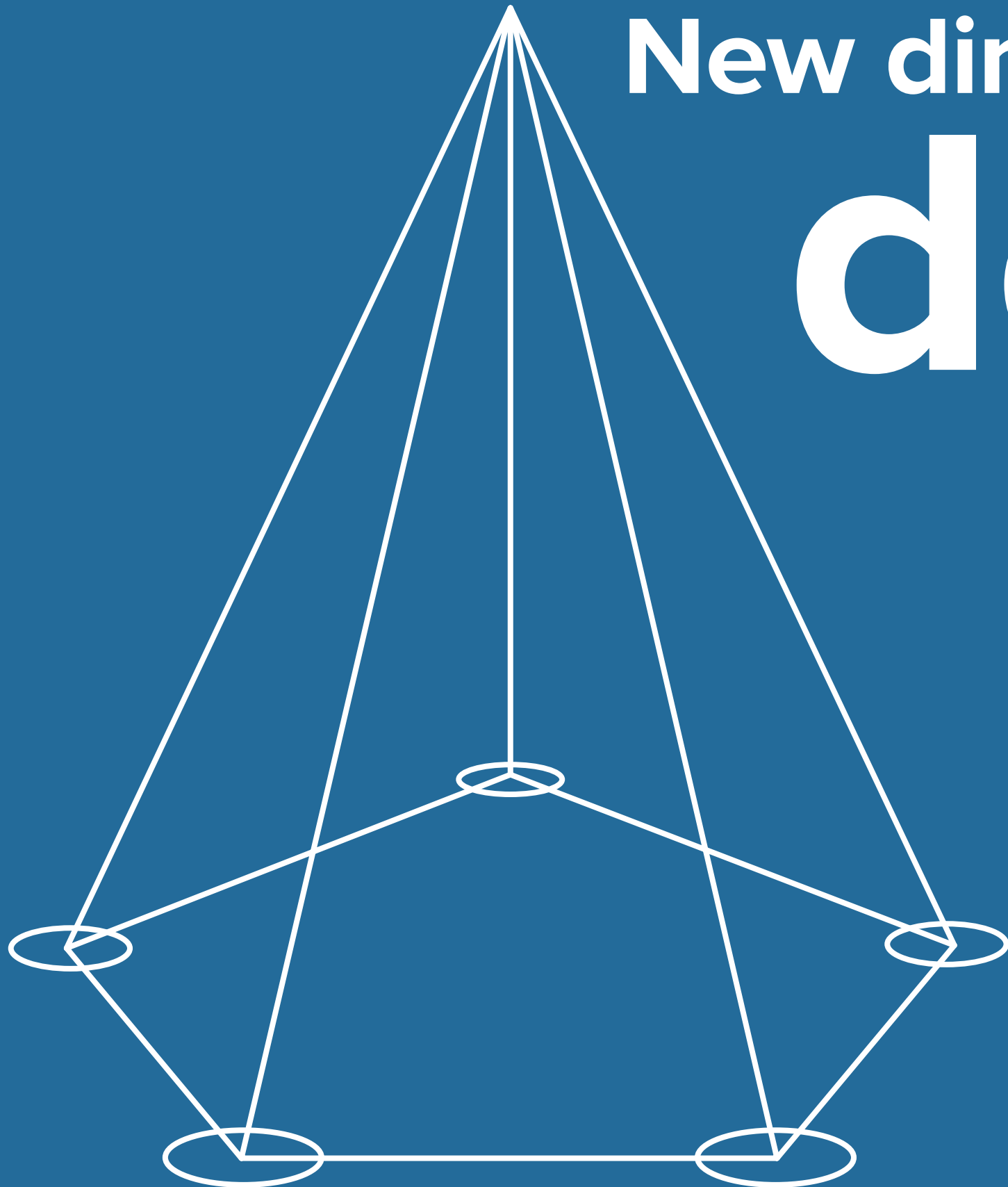


New dimensions to delivery



The role of collaboration and technology in improving asset delivery and the performance of infrastructure in use

April 2020

This paper is about delivering the right outcomes in the right way

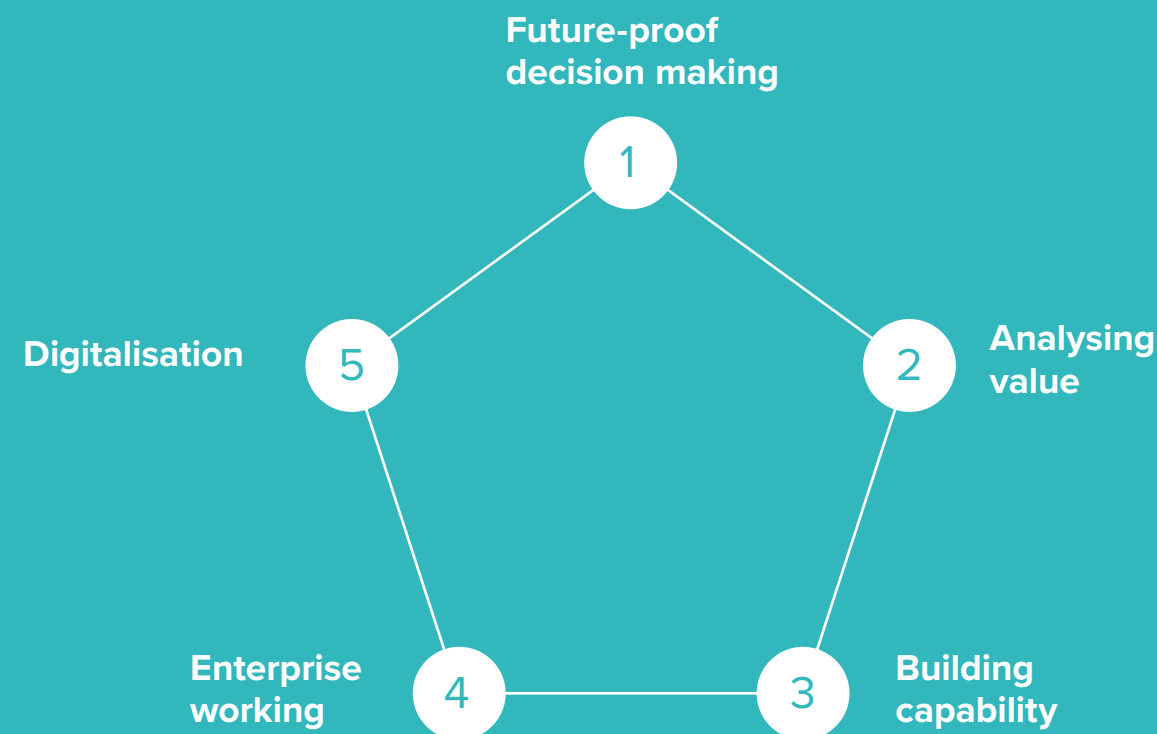
Transformational change is required if the infrastructure industry is to overcome its traditional delivery challenges as well as respond to a host of emerging imperatives. This paper highlights some of the key steps that are needed in the transformation journey.

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Introduction

Transforming infrastructure

Proposing a solution



What does smarter delivery mean for you?

- > The transport planner
- > The programme manager
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Defining the problem

- > Challenges with **delivery**
- > Challenges with **integration**
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- > Upgrading Waterloo Station
- > Expanding Sydney's Metro system



‘Safe, on budget and on time’ have been watchwords in our industry for decades. They continue to challenge all involved in delivering and managing infrastructure, even as new imperatives emerge.



Like safety, cost and schedule management, some of the new drivers are about how interventions are carried out – the ‘right way’ part of this paper. They include low/zero carbon, sustainable resource use and industry recruitment, skills and professional development.

Other new drivers bring into question the what and why of the intervention itself – the ‘right assets’ part of the paper. They include response to socioeconomic and technological change, resilience to the physical impacts of climate change, the pursuit of socially inclusive growth, whole-life performance and value, the need for adaptability over time, and public health and wellbeing.

Tools for the job

The question of how to deliver projects better has generated a wealth of literature and recommendations, much of it excellent. In preparing this paper we haven’t sought to invent new remedies. Instead, we make the case for integrated thinking, bringing together a number of leading methods, strategies and tools, to address the full breadth of our industry’s increasingly complex challenge: delivering the right outcomes in the right way.

The purpose of this paper is to...

... invite a discussion about change – and the adjustments needed to organisational structure and culture, leadership, strategy, planning and commercial arrangements.

This paper is aimed at...

... everyone involved in decision making around the planning, delivery, integration and operation of infrastructure assets. It recognises that ultimate control over project delivery lies with client organisations, so it is aimed particularly at them – and in particular heads of asset management, customer service, digital, finance, operations, planning, procurement, and programme and project management.

This paper also recognises the importance and influence of the supply chain. Consultants, contractors and suppliers need to be aware, receptive and responsive to change that clients want to initiate.

Policymakers and regulators who shape the operating environment for infrastructure owners and operators should know how to challenge industry performance in a positive way.

It is part of a wider programme

In 2019 we initiated Transforming Infrastructure, a programme of inquiry into key challenges facing those involved in creating and managing the built environment. This exploration of issues in infrastructure delivery is the first output and it flags themes that will be explored in greater depth by future Transforming Infrastructure workstreams:

- inclusive growth
- the digitalisation of social and economic infrastructure – both in the way it is created and used
- carbon reduction and resilience to climate change.

Get in touch

If you’d like to discuss any of the issues, recommendations or opportunities in this report we’ll be delighted to hear from you – you’ll find the names and contact details of subject experts throughout.



Transforming infrastructure

Delivering the right outcomes in the right way

The demands placed on infrastructure and the infrastructure industry are changing at an ever-faster pace. The speed and scale of social, technological, economic, environmental and political change is already disruptive; the degree of uncertainty is unprecedented.

Our 'Transforming infrastructure' programme is a response to that, examining the major issues affecting infrastructure delivery and management, and the social, economic and environmental outcomes achieved.

Our aim: to share best practice and provide insight, to challenge industry thinking and behaviour, to stimulate discussion and collaboration, to ask important questions and advance solutions. Above all, to deliver better outcomes.

Projects and interventions need to deliver positive outcomes today and in the long term. Individual assets last decades. Many of the infrastructure systems they are part of have existed for centuries.

The whole-life performance of infrastructure presents important challenges for today's engineers. The way those challenges are addressed can make the difference between existential threat or potential opportunity.

The following are the most prominent current and emerging crunch issues, requiring a transformational response from the industry.

Decarbonisation

The overwhelming evidence of climate change and growing recognition globally that it is a manmade emergency requires an urgent response. Developed countries must cut their emissions of greenhouse gases (CO₂ equivalent) to net-zero by 2050, to play their fair part in halting the further concentration of CO₂ in the Earth's atmosphere. For infrastructure owners, operational and capital carbon reduction are an essential part of a wider climate-related risk management response, but also a means of achieving commercial efficiencies and cost savings, safeguarding their reputation and attracting investment.

Physical adaptation and resilience

As part of their response to climate change, infrastructure owners must adapt to the physical impacts of climate change. Even if emissions ceased now, global warming will continue due to the locked in effects of historic emissions with consequential sea level rise and more extreme weather, resulting in more severe and frequent flooding, drought, wildfires and storms. Infrastructure and populations need to be protected and, where damage is inevitable, systems put in place to ensure early warning and speedy recovery. Predicting what adaptations and resilience improvements are required, and financing these, is a major challenge for the industry globally.

Social inclusion

Most people agree it is not acceptable to promote economic growth at any cost. Government and private companies are increasingly talking in the language of 'inclusive growth'. The Organisation for Economic Co-operation & Development defines inclusive growth as that which "creates opportunity for all segments of the population and distributes the dividends of increased prosperity, both in monetary and non-monetary terms, fairly across society." Internationally, the agenda aligns with the United Nations' Sustainable Development Goals principle of leaving no one behind. Infrastructure owners are increasingly expected to ensure that their projects and interventions achieve positive social as well as economic and environmental outcomes.



Digitalisation

There are two principal facets to digitalisation: its effects on society and society's use and expectations of infrastructure; and its use by the infrastructure industry to plan, deliver and manage assets and asset systems. In response, the whole infrastructure industry is having to adopt new tools and methods, and adapt their skills and culture.

Digitalisation of society. Digital technologies are rapidly changing work, travel, retail and leisure possibilities, expectations and patterns. Infrastructure systems and services are already having to adapt, and the planning and delivery of new infrastructure is having to become more flexible to cope with uncertain future requirements. At the same time, digitalisation is enabling users unprecedented choice and control over how they access and 'buy' infrastructure services, effectively raising expectations regarding the quality of service provided.

Digitalisation of infrastructure delivery and management. In the delivery and management of infrastructure, the ability to create and harvest data, analyse, model and share it, offers the potential to improve efficiency, outcomes and value over the whole of the asset lifecycle. Digitalisation offers unprecedented potential to do more for less by enabling problems to be understood and solved better, to target investment and resources where they'll do most good, to anticipate risks and manage them, and to respond swiftly to incidents. However, achieving all this requires transformative change – from the overlaying of digital infrastructure on existing physical infrastructure, to the adoption of common tools and methods for digital collaboration. Enterprise working, supported by the right contracting arrangements, may be required to bring about the desired step change.





What are we delivering?

What does our industry – the infrastructure industry – think and talk about most? Projects that create new assets. While building new infrastructure is important, the focus is wrong.

