be a learning and listening organisation – continue to feedback and understand the real challenges and solutions within your organisation and collaborate and share with other industry organisations.
- **Long-term funding and vision for learning and development –** Make DE a business activity and not a specialist activity, integrating it into the organisation to serve the parent problems and objectives.

Chapter 4: Implementation

Key recommendations for agencies explored in this chapter include:

- **Implement DE across the asset lifecycle –** an agency is the driving force for successfully and consistently implementing DE capability across the entire asset lifecycle including departments and projects. Agencies have a key role to play in not only how they plan out their DE programs but also in taking active steps to implement these plans by being willing to participate actively at every level along the way.
- **Manage information requirements –** implementing a framework for capturing information requirements. The key opportunities and outcomes when an agency directly drives the management of their information requirements, described in relation to procuring DE deliverables and outcomes while maintaining access and control of data across the asset lifecycle.
- **Align capabilities systems and ways of working –** An agency should seek to understand how departments can work together and with external partners through collaborative working to produce, manage and leverage DE across the asset lifecycle, the role of standards in enabling this and the concept of a CDE, as per ISO 19650, in terms of a consistent and governed workflow to be enabled by a suite of enabling technologies and aligned with other stakeholders and systems.
- **Leverage enabling tools and technologies –** An agency should continuously explore, with industry, how technology can enable strategic, management and technical outcomes. Key methodologies are also considered which agencies may adopt or procure in terms of DE outcomes or data deliverables for various purposes in a quality-controlled manner supported by a CDE solution aligned to specific agency requirements.
- **Implement with a phased and measured approach –** An agency should take a phased and pragmatic approach to dealing with legacy data and systems, the implementation of a CDE for enterprise and project applications and measuring and monitoring progress and impacts that new DE capabilities are making.

Chapter 5: Learning and development

Here are some key recommendations when developing a learning framework for DE:

- **Involve multiple stakeholders –** When designing a learning framework, it is crucial to involve multiple stakeholders such as subject matter experts, HR professionals, and employees. This ensures that the learning framework meets the needs of all parties involved and is aligned with the agency's goals.
- **Stay up-to-date with industry trends –** DE is a rapidly evolving field, and it is crucial to stay informed about the latest trends and technologies. This will help ensure that the learning framework remains relevant and current.
- **Encourage continuous learning –** In the fast-paced world of DE, continuous learning is essential. The learning framework should encourage employees to continue developing their skills and knowledge even after completing formal training programs. This could include providing access to online resources or organising regular workshops and seminars.
- **Promote a learning culture –** A learning framework is only effective in a company that promotes a culture of learning and growth. Leaders should lead by example and actively participate in the learning process. This will help create an environment where continuous learning is valued and encouraged.
- **Shared learning and in-person collaboration –** Capturing lessons learnt and case studies is essential for continuous improvement. In-person collaboration also often enhances these outcomes and the clarity of which key findings are captured and understood.
- **Develop a capability framework that has mandatory and desirable skills and capabilities –** Ensure this includes measurable competencies while considering the need for diversity within teams.
- **Measure training ROI and map value chains –** Establish a measurement system to track the learning outcomes from investment in learning and development and how this is applied within an agency and across projects.
- **Implement DE approaches via shadowing and tailor them to project needs where necessary –** Measuring two similar projects to compare the impact of traditional vs DE approaches to provide clear metrics about the ROI.

Chapter 6: Case studies

Across the use cases provided as part of this DE Guide, several areas of key recommendations have been identified which include the following:

- culture
- standards
- information management
- interoperability.

Culture

Focus on fostering a culture of unity and collaboration across your project(s). The success of any transformation initiative heavily relies on obtaining buy-in from all of the team and ensuring their active participation in the change process. To achieve this, it is essential to create an environment where everyone feels included and engaged.

Encourage open communication and transparency throughout the project. Establish channels for sharing information, updates, and progress. This can include regular team meetings, town halls, newsletters, or even dedicated communication platforms. By keeping everyone informed and involved, you foster a sense of shared purpose and ensure that no one is left behind.

Emphasise the importance of learning and development as part of the transformation process. Offer training programs, workshops, and resources to help your team members enhance their digital skills and knowledge. This not only equips them with the necessary tools to adapt to the changes but also demonstrates your commitment to their growth and professional development.

Empower collaboration and create opportunities for cross-functional teams to work together on digital initiatives, promoting a sense of camaraderie and shared ownership. Foster a culture where ideas are welcomed from all levels of the organisation, and individuals feel empowered to contribute their unique perspectives and expertise. Recognise and reward collaborative efforts and successes to reinforce the desired cultural shift.

In summary, to nurture a culture that supports digital transformation, focus on fostering unity, collaboration, and a shared sense of purpose. Engage in open communication, provide learning opportunities, encourage cross-functional collaboration, and lead by example. By building a strong cultural foundation, you will pave the way for successful change adoption and reap the full benefits of your digital transformation efforts.

Standards

Establish and adhere to a set of common and consistent standards, methods, and procedures. This includes identifying the applicable regulations, guidelines, and best practices that govern your operations. Where possible, align with international, national, and local standards. By adopting established standards, you not only promote compliance but also benefit from the wealth of expertise and knowledge embedded within these frameworks.

Once the standards are established, clear and continuous communication across the entire team is vital. Ensure that all team members are aware of the standards, their purpose, and the specific requirements associated with them. This can be achieved through regular team meetings, training sessions, and the use of internal communication channels. By fostering a culture of awareness and understanding,

you create a shared responsibility for maintaining compliance and upholding the established standards.

