UNLOCKING DIGITAL TWINS IN CANADA

Mapping the Way to Digital Transformation in Infrastructure

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ABOUT THE FUTURE OF INFRASTRUCTURE GROUP

The Future of Infrastructure Group brings together industry leaders in the sector to provide a positive, and coherent voice to help governments across Canada deliver the best value from infrastructure investment. This group discusses and shares their expertise on best approaches to prioritizing, planning, procuring, constructing, maintaining, and operating infrastructure.

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Author: John Allen, Future of Infrastructure Group and Global Public Affairs

FIG Digital and Data Chairs:
Lindsay English, Arup
Carol McClellan, Arup

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FIG Members:

AECOM ARCADIS ARUP AtkinsRéalis Bentley

Colliers Project Leaders GRAHAM Liberty Mutual INSURANCE POMERLEAU WSP

GLOBAL PUBLIC AFFAIRS FROM INSIGHT TO IMPACT

APPROACH

The Future of Infrastructure Group's digital working group undertook a series of activities to pull together this paper over the course of 2025. This included a survey with input from 15 experts in the sector reviewing current state of play, barriers, and best practices. This was augmented by further interviews with FIG digital and data working group members to share specific insights.

This was followed by workshops in Toronto and Vancouver with a total of 112 participants from industry, government, and academia working across a range of projects right across Canada.

We were fortunate to hear from a range of leading initiatives, notably the work of the UK's National Digital Twin Programme from the Programme Director Alexandra Luck and insights from Simon Evans from Arup around best practices globally. We also heard about government approaches in Ontario from Infrastructure Ontario, and federally from the National Research Council.

We also heard from digital twins deployed across Canada including Eglinton Crosstown West Extension, City of Burnaby, Fraser Health, Ciment Quebec, and YVR.

The report presents the findings from the workshop, surveys, interviews and case studies, as well as delving into international best practices to lay out a path forward for Canada. This work will provide a launchpad to look at some specific areas of government policy that could help unlock the potential of digital as a catalyst for change overall.

FUTURE OF INFRASTRUCTURE GROUP - DIGITAL & DATA WORKING GROUP

FIG Digital and Data Chairs:
Lindsay English, Arup
Carol McClellan, Arup

Members:
Peter Reinecke, Aecom
Lucy Casacia, Arcadis
Riccardo Cosentino, AtkinsRealis
Meaghan Swinkels, AWS
Taylor Briggs, AWS
Daniel Galle, Bentley Systems
Rowan Mills, Colliers Project Leaders
Daniel Meissner, EllisDon
Veronika Utkina, Graham Construction
Karla Firth, Graham Construction
Amber Sandhu, Liberty Mutual
Yuri Bartzis, Pomerleau
Keith Anthon, WSP

Thanks to Arup, AWS and Bentley Systems for hosting workshops and roundtables. Thank you to the BC Construction Roundtable for their support in gathering market insights. Thank you also to Jenny Zhou from Arup and Ellen Chin from Global Public Affairs for all their support around the report.

ARUP aws Bentley

A

SUMMARY

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DIGITAL =
CATAYLST FOR CHANGE

Successfully delivering infrastructure is a hugely complex task but the need for continued investment is critical to meeting Canada's overall ambitions. The level of investment currently planned or underway is at levels rarely seen in Canadian history, but this has been accompanied by a challenging environment for project delivery that has seen project delays and cost overruns, as well as overall cost inflation as projects get bigger and more complicated. Digital technology provides a platform to enable transformation of the sector.

Changes are happening quickly, and Canada is on the verge of a major shift in how infrastructure is planned, delivered, and maintained with the greater use of data and digital tools. Overall change is overdue as the sector is among the least digitized, spending less than one percent on revenues on information technology, less than one third of what is typically spent in the automotive or aerospace sectors. At the same time Canadian construction leaders recognize the need to invest with 9 in 10 respondents to a Canadian Construction Association survey stating the sector needs to embrace advanced technologies to address sector challenges, notably skills and labour gaps.

The benefits of digital transformation are clear. Research by McKinsey estimated that leveraging digital twins across planning and delivery of infrastructure into operations promises can bring improve capital and operational efficiency by 20-30%. There are numerous benefits along the way from moving paper-based records and processes into the digital space with the volume of information shared, and the number of stakeholders involved in each project.

A more structured, organized approach to data built on common international standards is the foundation for change. It unlocks a range of other digital tools and process improvements that could help provide greater value for infrastructure investment, save on operating costs, and deliver better services for end users. Along with digital twins, technologies such as Artificial Intelligence, Internet of Things, drones, and offsite manufacturing could all play a greater role if there is a solid foundation of quality, standardized data.

9 in 10

Construction leaders in Canada state the sector needs to embrace advanced technology to address sector challenges, notably skills and labour shortages
Canadian Construction Association, 2025

20-30%

Improvement in capital and operations efficiency with the use of Digital Twins
McKinsey, 2025

2007

Finland made Building Information Modelling mandatory for state funded projects in 2007

$9

Return on investment for every $1 spent on digital twins for infrastructure
KPMG, 2023

95.5%

Of all data collected by engineering and construction industry goes unused
Autodesk, 2025

What is a Digital Twin?

One of the biggest questions around digital twins is around the definition. There are many differing notions of what it is, and what it is not. The truth is that there is a fairly broad definition that various key government bodies have aligned on that it is ultimately a methodology, rather than a technology, and there are different types depending on user need.

Definition used by UK National Digital Twin Program: A digital twin is a virtual model of an object, a system, or a process. It is connected to its real-world counterpart by a 2-way flow of right-time data, meaning it mimics it in all aspects.

Types of digital twin:

- **Component twins:** Basic representing a single part of a larger system, eg a heating unit in a building.
- **Asset twins:** Combination of component twins that form a complete product, such as a heating and cooling system for a building.
- **System twins:** Combine multiple asset twins to model how different products or systems interact, like a building complex eg a hospital.
- **Process twins:** The broadest type represents entire processes or a whole organization, including how systems and people work together, like an entire city or country.

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ROADMAP
SUMMARY OF RECOMMENDATIONS

If digital twins are the destination, there is significant work that needs to go into creating the foundations to enable them to make a truly positive impact. In the FIG workshops Digital Twins were consistently described as a methodology over a technology. As such the change required is as much human as technological. Based on the discussions and overall feedback five main areas of focus emerged which align with international best practices.

Clear Direction

A clear direction overall laid out in a plan released to the market with timelines for adoption and a clear BIM mandate.

Quebec BIM mandate saw

250%

increase in projects using BIM between 2021 and 2025

SQI, 2025

Empowered Leadership

Clear leadership to drive a digital-by-default mandate across government projects, fast approvals for new technology, digital expertise and training across roles, consistent processes, and legal certainty.

Success of digital transformations goes from 30% to

80%

when 6 factors are prioritized: clear strategy/goals, leader commitment, talent, agile governance, tracking progress, modular technology/data

BCG, 2022

Enabled Market

Timelines to invest, train and adapt to digital reality, industry-government advisory boards to develop processes and sector training, and incentives to invest and drive early adoption.

Companies classified as data leaders see a

50%

increase in average profit growth rate each year compared with beginners

Autodesk, 2025

1 **Creating a Canadian digital infrastructure policy** – Canada should develop a clear national data and digital twin strategy for infrastructure and construction based on solving real world issues. This should be in collaboration with provinces, municipalities, and industry to set a framework for digital twins and digital transformation overall. This must include clearly delegated leadership and lines of responsibility, set milestones, and mechanisms to support adoption including funding, timelines, available expertise, and tools and processes that ensure digital is embedded in planning through to operations.

2 **Enable early adopters and momentum** – Identify high impact pilots in a range of sectors aligned with key challenges faced within the sector overall to showcase tangible benefits and share learnings. Leverage funding, visibility, and competitions to drive early adoption at the department, agency, municipal and company level.

3 **Building a strong data foundation** – There needs to be consistent open standards built around ISO 19650 and other key standards listed adopted across Canada with staged BIM mandates associated to receiving funding starting with the largest projects. Infrastructure data should be shareable and digital-by-default and accessible via the cloud with guidance on what data is typically needed and adds value.

4 **Preparing the market** – Both public sector and private sector needs adequate training and support to ensure that people are prepared at three priority levels: strategic (policy and agency leaders), operational (process and procurement), and technical (BIM, data, Digital Twin). There should be skills assessments for the market and a government-industry advisory board including strategic and operational expertise to guide rollout.

5 **Enabling legal and regulatory innovation** – Update policies and contracts to enable data sharing and reuse beyond project close-out and across organizations. Require regulatory and permitting approvals to be digital-by-default, with timelines for a single digital platform for reviews and approvals linked to project data and digital twins. Address any lingering legal barriers to sharing data by providing clarity and restricting any carveouts.

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ROADMAP
FOR DELIVERING TRANSFORMATION

Accountability

Transformation

1 Empowered Leadership Appointed

First step should be to have an organization tasked with developing a plan and driving transformation

Clear Mandate	Agile Process	Access to Resources
Cross-government authority, objectives, and timelines	Internal governance and processes that enable change	Change management and technical expertise, funding

2 Issues to Address

Critical piece of where digital can act as a catalyst for improvement to shape the approach

People	Information	Time
Fostering trust, collaboration, and problem solving	Informed decision-making and shared visibility of progress	Focus on schedules, early action and timely decisions
What areas are causing most friction and disputes?	Where are there gaps in visibility causing issues?	What takes the most time or is most unpredictable?

Direction

3 Digital Strategy

A clear direction with timelines, underpinned by consistent standards for data collection and use and which tools would enable transformation

Priorities	Requirements	Supports
Issues to address, goals to achieve, and high impact opportunities	Expectations and timing around digital delivery and a BIM mandate	Training and funding, tools and resources, as well as early adoption pathways

Data

Comparable	Shareable	Reliable	Secure	Ethical
Based on consistent standards	Accessible to all who require it	Based on good quality input	Meets cybersecurity standards	Respects privacy and adds societal value

Tech

Foundational	Collecting	Processing	Visualizing
BIM, Digital Twin	Drones, IoT sensors, image capture, LIDAR	AI, Analytics, modeling	Digital Twin, virtual reality

Delivery

4 Implementation

Top down and bottom up, to enable organizations to move forward in as frictionless way as possible

Barriers	Visibility	Early Progress	Wider Access
Addressing any legal or procedural barriers	Reporting on progress, sharing lessons, profiling success	Incentives, visibility and tools to enable early adoption	Training and funding to support smaller organizations

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LIST OF RECOMMENDATIONS

The full list of recommendations is listed below and covers organizational, people, and technical aspects. Over and over again the challenge of overcoming organizational barriers to change and providing adequate technical and leadership training were raised as being the most difficult to get right.