Mature economies have extensive, highly evolved, integrated and interdependent infrastructure systems that provide all society's essential services. Much existing infrastructure is many decades old and parts of it centuries old. New construction adds only 0.5% by value, annually, to the existing asset base, showed a study of the UK water sector. The ratio of new to existing is similar for other infrastructure sectors.

Even the largest projects are 'merely' add-ons to existing infrastructure systems.

Sustainable systems of services

Infrastructure exists to support economic and social wellbeing. Poor infrastructure results in poor economic, social and environmental performance. Our times demand that we reimagine the 'infrastructure industry' as more than simply builders, to become the stewards of sustainable systems of infrastructure services. These services underpin the quality of life of all people today and must deliver optimum outcomes for generations to come.

We must recognise that infrastructure enables – or can inhibit – a flourishing society and must be created and managed within the Earth's productive and absorptive boundaries.

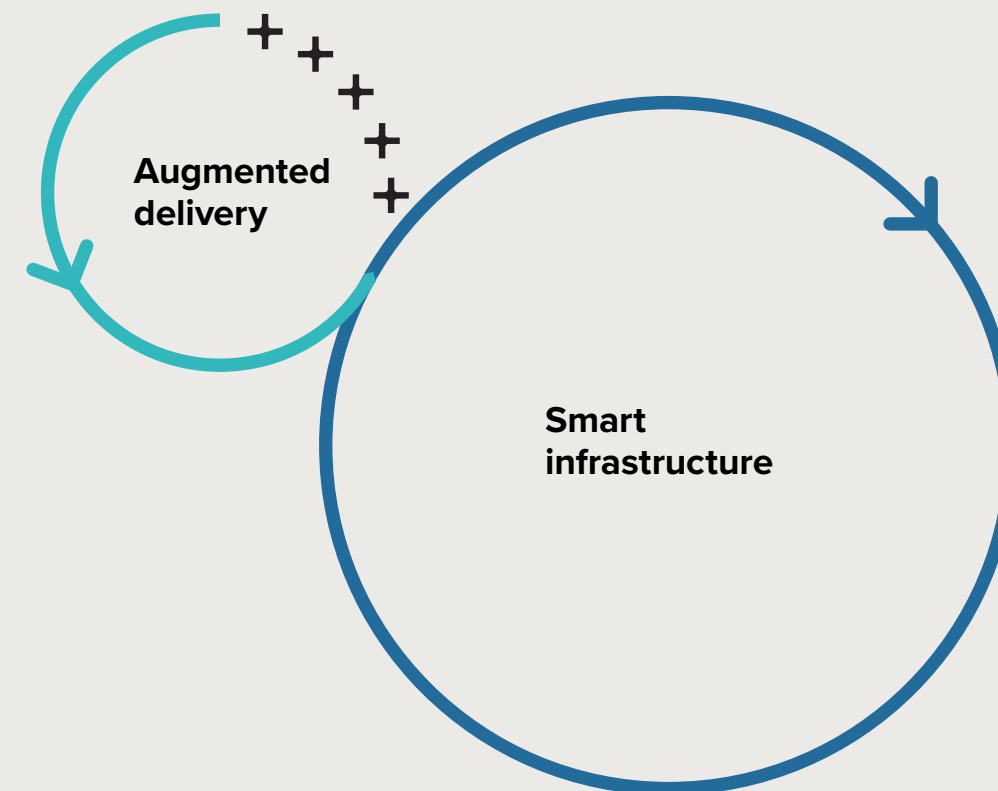
A joined-up system of systems

Infrastructure systems, from mass transit to water supply, are made of many assets, processes and systems that must work in harmony to yield the required services. Infrastructure owners and operators rely on multiple asset systems to function effectively. Many systems are connected to and dependent on one-another within and across different sectors – communications, electricity, transport and water, for example – and between organisations, regions and nations. It is important to be aware of interdependencies between systems because of the potential for failures to cascade, and for inefficiencies in one system to drag on others. Equally, improvements in one system may fail to deliver their full value unless blockers are removed in others.

High-performing infrastructure

Changing social, economic, environmental or legislative needs may require new assets – and new kinds of infrastructure services. For example, decarbonising our economy demands and creates opportunity for new businesses and operating models, employing new technologies. The first step is to see if the need can be met with existing assets. Tackling the need at source is sometimes possible by working with customers and other stakeholders to change their behaviours – to reduce demand for power, water or road capacity, for example, or by altering land use practices to limit the risks of flood and drought and improve water quality.

'No build' solutions can be found by making existing assets work better. This involves taking a holistic view of asset management – developing the organisational capability to make infrastructure smart, resilient and sustainable.



Through-life delivery

Assets have lifecycles, but our infrastructure as a system of systems does not. It has to last for ever – for as long as society lasts. Whether a project involves creating, extending, maintaining, enhancing or adapting assets, these are all simply interventions on the system. Augmented delivery involves using human and technological expertise to make the right intervention decisions, with each intervention requiring effective delivery in its own right. Marrying physical infrastructure with digital technology (smart infrastructure) boosts outcomes across the system: Data created during asset delivery aids operation, while operational data improves the planning of investment in, and delivery of, future interventions.

Smart infrastructure marries digital technology with physical assets, using data to make better decisions, faster and cheaper. Creating high-performing, smart infrastructure is itself a delivery challenge, requiring multiple programmes of interventions on existing assets and systems, as well as hard-wiring new assets so that they are smart from the start.

Value of the system

Whether intervening to sustain, adapt or improve existing assets, or building new ones, delivery should start by considering the value of the system as a whole and what value the intervention will add.

This is not as complex as it might sound. There are many examples now of best practice in collecting data, making sense of it and then using it in real-time to make beneficial infrastructure decisions, both for the infrastructure owner and end users and beneficiaries.

New assets and infrastructure as a whole should optimise economic, societal and environmental outcomes, perpetually, for all stakeholders – with particular attention to customers and affected communities. It means creating alignment between customers, communities, owners and deliverers, throughout the entire lifecycle of infrastructure. This delivers best value for the owner, investors and the ultimate customer, society.

Which is why new dimensions to delivery are important – to develop and adopt the means of achieving the right outcomes in the right way.



Defining the problem

Traditional approaches to project delivery don't adequately address the requirements of today's infrastructure and the organisations that create and manage it. Here's why.

Challenges with delivery

Blowing the budget

For this paper, we reviewed delivery-related literature and analysed the performance of 20 major transport infrastructure projects around the globe to identify the most common causes of delivery problems.

We found that large rail projects go over budget by 45% on average,¹ bridges and tunnels by 35%, and road projects by 20%. The larger and more complex a project is, the greater the apparent risks of it running into difficulties: among infrastructure ‘megaprojects’ that exceed US\$1bn in value, nine out of 10 go over budget, according to a 2014 study by Professor Bent Flyvbjerg of Oxford University.²

Faulty forecasts

Initial estimations of cost and time are fraught with difficulty. Some variables depend on the result of activity (for example, site investigation to determine geotechnical risks) which is impossible to perform without full access to the site. Other potentially costly items (such as utility relocations) may hinge on third parties.

Even if estimations are based on information that is as complete as possible, they are often unduly optimistic, especially when they are drawn up by people or organisations with an interest in the project going ahead.

Poor decision making and scope creep

If the aims of a project are poorly defined at the outset, late requests and changes are almost inevitable. During design or construction these can force completed work to be redone. Failure to consult widely enough early enough can be a source of problems if adjustments have to be made after the initial scoping, optioneering and outline design phases. The involvement of multiple stakeholders with competing priorities (from within the client organisation or without) can add to the risk of scope creep.

On average

Large rail projects go over budget by...

45%

Bridges and tunnels go over budget by...

35%

Road projects go over budget by...

20%

Political change

Most infrastructure projects have a degree of political involvement, as they can have significant impacts on the community, jobs, economic growth, public finances and the environment. As planning, design and delivery will normally span more than one electoral cycle, they are often a subject of political interference that can lead to delay, additional cost, cancellation or reinstatement, in particular when there is a new incumbent.

Confrontational contracting

Procurement and contracting can produce perverse results. A classic pitfall is over-emphasis on low cost when inviting tenders, and the contractual offloading of disproportionate risk on to members of the supply chain. It results in a claims culture that escalates cost and eats time. Unrealistic targets and transactional contracts can also produce unhelpful behaviours, such as corner-cutting, or sweeping emerging problems under the carpet when they had better be addressed. The lesson is that transactional contracting often translates as confrontational contracting. Small wonder that the result is a breakdown of trust: only 32% of infrastructure owners say they have a high level of trust in their contractors, according to the 2019 Global Construction Survey by consultancy KPMG.³

Governance failures

The larger and more complex a project is, the more it must be broken down into individual work streams handled by different teams. This increases the importance of co-ordination to minimise the potential for a problem in one area to create delays and cost impacts elsewhere. Strong governance is especially important if innovation is being encouraged or used so that risks can be managed and benefits maximised.

Missed opportunities

Physicist Albert Einstein is credited with a maxim that is frequently paraphrased as: ‘If you want different results, you have to try different approaches.’ The challenge can be to find a different approach that works. Repeated focus on cost and schedule haven’t provided any dramatic performance improvements. However, organisations that have adopted a different lens are achieving transformative results. Carbon is a proxy for resource use and therefore for cost. The pursuit of carbon reduction in capital delivery and asset operation has enabled clients and their supply chains to drive and upscale innovation repeatedly. UK experience over the past decade has shown that carbon and cost savings are achieved at a ratio of 2:1. Industry leaders are achieving 70% carbon savings across multi-year, multi-billion pound investment programmes, yielding cost savings of more than one third compared with benchmark metrics. Their methods are available to all organisations, everywhere.

Too few good people

The industry has bemoaned shortages of suitably skilled and experienced people for as long as it has been berated for poor delivery. Some major clients, contractors, consultants and even projects are acting to address it by sponsoring courses and training providers, making themselves more attractive organisations to work for through cultural, work environment and pay adjustments. Safer site conditions, the replacement of onsite processes through use of prefabrication, and the introduction of digital technologies in the office and in the field are all helping careers in infrastructure to compete with those in other industries. But building the skills base is a multi-year effort, requiring support from many organisations.

1. McKinsey, July 2015 www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/megaprojects-the-good-the-bad-and-the-better

2. Bent Flyvbjerg, “What you should know about megaprojects and why: An overview,” *Project Management Journal*, 2014, Volume 45, Number 2, pp. 6–19

3. KPMG Global Construction Survey

Challenges with integration

Poorly joined up

Our industry has an identity problem: it is commonly referred to as the ‘construction industry’, emphasising the role of capital delivery. It should be better thought of as the ‘infrastructure industry’, encompassing the operation and care of existing as well as new assets as part of an in-use system.

Lack of operational readiness

Capital delivery, asset operations and maintenance are commonly siloed disciplines – people, work processes, culture, objectives, performance metrics and incentives seldom connect. The things that make for successful construction don’t always translate into success when it comes to integrating new assets into operational systems. Leaving out O&M staff during project definition and delivery can be a recipe for interface problems between the new asset and existing systems, commissioning difficulties, operational underperformance and inefficiency, and sometimes poor safety for operatives and maintainers. Considering the operational end-state can make a critical difference to people’s working lives.

“Technocratic solutions have a negative impact on people by reducing amenity, causing nuisance, or creating barriers to inclusion.”



Loss of focus

Major projects that are many years in the making can develop lives of their own. Attention is so focused on project development and delivery that the team loses sight of what is happening in the existing, wider infrastructure system, and how the whole will function. This locks in outdated thinking and technologies. It can also result in missed opportunities to improve performance in the wider system or to respond positively to environmental, social or economic changes.

Absent end users

The infrastructure industry often seems to operate within a ‘bubble’, in which infrastructure professionals are absorbed by technical and commercial issues to the detriment of end-users. There is too little meaningful engagement with communities and little two-way dialogue. The result has been technocratic solutions that have a negative impact on people by reducing amenity, causing nuisance, or creating barriers to inclusion.

Arm’s-length relationships

Traditionally, asset owners and their consultants have been reluctant to engage contractors and suppliers early in the design process on the basis that it would limit competition when it came to inviting tenders for construction. Designers have been reluctant to include advice and information from the supply chain because they are exposed to contractual risk if the advice/information turns out to be wrong. Meanwhile, operators have had limited influence beyond giving approval at particular points in the process.

Challenges in use

Narrow vision

Project planning and appraisal often fails to adequately address non-financial and long-term benefits. Too narrow a focus results in missed opportunities to add social, economic and environmental value. And too much optimism combined with insufficient analysis produces projects that fall short of expectations: promised environmental and social benefits fail to materialise, leaving owners, operators, investors, politicians and end users wondering whether money has been well spent.

Difficulty of improvement

Bad performance during delivery often persists post-handover. Evidence shows that, where this is the case, too little attention is paid to understanding the causes of operational under-performance and finding ways to improve it.

Delivery problems cause years of disruption

The effect of delays and budgetary overruns can stretch far beyond the financial cost. Setbacks on a major project can cause years of inconvenience and disruption to the travelling public, leave operators facing loss of income and reputational damage, and produce uncertainty that dents investor confidence and holds back associated private sector business activity. One of the most high-profile examples is Berlin Brandenburg Airport, which is still unfinished despite being originally scheduled to open in October 2011. Its budget has spiralled from €2bn to €6bn, and it is now due to come into operation nine years late in autumn 2020.⁴ The long delay has resulted in Berlin's Tegel airport being overburdened for the past decade, and the customer experience of the city's residents and visitors has suffered.