To ensure the practicality and achievability of the standards, it is essential to assess their feasibility within the context of your project(s). Carefully evaluate the resources, capabilities, and existing systems to determine if the requirements are realistic and can be effectively implemented. It may be necessary to adapt or customise certain aspects of the standards to fit the unique needs and limitations of your organisation and/or project. Strive for a balance between compliance and operational efficiency.

Assigning ownership and purpose to all data and information is a crucial aspect of effective standardisation. Clearly define who is responsible for each piece of data or information, ensuring accountability and clarity. Additionally, establish a clear understanding of the purpose behind the collection, storage, and usage of the data. This helps align efforts across the organisation and/or project and ensures that data-related activities are driven by defined objectives.

Regularly review and update the standards to accommodate evolving industry practices, technological advancements, and regulatory changes. Standards should be seen as dynamic and adaptable, rather than rigid and static. Encourage feedback and input from team members to continuously improve and refine the standards framework.

Information management

Focus time and effort on effective information management practices to maximise the value and usability of your project's data and information assets.

Develop a clear and consistent approach for how data and information are developed, managed, and shared across your project(s). This includes defining standardised processes, workflows, and best practices that guide the entire information management lifecycle.

Communicate this approach to all stakeholders to ensure a shared understanding and adherence to the established standards.

Prevent the isolation of datasets within different departments or systems. Foster a culture of collaboration and integration by ensuring that systems are interconnected and capable of sharing data seamlessly. Pay close attention to the enablement of data integration throughout your project(s). This involves ensuring that data is adequately prepared and structured for integration purposes. Implement data integration mechanisms, such as standardised naming conventions, metadata management, and tagging systems. These practices enable efficient data discovery, improve data quality, and facilitate cross-functional analysis and decision-making.

Recognise that setting up information management systems and processes requires time, effort, and resources. Allocate sufficient time for planning, designing, and implementing these systems. Identify and allocate the necessary resources, including personnel, tools, and technologies, to support information management throughout the lifecycle of your projects. Adequate resourcing will help ensure the long-term sustainability and effectiveness of your information management initiatives.

Information management is an ongoing process that requires continuous improvement. Regularly review and refine your information management approach, processes, and systems. Stay abreast of emerging technologies, industry standards, and best practices to continuously enhance your information management capabilities. Encourage feedback from users and stakeholders and foster a culture of learning and adaptation to optimise your information management practices over time.

Interoperability

Ensuring data interoperability is essential for seamless information exchange and collaboration across different applications.

Evaluate the compatibility of the different applications being used within your project(s). Consider how these applications reference and link data between each other. Identify any potential interoperability issues that may arise due to differences in data formats, structures, or communication protocols. Understanding these challenges will help you develop effective strategies for achieving data interoperability.

Identify the desired data delivery format(s) for interoperability. This includes specifying the data exchange standards, file formats, and protocols that should be followed. By establishing clear expectations early on, you can avoid issues and delays related to incompatible data formats later in the project lifecycle.

Conduct early testing to verify the applications' ability to export data in the desired format. This will help identify any limitations or technical constraints that need to be addressed.

Regular testing and verification throughout the project lifecycle will help maintain data interoperability.

Consider adopting common, interoperable data models such as Industry Foundation Classes (IFC). These standardised data models provide a common framework for representing information across different applications and disciplines. Test the compatibility and interoperability of the different applications' output with these common data models, recognising that there can be discrepancies between the outputs from different applications. Identify any discrepancies or inconsistencies and work with your teams, ensuring seamless data exchange and integration.

Foster collaboration and open communication between stakeholders. Encourage the sharing of information, experiences, and best practices related to achieving data interoperability. Establish cross-functional teams or forums where representatives can discuss and address interoperability challenges. This collaborative approach will help identify innovative solutions and build a collective understanding of the importance of data interoperability.

Case study benefits capture guidance

The following key steps outline some best practices that can help agencies develop more effective case studies:

- **Be specific and concrete:** Use specific numbers, data, and examples to make your case study more credible. This will also help key stakeholders understand the tangible benefits of your product or service.
- **Provide a call to action:** Use your case study as an opportunity to encourage decision-makers and leaders to act and explore new opportunities to implement DE and further the collective DE capability.
- **Focus on the outcome:** Rather than just showcasing features or capabilities, highlight the outcomes and benefits that your implementation of DE provided. This will help key stakeholders understand how your approach can directly impact their project or team.
- **Include visuals:** In addition to using visuals within the case study itself, consider creating a visual representation of the results achieved. This could be in the form of site photos, a process map, a graph, a chart, or an infographic.
- Include challenges and obstacles: Highlight any challenges or obstacles faced during the implementation of DE and how your approach overcame these challenges.
- **Track and analyse results:** Use tracking tools to measure the impact of your case studies against the project and DE strategy goals. This data can help refine approaches and create even more effective case studies in the future.

Benefit capture in DE involves a systematic process to realise the potential advantages brought by more consistent and collaborative ways of working, data and digital technologies which includes:

1. **Requirement analysis:** Identify the objectives and the associated needs of your project. Understanding what you aim to achieve with DE is the first step towards capturing its benefits.
2. **Solutions assessment:** Evaluate alternate ways of working, available digital tools and technologies, and their applicability to your project. This involves understanding the capabilities of different processes, data and technologies and matching them with your identified needs.
3. **Implementation planning:** Develop a strategy for adopting the chosen technologies. This includes planning for necessary infrastructure, training, and support systems.
4. **Execution and monitoring:** Implement the technologies and monitor their usage and effectiveness. This also involves gathering user feedback and adjusting accordingly.
5. **Evaluation and adjustment:** Assess the achieved benefits against the set objectives. Make necessary adjustments to the technology or its usage to enhance benefits capture.