1 Creating a Canadian Data and Digital Twin Policy

Clear Digital Strategy

1 Develop an overall digital strategy mapping out transformation, goals, and timelines
2 Set out a timeline for a national BIM Mandate for federally funded projects and provincially
3 Set a requirement that infrastructure processes are digital by-default

Delegated and Empowered Leadership and Expertise

4 Appoint a designated leader with cross-government responsibility for transformation
5 Create a dedicated team with experts to work in coordination with other ministries
6 Have a clear ministry or agency responsible for enabling the transformation

Clear Process, Procurement, and Contracting Approach

7 Create overall digital guidance that is embedded in overarching processes
8 Develop a tool to support decision making for the right fit for incorporating digital
9 Leverage contracting strategies, provide language and budgets to realize benefits

2 Enabling Early Adopters & Gaining Momentum

10 An audit to identify challenges and high impact opportunities for digital
11 Set transparent milestones that enable incremental benefits
12 Set up a demonstrator program to drive adoption, shares results and refine approach
13 Establish competitions with funding and visibility to enable grassroots adoption
14 Track tangible impacts to demonstrate benefits in key areas

3 Building a Strong Data Foundation

Data Structure

15 Outline the core open standards that are required to drive consistency
16 Provide quality assurance through standards and processes
17 Provide guidance on information requirements for different types of projects

Data Availability

18 Host infrastructure data in the cloud to allow for sharing
19 Create a common data environment to drive consistency
20 Introduce an information exchange standard
21 Develop contract language ensuring that data can be shared by default

Data Skills

22 Undertake an audit of skills gaps for digital in government and across the sector

Data Ethics

23 Provide clear principles of use that cover privacy, ethics and security
24 Create robust policies to safeguard privacy and security but enable progress

4 Preparing the Market

25 Undertake a concerted program of engagement and awareness building
26 Require early market engagement around data requirements and market experience
27 Ensure all documents use plain language that is more widely accessible
28 Provide training programs from strategic to technical levels
29 Develop supplier digital assessments to ensure they are adequately prepared
30 Provide funding opportunities for training and investment in digital

5 Enabling Legal and Regulatory Environment

Data Requirements

31 Clear policy direction that sets the expectation around data in the infrastructure sector
32 Legislation to address any specific barriers to data sharing
33 Require established open international standards
34 Develop regulatory sandboxes to test technology and innovations

Project Related Regulatory Requirements

35 Map regulatory and permitting requirements, and make that process digital-by-default
36 Provide a single platform for regulatory submittals

B

OPPORTUNITY & BENEFITS

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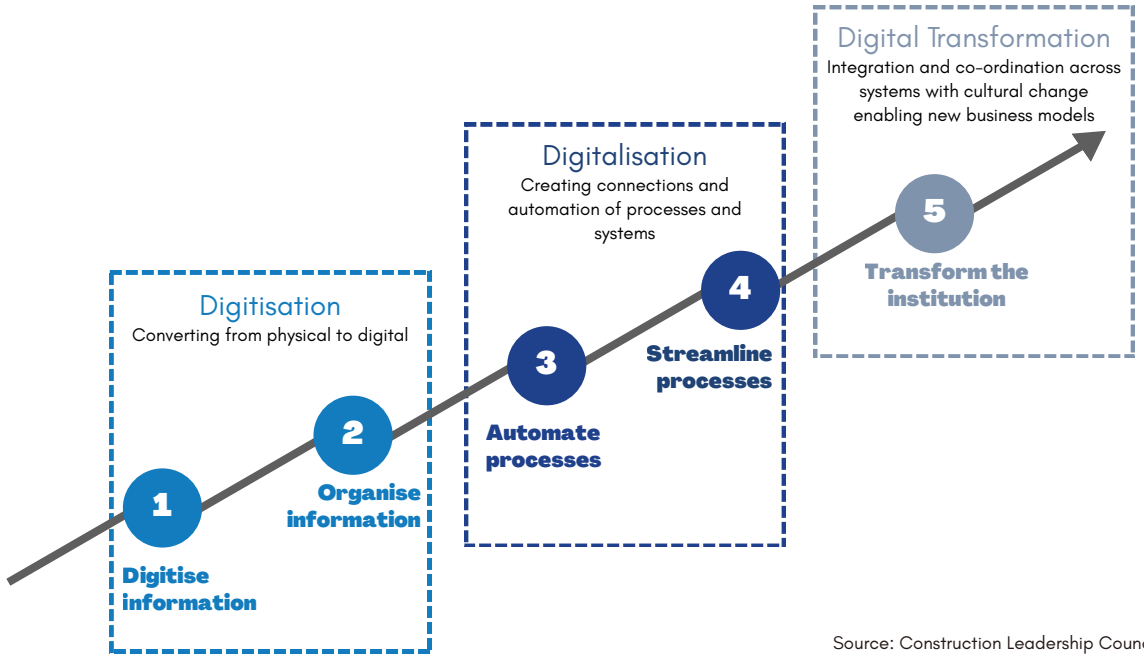
TRANSFORMATION
DIGITAL AS A CATALYST

"Some estimates suggest that large infrastructure projects may currently produce, on average, 130 million emails, 55 million documents and 12 million work orders."
WEF, 2025

Incremental benefits are unlocked through the journey to digital twins and beyond. From digitizing documents, to organizing data and adopting building information modeling, to digital twins and leveraging AI the potential benefits for the infrastructure sector are huge. This starts with moving documents online and creating more structure and organization, to leveraging technology to be a true catalyst for organizational change.



Source: Construction Leadership Council

Technology in the Sector

There is a variety of technologies ready to make a big impact in the infrastructure sector, but their success will be built on effective processes, people, and common standards.

Virtual Modelling
provides a digital version of an asset or group of assets via BIM, digital twin

Virtual Reality
provides a digital overlay and simulation of designs for better vizualization

Drones
used to capture images, monitor progress or undertake inspections

3D Printing
components or structures created from digital models

Automation
machines that can carry out tasks like moving heavy materials

Wearable Tech
helmets or watches that can be used to monitor safety or track location

LIDAR
uses lasers to create precise 3D maps and models

Internet of Things
sensors on site that collect and transmit data to track progress or safety

Telematics
uses GPS, sensors and analytics to locate materials, enhance safety

Data Analytics
process to analyze, clean and interpret data to find trends

Collaboration
platforms and tools to enable seamless communications

Planning Tools
tools to manage progress, allocate resources, manage workflows

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BENEFITS
OF DIGITAL IN INFRASTRUCTURE

Planning, designing, and delivering infrastructure projects is incredibly complex with multiple stakeholders involved, networks of companies providing services and materials, and a range of external factors to consider. The use of technology and data provides better visibility and insight that can have a range of benefits at a project level, and more widely. This can be a catalyst to address many of the challenges facing the sector if done in conjunction with an overhaul of processes and building capacity across the sector.

Project Benefits

20-30%
cost savings over capital and operations of digital twins
McKinsey, 2025

Lower overall costs - With earlier insights on potential issues and simulations, enhanced project management and communication, reduced waste, and better end designs, digital twins improve public sector capital and operational efficiency on large-scale public infrastructure projects by 20 to 30%. The use of advanced data analytics and AI could save as much as 10-15% on construction costs.

7x
more design errors identified from using BIM
EC3, 2023

Lower project risks - Better use of digital tools enhances information gathering and communication, reduces human error from replicating or re-entering data, and enables greater use of simulation tools to identify and manage risk. The use of BIM alone has been shown to reduce the number of design errors with 7 times more identified among BIM users.

1:6
cost benefit from every £1 invested in information management delivers £6 worth of benefits
CDBB, 2021

Better decision-making - With one single source of truth, it provides an instant snapshot of project status, ability to analyse vast amounts of data, and a data-driven basis for making decisions. At a project level every £1 invested in information management potentially delivers up to £6 in labour productivity improvements.

20%
faster completion of projects leveraging BIM alone
Springer, 2025

Faster project completion - Through better planning and scheduling, the ability to overlap approvals and automate some routine activities, and early risk detection and informed decision making, digital twins can significantly reduce project timelines. Using BIM alone has been shown to deliver 20% faster completion of projects.

14-30%
reduction in lifecycle carbon emissions from using BIM
JCP, 2023

Reduced emissions and waste - Through a combination of optimized design, material selection, less waste, smarter urban planning, and optimized operations and maintenance, using BIM has yielded 5-15% reductions in carbon emissions.

3-6%
cost reductions through value chain digital twins
BCG, 2024

Supply chain optimization - Better coordination across the network of suppliers improves project outcomes, reduces risk, and helps proactively anticipate issues. It provides end-to-end visibility across complex networks of subcontractors and suppliers.

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The use of data up front has benefits across the lifecycle of infrastructure which can account for up to 80% of total costs of the asset through operations and maintenance costs. Beyond direct benefits around projects, those benefits extrapolate in a connected environment where linkages and trends can be identified.

Operations & Maintenance Benefits

16%

difference in academic achievement linked to classroom design

University of Salford, 2015

Better project outcomes – Using digital twins helps to ensure that the end state of a project is a focus form the start, enabling better designs and input from key end users. This can help to drive improvements in areas such as recovery of patients, student achievement, or reducing travel times and accidents for commuters.

up to 8 km

nurses can walk on average per shift

Hospital News, 2025

More efficient operations – Considering how employees will use facilities to provide services can drive significant time savings and help improve service quality and retention. For example, nurses could walk up to 8km on a shift that could be reduced with smart layouts.

30%

reduction in train breakdowns from Network Rail leveraging data and twins

International Union of Railways, 2024

More reliable assets – Using digital twins during operations helps identify issues early, or even predict when they could happen and schedule maintenance in advance. This predictive maintenance can significantly reduce costs and also reduce downtime of operations, making services more reliable.

20-40%

extensions in lifespan from predictive maintenance

Nucleus, 2023

Infrastructure lasts for longer – Early insights in planning can design buildings and assets that are easier to manage and more resilient. Smarter, predictive maintenance also significantly extends the life of the infrastructure.

40%

opportunity around reducing total cost by using lifecycle management and data

Woolpert, 2025

Reduced running costs – early insights in planning can design buildings and assets that are easier to manage and run and more resilient. Twins can be used to provide a reliable understanding of the current status of the asset and where to focus repairs, as well as providing real-time analysis that can make maintenance predictive.

Planning Benefits

400

datasets integrated to guide joined up planning for Adelaide

Arup, 2025

Better communities – by mapping the natural and built environment on an interconnected system, this enables planners to better link transit, utilities and public service amenities with the needs of the local population. This helps identify gaps and improve quality of life.

30%

reduction in sewer overflows in Sao Paulo

Institute for Sustainable Infrastructure, 2025

Environmental benefits – the ability to connect built and natural environments enables better vizualization of impacts and resilience to plan communities more effectively using modeling and simulations. For example, by mapping water runoff and testing more cost effective solutions.

50%

cut in constructon permitting time

KPMG, 2024

More effective permitting – There is evidence to show approvals and permitting times can be cut in half using digital twins. As well as the ability to integrate the permitting process into digital models, there is an ability to provide data-driven mitigation to reassure local communities.

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STATUS
AND POSSIBILITIES OF DIGITAL

Technology presents an opportunity at every stage of infrastructure lifecycles enabling better designs, more efficient delivery, and reduced operating costs. The foundation for digital technology having an impact is to have a consistent standards. The core standard for the built environment sector is ISO 19650, or the Building Information Modeling standard. Across the world, countries have been adopting BIM mandates to accelerate adoption of digital technologies, providing a clear direction to the market to accelerate adoption.

Based on previous FIG research, only Quebec had published a plan for driving digital adoption in the construction.

- **Quebec** - offers the most comprehensive approach with a BIM Roadmap released in 2021 from the Société québécoise des infrastructures.
- **Alberta** - there is a policy to encourage the use of digital tools with a series of resources to help owners incorporate tools in delivery.
- **Federal** - the federal government introduced the Construction Sector Digitalization and Productivity Challenge Program under the National Research Council which has been leading federal efforts.

BIM Mandates Around the World

Digital Twin Leadership

National Digital Twin Programme

The UK launched their programme in 2018 to create an ecosystem of interconnected digital twins. It has a focus on creating the right policy environment and an Information Management Framework. The goal is to improve decision-making for the built and natural enviuronments.

Virtual Singapore

Singapore integrated a digital twin into its Smart Nation initiative and was first launched back in 2014 and completed in 2022. It represents the first national scale digital twin and serves as a platform for various government agencies for urban planning, traffic management, asset management, disaster management and construction.

Ontario Digital Twin Pilot

The provincial government announced a digital twin pilot involving three projects in 2024, as well as exploring the potential for underground utility mapping. The goal is to use findings to modernize public infrastructure delivery, reduce project delays and cost overruns, and improve safety and efficiency throughout asset lifecycles.

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DIGITAL TWINS IN CANADA

The primary question around data, technology and digital twins is, "what is it trying to solve?" Governments across Canada are making huge investments to meet the needs of a growing population, support economic growth, and to maintain existing assets in a state of good repair. As investments have increased, the sector has experienced significant cost inflation, challenges around project delivery, and a labour and skills crunch. Data and technology provide a window to root causes, as well as a catalyst for transformation if implemented as part of a wider program of change.

Challenges in the Sector

Scale
of infrastructure ambition

Inflation
across infrastructure sector

Productivity
lagging other sectors

Repair
backlog of existing assets

Labour
and skills shortages

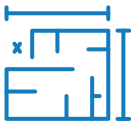
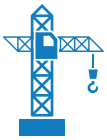
Risk
of delays and cost overruns

What Data Provides

 Better project visibility and communication	 Real-time collaboration across partners	 Faster, data-driven decision making	 Ability to identify risks, trends and run scenarios

Data Needs Across Project Stages

The infrastructure sector collects huge amounts of data, but as much as 95.5% goes unused. Data has the ability to be transformative for the sector, but there needs to be agreement on what is collected, how it is consistently measured, and how it is shared.

