DIGITAL ENGINEERING: OPTIMIZING CONSTRUCTION'S DIGITAL FUTURE

CONTENTS

INTRODUCTION

While there remains no agreed universal definition of digital engineering, it is a term associated with the digitization of the processes involved in the delivery and operation of a built asset, supported by one central data source, intended to add value and streamline practices.

Governments around the world are slowly recognizing the importance of digital engineering and are introducing initiatives to encourage innovation, such as the National Digital Twin program in the UK which will deliver a powerful framework aimed at organizations who want to advance change and embrace connected digital twins. Similarly, the Transport for New South Wales program in Australia is developing a framework for a more unified, reliable, and reusable approach to digital engineering across their transport network.

As a provider of digital solutions for infrastructure and capital projects globally, Asite is well-positioned to put forward a case for the wider implementation of digital technologies and offer use-cases to drive operational change. As such, we have determined that digital engineering is not just the uptake of new technologies but, instead, the concerted effort to use smart technologies to unlock greater value across the entire lifecycle of a capital asset.

This report examines digital engineering throughout the project lifecycle, from planning and design to procurement and construction and further on to operation and maintenance. This process-centered approach will provide insight into the technologies set to be the most transformative while also examining the drivers behind the push to maximize the potential of digital engineering.

By setting the foundations for how we can advance our approach to digital engineering, the industry can unite behind an agreed method of development that is based on interoperability and works towards resolving the fragmented nature of the industry, offering a more holistic alternative to how it operates.

MESSAGE FROM **THE CEO**

As our industry continues to recover and rebuild as we adapt to the new realities of COVID-19, digital engineering provides us with the opportunity to build a digital ecosystem, working with and building on the learnings of innovative organizations around the world.

The integration of digital engineering technologies and processes is our industry's next great challenge and one we must meet together, ensuring no one gets left behind. If implemented correctly, they have the capabilities to streamline how we work and transform our industry.

For years Asite has been at the forefront of digital integration across the AEC industry and, in this capacity, has built a strong reputation for working on some of the most challenging and complex construction projects worldwide.

Creating solutions that enable our clients to incorporate digital processes in their work is truly at the heart of what we do.

NATHAN DOUGHTY

ASITE CEO

PLANNING

STAGE OVERVIEW

Construction planning is the process of identifying the activities and resources required to make a design a physical reality.[1]

The data collected at this stage provides essential information to determine project feasibility, and optimize the design, construction and operation of a built asset. Therefore, the accurate and efficient management of data and information is imperative.

CHALLENGES

Ensuring the accuracy of this information is a key challenge facing planners. Along with being a health and safety risk, manual surveyance is a timely and expensive process prone to inaccuracies, with unforeseen surprises a major cause of project delays.

Discrepancies between ground conditions and early survey estimates can also cause a project to go over budget as last-minute changes to project scope and design can be costly.[2]

BARRIERS TO ADOPTION

Despite the clear advantages for using data to optimize planning, construction planners have been largely absent from the discussions surrounding adoption.[3]

Integrating BIM with visual data collected by drones opens up new avenues for gathering data. However, despite their broad potential and strong promotion, their widespread adoption has been limited by the lack of support from owners and project managers. Likely due to the fear of additional liabilities associated with insurance around drone usage.[4]

Overcoming this barrier requires a comprehensive understanding of the benefits and risks that drones bring to operations.

SOLUTIONS

While project management solutions can provide organizations with the tools required to effectively manage their information, new technologies are at the forefront of providing the capabilities to gather the detailed information required.

New techniques that integrate high-definition photography, 3-D laser scanning, and geographic information systems, enabled by recent improvements in drone and unmanned-aerial-vehicle (UAV) technology, can dramatically improve accuracy and speed. This advancement in geospatial techniques aids data capture, including identifying the locations of water pipes, sewers, phone lines, fiber optic cables, and power lines, and feeds that into digital planning tools that are immediately available to the project manager.

Drones are being utilized in construction projects; at this phase, they allow surveyors to safely and efficiently perform land inspections and conduct estimations. Drone technology is particularly useful when used in conjunction with visualization tools, such as geographic information systems or AR.

AR, specifically, allows maps, images, distance measurements, and GPS positions to be overlaid or enables clients to see a realistic rendering of the asset before construction begins.

[1] Carnegie Mellon University

[2] McKinsey

[3] RIBA & Arup

[4] Golizadeh et al

CASE STUDY

MICROSOFT REDMOND CAMPUS

(Washington, USA)

In 2015, Microsoft announced it would be redesigning its campus in Redmond, Washington.

Work began in 2017 and, when completed, the multi-billion-dollar project will create approximately two million additional square feet for the campus, allowing for an additional 8,000 employees.

The new campus is using a range of digital tools to ensure a data-driven construction project. One such example is their use of an autonomous drone surveying system.

The use of drones is helping Microsoft revolutionize its campus rebuild.
During each week of the planning and construction process, an unmanned aerial vehicle (UAV or drone) passes over the site to create high-accuracy GPS scans of the construction progress.

Pictured
Microsoft Redmond Campus

The UAV captures aerial data on excavation, foundation, and utilities. This data is then processed in the cloud and made available to over 150 stakeholders on the project through the online portal.

This 3D data is then fed into over 100 BIM models that contain more than 2.8 million individual 3D building components and provide data to more effectively tackle challenges as they arise, plan ahead, and monitor construction progress.

This weekly process helps stakeholders map out the construction project and site, allowing project stakeholders to safely and efficiently perform inspections and conduct estimations. It also provides a unique view of the project while aiding the reduction of rework and helping to predict project schedules.

OUTCOMES

100 BIM models
fed with information collected by drones

150 stakeholders
receive real-time updates via the cloud

131
buildings on the new campus

PROJECT LIFECYCLE - STAGE 2

DESIGN

STAGE OVERVIEW

During the design phase of the project, the client's requirements are captured and encapsulated in detailed plans and specifications. In addition to meeting the needs of the client, ensuring that the design fulfills the project objectives is imperative at this stage.

These decisions have a direct impact on the lifecycle of the asset, demonstrating the integrated nature of the construction industry.

CHALLENGES

The exchange of information during the design phase can be difficult to plan and coordinate.

