



CIVIL INFRASTRUCTURE

STRATEGIC INDUSTRY FORESIGHT

The digitalization of Infrastructure



FOREWORD

THE WORLD IS CHANGING. Today's infrastructure is not only aging—the approach to planning, design, and constructing it is rapidly becoming out-of-date as well. This report is Autodesk's business look forward for the future of the Infrastructure industry. A complement to Constructing with the Power of Digital, it discusses how trends in technology are poised to deliver a profitable, resilient and agile industry, and a better built environment.

OVER THE NEXT 20 YEARS, population growth, urbanization, and economic expansion are set to push demand for infrastructure to unprecedented levels. If that alone wasn't enough, trends in technology are changing the way in which industry professionals, across all civil infrastructure sectors, plan, design, build, and maintain the world's infrastructure. Innovation now is no longer optional. What hasn't changed is constant concern for how to address risk and, of course, increase profits as the industry transforms.

Autodesk and our customers have proven that BIM has an important role to play in the efficient and innovative approach for a stable, fit for purpose, built environment. We need resilient and sustainable infrastructure that protects the environment, enables people to thrive, and creates economic value. This will require infrastructure owners and design firms to change the way they work. All infrastructure challenges going forward must be accounted for in parallel as they exist in reality. It is about changing the process by placing focus on the right way to increase infrastructure—by taking into account the interdependency

of all adjacent infrastructure systems, and more importantly the costs over the lifecycle of that system—all targeted to help future-proof that system for growth, adaption and resiliency. The need to spend taxpayer dollars wisely, means most practical gets replaced by best possible.

Cities and their infrastructure must be designed where the inherent capability of these systems is to adapt and respond in ways it was not explicitly intended to do when first conceived. The rise of reality cloud computing coupled with hardware and software advances have resulted in the ability to quickly and cost-effectively capture information about the physical world and make it digital. For the first time, we are getting much closer to having a true digital mirror of our physical world. This information will soon be used to support and inform decision-making during planning, design, construction, and eventually operations—minimizing environmental disruption and benefitting project design firms, contractors, and infrastructure owners.

This document provides the details on these disruptions but also the inspiration for innovation. With the power of BIM, big data, cloud computing and analytics, we can now better tackle and answer the questions that need to be answered to solve our world's \$57 trillion infrastructure challenge¹. Going forward the role of infrastructure planners, designers and contractors fundamentally changes. Building the infrastructure right is no longer good enough. In this impending connected era, we now must answer the more important question: "Are you building the right infrastructure in the first place?"



Cities and their infrastructure must be designed where the inherent capability of these systems is to adapt and respond in ways it was not explicitly intended to do when first conceived.

TERRY D. BENNETT
LS LPF MRICS ENV SP LEED® AP
Senior Industry Strategist
Thought Leader, Civil Infrastructure
Autodesk Inc.

INFRASTRUCTURE TRENDS

OUR GLOBAL INFRASTRUCTURE is at a tipping point. Decades-old approaches coupled with century-old delivery processes are unable to keep pace with rapid urbanization and population growth. On top of this, the pressure on our existing infrastructure systems continues to grow. And many of these systems are well beyond their life expectancy and are failing faster than they can be recovered during a time of fiscal challenges.

Urbanization, congestion, environmental regulations, and economic expansion are set to push demand for infrastructure to unprecedented levels. McKinsey Global Institute estimates that nearly \$49 trillion worth of infrastructure investments will need to be spent between 2016-2030 just to keep up with current global demands. Additionally to keep pace with projected growth, the world needs to invest another \$3.3 trillion annually through 2030. Currently it invests approximately \$2.5 trillion.

Against this backdrop, the infrastructure market is experiencing fundamental changes. To help bridge the gap in public-sector

infrastructure funding, alternative financing vehicles such as public-private partnerships (PPPs) are producing an infusion of private capital in public infrastructure projects. New client expectations and increasing globalization of the market are recasting the competitive landscape as new ways of delivering projects compete with established ones. Sustainability and resiliency are becoming requirements instead of a desirable characteristic, affecting both the construction process and the built asset itself. Owners are seeking end-to-end life-cycle workflows, including improved digital handover and the opportunity to better manage assets and portfolios over time. In the midst of these changes and demands, construction productivity remains as one of the largest issues for the infrastructure industry. Study after study reports double-digit cost overruns on large projects. These problems highlight an enormous opportunity. Governments must transform their institutions, as well as the capabilities and processes under their direct control, to make infrastructure delivery systems more effective.

And the infrastructure industry, which currently invests only 1.2 percent of operating expenses on IT compared to 3.3 percent for the manufacturing industry, must make better use of technology. Most of the industry's current techniques and technology hail from a time when there were fewer people, less urgency, and lower demands. But today, larger project sizes, increased complexity, and aging infrastructure are driving the need to better simulate alternatives, reduce delivery schedules, maintain high quality, minimize cost, and ensure safety.

These are needs that technology can help meet. Full-scale digitalization – the development and deployment of digital technologies and processes such as Building Information Modeling (BIM) – could have a significant impact. Estimates show that it could lead to annual global cost savings of 10 to 25 percent in the engineering and construction phases, and 8 to 13 percent in the operations phase².

BIM, big data, cloud computing and analytics is changing how infrastructure is planned, designed, built and managed. Technology will better connect people, processes and ideas for the creation of more resilient and sustainable infrastructure.