	 **Planning**	 **Designing**	 **Construction**	 **Operations & Maintenance**
Data needs	Understand needs, assess options, justify investment, and build picture of site and local considerations, secure approvals	Create asset for end user, ensure constructability, manage risks, manage costs, lifecycle performance	Monitor and control costs, schedules, manage risks, quality and safety, coordinate and communicate effectively	Track use and user experience, manage costs, maintain condition of assets, identify efficiencies
	Asset inventory	Geometry	Progress	Dimensions
	Topographic and geotechnical	Time	Sequencing	Asset registry
	Environmental	Cost	Costing	Maintenance & inspections
	Demographic and demand	Materials	Quality inspection	Work orders, failures
	Land ownership	Coordination	Change orders and revisions	Energy use
	Cost benchmarking		Safety	Lifecycle costs
	Carbon		Supply chain	
	Permits and regulations			

Site survey, functional requirements, preliminary costs, environmental constraints → Detailed building geometry, material specifications, cost estimates, clash detection, schedule, regulatory approvals → As built geometry, equipment data (eg serial numbers, warranties), maintenance schedules

Data handover

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DIGITAL TWINS IN CANADA

Municipal	6
Health	2
Transport and Transit	6
Port	3
Airport	2
Water	1
Other	1

Digital Twin Leadership

Depending on the definition chosen, there are many examples of digital twins in development or operations across Canada. The experiences gathered to date could provide a trove of learnings to guide future adoption based on asset type or specific use.
*(list is not exhaustive)

1	YVR	virtual representation enabling real-time monitoring of air traffic, passenger movement, and 100s of other systems to optimize operations and enable scenario planning
2	Canada Line	enables remote monitoring of track to reduce operational costs, improve reliability and remove need for physical inspections
3	Fraser Health	twin from planning through to end use to integrate building design with patient care
4	St Paul's Hospital	twin of emergency department to inform construction, optimize design, streamline workflow and simulate operations
5	Fraser River Tunnel	twin used for design and planning and into construction to reduce risk and enhance future operations
6	City of Burnaby	twin of building assets to improve operations and maintenance and reduce costs of building portfolio
7	Port of Vancouver	digital twin focused on predicting container dwell times, optimizing gate operations, anticipating congestion points
8	Eglinton West LRT	model of complex underground utilities, enhance safety, improve efficiency during construction
9	Ontario Line	virtual model of transit line and surrounding infrastructure during construction for clash detection, lifecycle management
10	Toronto Water	twin of water system to monitor day-to-day operations and emergency water management, drive preventative maintenance
11	Ontario Place	twin to guide development, risk management around potential conflicts, improve safety, and enhance efficiency
12	St Clair-Old Weston Station	twin of transit station, tunnels, bridges, roads, utilities reducing projects risks and driving better coordination
13	Town of Innisfil	digital twin used for climate action, floor management, and future urban development
14	City of Ottawa	used as a basis for urban planning and decision-making around infrastructure and land development, and engagement
15	Parliamentary District	twins for range of assets from heritage buildings to laboratories to support maintenance, capital planning, and conservation
16	REM Montreal	digital model used in design and construction and extended into operations and maintenance for 67km metro
17	Port of Montreal	digital model of port used for security and fire prevention training, infrastructure planning and development
18	City of Bécancour	blends physical and government data to support planning, transportation and traffic management, snow removal
19	City of Levis	digital map of road network to support infrastructure planning, optimize planning and operations, improve asset management
20	Port of Halifax	model to enhance safety and efficiency in operations, and streamline decision-making
21	Halifax Airport	scan of existing conditions to enhance design accuracy and team collaboration to de-risk construction

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DIGITAL USE CASES

The best route to widespread adoption of digital technologies is the link to real world challenges faced or in unlocking benefits for the project, organization, or individual involved. Demonstrating value through saving time, enabling coordination, or providing valuable insights will ensure that the technology becomes an integral part of project delivery.

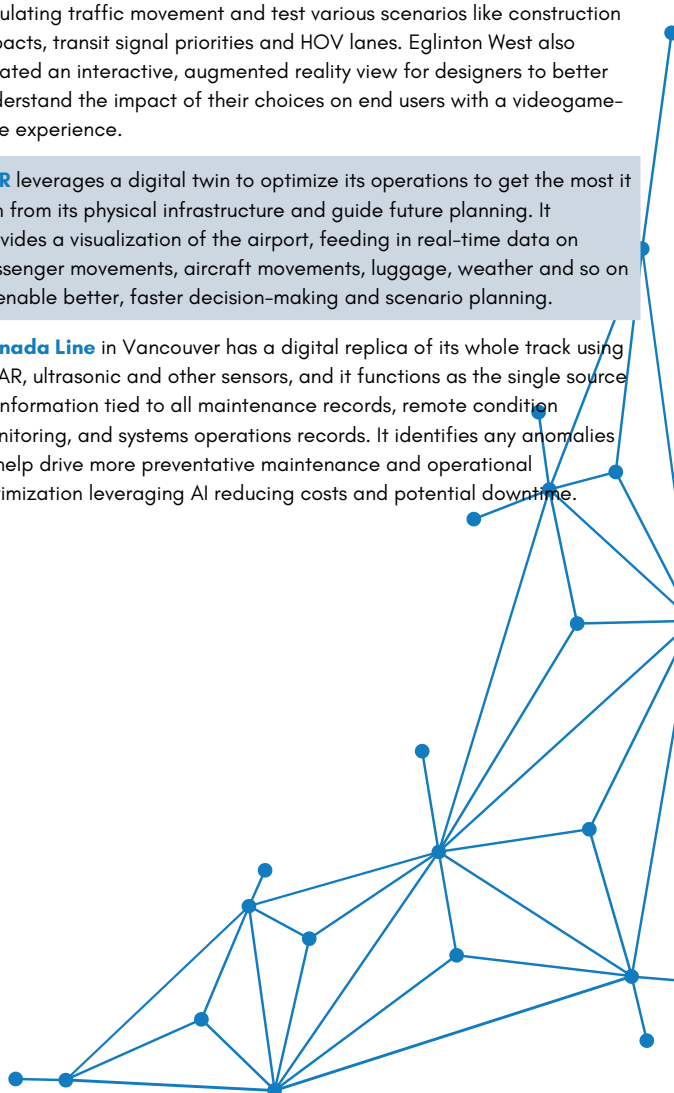
Value of Digital

Many parties involved	Intense coordination required	Overlapping responsibilities	Interdependent schedule	Lots of information to process	Complex or high risk projects	Multiple sign offs required	Need for informed decision making	Opportunity to innovate

Real World Use Cases

	Issue	Examples
Planning	Planning processes can be drawn out and plans themselves can be fragmented and uncoordinated due to a lack of visibility with many different owners, interests, and operating on different timelines.	**REM in Montreal** created a living plan that provided visibility for the rail project and adjacent developments to enable better alignment, coordination, and better end outcomes. The **City of Ottawa** is developing a digital twin to enable planners and the community to visualise impacts of new construction.
Procurement	Procurement sets the tone for a project, requires a lot of information sharing, and can involve a lot of different organizations. The process can be long and inefficient, and often resorts to selecting the lowest bidder as it can be difficult to assess true value.	**Norway's Statens Vegvesen** (highway agency) has been a pioneer in leveraging digital models for major road tenders, enabling contractors to input on construction approach and planning. It has cut procurement timelines, reduced cost variations, and improved design constructability.
Permitting	Securing necessary permits and regulatory approvals can be a time consuming and unpredictable process, often based around paper submissions and resubmissions. Delays in getting necessary approvals can have significant impacts through project and hinder the ability to effectively plan.	Singapore consolidated its regulatory approvals process for building works on one platform called **CORENET X**, cutting over 20 approval stages down to 3 key submission milestones using BIM. It has driven harmonization across key agencies, and reduced administration on resubmittals with time savings almost always over 20%. **Ontario** has taken steps to accelerate the digital permitting process with MPAC partnering with the Association of Municipalities of Ontario.
Utilities	Utilities represent one of the biggest risk areas for horizontal infrastructure like roads, transit, and utilities themselves. Lack of certainty around true locations, the process for gathering that information, and the associated work required to relocate utilities all add a significant potential for additional costs and delays.	The UK has been developing a National Underground Asset Register that maps out gas lines, water, electrical, and telecoms to increase efficiency, reduce accidental damage, and enhance safety. It has been shown to have an overall economic benefit of C$900 per year. Ontario announced a partnership with the UK to develop a similar map to explore the development of the **Ontario Underground Infrastructure Mapping Strategy**.
Geotechnical	Geotechnical conditions are the state of rocks and soil below the surface and are seen as one of the biggest project risks across infrastructure types. Unexpected conditions can add significant costs, especially if construction is already underway.	The **North East Link** is one of the longest road tunnels in Victoria, Australia. They developed a 3D model to visualise the complex geology and risks and enable better communication by incorporating data from 1900 boreholes. It spotted three specific issues to tweak design and saved 10,000 work hours by better sharing of information.
Environmental Assessments	New infrastructure can impact the existing environment in many different ways in terms of water runoff, impact on habitats, and changes in emissions. Environmental assessments take these changes into account and either pass judgement on whether a project should progress, or what steps should be taken to minimize and mitigate the environmental impact.	**East West Rail** in the UK used a data-driven approach to offset environmental impacts of the new railway, resulting in 10% increase in biodiversity. Machine learning captured baseline biodiversity mapping, assign habitat distinctiveness, condition and strategic significance to all pre-and post-construction habitat types and designers were able to quickly evaluate alignment decision impacts.
Design Changes	Designs mature along the project lifecycle and can often be done in a silo. This can cause changes along the way that have cost impacts and cause delays. Digital tools can bring in contractors and suppliers to avoid the need for later changes and also to optimize costs.	**Halifax Stanfield Airport** created created a digital twin to significantly improve design accuracy. 500 high-resolution scans enabled early detection of discrepancies to reduce rework and de-risk construction.
Clashes	There are many different types of construction, systems, and existing site considerations. Often the people responsible for the many parts of a building or piece of infrastructure work apart and effective communication and shared understanding of the bigger picture can be challenging.	The **University of Toronto Academic Tower** used 3D clash coordination in the Mass Timber and mechanical, electrical, plumbing scopes. It significantly streamlined project execution by enabling precise pre-drilling of service openings at the fabrication stage enabled clash detection and enhanced collaboration.
Communication	The huge number of organizations and individuals involved in infrastructure projects makes effective communication difficult. Duplication of documents, human error in replicating information, fragmented plans, and paper-based processes all hinder the ability to deliver a project effectively.	**Ontario Line** leveraged a digital twin to create a single, connected data environment that enabled the efficient sharing of information across various teams securely. To date it has saved around 15 hours per week from manual reporting of progress, and enabled progress reports to be accessed 50% faster. There has also been a clear benefit around constructability and scheduling meetings 60% more efficient.

