How artificial intelligence can unlock a new future for infrastructure

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Foreword

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One of the greatest constants in the world is change. Sometimes, change is incremental, but at other times, it can be monumental, instrumental, or even disruptive. The world is grappling with a number of truly global challenges, such as meeting net zero, achieving more for less and improving societal outcomes. The infrastructure sector is vital for driving such changes and improvements forward.

At the first Global Leadership Forum (GLF) summit, much of the focus was on net zero, and this challenge remains. Another reoccurring theme, however, continued to emerge: how we can use technology and AI to supercharge progress, reduce waste, and improve project delivery. This inevitably led to global leaders asking how such technologies were going to affect not only the wider sector but also their own operations.

FIDIC's collaboration with EY remains strong, and this report continues to show the GLF's commitment to tackling the most significant challenges the infrastructure industry faces. Undoubtably, artificial intelligence (AI) is here to stay, and our sector will not be immune to this change. It is, however, also important to note that there is no single version of AI and that there is a common misconception of the different models and tools that are being developed.

Only recently, the Financial Times[1] reported that the next versions of large language models from ChatGPT and others will be capable of reasoning. Individuals such as Elon Musk in 2024 suggested we'll have AI that is smarter than any one human, probably around the end of next year, and that within the next five years, the capabilities of AI will probably exceed those of all humans[2].

This report demonstrates how transformative AI could be for the infrastructure sector, how the various sector players will need to interact in the future, and how business models may need to change. It also shows that there are grassroots and examples of AI utilisation occurring, but that traditional siloed thinking, amongst other things, is holding us back.

At the Global Leadership Forum Summit in 2024, world leaders had the opportunity to discuss a working version of this report and help shape its findings and outcomes. Some of the biggest challenges they identified in the sector such as labour skills shortages, asset use optimisation and climate change all have the potential to benefit significantly from AI.

AI technologies offers potential when there is a global shortage of engineers to improve productivity, value add and drive better environmental and societal solutions. The implementation of AI in the infrastructure sector, however, is fragmented, and as such, the challenges we are trying to solve may not benefit fully from its advantages unless we collaborate and invest in a potentially quite different way of working in the future.

Finally, I would also like to thank EY, GLF members, and the FIDIC team for their continued support and commitment to driving progress across the sector for a better future.

Chris Lewis
UK Infrastructure Leader

Steve Lewis
Partner, Head of Infrastructure Hong Kong and Global Infrastructure Technology Leader

It is a great pleasure for EY to have been a strategic advisor to FIDIC in the development of this report on the adoption of Artificial Intelligence (AI) in infrastructure. In recent years, AI has emerged as a transformative force, revolutionising various industries and sectors. Now, we stand at the precipice of a profound shift in how we design, build, and manage our infrastructure.

AI offers immense potential to enhance our built environment's efficiency, safety, and sustainability. This report explores the key trends, challenges, and opportunities surrounding AI adoption in infrastructure. It explores how AI-powered technologies can optimise planning, design, construction and asset management, and enable smart decision-making. It also looks into the enablers needed from various stakeholders in the industry to generate a wider and faster adoption of AI, along with the new business models needed to make that adoption a reality.

As we navigate an increasingly interconnected world, harnessing the power of AI to overcome complex infrastructure challenges is crucial. However, it is equally important to address ethical considerations, data privacy, and cybersecurity concerns along this transformative journey.

The consideration of how AI can be adopted to help solve the macro challenges faced by society and, in turn, by infrastructure is at the heart of how we at EY think – we endeavour to build a better working world, and we believe AI will have a role in that. We hope this report goes some way to demystifying AI and its potential for us all in infrastructure and that it serves as a guide, empowering policymakers, industry leaders, and innovators to embrace the potential of AI and shape a future where our infrastructure is smarter, safer, and more sustainable. AI gives the construction and engineering industry the opportunity to embrace technology to drive productivity and innovation. Building Information Modelling (BIM) has been seen as too complex for many infrastructure organisations. Now AI offers the potential for universal adoption, expanded benefit realisation, and the driving of leading practices across the industry.

We extend our gratitude to everyone at FIDIC and the Global Leadership Forum who contributed, challenged, and encouraged the development of this report. We are especially grateful to those who took the time to complete the survey and participated in the workshops at the summit, as their valuable input has helped us draw meaningful conclusions and insights. Particular thanks must be extended to Jim Johnson of Arup, Fidel Saenz de Ormijana Valdes of Ferrovial, Mike Haigh of Mott McDonald, Catherine Karakatsanis, Graham Pontin, and Sara Lipscombe of FIDIC, and Nelson Ogunshakin whose passionate leadership, commitment, and joviality were continuously employed for the compilation of this report and wider industry transformation. In addition, thank you to the multinational team at EY who worked tirelessly.

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Executive Summary

Context and the need for a new approach

The infrastructure industry will face major challenges over the coming decades. These include climate change, urban expansion, economic uncertainty, labour shortages, and supply chain disruptions amongst others. To address these issues, we need new ways to deliver projects faster, more cost-effectively, and more sustainably. Artificial intelligence (AI) will certainly be a crucial tool in this effort, but while the industry is getting to grips with AI capabilities, its true potential is still to be fully unlocked.

To better understand the industry's current perspectives and AI adoption, we surveyed FIDIC Global Leadership Forum (GLF) members – representing the key players and leaders in the infrastructure industry – and ran a workshop at the FIDIC GLF meeting in April 2024, focusing on:

- Their current use of AI
- Barriers to AI adoption in infrastructure
- What is needed for wider AI adoption
- The potential benefits of AI

The survey results from 44 senior leaders and industry observations show a mixed picture. The respondents tell us they are investing in AI to varying degrees – in line with findings from other industry reports. Some organisations are investing conservatively (less than 2% of their revenue) while others are taking bolder steps (of up to 10%). In addition, startup funding for AI-driven businesses in the built environment is outstripping that of AI-enabled Fintech solutions. However, this investment is resulting in spot solutions, mainly focused on the early project stages.

This is understandable when AI solutions are trying to operate in the traditional, siloed delivery models that define infrastructure delivery today. Other barriers to AI adoption include unclear returns on investment, cultural resistance, skill gaps, and technological fragmentation.

With these barriers in place, it's unsurprising that AI adoption is low and that we are yet to realise its true value. To address this and to help move the industry to an informed sector that understands the benefits of AI and deploys it to the best effect, this report seeks to bring greater clarity of the different types of AI in the market, how they can be used in different stages of an asset lifecycle and the benefits and outcomes they deliver to the sector and society more broadly. It also explores how AI can unlock new opportunities and value across the infrastructure ecosystem and for the many stakeholders who work within it.

The sector has made a good start into the world of AI but to harness its potential to improve decision-making, build resilience, increase productivity, and enhance outcomes throughout an asset's life, the sector needs to accelerate its adoption of AI tools.

Unlocking value from the complex, interconnected system of infrastructure delivery

Traditionally, infrastructure planning, delivery, and operations have often occurred in isolated, linear ways. Infrastructure development is also inherently complex, involving many interconnected parts and dynamic interactions. To manage this complexity, the asset lifecycle has traditionally been broken down into a series of steps: planning, design, construction, and operation, each involving many stakeholders.

One way of thinking about the value and opportunities of AI is looking at it through the lens of a 'systems thinking' approach to infrastructure development. With its immense processing power and advanced abilities in data analysis, relationship discovery, and outcome prediction, AI can handle complexities that traditional linear approaches cannot. AI can analyse vast amounts of data to uncover hidden patterns, predict potential issues, and best use resources across all project phases. This would break down barriers between stakeholders, reduce costs and expedite delivery.

Five guiding principles that frame the traditional asset lifecycle can support the 'systems thinking' approach and illuminate AI's potential. By building the connections of various factors across all five guiding principles, better decision-making can be achieved.

1. Determine purpose – AI improves asset planning and selection.
2. Plan end-to-end delivery – AI enables more comprehensive insights for robust business cases.
3. Confirm operating model – Data-centric digital twins facilitate AI adoption.
4. Integrate ways of working – AI enhances controls and performance oversight.
5. Operate responsive assets – AI improves operations and sustainability.

To accomplish the systematic change, however, requires targeted cross-stakeholder collaboration across eight key groups — asset owners, operators, consultants, contractors, government, academia, technology providers and capital investors. They must all align on shared 'ambitions' to use AI to improve infrastructure.

Three innovative models provide blueprints for overcoming challenges

To aid a move to a 'systems thinking' approach, we have outlined three innovative models that provide blueprints that address core barriers within the industry – each one uses AI to connect all parts of the infrastructure system:

1. Integrated data and AI platforms: These allow everyone to see and share information, making it easier to work together.
2. Data-as-a-Service: This lets different groups share and make money from their own data.
3. New contract types: These encourage companies to use AI and invest in innovation.

These models help us see AI not just as a separate technology but as providing enormous potential to improve how all parts of infrastructure work together. They show how we can move from thinking only about individual projects to considering how infrastructure serves society as a whole.

To reap this level of AI potential requires consistent adoption of AI technology throughout the sector. Through incremental use of AI in all project phases, the infrastructure sector will naturally find greater opportunities to connect with other stakeholders and find symbiotic uses of AI that benefit more than one set of stakeholders.

To reach this position faster, it is crucial for industry professionals who want to adopt AI to foster an innovative mindset, be equipped with the necessary skills and have the right tools.

FIDIC aims to lead the way in integrating AI effectively and ethically into infrastructure projects through:

- **Mindset:** Cultivating an open and collaborative environment is essential for the successful adoption of AI. This involves raising awareness, fostering discussions, and addressing legal and ethical considerations to build trust and encourage the sharing of data and insights.
- **Skillset:** It is crucial to develop the competencies required to leverage AI in infrastructure. This includes providing training, certifications, and workshops that equip professionals with the knowledge and expertise needed to integrate AI technologies effectively and keep the infrastructure industry attractive to future generations.
- **Toolset:** Offering the right tools and frameworks is vital for practical implementation. This involves developing standardised data collection methods, secure data-sharing protocols, and AI-specific contract provisions that support innovation and collaboration.

How FIDIC can support in unlocking of value by AI

FIDIC believe that this research led by the GLF has shown there are five clear areas where FIDIC can represent the sector and aid the sharing of knowledge to drive continuous innovation and realise the benefits of AI as the industry aims for dramatic improvement in delivering and operating assets:

1. FIDIC will identify methods and opportunities, where appropriate, to make its extensive repository of content, accessible in a structured and usable format to enhance their utility in AI applications.

2. FIDIC will organise targeted events to highlight the latest developments, use cases, and benefits of AI in infrastructure, driving greater understanding and collaboration among stakeholders.

3. FIDIC will investigate methods and opportunities to develop training and certification on the use of AI in infrastructure to ensure that industry professionals are equipped with the necessary skills and knowledge to effectively integrate AI into their projects.

4. FIDIC will act as a repository to collect and share value stories and lessons learned from real-life implementation of AI in infrastructure to enhance collective knowledge and drive innovation.

5. FIDIC will explore the possibility that future contracts holistically address the dynamic nature of AI and include provisions to support AI integration effectively, maximising the benefits of AI technologies while managing associated risks.

Through the above, FIDIC will help bridge the knowledge gap, promote the adoption of AI, and support a transition to infrastructure projects that can fully leverage AI technologies effectively and ethically. This holistic approach will be a major step towards fostering an innovative mindset, equipping professionals with the necessary skills, and providing the right tools. These foundational changes will allow the unlocking of value in the infrastructure by AI.

01 What are the societal challenges AI could help infrastructure address?

In recent decades, the global shift to urban living has led to over half of the world's population now living in cities and The World Bank expects this figure to double to 8 billion by 2050[3]. Alongside urban expansion, other challenges, such as the aging population, climate change, and economic uncertainty, are also increasing pressure on our infrastructure, and the sector needs to adopt new approaches to deliver infrastructure that meets the demands of an evolving society.

Additionally, the escalating costs of building infrastructure require the industry to select, plan, and deliver projects faster and more cost-effectively and then operate built assets more efficiently to ensure we have infrastructure that supports a sustainable future.

With the rise in advanced technologies that can respond to, and mitigate, the impact of these challenges, stakeholders across the infrastructure industry should explore and embrace the opportunities they bring.

Artificial intelligence (AI) is one technology that can't be ignored, but do we truly understand how it can help us address the macro challenges facing infrastructure delivery and operation and, in turn, society at large? And are we adopting it fast enough in the infrastructure sector?

The answer is, generally, no. To change this, we must continuously monitor the most urgent macro challenges facing both the industry and the societies that infrastructure serves so that we can focus and prioritise the areas that AI can support.

Major macro challenges require a new approach to infrastructure strategy

Infrastructure development is guided by the need to meet today's needs while sustainably planning for the future. Today's societies face significant macro challenges that demand immediate and specific actions from the infrastructure industry. These challenges, outlined below, are also accelerating and need far greater investment to alleviate them – as well as different industry responses.

1. **Climate change** is causing significant financial loss to global economies due to climate-related disasters, driven in large part by infrastructure which contributes up to 79% of total global greenhouse gas emissions annually[4].
   a. **Investment needed to mitigate:** To move towards net zero by 2050, an estimated $US139 trillion in sustainable infrastructure investment is required globally[5].
   b. **Industry response:** Adopt innovative measures that reduce carbon in new infrastructure, increase the resilience of existing assets, and enhance carbon-centric planning and decision-making.

2. **Urbanisation and population growth** put immense pressure on infrastructure as cities grow rapidly.
   a. **Investment needed to mitigate:** The World Economic Forum estimates the corresponding infrastructure investment needed stands at US$3.7 trillion per year until 2050[6].
   b. **Industry response:** Continuously find new ways to manage assets more efficiently and develop infrastructure faster and based on design and planning decisions that lead to more resource-efficient assets.

3. **Economic uncertainty** and recent significant increases in the cost of living, energy prices, and the cost of capital have impacted infrastructure delivery and operations and pose challenges for developing essential infrastructure in developing countries.
   a. **Investment needed to mitigate:** Infrastructure investment must reach US$94 trillion by 2040 to close existing gaps and align with future economic changes[7].
   b. **Industry response:** Invest in solutions that boost productivity and reduce construction costs.

4. **Availability of skilled labour** is a pressing concern in the infrastructure industry due to labour shortages and an aging workforce.

a. **Investment needed to mitigate:** To meet planned demand, Europe alone is estimated to need over two million more workers in the construction sector by 2030[8].

b. **Industry response:** Find ways to reduce reliance on manual labour and increase output per worker by developing and adopting innovative technologies that maximise productivity, reduce reliance on human labour, and make the industry more attractive to younger generations.