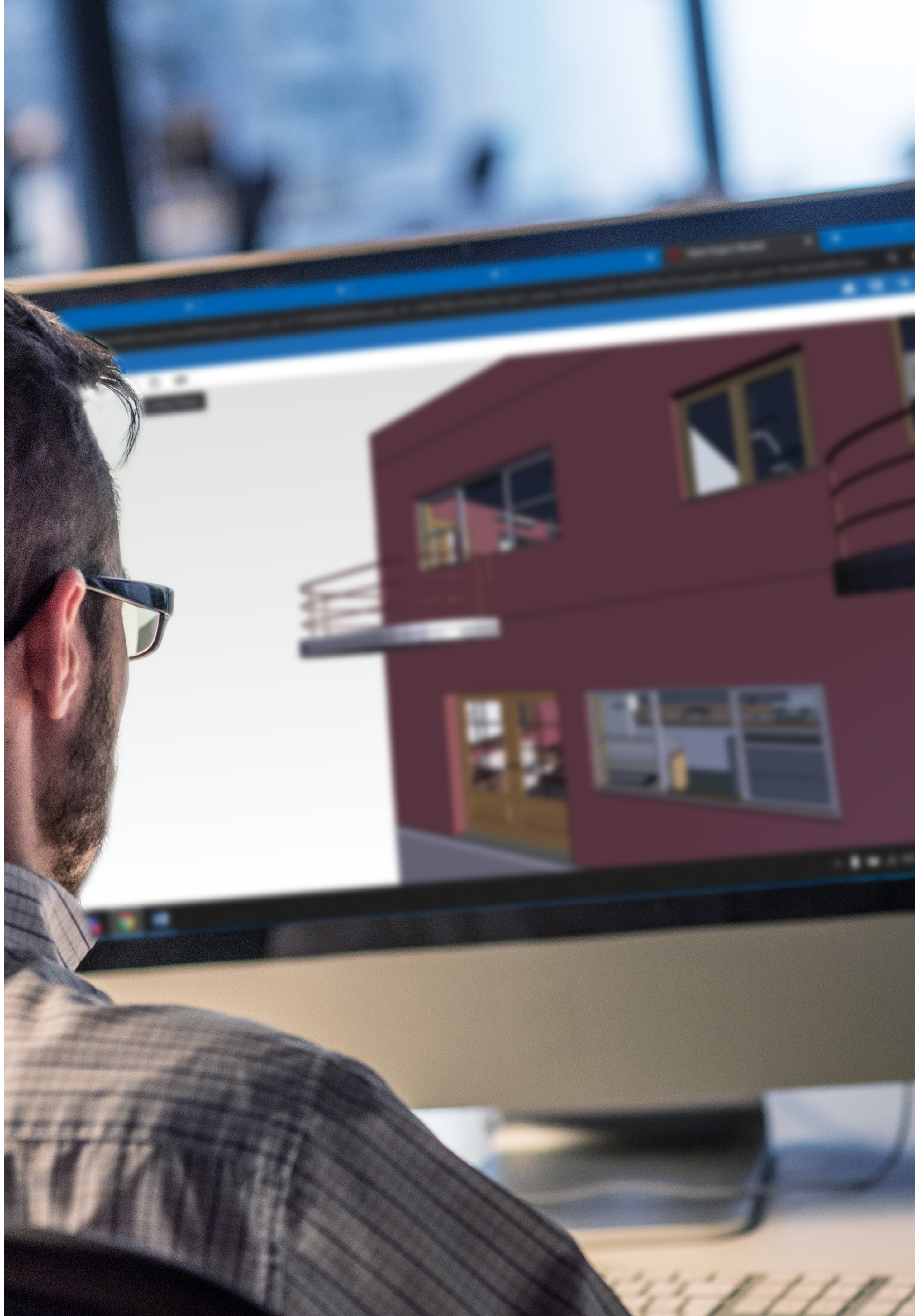
One of the most common issues faced during this phase are clients framing information requirements for projects around traditional 2D deliverables, potentially discouraging design teams from leveraging more value from their federated model or using other innovative ways of working.[5]

BARRIERS TO ADOPTION

The use of data to optimize design is an area that has not been fully utilized by the industry.

Urban planners have been largely absent from the discussions on the use of data despite its obvious benefits.[6]

This apprehension is attributed to the lack of awareness surrounding when data is needed, and how it should be captured, used, and shared. Low development and the consequent high cost of data capture tools are similarly attributed to the lack of understanding and engagement between designers and smart technologies.[7]



SOLUTIONS

The use of data presents real opportunities to optimize design, while ensuring digital engineering capabilities later on in the project lifecycle, and helps to maximize project return on investment.

Data optimizes design decisions, drives smart construction processes, and enhances operational efficiency.

In the UK, ISO 19650 information management standards depict a process that promotes thinking about the asset operation and impacts from the start.

The standards are designed to create reliable information models that are comprised of data, which can be used to answer the client requirements.

As seen in construction projects globally, BIM enhances design and engineering processes, allowing the merging of models and collection of data to identify interdependencies and clashes, and rapidly evaluate design iterations.[8]

The interoperability of this data is imperative, and performance optimization is dependent on systems working together and speaking to one another to deliver collaborated solutions.

[5] RIBA

[6] RIBA & Arup

[7] RIBA & Arup

[8] Boston Consulting Group

CASE STUDY
CROSSRAIL

An Asite Project
(London, UK)

A fully-owned subsidiary of Transport for London (TfL), Crossrail is the biggest construction project in Europe and one of the largest single-infrastructure investments to be undertaken in the UK, with a construction value of £19 billion.

To fulfill their role in transforming transport connections throughout London and in an effort to drive forward design innovation within the construction industry, Crossrail is exploiting the opportunities BIM can bring to a project.

This mandated use of BIM by Crossrail, coupled with BIM being placed on the national strategic agenda, has attributed to the UK becoming one of the world's highest BIM adopters.

Crossrail aims to be the first major infrastructure project to fully realize the BIM lifestyle concept. Crossrail works in a Common Data Environment (CDE) with collaboration between no fewer than 60 major contractors and 25 design consultants.

Designers and engineers use a set of linked BIM databases to integrate about 1.7 million CAD documents into a single information model.[9]


Photo © Crossrail Ltd

This enables Crossrail to create detailed static and moving visualizations of specific elements of the project to, essentially, bring elements to life prior to any construction work.

Moreover, in the design phase, this process helps define the spatial relationships between all the component elements and ensures no clashes are found between different aspects of the build.

Malcolm Taylor, Technical Information Manager for the project, asserts that "models and databases are important at different lifecycle phases. When building something like Crossrail, you need to recognize the databases are just as important as the 3D models, and so you need to plan them at the same time."[10]

The use of BIM on Crossrail has unequivocally enhanced the design process and reduced risk, thanks to greater project visibility. The usage of only the most appropriate version of models, drawings, and documentation have reduced errors, the incorporation of linked data sets has improved collaboration, and the creation of a "virtual" Crossrail before construction using these linked data sets has allowed for design refinement.

The project has staggered completion dates with full services across the Elizabeth line route in operation by mid-2022.