	Issue	Examples
Progress Tracking	Having an accurate picture of the current status of a project helps to guide planning and address emerging issues to avoid them spiraling. This process is typically quite time-consuming and can be tainted by errors or biases. The use of digital tools could reduce time and enhance accuracy.	**Limberlost Place** at George Brown College in Toronto leveraged laser scanning, coordinated BIM models, project schedules, and Internet of Things data to track progress, quality, and schedule. This helped cut down on manual input and potential for human error, as well as enabling early identification of issues.
Scheduling	Successful delivery relies on a series of tasks being completed on time with some critical tasks having much wider impacts. Understanding the interdependencies, prioritizing critical tasks, and being able to adapt to delays keeps a project on track.	**LNG Canada** used AI to anticipate schedule risk looking at historical risk factors. Based on their analysis of 30 schedule risk items, 150 days of avoidable delay were identified focusing on just 0.5% of the riskiest activities. Typically, using traditional methods, it would have only been possible to undertake four analyses over the same period.
Safety	Construction is one of the most dangerous jobs with sites full of heavy equipment, moving machinery, live electricity, and other hazards. Workers can also be from subcontractors and suppliers not familiar with the site.	The **Port of Montreal** uses a digital twin to train employees on emergency scenarios like fires, spills and security incidents, enabling them to work through emergency response checklists and procedures.
Claims	Any construction project experiences issues that can escalate to claims then disputes for the unexpected or out of contract arising. Disputes can significantly add to the cost of a project and cause delays.	**Eglinton Crosstown West Extension** developed a digital twin with a mobile app to allow site inspectors to upload real-time, spatially-located site conditions and photos reduced need for site visits to approve payments and reduced research required to investigate claims.
Emissions	The built environment is one of the biggest emitters of carbon across materials production, through construction and into operations and end-of-life. Lots of decisions go into selecting the location, design, materials used, and how systems operate.	**National Highways** in the UK set a target of reaching net zero construction and maintenance highways by 2040. At the heart of this effort is their Digital Roads strategy to harness data and technology to improve how roads are designed, built, and operated leveraging a Built Environment Carbon Database to optimize designs and material use.
Supply Chain	Projects rely on a complex network of suppliers of goods, equipment, and services. Some suppliers can offer insights that could significantly benefit the project approach, and others can present significant risks if they or what they are offering are in short supply.	**Sydney Metro** developed a supply chain digital twin with an online app to track movements of concrete segments, steel and mechanical and electrical components. This helped manage supplier performance and maintain stock levels, delivering a 30% improvement in on-time delivery.
End User Experience	Smart design of infrastructure has a tangible impact on the services being delivered, for example better designs can reduce length of hospital stays, boost academic achievement, or make roads safer and flow better.	**York Region** developed a Dynamic Traffic Assignment Model to improve traffic flow in the region, avoiding unnecessary road expansions by simulating traffic movement and test various scenarios like construction impacts, transit signal priorities and HOV lanes. Eglinton West also created an interactive, augmented reality view for designers to better understand the impact of their choices on end users with a videogame-type experience.
Operations	Optimizing operations can have a significant impact on the value of an investment. Relatively small changes can significantly enhance the value of services provided or increase capacity for example in looking at how more trains can run on rail lines or how walking time can be cut down for medical workers in hospitals.	**YVR** leverages a digital twin to optimize its operations to get the most it can from its physical infrastructure and guide future planning. It provides a visualization of the airport, feeding in real-time data on passenger movements, aircraft movements, luggage, weather and so on to enable better, faster decision-making and scenario planning.
Maintenance	Infrastructure design has an impact on costs that lasts for decades. The operations and maintenance phase of an asset can account for 75% of total costs. Incorporating these considerations up front can have a major impact on cost savings for years.	**Canada Line** in Vancouver has a digital replica of its whole track using LiDAR, ultrasonic and other sensors, and it functions as the single source of information tied to all maintenance records, remote condition monitoring, and systems operations records. It identifies any anomalies to help drive more preventative maintenance and operational optimization leveraging AI reducing costs and potential downtime.



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HIGH IMPACT
USE CASES FOR CANADA

Demonstrating value is a key part of driving further adoption. Within Canada there are a number of opportunities to have a meaningful impact that could significantly reduce project risk, save time, and add value. These high impact use cases could be leveraged across different projects, and in some cases steps are already being taken, such as for Ontario's work around looking at the feasibility of mapping underground utilities, and BC exploring a one-window approach for permitting.

Permitting

Many provinces and the federal government have introduced strategies to reduce regulatory burden and create a "one window" approval process. Canada ranked 64th in the World Bank's Doing Business ranking for securing construction permits. Energy and infrastructure projects can take 4-6 years. They do however play an important role in protecting the environment or community interests, so it is important they are rigorous and mitigate impacts. They are also often sequential, where one approval process only starts when another has been secured.

20 Approvals Down to 3 Submission Milestones

A single government window in Canada could be developed based on the CORENET X platform in Singapore. This platform was developed in partnership with regulatory agencies and the private sector to create a seamless process for securing approvals through a digital BIM window. The language used is to have a regulatory process that is "customer centric" and collaboration across regulators - enabled through the single digital platform. The platform also enables automation where submitters can self-check and correct before submission, as well as automating more simple checks and cutting down on duplicative information requirements.

Utilities

Underground conditions, particularly utilities, are frequently highlighted as a major challenge for successfully delivering projects. The location of utilities is difficult to find with multiple utility companies involved and unreliable records, and responses can take days. There is also a risk of accidental strikes on utilities that poses a safety risk and can throw delivery schedules off track. Better visibility early could also shape design choices to avoid costly relocations of pipes and cables.

5-10 Days for Utility Locates to Instant Access

Certainty around third party timelines is hugely valuable for projects. The National Underground Asset Registry is a digital map of underground asset locations from over 600 gas, water, electricity, and telecommunications companies. The process went from an average of six days to instant access, providing an annual economic value of $900 million per year through increased efficiency and fewer accidental strikes. The register secured all the data from utility owners despite some pushback, though ultimately legislation compelling sharing was required in some cases. Ontario is leading the way in Canada with its Underground Infrastructure Mapping Strategy. There is currently a legal requirement to provide locates within 5 days and this could make data available instantly.

Procurement

The procurement process shapes the success of a project with a disproportionate impact in those early project stages. It involves a lot of information sharing, involves a lot of stakeholders, and can be a process involving a lot of paper or PDFs. There is an opportunity to make the process more interactive and for it to add more value through the project lifecycle overall. There is also a general consensus is that getting contractor (and supplier) input early adds value to all in identifying risk and driving better constructability.

10% Saving from Market Engagement in Procurement

By requiring tenders to be uploaded via a BIM platform, it has demonstrated a number of benefits for Statsbygg in Norway (the government's construction and property manager). There are benefits including automated checks against tender requirements enabling faster evaluation. It makes the procurement process more interactive, with fewer requests for information due to more transparency. Bidders can work together with the government to have a single source of truth in areas like geotechnical risk which could, for example, enable bidders to understand risk better and give a more accurate price and reduce contingencies. It can also significantly reduce design clashes further along as issues can be detected early in procurement and market engagement.

Logistics and Supply Chain

Recent experience with the pandemic and trade disputes have caused major uncertainty and added delays and costs to projects. The market is also seeing major investments across all different kinds of infrastructure and buildings, all being delivered by different public and private sector organizations with little visibility of demand, stocks, and timelines for delivery. Project logistics can also be a major challenge with constricted sites and remote projects.

1 Day a Week Lost to Worksite Inefficiency

Other sectors have used digital twins to improve visibility, drive productivity, reduce risk, and unlock innovation across their supply chains. A digital supply chain strategy helps unlock efficiencies such as with Heathrow Airport's off-site construction hubs that work off the basis of a digital twin and cut traffic and construction activity at the airport. Sydney Metro also leverages a platform to optimize logistics with a digital booking system, visibility of supply chain, resource optimization, and logistics control. There is also an ability to develop regional plans to further reduce local congestion and boost on-time delivery.

C

ROADMAP & RECOMMENDATIONS

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MOVING TOWARDS DIGITAL: TRANSFORMING

There are five main areas of focus that form the basis of a digital transformation that could have a meaningful impact on Canadian infrastructure and overall planning. This includes: clarity of direction with a clearly laid out digital twin policy; incentives to drive early adoption; introducing consistent standards and systems around the use and sharing of data; preparing the market with tools and training; and finally ensuring the legal and regulatory environment is enabling rather than restricting.

The technology itself offers part of the solution, but it requires buy in from people. It needs to be part of the process to ensure it is truly adding value, and it needs to show benefits. There are also a lot of legacy or perception issues that must be addressed that have to date hindered the uptake of digital tools in the infrastructure sector in Canada. There is a real opportunity for the different levels of government within Canada to work together to drive a consistent approach that would deliver value for all.

Focus Areas

1. Creating a Canadian Data and Digital Twin Policy
2. Enabling Early Adopters & Gaining Momentum
3. Building a Strong Data Foundation
4. Preparing the Market
5. Enabling Legal and Regulatory Environment

Barriers to Adoption

Market Opportunity

The main overarching challenge relates to the lack of consistency of approach and demand across Canada, creating a siloed approach. A clear national vision, built on shared standards, and clear goals across the lifecycle is needed to provide confidence to invest and deliver on the true potential of technology and data.

Cost & Benefit

The up-front cost of digital tools and twins can appear high. The benefits can be unclear or too far in the future, and savings over a lifecycle are viewed differently to upfront cost savings. The concept itself can be intimidating with many add-ons that may or may-not create value. This can all dissuade organizations from investing.

Role of Digital

Digital twins, and technology in general, are seen as a silver bullet, where it can be applied to solve any problem without addressing some key underlying factors. Digital twins and data should be considered in the context of the value they provide and as more of a methodology than a technology.

Procurement & Contracting

The current procurement approach was cited as often being too vague around requirements, too over-prescriptive, or missing an opportunity to add value at every stage via the types of insights and innovations that data could provide. Contractually there are also often provisions restricting the sharing of data.

Data Issues

Data lies at the heart of the opportunity and is the root cause of many of the barriers. Who owns the data, how it is structured, its quality, how it is described, what data is needed, if it is interoperable, how it is protected, how it is used, where it is hosted, are all front of mind issues that stall progress.

Legal Uncertainty

Many of the requirements around projects are often still paper-based or required via standalone platforms or processes in Canada. This includes external permits, bylaws, and regulatory requirements; project reviews and sign-offs; and internal project requirements. There are also concerns about reliance on technology and how data can be used in disputes.

Skills Gaps

There are different types of organizations across the infrastructure sector of different sizes, specialisms with different capabilities. The organizations and the individuals who work for them come from very different starting points when it comes to having the skills needed to make digital use a success. There are gaps from the technical level to leadership.

Risk Aversion

As with anything new, it will change how people and organizations have done their jobs for years. Change requires internal and external capacity building, a process geared towards change, a staggered approach to adoption, and resources to help all jointly reach a clear shared goal.

1 CREATING A CANADIAN DATA AND DIGITAL TWIN POLICY

The true value of a Digital Twin is moving beyond a specific project to feeding into more of a connected ecosystem where a large, fragmented group can coordinate for better outcomes. This requires a change on approach, which will ultimately need clear direction and leadership.

It is important to create an environment where those wanting to be at the cutting edge of digital adoption are able to move ahead. At the same time there needs to be guidance and goals to move the sector into a more data-driven, evidence-based state.

Clear Digital Strategy

1 Overall Digital Strategy – whether a specific digital twin strategy or a wider strategy for digital transformation in the sector, government has the potential to provide clarity and certainty that would remove internal barriers and encourage companies to invest. Many governments have set a goal of becoming "digital by default" in the approach to planning, designing, delivering, operating and maintaining infrastructure.

- How it aligns with government priorities – technology should enable government to meet its objectives more broadly and specifically associated with its infrastructure plans.
- Anticipated benefits – setting out some key areas where there will be benefits in areas such as cost reductions, time savings, improved outcomes – all help to build more broad-based support.
- Focus areas and problems to solve – providing areas where there is a clear need and the government hopes to see real transformation helps to show momentum and maintain motivation. Singapore included several key areas to in their integrated digital delivery plan, and the UK also identified some high impact areas as part of their National Digital Twin Programme. This should ensure that technology is adding value and becomes a true catalyst to how infrastructure is planned, procured and delivered.
- Goals and timelines – the journey towards digital twins requires a number of foundational steps that starts with creating an environment with reliable, interoperable data, and requires skills and processes to ensure digital approaches are an integral part that contributes fully to projects.
- Steps required – ensuring that each requirement is set out sequentially to drive successful transformation, and enabling the demonstration of benefits along the way. This should cover legislation, data, processes, and people and capacity building. It should also have prioritization of actions to build momentum and address barriers.
- Responsibilities – there are roles across government, as well as in the private sector, that will be critical to success. This includes infrastructure agencies that procure and deliver infrastructure, capital ministries that plan projects, treasury boards that set policies and budgeting, industry ministries that provide funding and set digital policies, labour and post-secondary ministries that provide training, and a number of public sector organizations and professional associations are regulators or provide approvals. There should also be designated leadership to drive change with a clear mandate.
- Incentives and supports – a range of other resources government can provide in terms of access to funding or training, tools and visibility, and other mechanisms that can enable a broad range of participation and capacity building.

2 BIM Mandate – providing a mandate from the Federal and provincial governments requiring Building Information Modeling on publicly funded projects would significantly help to shorten the time needed for adoption. In Quebec where a mandate was required for certain owners there was a 250% expansion in the use of BIM between 2021 and 2025. This will provide the basis of common data that can unlock other approaches such as digital twins and AI. This should be done in stages, as has been the case in other markets, whereby it only applies to projects over a certain size or budget, with smaller projects phased in at a later stage.

3 Digital-by-Default – this mantra has been a core element of government transformation efforts. It sets clear expectations that can help to overcome any inertia. Often processes remain based around legacy approaches that are siloed and paper based. If there is a digital component it is often only elements of the process, meaning that opportunities for productivity enhancements and synergies are lost. Digital by default has become a key policy to drive digital change with all in government expected to adopt a digital solution or explain why not, rather than vice versa. It was a recommendation from Infrastructure Australia as part of the Australian Infrastructure Plan, and all submissions were required to be digital on the Crossrail project in the UK.