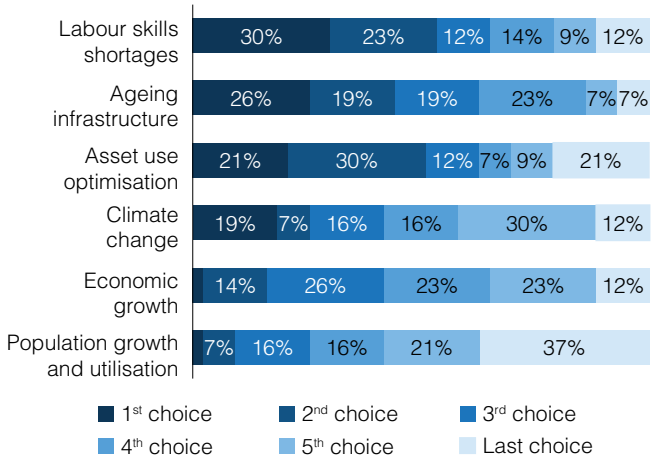
5. **Supply chain challenges and geopolitical events** in recent years have hindered infrastructure investment and development and had a substantial impact on business case assumptions and profit margins. An increase in construction cost, risk profiles, and claims has led to high levels of contractor insolvencies, with the UK construction market experiencing the highest number of insolvencies across all industries in the 12 months ending Q3 2023 and the highest levels experienced in the sector in over 10 years[9].

a. **Industry response:** Deploy technologies that enhance cost intelligence and build resilience to address these uncertainties.

Technology has a significant role to play in supporting the industry as it seeks to address these macro challenges. AI, in particular, has the potential to accelerate the industry's response to each challenge, yet the industry's understanding and implementation of AI remains limited. Recent research by the UK's Office for National Statistics[10] found that 87% of the UK construction sector is more likely to report that current AI use doesn't apply to it, compared to 63% of the IT sector and 71% of the retail trade sector.

To address these significant challenges and drive AI adoption, industry stakeholders need to improve their knowledge and understanding of AI and allocate the necessary resources required to build the required capabilities. Although all of the macro challenges described above are crucial to address, survey responses by GLF members[11] (Figure 1) suggest that focusing efforts on a prioritised shortlist of these challenges could yield more immediate wins. These insights reveal key opportunities include leveraging AI to address the skills shortage through its ability to increase design and construction productivity and optimising asset operations through AI applications such as those that enhance predictive maintenance.

Figure 1: Survey responses – Ranking of macro challenges that could be addressed (FIDIC GLF members)



Traditional infrastructure methods have significant room for improvement: an industry shift and refocus is needed

Infrastructure projects and the resulting assets delivered are increasingly complex, often experiencing continued scope change as they are procured. Many fail to deliver on time, within budget, or provide the promised benefits, which creates an unacceptable amount of wasted resources in recovering these projects or undelivered societal impact.

This means that traditional infrastructure delivery methods are becoming less relevant, and project owners and stakeholders need to shift their focus to consider the full project ecosystem that integrates physical and digital assets and end users within the wider external macro environment.

The compelling case for AI-driven transformation in infrastructure

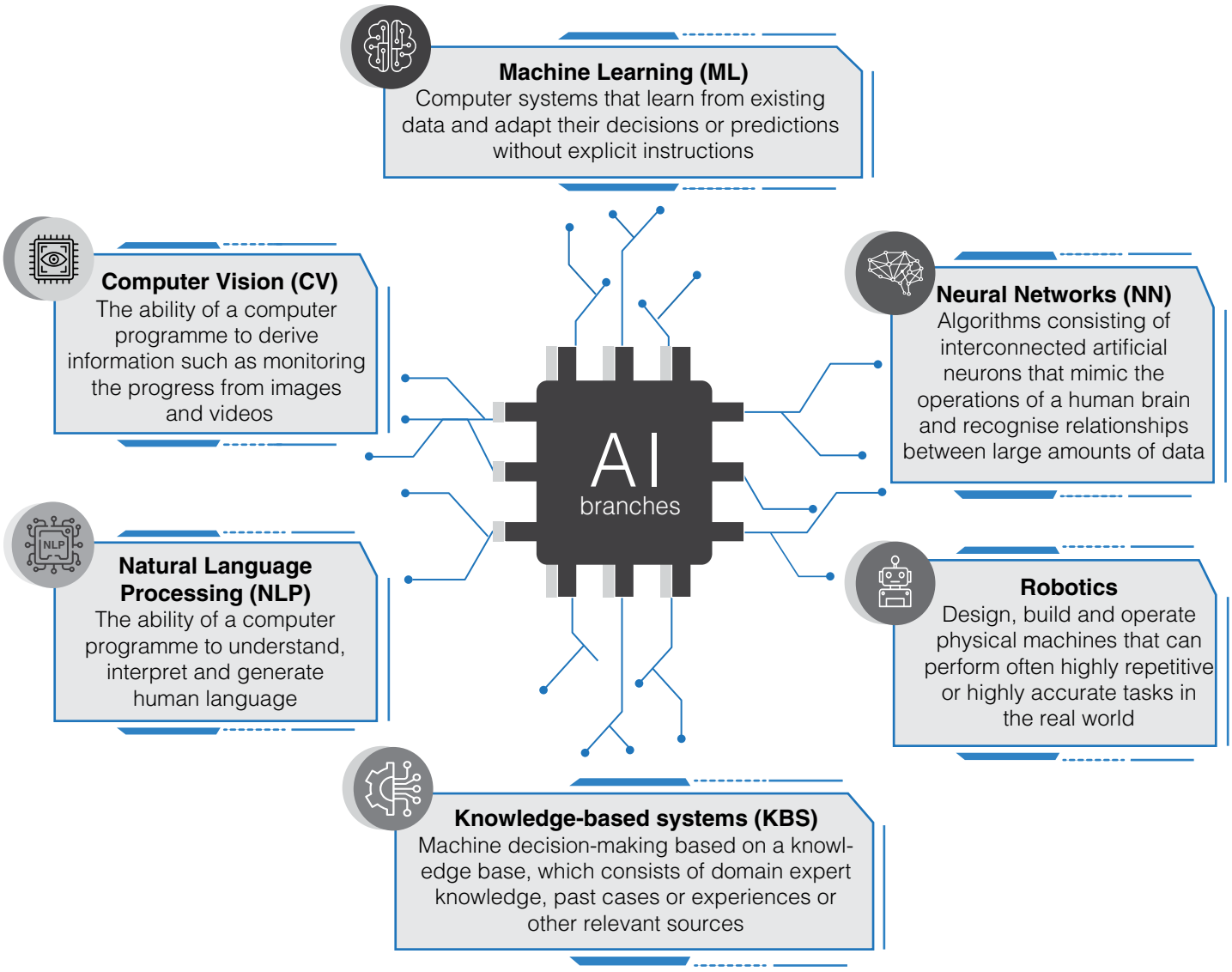
The infrastructure industry must update its traditional methods and technologies to improve project outcomes in the face of complexity and interconnectivity challenges. Stakeholders can no longer view AI as a tool that is relevant only to other sectors. Related industries like transportation and manufacturing are already breaking down silos and operating as interconnected ecosystems. As industries converge, solutions and tools once considered industry-specific are likely to find broader applications. The infrastructure sector must adapt to this rapid cross-sector disruption.

AI has already proven its ability to significantly improve decision-making, resilience, productivity, and the industry's capacity to address major challenges at both macro and micro levels. However, the infrastructure industry, historically slow to adopt new technologies, needs to speed up and expand its adoption of AI.

02 What is the current state of AI adoption and maturity in infrastructure?

AI technologies have been available, in some form, since the 1950s. However, the recent surge in its use started following the November 2022 launch of ChatGPT, a widely used, open AI large language model (LLM). Despite the recent adoption in many sectors, AI is still new to many in the infrastructure industry, and there remains an inconsistent understanding of what it means and what it can do. It is often misunderstood and even feared: is it a single solution or a collection of technologies? Is it a threat or an opportunity? It is important to clearly define AI and explain how it can be used. Figure 2 below shows the discrete branches of AI in infrastructure:

Figure 2: The six common discrete branches of AI in infrastructure



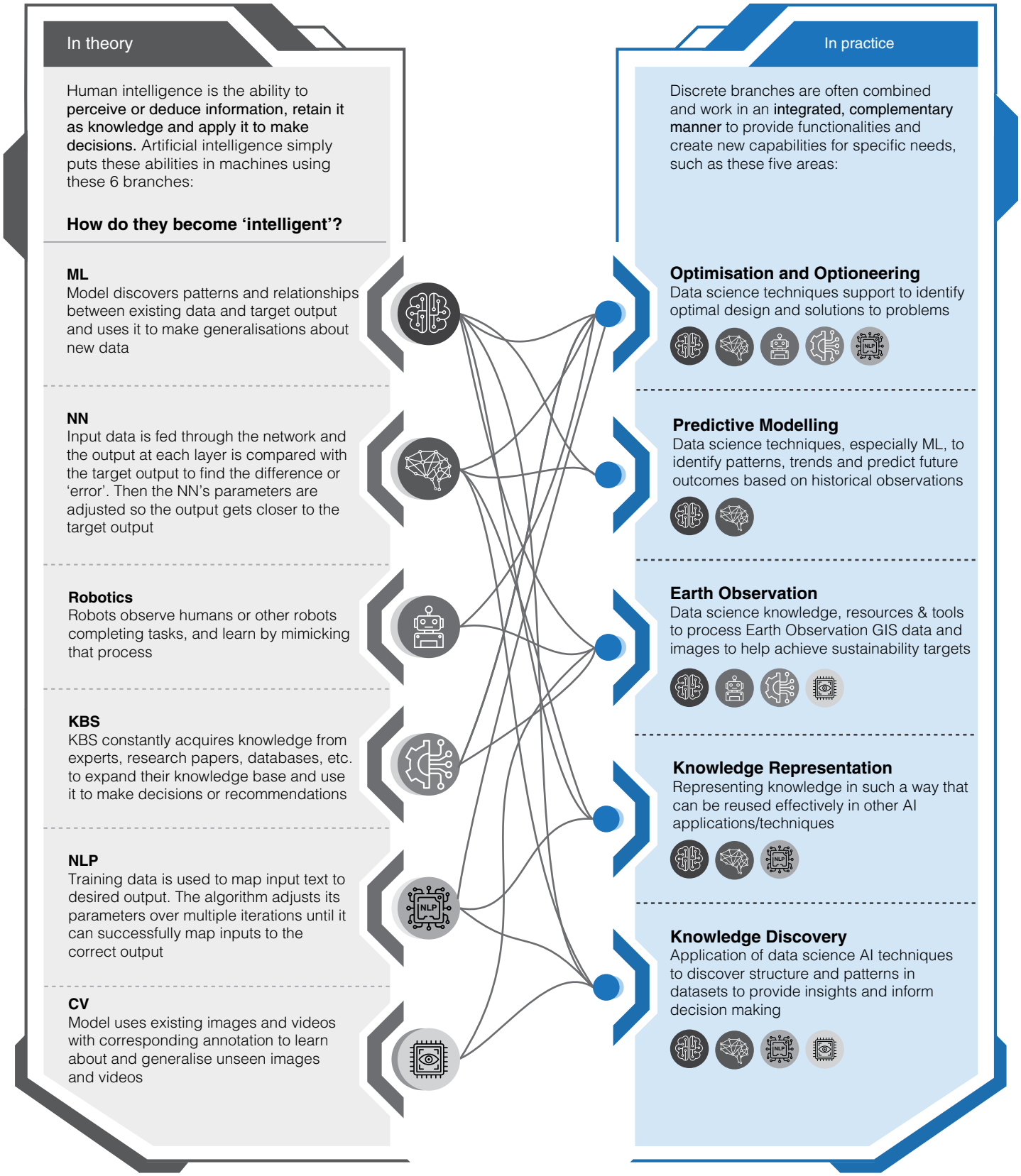
CASE STUDY: AI-driven road maintenance in Australia: The Asset AI® Project

The NSW Government's Asset AI® project leverages artificial intelligence to enhance road maintenance and safety. Council vehicles equipped with dash-mounted cameras and sensors gather near-real-time data on road conditions, which includes input from private vehicles. AI technology analyses this data to automatically identify and classify road defects such as potholes, cracks, street litter, faded line markings, and damaged signs. This information is sent to the Asset AI® digital platform, which assesses defects and recommends response times. Councils can access this data to schedule maintenance work, reducing risks to road users. By harnessing AI, the project aims to revolutionise road asset maintenance and operations, leading to faster repairs, cost savings, and safer roads. The project also aims for a 10% efficiency gain in managing public assets by reducing maintenance backlogs, ultimately enhancing overall road safety and operational efficiency.

Source: AssetAI® – SmartNSW case study | NSW Government

While AI can be broken down into six discrete branches, in industry practice, it will be adopted in a more integrated way. Figure 3 illustrates the difference between the branches and the five key areas of AI adoption currently in use within infrastructure, where they work together in an integrated and complementary manner. These five key emerging areas are namely optimisation and optioneering, predictive modelling, earth observation, knowledge representation and knowledge discovery.

Figure 3. Key areas of AI adoption in the infrastructure sector



Systems that integrate multiple core branches of AI are more usable and effective

In addition to the core branches and key areas of adoption, the future of AI in the infrastructure industry will rely more on combined systems. These combined systems merge multiple AI technologies to provide more powerful and versatile solutions, acting as a "wrapper" around the core branches. Key examples of these combined systems are:

- **Generative AI:** Systems that create new content, such as images, text, or audio, based on the data they have been trained on. These models boost creativity and innovation and can speed up infrastructure design and planning. For example, generative design algorithms can create multiple design options for civil engineering projects, balancing and optimising constraints and requirements.
- **Multimodal AI:** Combines information from multiple data sources and types, such as text, images, and sensor data, to make more informed decisions. In infrastructure, this allows the simultaneous analysis of diverse datasets, improving predictive maintenance and project monitoring.
- **Explainable AI (XAI):** Makes AI decision-making processes clear and understandable to humans. XAI can help build trust and ensure regulatory compliance in the infrastructure industry by showing how AI systems reach specific recommendations or decisions, improving risk assessment and outcome validation.
- **Spatial computing:** Uses digital and physical space to interact with, manipulate, and enhance real-world environments through technologies such as augmented reality (AR) and virtual reality (VR). For infrastructure projects, spatial computing can help visualise complex data in a geospatial context, improving site inspections, construction management, and urban planning.
- **Federated learning:** A way to train machine learning models across multiple sites without sharing raw data. This is useful for the infrastructure industry, where data privacy and security are crucial. By using decentralised data sources, Federated learning helps develop robust AI models while keeping data confidential.

Looking to the future, AI agents will emerge as sophisticated interfaces that combine various AI technologies, allowing autonomous decision-making and seamless integration of multiple AI capabilities. These agents can choose which underlying AI technology to use based on the task. By acting as a central interface, AI agents simplify the user experience and enhance operational efficiency, dynamically using the core branches and combined systems discussed above.