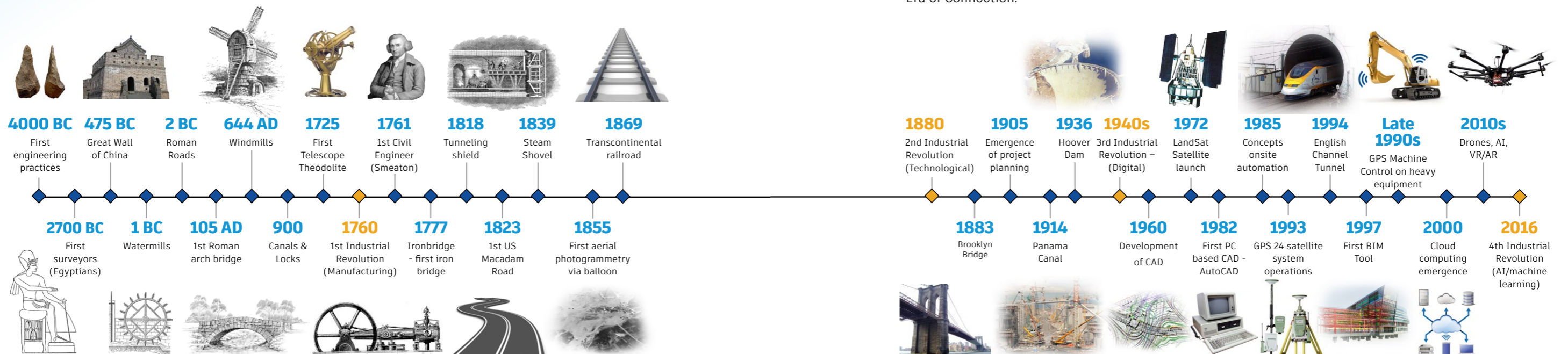
The digitalization of our infrastructure ecosystem will help transform how infrastructure is planned, designed, built, and managed. Intelligent, virtual infrastructure projects will help us improve the way we envision, iterate, and collaborate socially to deliver future infrastructure that meets our future needs. Technology can help us connect people, process, ideas, and big data in a way that will enable us to make well-informed decisions for infrastructure projects and future needs. This vision is the Era of Connection.

AUTONOMOUS VEHICLES: Broad adoption could significantly shift traffic from public transit back to cars, increasing road traffic and changing traffic flow patterns. These vehicles could substantially increase road capacity as vehicle-to-vehicle communications enables tighter vehicle spacing. Accommodating multiple modes of travel—walking, biking, mass transit, and autonomous vehicles (including potentially people carrying drones) – will soon have a big impact on how integrated transportation systems are planned and designed.

UNMANNED AERIAL VEHICLES (UAVS): UAVs or drones are already beginning to be used in planning, design, construction and operations to digitally capture existing conditions, track construction progress and provide as-builts once an infrastructure project is complete. UAVs also have a potentially significant delivery role in the future, which will reduce the number of ground-based delivery vehicles and lessen demand on road networks, but will also require new approaches for air traffic control.

MANUFACTURING INNOVATIONS: Additive manufacturing, 3D printing, new materials, and advanced automation could redefine and shorten manufacturing supply chains while moving production to the point of consumption or assembly.

ALTERNATIVE RESOURCES: Advanced materials and renewable or unconventional energy will alter the demand for traditional natural resources.



SHIFTING INFRASTRUCTURE for the 21st Century

We have some infrastructure challenges. And a lot of things are going to have to work well – that is, we are going to have to do a lot of things differently – if we are to meet those challenges successfully. Poor project outcomes are largely the consequence of failing to think and plan system-wide.

DR. KEN HENRY
Former Secretary
Department of Treasury
Australia



Technology disruptions are the paradigm shift that will usher in the connected era of infrastructure. Digitalized workflows and the interaction between digital models, people, social networks, and big data analytics will provide new insights to improve project predictability, long-term lifecycle understanding, quality, safety, and costs. They will redefine traditional workflows like never before and introduce an era of great potential, but also great business risk if not planned for and managed correctly by AEC firms.

INFRASTRUCTURE PLANNING, DESIGN, CONSTRUCTION, AND OPERATIONS is a demanding business that impacts all our lives, and is therefore under ever-increasing scrutiny. This is especially true in cities. The past decades have witnessed unparalleled rates of urbanization. Today, more people live in urban and suburban areas than in rural areas worldwide (54 percent versus 46 percent in 2014) and the UN estimates that by 2050, 66 percent of the world's population will be living in urban or suburban areas³.

Given this migration to cities, its infrastructure demands represent the challenge that the industry faces in the 21st century. The growth of cities demands new priorities and changes during the continued struggle to define and fund what they want to become in the future. Many cities are exploring the use of technology and data to improve the efficiency of services and become a 'smarter city'. But what does that really mean?

Cities need to be productive and accessible, but they also need to be livable with a clear focus on serving their citizens. Smart cities will connect people to places and information while also optimizing the sustainable operation of their infrastructure assets into the future. Technology can help by providing the platform to create, communicate, and evaluate options, resulting in more connected, sustainable, and resilient communities. By powering a collaborative process, technology enables the creation and exchange of relevant digital information throughout the lifecycle of a built asset.

Together, these kinds of smart infrastructure connections—connections at the personal, community, metropolitan, or even national level underpinned by technology—will change the vision of smart cities. The connections provide the foundation for more holistic planning, where all kinds of infrastructure are connected to each other to optimize and prioritize needs and performance, minimize energy use, and make life more enjoyable and productive for the people who live in them.