Capturing benefits from DE is an iterative process, necessitating frequent reviews and adjustments to align with the evolving objectives and needs of the project. Additionally, it is crucial to involve all stakeholders throughout the process to ensure their buy-in and support for successful implementation.

DE business case outline

The below outline provides an example structure and content for Agencies to utilise in developing a business case for DE initiatives and programs, based on the Five Case Model.

Executive summary

- Succinct summary of the business case, key findings and recommendations.

Introduction

- Background information about the project.
- Objectives and scope of the business case.

Strategic case

- Assess the project's alignment with corporate strategy and vision.
- Detail the benefits to project delivery, collaboration, and operational efficiency.
- Examine how the project will reinforce the company's standing in the industry.

Economic case

- Evaluate cost savings against potential revenue increases from improved offerings.
- Forecast ROI considering all costs and benefits associated with the project.

Commercial case

- Scrutinise the project's impact on product time-to-market and competitive advantage.
- Analyse market demand for digitally engineered services.
- Explore strategic commercial partnerships that align with project objectives.

Financial case

- Break down of projected capital investments and operational expenditures.
- Present financial performance forecasts including cash flow estimates.
- Identify funding mechanisms and financial support options.

Management case

- Define project governance, pinpoint roles and responsibilities of stakeholders.
- Outline project management strategies addressing milestones, schedules, and risk.
- Propose initiatives for enhancing team learning and improvement practices.

Stakeholder analysis

- Identify key project stakeholders and summarise their interests and concerns.
- Transport agencies' interests and concerns:
  - Financial implications regarding project costs.
  - Understanding of value, benefits and priority use cases.
  - Risks associated with project implementation and mitigation strategies.
  - Guidance on initiating the project effectively.

Risks and issues

- Undertake a thorough risk assessment, identifying potential obstacles and proposing mitigation strategies.

Conclusion

- Recapitulation of the business case's main points and the projected positive outcomes from the project.

Appendices

- Supporting documentation and detailed analysis back-up.

This outline is structured to be comprehensive, keeping the focus on the objectives and strategic alignment of the DE project, and how it serves the interest of key stakeholders. Each section provides the necessary framework for developing a robust case to achieve stakeholder buy-in and successful project execution.

It should be noted that business case development should be tailored to suit the assurance pathway and approach with relevant detail to suit the key decision-makers within each Agency.

APPENDIX B: ENABLING TECHNOLOGY UTILISATION MATRIX AND USE CASES

APPENDIX B:

ENABLING TECHNOLOGY UTILISATION MATRIX AND USE CASES

Asset lifecycle technology utilisation matrix

Table B.1 – Lifecycle DE use cases for feasibility and design

Technology application and use	Feasibility			Design stage		
	Maturity	**Gaps**	**Opportunity**	**Maturity**	**Gaps**	**Opportunity**
Agency/client	Application – Weak Use – Medium	Required deliverables are usually in report format	Requirement to deliver digital output and platform that can be extended into project	Application – Weak Use – Weak	Focus on purely 2D deliverables and traditional document control procedures.	Change focus from traditional deliverables
Supply chain	Application – Medium Use – Strong	Planned onward use of digital data is seen as an opportunity to charge more	Focus on quality of digital outcomes as opposed to cost of creating paper based reports	Application – Medium Use – Strong	Quality of digital deliverables prevent future onward use beyond design	Improved quality of outputs such data is properly fit for purpose

Maturity Legend

Application – How well a digital technology is implemented
Use – How broadly a digital approach is utilised

Table B.2 – Lifecycle DE Use Cases for procurement and construction

Technology application and use

	Procurement stage			Construction stage		
	Maturity	**Gaps**	**Opportunity**	**Maturity**	**Gaps**	**Opportunity**
Agency/client	Application – Weak Use - Weak	Digital requirements not tied to contracts	Change in contracts to drive use of digital deliverables	Application – Weak Use – Weak	Client requirements fall largely around traditional document control and deliverables.	Progressive validation and review by client. Active participation delivery of Asset
Supply chain	Application – Weak Use – Weak	Supply chain is largely driven by client requirements and process	Permitted use of current data so support proposals	Application – Low Use – Medium	Actual use in construction and in particular the wider supply chain	More holistic use greater quality, improved safety etc

Maturity Legend

Application – How well a digital technology is implemented
Use – How broadly a digital approach is utilised

Table B.3 – Lifecycle DE use cases for handover and operations

Technology application and use	Handover			Operations		
	Maturity	**Gaps**	**Opportunity**	**Maturity**	**Gaps**	**Opportunity**
Agency/client	Application – Weak Use - Weak	consistency between agencies and asset owners needs	Minimum standard of integrated digital information	Application – Medium Use – Low	Misalignment between perceived and actual needs and benefits	Inclusion of asset owners at earlier stage of lifecycle
Supply chain	Application – Weak Use – Weak	Scope clarity Cost of as-built models Information requirements	Progressive completions Point cloud vs model validation	Application – Weak Use – Medium	Quality of information handover not a priority	Greater emphasis on what, why and how in contracts