As AI agents evolve, their role in the infrastructure industry will become more important. They represent the next step in AI integration, offering a unified solution that uses the strengths of various AI branches and combined systems. The ability of AI agents to autonomously manage and deploy sophisticated AI techniques will lead to significant improvements in project efficiency, cost savings, and overall project outcomes, shaping the future of infrastructure development and management.

CASE STUDY: Improving safety and efficiency public works delivery through advanced AI technology, Hong Kong

Construction site safety remains a priority for the Hong Kong government. To show their commitment, the Civil Engineering and Development Department (CEDD), responsible for public infrastructure delivery, has recently implemented world-leading AI-enabled smart site safety systems to improve safety performance and project delivery.

On the Tung Chung New Town Extension, a major project covering 130 hectares of reclaimed land, the CEDD has installed:

1. High-resolution camera systems using computer vision to monitor high-risk tasks and detect safety violations in real-time
2. Systems that automatically identify:
   - Personal protective equipment compliance
   - Unauthorised access to restricted zones
   - Workers crossing designated danger zones
3. Real-time traffic monitoring that:
   - Alerts when traffic queues form
   - Flags disruptions to temporary traffic arrangements
   - Monitors construction vehicle cleanliness to consider the local community

The safety data and automated insights from these AI technologies help the CEDD project team to:

- Identify subcontractors with poor safety performance
- Target follow-up actions such as training or increased monitoring

These systems are improving site safety, project delivery efficiency, and productivity by enabling timely decision-making and interventions.

Startups have led AI investment in infrastructure, but adoption and joined-up thinking remains limited

The growing startup and venture world has primarily driven AI applications in the infrastructure industry, leading to more organisations testing various AI solutions to address business and industry challenges. There has been a clear increase in AI-based startups focusing on Internet of Things (IoT)-enabled urban infrastructure, smart mobility, intelligent waste management, and digital twin technologies[12]. For example, OpenSpace offers AI-driven building information modelling (BIM) technology for construction projects[13]. Another startup, nPlan, has gained significant industry uptake by providing project and portfolio managers with unbiased schedule assurance insights. Their AI Deep Learning-powered forecasting engine utilises past project schedules to show project deliverability before key decision points[14].

More established software vendors are starting to expand their offerings to include AI capabilities. Procore Technologies, a well-known cloud-based construction management software application, recently developed an AI-driven construction project management platform. This platform uses machine learning algorithms to simplify and automate workflows and repetitive tasks. It also gives insights that help project managers predict and address issues before they arise[15]. The combination of startups and established software vendors offering AI solutions is leading to a diverse array and use of AI core technologies for various applications, as captured in the survey responses (see Figures 4 and 5).

AI-enabled technology start-ups focusing on the built environment have attracted substantial funding, securing US$12.3 billion between 2020 and 2023 in North America and Europe alone, even outstripping AI-enabled Fintech startups in terms of deal count in 2022[16]. This investment level and the solutions being developed show that AI is creating pockets of value across the infrastructure industry. However, much more investment is needed in the development and integration of the technology to drive widespread adoption, and in broader foundational issues like breaking down siloes, upskilling industry members and tackling data availability and sharing. Interest in AI from the industry's major players is further supported by our survey. The respondents indicated that they're spending, albeit some conservatively (less than 2% of their revenue) and some taking bolder steps towards 10% (see Figure 6).

Figure 4: Survey response – AI technologies currently used by FIDIC GLF members

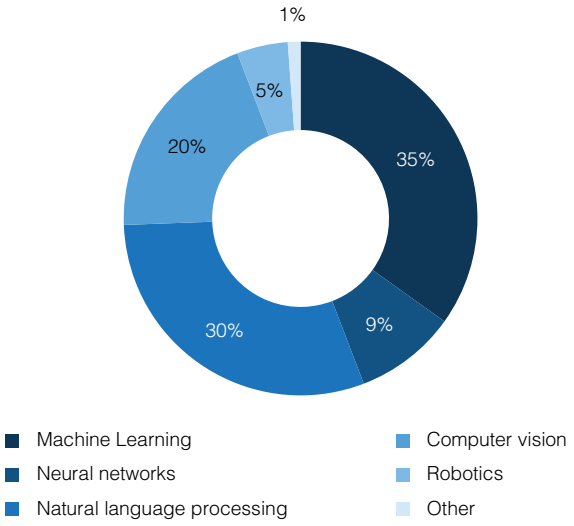


Figure 5: Survey response – AI applications currently used by FIDIC GLF members

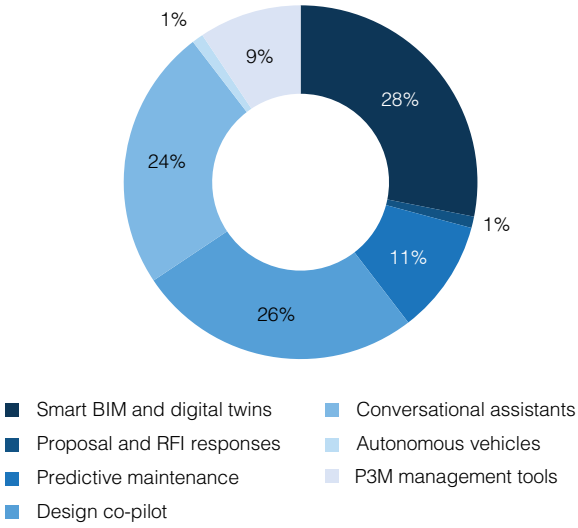
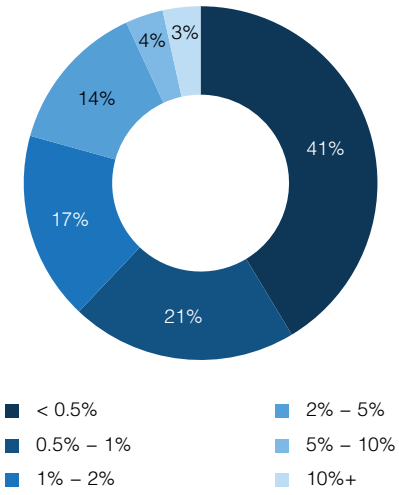


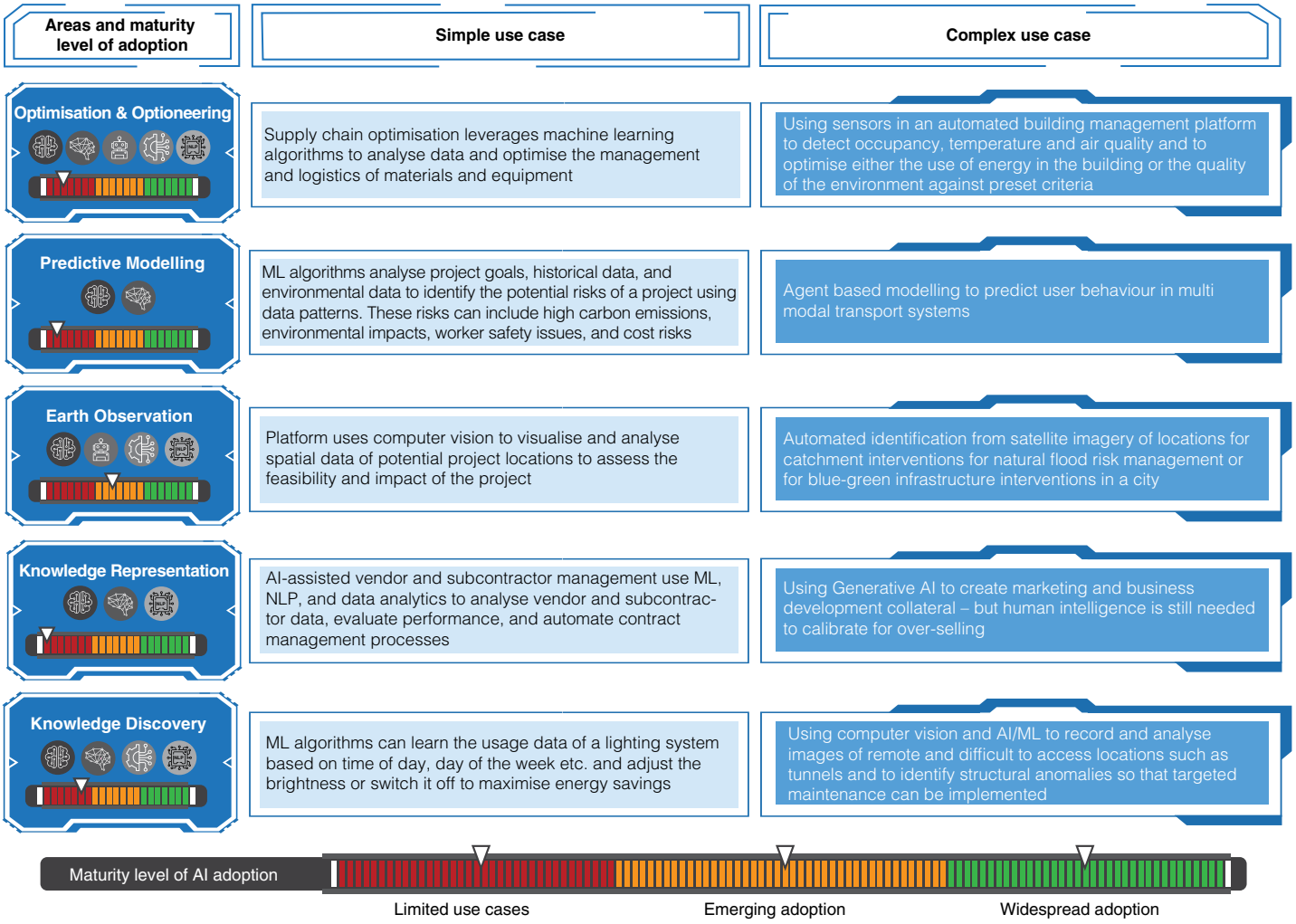
Figure 6: Yearly AI investment as a percentage against revenue by FIDIC members



AI use cases in the infrastructure market are largely discrete point solutions, with AI integration remaining fragmented and limited

Key regulations, standards, and guidance to support best practices and interoperability are still in early development. Our research indicates that the industry's maturity in embracing AI across the five key areas, outside of particular spot solutions is generally low suggesting that AI's full potential to significantly improve performance and outcomes is far from being realised. Figure 7 illustrates the adoption spectrum and provides examples of the relatively simple and more complex use cases of AI branches, showing that most areas are in the early stages of development.

Figure 7. AI adoption maturity level, with simple and complex use cases in the respective identified areas



When examining project-level use cases across the infrastructure asset lifecycle, feedback from GLF members indicates an industry belief that AI is currently best suited for the early stages of project delivery. Figures 8 and 9 both support that the design stage is where members believe AI can add the most value and as a result, this is where efforts and commitments are being targeted and prioritised. This focus can likely be explained by several current factors:

- The current rapid growth of generative AI capabilities
- The relatively data-rich nature of the design stage
- The controlled environment in which these technologies can be used

These elements make the design stage particularly suitable for using AI to significantly improve efficiency, accuracy, and innovation.

Figure 8: Survey response – Ranking of project level challenges that could be supported by AI (FIDIC GLF members)

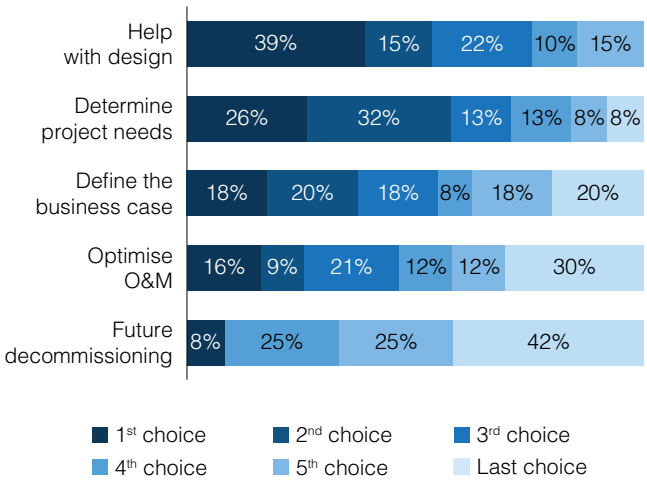
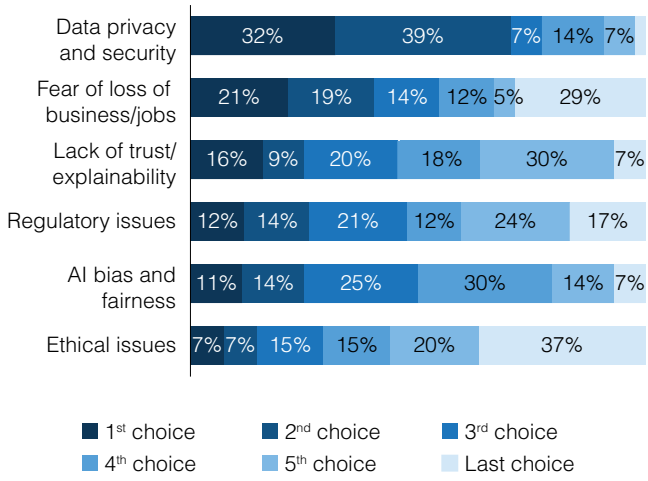


Figure 9: Survey response – Ranking of target commitments to enhance AI adoption (interest by FIDIC GLF members)



In the near future, a big improvement in the development of AI design-related solutions, such as optimisation and optioneering as well as predictive modelling, can be expected, making them an industry standard.

Growing AI adoption: Unleashing the potential of complex interconnected systems

The increasing adoption of, and investment in, AI in infrastructure presents an opportunity to bridge the connection between infrastructure planning, project delivery, asset operation and the dynamic complexities of the societies in which they exist. Infrastructure projects are inherently complex, with numerous interrelated components, variables and external influences. While traditional spot solutions focus on specific parts of a project, they often fail to unlock the full value embedded within these interconnected systems – to date this is true of AI solutions available for infrastructure.

AI, however, has the capability to significantly expand the toolset available to industry to interrogate and understand these complex interrelationships, providing a comprehensive view of the entire system. By considering these intricate environments, we can employ a methodology called 'systems thinking'. This systems-based mindset will allow the understanding of the interactions between system elements, identification of the right stakeholders at the right time, and broadening of the range of AI choices and solutions available. This approach will accelerate the delivery and transformation of infrastructure to meet the macro-level challenges society faces.