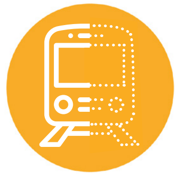
[9] Boston Consulting Group

[10] BIM+

OUTCOMES


74 miles
of new railway track

1.7 million
CAD documents integrated


Virtual Crossrail
created using linked data sets

PRECONSTRUCTION –
TENDERING, CONTRACTOR BIDDING & PROCUREMENT

STAGE OVERVIEW

The pre-construction phase encompasses a wide range of activities, including the tendering process for contractors, procuring materials and equipment, and securing permits and entitlements. The time and complexity of these activities depend on the size of the project, but this is often the most time-consuming phase.

The tendering process, in particular, involves the exchange of documents and sometimes quite protracted negotiations, which can negatively impact project delivery. As such, it represents a fertile ground for innovation and transformation.

CHALLENGES

Overall, the pre-construction phase has huge implications for the timely and economic delivery of a project. In the case of the tendering and bidding process, a lack of transparency and information increases both risk and cost.

Basically, the more transparent communications are, the more exact the offers will be, thus ensuring the least possible number of unforeseen obstacles during the construction itself.[11]

Ultimately, the tendering and procurement processes can either unlock significant value for a project or lose it.

BARRIERS TO ADOPTION

While innovation and technological advancements may have the capacity to add value, new processes will, of course, expose a project to some risk. For this reason, there is reluctance to embrace technologies that require up-front investment.

Additionally, the tendering and procurement processes involve various stakeholders, so the successful uptake of any solution would require the buy-in of all of them. In cases where software tools are implemented, the user-friendliness has a significant impact on the widespread adoption of the tool.

A lack of accommodating solutions is a major hindrance to the proliferation of digital solutions.

SOLUTIONS

Innovative construction software tools and cloud-based applications have a key role to play in these early stages of the lifecycle. As capital projects increase in size and complexity, the integration of digital project management solutions into day-to-day IT systems work to close the productivity gap and add value across the lifecycle.

The digital transformation of these processes and move away from paper ensure transparency and collaboration, timely progress and risk assessment, quality control, and, eventually, better and more reliable outcomes.[12] A single platform solution for supply chain management ensures that inquiries are submitted securely and are compliant with any regulations or formal requirements.

Additionally, big data and advanced analytical tools allow for tender pricing and selection to be optimized based on past performance, thus reducing risk and preventing contracts which are based on guesswork.

[11] DLA Piper Real Estate Gazette

[12] McKinsey

CASE STUDY

LAING O'ROURKE

An Asite Client

The Laing O'Rourke Group is responsible for building many of the world's biggest and most technically challenging projects. The company's vision is to be the first choice for all stakeholders by challenging and changing the image of construction worldwide, both lean and agile.

Laing O'Rourke was one of the first construction companies to adopt a digital approach to collaborating with suppliers, aiming to process 68 percent of their procurement transactions electronically.

Laing O'Rourke already had a purchasing application operating across the group. The challenge was to allow any of its key suppliers to trade with them using a single integrated, collaborative and secure platform. This one-time integration would then allow Laing O'Rourke to connect to its other preferred suppliers digitally.

Asite enabled Laing O'Rourke to exchange purchasing and accounting information electronically with its key suppliers. To place an order, Laing O'Rourke can now select products from a supplier's online catalog and issue an online purchase order via its existing purchasing application.

The catalog is hosted on the Asite cloud platform and holds real-time product and pricing information, which eliminates the need for Laing O'Rourke to manage its supplier catalog. The company's suppliers can now receive purchase orders by simply logging onto Asite, where they can also generate and send invoices directly to their accounting system.

The Asite Supply Chain Management (SCM) solution provided Laing O'Rourke with the ability to automate existing sales order management, electronically change or adjust orders and trace order history through a full audit trail. The system also enabled the company to create automatic invoices from purchase order data.

A major step towards minimizing its purchasing cycle, Laing O'Rourke can now provide its customers with greater flexibility, while maintaining control of its expenditure. Laing O'Rourke now conducts business digitally with its suppliers and integrates the systems that its supply chain uses.

By integrating its purchasing application with Asite and moving to purchasing online, Laing O'Rourke reduced processing costs for invoices, orders, requisitions, site orders, and Goods Received Notes by up to 56 percent. The adoption of the software also enabled 30 members of its supply chain to use the SCM solution and reduce invoice processing costs saving 25 percent per transaction.

Pictured
Heathrow T5

OUTCOMES

30+
supply chain members integrated

25%
reduction in invoice processing costs

56%
reduction in order processing costs

MODERN METHODS OF CONSTRUCTION -
ADVANCED BUILDING MATERIALS (ABM) & TECHNIQUES

STAGE OVERVIEW

The solutions emerging from building materials are numerous and wide-ranging – from incremental innovation of traditional materials and existing characteristics to radically innovative materials with entirely new capabilities.[13]

Additionally, Modern Methods of Construction (MMC) – namely, standardization, modularization and prefabrication – could drastically boost productivity in construction.

CHALLENGES

Traditional materials associated with construction, such as concrete, bricks, steel, glass and woods have their limits, specifically as it pertains to sustainability and the natural life of structures. For instance, the worldwide production of concrete amounts to about 5 percent of human-generated CO_2 emissions every year and brick production is also blamed for a range of ills.[14]

Moreover, the unprecedented rate of urbanization across the world has led to increased demand for affordable housing; a demand, it can be argued, the industry is not well-positioned to meet. Globally, labor-productivity growth in construction has averaged only one percent a year over the past two decades, compared with growth of 2.8 percent for the total world economy and 3.6 percent in the case of manufacturing.[15]

BARRIERS TO ADOPTION

Despite their great potential, ABMs and MMC often fail to penetrate the market or gain widespread acceptance, particularly in emerging countries, because they often require a higher initial investment, with the benefits generally realized later. Also, the successful implementation of these approaches usually requires that companies dramatically change their processes across the entire project lifecycle.

All of that points to another serious impediment: the liability risks that engineers, contractors and suppliers would face if they recommend a new material or method of operation.[16] Ultimately, ABMs and MMC still lack a substantial track record of success and the information needed to make difficult trade-offs financially.

Pictured - an Asite project
Ras Abu Aboud Stadium, Doha Qatar.

Photo courtesy of Supreme Committee for Delivery & Legacy

SOLUTIONS

The adoption of new building materials, such as self-healing concrete, aerogels, and nanomaterials, along with innovative construction approaches, such as 3-D printing and preassembled modules, can lower costs and speed up construction while improving quality and safety.[17]

Off-site construction could radically change the way that we plan, design, and deliver projects. For example, the use of modular and prefabricated elements in the design of Ras Abu Aboud Stadium will allow it to be fully dismantled and repurposed for other projects after the 2022 FIFA World Cup Qatar™.