Maturity Legend

Application – How well a digital technology is implemented
Use – How broadly a digital approach is utilised

Technology as an enabler use cases

Table B.4 – DE enabling technology use cases

DE use case area	Lifecycle stage	Description	Technology enabler
Feature survey	Feasibility	Traditional capture of feature survey which depicts the project area. Advance in technology now enable extraction of Features from point cloud surveys which can improve program and provide multiple benefits.	Digital survey
Context capture		Use of drone camera footage to develop an overall 3D Mesh which shows the overall project area. This advancement provides a good base for early site studies as well as visualisation but is limited in terms of its accuracy and does not replace more traditional feature surveys or laser scanning.	Drone capture
Existing utilities		Capture of existing utilities information beyond that provide in dial before you dig data. Use of traditional survey and non-destructive digging methods (NDD) provide good access to QL A data in accordance to AS4688. Newer development using ground penetrating radar (GPR) now provides opportunity to capture a greater area of utilities to QL B.	Digital survey
Solution optioneering		Use of parametric driven geometry and advances in conceptual design solutions technologies now mean the ability to develop multiple solutions in shorter timeframes is more feasible and practical than previously. This is an area where focus on digital deliverables not paper outputs can provide significant benefit.	Parametric design solutions
Site analysis		Using a combination of geospatial design solutions and geospatial information systems (GIS) to develop an accurate understanding and representation of the proposed project areas.	GIS
Initial costings/budgets		Data and model driven cost early cost analysis can be supported using solution optioneering as defined above. Understanding of the amount of pavement, earthworks etc are all by-products which generate information that feed into initial cost models.	Digital models
Buildability		Early use and interrogation of digital models to review construction feasibility and potential impact on costing. This is a potential area for use of differing contracts to provide contractor input into the feasibility of a particular design option.	Digital models
Stakeholder impact		Understanding and visualisation of impact on project surroundings, dwellings, shops, residents etc using geospatial analysis as well as capture of community feedback via online digital platforms.	GIS web applications

DE use case area	Lifecycle stage	Description	Technology enabler
Alignment options	Feasibility	Development of multiple alignment options considering various constraints and requirements to establish an optimal proposal can be achieved using current design methods combined with parametric geometry creation.	Parametric design solutions
Environmental and heritage impacts		Similarly to stakeholder impact the use of a GIS platform and data modelling techniques can enable early stage analysis of environmental and heritage impacts on a project proposal and the surround area.	GIS modelling and analysis
3D focused design	Design	Development of full design solutions in 3D with embedded data	Digital design applications
Safety in design		Review and analysis of safety aspects to proposed design using a combination of a coordinated 3D model to aid the review with all identified risks be capture and recorded as Risks within the model dataset.	Digital review
Risk management		Like SiD but with a focus on identifying and recording key risks for the project.	Digital review
Requirements management		Use of the Federated Design Model in conjunction with a requirements database to capture, review and validate the design.	Digital validation
Model based QTO		Provision of model driven quantities for core elements of the project to assist in the early-stage cost impact analysis and to be able to track design creep.	Digital review
Design coordination		Development of a 3D Federated model incorporating All disciplines to support the overall design coordination. This model would be used to support tracked design issues as web accessible central data set.	Digital review
Change measurement		Tracking of design change and scope creep through identification of change within the model from one progression to the next.	Digital validation
Progressive assurance		A process whereby design assurance evidence is gathered progressively at the finalisation and review of each major design phase. This is done in conjunction with the overall requirements management and capture digitally across the appropriate elements of the CDE.	Digital validation

DE use case area	Lifecycle stage	Description	Technology enabler
Model based QTO	Procurement	As per design but with a focus on supporting the pricing of the overall works package or packages.	Digital review
Point cloud survey		Use of digital laser scanning to create a high density survey registered point cloud of the entire project site or critical interfaces with existing structures for example.	Digital survey
Digital fabrication		Development of a validated Design 3D model into a shop detailed fabrication model.	Digital manufacture
Estimate (5D)		Utilisation of digital models to provide a outputs or data connectivity to estimating packages in the form of a traditional Bill of Materials.	Digital validation
High level staging		Production of conceptual construction models utilising the provided 3D design to demonstrate construction methodology and overall staging to support the bid process.	Digital planning
Visualisations		Production of rendered still images or videos from the 3D model to support the bid process.	Digital review
Client requirements		Using both the digital model and geospatial data to aid understanding and compliance of and to the clients' requirements.	Digital validation
Buildability		Development of construction models based on the provided Design 3D model to enable studies and review of certain elements in respect to the actual construction process. For example, this could be the installation of a new water main that requires complex temporary works.	Digital planning
Traffic disruption		Visualisation and testing of varying traffic management solutions incorporated with and against traffic modelling done as part of the design. This will extend through into temporary construction stages.	Digital planning
Program (4D)		Integration of the overall program into the Federated Model to provide the ability to visually simulate the program in order to fully test initial thinking.	Digital planning