CASE STUDY: Developing the world's first hyper-connected smart city – NEOM, Saudi Arabia

NEOM, a megacity project under construction in Saudi Arabia, is planned as a model for sustainable and technologically advanced urban living. A key part of this plan is the city's AI-driven initiatives that expand the asset lifecycle, including:

- AI-powered solutions used to conduct quick design simulations before construction starts
- AI algorithms that improve the high-speed underground rail system to ensure efficient, reliable transportation for residents
- In utilities, AI-based monitoring and management systems will oversee the city's energy, water, waste, and air quality to reduce environmental impact
- In healthcare, the city will use AI-powered diagnostics and patient monitoring systems for personalised medical care
- AI-enabled security systems will ensure resident safety through smart surveillance and predictive analytics
- NEOM's efforts also include wildlife conservation, where AI-driven monitoring and management systems will support the city's efforts to reintroduce and protect native species

The development of NEOM and its extensive use of AI showcases Saudi Arabia's ambition to become both a global leader in smart city development and the world's first hyper-connected smart community through its commitment to leading the way in the adoption of AI.

As the megacity project progresses, it will offer valuable insights as a blueprint for the global infrastructure industry and governments aspiring to create a more technologically advanced, liveable and environmentally responsible future.

03 What is the broader impact of AI on infrastructure and society?

Removing barriers allows AI to embrace the complexity of infrastructure development

Traditionally, infrastructure planning, delivery, and operation have often occurred in isolated, linear ways. Infrastructure development is inherently complex, involving many interconnected parts and dynamic interactions. To manage this complexity, the asset lifecycle has been broken down into a series of steps: planning, design, construction and operation, each affected by many stakeholders. This step-by-step approach is used because of:

- Limited resources
- Need for simplicity
- Contractual requirements
- Limits of human ability to manage and understand lots of information at once

AI offers an opportunity to shift toward a 'systems thinking' approach in infrastructure development. With its immense processing power and advanced abilities in data analysis, relationship discovery, and outcome prediction, AI can handle complexities that traditional linear systems cannot. AI can analyse vast amounts of data to uncover hidden patterns, predict potential issues, and best use resources across all project phases.

Importantly, adopting 'systems thinking' does not require an overhaul of the entire industry. The systems are already in place; the focus should be on breaking down the barriers enforced by the siloed nature of current practices. Enhanced data sharing and collaboration can help unlock the potential of AI and maximise investment return, helping to bridge gaps between industry stakeholders who might resist AI adoption, and ultimately creating lasting value across the asset lifecycle.

The infrastructure asset lifecycle and society are closely linked and always changing, with human behaviours, mobility, technology and economics all creating significant, ongoing influences

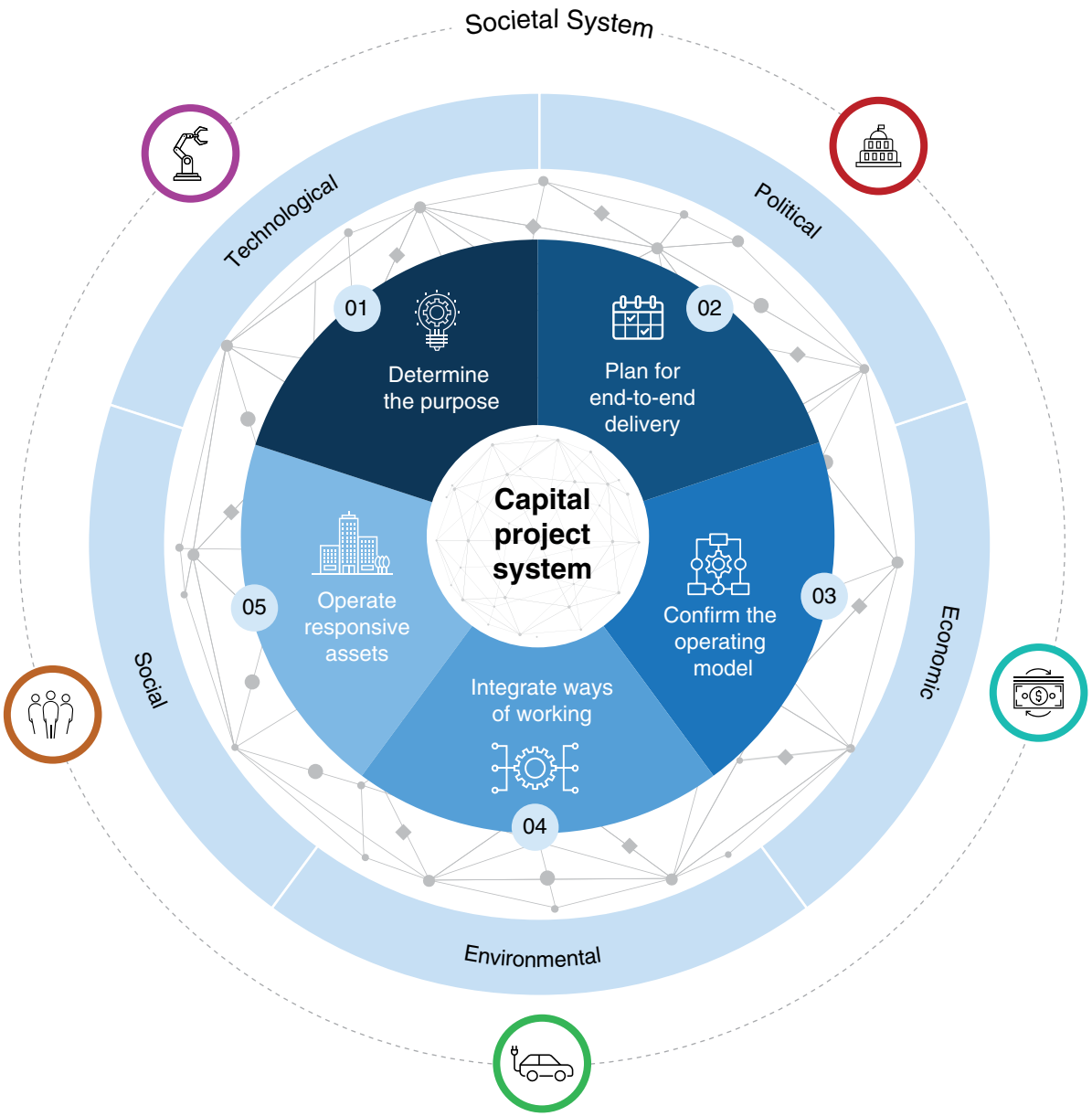
'Societal systems thinking' is typically done by governments and planners. However, it's becoming more important for all industry stakeholders to think about the societal system to properly address changing risks and opportunities over an asset's lifecycle. 'Systems thinking' uses the connections between various parts involved in infrastructure delivery as an ecosystem to integrate assets and their end users within their operating environment. This ecosystem can be described as two systems: the 'capital project system' and the 'societal system':

The 'capital project system' – infrastructure projects that work as ecosystems within and across the societal system. These are organised around five guiding principles that are important throughout an asset's lifecycle.

The 'societal system' – the political, economic, social, technological, and environmental influences that impact all of society, and drive infrastructure decisions and end-user needs.

Integration of these systems can develop more resilient, adaptable, and impactful infrastructure that creates lasting value for both the project and the broader society. The interconnected nature of the systems environment is illustrated in Figure 10.

Figure 10. The interconnected infrastructure systems environment



Technological
- Technological capacity, innovation and integration
- Data requirements, availability and management

Economic
- Financial viability and lifecycle cost-benefit
- Economic growth, job creation and productivity enhancement
- Trade facilitation

Political
- Development priorities
- Land allocation and policy formulation
- Governance frameworks and regulations

Social
- Community engagement, needs and equity
- Skill set and labour diversity
- Cultural heritage, traditions and community identity

Environmental
- Sustainability in terms of its impacts on biodiversity, natural resources and climate
- Climate resilience

AI can help the industry shift to a 'systems outcome-focused systems mindset' by addressing each of the five guiding principles that define the capital project system

Five guiding principles that frame the traditional asset lifecycle have been defined to support the use of a systems thinking mindset in infrastructure development to enable the adoption of AI. As illustrated in Figure 10, these principles outline the framework of the system within which infrastructure is delivered and operated. By enhancing the ability of infrastructure industry stakeholders to more effectively consider and build the connections of various factors across all five guiding principles, better decision-making and outcomes can be achieved. Adopting AI-driven solutions that encourage collaboration and simplify the complexity of the interdependencies across the capital project system would significantly increase the likelihood of projects achieving their intended outcomes.

These five guiding principles provide opportunities to create value at every stage of the asset lifecycle and form the basis upon which AI technologies can unlock benefits for society.

1. **Determine the purpose:** Meeting end-user needs should be the primary focus of planning and decision-making. AI can assist in analysing vast amounts of data to understand societal needs and predict future demands, ensuring assets are developed to benefit society, with resilience and responsiveness as key priorities. As we transition to a circular and net-zero economy, designers, contractors, and operators can no longer work in silos. All stakeholders have critical experience and knowledge of how an asset can meet its targeted outcomes and benefits, which evolve through the planning and delivery stages. This expertise must be used to achieve better outcomes.

2. **Plan for end-to-end delivery:** Creating a robust digital and data strategy during the infrastructure business case development process is critical for success. The industry must invest more time in thorough up-front planning to ensure projects are doable and affordable before making commitments. AI can significantly improve planning, design and preparation for project execution by optimising resources and predicting potential challenges if sufficient investment is made early on. In the early stages, the highest degree of influence is achievable at the lowest cost, meaning that early investment will be repaid many times over during delivery.

3. **Confirm the operating model:** Traditional delivery and operating models are no longer sufficient for delivering major infrastructure. Setting up projects and programmes with governance and contracting arrangements that support the ambitions of wider portfolios is a strategic priority. Opportunities for creating value through adopting technologies that improve collaboration and efficiency exist across all operating models, from traditional transactional models to highly collaborative enterprise models.

4. **Integrate ways of working:** As infrastructure assets and the external environment are becoming more complex, the capabilities required to successfully deliver and operate them have never been more challenging. Asset owners must actively participate from the outset to ensure they have systems and teams with the right capabilities to act as intelligent clients. AI can support the development and deployment of resources by identifying skill gaps and predicting future talent needs. Meanwhile, supply chain providers must continuously develop their businesses to deliver high-quality outcomes. These resources must be developed and deployed not only to satisfy current project requirements but also with a forward-looking focus on developing and filling future skills and talent needs in areas such as digital, automation, and sustainability.

5. **Operate responsive assets:** Operational considerations must be kept at the forefront of decision-making during the planning, design, delivery, handover, and initial use or occupation of built assets. AI-driven solutions can analyse asset performance data in real time, comparing it against assumptions and targets to ensure optimal operation. This requires collaboration between designers, contractors, operators, and end users, as well as data-driven solutions that analyse asset operational performance against assumptions and targets. By focusing on better outcomes for built assets, greater value can be delivered throughout the operational lifecycle of assets.

An overview of the AI branches and functions as well as 'in practice' example within each of the five guiding principles is provided over the following pages.

AI use cases in infrastructure and how they support the five guiding principles

Guiding principle 1: Determine the purpose

AI use case (1a): Spatial location intelligence

AI branch: Machine Learning (ML) and Computer Vision (CV)

Function: ML and CV algorithms analyse remote sensing satellite imagery to help identify and classify landscape features and built infrastructure, producing digital maps of current site conditions during the project planning stage. This makes digital maps faster and at a significantly lower cost than traditional methods, enabling better site investigation and due diligence for planned developments. This enhances the capability of decision-making to select the most appropriate locations for new developments.

Example in practice: ML algorithms process satellite images to visualise and analyse spatial data of potential project locations[17], measure biodiversity baselines and trends[18], and provide feasibility insights based on the potential impact on the site and surrounding geography. The outputs have additional uses during planning stages, such as serving as an early basis for optimising site access routes to support planning approvals or logistics modelling in construction to support planning approvals at an early stage.

AI use case (1b): Automated Environmental Impact Assessment (EIA)

AI branch: Machine Leaning (ML)

Function: ML algorithms conduct automated AI-enabled environmental impact assessments (EIAs) by assessing a project's potential impact on the surrounding environment. These algorithms identify patterns and relationships between key environmental factors such as water, air, noise quality, and climate impact. This speeds up the EIA process and improves the output quality by providing data-driven trends and insights while minimising human guesswork.

Example in practice: ML algorithms are deployed to identify environmental risk factors on proposed infrastructure sites that can adversely affect biodiversity, including flora and fauna. These algorithms model pollutant levels and habitat invasion due to the construction process and provide recommendations for effective mitigation strategies to reduce negative impacts.

Guiding principle 2: Plan for end-to-end delivery

AI use case (2a): Generative concept design

AI branch: Machine Leaning (ML) and Computer Vision (CV)

Function: ML creates new design ideas using existing data, while CV solutions analyse design codes, user preferences, and requirements to generate multiple design alternatives. This optimises repetitive tasks, allowing designers to focus on complex engineering challenges and stakeholder management.

Example in practice: Designers deploy ML and CV AI techniques to automate concept design processes, such as analysing complex structural drawings, combining requirement texts, and performing pattern recognition and topology optimisation[19]. This increases the speed of exploring options, and improves design outcomes.

AI use case (2b): Intelligent risk and contingency quantification

AI branch: Machine Learning (ML) and Natural Language Processing (NLP)

Function: ML and NLP solutions automate the analysis of industry trends and project performance benchmarks. They assess the realism of project cost estimates, schedules, and contingency allowances. This helps reduce optimism bias and identify emerging risks earlier.

Example in practice: LLM solutions use historical schedule data to produce unbiased forecasts and deliverability assessments. This provides project owners with more realistic schedule assessments, enabling better collaboration with contractors and proactive portfolio management.

Guiding principle 3: Confirm the operating model

Use Case (3a): AI-ready digital twins

Function: AI adoption requires quality data throughout the asset lifecycle. This needs a strategy spanning design, construction and operation phases, where data from multiple stakeholders is shared and integrated. By requiring digital twins, project owners improve collaboration between stakeholders via a shared virtual platform. This creates a strong foundation for AI-ready asset data, essential for using AI solutions across the entire infrastructure development lifecycle.

Example in practice: Combining BIM models with asset information to form mature digital twins provides a platform for integrating AI with Internet of Things (IoT) sensors. This supports digital asset management, predictive maintenance and real-time monitoring, improving asset performance and operational efficiency.

Guiding principle 4: Integrate ways of working

AI use case (4a): AI-Powered Project Management Office (PMO)

AI branch: Machine Learning (ML) and Natural Language Processing (NLP)

Function: ML and NLP solutions streamline the project management office (PMO) by automating functions like scheduling, resource allocation, document management and progress monitoring. This improves control, insights and productivity, producing better, real-time project and portfolio performance information. It allows project managers to identify early signs of project failure and make actionable recommendations.

Example in practice: ML and NLP solutions analyse historical and current portfolio performance data, market conditions and external factors to predict potential project delays, budget overruns and resource shortages. This enhances forecasting accuracy and provides real-time insights for risk management and mitigation, reducing delays and cost overruns.