Standardization offers greater certainty of outcomes and reduced costs for end-users, as submodules or concrete structures can be completed before assembly, like Laing O'Rourke's Explore Industrial Park (EIP). EIP develops the design models, which are then used to create the precast elements required for the individual project at hand.[18]

The integration of off-site processes could significantly enhance design capabilities and variability, improve precision and productivity in manufacturing, and facilitate logistics.

[13] World Economic Forum

[14] IET E&T Magazine

[15] McKinsey

[16] World Economic Forum

[17] McKinsey

[18] PBC Today

CASE STUDY

MANIFESTO SMICHOV

(Prague, Czech Republic)

Launched in 2018 and located in Prague's city center, Manifesto is an internationally acclaimed food and culture hub developed by Martin Barry, founder of reSITE – a global non-profit acting to improve the urban environment.

Building on the popularity of this first location, a second location was opened with a similar regeneration mission on a former empty parking lot adjacent to the art-nouveau events building known as the National House of Smichov.

Architecture studio, CHYBIK + KRISTOF, were commissioned to design the contemporary modular units to create this unique pop-up recreational space, dubbed Manifesto Smichov.

The Manifesto brand is built around sustainability, creativity and innovation, and the development of this second location in Smichov is reflective of this. All of the modular buildings on the property were manufactured and assembled by Koma Modular, who develop, design, produce and construct custom modular solutions as well as ready to use units.


Pictured
Manifesto Smichov

The 11 corrugated-metal covered units that make up the sleekly-designed modular market boasts two bars and six restaurants, offering visitors an international gastronomy experience and dynamic cultural program of top local DJs, live music, performances and classes.

The "summer oasis" has successfully reinvigorated this previously-neglected area of the city. The use of modular design allows for increased accessibility and the easy installation of additional elements. The off-site manufacture of components significantly minimizes the impact of the structure on the surrounding area, while the use of sustainable materials similarly reduces any negative environmental effects.

Modular construction offers a faster, innovative, cheaper, and more sustainable alternative to traditional construction – particularly in urban areas. Manifesto Smichov is evidence of this. Client demand for individual solutions often discourages the use of standardized processes and components; however, Manifesto have successfully used this technique to create a pop-up complex that is now a city staple.

OUTCOMES

135 m²
market space

11
corrugated-metal covered units

Two weeks
length of assembly

One week
manufacture time

CONSTRUCTION

STAGE OVERVIEW

The actual execution of the project, or implementation phase, is where all the planning, preconstruction activities, and collected data come into play. The ultimate goal of this stage is to ensure that all plans move forward without issue; however, the construction stage is prone to delays, cost overruns, and quality problems.

While this more visible and labor-intensive phase of the asset lifecycle is the one most associated with the construction industry, its success is largely dependent on the work completed in the previous stages. Likewise, the successful delivery of this stage has a significant impact on the operation phase – it is key to reducing lifecycle costs and may also extend the lifespan of the built asset.

CHALLENGES

The construction industry still mainly relies on manual labor, mechanical technologies, and legacy business models. These prevalent methods of operation make scaling up to effectively meet the demands of complex capital projects almost impossible – 98 percent of megaprojects suffer cost overruns of more than 30 percent, and 77 percent are at least 40 percent late.[19]

Additionally, construction workers devote only about 30 percent of their working time to their principal activity. The remaining 70 percent is taken up by running errands, transporting materials, cleaning up, rearranging the building site and looking for materials and equipment.[20]

BARRIERS TO ADOPTION

Implementing such solutions is difficult as contractors have very little incentive to embrace new methods during their short-term involvement with a project. This isn't helped by the fact that AI initiatives are often not planned at a strategic level. The aims and objectives of operations, from data gathering to how the insights uncovered are communicated across the workforce and put to work, are not properly established to inspire buy-in, creating further deterrents.[21]

Moreover, the impact of AI is contingent on having the right data. E&C leaders cannot take advantage of AI without first undertaking sustained digitization efforts. This includes investing in the right tools and capabilities for data collection and processing, such as cloud infrastructure and advanced analytics, from the offset.[22]

SOLUTIONS

A Common Data Environment (CDE) provides a central repository for the vast amounts of data and information produced across the asset lifecycle. And, as already discussed, the deployment of adequate information systems, and a single source of information, from the outset of a project creates greater efficiency and reduces risk.

Enabled by the increasing amount of data collected in the earlier phases of the project lifecycle, advances in AI – specifically, machine learning and robotics – have the potential to bring about major shifts in how projects are executed.

Machine learning uses neural networks and statistics to allow computers to learn and draw insights from data without being explicitly programmed. In the construction phases, machine learning can optimize inventory management and resource allocation, thus reducing logistical burdens and non-value-adding activities (such as waiting, moving personnel, and transporting material and equipment).

Similarly, robots and intelligent machines enhance productivity, precision, and safety at the site with automated and autonomous construction. Remote-control systems and 3D-model guidance enable advanced levels of automation for excavators, mobile cranes, and dump trucks, for instance.[23]

Also, a driverless crane could transport materials and supplies, or an aerial drone could gather information on a worksite to be compared against the plan and help predict what tasks are required.

[19] McKinsey

[20] Roland Berger

[21] Bernard Marr & Co.

[22] McKinsey

[23] Boston Consulting Group

CASE STUDY

SOUTH FLANK IRON ORE

(Pilbara, Western Australia)

BPH's $3.6 billion South Flank iron ore project is set to be one of the world's largest iron ore production hubs, integrating the latest advances in autonomous-read fleets, digital connectivity and modular design.

To support the project, Japanese construction equipment manufacturer, Komatsu, has deployed an unprecedented 41 new model Komatsu 930E-5 ultra-class haul trucks, made autonomous-ready.

Located in BHP's Mining Area C, the deposit is expected to supply BHP's Western Australia Iron Ore division with roughly 80 million metric tons per year over its 25 years of estimated project life, replacing production from the Yandi mine, which is reaching the end of its economic life. The production of first ore is expected in 2021.

Billed as "setting the new standards for the future of the resources industry", the South Flank deposit is 26 km long and will require a significant investment in infrastructure and operations.

Komatsu has a proven record in safety, productivity, and lower haulage costs, and has made ground-breaking contributions to autonomous technology solutions in the industry.

Komatsu's Autonomous Haulage Systems (AHS) are tried and tested in harsh conditions and climates, including ambient temperatures of minus 45 degrees, in temperatures higher than 40 degrees and finally at extreme altitude.

Komatsu has deployed 250 AHS trucks worldwide and 180 currently in operation globally. The company boasts over two billion tons of material moved autonomously with zero injuries.

AHS work in harmony with active site plans that are digitally created and frequently updated. While there is no need for drivers, the vehicle still requires considerable manpower to operate, including technicians, apprentices, mechanics, welders and electricians.

Alongside optimizing processes and driving productivity at the site, the deployment of these machines at South Flank will also drive job creation and upskilling in the local community.