DE use case area	Lifecycle stage	Description	Technology enabler
Existing utilities	Construction	The evolution of the process to ensure that a singular utility dataset now incorporating design data is used to aid excavation permits.	Digital survey
Feature survey		An update or capture of new areas of scope to provide the survey base for the construction phase of the project. As noted earlier this can now be done in conjunction with point cloud surveys.	Digital survey
As-built point cloud survey		Utilisation of point cloud laser scanning to capture the as-built condition as construction work progresses.	Digital survey
Existing conditions		Development of an existing conditions site model to be included in the overall federated model and to provide a basis for any further temporary earthworks modelling or data capture throughout the construction phase.	Site modelling
Temporary works		Development of accurate 3D models of major temporary works including earthworks, propping, structural platforms etc to aid in the constructability, staging and model validation.	Digital planning
Equipment logistics		Introduction of actual site equipment and movement to improve overall 4D capability. This can range from crane movements and swing paths right down to animation of haulage etc to test and show the delivery of large equipment into the site can be done safely.	Digital planning
Digital work packs		Digital work packs are as the term suggests a digital representation of all of the elements, and documents needed to plan, construct and handover an individual work pack.	Quality
Digital method statements		Similar in nature to 4D or staging a digital method statement is used to describe a particular element of work in essential detail to ensure the safe working methods are achievable. Use of the model to both test and document this extremely valuable.	Safety
Interface management		Through a combination of the Federated model and GIS platform, interface management can be greatly improved both in respect to communication and clarity of interfaces to actual validation of them.	Digital coordination
Construction safety		Utilisation of the Federated model in a construction state to safely examine and spot check safety methodologies, temporary works, scaffolding. Automated checks for thing such as falling from heights are also possible.	Safety
Cranage strategies		Introduction of actual site equipment and movement to improve overall 4D capability. This can range from crane movements and swing paths.	Digital planning

DE use case area	Lifecycle stage	Description	Technology enabler
Logistics	Construction	Through a combination of integrated project controls, planning and model data, a digital logistics strategy can be adopted to better track and manage vehicle delivery, site access and component tracking.	Digital planning
Cost control		Utilisation of digital models to support the overall cost control process defined through project controls.	Data integration
Environmental tracking		Adoption of GIS to support the overall management, tracking and adherence to all environmental requirements.	Data integration
Construction progress		Planned versus Actual. Validation of work as completed on site, captured digitally such it can be re-introduced alongside the base program to track progress and present visually.	Digital planning
Materials tracking		Use of drone capture or lidar can support the mean so tracking for example earthworks or material movement on a linear site.	Drone capture/ Lidar survey
Component tracking		Use of embedded RFID tags or QR Labels aligned with individual component tagging protocols can provide and overall visualisation of each individual components journey from design through fabrication into installation and handover.	RFIDs
Quality due process		Integrated data and systems enable the ability to track progress and close out of all quality and safety procedures which can be presented through interactive dashboard reports.	Data integration /dashboarding
As-built point cloud survey	Handover	Use of Point Cloud Laser scanning to capture as-built conditions progressively as elements are constructed. Technology can be scaled to suit requirements where for example lidar capability in phone technology can provide sufficient accuracy and ease of capture for certain elements.	Digital capture
As-built survey		Traditional capture of as-built survey using total station and poles to do spot spick capture as point and line elements in as-built survey files. Advance in technology now enable extraction of features from point cloud surveys which can improve program and provide multiple benefits.	Digital capture
WAE models and data		Development and progression of discipline specific models through fabrication as required and then post validated against Point cloud survey to provide a combined file represented work as executed.	Digital capture /digital modelling
As-built models and data		Development of Issued For Construction design models into As-Built Record models where any changes in design through construction are captured and updated within the model.	Digital modelling

DE use case area	Lifecycle stage	Description	Technology enabler
As-built 2D drawings	Handover	Traditional capture of changes to design through construction captured as red-line mark ups and updated in drawings to form As-Built drawing documentation. This process can be digitally enhanced by use of a collaborative platforms that enable capture of comments in the field to be transferred directly to design teams for progressive update.	Digital collaboration
Models links to as-built drawings		Creation of hyperlinks from Federated model elements to individual design drawings. This can de used through design, construction and on into As-Built as URL's for drawings should remain constant.	Digital record modelling
Systems testing		Progressive capture of testing and commissioning records associated to individual equipment and systems within a connected/integrated data set. This supports the progressive and packaged handover of data to the operator.	Asset data capture
Progressive completions		Progressive capture of relevant / required associated to individual equipment and systems within a connected/integrated data set. This supports the progressive and packaged handover of data to the operator.	Digital validation
Progressive assurance		Progressive capture of evidence to support the validation and close out of client requirements. This can be supported through an integrated data strategy and combining specific platforms such as Doors NG as part of the overall approach.	Digital validation
As-built tolerance validation		Validation of As-Built components against design information using a combination of Point Cloud survey and Federated Models to run tolerance analysis	Digital validation
Digital asset data validation		Automated checking of data completion and validation within the federated model to ensure that models and data are being delivered in line with the project's requirements. This can be done in conjunction or as part of a progressive completions approach.	Asset data capture
Model and asset data integrations	Operations	Embedment of specific asset data and naming protocols within the overall Federated Model to support data integration or direct transfer of data into operations-based management systems.	Asset data capture
Operation safety testing and scenarios		Use of the Federated model to aid in the early access to acceptance testing for operation purposes. Use of Virtual Reality technology to provide access to proposed design can enable capture of comments. This can be further enhanced through specific testing scenario's embedded with in a VR experience.	Virtual reality
CAFM model integration		Progressive transfer or direct integration of Asset model and associated data and documents into the agreed CAFM system. This provides day one readiness in respect to capture of all Asset data and requirements to support operational readiness.	Asset data capture

APPENDIX C:
CASE STUDY BENEFITS CAPTURE GUIDANCE

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CASE STUDY BENEFITS CAPTURE GUIDANCE

The value of case studies and benefits capture

Creating effective case studies that showcase the value of implementing DE is important to capture and share lessons learnt, demonstrate the return on investment and support continuous improvement and investment in DE capability. Additionally, regularly updating case studies will help keep them relevant and demonstrate how the DE approaches and solutions continue to provide value to agencies and projects. When done well, case studies can have a significant impact on an agency's growth and performance so is a worthwhile investment of time and resources towards achieving this.