AI use case (4b): Autonomous construction solutions

AI branch: Machine Leaning (ML) and Computer Vision (CV)

Function: ML and CV-enabled smart construction robots autonomously perform site operations, such as detailed scans of structural components for quality assurance, aerial drone surveys to create digital twins, as-built surveys, and basic tasks traditionally performed by workers, like lifting and moving objects, transporting materials and monitoring sites for safety issues. These AI-driven autonomous construction solutions collectively increase productivity, reduce risk in a high-hazard industry, and tackle issues related to skilled labour and housing shortages.

Example in practice: ML and CV-powered semi-autonomous swarm robots deployed to undertake underground construction via an innovative method that eliminates traditional tunnelling. The AI powered robots perform horizontal directional drilling, boring a series of small openings that form tunnel outlines. They deploy cartridges of construction chemicals through the bores to 3D print the tunnel's structural shell, upon which a continuous concrete layer is sprayed to complete it. This technique is faster, safer and more environmentally friendly than current tunnel construction methods, reducing costs and enabling the industry to satisfy the growing demand for tunnels more sustainably.

AI use case (4b): Autonomous construction solutions

AI branch: Machine Learning (ML) and Computer Vision (CV)

Function: ML and CV, combined with drone technologies, use high-resolution cameras and LiDAR sensors to capture aerial imagery and 3D data. This data is then processed to provide insights, detect objects, identify patterns and create detailed 3D models, enabling real-time monitoring and analysis of infrastructure to detect issues, track progress and optimise operations.

Example in practice: On construction sites, drones equipped with AI solution capture aerial data, providing a comprehensive view of the site. AI algorithms analyse this data to monitor construction progress, identify potential safety hazards, and improve project management in real-time.

Guiding principle 5: Operate responsive assets

AI use case (5a): Predictive rail maintenance

AI branch: Machine Leaning (ML)

Function: ML-powered predictive analytics help rail operators anticipate potential failures, optimise maintenance schedules, and ensure uninterrupted train operations. By providing an early warning system, the risk of accidents and derailments can be significantly reduced, protecting passengers and crews.

Example in practice: An ML solution uses predictive models to automate railway wheel and track condition monitoring based on real-time sensor data. It quickly identifies wear patterns and predicts maintenance needs, preventing hazardous situations.This enhances safety, minimise downtime, improves passenger experience and optimises rail operations by reducing unnecessary maintenance expenses.

AI use case (5b): Smart building energy management

AI branch: Machine Leaning (ML)

Function: ML-based solutions provide AI-driven smart energy management systems for new and existing built assets through advanced data analytics and optimisation algorithms. These smart systems help optimise energy consumption and efficiency to achieve operation expense savings, enhanced environmental performance and better end-user experiences.

Example in practice: An ML system combines data obtained from a building's existing energy management system with other sources (e.g., weather data) to optimise energy use in real-time. The system predicts the building's energy use 24 hours in advance based on past experience. It also monitors electricity prices and generation mix, allowing it to adjust the building's electricity use based on cost or carbon intensity at any given time.

Maximising AI's potential will lead to faster, more efficient, and socially responsive planning, execution and operation of infrastructure

The use cases demonstrate how AI can improve the planning and execution of assets, making it more likely to achieve their intended benefits that address society's macro challenges. However, the industry lacks understanding of how and where these AI use cases can be used in the asset lifecycle, which slows down adoption – there is a skillset issue that needs to be addressed. By viewing infrastructure development as interconnected systems and outcomes, we can better understand how AI can bridge gaps between systems and desired results.

High levels of AI adoption could lead to faster project delivery and greater societal benefits for end users

As infrastructure and its development and operational systems become more complex, we need to understand options and trade-offs faster throughout the asset lifecycle to make better decisions and respond more quickly. The AI use cases in infrastructure show how AI-enabled technologies can improve connectivity, deliver faster and 'declutter' the connections between societal and project systems at all stages of the asset lifecycle.

New AI technologies focus on helping industry stakeholders overcome major infrastructure challenges, including cost and schedule overruns and safety concerns. AI will uncover connections and drive insight-driven decision-making by increasing the industry's ability to use automated analysis and identify patterns in vast amounts of data created through the asset lifecycle. These new capabilities can create greater efficiencies, increase productivity and lead to successful outcomes in less time. Given AI's power and opportunity to enhance our ability to deliver resilient infrastructure, finding ways to speed up and enable pathways to adoption of this toolset is crucial for the industry.

CASE STUDY: Revolutionising tunnelling technology through advanced AI-enabled robotics

Tunnelling is expensive and complex, making it a priority infrastructure activity that could benefit from solutions that reduce risk and improve delivery efficiency. HyperTunnel, a UK-based technology start-up, has developed a solution that uses swarms of autonomous robots with AI and machine learning to significantly improve traditional tunnelling processes.

HyperTunnel's approach:

1. Drill and insert special pipes into the soil to form a grid
2. Use survey bots to gather geological data and predict soil conditions
3. Create a digital twin of the structure
4. Use robots inside the pipes to drill access points and fill them with a hardening material to form the tunnel lining
5. Use drills to break up the soil, which is removed by autonomous trucks
6. Leave a ready-made tunnel for workers to complete finishing works

In October 2022, HyperTunnel tested their technology by completing 'Peak XV', a 6m long by 2m wide tunnel in their R&D facility. In 2024, they secured government funding to build a 20m pedestrian underpass in South Wales, showing the potential of AI to change traditional delivery processes, increase construction productivity and improve safety.

Human-AI collaboration in infrastructure delivery is imperative

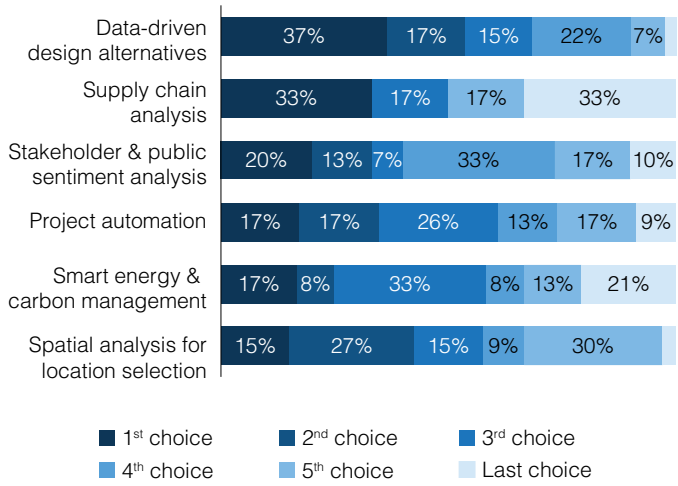
While AI has many strengths and opportunities, it is important to recognise its current limitations and the irreplaceable value of human expertise in the infrastructure industry. AI excels in repetitive tasks, data analysis, content creation, and optimisation. These capabilities can greatly improve efficiency and accuracy in areas like predictive modelling, project scheduling, and design optimisation.

However, AI is not adept at tasks requiring significant dexterity, like manual construction, or those needing a deep human connection, like team management. AI also lacks the intuitive and creative capabilities essential for high-level concept design and strategic decision-making. These tasks rely heavily on human intuition, experience, and emotional intelligence, which AI has yet to replicate.

The augmentation, or 'supercharging', of infrastructure professionals throughout the delivery cycle shows great promise. AI is particularly effective at handling boring and repetitive tasks, allowing human specialists to focus on more complex, creative, and rewarding aspects of their work. This partnership between humans and AI can lead to a more dynamic and innovative industry, where human intelligence and creativity are augmented by the precision and efficiency of AI, which will make the industry more attractive to the next generations.

Furthermore, we must reassure our existing workforce that AI will not take all the jobs — a key concern highlighted in Figure 11. Instead, AI will transform roles and create new opportunities for human-AI collaboration. Keeping humans involved is essential not only for saving jobs but also for building trust and transparency. By ensuring human oversight is an integral part of AI processes, we can promote greater transparency and accountability in AI-driven decisions.

Figure 11: Survey response – Ranking of potential risks associated with implementing AI (by FIDIC GLF members)



Infrastructure professionals should welcome the idea of working alongside these advanced technologies. This collaboration offers a new challenge and opportunity to improve their roles and move the industry forward, while addressing the macro challenge of labour shortages highlighted at the beginning of this report.

By combining AI's strengths with human expertise, the infrastructure sector can achieve meaningful gains in productivity, decision-making, and project success.

04 What are the barriers to deploying AI at scale, and the strategies to overcome them?

AI adoption in infrastructure has enormous potential, but cultural hurdles are preventing widespread adoption

AI integration in the infrastructure industry remains mostly disconnected, compartmentalised, and underutilised due to nascent regulations, concerns around new, technology, and the fact that AI solutions are trying to fit in an old-fashioned industry. This is exacerbated by common concerns related to data sensitivity, such as security, privacy, consent, transparency, ownership, and ethical considerations (as identified in response to Figure 11 above). These factors create barriers to sharing both internally, between government projects, and externally, between government and industry, as well as between developing and developed countries.

Accelerating AI adoption requires buy-in from key industry stakeholders. However, the appetite for change is low, and a culture of suspicion persists. While AI in infrastructure has grown organically recently, faster acceleration is needed to improve the industry's performance and address societal challenges. The risk-averse nature of this safety-critical industry has made it fall behind others in technology adoption due to resistance to change.

To accelerate AI adoption, we must bridge the knowledge gap in the infrastructure industry

The infrastructure industry relies heavily on traditional practices and established methodologies. Additionally, there remains an emphasis on hands-on skills and experience over digital literacy, meaning that the workforce may lack the expertise to effectively use new technologies like AI, creating a skills gap between age groups. This resistance is also seen at the entry-level, where infrastructure-related curriculums have frequently been slow to include new practices and emerging key industry trends until they become mainstream. This cultural dynamic poses a significant barrier to AI adoption that requires a focused response to overcome.

There is significant technological fragmentation and integration challenges throughout the asset lifecycle

Access to asset data created through public and private sector infrastructure planning, delivery, and operation is a significant barrier. Infrastructure delivery is fragmented and complex, involving multiple stakeholders at various stages. Coordination amongst diverse stakeholders can be difficult, leading to slower decision-making processes and reluctance to invest in technology to foster collaboration. The technology landscape itself is also fragmented, with various software solutions, hardware options, and compatibility challenges. The lack of standardisation and data interoperability makes it difficult for stakeholders to select and integrate technologies seamlessly.

Whilst we are seeing significant funding, wider adoption of AI in infrastructure requires more investment in core areas, increased collaboration, and the development of advanced networking systems. Also, high initial AI implementation costs and unclear return on investment (ROI), coupled with uncollaborative delivery models, siloed project delivery models, and transactional contracts with the supply chain that limit data sharing, are slowing down adoption. Changing business approaches, commercial models, and diversifying operating models across key industry stakeholders are critical to increasing AI uptake and achieving successful project outcomes.

Additionally, while there is funding available, it often focuses on point solutions rather than foundational toolsets that can support widespread AI deployment. The industry needs to invest in comprehensive AI infrastructure, including data integration platforms, standardised protocols, and robust cybersecurity measures to facilitate seamless AI integration across all stages of infrastructure projects.

CASE STUDY: AI-enabled solutions for advanced urban flood management in Shanghai, China

Aging drainage infrastructure and high groundwater levels in Shanghai have caused recurring problems of stormwater flooding and water pollution. In 2018, the city asked infrastructure consultants to help develop effective solutions. This led to the creation of AI-enabled technology that uses remote sensing imagery and machine learning to gather critical data, identify landscape features, create digital maps, and classify development asset types across the city. This data-driven approach enabled an integrated water-cycle-management strategy that includes underground drainage infrastructure and above-ground solutions like parks, trees, green roofs, and urban river management.

By using AI technology, the city can map Shanghai's water management facilities in real-time to perform advanced urban flood modelling. This helps identify opportunities and challenges within its network of urban rivers, flood defenses, pumping stations, and tidal controls. This advanced monitoring and control system allows for more targeted interventions across the city's drainage network. The result is AI-driven insights that improve decision-making on infrastructure investment and ensure a proactive and responsive approach to urban flood management.

An industry rethink of business and operating models is required to accelerate AI adoption

Key industry stakeholders need targeted support and incentivisation to adapt. However, there is no single top-down, one-size-fits-all approach to improving AI adoption. Governments and industry need to work together to create a favourable environment for AI innovation. In this environment, success is scalable, risks are reduced, and issues are managed. Widespread adoption requires getting executive-level support from key stakeholders and providing targeted support that enables, encourages, and rewards AI adoption.

Accelerating innovation in infrastructure requires rethinking business and operating models, which the industry has historically been reluctant to do. Just as digitalisation transformed construction and engineering, AI has the potential to bring transformative changes. To disrupt the status quo on project planning, design, construction, and management, businesses must adapt their models to extract value from innovative project delivery approaches and create novel service capabilities.

Three business model options have been identified to accelerate a transition from traditional business and operating models to service and enterprise-centric models

While AI can create value across the infrastructure asset lifecycle, the industry's technology market and delivery models remain highly fragmented, driven by individual point solutions with room for further integration. To realise AI's benefits, we need to move from a cost-oriented approach to a service-oriented business model mindset.

The current landscape involves two key dimensions:

1. AI's internal value proposition for individual stakeholders
2. How project operation models can collectively benefit from increased AI adoption.

To drive this fundamental shift, three options move beyond status quo business and operation models.

Option 1: Integrated platform models

These models use system thinking to connect different stakeholders through widespread adoption and integration of various data platforms. These platforms offer infrastructure services, data management, analytics, and other functionalities. They can enable data sharing, joint development of AI models, and implementation of innovative solutions benefiting the entire ecosystem.

To achieve this, we need to see digital platforms as business ecosystems not just as technological solutions[20]. Asset owners can adopt this approach by setting up agreements that require delivery partners to work together and use common data environments and share target outcomes.

Option 2: Data monetisation models

The goal is to get value from data resources and turn them into tangible business outcomes. This can be through direct revenue generation or improving operational efficiency. AI needs access to relevant and diverse datasets to fuel algorithms and models, allowing them to learn, make predictions and generate insights effectively.

Key industry stakeholders like governments, asset owners, consultants and contractors have high-quality infrastructure data that can be aggregated and monetised through various channels like licensing as a product, partnerships, or joint data exchanges to share or sell to other stakeholders or third parties with specific use cases. Data-as-a-Service is an advanced option where data is provided from remote services or cloud platforms, enabling stakeholders to access and utilise curated datasets without managing underlying technical infrastructure.

Option 3: Contract incentivisation models

These models encourage other stakeholders to adopt AI during project development stages. One approach is to adjust tender scoring criteria to prioritise innovation and AI adoption. For major programmes, contracts can include rewards for achieving common strategic goals. Benefits include cross-project collaboration, leveraging collective insights, driving efficiencies, optimising resource allocation, and aligning stakeholder communication. The question now is: How do we put these ideas into action so that industry stakeholders embrace, trust and adopt these developing technologies in an AI-friendly environment?