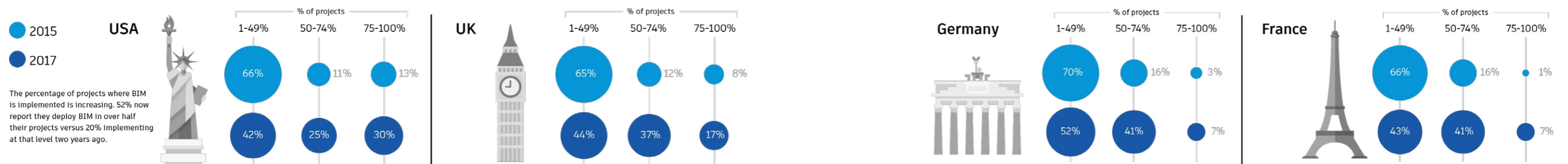
BIM WILL PLAY A VITAL ROLE in meeting urbanization demands. It represents a holistic platform for how infrastructure and resource assets are planned, designed, built, managed, and maintained. This is true for creating smarter cities, as well as building new cities, connecting existing cities, or providing the infrastructure foundation under these cities.

And although BIM has already been shown to lower risk and provide better predictability of project outcomes⁴, it needs to go well beyond the design, into construction handoff and operations. This digital connection between an asset's optimized design and its lifecycle phases would broaden BIM's impact and return, saving even more money and increasing margins for all the project stakeholders, while still delivering a better product at a cheaper price and in a more predictable fashion.

Dodge Data & Analytics 2017 Value of BIM in Infrastructure SmartMarket report provides a look at the level of adoption, most frequently practices, benefits received and investments made to grow and improve BIM programs in the United States, United Kingdom, Germany and France.

[Learn more >](#)

LEVEL OF BIM IMPLEMENTATION



TECHNOLOGY AND RISK

A central part of envisioning and delivering civil infrastructure is risk. Or more specifically, reducing risk to a manageable level. Risk lies in each decision made for investing, divesting, or reinvesting in infrastructure systems. Is there enough money to finance what needs to be built to keep society moving forward? Are there investors willing to contribute? For infrastructure firms, choosing the right project to work on itself is a risk.

Unlike other industries and projects, designing and building incredibly complex, interconnected systems of infrastructure carries huge risks. The risk of delivering these assets and systems based on time schedules and prices arrived at years (or even a decade) ahead of the final product itself. The risk of what happens if the final product is not maintained well enough to reach its intended life span. And today—as we enter the world of cloud, mobile, and social connectivity—there are risks surrounding data, integrated hardware/software systems, and, most of all, cyber security.

All project decisions come with both short and long-term implications and risk. Understanding the impact of risk for both design and construction is the key to reducing risk. Design and construction intelligence based on the use of big data analytics could revolutionize risk management. In turn, this could help industry better identify, quantify, and mitigate project risks or perhaps even turn risks into vehicles that increase profits and make margins more predictable. In a connected era of infrastructure, we will be able to calculate, not just speculate on, the long-term implications of a particular design decision or approach.

Moreover, connected devices and the Internet of Things will help us better account for risk and uncertainty throughout the life expectancy of infrastructure assets. Sensor data from a bridge for example will give us ability to detect the initial forming of cracks and other malfunctions that can be quickly and cost-effectively addressed before a serious failure occurs. In addition, we can proactively examine similarly built infrastructure to preempt similar failures and rethink similar designs still in process 'to resolve the issue before it ever exists.

OPERATIONAL REALITIES

THE OPERATIONAL REALITIES facing the infrastructure industry continue to evolve. Firms are constantly struggling with how to reduce risk. Investors are wary to invest in infrastructure due to risk of project cost, schedule overruns during construction and a unclear pipeline of approved projects. These investment concerns are well placed when coupled with the unproven performance of an unfinished infrastructure asset like a road, bridge, interchange, or water system, that have very large price tags and impact a lot of people. In today's digital world of social media, every infrastructure project, regardless of location, size or cost, is seen on the mobile devices of affected citizens sometimes long before construction and even regulatory approval.

With over \$218 trillion worth of existing infrastructure assets⁵ requiring care and upkeep in the world's top 32 countries, the need to do things differently is critical. In fact, the cost of not repairing infrastructure is an issue that the American Society of Civil Engineers says could cause the U.S.

alone a \$3.1 trillion loss in gross domestic product by 2020⁶. The question becomes, "Are there ways to improve performance?"

The answer is yes. Deploying digital technologies and processes such as BIM have already proven their worth by helping to deliver better predictability of project outcomes⁷. Digitalization in the connected era is expected to deliver 15 to 25 percent savings in engineering and construction costs on infrastructure projects such as transportation⁸.

The evolution of reality capture and modeling technology have resulted in the ability to quickly and cost-effectively capture information about the physical world and make it digital. As this technology develops, we get closer to having a true digital mirror of our physical world. This information will be used to support and inform decision-making during planning, design, construction, and eventually operations—minimizing environmental disruption and benefitting project design

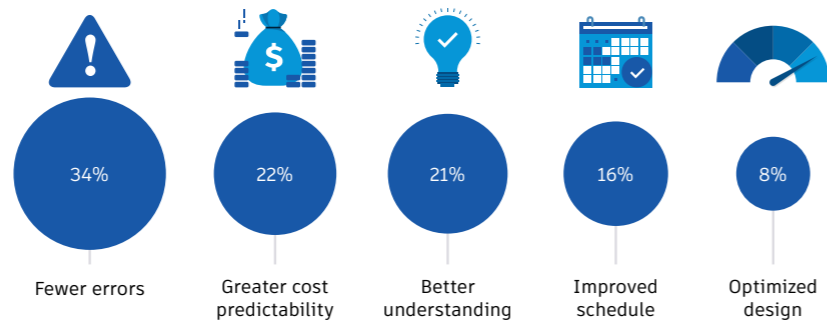
firms, contractors, and infrastructure owners. Given the velocity of technology development and its impact, infrastructure professionals need to overcome their traditional risk averse perspective of new technology and processes to avoid being marginalized by outside entrants to the industry who will take advantage of the digitalization opportunity. Infrastructure executives should embrace these disruptive innovations, beginning with an internal audit of their firm's digital capability compared to the standard of technology now available.