Delegated & Empowered Leadership

Experience from any form of government transformation points to the need to have a political champion, an empowered leader, supported by a highly experienced team with a clear mandate for change. Setting up a wider advisory group including other levels of government, industry, academia and training, and independent experts can also be advantageous.

4 Designated, Empowered Leader – successful government transformation requires leadership. A political champion, and a leader, empowered, with a clear mandate helps to cut through any siloes and deliver change. They should be supported by a dedicated and skilled team to enable change and show value and expertise to partner organizations. It is important that this leader is empowered to drive change with a clear mandate and adequate resources.

5 Dedicated Team of Experts – a small, core team brought together to enable transformation should work with other bodies to help with the deployment of digital twins and support capacity building. They can work collaboratively with designated counterparts within other government departments or agencies to achieve shared goals. A good example is the role the UK Government Digital Service was set up to enable success, with a small team of experts working collaboratively with counterparts within different agencies and ministries to drive digital transformation.

6 Clear Ministry Mandate – an effective way of bringing a range of ministries and agencies along is to collectively identify key challenges and set shared goals within set timelines. This ensures that solutions match needs, it drives consistency, and brings accountability across government. The Office of Project Victoria sets out guidance for the types of roles that are required to make digital transition a success and calls for each department or agency to have a sponsor who is in an executive function and a lead who has more of a technical role around implementation.

Clear Process, Procurement and Contracting Approach

Technology and data can add huge value to a project across a numerous areas, but if it is not integrated as part of the process it risks becoming a side task that eats time and costs and adds no real value. That is why technology alone will not solve all the issues facing the sector. Significant attention needs to be paid to the processes at every stage of the infrastructure lifecycle and identifying where digital fits in and can add value. A clear process would help government, contractors and suppliers to be aligned on what is required, when, and what benefits it is expected to bring.

Procurement was also regularly cited as being a major block to adoption of digital tools and more effective use of data, as well as being key to unlocking further value. There needs to be clear requirements set for what is expected in terms of data to be collected and usage, as well as roles and responsibilities. Data collection can be time-consuming, so it needs to be budgeted for. The procurement approach chosen also impacts the realization of benefits and needs to incorporate early engagement and an incentive mechanism that rewards innovation.

7 Overall Process Guidance – a clear step-by-step guide that provides clear direction on where and how data and digital twins fit in with the overall approach to infrastructure planning, procurement, delivery, and operations is critical.

- Specific digital guidance – having standalone, clear guidance around the steps necessary to roll out a digital twin and leverage data more broadly would provide significant support and could be a critical tool across all levels of government as well as for partners. Singapore's Integrated Digital Delivery provides a range of tools and processes to guide the use of digital technology at every project stage. The Victoria Digital Asset Policy provides guidance to all government departments, setting minimum requirements. Scottish Futures Trust also has a BIM Guidance Portal that provides a range of guidance and tools for the public sector.
- Overall delivery approach – it is critical that technology is incorporated into existing processes with designated roles that are integral to any project or asset. This ensures that digital tools add value throughout the lifecycle of any project. The UK Government's Project Routemap provides guidance for more novel, complex projects, whereas the Construction Playbook is aimed across asset classes – both include emphasis on where digital fits. This should include an internal approach to innovation and new approaches.

8 Tools to Assess Right Fit – there is no one-size-fits-all approach as each project and organization has different capabilities and needs. The scope of data that needs to be collected and sophistication of the tools created need to be weighed against the benefits. The Scottish government has an online tool to help public sector agencies determine what level of data they would require and what they should ask for in terms of BIM level.

9 Optimizing Contracting Strategy – experience has demonstrated that benefits from adopting new technologies such as digital twins will only be realized if the contracting structures are right. There needs to be built in incentives for collaboration and data sharing, as well as providing incentive mechanisms that draw on the value of enhanced insights to provide savings. Experience among earlier adopters of digital tools has found that real value is only unlocked if all parties are incentivized to use the enhanced visibility to provide actual solutions and savings.

- Standard contract language will help bring greater certainty to the market on what exactly is expected. As with any procurement, bidders want to have clarity on what is required so they can accurately budget. Overall, there was a perspective that contract language needed to be fairly specific around requirements. An example clause can be found in NEC4 contracts - Option X10, this covers requirements for information modelling and collaboration.
- Getting the right digital solution for a project requires investment. There should be an acceptance that it will cost money to provide a digital model of an asset, but Scottish Futures Trust developed a tool to help ensure only the necessary requirements are used for any given asset based on need and capabilities. Clear requirements within procurements, based off market engagement, will ensure that each bidder prices their digital offering accurately.

Best Practice: UK Government Project Routemap

The UK's Project Routemap provides consistent guidance for each stage of novel or complex major projects. There is also the Construction Playbook that provides broader guidance. The routemap involves step-by-step guidance focusing on the front end around project feasibility, appraisal and selection, and definition. It was refreshed in 2021 to incorporate a digital and technology component.

There are eight modules covering: requirements; governance; systems integration; organizational design and development; procurement; risk management; asset management; and delivery planning.

Under the cross-cutting themes there are four questions focused on digital and technology:

- Have digital and modern methods been considered at the earliest point in the life cycle to maximise their impact on benefits?
- How has the project assessed and addressed digital capability within the sponsor, client, asset manager and market?
- Has the project considered how information, data and knowledge will be shared across the project including with the supply chain?
- What consideration has been given to potential changes in technology that may influence benefits realisation?

Best Practice: Integrated Digital Delivery, Singapore

Singapore has a range of tools to available to ensure that data and digital tools are embedded in existing processes. The overarching goal is to streamline different stages of construction by incorporating digital technologies. There are some key use cases identified along the value chain including design optimization, collaborative production, component identification, and digital inspection.

It has a range of resources including:

- Integrated Digital Delivery requirements and specifications;
- data standards;
- handover technical guides;
- information requirements; and
- a gateway for accreditation for both government and industry.

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PLANS GUIDING DIGITAL TRANSFORMATION

A clear plan has a major impact on providing certainty and direction across both government and the private sector. By setting out overall objectives, responsibilities, timelines, and expectations within government and with partners, it ensures there are no surprises and secures more buy-in - especially if the plans have been developed in consultation with different government entities and private sector partners.

Best Practice: National Digital Twin Programme, UK

The National Digital Twin Programme was set up in 2018 out of a report from the National Infrastructure Commission (Data for the Public Good). The aim of the programme is to develop standards, frameworks, guidelines, methodologies and tools to create the foundation for the deployment of integrated digital twins across the country. The programme creates an environment that enables organizations of different types and sizes to play a full role, with the confidence they are operating in a safe, secure, and ethical environment.

The program includes:

- Use cases: to create learning grounds in areas such as retrofitting in housing; energy system; asset resilience, emergency planning and response; planning; and vulnerable people.
- Real-world problems: looking at real world problems such as energy waste; carbon emissions; fuel poverty; grid instability; renewable integration; infrastructure degradation; climate vulnerability; emergency response coordination; cross-agency communication.
- Standards, frameworks, guidelines, methodologies and tools: the use cases and problems are used to validate and refine information exchange standards; integration architecture; deployment playbooks; data pipelines; and data exploitation tools.

Best Practice: Infrastructure Digitalisation Program, NSW, Australia

New South Wales' Infrastructure Digitalisation Program aims to accelerate adoption of technologies, processes, and systems with a goal of enhancing productivity, service quality, and societal and environmental outcomes. The program is focused on three key areas:

- Allow project information to be shared more easily, reducing rework and supporting standard designs and modern methods of construction
- Enable more accurate cost estimates and schedules, reduce risks and create efficiencies of scale
- Support more effective asset management decision-making

NSW sets out a goal to become digital by default and has focused on four workstreams:

- People and Governance - vision and leadership, digital skills capabilities, partnering with industry.
- Policy and Standards - whole of government standards and guidance, agency policies, procurement requirements.
- Data - data standards and interoperability, common data environment, security.
- Technology and Systems - system innovation, systems through lifecycles, cybersecurity.

CHANGE MANAGEMENT & INNOVATION WITHIN GOVERNMENT

Across government innovation can be difficult, especially for the infrastructure sector. Internal processes and aversion to risk can block any new approaches or technologies, and traditional procurement that requires multiple bidders is unsuited to truly innovative solutions.

Approach		Examples
Innovation Mandate – a clear mandate across government helps to ensure that people across government and within the private sector are aligned and have clarity on the future. Setting out innovation as an organizational goal is critical to drive culture change.		**Rijkswaterstaat** (Ministry of Infrastructure & the Environment) in the Netherlands launched an innovation agenda in 2013. The goal was that each innovation should contribute to reducing lifecycle costs by 30%, increase functionality by 30% and increase safety and sustainability by 30%. The Dutch government overall set a goal of spending 2.5% of its budget on innovation, which included infrastructure.
Digital by Default – setting expectations that all processes should be done digitally unless there is a truly compelling reason not to has been shown to drive change in digital adoption. This should feed into internal project guidance, training programs, and professional development. It is important as part of this process that the digital approach clearly demonstrates value to solve real-world challenges.		**Infrastructure Australia** recommended digital-by-default as part of its Australian Infrastructure Plan. This is backed up by calling for digital asset champions on each project to support the change as well as coordinated national processes and guidance.
		The **Centre for Digital Built Britain** created a Skills and Competency Framework to ensure that the skills across the sector aligned with the ambitions around digital transformation. This includes technical skills, but also the transformational leadership required that may not need to have deep technical knowledge but should recognise the opportunity and benefits of data and data sharing.
		**Scottish Futures Trust** provided a portal for the public sector with comprehensive guidance, including a return on investment tool, to demonstrate the cost and quality benefits of using BIM, as well as providing case studies.
Early Adoption – as with any organizations, there are eager participants. Their enthusiasm should be channeled and amplified. There are a number of approaches that can create a positive internal environment that enables change. This goes from information sharing through learning hubs and knowledge capture, to encouraging ideas through internal competitions and structured calls for innovation. Major projects can also be a good basis to try out innovations with broad applicability.		The **UK water sector** is a leader in internal innovation driven by requirements from their regulator. They use a variety of approaches including Challenge Forums for internal teams to propose solutions, internal portals for idea submittals, and internal funding and incentives.
		Canada's **Smart City Challenge** provided funding to support municipal innovation via a competition. The funding was linked to specific outcomes and could provide a template for infrastructure innovation.
		**Crossrail** developed a Learning Legacy that both recognized and celebrated achievements. The project itself had an innovation strategy that aimed to use the massive project as a catalyst for change across the sector. It proactively sought to draw in innovation from other projects and sectors to identify and implement innovation from incremental changes to radical new approaches.
De-risking Innovation – there is a risk aversion around innovation in the public sector for good reason. In areas such as data use and the potential use of Artificial Intelligence, the lack of clarity on what is legally permissible has been cited multiple times as halting proposed pilot projects or wider deployment of technology. The use of a regulatory sandbox gives the space to try out new technologies in a controlled environment; designated innovation funding or financing provides an opportunity to solve issues outside the project budget; providing a vehicle for procurement of truly innovative solutions; and providing a basis for sharing proofs of concept around innovation can all help accelerate adoption.		The **Ontario Energy Board** launched a regulatory sandbox to try out new innovations around specific challenges outside of existing regulations. The OEB provides some funding as well as regulatory guidance to test innovations with an opportunity for industry to propose other challenges.
		As part of **l'Initiative Québécoise pour la Construction**, the province provides a "Digital Chest" where companies can select from approved software tools that align with open standards. **Innovate BC** too set up an Integrated Marketplace that supports development of technology and has been used in other markets to enable procurement. Other organizations such as Rijkswaterstaat and Singapore's Building and Construction Authority have pre-approval processes for new technology.
		The **US Federal Highways Administration** has Every Day Counts, a state-based model to accelerate the adoption of proven innovations across the US leveraging the State Transportation Innovation Council and Accelerated Innovation Deployment Program.

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2 ENABLING EARLY ADOPTERS & GAINING MOMENTUM

There needs to be a focus on driving early success that really demonstrates the benefits of a digital approach more widely. Mapping out the challenges faced as well as opportunities to deliver enhanced value should provide the basis for a roadmap that unlocks incremental improvements. Early success drives momentum and demonstrates what is possible, identifying where technology and Digital Twins can have the most impact, as well as looking at more digitally mature organizations that could be early and eager adopters.