CASE STUDY: Using AI to enhance railway inspection and maintenance in the UK

Traditional manual inspection of railway tracks has several problems:

- It's time-consuming
- It's expensive
- It puts workers at risk by requiring them to be on live tracks

A new solution: An industry-academia partnership, supported by the UK's Innovation Agency, has developed an AI-driven solution to digitise and automate UK railway line inspections.

How it works:

1. Cameras are attached to the front of moving trains
2. These cameras capture high-definition images of the tracks
3. An AI-powered computer vision system analyses these images

The system uses computer vision and machine learning to:

- Identify key track components
- Detect potential faults
- Flag areas that need further inspection or maintenance

Benefits of this automated approach:

- Enables proactive detection of issues
- Allows for preventative fixes
- Reduces unplanned service disruptions
- Improves safety for railway personnel by reducing their exposure to live tracks
- Reduces time needed for manual inspections
- Cuts costs: Estimates suggest this AI-driven inspection solution could save £10 million annually

This project shows how effective collaboration between industry and academia can speed up the development and adoption of AI technologies in the infrastructure industry.

05

What actions can infrastructure stakeholders take to fully realise the potential benefits of AI adoption?

Increasing AI adoption in infrastructure requires a targeted industry effort driven by industry ambitions and supported by enablers from key players who can facilitate change

While organic AI solution improvements are happening, accelerating growth and maturity needs industry-wide strategic and targeted intervention. The targeted effort involves stakeholder groups owning focus areas (ambitions) to increase AI adoption across the asset lifecycle, by enablers provided by other stakeholder groups.

Realising these ambitions requires cross-stakeholder collaboration to identify and implement key enablers from others. Ambitions may differ based on how AI addresses stakeholders' business and policy needs, while certain stakeholders hold keys to enabling adoption at different lifecycle stages.

Eight key stakeholder groups or organisations play crucial roles in infrastructure AI adoption:

1. **Asset managers:** Operate, maintain and upgrade infrastructure assets.
2. **Asset owners:** Fund asset development (either the private or public sector) and own the asset.
3. **Consultants:** Advisors, planners, architects, designers, cost consultants, engineers etc., that are appointed throughout the development and delivery stages.
4. **Contractors:** Coordinate and execute construction works (includes main contractors and subcontractors).
5. **Educational institutions:** Contribute knowledge, provide specialised training.
6. **Government:** Oversee relevant infrastructure policies, regulations, standards.
7. **Technology providers:** Develop and provide AI-powered technology and software solutions.
8. **Capital investors:** Provide funding and financial resources for development and adoption of AI in infrastructure.

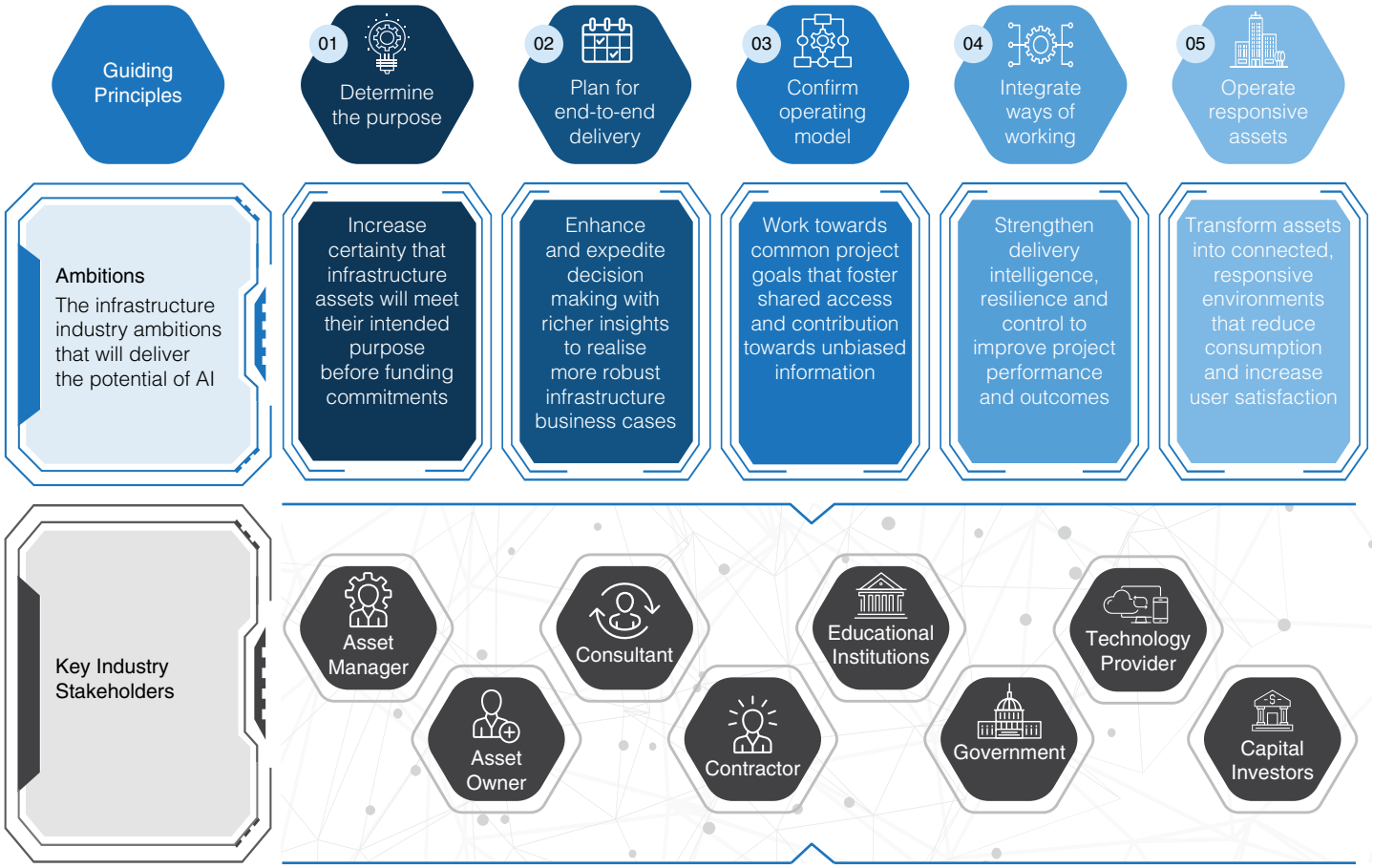
Each group has diverse interests, concerns and influences critical to balance their complex interactions and stakeholder needs.

Realising the industry's AI ambitions requires various stakeholders to implement enablers to address the diverse interests

Unlocking AI's value across stakeholder strategies and value chains requires creating an environment that benefits each group. Five key ambitions aligned with the five guiding capital project principles – along with enablers required from key stakeholders – have been identified to increase AI adoption and deliver more efficient infrastructure. See Figure 12.

These ambitions and enablers collectively aim to facilitate automation, reduce duplication, strengthen controls and enable evidence-based, data-driven decision-making. This environment will boost productivity, increase confidence in infrastructure business cases and more consistently deliver end-user benefits, allowing 'more with less' to meet current and future challenges.

Figure 12: The ambitions aligned to the five guiding principles and the key industry stakeholders required to realise acceleration of AI adoption



To realise the ambitions aligned with the five guiding capital project principles, a proactive industry response is required from the key industry stakeholder groups. These stakeholder groups need to connect and collaborate in a complex industry environment within which the relationships change over time. On one hand, the stakeholders are the AI users who must make commitments to adopt the AI solutions, whilst on the other, have the ability to exert influence by providing enablers to AI users.

Considering this dynamic stakeholder environment, can we establish an industry-wide framework that sets out the relationships between the guiding capital project principles and the ambitions and commitments required from individual stakeholder groups to realise the ambitions? And what are the specific enablers identified from the previous section that are required from other individual industry stakeholder groups to realise the ambitions at each stage of the asset lifecycle? These relationships are explored and illustrated over the following pages.

Industry wide commitments

Regardless of the stage of the asset lifecycle, and the particular interaction of various stakeholders, it is essential that industry as a whole commits to embracing AI and the changes it can bring, developing AI-specific skills and investing in creating fit-for-purpose solutions. The industry commitments include:

Mindset: Cultivating an open and collaborative environment is essential for the successful adoption of AI. This involves raising awareness, fostering discussions, and addressing legal and ethical considerations to build trust and encourage the sharing of data and insights.

Skillset: Developing the competencies required to leverage AI in infrastructure is crucial. This includes providing training, certifications, and workshops that equip professionals with the knowledge and expertise needed to integrate AI technologies effectively as well as keeping the infrastructure industry attractive to future generations.

Toolset: Offering the right tools and frameworks is vital for practical implementation. This involves developing standardised data collection methods, secure data sharing protocols, and AI-specific contract provisions that support innovation and collaboration.

Principle 1: Determine the purpose

Ambition: Increase certainty that infrastructure assets will meet their intended purpose before funding commitments.

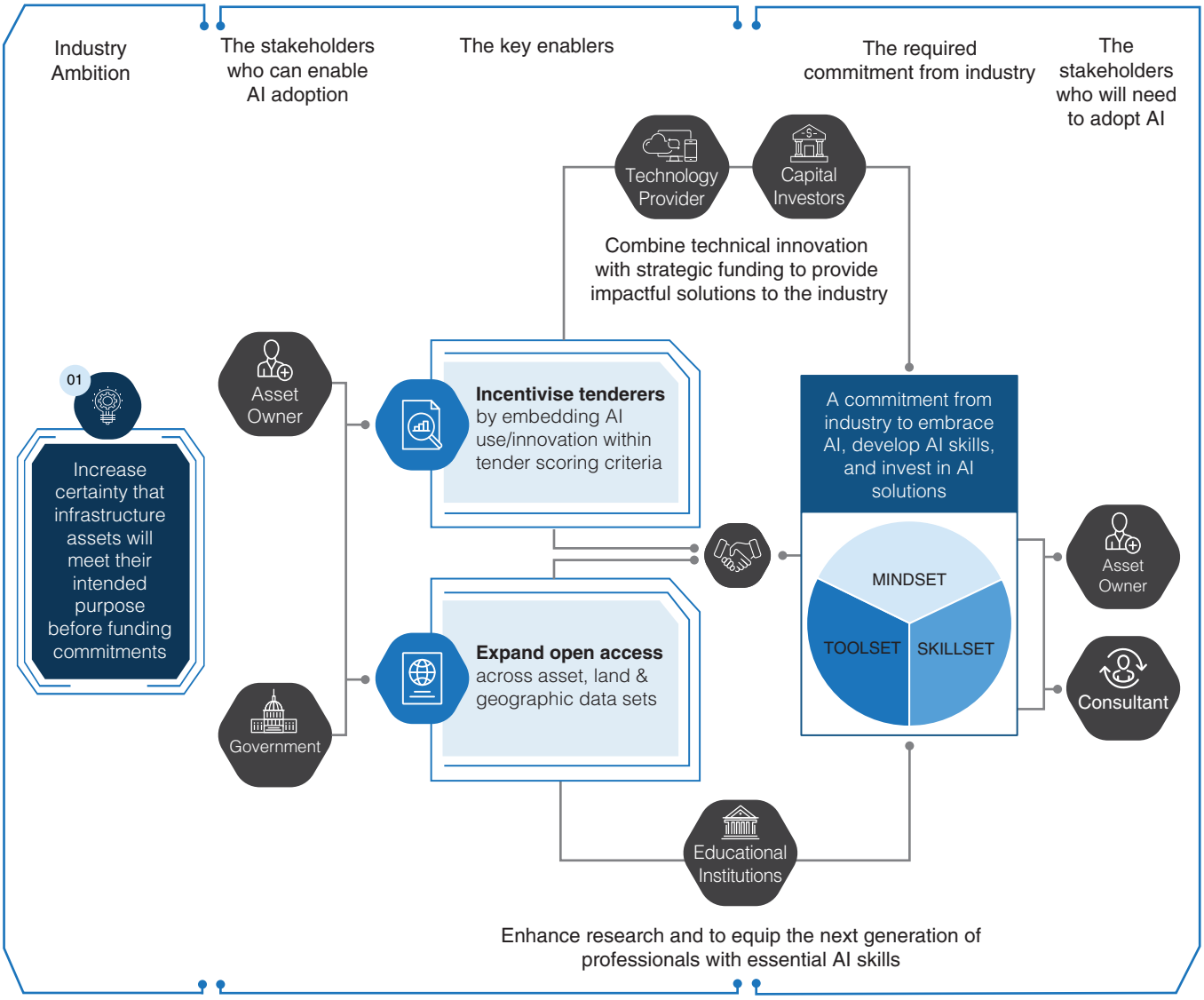
Proactive industry response required: Incentives and enablers initiated and implemented by *asset owners* and *government*, internally to achieve buy-in and sponsorship, and externally to *consultants*.

Key enablers include:

- **Incentivise tenderers:** Asset owner led balanced scoring of consultancy tenders factoring AI innovation adoption (e.g., AI-enabled spatial intelligence solutions in use case 1a)
- **Expand open access:** Government expansion of open data access to asset, geospatial and other types of data used in AI tools like automated EIAs (use case 1b)

Target outcome: Increased adoption of AI upfront to provide more certainty that assets will meet their purpose before funding commitments. Figure 13 illustrates the relationship between the industry stakeholders and enabler types identified to increase adoption of AI against this ambition.

Figure 13. Enablers, commitments and key stakeholders required to realise the 'determine the purpose' ambition



Guiding principle 2 – Plan for end-to-end delivery

Ambition: Enhance and expedite decision-making with richer insights to realise more robust infrastructure business cases that achieve more sustainable outcomes.