Bad forecasting creates reputational and investment risks

Even once the ribbon is cut on a completed project, it can disappoint and embarrass the business leaders and politicians who approved the work. Rail projects overestimate the number of passengers who will use the new services by an average of 51.4%, according to Flyvbjerg.⁵ A notable example is the High Speed 1 (HS1) rail link which carries international passengers from London to France via the Channel Tunnel. Four years after it was completed in 2007, it was carrying only one-third of the passenger numbers predicted at the outset of the project in 1995.⁶

Predictions for road projects are similarly overoptimistic. The M7 Clem Jones Tunnel in Brisbane, which opened in 2010 at a cost of A\$3.2bn, carried 50% fewer users than expected in its first two years of operation. The shortfall in tolls led to insolvency for its operator, RiverCity Motorway.⁷

“Even once the ribbon is cut on a completed project, it can disappoint and embarrass the business leaders and politicians who approved the work.”

4. BBC News, 29 June 2019 www.bbc.co.uk/news/world-48527308
5. McKinsey, July 2015, www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/megaprojects-the-good-the-bad-and-the-better
6. www.p13.org.uk/wp-content/uploads/2018/04/From-Transactions-to-Enterprises.pdf
7. [web.archive.org/web/20120321065115/http://www.rivercitymotorway.com.au/userfiles/file/Daily%20Traffic%20Volumes%20February%202012%20\(23\).pdf#](http://web.archive.org/web/20120321065115/http://www.rivercitymotorway.com.au/userfiles/file/Daily%20Traffic%20Volumes%20February%202012%20(23).pdf#)





What does smarter delivery mean for **you**?

The transport planner

As a transport planner, you assess the functioning and needs of your infrastructure system in order to build the business case for possible interventions. It's your role to understand the link between transport and the future shape of towns and cities, and to get under the skin of what infrastructure development means for the customers and society you serve.

You need to consider...

... whether you have the full picture on the benefits and costs of the possible interventions your organisation could make. Are you attaching enough weight to social and environment outcomes as well as economic ones? Do your forecasts truly reflect whole-life cost and value, and use real data derived from operations, or do they rely on optimistic assumptions? And are you collaborating with key stakeholders early enough in your planning process?

You could benefit from...

... digital models that give you an accurate picture of how the transport network is performing now, and allow you to predict the effect of future changes. Smart infrastructure could help you to analyse data, see the big picture, liaise with more stakeholders, absorb their ideas and information, and secure confidence in the plans that are taken forward.

To make smarter delivery a reality you should talk to...

... operational and IT colleagues about the data that is available from the existing transport network and how this might be made more accessible to you in digital form. Consider smart infrastructure solutions to help you gain fuller insights from it. Meanwhile, investigate opportunities to talk to different stakeholders that could give you better data on social and environmental outcomes.



Proposing a solution

This section of the paper presents five enablers of better delivery:

Digitalisation

New tools, approaches and solutions

Future-proof decisions

A method for defining the right asset and developing a future-ready solution

Analysing value

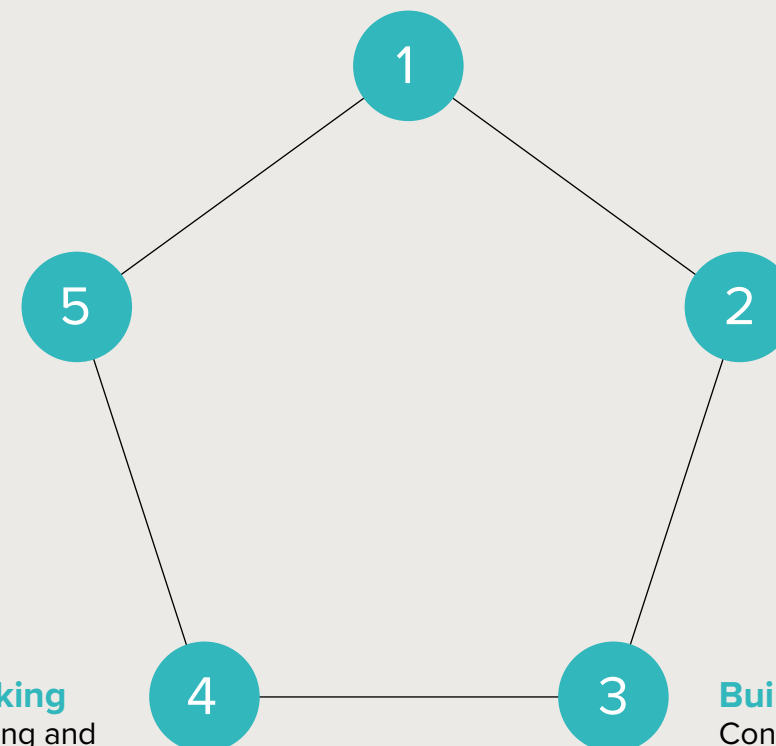
Considering social and environmental as well as whole-life economic outcomes

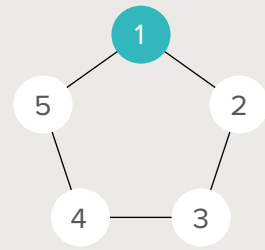
Enterprise working

Assembling, aligning and incentivising the team

Building capability

Contracting for success using the Project Initiation Routemap





Future-proof decisions

A method for defining ‘the right asset’ and developing a future-ready solution

Planning for the future has traditionally involved ‘looking in the rear-view mirror’, making predictions about future needs based on past trends. But the increasing dynamism and volatility of social, environmental, technological and economic changes make managing opportunities and threats more difficult. Planning and decision-making in the face of future uncertainty call for a different approach to set and pursue a vision, and navigate change to deliver resilient solutions.

FUTURES

With the University of the West of England, Bristol, we have developed the Future Uncertainty Toolkit for Understanding and Responding to an Evolving Society – FUTURES. It is designed to help national agencies and infrastructure operators to inform policies and programmes; regional authorities and asset owners to guide strategies and prioritisation processes; local authorities to support the planning process for infrastructure; and owners, investors and developers to set the vision and delivery mechanisms for strategic sites and assets.

The FUTURES approach has six modules that can be used individually or together. All are adaptable to the needs of each organisation and situation, depending on the stage of the planning cycle and work already undertaken.

1. Gearing up

The preparatory stage helps you to understand the overall FUTURES approach and its underlying philosophy. It is important that you identify and engage the right external and internal stakeholders so that everyone understands the FUTURES approach and it can be tailored to your needs.

2. Preferred futures

This stage focuses on the purpose, performance and outcomes you want to achieve, weighing social, environmental, economic and technological drivers and considerations in deciding the future you and your stakeholders want. The output is a vision and a high-level strategy that is tested and developed in stages 3, 4, 5 and 6.

3. Opening out

Opening out involves testing your vision and high-level strategy against plausible future scenarios. The range of considerations is potentially extensive and needs to account for emerging issues such as the imperative to reduce greenhouse gas emissions to net-zero, the need to protect against more extreme flooding and the effects of the digital revolution on demand for infrastructure services, for example. Exposing the extent of possible change, challenge and uncertainty initiates a process of addressing issues to improve the robustness of your forward planning.

4. Options

The opening out phase enables the development of strong, realistic, forward-looking options for realising your vision.

5. Closing down

This stage helps you to examine how your options could perform in different futures. Do they align well across all scenarios in terms of achieving the outcomes you seek, or is alignment poor in some scenarios, suggesting high risk? Communication is a key aspect of this stage. Closing down requires re-engagement with your stakeholders, who have a key role to play in helping to evaluate scenario-based future performance and risk. At the end of the closing down process you should have narrowed your options and have confidence that they will enable you to fulfil your purpose and vision, and should therefore be included in your strategy.

6. Review

This final stage is continuous. Regular performance monitoring and strategic review are essential in light of your changing market and operating environment. Adapting to conditions may involve re-running parts of the approach (perhaps in a lighter touch way). Such re-running may also be helpful as your staff and stakeholders change over time.

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Asset management – key strengths

When considering a project or programme, you need confidence that you are making the right decisions for the right reasons. This confidence comes from your abilities as an organisation to identify your infrastructure needs and decide to intervene in the right way at the right time.

An organisation that has effective asset management will seek to create new assets only when that is the best solution for the system. Furthermore, it will be clear about the way the new infrastructure will be managed, operated and maintained to maximise whole-life value. Asset management is a key capability, without which it is difficult to plan for effective change, protect against risk, respond to customer need, or respond to market opportunities.

Our approach to asset management looks at the key areas of strength that an organisation needs to cope with today's challenges and plan for the future. We know that, when any of them is weak, an organisation will be poorly protected against risk and may be unable to adapt in response to opportunity. It may even struggle to fulfil its core purpose and objectives.

Conversely, the greater an organisation's overall strength, the better protected and more capable it will be. We'll help you to achieve that, looking at your infrastructure, data, people, processes, investment, techniques, tools and technology.

In partnership with you and your stakeholders, we'll tailor our approach to your individual needs. The objective is a well-oriented and clearly mapped direction of travel for you, enabling practical steps for making the journey, providing the means to measure progress – leading ultimately to improvement.

“Asset management is a key capability, without which it is difficult to plan for effective change, protect against risk, respond to customer need, or respond to market opportunities.”

Infrastructure in the round

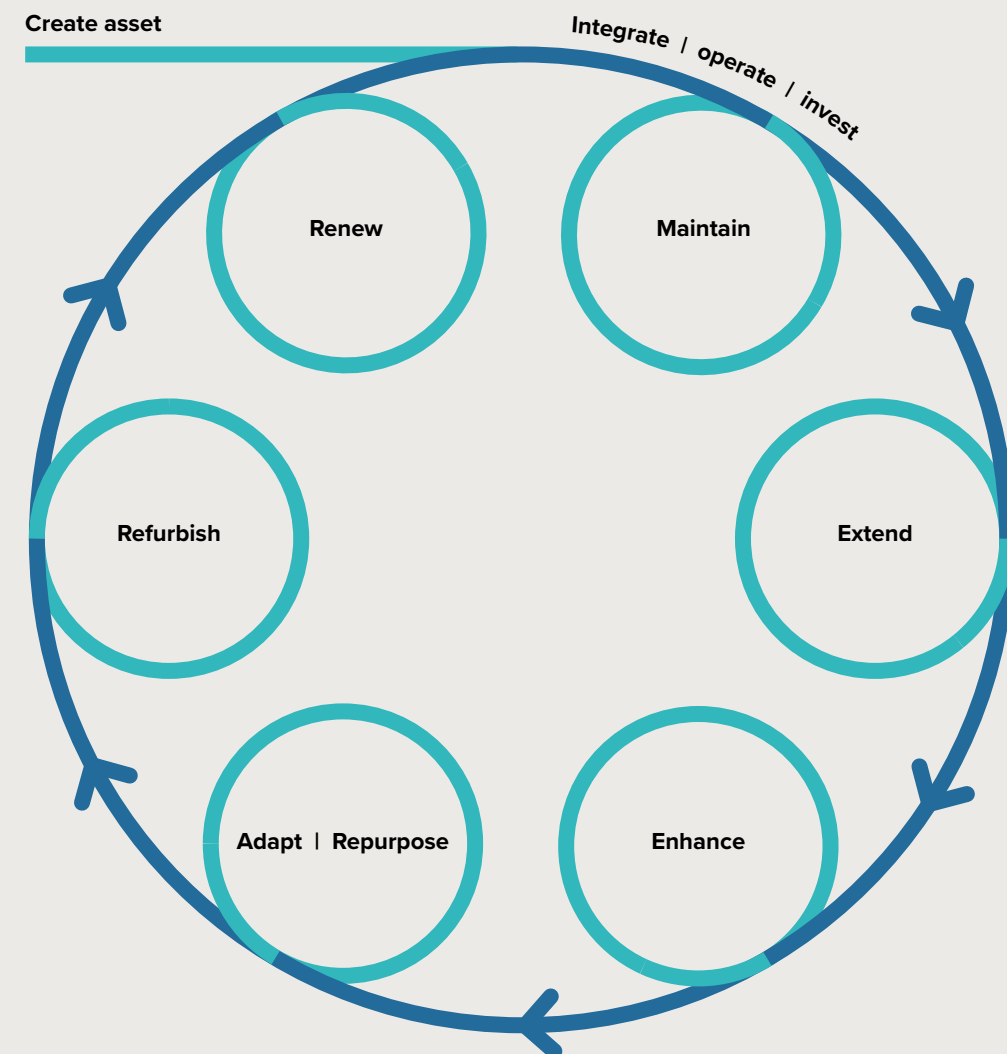
Asset management optimises the whole-life performance of individual assets and integrated asset systems for the benefit of owners, operators and customers.

People commonly think asset management is what happens after an asset has been created, and is only about assets! We view things much more holistically.

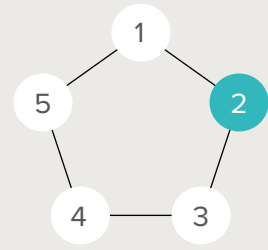
For us, asset management is about the whole life of assets. It's about the integration of discrete assets into bigger asset systems – even systems of systems – and how they perform together.