10 Issue and Opportunity Audit – the complexity and scale of moving a piece of infrastructure from a concept to a functioning asset involves countless stakeholders and processes, many internal and external requirements, and a significant number of risks. By engaging internally within government, it should be possible to identify areas that add the most cost and time to projects, or the areas that reduce the value of the outcome. This could look at: duplicative information requests, paper-based processes, sources of claims or disputes, non-conformities, resubmittals, time required for specific approvals, information requirements that would enable better decision-making, and so on. By mapping these out it provides a basis to ensure that the digital transition, and the development of a digital twin, contribute to project success and better outcomes.

11 Transparent Milestones – setting sequential objectives provides clarity both within government and externally that helps maintain momentum. These milestones should be developed to help demonstrate value early. There are also the milestones associated with a BIM mandate rollout. There are internal requirements in setting up capacity, implementing requirements such as digital-by-default, or migrating data to the cloud. Clear milestones provide accountability and certainty to both government and the market.

The use of digital twins is part of a broader journey to better use data and insights to add value on projects. There are a number of steps that can deliver incremental value along the way from purely digitizing paper records, to driving better information management overall, to enabling better project communication, to anticipating future issues, and beyond.

12 Establishing a Demonstrator Program – critical to unlocking progress is the identification of a number of high-impact projects that can help to road test how a Digital Twin could work, demonstrate the benefits, and what could be improved ahead of wider adoption. These can be chosen based on appetite from the organizations involved, digital maturity, potential impact and wider application. To be truly impactful these should look to address specific challenges, or help provide a template approach for specific assets.

In the UK as part of a wider digital transformation, 25 high-potential government services were targeted for transformation within 400 days, with government departments offered full support from a skilled team of experienced professionals.

13 Developing Competitions to Encourage Grassroots Adoption – to encourage innovation and early adoption, as well as helping to address specific challenges facing the entire sector, governments have leveraged challenges with the carrot of funding for the winners. Governments in Canada have leveraged competitions around specific challenges in the past. The Smart Cities Challenge in Canada is a good example of a way to drive innovation around a specific set of challenges.

14 Demonstrating and Reporting on Tangible Impacts – given the data collected, it gives a major opportunity to assess where issues may have added costs or delays, or impacted the final outcome, and provide a platform to drive improvement. Certain jurisdictions, such as Australia and New South Wales, produce post-completion reports that are invaluable in driving improvement. Having access to a greater wealth of data could be truly transformative in enhancing project success.

Transparently reporting on rollout, challenges faced, and benefits accrued provides learning opportunities across government that creates a virtuous cycle. It also helps others to avoid potential speedbumps or worse. Where possible these should provide evidence of quantifiable benefits that demonstrate the business case.

Demonstrator Programs

As part of their **National Digital Twin Programme** the UK identified three demonstrator projects that touched on the national energy system, building retrofits, and resilience and emergency response. It also laid out real-world problems to address including: energy waste, carbon emissions, fuel poverty, grid instability, renewable integration, infrastructure degradation, climate vulnerability, emergency response, and cross agency coordination.

In Scotland the approach used around BIM adoption was named Pathfinders run by **Scottish Futures Trust**, which provided rich insights to help guide wider policy and support. The pilot process identified:

- Four key challenges: lack of coherent BIM strategy; lack of appropriate contractual protocols; scarcity of properly trained BIM resources particularly in BIM workflows; lack of mature data sets in construction industry
- Seven key benefits: more effective coordination and clash detection; hugely reduced redesign effort; decreased supplier cost; better client service; cost savings for operations and maintenance; better site personnel engagement; more effective options appraisal potentially saving substantial sums

Singapore's Integrated Digital Delivery referred to them as Lighthouse projects that focus on integrated digital delivery. Singapore also listed 19 different use cases through their Integrated Digital Delivery program that cover real-world challenges. These include: carbon management; visualization and design checks; BIM-based documentation; integrated concurrent engineering meetings; submission and approval; request for information; BIM-based cost estimation; contract management; construction scheduling and sequencing; logistics; safety planning and management; site management; progress monitoring; defects management; handover; real-time monitoring of asset performance; and operations and maintenance.

Ontario also rolled out three pilot projects to test the concept and what was needed to encourage more widespread adoption.

FUTURE OF INFRASTRUCTURE GROUP

3 BUILDING A STRONG DATA FOUNDATION

Better organized data means better decision making. Data lies at the heart of any Digital Twin, and is also the root cause of many of the challenges to wider adoption. The key fundamental requirements are interoperability, enabling data to be shared, and ensuring it is of sufficiently high quality. This must be built on clear standards adopted across governments in Canada to truly add compounding value.

Many governments have adopted overarching digital strategies that aim to unleash the power of data on public services and across the economy, including in the infrastructure and built environment sector. These strategies aim to overcome barriers to access such as hoarding of data, unclear access rights, or underuse of the data collected. They often focus on data structure; availability; skills; and ethics.

Without question data underpins any new technology in the sector, and it is important that this is addressed early in any roll out of digital twins. The data collected, if able to be shared, can also unlock a treasure trove of value and insight, as well as having wider economic benefits.

Data Structure

The value of digital twins is built around standardised formats, reflects the needs of the sector, is consistent, high quality, and is interoperable and shareable. The requirements must also be designed so as not to be too much of a burden for potential bidders and suppliers, or government owners.

Governments have the ability to create the standards, guidance, and rules that can provide a clarity and unlock broad-based innovation for the infrastructure sector. This needs clear government direction to overcome risk aversion and encourage change there needs to be a clear direction set by government to unlocking data as a strategic asset. There also needs to be someone designated at a senior level, as well as resourced and given authority and accountability to drive change across government.

Though it may it not be a legal requirement, governments can consider legislation to clarify what a public sector entity can and cannot do with data. There are some real, and many perceived barriers related to sharing data even within governments, not to mention with project partners. The UK used the Digital Economy Act to provide legal clarity for sharing of public data for specific purposes. [see below]

15 Providing national core standards – lack of standards used in the Canadian market drives inconsistencies and undermines quality and reliability. ISO 19650 is an international standard that provides the gateway to Digital twins by bringing consistency and quality to data. It is the basis to bring all parts of the infrastructure value chain together in how they develop, exchange, and use data for construction and infrastructure across all phases of an asset's life. There are other complementary standards to consider too that cover areas such as descriptions, categorizing data, costs, and asset management. [see box]

16 Providing a Quality Assurance Framework – data comes from multiple sources both internal and external and can be of varying quality. It can come from sensors to manual inputs. Clarity around data standards will help improve quality. Technology can play a role in cleaning and structuring data, even in written form, but creating structure and developing systems for ease of input will significantly improve data quality. The role of technology can also automate input. To drive higher standards the UK established a Data Standards Authority and a Data Quality Hub with clear ownership and roles around improving quality across government.

17 Defining Information Requirements – within the process of project delivery the owner should determine what data is required together with the supply chain and the entity responsible for operating and maintaining the asset. It is important that information requirements remain anchored to project objectives and determined at the onset of the project.

Core Standards

Data interoperability is a critical foundation for the ultimate successful deployment of Digital Twins. Together it establishes common understanding, enables comparisons, integrates different parts of the construction value chain, enhances security, and accelerates scalability. By requiring the use of open standards it ensures the software tools selected to adhere and drives greater consistency and interoperability.

Core Information Management	Classification for Assets, Components & Activities	Data Format for Sharing	Cost & Carbon
ISO 19650 An international standard for managing information on construction projects throughout the lifecycle from design to operation. It provides a structured approach to information management including information requirements, workflows for information exchange and management, establishing roles and responsibilities, and addressing security.	**Unified Classification System (Uniclass)** Made up of a set of tables, that can be used by different parts of the industry to classify materials, products, asset types, locations, activities across the construction lifecycle. It is hierarchical so for example it can break down hundreds of types of doors so records are accurate. (ISO 12006-2)	**Industry Foundation Classes (IFC)** A set of standardized, digital descriptions of the built asset industry which focuses on interoperability, also known as ISO 16739. It is an open file format that enables data sharing by categorizing objects, spaces, and systems for consistency from design through to operations. It defines the interrelationship between different components of a building or asset and how they fit together, essentially like a blueprint.	**International Cost Management Standard (ICMS)** This standard covers how to classify, define, measure, record, analyse, present, and compare lifecycle costs. It provides a baseline for consistency for cost analysis and planning, and recently incorporated carbon.

Data Availability

To have a transformative effect it is important that data is based on open standards and can be shared across government and with government partners. This would help to determine how current infrastructure could support new housing, or how health system infrastructure could be designed to support better patient care. Without those interlinkages there is serious untapped value lost.

More open data and information sharing help to build knowledge and understanding and drive improvements. Some governments have adopted an open data policy and have seen benefits including the development of new technologies and services providers. Canada should look at data that can be made fully open to unlock the potential for innovation. Scotland for example works off a principle of data being FAIR - findable, accessible, interoperable and reusable. But at the very least open data standards should be the bedrock of any approach to enable information sharing.

18 Hosting data in the cloud - a major issue in digital transformation is hosting data on legacy systems. These legacy systems, often on-premise servers, can lock government organizations into out-of-date technology and approaches. Overall this can reinforce siloes through an inability to exchange data. A government-wide cloud-first strategy that requires non-classified data to be based in the cloud, enables data to be shared more freely and securely and opens up a world of possibilities around the insights that can be derived, and the technology that can be unlocked. The Government of Canada has had a cloud first strategy since 2018. Quebec, Ontario, and British Columbia also have cloud first policies in place.

19 Common Data Environment – provides a shared space for all project stakeholders to access, manage and share project information. It provides the foundation for any Digital Twin, acting essentially as a data hub at a project level, laying out the processes for information management, and can also connect into a wider network of twins.

There are many software providers who provide this technical resource, but the software must comply BIM standards to enable sharing. This becomes the project's single source of truth, but requires that workflows are based around this resource. The platform should be user friendly to encourage use and increase data quality.

20 Information exchange standard – a point that came up again and again was the need for data to be interoperable. This ensures data from one project can become part of a bigger network of projects and unlock much wider benefits. It also breaks down barriers between project stages, so valuable information collected can be used through the project lifecycle. That is why the ISO 19650 and complementary international open standards provide the best foundation for information exchange in the built environment.

21 Provide template contractual language – the key element here is that data must be shareable across a project and beyond the project. As stands contracts are often established in ways that prevent data sharing beyond the project so data effectively dies once the project ends. Contracts may also not encourage sharing within the project itself. Open access to data could unlock a wider range of benefits, but it needs to be addressed via a change to current contract practices.

A critical piece is data ownership. Across other jurisdictions the data is typically owned by the party that generates it, with the client given access to what they require as part of their agreement and compensated accordingly. It is important for companies to be able to leverage the data they collect to help them to innovate, but the same is the case for clients. Most important is that the data is in a shareable format.

Best Practice: Information Management Framework

The UK developed the Information Management Framework which provides a collection of open, technical and non-technical standards. This aims to provide a common language as a basis for developing connected digital twins. The framework supports secure and resilient sharing and integration of data.

There are three core technical resources:

1. Foundation data model – clear language of what constitutes a digital twin
2. Reference data library – particular set of classes and properties used to describe digital twins
3. Integration architecture – protocols that enable the managed sharing of data

There are also non-technical resources including guidance on how to improve information management:

- The Gemini Principles that anchor the rollout to the public interest
- Legal, commercial and regulatory standards to facilitate the market for connected digital twins

Best Practice: Digital Project Delivery Requirements, Alberta

Infrastructure Alberta published a catalogue of requirements for digital project delivery that can be used on a modular basis. Contracts state that projects must comply with the province's Digital Project Delivery requirements where applicable, with the specific modules applying depending on project size, complexity and type.

Contracts require the use of BIM as well as the submission of a BIM Execution Plan. There is a requirement for documentation to be submitted electronically to enable more data driven processes.

Data Skills

It was frequently highlighted that success requires established and emerging skillsets both within government and the private sector. This requires an understanding of where there are gaps and a plan to address those gaps.

22 Audit of skills gaps: both government and the private sector have to understand where there are gaps around managing and leveraging data and associated technology, as well as using that data strategically within their respective organizations. The Centre for Digital Built Britain developed a Skills and Competency Framework that lays out the technical and non-technical skills required, as well as the range of roles that should be needed.

23 Recruiting experts: a central resource comprising people with experience and expertise should be created and/or empowered to support transformation efforts. Some government also leverage temporary secondments of experts to support truly significant projects, such as the UK with its Innovation Fellowship Scheme and the US Digital Service's tours of civic service.