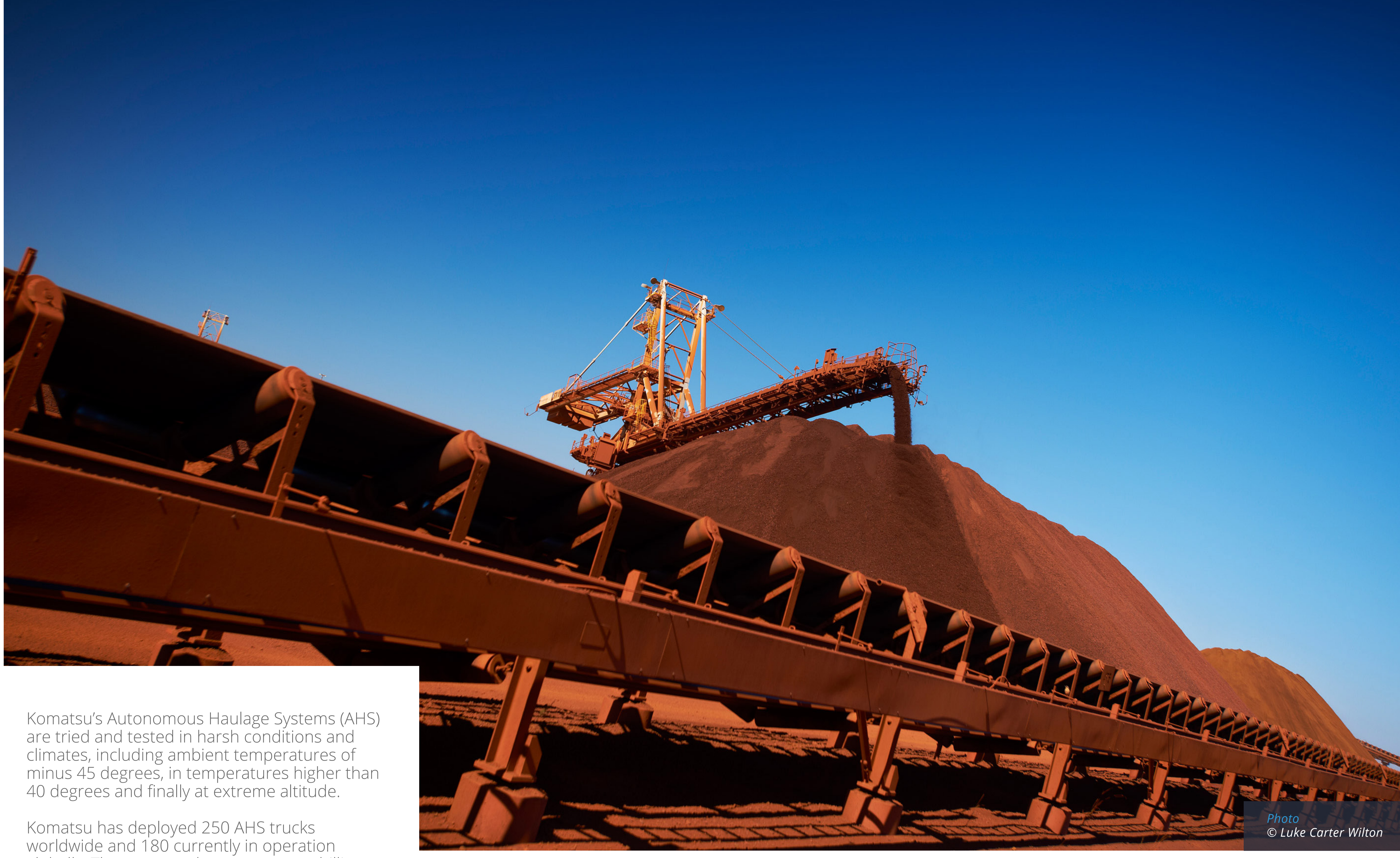


Photo © Luke Carter Wilton

OUTCOMES

41
autonomous-ready haul trucks deployed

80 million
metric tons per annum

25 years
estimated project life

£3.6b

US$3.6 billion
project

OPERATION & MAINTENANCE

STAGE OVERVIEW

The ultimate goal in the operate and maintain stage of the asset lifecycle is to support the finished asset in achieving operational excellence.

It is intrinsically linked to the design and planning stages; processes undertaken and decisions made about materials, tools, and facilities during these stages impact how the finished asset will be managed.

Operation and maintenance considerations must be defined in the Asset Information Requirements (AIR) at the beginning of any construction activity to optimize the lifecycle of a built asset.[24]

CHALLENGES

Maintenance planning has always been one of the biggest challenges for asset managers. A key challenge facing asset managers is how they minimize downtime, as unscheduled downtime, directly attributed to ineffective maintenance practices, is a big issue they face.[25]

Predictive maintenance and servicing at fixed intervals or cycles can overcome this. Adopting this measure, coupled with utilizing data, can create a more streamlined method of operating and maintaining a built asset. However, this poses its own challenges, most notably connecting data gathered from different technologies.

Finally, another prominent challenge facing the adoption of digital engineering techniques is the lack of data available about existing assets.

BARRIERS TO ADOPTION

Research conducted by Alpha FMC, leading global consultancy to the asset and wealth management industry, found that while digital transformation was a priority for asset managers, nearly a quarter of those surveyed felt their digital maturity is "frustratingly fragmented" and that they are beginning to lag behind other organizations.[26]

This lag has been attributed to the barriers preventing widespread digital adoption. These are cited as legacy technology, the need for comprehensive change in company culture and mindset, and a lack of resources or relevant skillsets. A lack of investment is also seen as an issue holding back digital innovation in the asset management industry.[27]

SOLUTIONS

During the operation and maintenance stage of the project lifecycle, a digital twin can optimize the effectiveness of the asset. A digital twin is a digital representation of a physical asset or the service it delivers, used to enhance decision-making. The digital twin collates real-time data and analytics from several different technologies to evaluate current conditions and send alerts when something deteriorates.

A digital twin integrates with Internet of Things (IoT) to create its digital simulation. IoT sensors collect real-time data about the object and send it to a cloud-hosted system to be processed.

It is also continuously updated, meaning that work completed on the asset during the operation and maintenance stage are documented, and this data is logged for future reference. The use of digital twins is rising globally for building and infrastructure projects.

Existing assets are also poised to benefit from the uptake of digital twins as they can be retrospectively created. A calibrated model can be created through the interrogation of data from a built asset, which is used to determine the appropriate inputs for a simulation model that, in turn, is compared to measured sensor and meter data. This calibrated model then becomes a digital asset.

Additionally, the creation of a National Digital Twin (NDT), which is an ecosystem of connected digital twins, can be used to unlock even greater value.