Urbanization, failing infrastructure, and increased risk of natural disasters underscore the need for a stable, fit-for-purpose built environment. Creating resilient and sustainable infrastructure that protects the environment, enables people to thrive, and creates economic value is possible. But it will require infrastructure owners and AEC firms to change the way they work and overcome the worries that affect their boardrooms.



BENEFITS OF BIM

In the 2017 Business Value of BIM for Infrastructure SmartMarket Report, the majority (87 percent) of BIM users in the study report that they are receiving positive value from their use of BIM. Most believe that they have only just begin to experience the full potential.

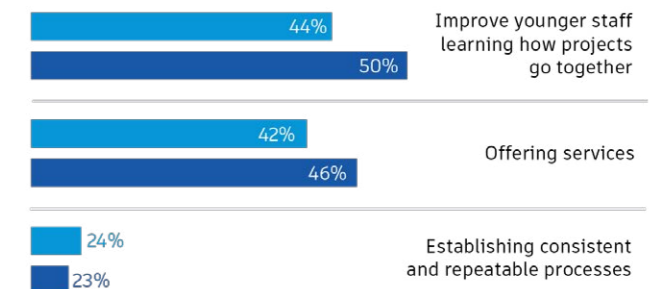


INTERNAL BENEFITS TO IMPLEMENTING BIM

Contractors



Engineers



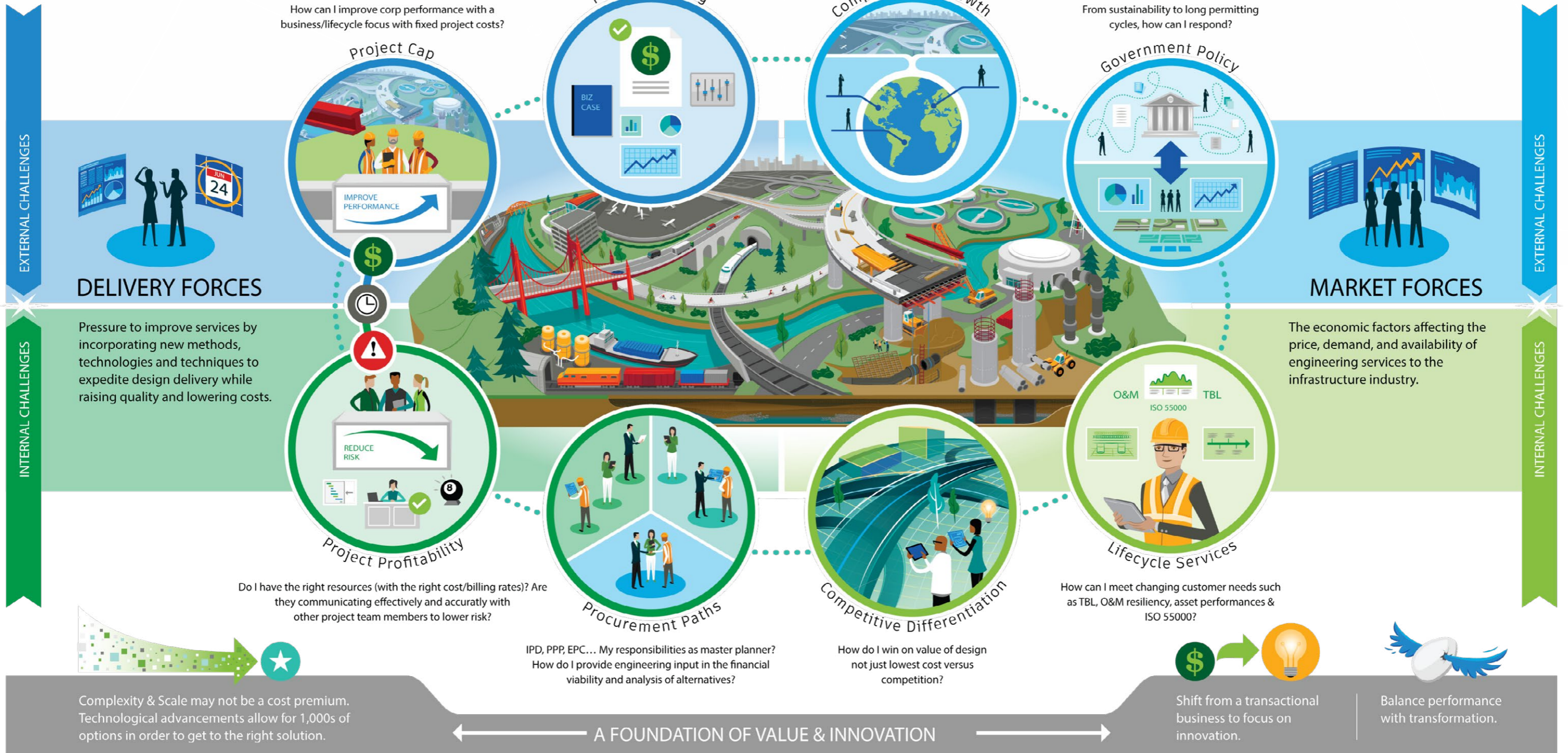
THE BUSINESS OF INFRASTRUCTURE

TRIANGULATING CHANGING MARKET TRENDS, changing commercial landscapes and entrenched operational realities produces a “basket of eight” of business challenges that are taxing the boardrooms of the world’s infrastructure professionals as they seek to return shareholder value.