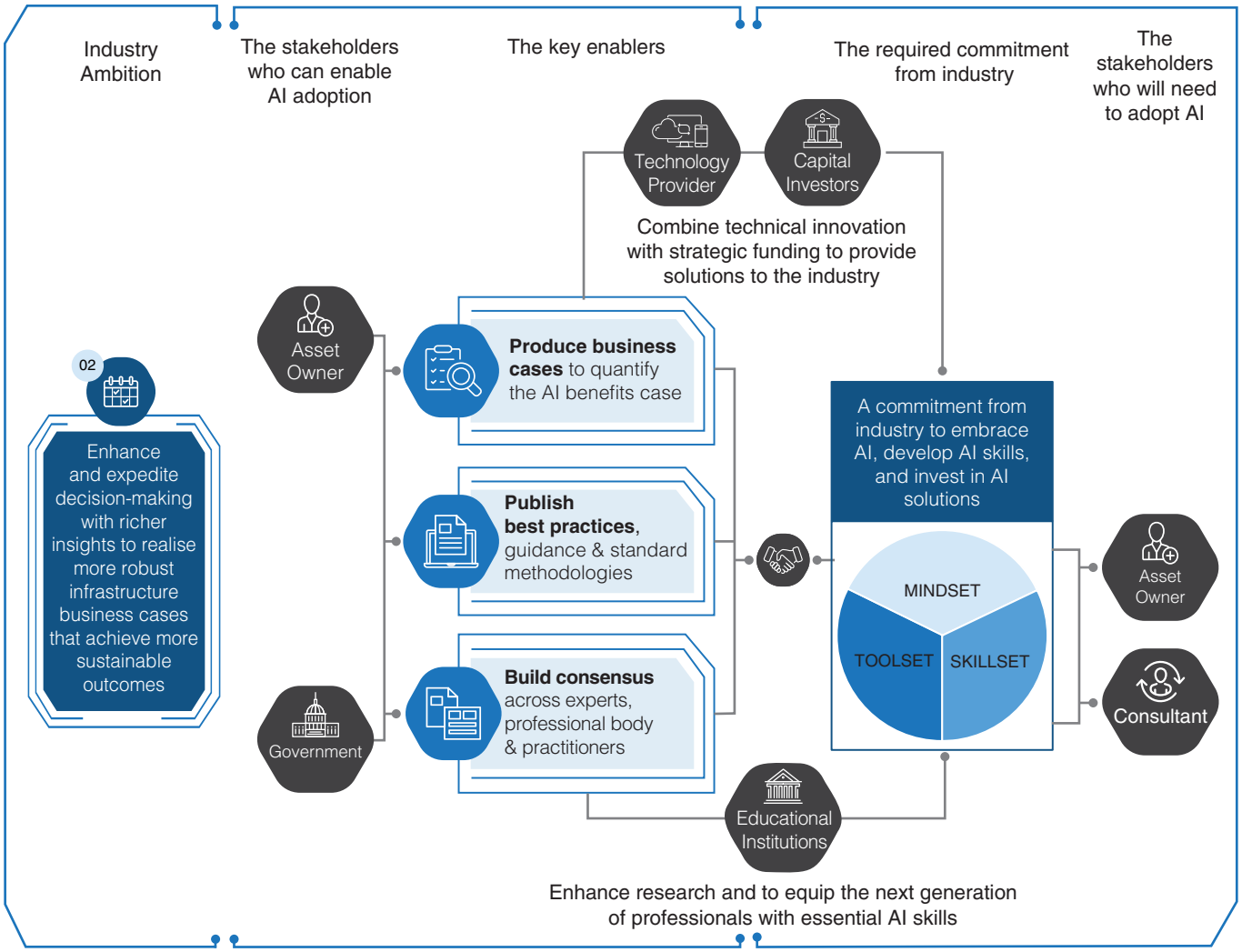
Proactive industry response required: Incentives and enablers initiated and implemented by *asset owners* and *government*, internally to achieve buy-in and sponsorship, and externally to *consultants*.

Key enablers include:

- **Produce business cases:** Asset owner produce fundamental business cases that quantify AI benefits for functionalities such as generative concept design (use case 2a), including potential time and cost savings, and environmental/social impacts to determine benefit to cost ratio, secure executive buy-in and incentivise funders
- **Publish best practices:** Government published best practices, guidance, standard methodologies for functionalities such as AI-enabled risk/contingency quantification (use case 2b)
- **Build consensus:** Diversified skills and experience-equipped expert, professional body and practitioner engagement to inform best practice and foster consensus

Target outcome: An uptick in adoption that leverages AI's richer data-driven insights from solutions like generative and sustainability concept design and risk quantification to enhance decision-making and deliver sustainable project outcomes. Figure 14 illustrates the relationship between the industry stakeholders and enabler types identified to increase adoption of AI against this ambition.

Figure 14: Enablers, commitments and key stakeholders required to realise the 'plan for end-to-end delivery' ambition



Guiding principle 3 – Confirm the operating model

Ambition: Set aside individual agendas to unlock value by working towards common project goals that foster shared access and contribution towards unbiased information.

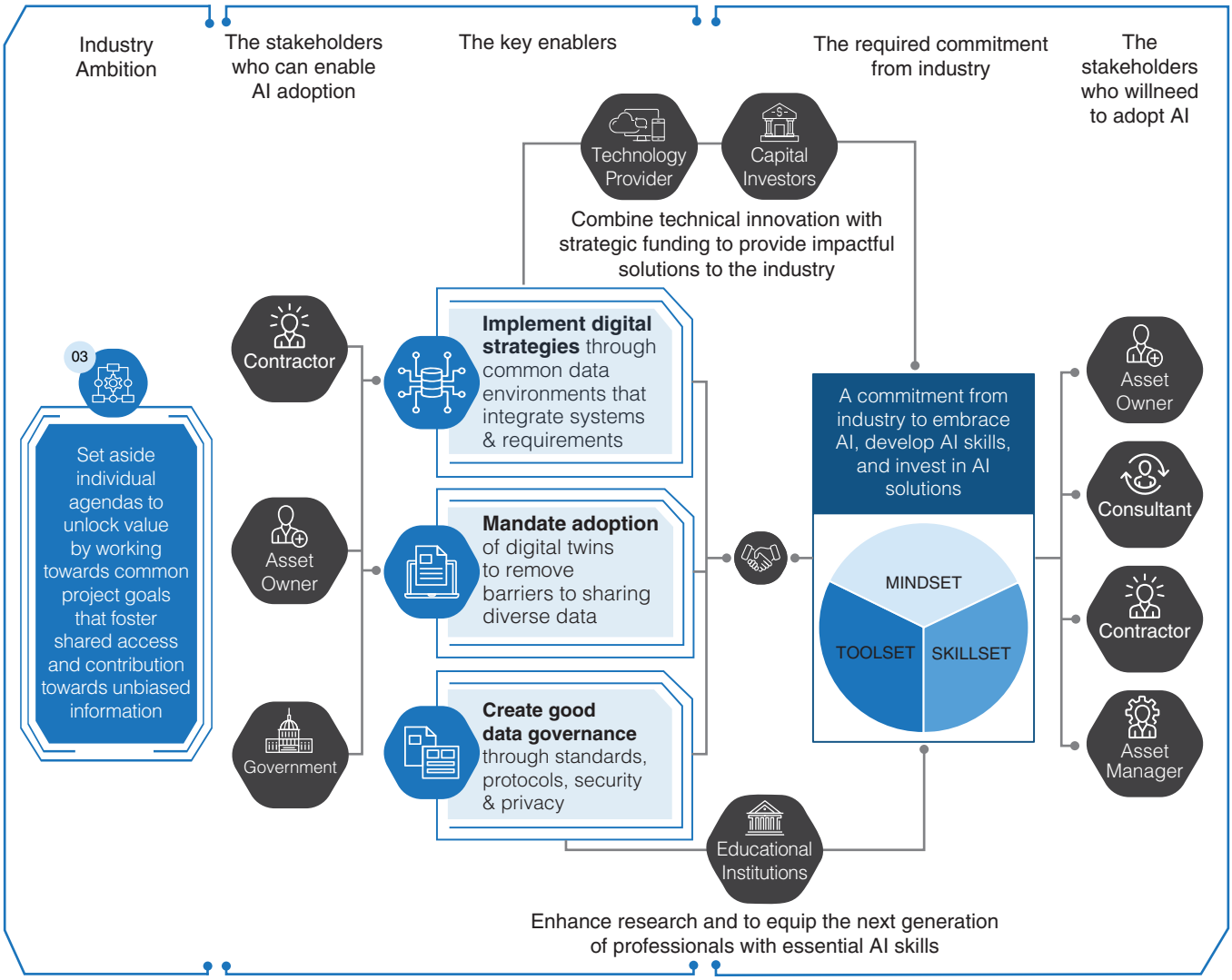
Proactive industry response required: Incentives and enablers initiated and implemented by *asset owners*, internally to achieve buy-in and sponsorship, and externally to *consultants*, *contractors* and *asset managers*.

Key enablers include:

- **Implement digital strategies:** Asset owner and contractor-led common data environments that enable unbiased information access and contribution across the project ecosystem
- **Mandate adoption:** Asset owner driven digital twin mandates for government funded projects to remove barriers to sharing high-quality, coordinated, current, diverse data (use case 3a)
- **Create good data governance:** Promote standards/governance for specific asset class data models, protocols, management, ethical use, integration, security and privacy

Target outcome: Set-up of projects and assets for AI-readiness as default by removing barriers to data sharing amongst project stakeholder organisations and ensuring availability of high-quality, consolidated data inputs that AI algorithms can utilise. Figure 15 illustrates the relationship between the industry stakeholders and enabler types identified to increase adoption of AI against this ambition.

Figure 15: Enablers, commitments and key stakeholders required to realise the 'confirm the operating model' ambition



Guiding principle 4: Integrated ways of working

Ambition: Strengthen delivery intelligence, resilience and control to improve project performance and outcomes.

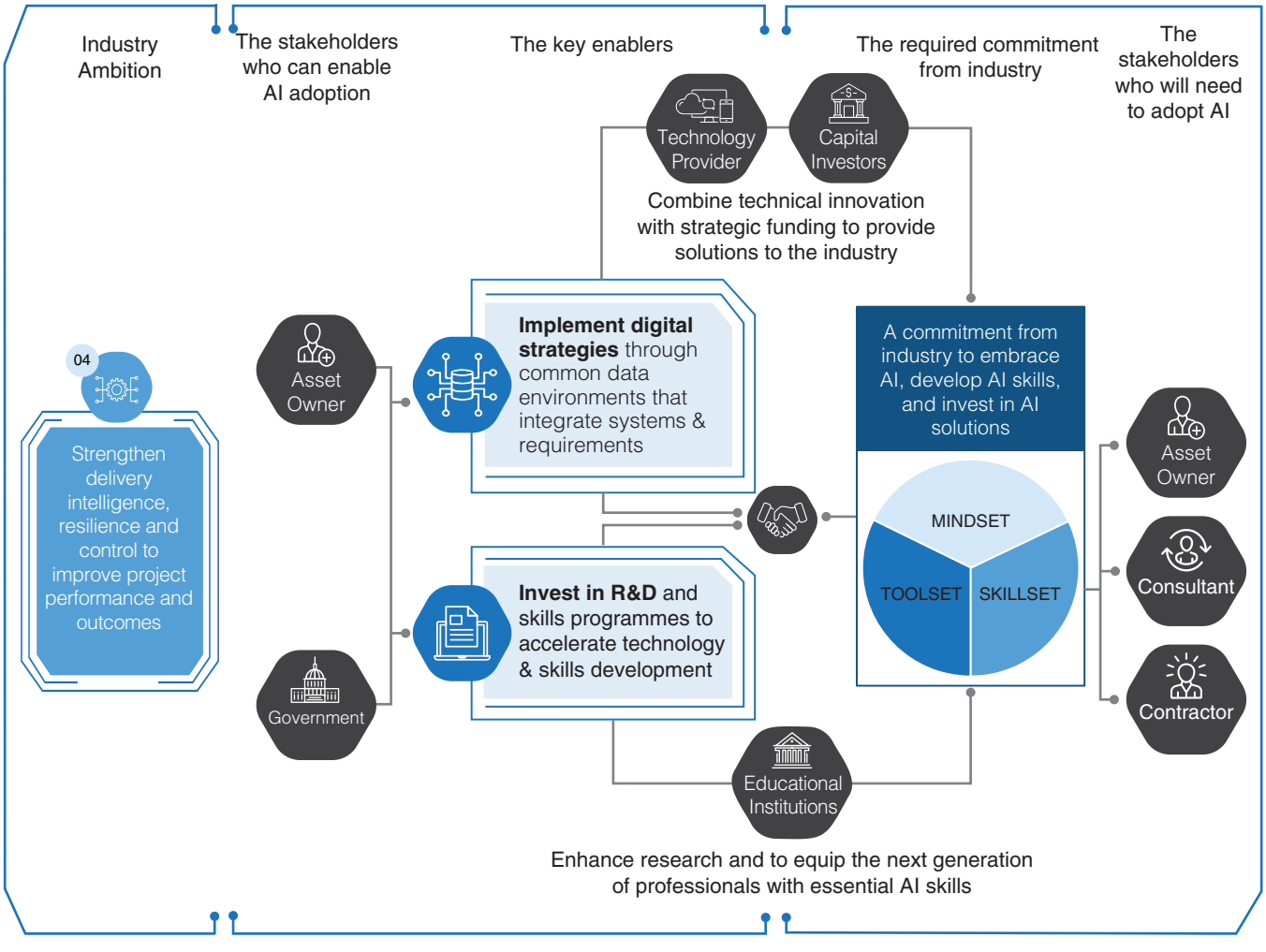
Proactive industry response required: Incentives and enablers initiated and implemented by *asset owners* and *government*, internally to achieve buy-in and sponsorship, and externally to *contractors* and delivery partners.

Key enablers include:

- **Create common data environments:** Asset owner and contractor-led common data environments achieved through the implementation of digital strategies that standardise data, systems and requirements for AI-powered PMOs (use case 4a)
- **Invest in R&D:** *Government*-funded R&D programmes for AI-enabled autonomous construction (use case 5a) to:
  - Improve construction quality and productivity using AI robotics
  - Bring together academics and industry experts to accelerate technology development
  - Support transforming labour-intensive processes to increase productivity to address the skills gap

Target outcome: Widespread uptake of AI solutions being leveraged on major projects to strengthen integrated project delivery by providing timely intelligence, resilience, and control over performance and outcomes. Figure 16 illustrates the relationship between the industry stakeholders and enabler types identified to increase adoption of AI against this ambition.

Figure 16: Enablers, commitments and key stakeholders required to realise the 'integrated ways of working' ambition



Principle 5 – Operate responsive assets

Ambition: Transform assets into connected, responsive environments that induce operational efficiency, reduce consumption and increase user satisfaction.