This guide has identified some key needs for industry in capturing the value from implementing DE, as outlined in Chapter 1 of this guide, which include:

- Development of data collection and metrics system to demonstrate benefits and justification of BIM/DE in Australia.
- Need to progress national historical outcomes from the use of BIM/DE:
  - Producing more reliable cost estimates is vital. Current cost estimation guidance is inconsistent, omits valuable tools, and can't draw on previous projects because we don't collect the data. (Grattan Institute report on estimates of transport infrastructure., Report No.2016–13, Oct 2016.).
- Lessons can be learned from examples of not collecting good historical information:
  - Agencies must collect information on past projects to grow and improve in their adoption and implementation of DE.
  - Cost estimation and risk management must allow for unforeseen as well as known risks, and the best way to prepare for unforeseen events is to learn from history.
  - It is essential to collect and publish Australian data on historical project outcomes, to allow better risk measurement and more informed and transparent decision-making.
- Compare project types to enable meaningful comparison.

Developing effective case studies and capturing benefits involves several key steps:

1. **Define the project and parameters:** The initial step is selecting a project, pilot or initiative that demonstrates the effectiveness and value of implementing DE.
2. **Research and data collection:** Conduct in-depth research to gather all the relevant data about the subject. This could involve interviews, observation, and reviewing documents or reports and ideally data aligned to a consistent agency or industry framework.
3. **Case study creation:** A case study should include an introduction, detail the problem, the solution provided, and the results achieved. Using data, graphics and visuals can enhance its impact.
4. **Review and edit:** Review and edit the case study for clarity, coherence, and accuracy. Ensure that it aligns with your agency DE strategy and project objectives.
5. **Publish and promote:** Once the case study is refined and has the required approvals, it is important to share it with other projects and teams within an agency, including suppliers to provide clear examples of DE implementation.
6. **Capture benefits and measure impact:** It is essential to capture the benefits DE delivered. You can measure impact through metrics like increased revenue, improved productivity, or stakeholder satisfaction scores.
7. **Update regularly:** It is vital to keep case studies up-to-date as an agency's DE approach and maturity capability to continue to communicate new approaches or benefits.

In summary, case studies are a valuable tool that can help capture and communicate the real impact of your DE strategy implementation and support continuous improvement and uptake across both projects and the wider industry.

Identifying the problem

Significant investment is underway into BIM on government projects in Australia and New Zealand. In response to this, many states and government agencies are continuing to develop their DE strategy and implementation within and between agencies, across projects and with their supply chain. It is anticipated this continued drive for a more data-driven collaborative DE approach, will lead to future influence on funding of projects and business cases. It is also anticipated that reliance on the return on investment from DE will increase significantly, placing further importance on DE's effectiveness.

The calculation of the return on investment of DE relies on data on its benefits. A data collection system is needed to be applied to a range of projects over time. The importance of establishing systems to collect important historical project data in key areas, and the problems it can cause if it is not done, is demonstrated by the recent national issue of poor data collection of major projects cost. The Grattan Institute reviewed national cost overruns in transport infrastructure delivery and reported: "Current cost estimation guidance is inconsistent, omits valuable tools, and can't draw on previous projects because we don't collect the data." (Report: Cost overruns in transport infrastructure, Australia, Grattan Institute, October 2016) Data collection of DE benefits needs to commence promptly under a structured system. The collection of benefits data should be processed using metrics and reported regularly to provide more consistent and meaningful trends and insights into the value of DE implementation.

Government delivery agencies and their major project teams are increasingly specifying DE. (The specifications should be written to target project specific areas that improve efficiency and value in delivery and asset management. However, there are significant challenges to quantifying the benefits of DE through investment early in the lifecycle with the understanding that this leads to returns later. There are challenges for organisations to demonstrate this early investment approach is correct. It requires a different funding profile than the common approach.

The lack of data on quantifiable benefits is causing problems in gaining approval at an organisational level and in general from funders of projects, resulting in broad level delays to BIM take-up. There is a need to establish a system to collect national historical data on DE benefits along with comparable and standardised metrics to provide easily understood reporting. This will support project teams, whole agencies, and whole jurisdictions' decision-making. (It is also noted that there is the common issue of the delivery stage divisions being requested to fund DE asset data information for the benefit of asset divisions. This is an issue that needs to be brokered at the organisation level and not by negotiation between divisions).

Demonstrating the benefits of DE is not simply done by collecting feedback data from projects. It needs to rely on meaningful comparisons between projects. Further, by only comparing a DE project to another we still can't achieve a meaningful comparison of benefits because of the vast differences in project characteristics and maturity levels of the respective parties and systems. To overcome these issues, a data collection system needs companion information on project categories and ratings of DE maturity such as project type, purpose, size, engineering disciplines, contractor maturity and delivery systems. Historical information through a structured system will enable tracking of benefits as BIM implementation occurs. The historical DE information will also enable effective benchmarking and comparison.

The demonstration of return on investment and the tracking of project costs of DE is within the context of a significant increase in expenditure on infrastructure in Australasia.