These challenges are all too familiar. External challenges include project cap; project funding; competition & growth and government policy. Internal challenges include project profitability, procurement paths, competitive differentiation and lifecycle services.

In a connected era, digitalization and other disruptive technologies will enable infrastructure firms to improve their business outcomes. The connected era will enable industry executives optimize their businesses in the context of ‘C-level’ business challenges, helping them grow their businesses while responding to changing markets and client demands.

[View boardroom challenges interactive >](#)



THE BUSINESS OF INFRASTRUCTURE

Understanding Risk

Technology becoming less well understood & not operating to its maximum capacity increases risk by technological failures and design faults in critical infrastructure systems.

Not remembering engineering is basically the modification of nature through the creation of tangible and intangible artefacts – i.e. infrastructure.

Cumulative effect of the chances of uncertain/negative occurrences when using new approaches.

Importance of engineering overlooked in sustainable development, climate change mitigation and importance of communicating this to policy-makers.

EXTERNAL CHALLENGES

EXTERNAL CHALLENGES

INTERNAL CHALLENGES

INTERNAL CHALLENGES



DELIVERY FORCES

Pressure to improve services by incorporating new methods, technologies and techniques to expedite design delivery while raising quality and lowering costs.



MARKET FORCES

The economic factors affecting the price, demand, and availability of engineering services to the infrastructure industry.



Oversight that engineering and technology processes require the synergy of individuals, machines and social organizations for success.



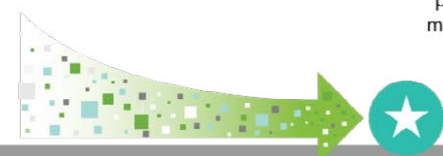
Efforts mainly focused in civil engineers' skills and knowledge, but they are not considering specific requirements for civil engineers as PPP practitioners and master planners of infrastructure development.



Discounting the rapidly changing nature of engineering and with it changes to be brought to society.



Engineers overlooking their role in the technological development that has created our modern society.



Complexity & Scale may not be a cost premium. Technological advancements allow for 1,000s of options in order to get to the right solution.

A FOUNDATION OF VALUE & INNOVATION



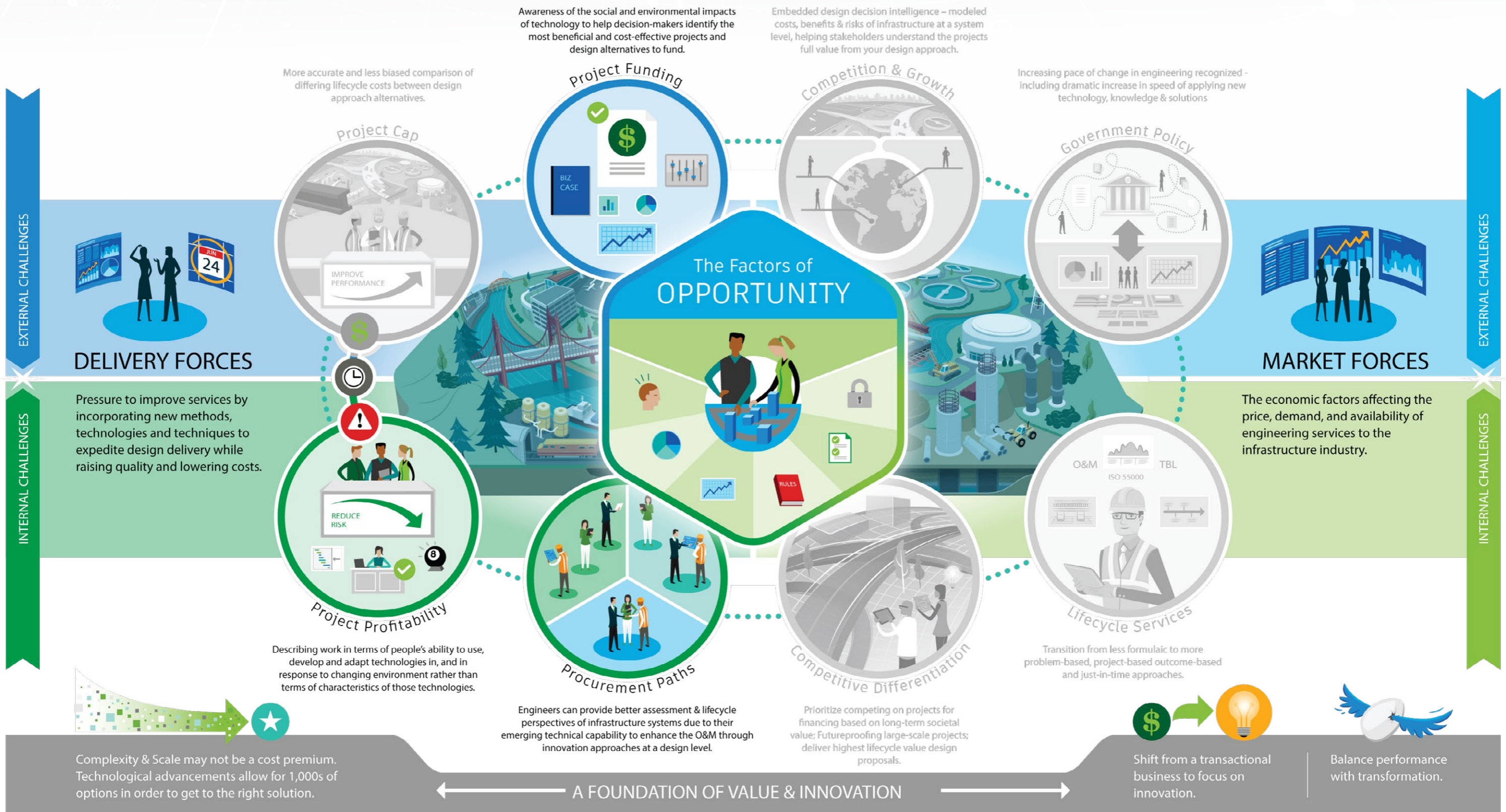
Shift from a transactional business to focus on innovation.