It's also about the organisational capabilities and strengths that are required to plan, invest in, create, operate, maintain, adapt and dispose of or renew assets. Fundamentally, asset management is about running a strong, successful and sustainable organisation – which is why the asset owner/operator and their core purpose and objectives is at the centre of our model.

In developing our approach to asset management we've taken care to align with the Institute of Asset Management's '39 subjects'; ISO 19650, the international standard for information management; and ISO 55000, the international standard for asset management.



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Analysing value

Considering whole-life social and environmental as well as economic outcomes

Minimising capital cost is often expensive in the long run. Maintenance, repair and replacement intervals, ease of access, the energy consumption of mechanical and electrical equipment, service disruptions due to asset failure, inefficiency, the duration of site possessions required to carry out work... each adds a layer of cost.

Adaptation required by social, technological or climate-related environmental changes can add substantially more.

That the effects of capex decision-making can have a negative impact on opex for the lifetime of an asset is common knowledge in the infrastructure industry. Yet segmentation across the sector and within organisations means that capex efficiency too often results in opex inefficiency.

Holistic thinking, considering total expenditure or 'totex', spanning the lifecycle of the asset, is necessary to achieve genuine capital efficiency. Owners need to open a different kind of dialogue with their lenders, shareholders, regulators and suppliers, whose understanding and support is essential. Totex requires them all to shake free of conventional business planning and financial payback cycles and embrace the principle of slower but more sustained (and sustainable) returns on investment.

Holistic thinking is also necessary regarding to the service that infrastructure provides and the outcomes it enables socially, environmentally and economically.

Benefits and costs

Forecasting the long-term benefits of infrastructure projects can be controversial. In the UK, the case for investing in infrastructure has been made using headline figures about the extent to which particular projects will boost the economy – which necessarily relies on assumptions. Those have become the focus of negative public comment and legal challenge.

To avoid similar controversies in the future, the Institute for Government think tank has recommended that the methodology for calculating benefits is transparent and published alongside the findings. It also recommends that the models used are consistent and, where possible, benchmarked against previous projects (reference-class forecasting).

One infrastructure owner that has implemented reference-class forecasting effectively is Highways England, which carries out a Post-Opening Project Evaluation (POPE) of all road schemes one and five years after they have opened. This assesses to what extent the benefits of the work anticipated pre-project have materialised. The data from these assessments is then systematically fed back into future forecasts, and as a result the organisation has achieved better value-for-money outcomes across its projects.⁹

8. Institute for Government/Project Management Institute, "How to Value Infrastructure" 2017. www.instituteforgovernment.org.uk/sites/default/files/publications/lfg%20Report%20CBA%20infrastructure%20web%20final1.pdf
9. Ibid.



Transparent Economic Assessment Model

We have developed the Transparent Economic Assessment Model – TEAM – which is a versatile tool designed to calculate indirect and local economic impacts of proposed infrastructure interventions and policies.

TEAM offers a different perspective from traditional cost-benefit analyses, which focus on macro-level impacts and fail to highlight local benefits. By contrast, TEAM starts with a micro assessment, highlighting job creation, increased wages, access to housing, education and healthcare, and gross value added to the local economy.

Increasingly, the social and environmental impacts of projects are under the microscope. TEAM assists decision-makers in understanding the effects over the lifecycle of a project on individuals, communities and societies, users and the environment.

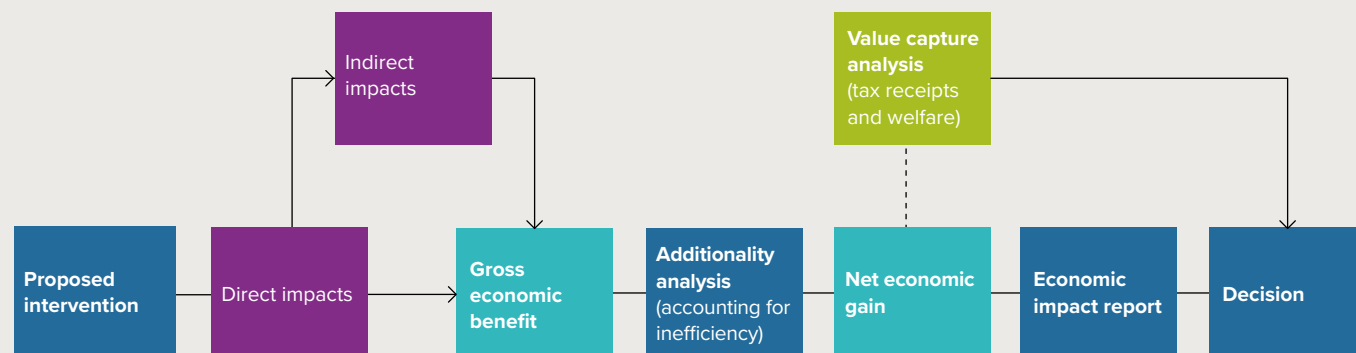
As well as considering multiple criteria across the three strands of people, planet and profit, TEAM analyses dynamic effects – examining the impacts of changes that will occur over time, interact with the project and affect its performance. This is in contrast to analysis of static effects, which consider the interaction between the project and the world as it exists now.

The comprehensive process of analysis helps to deliver projects that are inclusive, avoid negative social and environmental impacts, and are commercially resilient.

TEAM has been designed by experts in economics, economic development, infrastructure and regeneration and is in line with the internationally recognised appraisal best practice: HM Treasury Green Book principles and the Homes and Communities Agency additionality guidelines.

Analysing value

TEAM provides a logical method for calculating the net benefits of proposed interventions, measured in gross value added (GVA) and jobs created. Economic impacts can be mapped geographically using GIS.



Don't rush to announce the cost

Even using advanced analysis tools, it is still difficult to predict with perfect accuracy the value a project will generate. It is equally difficult to be precise on cost but, nevertheless, the infrastructure industry can produce robust cost estimates. When it comes to public perception of delivery performance, a key lesson is to do so before making an announcement.

Evidence shows that the earlier a budget for a project is announced within the development cycle, the less likely it is to be stuck to. In 2016 the Grattan Institute think tank examined 836 transport projects built in Australia between 2000 and 2015 costing A\$20M or more. One third of these were announced early by politicians prior to formal budget commitments. It was these projects that were responsible for three quarters of budget overruns.¹⁰

Single-point estimates of cost, made at an early stage and then reported in the media, can be particularly unhelpful. Quoting costs within a range of variables, where they exist, is more prudent in terms of setting expectations as well as being a better reflection of reality.

When it comes to communicating plans to the public, ideas of cost and value should go hand in hand. It is important to be upfront about both, and to convey objectives and financial figures in terms that relate to the end user and the impact the project will have on their lives.

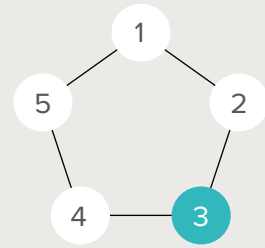


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10. www.theguardian.com/business/2016/oct/24/transport-infrastructure-costs-blew-out-by-28bn-in-15-years-says-grattan-institute



Building capability

Setting up for success using the Project Initiation Routemap

The capabilities of the client are a major determinant of any infrastructure project's success.

One tool clients can use to assess if they are equipped to take on a project – and whether or not they must build capability or should seek help – is the Project Initiation Routemap (PIR). It was developed by the UK government's Infrastructure & Projects Authority with the University of Leeds and the Infrastructure Client Group.

The PIR considers the complexity of the project and the client's ability to deliver it, helping identify competence gaps. It focuses on seven areas that organisations typically need to consider – risk management, procurement, organisational design, execution strategy, governance, requirements, and operation and maintenance. Learning resources and guidance are available in each area.

Health check

'Health checking' before or during project initiation can avoid a raft of problems by informing key decisions about what is required from the supply chain and what kind of relationship between client and supply chain is appropriate to the size and complexity of the project, paving the way for selection of the most appropriate form of contract.

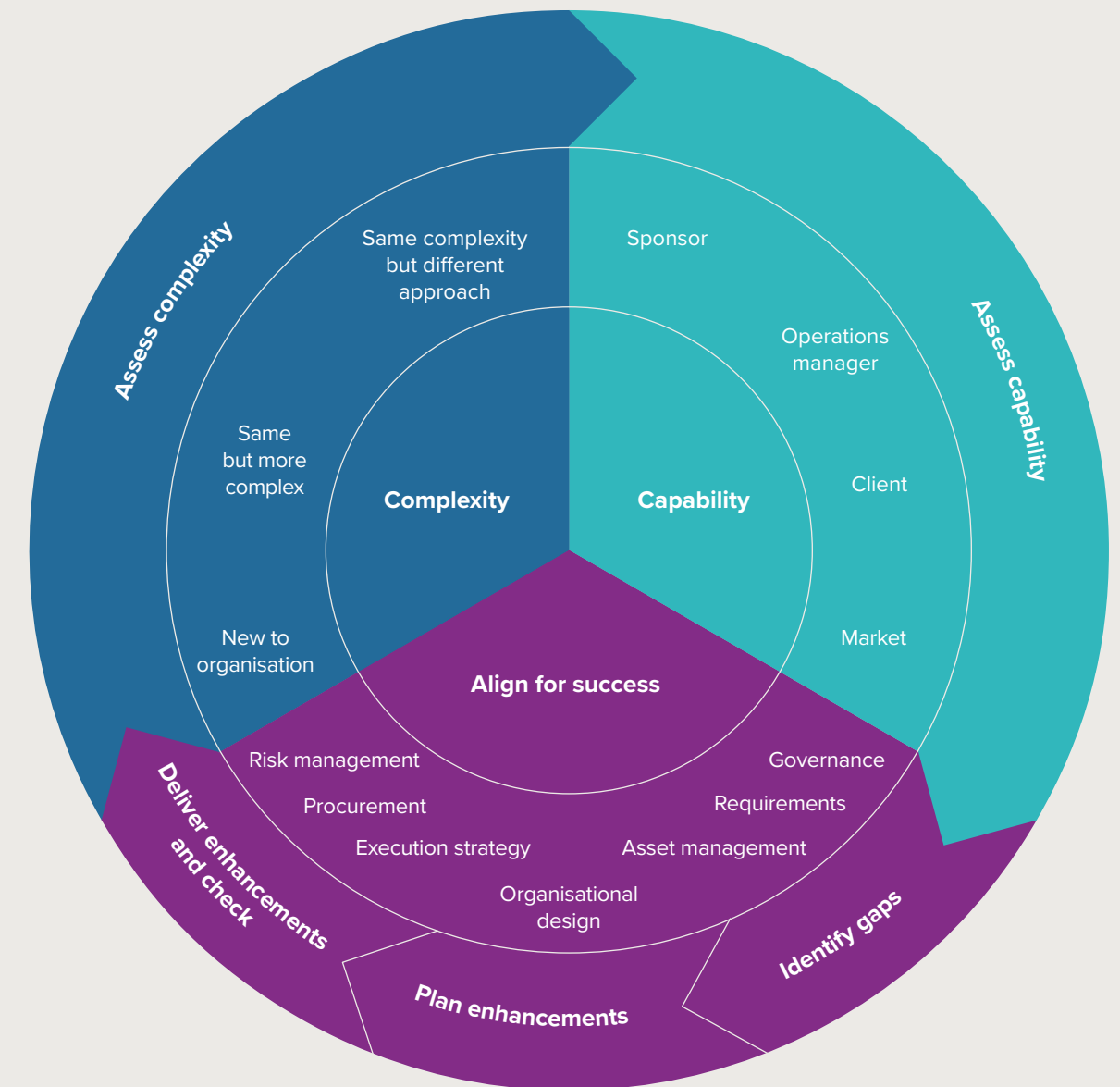
Helping you with the Project Initiation Routemap

Our Project, Programme and Commercial Management practice is working to develop the PIR from a guidance document into a project-ready service available in an easy-to-use digital format. We can help you to go through the process of assessing your capabilities using the PIR, for major projects yet to take place and for those in progress. Our professionals can advise on project set-up and organisational design, governance, procurement and risk management.

"A project that starts badly never recovers. So we place a lot of emphasis on project initiation. We have taken the learning from many years of research into major project success and failure and distilled it into a handy ready reckoner for organisations that are embarking on project initiation – the Project Initiation Routemap."

Professor Denise Bower

Mott MacDonald Group external engagement director



The Project Initiation Routemap

Infrastructure owners can use it to assess the complexity of the project (top left), their capabilities to deliver it (top right), and any areas they need to strengthen to align for success (bottom).

What's the right contract?

As any experienced practitioner knows, the choice of contract has a major bearing on the culture and behaviours of the delivery team – indeed, it decides whether those involved in delivery behave as a team at all, or as warring factions. Experienced practitioners also know that the root of confrontation is not transactional contracts, but of poor planning. For some projects and relationships, a transactional contract form is appropriate. In other situations it won't work.

The right procurement model for a major project or programme will depend on the size and experience of the client, the nature of the project, and the geographic, political and cultural context.

Generally the more complex the project and the more demanding the target outcomes, the more likely it is that a collaborative procurement model will be suitable. Early contractor involvement, alliancing, progressive design and build, and the Canadian Alternative Financing and Procurement (AFP) Model (see page 18) are among approaches that are gaining in popularity as infrastructure owners seek models that are less transactional and more collaborative.