Data Ethics

Data can yield huge value, but it is important that using that data considers people's data rights and organizations' intellectual property. Any approach needs to be based on strong principles that engender confidence and trust, and infrastructure that is safe and secure. This becomes especially critical as tools such as AI become more widely used in the sector.

24 Principles of use - the UK established the Gemini Principles to provide the values to guide the development of individual and connected digital twins, to ensure these deliver public benefit in perpetuity.

- Privacy - for infrastructure privacy is less of a concern that other areas such as health, but still shouldn't be discounted. The use of sensors and requirements to enter data, as well as data collected around end users all may have personal components. It is important that these are factored into overall planning, and that personal data is anonymized where necessary.
- Security - overclassification of data can be used to prevent data being used more widely. At the same time critical infrastructure is regularly targeted by bad actors so security needs to be factored in at every stage. Established international standards factor these requirements in.

Best Practice: Gemini Principles

The Gemini Principles developed in the UK anchor the development of Digital twin to the public interests. It provides a set of nine guiding principles published in 2018 by the Centre for Digital Built Britain. They are focused under the core values - purpose, trust and function:

1 Purpose - why the digital twin exists

- Public good - deliver clear benefits for society, economy, and environment
- Value creation - enable positive outcomes, including efficiency, innovation, and improved decision-making
- Insight - improve understanding of the built environment and support better actions

2 Trust - ensuring people can rely on the digital twin

- Security - secure by design, protecting sensitive data and critical infrastructure
- Openness - data and models should be as open as possible to promote innovation and transparency
- Quality - data and information must be trustworthy, accurate, and well-maintained over time

3. Function - making it technically and operationally effective

- Part of an ecosystem of connected twins, rather than a single, centralised model
- Curation - information should be carefully managed, kept-up-to-date, and preserved for long-term value
- Evolution - should adapt to changing needs, technologies, and data sources

STRUCTURING: A BIM MANDATE

Given the challenges facing the infrastructure sector, a BIM mandate would significantly help accelerate adoption of digital twins and other digital tools by creating a foundation of standard data. Data is currently siloed across Canada with limited coordination or interoperability holding back progress. Consistent, quality data is the bedrock of a swathe of technology solutions that could yield significant benefits in terms of reducing project costs, ensuring more projects are delivered on time and on budget, and overall infrastructure investment is better aligned and delivers better outcomes.

Other countries have gone different routes, but a phased in mandate, with associated supports to help companies adapt is recognized as the most effective way, starting with a BIM mandate built around the adoption of international ISO 19650 standards. It would send a clear direction and expectations that if they want to participate in government funded projects over a certain size they should be equipped to operate in a digital way.

The value of a mandate with set timelines is the clarity it provides to the sector. It provides a consistency to the market that can accelerate investment by the private sector, and enable coordination across owners to provide a more consistent approach and the ability to share insights. The 250% rise in use of BIM in Quebec demonstrates the impact a BIM mandate can have.

Quebec

Within Canada Quebec is leading the charge with the publication of the Quebec BIM Roadmap in 2021 which stems from the province's Action Plan for the Construction Sector. The Action Plan formalized the government's commitment to implementing BIM and making it a requirement for the execution of public infrastructure projects across eight major public project owners including the province, Hydro Quebec, and three major municipalities.

Every year the province reports on the number of projects using BIM rising from 77 in 2021 to 194 in 2025, with the Société québécoise des infrastructures responsible for 90 of those projects. SQI is also at the forefront of meeting mandatory targets with all projects over $50 million having to integrate BIM in 2021, down to all projects over $5 million in 2023, and finally full adoption by 2026. The plan includes a series of supports to help owners, contractors and the supply chain adapt.

UK

The UK published Government Construction Strategy in 2011 which provided a BIM mandate. Their process began with pilots before a mandate kicked in in 2016 for all centrally procured government projects requiring BIM level 2. They also developed an internal BIM Working Group to embed BIM level 2 and realise benefits. In 2016 the updated Government Construction Strategy upgraded its requirement to BIM level 3 based off ISO 19650 standards originally by 2020, but revised to 2025. This enables greater real-time collaboration, enhances interoperability, incorporates lifecycle aspects and lays a platform for Digital Twins, Artificial Intelligence, and Internet of Things. In 2018 the government launched its National Digital Twin Programme to foster the development and adoption of Digital Twins.

Singapore

Singapore's Building and Construction Authority launched a roadmap for BIM adoption in 2010. As of 2015 all plans for buildings over 5,000 m2 had to be submitted in BIM format with a goal that 80% of the construction industry would use BIM by 2015 and a goal to improve sector productivity by 25% over the subsequent decade. A major challenge cited was the need for training and upfront investment across the private sector. A second BIM roadmap launched in 2014 focused on greater collaboration through the value chain. Singapore set a target of all regulatory submittals for new builds to go through their CORENET X platform by October 2026.

Ireland

Ireland recognized that the public sector represents 25% of construction activity and is therefore critical in driving sector digitalization. The government published its BIM Guidance and Public Works Strategy in 2023 with a phased timeline so all projects over €100 million by January 2024 for designers, then one year later for contractors and the supply chain. The subsequent milestones are at €20 million, €10 million, €5 million and €1 million with designers expected to lead followed by contractors and supply chain in each case. The final milestone for contractors and suppliers on contracts over €1 million which has to be reached after a four-year transition from January 2024.

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4 PREPARING THE SECTOR

A major barrier to change relates to the buy-in and interest, particularly at senior levels, across the infrastructure supply chain. Part of this is addressed through a clear overarching strategy that provides clarity around future expectations, as well as setting consistent standards. This gives industry confidence to invest in the talent and tools to enable them to play a full role in the market and be successful in the long-term.

The adoption of digital twins and associated technologies, and especially the introduction of any requirements that are made mandatory need to consider the current experience within the market and the time and cost needed to adapt. A coordinated program of resources including toolkits, training, and funding can help overcome those local barriers and drive more successful outcomes.

25 Engagement and Awareness Building – as with any major change in approach there needs to be a program of awareness building and engagement to identify and work to address any issues of concern that could hinder adoption. Governments should look to include industry in the development of goals, processes, rollout, and potential supports. A good example if the widespread awareness building program undertaken by Infrastructure BC when they were introducing new procurement models in the market.

- An advisory group that brings together different end users, industry players, public sector clients, technology players, training and academia, and select specialists. This group can act as a sounding board around realistic timelines for reaching set goals, types of supports and guidance that would be most helpful, and raise any concerns that may stall progress.
- As with any change, some organizations and projects will enthusiastically adopt the new approach, while others will take longer or resist any change. The roll-out should look to provide incentives and remove barriers to accelerate and encourage early adoption of digital twins.

26 Digital incorporated in early market engagement – early and open dialogue with the pool of bidders and suppliers plays an important role in determining digital capabilities and any specific information or data needs that could benefit the project. Early contractor involvement or incorporating market engagement provides a basis for delivering greater impacts from the use of technology, as well as ensuring the market is sufficiently experienced to meet the requirements set down as part of any tender. This also helps to build understanding of requirements and boost confidence as part of the transformation process.

27 Plain language guidance – the concept, acronyms, and language used to explain digital twins, data, and requirements is difficult enough to understand. It is important that guidance, procurement and contractual language is reviewed to ensure it is brief, clear, and easy to understand for a non-technical audience. This has underpinned successful digital transformation efforts in the UK in particular with plain language emphasized as a critical piece to enable adoption.

28 Training – preparing the sector requires three levels of training that cover both the public and private sector. The UK's Construction Leadership Council produced a framework for skills that are needed within the sector as a basis for training. This extends beyond pure technical skills to address knowledge of how the use of digital twins can be leveraged across a project lifecycle to deliver value. These include: (Source: UK BIM Task Group)

- **Strategic** – what are digital twins, what benefits they provide.
- **Operational** – change management, governance, procedures, policies, standards, and contract management.
- **Technical** – technology and tools, data, standards, and reporting.

29 Supplier digital assessment – to provide clarity around general competency requirements, and to streamline procurement, supplier digital competence should be assessed. Scottish Futures Trust, Scotland's infrastructure agency, uses a Supplier BIM assessment form to assess competence, understanding and maturity. Quebec also uses a similar approach as a basis to develop a more tailored training and support program.

30 Funding – providing the carrot of funding helps organizations adapt to new technologies. Funding can be targeted at costs of training or new equipment or software, as well as potentially providing competition based funding where organizations can respond to certain challenges that would help guide wider policy.

- Businesses – funding for companies helps to encourage adoption, and reduce any opposition to the new approach of ultimately using digital twins. Funding should be targeted, and staged for impact.
- Public sector – there should also be funding targeted at municipal governments and the wider public sector to adopt digital twins. A good template would be Ontario's Municipal Modernization Program which provided funding for primarily small and rural municipalities to modernize their services through the adoption of technology.

Best Practice: IQC 4.0, Quebec

l'Initiative Québécoise pour la Construction was set up by the Ministry of Economy and Innovation in Quebec to support the construction industry in a major digital transition. This initiative has four parts:

1. Diagnostics – organizations are selected and through interviews and assessments of current status and goals an individualized action plan is developed for the organization to follow. This diagnostic is also available for the public sector.
2. Training and support – firms can be reimbursed up to 50% of the total value of their digital transformation for training and technology costs. Companies are selected and it requires commitment from company leaders. A personalized approach is provided that includes employee training, technology integration, and pilot projects based on an individualized action plan.
3. Project Locomotives Funding – targeted funding for improvement projects that involves implementation of digital technologies and training with. It follows an intake process and successful submissions get 50% reimbursements.
4. Digital Resources – a "Digital Chest" provides a space where all Quebec construction companies can select from approved software tools that align with open standards covering administration and management, design and modeling, and consultation and sharing.

Best Practice: Skills and Competency Framework, Centre for Digital Built Britain

The Centre for Digital Built Britain recognized that the success of any move towards a digitally enabled sector was less about the capabilities of the technology and more about people and skills. Overall they recognized that the sector lacked digital readiness. As well as data standardisation, compatible systems, clarity of roles and responsibilities related to digital capabilities, the most important aspect was individual capability – which it aimed to address through this framework.

It is organized into four parts:

- Skills gap – they identified key business skills that ensure technology is impactful, as well as digital skills in areas such as user experience and cyber security specialists
- Priority skills – across the roles needed there were shortages in some areas and some roles that were completely new
- Role profiles – covers responsibilities, specific business and digital skills requirements for needed roles
- Tools – it provided competency scorecards for specific roles to support planning and hiring

PREPARING: THE MARKET

Within the infrastructure sector there is a wide disparity between the experience around digital technology and the capacity to adapt. To enable successful adoption there should be a mix between providing incentives and a barrier free route to application for early adopters, while providing certainty and support to the wider sector.

Approach	Examples
Clear Timelines – a the private sector values clarity and advanced notice of significant changes. A phased BIM mandate can provide a clear expectation of government which starts with the largest, and most complex projects and is gradually expanded over time. Clear expectations and dates should give enough time for companies to adapt, invest, and recruit and train people with the required skills.	The **Province of Quebec** provided a phased mandate over 5 years, starting with projects over $50 million. Further clarity was provided with a BIM Roadmap that outlined key dates when there was an expectation that projects of a certain size would be required to use BIM, and supports available to help companies prepare. They also reported on uptake via a report.
Awareness Building and Support – as with any major change there needs to be a sustained drive to build awareness and proactively answer questions and address concerns. The sector needs to be involved in the development and implementation of digital tools through consultation and potential standing advisory boards.	**Transport for NSW** hosts an annual InMotion supplier and contractor engagement event to build understanding of the overall future direction of the organization, including new initiatives and innovations. **Infrastructure BC** holds pre-procurement workshops on projects to tap into local market sentiment, get perspectives on procurement models and projects risks and this approach can be used to determine digital maturity and data needs.
Capacity Building - There needs to be a comprehensive approach to providing training aimed at different levels within the market from leadership to technical skills. Understanding the digital maturity level helps to target interventions and training where it is most needed. There should also be funding available for training and investing in technology to encourage early adoption and support strategic parts of the industry who most need help.	**France Num** is a program specifically focused at smaller companies (across al sectors) providing resources including simple "how to start with BIM" guides, offers vouchers and funding for initial digitalization projects. There are various funding programs across Canada focused on digital adoption including the **Canada Digital Adoption Program**, Business Development Bank of Canada loans for digital transformation, as well as provincial programs, as well as existing provincial programs to support investment and training. The **Construction Leadership Council** developed an industry-based digital skills report which mapped out broader and enhanced digital competencies for companies of all levels.
Standard Approaches and Process - simple, standard approaches build consistency and understanding across the market. Having consistency makes it easier to build capacity in the market through the rollout of agreed standards and procurement and contract templates.	**Scottish Futures Trust** created a Standard Information Management Plan which provided greater consistency of information requirements, they also have tools including an return on investment tool for the public sector and a supplier digital maturity assessment. The Netherlands has **BIM Loket** which provides a national portal that aims to provide consistency across the market. It acts as a hub with a focus on promoting open standards, provides templates, guidance, runs events and webinars, offers training, and provides hands-on support. It also worked on early-adopter pilots, which have become case studies for training.
Early Adoption – many companies are already quite advanced in their use of digital technologies. This provides a readymade cohort to drive early momentum. This enthusiasm should be leveraged by providing clarity on direction, providing clear standards, unblocking any barriers, and providing funding and other incentives.	The **Digital Twin Hub** in the UK was set up to be an industry-led hub to share knowledge, agree common approaches, and shape future standards. It is home to a toolkit, supplier register, online training, and forum. It is also part of the UK's innovation accelerator network of catapults which provides pilot opportunities and supports business development. **Transport for New South Wales** has a Gateway to Innovate portal which provides a route for companies to propose "tools or processes could we introduce or change to increase productivity on our projects and make our industry more efficient". It provides guidance on the types of areas they are trying to improve upon, including project management and automation. It does not provide grant funding, just a route to market.