This increase in spending is placing demands on project managers in the areas of project controls and detailed justification of costs. Like other cost items, DE implementation is subject to detailed scrutiny and justification. However, DE investment is unique in its highly focused method of justification through early investment. This presents a challenge for project teams to justify BIM and to overcome a long-standing mindset of up-front cost.

The measurement of DE benefits is needed, commencing at the strategic options stage through to handover to asset management groups.

Clarify the need

DE can only be justified if it is approached on a proper return on investment basis. This includes not only the area of justification of the broad concept of DE but also the details like the scope, specification and contracts. To support the detailed justification areas, the needs of the end users must be properly understood. This will require consultation and checking of processes. By clarifying the need, we can identify the areas that BIM will provide the most value. By maximising these value areas, the most benefit will be gained.

The method to clarify the need and value, and to develop DE specifications, requires major projects' experience. This means the system development team will include members who are experienced in major project delivery and maintenance. These persons have worked on sites and managed contracts and have developed a proper understanding of the interaction of design and its physical execution. Some examples of obtaining end-user needs are given below:

- **Request for tender process:**
  - Consult with end users to justify DE implementation during the design and construction stages.
- **Quality assurance:**
  - Assurance is needed for the DE data structure and quality to be delivered to the specified information requirements in a form that is compatible with client systems.
  - Construction stage contract management needs easy access to digital quality records.
- **Design:**
  - DE designs need to support practical methods to address construction risks including the investigation and analysis of complex issues. For example, the temporary excavation and clearance of a pile cap to be executed next to traffic and pedestrians.
  - A core responsibility of some agency road project teams is to ensure the safe and efficient operation of the network in temporary traffic arrangements. The staging of projects at the broad and detailed levels is to be developed in 3D.
- **Project management:**
  - An intelligent project model is needed for an appropriate level of information needed for the management of the project, construction contract and future modification.
  - Easily understood and prompt access to information is required.
- **Construction:**
  - The model information from the design stage needs continual updating to an appropriate level of information needed during construction.
  - The model is progressively updated for the handover of an as-constructed model and works as executed information.

- Asset data and operation:
  - Handover data is specified in the asset information requirements (AIR).
  - Before the AIR details are finalised for the request for tender, it needs to be tested against the organisation's asset management system through confirmation with asset owners and facility managers.

Development of a system

Agencies need to develop a system of data collection of DE benefits to enable benefits measurement and meaningful comparison of projects. The analysis of DE benefits should be captured and monitored regularly to support the use of business intelligence.

A defined DE benefits system will provide meaningful comparison, but it also respects the confidentiality of government agencies in their management of contracts and public funds. Where possible, a system should be developed to maximise the use of publicly available information. This is also combined with relative changes in contract performance rather than absolute changes that are generally confidential (e.g., % changes in time and cost to the original contract requirements rather than actual cost increase from claims).

It should be recognised that there is an imperative to the timely commencement of the collection of historical DE benefits data.

Two valuable resources available to transport agencies to assist in capturing more quantitative data when developing case studies include SBEnrc's BIM Value Tool, hosted by Natspec and ABAB Guidance to Case Study metrics, which will be made available to industry alongside existing publications.

The following key steps outline some best practices that can help agencies develop more effective case studies:

- **Be specific and concrete:** Use specific numbers, data, and examples to make your case study more credible. This will also help key stakeholders understand the tangible benefits of your product or service.
- **Provide a call to action:** Use your case study as an opportunity to encourage decision-makers and leaders to act and explore new opportunities to implement DE and further the collective DE capability.
- **Focus on the outcome:** Rather than just showcasing features or capabilities, highlight the outcomes and benefits that your implementation of DE provided. This will help key stakeholders understand how your approach can directly impact their project or team.
- **Include visuals:** In addition to using visuals within the case study itself, consider creating a visual representation of the results achieved. This could be in the form of site photos, a process map, a graph, a chart, or an infographic.
- **Include challenges and obstacles:** Highlight any challenges or obstacles faced during the implementation of DE and how your approach overcame these challenges.
- **Track and analyse results:** Use tracking tools to measure the impact of your case studies against the project and DE strategy goals. This data can help refine approaches and create even more effective case studies in the future.

Capturing the benefits

Benefit capture in DE involves a systematic process to realise the potential advantages brought by more consistent and collaborative ways of working, data and digital technologies which includes:

1. **Requirement Analysis:** Identify the objectives and the associated needs of your project. Understanding what you aim to achieve with DE is the first step towards capturing its benefits.
2. **Solutions Assessment:** Evaluate alternate ways of working, available digital tools and technologies, and their applicability to your project. This involves understanding the capabilities of different processes, data and technologies and matching them with your identified needs.
3. **Implementation Planning:** Develop a strategy for adopting the chosen technologies. This includes planning for necessary infrastructure, training, and support systems.
4. **Execution and Monitoring:** Implement the technologies and monitor their usage and effectiveness. This also involves gathering user feedback and adjusting accordingly.
5. **Evaluation and Adjustment:** Assess the achieved benefits against the set objectives. Make necessary adjustments to the technology or its usage to enhance benefits capture.

Capturing benefits from DE is an iterative process, necessitating frequent reviews and adjustments to align with the evolving objectives and needs of the project. Additionally, it is crucial to involve all stakeholders throughout the process to ensure their buy-in and support for successful implementation.