Some of the principles of a successful procurement model include:

Focus on outcomes

Procurement is most effective when partners are brought on board early to consider different ways of achieving the desired outcomes. Procurement that is focused on delivering specific outputs closes off opportunities for innovation and interpretation that may yield more beneficial results.

Flexibility

The more complex a project is, the more important it is to explore multiple solutions at the design stage and subject these to scrutiny by operators, contractors and other stakeholders and experts. Once a design has been chosen and progressed to its later stages it is much more problematic to introduce fresh thinking.

Incentivise innovation

New technologies and approaches require flexibility, trust, and co-operation. The delivery team knows what it has to achieve but enjoys relative freedom to find the right solutions. This creates an environment where skilled individuals enjoy their work and can flourish. Examples include the use of design for manufacture and assembly (DfMA), carbon reduction, pollution control, building information modelling (BIM), the use of digital twins (see page 29) and delivery for operational readiness, which require client, designers and builders to address novel challenges and risks – and maximise the benefits – together. If consultants, contractors, specialists and suppliers are engaged separately through the procurement model there is little opportunity or incentive for them to do this, but a collaborative model that brings them together in an enterprise can provide both the opportunity and the incentive to do so.

Trust and openness

Many project delivery failures are characterised by the parties not communicating effectively and letting bad news or potential issues fester. The result is that when problems develop, they can become full-blown disputes that end up in court. To avoid this, procurement should be designed and administered in such a way that it fosters an atmosphere of openness and trust from the outset.

Consistency

Whatever the model chosen, it is important to use it repeatedly to embed positive behaviours and learn from experience – positive as well as negative. This is impossible if an organisation keeps changing procurement model from one project to the next.

One sign that contractual trouble may be down the line is the excessive involvement of lawyers in drawing up complex contracts. A project team that has been set up as an enterprise (see page 21) can often work under surprisingly short, simple contracts, with clarity on and fair reward for achieving shared goals.

This is not to say that the contract has no teeth. In an alliance, the contract is fundamental to defining the right culture, expectations and behaviours, and incentivising adherence.



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Contracting pros and cons

An analysis of the most common procurement models and the advantages/disadvantages of each.

Key

Negative

Medium

Positive

	Design-bid-build	Design and build	Design and build (with private financing)	Early contractor involvement	Alliancing
Cost of procurement for owner	Low – all tender costs borne by the bidder	Low – all tender costs borne by the bidder	Low – all tender costs borne by the bidder	Medium – owner pays for first stage	High – owner bears cost of setting up alliance
Allocation of risk	Owner bears programme risk	Contractor bears most risk	Contractor bears most risk	Mixed picture, can be unclear	Risks shared between participants
Project owner’s control of design	High – owner retains control of design	Medium – owner cedes control but maintains influence	Medium – owner cedes control but maintains influence	Medium – owner cedes control but maintains influence	High – owner involved in design via alliance
Ability to exploit innovation	Low – due to disconnect between designer and constructor	High – with design and construction working together	High – design, O&M and construction work together	High – design is influenced by two-stage competitive process	High – plenty of input and collaborative challenge
Design-construction interface	Poor – constructors arrive after design completed	Good – design and construct teams put together early	Very good – concessionaire provides O&M input	Very good – helped by two-stage process	Very good – arrangements promote close working
Ease of managing contract	Medium – multiple contracts to manage	Good – few contracts to manage	Good – concessionaire makes things easier for owner	Medium – owner has more to do than in simpler forms	Medium – looser relationships make admin less clear cut
Resolution of disputes	Good – suppliers have relative clarity	Medium – disputes that develop can turn bad	Medium – disputes that develop can turn bad	Medium – disputes that develop can turn bad	Good – collaborative set-up helps resolution
Size of project owner’s in-house team	Large and costly	Relatively small	Can be very small	Relatively small	Moderate sized presence

Canadian Alternative Financing and Procurement (AFP) Model

Alternative Financing and Procurement (AFP) is a form of private-public partnership (P3) used in Canada, which has an excellent record of project delivery on time and on budget.

It was developed at provincial level by Ontario and British Columbia in the early 2000s and is now used throughout the country. For example, in Ontario it is mandated that all province-funded projects over the value of CA\$50M must be considered for AFP. Under AFP, the public sector project owner establishes the scope and purpose of the project. It then issues a reference design with contract and conditions that are developed collaboratively during the tender design stage through a process that progressively clarifies and locks down all the project requirements.

Losing bidders in this competitive process receive financial compensation from the project owner in return for their ideas having contributed to the process. Once this reference design is completed and contracts are awarded, construction is financed and carried out by the private sector partner, which bears the risk for any delay or overruns. The Canada Infrastructure Bank (CIB) provides loans, equity and loan guarantees to the private sector to make projects commercially viable. This allows financing at competitive rates and allows the CIB to exercise value-for-money judgements on projects before they proceed.

Various contract arrangements are used under AFP. In some, the private sector participant is responsible for the maintenance of the infrastructure asset over a period of up to 30 years. Since 2006, more than CA\$23bn of major projects have been delivered using AFP. Most of these have been delivered within time and budget, with no additional cost to the public purse arising from delays and overruns. Successful projects have included the GO East Rail Maintenance Facility, the Canada Line in Vancouver, the Ottawa light rail transit, and the Union Pearson Express in Toronto.



Case study

Setting up for success at JFK International Airport

JFK International Airport in New York is a major gateway for visitors to the United States, handling 60M passengers a year, but as of 2019 it had slipped to number 74 among the world's top 100 airports in quality of service provided. New York State Governor Andrew Cuomo set out a vision to restore it to the top tier.

In 2017 we were awarded responsibility for master planning and programme planning the redevelopment of JFK in 2017. As part of this work we undertook a comprehensive benchmarking exercise among top airports to establish what makes them world class. Six common characteristics were found: deliver the brilliant basics before providing delight and surprise, focus on the whole journey, drive continuous improvement, use technologies to maximise performance, embed sustainability into everything that is done, and surround it all with great governance.

The redevelopment, worth around \$15bn, touches all parts of the airport with most of the investment provided by the private sector which operates the terminals.

The expanded site will be actively managed by an Airport Operating Centre, which anticipates and avoids problems before they occur. Digital information management will be embedded throughout, and the customer journey from start to finish will be monitored and reviewed to ensure the system operates with continuous improvement. The watchword of the system will be 'brilliant basics', recognising that it is day-to-day aspects such as the comfort of waiting areas, availability of toilets, accessibility of facilities and clarity of signage that make the difference to a customer's experience.

Construction is set to begin on the project in spring 2020 and take five years, with a partial opening due in 2022.

What does smarter delivery mean for **you**?

The programme manager

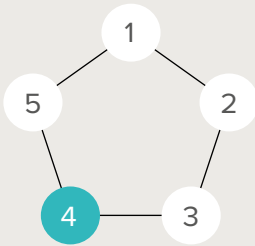
As programme manager, you are in charge of engineering and oversight of major construction and infrastructure improvement projects on behalf of your organisation. You have responsibility for governance, control and co-ordination, and have a primary concern with making sure that outcome and benefits from the projects under your control are realised.

You are concerned with...
... the outputs from multiple projects and the ability to improve from one to the next so as to achieve efficiencies programme-wide. When projects under your control are delayed or increase in cost, or fail to produce forecast benefits, it makes you question the people and processes you work with and undermines your confidence in bringing forward future projects.

You need to consider...
... whether the procurement model and contracting arrangements you are using are contributing to the problem. If everybody involved in a project, whether working from your organisation or for commercial partners, was incentivised to meet particular outcomes, would this enable more creative problem-solving and make your projects more successful? Would a longer-term contractual arrangement with key partners foster the mutual trust and co-operation you need for better delivery?

To make smarter delivery a reality, you should talk to...
... your procurement department, innovation manager or board sponsor about adopting a more collaborative delivery model for your next project or series of projects. Remember that any change will need to be supported by communications and/or training so colleagues and partners are fully on board.





Enterprise working

Assembling, aligning and incentivising the team

So, you think you require a new asset. There is an army of people who can help you to develop the optimum solution and maximise its value – if you can get them to work with you in the right way.

End users, designers, constructors, technical specialists, sustainability advisors, suppliers, planners and operators can each provide clarity about the need and value, cost and practicalities of different aspects of a project. Each will be able to suggest better options, contribute new thinking, see connections and identify risks and opportunities the others can't.

End users can tell you whether your assumptions about them are correct, work with you to understand and address local sensitivities, mitigate nuisance, address community fears and hopes, meet skills needs while creating local employment opportunities during delivery, and tweak the project parameters so that it works best for them, as well as you, long term.

Customer service representatives will be able to flag performance shortcomings in existing infrastructure that can be avoided in new assets.

Operators and asset managers are in the best position to advise on how new assets should be integrated with existing infrastructure and how they should be maintained and managed. They may also be able to advise how existing infrastructure can be adapted, helping to optimise whole-life value.

Investors can advise on how to maximise the economic potential of the project.

Contractors and specialist suppliers are in the best position to advise on practical construction challenges (for example logistics, materials and safety) which may add to the cost. Companies in the supply chain are also in the best position to suggest innovative technologies and techniques – such as design for manufacture and assembly – which could provide better value and better outcomes.

Better outcomes from early engagement and higher influence
Too often, at the most crucial stage for determining project performance, value and cost – planning and initial design – these parties are either sidelined or given limited opportunity. Being involved in a project early gives any stakeholder a higher level of influence over the eventual outcome. Later in the project, the amount of money being spent increases, but the potential for any stakeholder to influence the outcome reduces. When they are able to influence the project, stakeholders add value and assist in achieving better outcomes. The earlier they are brought onboard the greater their positive influence is.

All of this matters in terms of project cost, performance more widely and value, measured in outcomes per whole-life dollar/pound.

“The earlier that these stakeholders can contribute to a project, the more influence they have.”

Snapshot: our changing industry
This simple diagram illustrates a transition that the infrastructure industry should seek to make. It recognises that, in mature economies, intensive growth of the built environment and infrastructure asset base is now in the past. Management and augmentation of extensive, complex and interconnected infrastructure systems require a shift in thinking and behaviour.

This diagram was developed by Mott MacDonald for the Institution of Civil Engineers' Infrastructure Client Group as part of its Project 13 workstream, From Transactions to Enterprises.

	From	To
Customer focus	Focus on asset creation	Focus on asset management and operation
	Focus on cost of initial build	Focus on long term performance and value
	Outputs for clients	Outcomes for the ultimate customer
Improved productivity	Traditional constructed solutions	Innovative integrated digital/physical solutions
	Fragmented, siloed organisations	Integrated enterprise team
	Limited reward for developing skills	Incentivised to improve skills and staff productivity
Sustainable industry	Purchase outputs	Reward outcomes and performance
	Short term transactional relationships	Long term sustainable enterprises
	Transfer risk	Incentivise joint performance

From transactions to enterprises

Enterprise working involves bringing together all the stakeholders in a single organisational team that is set up to focus on outcomes rather than individual outputs.¹¹

The enterprise approach to project delivery has been used with great success on isolated projects and programmes for more than 10 years, but in a famously conservative, habitual and precedent-oriented industry, has not yet become widely known. It is described in a paper, *From Transactions to Enterprises*, published in March 2017 by the Infrastructure Client Group, a panel of the UK Institution of Civil Engineers (ICE).

In an enterprise, all the participants are incentivised according to the outcomes achieved by the whole enterprise, meaning that they are encouraged to collaborate to achieve the optimum results from the project for the client and end-users. The asset owner's risks are not transferred to the supply chain; instead, all the parties in the enterprise take a share of the risk and are jointly incentivised to minimise and mitigate it.

Essential integration

The Infrastructure Client Group workstream that articulated the enterprise model was known as Project 13, or P13. In addition to putting the spotlight on the importance of integration within the project delivery team, P13 emphasises the need for integration between existing systems and new assets, and between different projects in a programme. Indeed, the June 2018 follow-up document *Project 13 Blueprint*, which explains how a successful enterprise should function, recommends the inclusion of the formal role of 'integrator' to perform this function alongside the roles of 'asset owner', 'advisor', 'investor' and 'supplier'.¹²

Not a prescription but a mindset

It is important to emphasise that Project 13 is attempting to bring about a shift in mindset, rather than a specific change to the procurement methods or contracts used. There is now a set of well-articulated principles for Project 13. At its centre is the idea of the 'capable owner', setting up long-term relationships with commercial partners with a view to achieving sustainable outcomes and long-term asset performance.

The principles of Project 13 have been taken on board by several infrastructure owners in the transport field which are exploring more collaborative procurement models and pursuing more integrated approaches. For example, London's Heathrow Airport is using collaborative supplier partnerships for its expansion project to enable a third runway, while Network Rail is trialling the use of regional alliances with operators to improve the UK rail network.

Getting different stakeholders to collaborate does require the selection of the right commercial model and contracts. It also requires a transformation in working culture, a workforce with the right skills and mindsets, and for the parties involved to have the right tools.

11. www.p13.org.uk/wp-content/uploads/2018/04/From-Transactions-to-Enterprises.pdf
 12. www.p13.org.uk/wp-content/uploads/2018/06/P13-Blueprint-Web.pdf



“In an enterprise, all the participants are incentivised according to the outcomes achieved by the whole enterprise, meaning that they are encouraged to collaborate to achieve the optimum results from the project for the client and end users.”