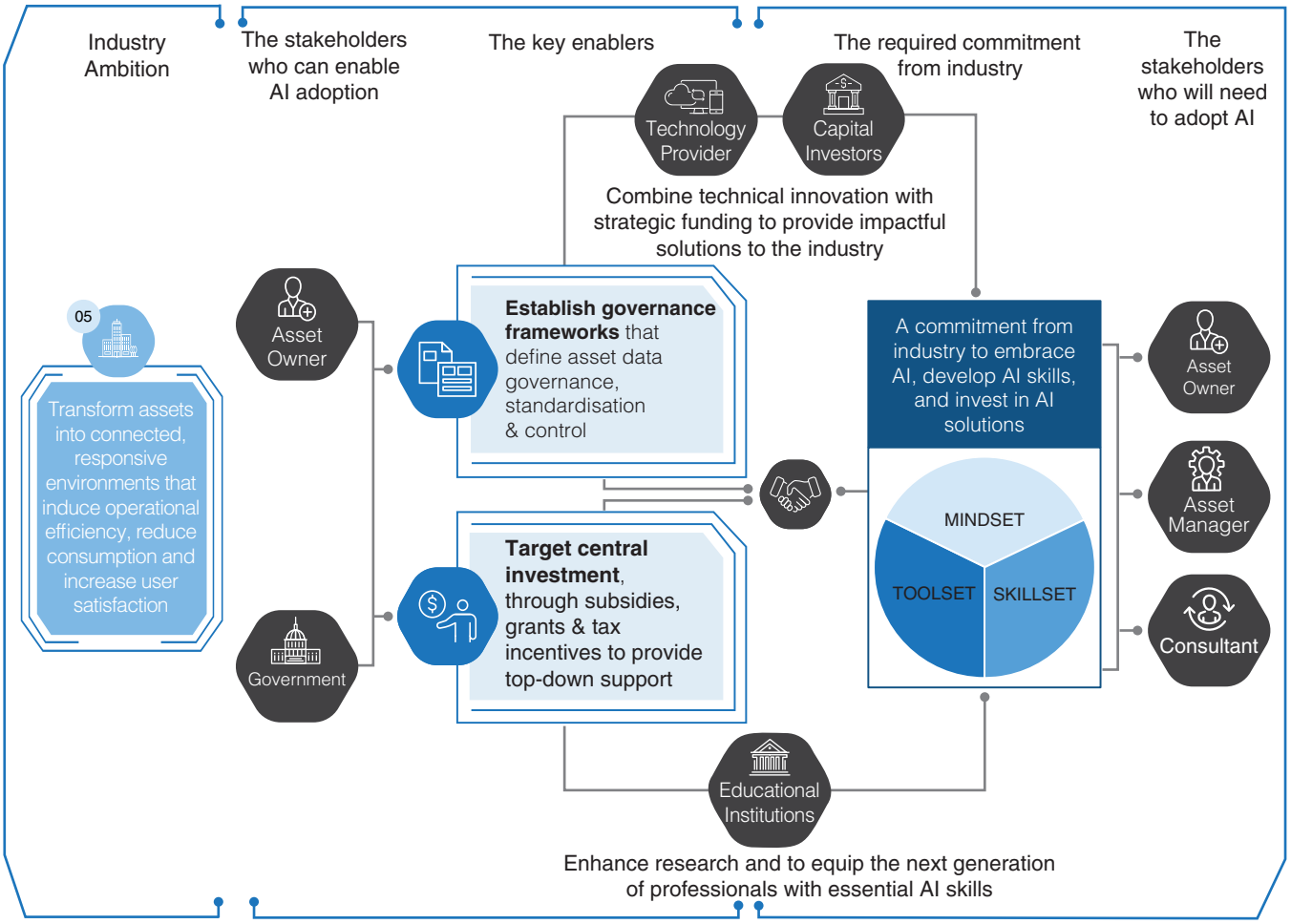
Proactive industry response required: Incentives and enablers initiated and implemented by *asset owners* and *government*, internally to achieve buy-in and sponsorship, and externally to *asset managers*.

Key enablers include:

- **Establish governance frameworks:** Asset owner-led data governance frameworks that define asset data standardisation and control that:
  - Mandate cross-functional digital twins for a 'digital by default' approach to enable functionalities such as AI-ready asset management solutions like predictive rail maintenance (use case 5a)
  - Provide standards/governance for specific asset class data models, protocols, management, integration, security and privacy
- **Target central investment:** *Government*-driven subsidies, grants and incentives which:
  - Financially support the integration of AI-enabled smart building energy management solutions (use case 5b)
  - Foster net-zero, energy efficiency, emission reduction, sustainable urban environments through proven AI technologies

Target outcome: AI solutions being routinely harnessed to transform assets into connected, responsive operating environments optimised for efficiency, sustainability and user experience. Figure 17 illustrates the relationship between the industry stakeholders and enabler type identified to increase adoption of AI against this ambition.

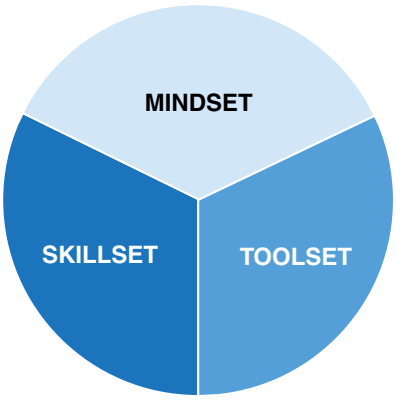
Figure 17: Enablers, commitments and key stakeholders required to realise the 'operate responsive assets' ambition



06 How can FIDIC help to drive progress?

This report shows that although use and application of AI technologies in the infrastructure industry is desired and steadily growing, its adoption remains fragmented and significant progress is required to realise its potential at scale. Together, the benefits of AI technologies have the potential to transform productivity and decision-making across the asset lifecycle. However, overcoming the barriers outlined in Section 4 and achieving the industry ambitions outlined in Section 5 of this report demands substantial effort and commitment from industry stakeholders.

To overcome these barriers, it is crucial for industry professionals to adopt a holistic approach encompassing the right mindset, skillset, and toolset. By fostering an innovative mindset, equipping professionals with the necessary skills, and providing the right tools, FIDIC aims to lead the way in integrating AI effectively and ethically into infrastructure projects by actively addressing the required wider industry commitments as identified in this report:



FIDIC believes that this research led by the GLF has shown there are five clear areas where FIDIC can represent the sector and aid the sharing of knowledge to drive continuous innovation and realising the benefits of AI as the industry aims for dramatic improvement in delivering and operating assets:

1: Identify options to prepare FIDIC for AI integration

In order to fully embrace the potential of AI within the infrastructure sector, FIDIC will identify methods and opportunities, where appropriate, to make its extensive repository of content, accessible in a structured and usable format to enhance their utility in AI applications.

To facilitate AI enablement within FIDIC, example options such as below could be considered:

- **Release data via API (DaaS):** Provide data in an ingestible format, allowing developers to easily access and integrate this information into AI applications
- **Electronic Contracts Management Platform (SaaS):** Create secure platforms that hold verified/signed versions of the contracts, which can be browsed and analysed using AI, such as for contract consistency verification
- **Develop FIDIC-GPT (SaaS):** Build a specialised AI tool to create a virtual contracts expert, assisting users in navigating and understanding FIDIC contracts with instant, expert-level insights

These initiatives would benefit the entire infrastructure industry by making essential content more functional, thus enabling more effective decision-making and innovation. Additionally, promoting sustainability through reduced reliance on printed hardcopies supports environmental goals. Collectively, these advancements would drive productivity and enhance the integration of AI across the asset lifecycle, ultimately transforming the industry and fostering greater efficiency.

2: Raise awareness and foster discussion on AI in infrastructure through targeted events

Raising awareness and fostering discussion on AI in infrastructure can significantly accelerate the adoption and integration of AI technologies within the industry. By organizing targeted events, FIDIC can create platforms that highlight the latest developments, use cases, and benefits of AI in infrastructure, thus driving greater understanding and collaboration among stakeholders.

To achieve this, FIDIC will explore the following such initiatives:

1. **Special conferences or dedicated sessions:** Arrange a special conference or dedicated sessions that focus on AI. FIDIC events would showcase the latest advancements, use cases, and benefits of AI in infrastructure.
2. **Networking opportunities:** Facilitate networking sessions to connect stakeholders, including AI experts, infrastructure professionals, and policymakers, fostering collaboration and knowledge exchange.

These initiatives would provide substantial benefits to the infrastructure industry by creating platforms for knowledge sharing and collaboration. By disseminating the latest insights and developments in AI applications, these events would enhance stakeholders' understanding and confidence in AI technologies. Moreover, fostering collaboration among diverse stakeholders would promote the integration of AI into infrastructure projects, driving innovation and efficiency. Ultimately, these efforts would support the industry's progress towards leveraging cutting-edge technologies for improved productivity and decision-making across the asset lifecycle.

3: Investigate the potential development of an "AI in Infrastructure Specialist" training and certification competency

FIDIC will investigate methods and opportunities to develop training and certification on the use of AI in infrastructure to ensure that industry professionals are equipped with the necessary skills and knowledge to effectively integrate AI into their projects.

To achieve this, the following initiatives should be considered:

1. **Offer training workshops:** Explore and create and offer workshops and training content tailored to equip professionals with the skills needed to integrate AI into infrastructure projects.

2. **Certification:** Explore the creation of new programmes or improving AI within existing certification programmes within FIDIC Credentialing Limited's activity and materials.

3. **Promote competency development:** Ensure that the above cover essential competencies in AI, enhancing the skillsets of industry professionals.

These initiatives would provide substantial benefits to the infrastructure industry by equipping professionals with the necessary skills to integrate and leverage AI within their projects.

By positioning FIDIC as a leader in promoting innovative technologies and methodologies, these programmes would enhance trust and accountability within the industry. Additionally, it would ensure that industry professionals are prepared to handle emerging challenges and opportunities associated with AI, making the industry attractive to younger generations and future-proofing both the people and the sector as a whole.

4: Act as a central knowledge/value repository

FIDIC as a facilitator can act as a central repository to collect and share value stories and lessons learned from real-life implementation of AI in infrastructure can significantly enhance the collective knowledge and drive innovation within the industry. By collecting and centralising this information, FIDIC can provide valuable insights and foster collaboration among stakeholders.

To achieve this, the following initiatives should be considered:

1. **Collect valuable real-life data:** Gather value stories and lessons learned from real-life implementations of AI in infrastructure projects. This effort will involve systematically collecting structured and comprehensive data that can provide actionable insights and inform future practices.

2. **Allow academia access for studies:** Provide anonymised data access to academic institutions for research and studies. This will foster academic collaboration while protecting privacy and confidentiality.

3. **Publications:** FIDIC will publish "trends" articles based on the collected data. This will showcase the latest developments, success stories, and emerging trends in AI applications within the infrastructure sector.

These initiatives would provide substantial benefits to the infrastructure industry by centralising and disseminating valuable insights and lessons learned, enhancing the collective knowledge of the industry. By using structured data to generate actionable insights and future trends, stakeholders can make more informed decisions and develop effective strategies.

Additionally, fostering academic collaboration will promote research and innovative solutions in AI for infrastructure. Finally, incorporating real-life examples and data-driven insights into FIDIC's events, training and FCL certification programmes will enhance their value, making them more relevant and impactful for industry professionals.

5: Consider future AI needs during the development of contract documents to ensure AI-readiness

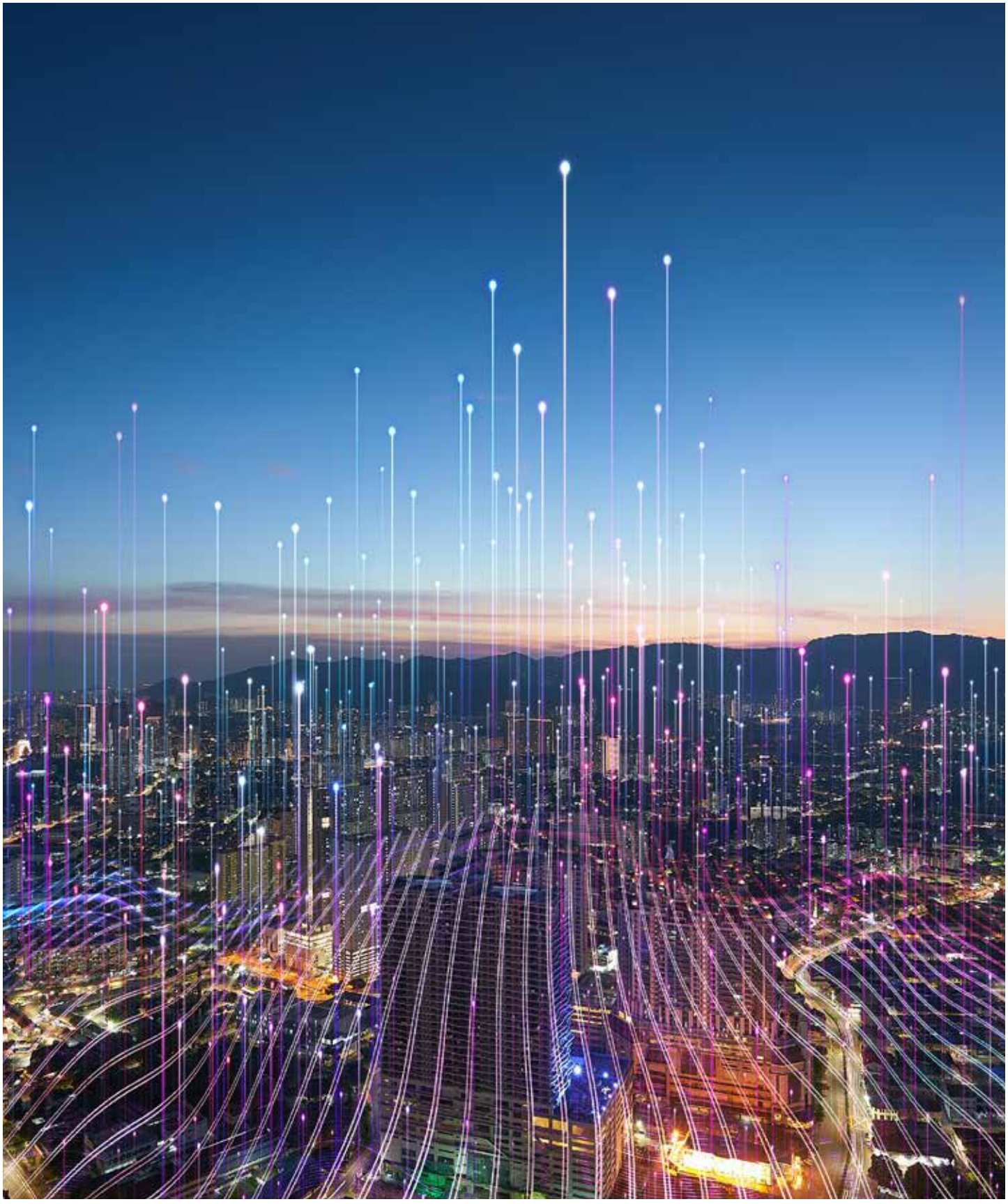
To fully leverage AI in infrastructure projects, it is essential to ensure that future contracts holistically address the dynamic nature of AI and include provisions to support AI integration effectively. By doing so, the industry can maximise the benefits of AI technologies while managing associated risks.

To achieve this, the following areas should be considered given the development of AI in future:

- AI-specific clauses
- Performance metrics and reporting
- Risk management
- Training and competency
- Ethical considerations
- Dispute resolution
- Continuous improvement

These initiatives would provide substantial benefits to the infrastructure industry by ensuring that contracts are equipped to make use of the AI to better handle the complexities and opportunities by using AI technology, enhancing project efficiency and outcomes.

Establishing clear performance metrics and risk management strategies will help manage the uncertainties associated with AI, while training requirements will ensure that personnel are adequately prepared. Addressing ethical considerations and providing mechanisms for dispute resolution will promote trust and accountability.



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08 Appendix

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