Balance performance with transformation.

THE BUSINESS OF INFRASTRUCTURE

Opportunity through technology innovation



FROM PRICE TO VALUE

Around the world, government agencies, along with public and private authorities are increasingly requiring the use of BIM in their new infrastructure projects.

In Scandinavia and the UK this is already the case with other European initiatives moving in the same direction, such as the Germany and pending EU mandate that BIM will be implemented on all federal infrastructure projects under the responsibility of the Federal Ministry of Transport and Digital Infrastructure by 2020. In the U.S., the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), the American Road and Transportation Builders Association (ARTBA), and the Associated General Contractors of America (AGC) are jointly promoting what they refer to as 'Civil Integrated Management' or CIM,

which is equivalent to what the rest of the world calls BIM for infrastructure. This type of standard starts the process of looking at full value of a design versus just the first cost or price that has been the traditional approach.

This will in time shift today's commercial landscape focused on price, to one of value as the default. Less on inputs, more on outcomes. This will bring in the connected era of digitalization. For example, instead of just worrying about whether the project is designed right – a city will ask itself "Is this the right project in the first place? Does the road need to be widened? Will it make local transportation faster and safer or is a different mixed-modal approach better? Will it expand commerce and produce jobs or impact patrons to nearby businesses?"

Transforming the infrastructure industry from an asset-centric view of an infrastructure system to a value-centric.

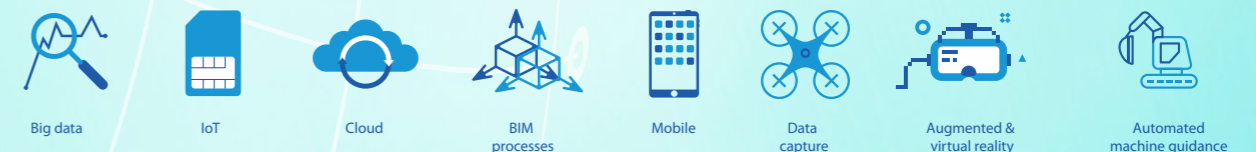
**Focus on value more than price.
Focus on outcomes more than inputs.**

We actually understand a lot about our assets already. Even though we haven't built anything, we have virtual assets and we know where they are down to a certain level of detail. We are capturing information about them now and that will continue to mature as we go through construction, moving to as-built asset information. The big benefit is having a really efficient hand-over of information from HS2 construction, to operations and maintenance. By working in a data driven environment now, and to a standardised approach, we will be able to hand over data easily.

JON KERBEY
Director of BIM
HS2 Ltd



The questions become value-centric: Is this the right thing to build? Will this make local transportation faster and safer? Will this expand commerce and produce jobs?



FOCUSING ON THE “I” IN BIM

THE PROCESS of imagining, designing, and creating infrastructure involves many people, tasks, deliverables... and a lot of data. Because there are so many types of projects, as well as so many ways to approach a project, BIM tools in a connected era must be flexible and focused on providing key components of functionality tailored to each infrastructure professional discipline. This balance combined with the ability to share rich design data and information (the “I” in BIM)—from project concept through to operations, within integrated infrastructure systems—will provide these key benefits. Infrastructure firms will be able to realize larger ROI on a project and the data that is created, deliver better designs and results to their clients, and ultimately become a more profitable business.

The constraints and challenges infrastructure professionals will face going forward will no longer be defined by just design rules (as was the case when using the first generation of BIM tools). Instead they will be defined by the transformative business and process outcomes they are required to solve.

Firms could use crowdfunding and social collaboration to successfully achieve a ‘social license to operate’. All of this will be achievable by using big data analytics to identify infrastructure needs matched to construction outputs that, when delivered, achieve the desired lifecycle objectives.

What will this look like in the real world? Take for example the design of a new transportation system. Cloud computing will crunch population demographics, economic forecasts, and user preferences (such as electric versus gasoline car, car versus mass transit, above versus underground conveyance & associated maintenance requirements, or desired maximum commute time) to understand the infrastructure implications, full lifecycle cost, and risk-based triple bottom line - cost benefit analysis’ (TBL-CBA) of various alternatives. Generative design logic will be used to optimize the combination of transit solutions that will address those outcomes. The result will be a balanced mix modal transportation system that can scale for the future and provide real-time feedback on its condition and performance. BIM tools in a connected era will provide the opportunity to learn and effect change in similar designs still in process progress—correcting unforeseen issues before they are constructed yet again. Technology disruptions are now making this possible, helping professionals capitalize on and augment the design data they need to profitability complete their project and deliver the associated infrastructure asset on time. Within this decade, the computer and designer/engineer will finally unite as co-creators of infrastructure, launching our 4th industrial revolution.

Using BIM as a planning tool improved our process on nearly every front, with BIM, we could reduce the environmental impact of our project, optimize designs across disciplines, and increase democracy and transparency in our planning.

KRISTIN LYSEBØ
Norwegian National Rail Administration

Arcadis wants to implement BIM – why? Because it enables us to produce the synthesis to live a better quality, more efficiently, so it’s about excellence and enabling collaboration within Arcadis

BRAM MOMMERS
BIM Business Development Manager
Arcadis

CHANGES AHEAD

TODAY, BIM STANDS FOR Building Information Modeling. Its focus is the optimization of assets using digital models. This focus categorizes our current use of technology as an era of optimization. BIM has enabled planners, designers and contractors to improve business delivery (how well they execute projects) by optimizing various design and construction approaches.