Case study

Upgrading Waterloo Station

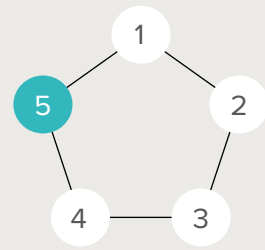
The £400M upgrade of London Waterloo rail station increased the capacity of the UK's busiest rail terminal by a third and improved the experience of the passengers who make 99M journeys to and from the station each year. The project involved bringing the former Waterloo International Terminal into domestic use, lengthening platforms throughout the rest of the station to allow for extended 10-car trains, creating a new connection to London Underground and constructing a new roof and pedestrian bridge. The station needed to remain open while the improvements were carried out.

To tackle this complex work, asset owner Network Rail formed a new delivery body, the Wessex Capacity Alliance (WCA), consisting of Network Rail as client, consultants Mott MacDonald and AECOM, main contractor Skanska and specialist contractor Colas Rail.

Participants signed up to an 'alliance charter', ensuring the team shared a common purpose to meet the required outcomes of the project. Under its integrated project alliance agreement (IPAA) contract, the WCA was incentivised to achieve these outcomes within budget. Any cost savings or overruns were shared between the partners as rewards or penalties.

The collaborative delivery structure allowed the alliance to draw on the expertise of all the partners at an early stage to solve key engineering challenges. At one point, it decided to pursue two parallel designs for the station, at an additional cost of £250,000, to ensure that a possible alternative proposal was fully considered. This alternative was eventually chosen, saving more than £50M compared to the original design.

The project was on time and within budget, creating a sustainable, user-friendly, expanded station for passengers.



Digitalisation

New tools, approaches and solutions

Our industry is entering a period in which it really does appear possible to address old project delivery challenges differently, tackle the scale and complexity of emerging issues – and crack them all. The difference in possibility between now and just 10 years ago is digitalisation.

The infrastructure industry is a relative latecomer to the fourth industrial revolution (sometimes referred to as the digital revolution and Industry 4.0). Exponential growth in computer processing power, innovation and diversification of the ways digital technology can be applied, increasing mass production of hardware and falling costs have enabled the proliferation of data and the advent of cyber-physical systems, where technology is embedded in machines.

It is estimated that 10–20% of capital project expenditure could be saved by digitising the engineering and construction processes used in infrastructure projects.¹³ But the opportunity for improvement that exists goes beyond this. It is not just about the technology, but also about people and processes, and how our infrastructure systems can better serve the public.

Digitalisation enables a range of things the infrastructure industry requires, in order to determine the need for new assets, specify them correctly, and optimise their performance in use.

Integration between organisations

Virtual workspaces with shared filing systems and documents ‘dissolve’ traditional boundaries, bringing together people in different companies, disciplines and locations. Read more in the following section on common data environments.

Joined-up work processes

Use of shared documentation and models with change tracking, alerts and version control eliminates traditional problems of fragmented communication, out-of-sequence comments and changes, and clashes between decision-making and design inputs from different members of the delivery team.

Inclusive communication

For example: helping other disciplines to understand one-another; and seeking input, explaining proposals and gathering feedback from the public, community stakeholders and external advisors such as the emergency services.

Knowing what you’ve got

Basic asset information on what assets are owned, their location, position and dimensions, and what they are made of is missing or hard to find for organisations right across the infrastructure industry, hampering efforts to manage risk, improve service and plan investment.

Ability to understand infrastructure use, condition and performance

For example: start-to-finish journey routes or energy consumption patterns; materials deterioration, imposed loading/demand, active/passive state; capacity, efficiency, failure.

Ability to see essential details

For example: carbon ‘hot spots’ within the design, safety issues, disability access and social inclusion shortcomings, operational and maintenance challenges, and construction sequencing issues.

Ability to manage information

The quantities of data involved in planning, developing and delivering an asset, and then in operating it, exceeds humans’ mental capacity. Digitalisation creates the means to order information and make it available in ways that better suit people’s needs, whether they are members of the project team, the local planning authority, investors, O&M operatives, or members of the public.

Retention of data and data value

The integration of organisations and joining-up of work processes produces ‘federated’ information. Commonly this is organised into data-rich models. These models can be handed on, from project inception to operation, to assist each phase of delivery and subsequent asset management.

Liberation of people

Some standard and repetitive delivery processes are starting to be automated or assisted by computers, freeing up human capacity to address issues that require creative problem-solving or a personal touch.

In-use performance optimisation

Harvesting and analysing data from infrastructure can reveal where interventions are required: emergency repairs, adjustment of operating parameters, maintenance, refurbishment or enhancement, or creation of an additional asset.

“Digital delivery promotes stakeholder engagement and management. It gives project stakeholders the opportunity to see the design as it evolves and assists their buy-in. It also enables progressive assurance of the scheme, rather than leaving it until the end, as when using traditional approval processes. Everything that has been reviewed and commented on sits in one environment, and the value of this is phenomenal when it comes to achieving final sign-off.”

Chris Dulake

Mott MacDonald major projects portfolio manager

It’s a journey

The fourth industrial revolution has made little impression on large parts of the infrastructure industry. Today it would be difficult to find any infrastructure organisation that is ‘digitally mature’ in root and branch. What’s important is to recognise the potential advantages that digitalisation could bring for your organisation, and its ability to deliver the right assets in the right way.

Like any journey, it is important to have a destination in mind. But most organisations would struggle to describe the ‘ultimate’ end-point they are aiming for. Rather, the journey should be guided by clear and achievable intermediate goals, with a rolling forward plan.

13. EUBIM Task Group (2017) Handbook for the introduction of Building Information Modelling by the European Public Sector. www.eubim.eu/wp-content/uploads/2017/07/EUBIM_Handbook_Web_Optimized-1.pdf

Enabling enterprise working with common data environments

Creating a unified digital workspace – a common data environment (CDE) – is the fundamental first step for developing both digital capability and an effective enterprise-based approach to delivery, which in turn are fundamental to achieving better delivery outcomes.

One reason why transactional delivery models have historically made sense is that when design takes place on paper it is impractical to have too much interplay between the actors, which are all performing different functions in the process of infrastructure creation. Poor systems for sharing designs and supporting information between consultants, clients and contractors have long been known to be causes of inefficiencies.

But digital design today can bring together all the relevant parties around a shared data model, with smooth information transfer between them.

Bringing it all together

Building information modelling (BIM) has been instrumental in the development of CDEs. BIM is a project design and development process centred on a shared model, which brings together, or ‘federates’, information – for example 3D geometries, structural loading, materials specification, quantity and cost schedules, carbon data, construction sequences, site conditions, supplier data, and more. The federated data model is hosted in the CDE, which provides a single focal point for information and documentation to be collated, updated, managed and disseminated.

The CDE allows for many more interactions between client, designer, contractor, supplier and other stakeholders than might have taken place previously. Rather than limiting interactions to major gateways such as concept design, developed design and technical design, progressive assurance can be achieved by interactions on a weekly, monthly or ad hoc basis.

Using a CDE can result in significant and measurable gains for the delivery of a project. For example, the design team for London’s Thames Tideway Tunnel East project used an industry leading CDE which combined product information, CAD, BIM and project controls on a single platform, bringing together 12 technical disciplines. Creating immersive visualisations from 3D BIM models enabled personnel at all levels to interact with and explore virtual spaces and structures, helping to refine and validate designs. Use of the CDE led to a six-month reduction in delivery time that enabled an overall cut of two years in the programme.

Right approach, skills and kit

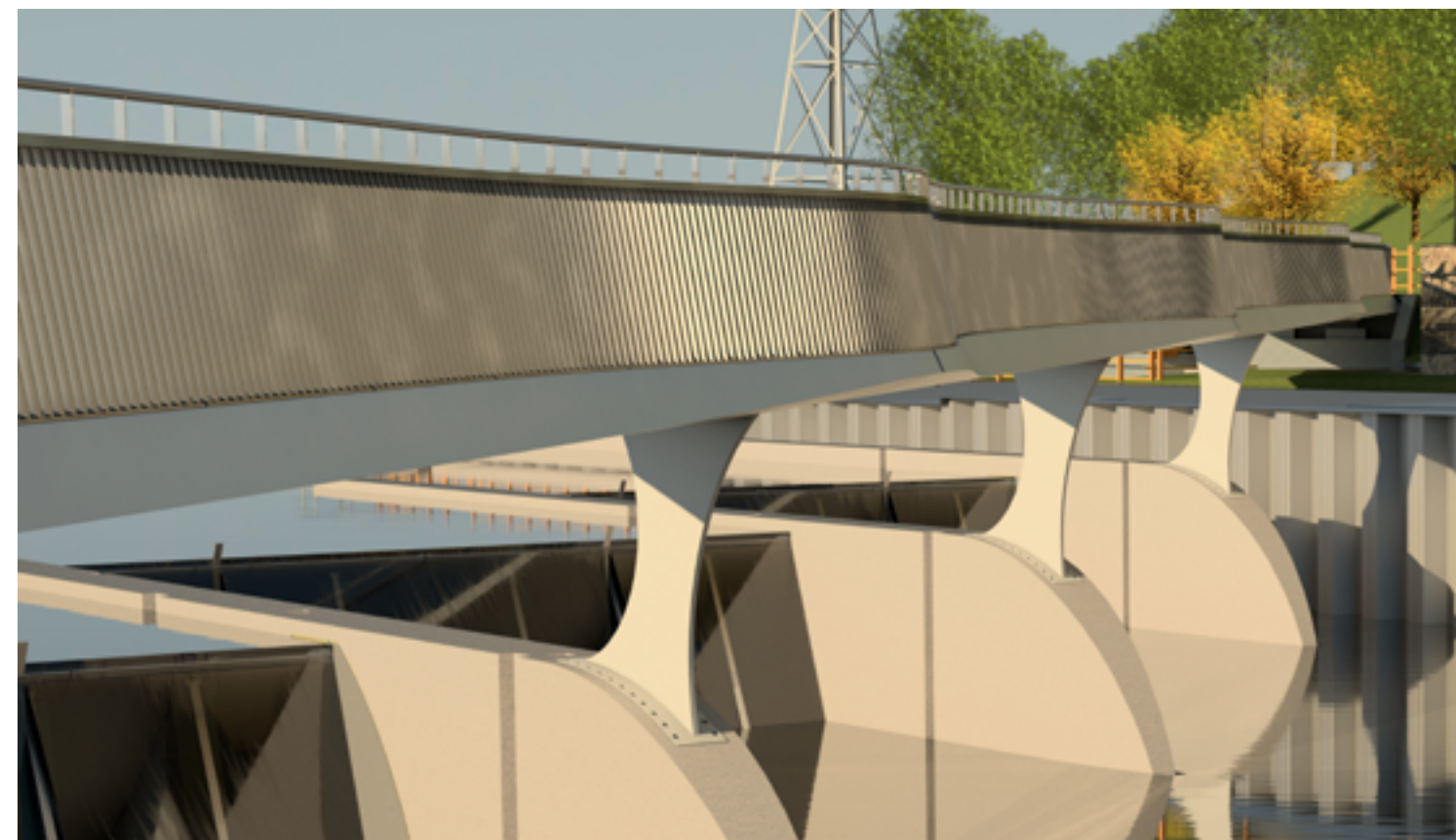
The CDE must be structured to suit the nature of the asset, and ideally will be cloud-based and hosted by a single party. Asset owners may wish to host and manage it themselves or ask a supplier to do so on their behalf.

As well as the shared software, the functioning of a CDE relies on the parties having the right computing hardware and an appropriately skilled workforce. Appointing an information manager for the project can be the best way to ensure the CDE functions effectively and the accuracy of the information within it can be trusted.

“People, process and technology are all vital for project delivery – success is about getting the balance right. You can have the best process in the world, but if you haven’t got the right technology to support that process, people will become frustrated. Equally, you can spend millions on the best technology, but if it hasn’t got the right process behind it or people don’t understand it, things are going to fall apart. And if the procurement model creates barriers between people that stop them collaborating efficiently, process and technology is not going to help.

ISO 19650 gives us a good framework for putting these elements together. If you have a process that brings people together, technology to support that, and everyone is aligned to work towards the same goal in the most efficient and effective manner, you can get a great outcome.”

Mert Yesugey
Mott MacDonald project principal



Pay attention to process

Marrying collaborative delivery models with digital information management represents a new way of working for many. Attention must be paid to how the stakeholders interact within the CDE. A new international standard, ISO 19650, provides guidance on CDE governance, creating consistency in data creation and management, and workflow.

The new ISO standard builds on established British Standards for BIM Level 2 (BS 1192 and PAS 1192) and codifies the interactions required in a collaborative environment. It provides a foundation for building consensus and confidence.

Originally developed to encourage built environment professionals in the UK to adopt BIM, the 1192 standards have become recognised around the globe. The publication of ISO 19650 creates an opportunity to build a common approach to project management information internationally.

Embracing BIM

Building information modelling (BIM) unifies planning, design and delivery activities, providing a 'single version of the truth'. It reduces the potential for misunderstandings and enables interdisciplinary clashes to be identified and addressed before they turn into significant issues. There are different levels of BIM maturity. Level 2 involves creating asset information models that add value beyond delivery and handover, through the operational lifecycle of infrastructure.