Furthermore, benefit capture in DE goes beyond just implementing new technologies. It also involves utilising existing digital capabilities effectively and efficiently. This includes leveraging data analytics, automation, and collaboration tools to improve processes and decision-making. Effective benefit capture in DE requires a holistic approach, considering the alignment of goals, technology capabilities, implementation strategy, and continuous evaluation and adjustment. By following this systematic process, companies can harness the full potential of DE and drive success in their projects.

The role of metrics in information collection and reporting

Metrics are part of the process of gathering and reflecting data back to an agency in such a way as to manage issues and improve the business. Key Performance Indicators (KPIs) are key areas that determine the success of an agency and these need to be supported by measured data and metrics.

Some metrics may be a simple statistic and others may be a combination of data and information that gives further important insight. For example, comparison of design issues on site of projects using DE to other projects that do not have DE.

Data collection details for project teams

Australasian BIM benefits report elements and timeline

The system applies to projects starting at the strategic option stage:

- Strategic options. (alignment, location, outline)
- Concept. (general arrangement, footprint, environmental assessment and public consultation)
- Detailed design
- Construction
- Handover to asset management group.

The data collection and processing consist of three corresponding system and timeline elements:

1. Project registration. (This includes categories and ratings for meaningful comparison).
2. Metrics and survey
3. Processing and report.

Information is collected and recorded, which may include data across a number of categories as outlined in Table C.1.

Table C.1 – Data collection categories and property examples

Data collection category	Data collection properties	Data collection category	Data collection properties
Project registration	• Project title • Project number • Description • Purpose • Jurisdiction • Location (local government, street address, chainage) • Announced cost-total project estimate • Announced timing of construction. Include duration and completion month • Funding source (federal, state, other) • Client organisation (government agency, division) • Delivery organisation (government agency, division) • Project manager (name, email, mobile) • Coordinator person (at jurisdiction or agency level) and contact information (name, email, mobile)	**BIM/DE maturity assessment**	• The maturity information is required for meaningful comparison to include client, contactor, systems and specifications, planned and completed work • Client BIM/DE maturity • Contractor BIM/DE maturity • Specifications and system: Information management • Specifications and system: GIS • Specifications and system for Design contracts and Construction contracts level • Specifications and system: Asset management • Completed work: Information management • BIM/DE status of verified successful implementation: GIS • BIM/DE status of verified successful implementation: BIM/DE complete in design and construction • BIM/DE status of verified successful implementation: Asset management
		Execution on site	• Execution on site. Partnering survey
Project type and procurement	• Project generic type • Project cost range $ (publicly available information) • Project construction duration (years) • Construction delivery system • Engineering major construction disciplines. (This will include multiple disciplines) • Physical context and adjacent areas • Design contractor (or government agency) • Construction contractor • Asset maintenance contractor • Operator	**Construction productivity indicators**	• Construction productivity indicators: Qualitative measures • Construction productivity indicators: Quantitative measures
		Value for money of BIM and the project	• Value for money of BIM and the project (qualitative and quantitative) **Note:** ABAB provides templates to support the adoption of BIM/DE in Australia and continues to develop templates and guidance

Communicating the value

Supporting access to cumulative knowledge

In the realm of DE, the coherent communication of its value cannot be overstated. It is a field marked by constant evolution and complex functionality, wherein the appreciation of its value proposition becomes pivotal for its adoption. Case studies and data insights represent two formidable tools in this endeavour, functioning as demonstrable evidence of the efficacy and efficiencies made possible by DE. Case studies provide tangible examples of its successful application, offering a comprehensive overview of the process, the challenges faced, and the solutions implemented. Data insights, on the other hand, provide quantifiable metrics of success, illustrating the measurable benefits and improvements. Together, they form a persuasive narrative that underscores the crucial role of DE in modern business operations.

The use of case studies and data insights is especially important when communicating with non-technical stakeholders who may not be familiar with the intricacies of DE. These tools provide a concrete understanding of its impact, making it easier to convey the significance and potential benefits of investing in this field.

Moreover, both case studies and data insights also serve as valuable resources for companies looking to implement DE in their operations. By studying successful case studies and analysing data insights, agencies can gain valuable insights into best practices and potential pitfalls to avoid. This proactive approach not only increases the chances of a successful implementation but also saves time and resources by learning from the experiences of others.

In summary, case studies and data insights are crucial components in effectively communicating the value of DE. They provide tangible evidence of its impact, aid in understanding and adoption, and serve as valuable resources for agencies looking to implement this continuously evolving field in their operations.

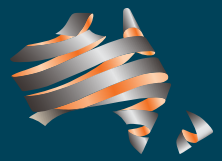
As the industry internationally continues to embrace digital transformation, the value of DE must be effectively communicated and shared. To further the knowledge, capability and ultimately successful implementation of DE.

Driving continuous industry improvement

It is important to continually update and create new case studies and data insights to keep up with the rapid evolution of DE. As technology advances and new techniques emerge, it is crucial to showcase these advancements through real-world examples. This not only highlights the continuous progress made in this field but also inspires companies looking to innovate and stay ahead of the curve.

Furthermore, as DE becomes more widely adopted, there will be a growing need for standardised metrics and benchmarks to measure success. Case studies and data insights can play a key role in establishing these standards, providing a common language and framework for agencies to evaluate their digital transformation efforts. This not only helps in better understanding the impact of DE but also enables agencies to set realistic goals and track progress.

Recommended further reading in relation to harmonising the approach to capturing benefits in relation to DE includes The Australasian BIM Benefits Reporting (ABBR), Guide to Information Collection by The Australian BIM Advisory Board (ABAB).



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