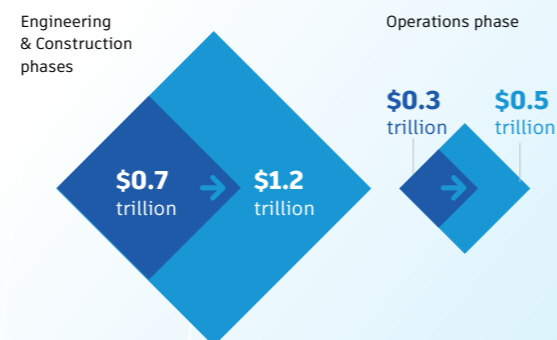
In the era of connection, BIM will most likely transform to be an acronym for Better Information Management. It will have a business and lifecycle system focus using better “IM” or information management and the cloud with generative logic to guide designs. This will enable planners, designers, and contractors to improve corporate performance based on a holistic, systems approach that enables highly efficient business delivery.

Within 10 years full-scale digitalization of the construction industry will lead to huge annual global cost savings. For non-residential construction, those savings will be:

Source: World Economic Forum

In this next era of BIM, infrastructure business challenges will be addressed by focusing on the outcomes or results as the deliverable. New priorities in this connected era include:

- Balancing infrastructure investment with operational, sustainable, social benefits inputs
- Operating more productively by designing infrastructure as a system of integrated technologies
- Addressing changing infrastructure requirements with dynamic asset and enterprise reconfiguration strategies that enable predictive asset management



“The constraints and challenges infrastructure professionals will face going forward are no longer going to be defined by just design rules as in the first generation of BIM. They will be defined by transformative business and process outcomes they are required to solve for their customers.”

There are some key technical disruptions that will support digitalization and the transformation from the era of optimization to connection. Cloud computing brings infinite computing power to many of the technology platforms that underpin the connected era. Digital twins (software models of a physical thing or system that are superimposed with calculated or measured data) will be used for visualization, construction QA/QC, monitoring, and to support asset management decision-making. Augmented reality (overlaying digital images or information onto a person’s view of the real world) and virtual reality (replicating a real or imagined environment and simulating a user’s physical presence in that environment) will enable users to digitally interact with these ‘realities’. And, of course, 3D printing will continue to revolutionize the infrastructure industry and the way we design and make things.

A connected era will also feature changes in production (both intellectual and physical) as well as changes in customer demand, as people become ever more connected via social networks and online news. With this connectedness, stakeholders will become increasingly more aware of issues affecting them. Thus, the definition of products—whether a highway, water system, or new urban center—will be transformed as the digital and physical worlds become deeply intertwined with the constituents that use them.

In a connected era, big data, cloud computing, virtual reality, and the other technology disruptions will support connecting people, data, and insights to produce connected outcomes. Potential projects will be evaluated in a system-of-systems manner, shifting the emphasis from costs and assets to outcomes and value. That will allow planners to start with the end goal in mind. So instead of wrestling with how best to connect two city hubs (for example), planners will ask “What’s the best combination of infrastructure to support increased economic growth in this part of our smart city, while minimizing construction risk, recycling capital, and delivering value of outcomes versus first/lowest cost assets?”

MOVING FORWARD

THE ERA OF CONNECTION and its new capabilities offers tremendous potential, but will require a change in mindset as we shift from price to value. A firm's performance on project delivery and the performance of assets themselves will no longer be hidden. The transparency of the design and its delivered value and outcomes will drive the industry to make better decisions as we deliver on physical systems that become deeply intertwined with their digital twins.

Digitalization will require infrastructure firms to recalibrate how their enterprises will function, how they re-imagine almost every past transaction process, and how they mitigate risk instead of passing it on. The shift from an asset view to a system/enterprise view will require an internal investment in digital innovation, where firms must look past the single project payback and align with long-term returns. As its value is achieved, digitalization will become a standard at a corporate level and then at an industry-transforming infrastructures business from the project-level to the profession scale.

Big data and the cloud are the backbone that is helping to drive this disruption of convergence and integration. It allows us to consider what new business value propositions will become available to those who embrace and drive the change. The Era of Connection will transform the industry... not by incrementally automating existing work processes, but by radically changing how the industry is operated, structured, and remunerated.

How will this impact infrastructure firms? It will lead to:

- A sustainable and predictable project performance that reflects the level of skill and professionalism your infrastructure firm brings to the table
- A greater resiliency for engineering firms to address changing owner requirements while also quickly shifting resources onto key growth sectors with minimal internal disruption
- Agility to transform your business by taking advantage of new technology, to address existing business segments in a new way, while also opening doors to new areas.

By leveraging infinite computing and big data, planners, designers and contractors will analyze the design for risk reduction from multiple perspectives. They will also look at multi-project resource balancing to land on the best strategy to create the optimized integrated infrastructure systems that best serve both present and future needs of their clients and the public at large.

Future infrastructure systems will be designed with the inherent capability to adapt and respond in ways they were not explicitly intended to do when first conceived. In turn, this will allow collaborators to adjust infrastructure design approaches to changing market dynamics and deliver outcomes that meet resiliency, financial performance, and social license to operate requirements.

All infrastructure challenges going forward will be accounted for in parallel as they exist in reality. We will view changes to any infrastructure system through the creation of intelligent "virtual infrastructure projects" that enable and improve the way we envision, iterate, and collaborate socially to deliver future infrastructure to address these challenges. The Era of Connection is all about determining what the right project is before getting the project right.