In the USA, the use of BIM has reduced construction costs by 5% on average, reduced time to project completion by 5%, and improved labour productivity by 25%, according to a survey of contractors by software firm Dodge Data & Analytics.¹⁴

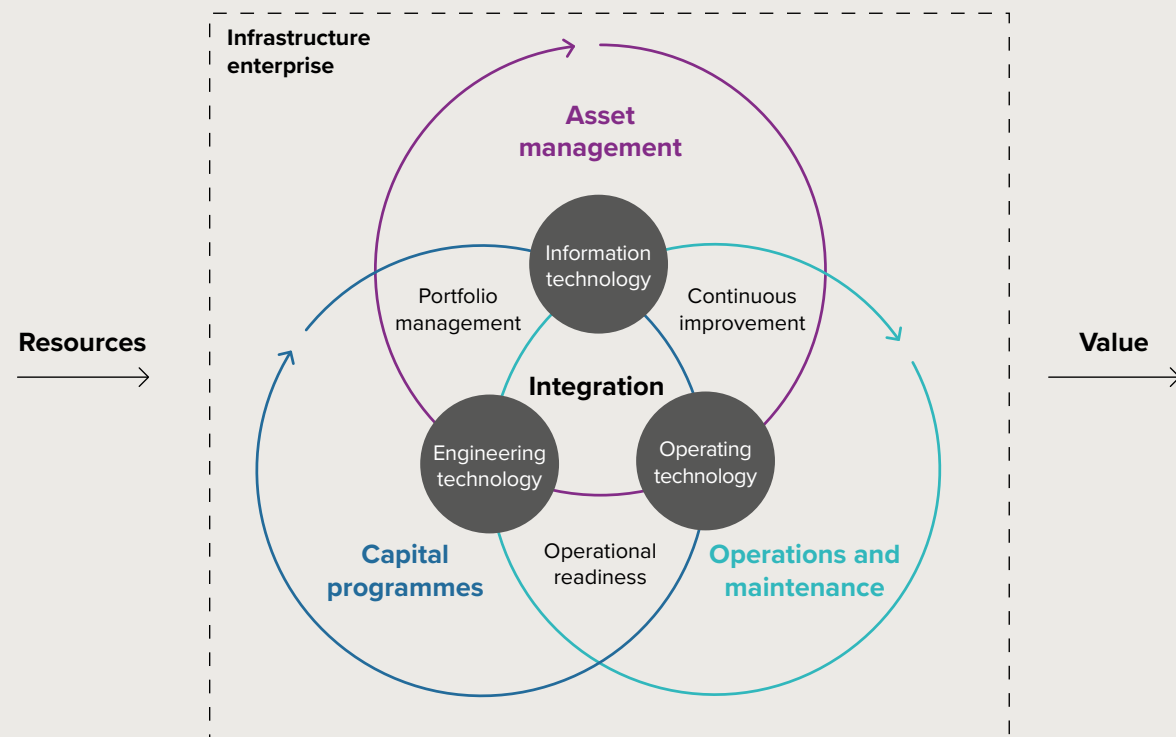
Since April 2016 BIM Level 2 has been mandatory on UK government projects. In a survey of UK engineering and construction professionals in 2019:¹⁵

- 81% agreed that using BIM had improved the co-ordination of construction documents
- 60% agreed it had resulted in delivery cost efficiencies
- 73% agreed it had resulted in operational and maintenance savings
- 72% felt that BIM should be used beyond the design stages
- 87% said that those who were able to collaborate effectively would gain the most benefit.

Our Information Management Network offers expertise to support our clients in maximising the delivery benefits from digital tools. Calling on experience across many engineering projects, we can advise on the upskilling of project teams in information management, helping you to unlock benefits across the project lifecycle.

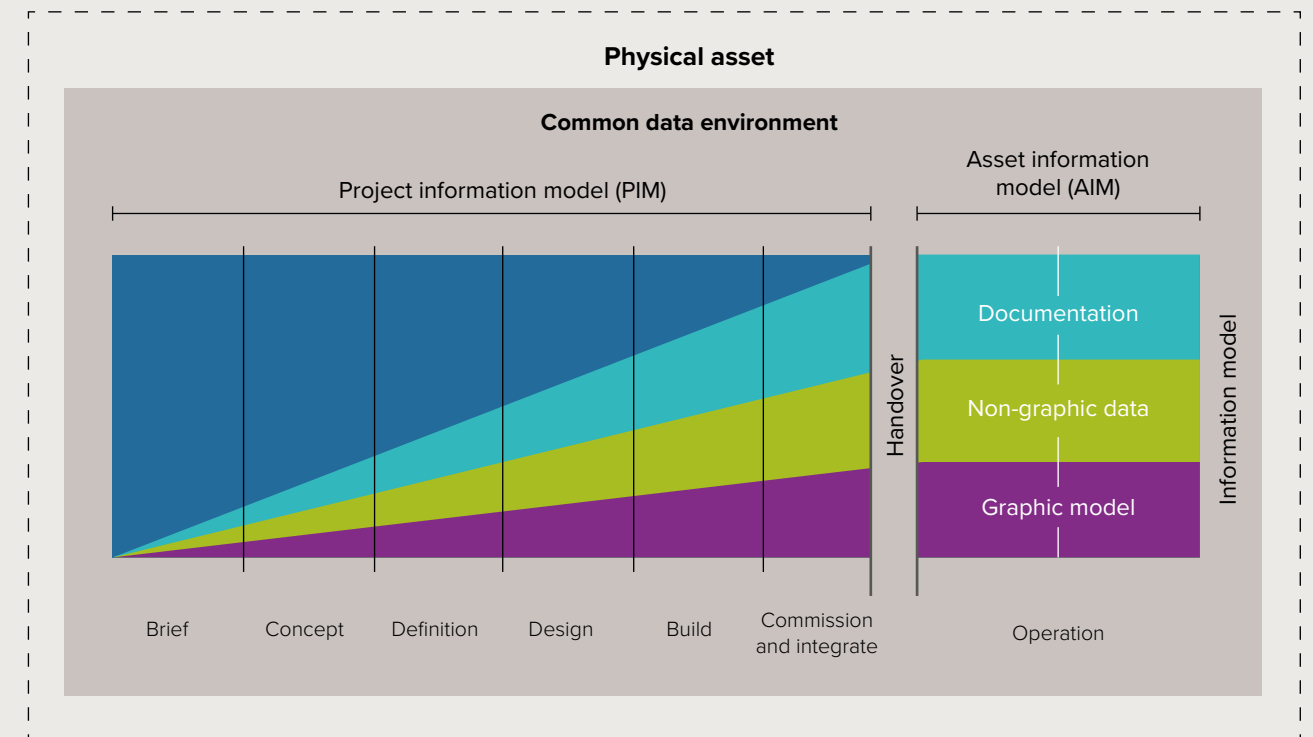
14. SmartMarket Brief: BIM Advancements No.1, 2017. As reported by: www.e-zigurat.com/blog/en/bim-in-the-united-states

15. NBS National BIM Report 2019



An essential new role: the integrator

With increasingly sophisticated and powerful digital technology we're on the cusp of being able to comprehend our industry as never before, seeing the interplay between capital delivery, operation and maintenance, and asset management. This diagram illustrates the importance of integration – and the role of an 'integrator' who can bring together technical disciplines, business processes, technologies and organisational management systems.



Creating a digital asset

Data generated throughout project delivery becomes a valuable resource for asset operation and through-life management.

Contact

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Case study

Expanding Sydney's Metro System

The A\$8.3bn Sydney Metro Northwest project is the first stage of Sydney Metro, Australia's biggest public transport project and the country's first fully automated railway network. The project links The Hills Shire, a fast-growing suburban area of Sydney, with the rest of the city, making commuting quicker and more sustainable and boosting economic development and quality of life in the region.

In joint venture with KBR and SMEC we delivered the detailed design for eight new stations, including three underground stations, three open-cut suburban stations and two elevated stations. We were also responsible for train stabling and maintenance facilities and the track and overhead power systems for the whole line.

Designing the 13 stations across the 36km line, including the conversion of five stations on the Epping to Chatswood rail link, brought together the expertise of a global design team with input from more than 450 people in our Adelaide, Brisbane, London and Singapore offices.

Digitalising the design process and using co-ordinated 3D BIM in a connected data environment enabled the elimination of 900 drawings and significant programme and cost savings.

Digital collaboration between architectural and engineering disciplines enabled a 50% structural steelwork saving on station roofs. The underground stations have more than 90% precast elements, a greater proportion than any in the world. Both innovations advanced sustainability and created significant delivery cost savings.

Process optimisation and augmented delivery

Augmented delivery involves collaboration between human engineers and machines. There is a fear that to use intelligent machines is to replace human expertise in the workplace, but this looks unlikely.

There are some skill sets, such as management, judgement and empathy, at which humans will always excel. There are others, such as numerical analysis, calculation, and the optimisation of solutions based on complex data, where the ability of machines already far outstrips that of the most intelligent person. With augmented delivery, humans and machines can play to their respective strengths.

How do humans and machines work together? Consider a linear asset such as a road or railway, or a water or gas pipeline. A central challenge in its design is the choice of its route. Many variables go into this choice: the type of land that must be traversed, its environmental and social value, the cost of acquiring it, and the difficulty of negotiating any obstacles.

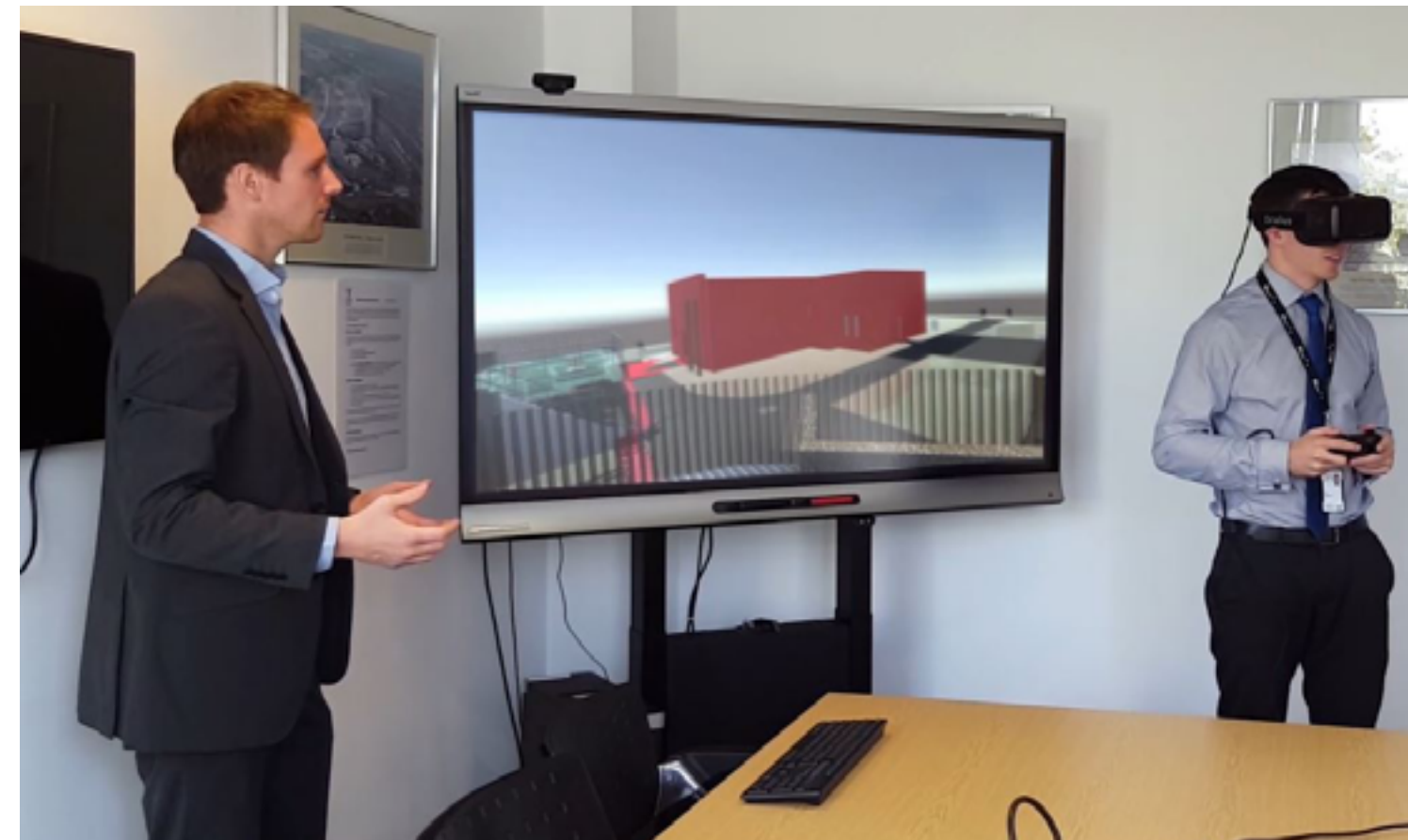
When you also factor in technical considerations – tunnels and bridges, for example – and the importance of considering whole-life costs, then the task of determining an optimum route is an extremely complex one.

Although a suitably skilled engineering team would use experience and judgement to come up with a number of sensible options, the same team could achieve a better result, more rapidly, aided by machines. Parametric models use genetic algorithms to weigh the relative benefits of all possible routes – similar to a chess computer analysing a universe of all possible moves – and come up with an optimal solution.

Our work using it to plan the route of water pipelines has delivered design time savings of 5%–15% compared with traditional methods.