[24] Whole Building Design Guide

[25] Lloyd's Register

[26] Alpha

[27] Alpha

CASE STUDY

'DUBAI HERE'

(Dubai, United Arab Emirates)

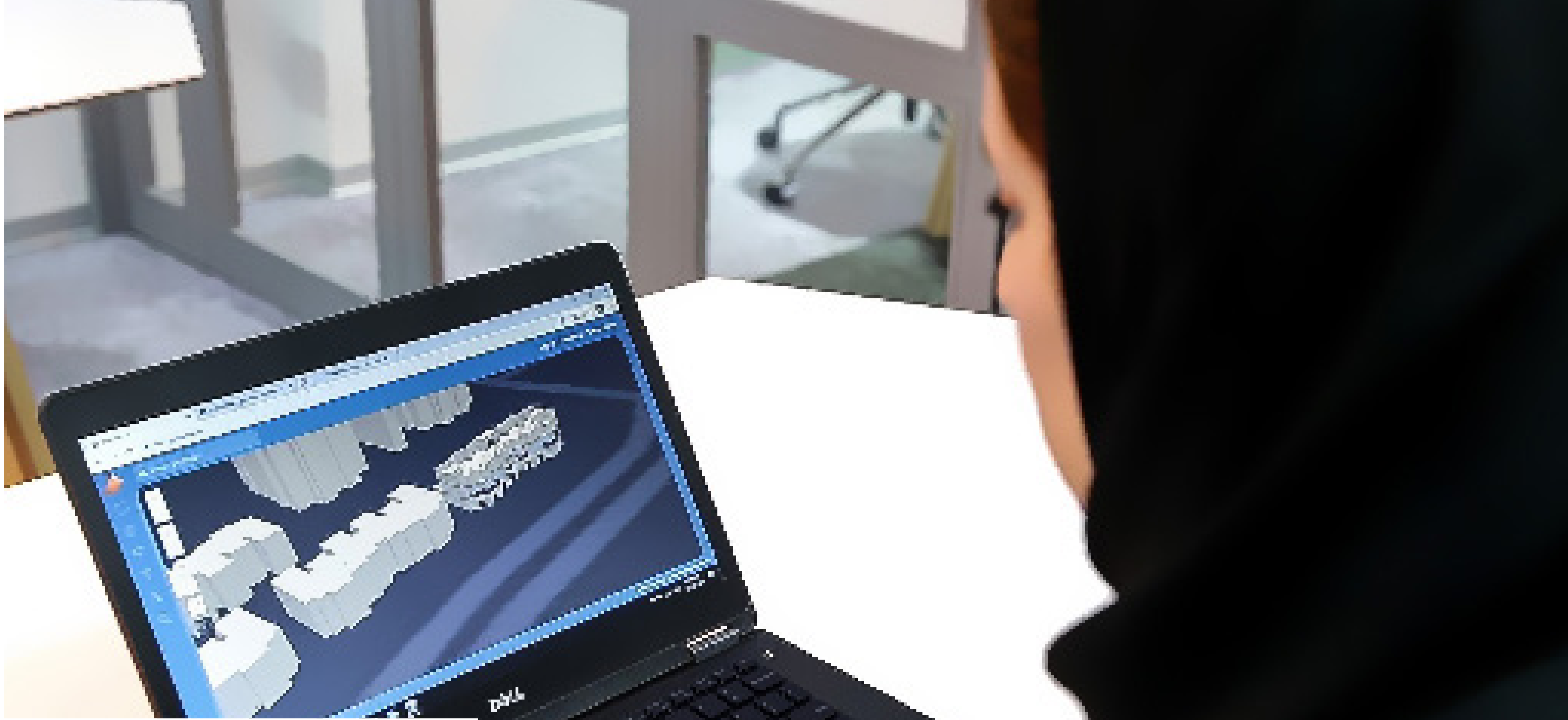



Photo © DXB Media Office

In June 2020, Dubai Municipality's Geographic Information Systems (GIS) Centre launched ‘Dubai Here’ – an electronic system that provides access to geospatial data and maps of the region.

The center aims to provide a digital twin for Dubai in the form of 2D and 3D maps of all assets in the city, including big-city landmarks and facilities, ranging from masterplans to interior details of buildings. It also covers other landmarks, such as roads, trees, bridges, green spaces, and utility lines, as well as details of residential units.

The digital twin is accessible on a web browser or a smart device and has been designed in a way that it can be easily shared and updated. It displays maps from a comprehensive geospatial database that all parties can contribute to and update.

Through gathering data throughout the city and mapping this digitally, the result provides a digital version that delivers necessary information for managing the city. It also provides access to details of housing units, service units, and networks, allowing city officials to operate the city effectively and efficiently. Information is also available on economic activity, the environment, health, and population, further increasing effective operation.

This technology enhances the effective delivery of smart services, especially when combined with the Internet of Things (IoT) and real-time information.

Alongside this, Dubai’s GIS Centre recently launched ‘GeoDubai.’ This initiative offers a comprehensive and unified base map that provides the background detail necessary for all engineering, planning, and development work in Dubai, enabling authorities to coordinate and cooperate to complete and update maps and information necessary to create Dubai’s digital twin.

These processes of retrospectively creating a digital twin of the city of Dubai is part of the effort to speed up cooperation between government departments to realize the Smart Dubai 2021 strategy.

The ‘Dubai Here’ project is creating the base map from which Dubai’s digital twin will grow, eventually incorporating different technologies to improve asset maintenance and operation.

The mapping processes will ultimately enhance areas of city planning, infrastructure, security, and health, which contribute to providing smart cities.

OUTCOMES

2D and 3D
asset maps

Unified database
for all engineering, planning and development work

Digital twin
of Dubai created

TECHNOLOGIES AT THE FOREFRONT

By identifying what technologies are needed at different stages and adopting a holistic approach to the asset lifecycle, stakeholders can make informed decisions that streamline practices, ensure project fulfillment, and increase overall value.

Due to the wide-ranging and varied nature of the industry, this report has focused on the technologies that are at the forefront of our digital engineering journey and have the capabilities to be the most transformative, while also helping to meet the societal, economic, and environmental demands placed on the construction industry.

ABMs

Advanced Building Materials

Increased focus has been placed on the need to operate more sustainably. Alternative construction materials are being highlighted as a way in which the industry can utilize technology to improve their carbon footprint and address global social challenges.

ABMs are a new generation of construction materials that demonstrate exceptional properties, making buildings and infrastructure smarter, more sustainable, energy-efficient and secure.[28]

Self-healing concrete, aerogels, and nanomaterials are prime examples of this. As the industry pushes to adopt more green materials, this is an area that will continue to grow in the coming years.