Explore these articles where infrastructure owners and AEC firms discuss what they are doing differently and why now is the time to change, and glimpse the future of infrastructure in the year 2050.



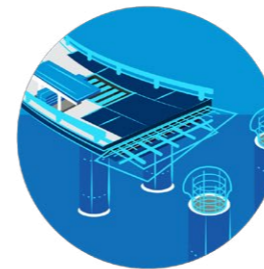
Designing a bridge today means thinking about the future of the bridge.
[Read more >](#)



Consider transportation and more in a city now versus one in the future.
[Read more >](#)



View a megacity in 2050.
[Read more >](#)



Construction managers were early adopters of BIM in infrastructure. See the real life of a construction manager.
[Read more >](#)



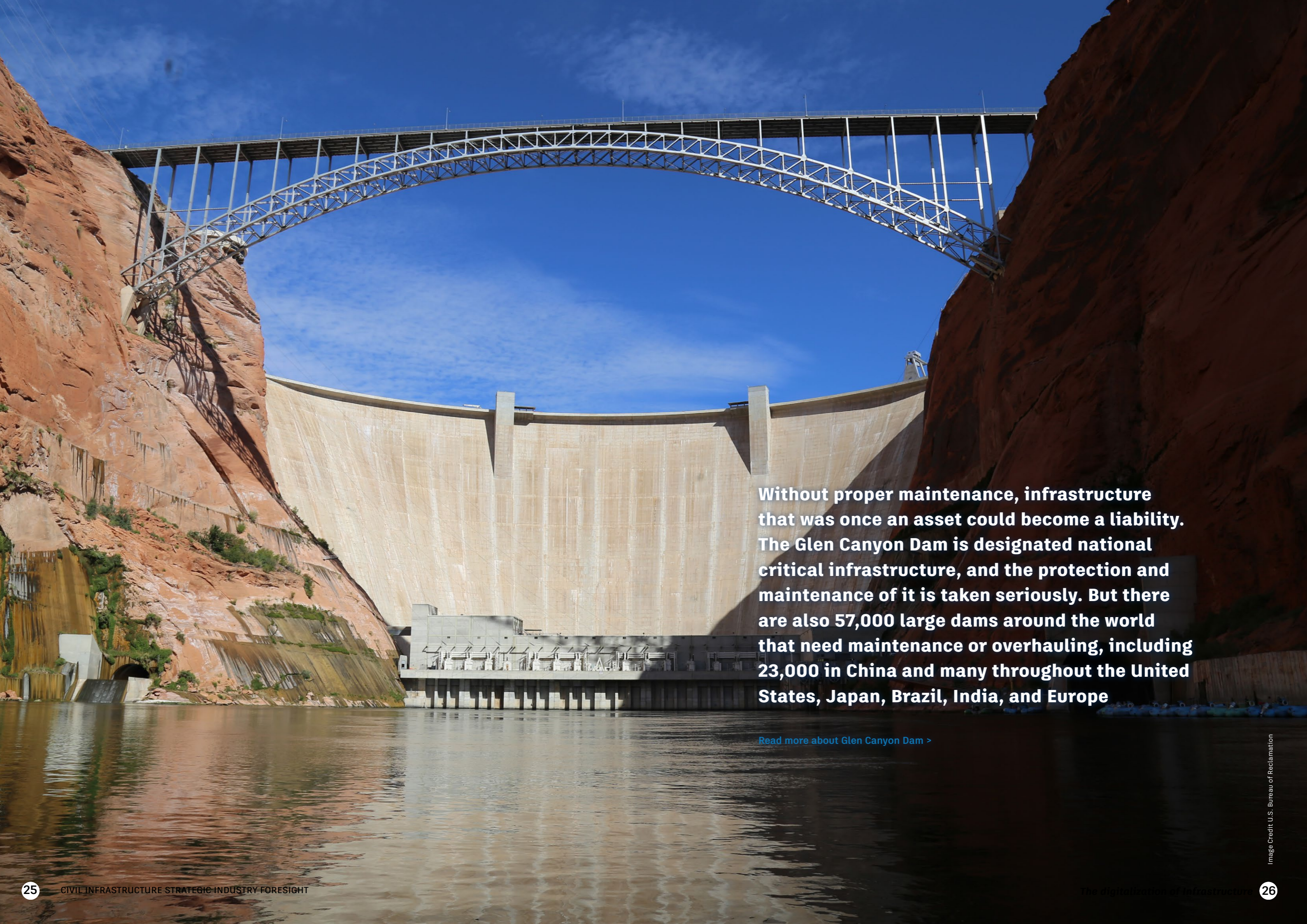
Take a global flight from New York to Hong Kong.
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Airports are taking the lead in defining project deliverables and BIM is at the center of these conversations.
[Read more >](#)



Ports must move beyond the status quo with larger ships, more expectations and more business; they just grow and adapt their infrastructure.
[Read more >](#)



Without proper maintenance, infrastructure that was once an asset could become a liability. The Glen Canyon Dam is designated national critical infrastructure, and the protection and maintenance of it is taken seriously. But there are also 57,000 large dams around the world that need maintenance or overhauling, including 23,000 in China and many throughout the United States, Japan, Brazil, India, and Europe

[Read more about Glen Canyon Dam >](#)

BIM in the era of connection is the process by which focus is placed on the right way to increase infrastructure—by taking into account the interdependency of all adjacent infrastructure systems and the costs over the lifecycle of that system—all targeted to help future-proof that system for growth, adaption and resiliency.

Notes:

- ¹ (2016), McKinsey Global Institute, Bridging Global Infrastructure Gaps, <http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/bridging-global-infrastructure-gaps>
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