Of course, human expertise and judgement have vital roles to play in setting the parameters, sense-checking the conclusions and tackling problems that no machine has been set up to solve. By considering the problem fully, a human may come up with solutions – such as enhancing existing assets or making operational changes – that do not involve building a new asset at all. This may be the best outcome economically, socially and environmentally.

“While a suitably skilled engineering team would use experience and judgement to come up with a number of sensible options, the same team could achieve a better result, more rapidly, aided by machines.”



Smart infrastructure

Digitally augmented delivery of new assets is important, but if you want to create the best service for customers in the future it's not sufficient. Information within the design model yields new value when used to assist operation and to optimise performance throughout the asset's lifecycle.

The 'golden thread' of digital information management can aid efficiency, resilience and customer outcomes, all bringing financial and reputational benefits for the owner/operator. The thread loops between asset delivery and operation: data from the delivery phase can be carried forward to inform asset integration and operation; data from asset operation can inform the need, specification and planning of the next intervention – whether the delivery of an entirely new asset or the enhancement of existing ones.

The data model created during design and delivery can be thought of as the kernel of a whole-life model that will need to evolve as the asset itself ages and is altered, and in response to organisational, market, and technological changes too. Because the design/delivery model consists of federated information, it can be extended to provide extra functionality, processing and storing historic and live data to assist with real-time command and control, or to inform near – and long-term decision making about operational and asset management interventions.

Recognising this, the ISO 19650 standard is soon set to expand to cover assets throughout their lifecycle, meaning there will be a common language and approach for managing information on infrastructure operation, maintenance, resilience and security.

Digital twins

Digital models created for the design of new assets are a starting point for an ongoing 'digital twin' which can be maintained alongside the physical asset throughout its years of operation. The Centre for Digital Built Britain has outlined the case for managing information using twins and creating a national network of digital twins. In its report 'The Gemini Principles' it lays out fundamental values that should underpin this, including the need for the twin to have a clear purpose and be trustworthy and functional.¹⁶

Digital twins have enormous potential for infrastructure owners to increase the efficiency and resilience of their assets and operations. Data sharing between organisations could take these benefits still further, leading to better decisions, performance and whole-life value across the infrastructure sector.

Unlocking this potential and developing the capability to own and manage digital twins requires infrastructure owners to put in place the right software, hardware, processes and people with the required skillsets. Other items to address include the practicality of a model's upkeep and legal concerns over the responsibility for the accuracy of information held within it.

Increasingly, infrastructure owners are not only custodians of a network of physical assets, but also parallel data assets, consisting of the information held in enterprise asset management (EAM) systems, computerised maintenance management systems (CMMS), geographic information systems (GIS), enterprise resource planning (ERP) systems, and others.

A new kind of asset

This information has tremendous value if it can be linked and organised effectively in a single data system. Digital twins, based on the models used in the delivery of new assets, can provide the backbone or structure to this data system, allowing you to harness the power of data. Better, smarter information management involves the owner taking responsibility for the data it holds and being clear about what it requires from suppliers. Just like a physical asset, the gathering and management of data needs to be specified carefully in order to be serviceable and value-adding.

To achieve this, infrastructure owners that are procuring a built asset need to define their information requirements, in terms of both content and sequence, alongside their procurement of the physical asset. They can then decide which suppliers they will require to provide what information. Once this decision is taken, the next step is to impose framework requirements for information exchange across suppliers, so that the different suppliers involved can work seamlessly in a single modular process.

Own the model, create value

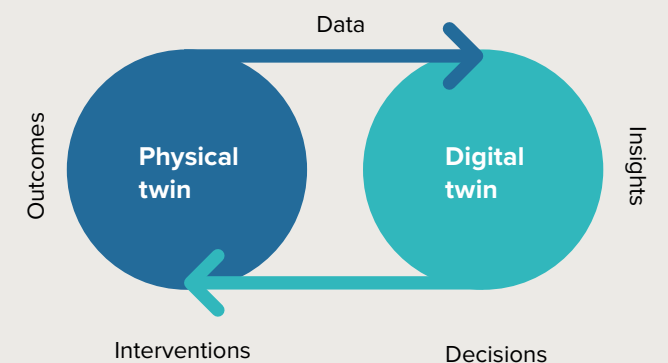
Collaborative delivery of new assets can support this approach because the asset owner is at least jointly responsible for the digital models developed during design and can have oversight and involvement in the way information is handled during the delivery phase. This lays the groundwork for a smoother handover and puts owners in a better position to realise through-life benefits.

In this way, smart delivery of new assets can assist in the evolution of smart infrastructure – the pairing of digital and physical assets to enable better decisions, faster and cheaper, in pursuit of enhanced value. Capital maintenance projects can present an opportunity to digitalise existing assets and create new data.

When information management systems put in place for new assets are proved to add value, it creates a strong case for rolling out digitalisation to the wider system. Smarter delivery is therefore about more than just producing new projects on time and within budget. It is the first step in a transformation that supports a brighter future for infrastructure and all the people and communities who use it.

Smart infrastructure puts four principles into practice

1. Infrastructure value. It is more cost-effective to add to the overall value of mature infrastructure via digital enhancements than by physical enhancements.
2. Customer value. Better value for money, measured in terms of improved customer service/experience.
3. Information value. Information itself has value, and loss of information represents a loss of value. Information value is created by increasing connectivity (the network effect) and increasing integration (reducing information loss at interfaces).
4. Integration value. Value is enhanced through integration and data sharing across:
 - The infrastructure process (use, operation, maintenance, investment planning, feasibility, design, manufacture, logistics, assembly)
 - The value chain (clients, asset managers, operators, contractors, consultants, suppliers, manufacturers)
 - Sectors (communications, energy, transport, waste and water, but also health, education, policy).



Digital twin

A digital twin is a virtual representation of a physical asset. It is used to make better decisions faster and cheaper, driving efficiency in the delivery and management of the physical twin.

What does smarter delivery mean for **you**?

The operational manager

As an operational manager, you are responsible for ensuring that assets produce maximum value throughout their lifetime, by ensuring that they deliver continuous, valuable and affordable service, and are resilient against risks. You are concerned with how assets operate as a system. To make the best quality decisions, you require useful data from all the assets under your control.

You could benefit from...
... a better interface with project delivery. Issues with project delivery can have a significant impact on your role: new assets that are difficult to maintain and operate, or do not easily yield the data you need, can create problems. In addition, out-of-date asset data that has not been maintained alongside the physical assets undermines your ability to do your job.

You need to consider...
... whether you are working in an integrated way with colleagues in capital project delivery. Are you making use of the digital models created during delivery and if not, why not? Do you have sufficient input into the design process for new systems – or are you working in silos? Is there scope for working together on a ‘digital twin’ that would improve your ability to make the correct decisions on behalf of your organisation and its customers?

To make smarter delivery a reality...
... you should talk to your project delivery colleagues about the digital models they use in the design of new assets and how these interact with your asset management systems. You may be able to pursue a more joined-up approach.





Recommendations

There are more ways to improve delivery of the right assets in the right way than ever before. The improvement process is a journey, which can start today.

1.

Review your capabilities

Infrastructure owners hold the key to change and need to become 'capable'.

This involves:

- understanding how your assets work together, as a system, to deliver the services on which your customers rely
- making decisions that optimise whole-life value for these systems
- building strength in key areas to match the demands of the projects or programmes you plan.



2.

Focus on outcomes

Create outcome-focused, collaborative enterprises to deliver complex or long-duration projects and programmes.

Form the enterprise early and empower it to explore multiple solutions.

Address whole-life cost and value by involving end users, affected communities, operational teams, specialist suppliers and other key stakeholders early, and engage with them regularly.

3.

Collaborate efficiently

Bring together the project team in a common data environment using standard processes and strong governance, as specified by ISO 19650.

4.

Deploy digital solutions

Augment delivery by combining the best of human and machine to drive efficiency and support innovation that will lead to better outcomes.

5.

Capture and use data

Throughout delivery, from initial planning to handover and operation, plan to capture and use data, developing digital twins to achieve delivery and operational improvement goals.



Things to remember...



Across the infrastructure industry, levels of maturity in developing and applying the enablers discussed in this paper are varied. There are pockets of excellence, but much of the industry is traditional in its thinking and behaviour. Steering infrastructure projects on to a different, better course will require significant change management.

Here are some guiding principles to help you on your change journey. Experience suggests that advancing any agenda is harder when any of them are absent.

Leadership

Vision: Describe what you want to achieve and provide the highest-level sponsorship and commitment.

Values: Embed goals in your organisation's DNA.

Policy: Deliver clear and consistent policies to support those goals.

Culture and communication

Behaviour: Be clear what behaviours are wanted and reward them.

Communication: Share knowledge effectively within your organisation, your supply chain, the wider industry and citizens.

Skills: Develop skills through training at all levels within your organisation and within key parts of your supply chain.

Metrics and governance

Baseline: Establish your starting point and measure performance against it.

Targets: Set stretching goals and strive to beat them.

Tools: Give the right tools to people who need them.

Visibility: Shine a light on performance, understanding and explaining successes and failures alike.

Governance: Build control into the delivery process.

Innovation and standards

Innovation: Demand, enable, incentivise and reward innovation across your supply chain.

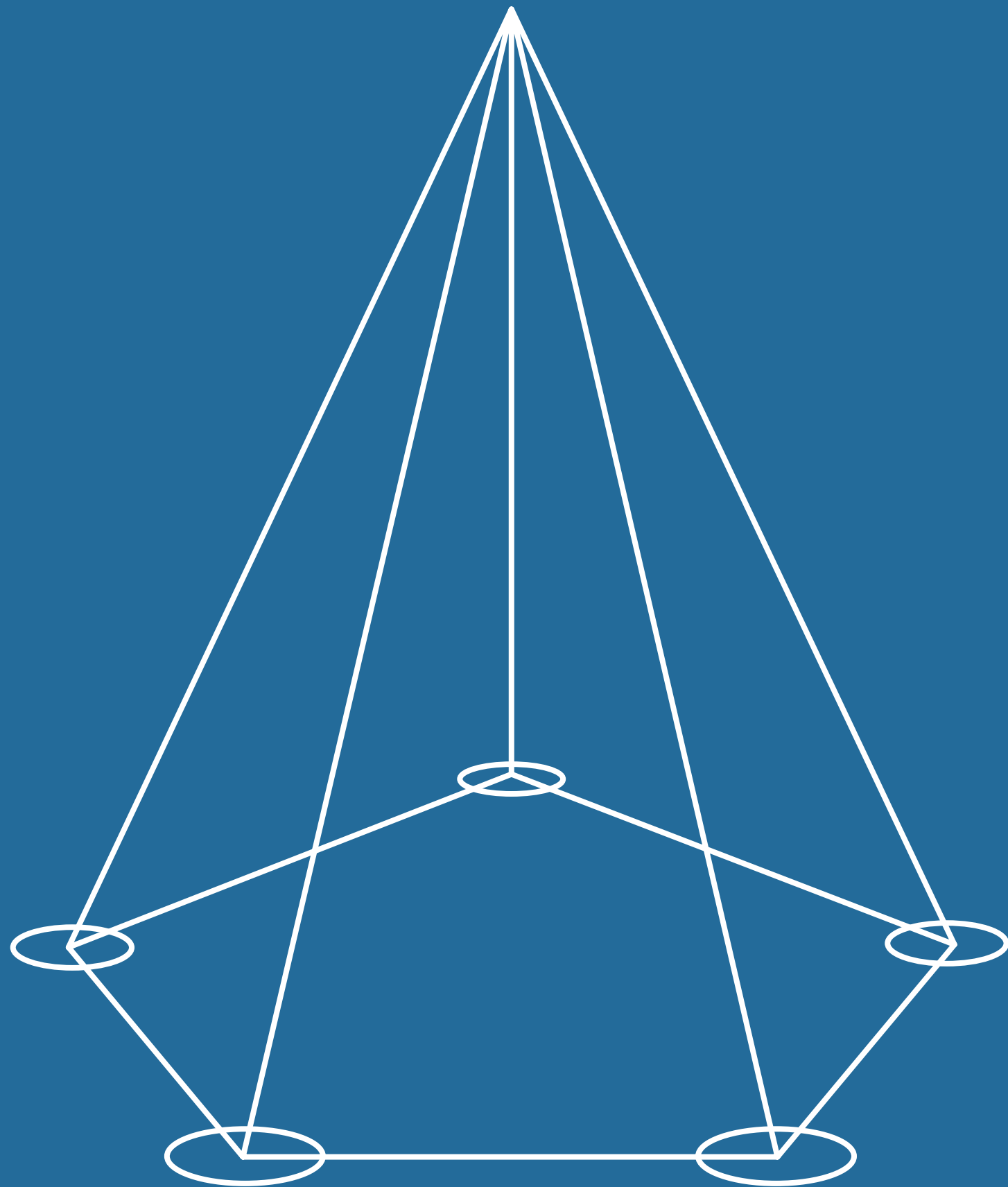
Standards: Enable existing standards and specifications to be challenged and set new standards for best practice.

Commercial solutions

Procurement: Embed your goals in contractual solutions.

Reward: Align supply chain objectives with your goals, provide long-term incentives, and share risks and rewards equitably.

Integration: Remove blockers in your supply chain.



Opening opportunities
with connected thinking.