SMART BUILDINGS

Smart buildings can be used in advanced ways to automate, optimize and connect systems in the built environment.[29] IoT and smart sensors embedded in devices and buildings power this type of smart construction.

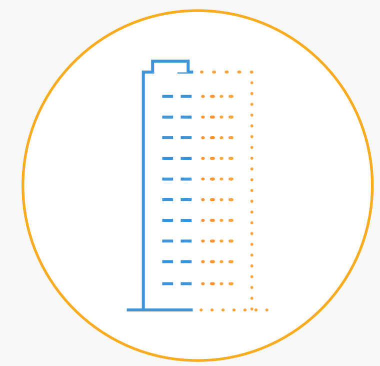
Both technologies can provide greater opportunities to harness, share and use data from a wide range of sources, ensuring better scope for making predictions and, ultimately, increasing productivity and maximizing efficiency.[30]

BIM

BIM is an essential process utilized across the asset lifecycle, and BIM compliance remains a principal goal for all construction projects.

BIM authoring tools used in conjunction with a Common Data Environment (CDE) allow for all digital assets and project information generated during the earlier phases to be stored in a central repository, which can then be supplemented or refined during the operations phase.

The central model ensures a golden thread of information is maintained through the project lifecycle, allowing any component or device to be located and its specifications checked. It ensures asset information is easier to retrieve and more trustworthy, as all information is maintained in a secure repository.[31]



DIGITAL TWINS

A digital twin takes the information of an asset one step further, working as an exact digital replica of a physical object. The physical entity can be monitored in real-time, providing insights to support better outcomes at each stage of the asset lifecycle.[32]

One such project utilizing this process is the Indian city of Amaravati, which will be built with a digital twin from the very beginning, joining Singapore, Glasgow, Boston, and Jaipur in having virtual counterparts.[33]

MMC

Modern Methods of Construction

Improved use of construction technology is also being touted as the solution to global housing demand. In particular, MMC, which centers around the use of off-site manufacturing and onsite technologies to build homes, is being utilized across the world. Modular homes are a prime example of this.

In India, where they have an urban housing shortage of 18.8 million, developers are embracing the advanced modular technology to build the 30 million homes needed to meet the government's 'Housing for All by 2022', 'Affordable Housing' and 'Smart Cities' initiatives.[34]

This quality-assured, quick, and cost-effective method of construction is estimated to revolutionize the housing industry.

[28] European Commission

[29] Financial Times

[30] Facility Executive

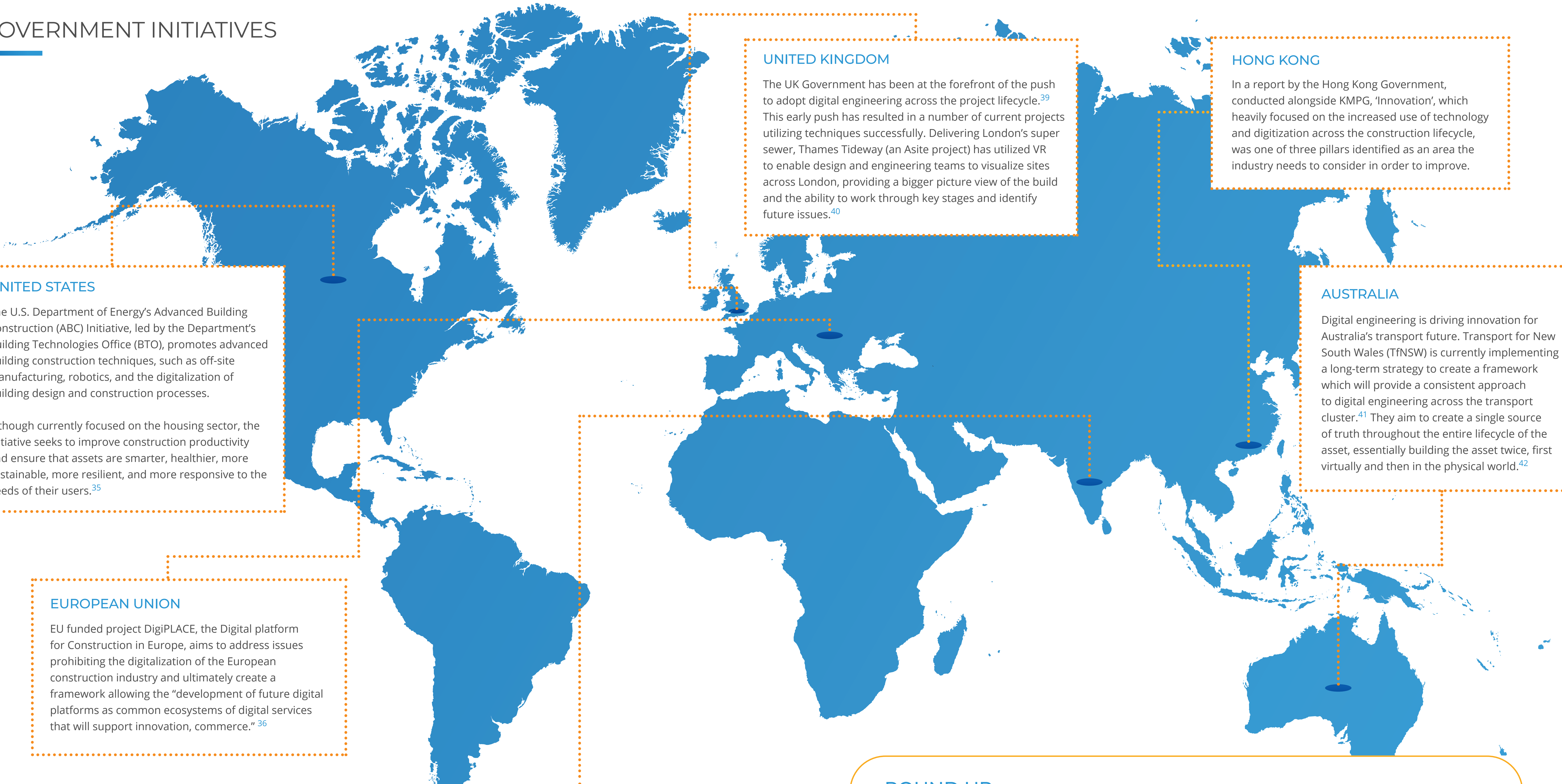
[31] Construction Times

[32] Total BIM Consulting

[33] Facility Executive

[34] Global Infrastructure Initiative

GOVERNMENT INITIATIVES



UNITED STATES

The U.S. Department of Energy's Advanced Building Construction (ABC) Initiative, led by the Department's Building Technologies Office (BTO), promotes advanced building construction techniques, such as off-site manufacturing, robotics, and the digitalization of building design and construction processes.