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5 LEGAL AND REGULATION

There are two components in the legal space, one explicitly links to the treatment of data, and the other the potential for synergies across wider regulation.

The challenge has been that many legal requirements have sometimes acted as a block to progress, due to being outdated and/or confusing. Specifically areas such as liability, data restrictions, security and integrity, intellectual property, and responsibility must all be addressed.

Many processes are anchored in paper or require standalone submittals that are hard to map and based around specific needs of regulators in each area. This illustrates that the technology itself will not be a silver bullet, there needs to be a change in approach. Digital twins provide a window into the future that could help regulators be even more impactful in ensuring projects meet their requirements around the environment or safety for example. Done right this could enable a complete shift in mindset from "whether" a project should be built to "how" a project can be built. It can also help existing facilities adapt or evolve to new realities such as health or environmental changes quicker and more effectively.

The COVID pandemic did drive a degree of change when it became clear that building permits that were required in paper form were holding up project progress and many municipalities and provinces used it as a spur to look at digital solutions. However many project reviews by planners, architects and engineers currently do not allow for submittal via BIM or digital twin.

Data Requirements

There is a major need for legal clarity around data use in infrastructure projects. As stands legislation fails to create certainty that enables the adoption of impactful technologies such as digital twins. There are real and perceived barriers that prevent data collection and sharing, and there is a real need for clarity via policy direction and potentially legislation to enable adoption of key technologies. Adding to the confusion is the fragmented approach to legislation around data, with provinces having their own legislation in areas such as privacy.

Privacy and security are often cited as reasons to not try new technology. Data ownership is both a legislative and contractual barrier, and intellectual property rights can also be unclear causing delays. There can be issues where local data hosting is required. There are also examples where agencies have held back from implementing new technologies due to a clack of clarity of how they should be treated by existing legislation. This is particularly the case for Artificial Intelligence and Machine Learning. Beyond these areas there are also concerns around how data can be used within legal cases and disputes relating to the project, or as part of Freedom of Information requests.

To overcome these real and perceived barriers there needs to be clarity from a political level, agreements in place to allow the sharing of data, and potentially legislation. There is also an opportunity to leverage tools like regulatory sandboxes, which allow governments to refine regulations so that they still serve their purpose without stifling innovation.

31 Clear policy direction – providing publicly stated policy goals helps provide certainty for people working on the front lines of project planning and delivery. Transport for New South Wales for example mandated the use of digital engineering for public transport infrastructure. For consistency this should align with broader infrastructure policy and digital government policy to eliminate confusion. Sharing of information and data on built assets should be the default position, especially where no personal data is involved.

Data sharing agreements and directives help overcome internal hesitation and reduce the need for legal reviews, some governments have implemented data sharing agreements to enable and encourage data to flow between government departments and agencies. It is widely recognized that better access to data across government has many benefits including greater efficiency, more responsive to issues arising, better coordinated, and more evidence-driven. Directives are also binding on the public service and would help provide clarity within government around data that should be shared for the deployment of Digital Twins and the benefit of delivering and operating infrastructure more efficiently.

Within Canada information sharing agreements are used within government, but should typically just apply to personal information. Ontario's Digital and Data Directive requires that data be open by default unless it is exempt for legal, privacy, security, confidentiality or commercially-sensitive reasons. Too often these reasons are cited for not sharing not only externally, but within government. Updating the directive or creating a standalone directive for core infrastructure data, could help to encourage greater information sharing.

Australia has an Inter-governmental Agreement on Data Sharing that commits all Australian jurisdictions to share public sector data as a default where it can be done securely, safely, lawfully, and ethically.

As highlighted above, the key open international standards that have underpinned digital transformation around the world have been road-tested and cover any conceivable requirement around ownership, shareability, security and ethical use. These can be adapted for the Canadian market, ISO 19650 for example already has a Canadian annex developed by the Canadian Standards Association.

32 Clear legislation - though it may not be strictly necessary, clear legislation removes uncertainty. It works best if done at a national level that aligns with international approaches. Without legal clarity public sector agencies and departments will often air on the side of caution and avoid sharing data. They will often defer to the exceptions as well of data being either legal, privacy, security, confidentiality or commercially-sensitive reasons.

There may be value in providing a specific carveout for built assets, with greater clarity on what those exemptions would cover specifically and providing less room for broad interpretations. Norway's Planning and Buildings Act requires digital models in planning and approval processes.

33 Regulatory sandboxes - regulatory sandboxes provide a controlled environment to test innovations in the real world without being subject to the usual regulatory requirements. Done under the supervision of regulators it provides a basis to learn, identify risks, and create more effective regulations that continue to serve their purpose but also allow technological advancement.

Best Practice: Model as a Legal Document

US Departments of Transportation have been moving towards accepting digital models as contractual documents as more agencies move away from paper to digital infrastructure models. This was further accelerated by a dedicated program included under the Infrastructure Investment and Jobs Act to encourage departments of transport to adopt digital technology.

The Utah, Pennsylvania, and Texas Departments of Transportation have been leaders on adoption developing comprehensive processes and tools to get the greatest value of the digital transition towards integrated digital delivery. A core part of that journey has been to ensure that three dimensional models can serve as legal documents to avoid unnecessary duplication. DOTs have developed a suite of documents to inform their journeys from assessing maturity, to guidance around internal and external engagement, to contractual terms.

Best Practice: Ontario Energy Board Regulatory Sandbox, Ontario

An example of a regulatory sandbox in Canada is that deployed by the Ontario Energy Board. It provides intakes based around specific market challenges where proponents can put forward projects and the OEB provides some funding as well as regulatory guidance to test innovations. There is a regular intake that is based around addressing specific challenges with an opportunity for industry to propose other challenges that have included topics such as grid services, deep retrofit technologies, alternative utility practices. Proponents provide proposals and secure up to $1.5 million as well as ongoing guidance to test their concept.

Other legal instruments:

- Data Use and Access Bill (UK) - provided certainty around development of National Underground Asset Registry
- Data Availability and Transparency Act, (Australia) - protects citizen data but enables sharing across government to enable coordination between transport, utilities, and environment for example
- Data Governance Act (EU) - enables sharing of public and private data for use on digital twins with consent and anonymisation/ Construction Products Regulation - encourages digital documentation and defines data ownerships and sharing rights
- Act on Information Management in Public Administration (Finland) - provided the basis for data security, quality and interoperability supporting deployment of BIM and enabling digital workflows

Project Related Regulatory Requirements

One of the biggest factors impacting project success is navigating the maze of requirements from regulators, professional bodies, municipalities, and other organizations that require approvals. Integrating these approvals into a Digital Twin could be a win-win in terms of reducing administrative overlap and uncertainty, while delivering better outcomes and assurance for regulators. Singapore has been leading the charge in developing a single window to streamline regulatory compliance called CORENET X. The technology provides a platform for a coordinated response and enables concurrent submittals saving significant time.

34 Mapping regulatory requirements - projects and programs of different kinds have to navigate a maze of different requirements that relate to their sector and location. External factors have been highlighted as a key area of risk on project and better visibility and coordination could yield significant time and cost savings. There is currently work underway by AECO Lab looking at the full range of regulatory standards, bylaws, and policies related to development approvals. Similar work mapping requirements for infrastructure projects could help to find synergies and conflicts, as streamline the process as part of one single digital model.

Governments have been moving to one-window approvals and digital delivery of services. This should extend to requirements for construction and infrastructure projects. A digital-by-default approach would provide an impetus for a variety of public sector entities to develop a more integrated approach to approvals, ideally via a single digital twin.

35 Platform for submittals - providing a central hub for key submittals can ensure more processes are brought online and avoid significant duplication. As levels of government seek to address barriers to constructing major projects, creating a one-window system linked to a digital twin could unlock a lot of valuable information and provide a catalyst for regulation to be more aligned and approvals to happen concurrently.

Best Practice: CORENET X, Singapore

Singapore worked with government and industry to transform the process for regulatory compliance across multiple agencies for all new buildings works. It relies on technology and BIM to streamline regulatory processes. It requires more upfront collaboration on designs prior to submission, but enables industry to conduct pre-submission checks and allows public agencies to review the submission and issue a coordinated response, avoiding the need for industry to deal with multiple agencies and having to reconcile the requirements. It also supports concurrent submission, enabling the approvals processes to overlap, saving significant time.

Submissions are made in openBIM format meaning that only the digital model is provided to obtain multiple approvals via a staged gateway process, so submissions are made at design, foundations, and construction. A gateway is only cleared after all agencies' approvals are obtained. As of October 2025, all projects over 30,000m3 gross floor area are required to be submitted via CORENET X, with a staged process for implementation where all new projects submitted by October 2026.

Best Practice: Binaa, Abu Dhabi, UAE

Abu Dhabi's Department of Municipalities and Transport streamlined the decision-making process for permits and approvals using the Binaa platform. It is based on a digital twin of buildings and infrastructure for planning, simulations and compliance checks. It incorporates a range of data including geospatial, property information, LiDAR scanning and enables planners and engineers to simulate impacts of infrastructure proposals and identify potential conflicts before construction. The integrated platform allows 15 government entities to review relevant documents, as well as providing a single platform for contractors, project owners and consultants to secure certifications and permissions to move forward at every stage.

NEXT STEPS:
PRIORITY ACTIONS

"Technology on its own cannot provide the answer to the need for greater efficiency and quality in construction. There have been celebrated examples of new technology being used to reinforce outdated and wasteful processes and it does not work."
Sir John Eagan, Rethinking Construction, 1998

There are no shortages of challenges facing the infrastructure sector, and technology in of itself will not solve the issues faced. It does however provide a catalyst that could bring greater visibility on projects, improve communications and collaboration, provide a better understanding of root causes and impacts, and provide a modeling function that predicts impacts of choices. It is worth examining the experiences of government digital transformations more broadly to learn from what has worked and what has not. To unlock these potential benefits there needs to be a staged plan with accountability and milestones. Below are some steps to implementation that could form a basis for a way forward across Canada.

Implementation

Stage 1: Setting Direction	1 Mandate and empower clear organizational leadership with high calibre expertise 2 Develop government industry advisory group 3 Consult industry on real world problems to solve and high impact use cases, as well as skills gap analysis 4 Publish clear strategy with goals and timelines, including setting out standards and BIM Mandate
Stage 2: Early Adoption	5 Announce first program of digital transformations based on impact against clear timelines 6 Governments and key industry associations develop and roll out training based on competency framework 7 Funding available for early adopters from municipalities and private sector 8 Publish toolkits, templates, and processes to provide consistency of adoption on digital hub 9 Targeted training for small and medium business and less experienced public sector organizations 10 Launch challenges around key challenge areas for infrastructure 11 Provide regulatory sandbox to test new approaches and technologies
Stage 3: Maintaining Momentum	12 Regular open reporting on progress 13 Awards for successful projects 14 Review of established processes to assess potential for transformation and technology potential 15 Tailored support for more challenged organizations/more complex areas 16 Legislative changes where necessary to remove persistent barriers

NEXT STEPS:
PRIORITY ACTIONS

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Implementation

Problems to solve

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