Although currently focused on the housing sector, the initiative seeks to improve construction productivity and ensure that assets are smarter, healthier, more sustainable, more resilient, and more responsive to the needs of their users.[35]

EUROPEAN UNION

EU funded project DigiPLACE, the Digital platform for Construction in Europe, aims to address issues prohibiting the digitalization of the European construction industry and ultimately create a framework allowing the "development of future digital platforms as common ecosystems of digital services that will support innovation, commerce." [36]

INDIA

The Digital India program is the Indian Government's flagship program to transform India into a digitally empowered society and knowledge economy.[37] The initiative, which was launched in 2015 with the aim of doubling the size of the country's digital economy, is currently undergoing a 'refresh'.[38]

In the building of the nation's digital infrastructure, technologies, such as AI, Big Data, and the Internet of Things (IoT), will play a prominent role in galvanizing sectors and overcoming the country's infrastructure deficit.

UNITED KINGDOM

The UK Government has been at the forefront of the push to adopt digital engineering across the project lifecycle.[39] This early push has resulted in a number of current projects utilizing techniques successfully. Delivering London's super sewer, Thames Tideway (an Asite project) has utilized VR to enable design and engineering teams to visualize sites across London, providing a bigger picture view of the build and the ability to work through key stages and identify future issues.[40]

HONG KONG

In a report by the Hong Kong Government, conducted alongside KMPG, 'Innovation', which heavily focused on the increased use of technology and digitization across the construction lifecycle, was one of three pillars identified as an area the industry needs to consider in order to improve.

AUSTRALIA

Digital engineering is driving innovation for Australia's transport future. Transport for New South Wales (TfNSW) is currently implementing a long-term strategy to create a framework which will provide a consistent approach to digital engineering across the transport cluster.[41] They aim to create a single source of truth throughout the entire lifecycle of the asset, essentially building the asset twice, first virtually and then in the physical world.[42]

ROUND UP

Advanced hardware and software technologies and an evolving supporting infrastructure has placed the construction industry at the brink of irrevocable transformation.

Along with significant use cases and solutions, urgent housing and infrastructure demands, sustainability goals and government policy have also presented the global industry with compelling incentives and drivers to incorporate digital processes.

However, to reach our full digital engineering potential, it is imperative that the data underpinning these technologies is properly captured, managed, and shared across the project lifecycle.

The capacity of digital engineering to address the industry's limitations and facilitate the delivery of increasingly complex megaprojects has been addressed time over, including in this report.

The question now stands – how can we create a framework that allows information to seamlessly move between stakeholders?

[35] Office of Energy Efficiency & Renewable Energy

[36] Faith + Gould

[37] Digital India

[38] The Economic Times India

[39] Faith + Gould

[40] CITB

[41] Transport for New South Wales

[42] Transport for New South Wales

> DIGITAL ENGINEERING RELIES ON THE SEAMLESS FLOW OF DATA FROM THE BEGINNING OF THE PROJECT THROUGHOUT THE ASSET LIFECYCLE AND BEYOND; WITHOUT THIS, DIGITAL SOLUTIONS ARE EFFECTIVELY REDUNDANT.

CONCLUSION

CREATING FERTILE GROUND FOR DIGITAL TRANSFORMATION

As demonstrated in this report, there are many junctures across the asset lifecycle at which value is consistently lost or, at best, left on the table. While we have found several use cases for digital solutions, our investigations have also made it very clear that to generate value from digital technologies, they must be implemented at the offset of the project and carried through to the operation of the asset.

At its very essence, the AEC sector is based on one-off projects and temporary relationships and, therefore, is fragmented and uncoordinated, offering arid ground for successful and scalable digital transformation.[43]

This report has concluded that to create a fertile foundation for digital engineering and innovation, we must first address the fragmented nature of the industry, which has led to a lack of knowledge-sharing, low incentives to adopt technologies and poorly utilized data.

OPTIMIZING INFORMATION FLOW

It goes without saying that construction projects are becoming increasingly complex – both in terms of organizational and technological complexity.

Consequently, how data and project information is shared across the project lifecycle has fast become one of the key challenges to a digitally-enabled industry. Projects now generate vast amounts of data; however, much of it is isn't even captured, let alone processed and integrated.

Digital engineering relies on the seamless flow of data from the beginning of the project throughout the asset lifecycle and beyond; without this, digital solutions are effectively redundant. Therefore, the burden on the AEC sector here is not necessarily the uptake of the latest technologies, but maintaining transparency and good housekeeping throughout the asset lifecycle.

Our analysis of the planning and design phases shows that, in theory, projects stakeholders can know almost everything about an asset before it is built and make actionable conclusions across the entire project lifecycle. However, fragmentation between project teams and insufficient knowledge transfer from project-to-project has meant that insights are routinely lost and deployed solutions are not optimized.

SHARING RISK

This report holds that it is the responsibility all of those operating in the construction industry to track the changing risk profile of projects as new technologies are utilized.[44] A lack of integration has meant that participants often try to pass on risk to other project teams, particularly in the procurement stage when drawing up contracts.

Reports show that contracts do not include incentives for risk-sharing and innovation, so contractors often do only the minimum required to meet contractual terms. Therefore, contracts should be explicitly mutually beneficial, clearly outline responsibilities, and allow owners and contractors to equitably share in the benefits that arise from the adoption of technological and process innovations.

An Asite Project

Using the example of Heathrow Terminal 5 in London, McKinsey outlines how Heathrow Airport held all the risks as the project developer, protected by a comprehensive insurance policy. So, instead of a traditional client–contractor relationship, Heathrow treated the different partners like team members.[45]

Risk and liability are a fundamental part of digital transformation, and if the insights from this project were captured and made widely accessible, other projects may be able to replicate its successes.

The development of an integrated global platform that can be easily interpreted by both software and users across regions will allow us to capitalize on the existing data and reap the benefits of digital engineering.

SCALING SOLUTIONS

Fragmentation is not just an issue in the context of individual projects but one that concerns the global industry. In such a highly fragmented and horizontal industry, many challenges need to be tackled collectively but, to achieve this, the industry needs to establish new forms of collaboration.[46]

For digital engineering to truly transform the AEC sector and produce the desired outcomes, technologies need to be deployed in an environment where they can thrive, and a global digital framework could facilitate this.

To borrow from the UK's National Infrastructure Commission, a digital framework can harness the benefits from sharing better quality information; how it is used, maintainedmaintained, and planned can enable a better understanding of the interdependencies between sectors and help to break down silos. Although referring to infrastructure, this concept could be expanded across the AEC sector in general. [47]

If industry players can agree to a basic framework, opportunities to develop scalable products and services could be significant.

> *Ultimately, the ability to freely share data and insights, as well as interpret them, will create the optimal conditions for digital engineering to transform the AEC sector.*

ACTIONABLE STEPS

The interplay of participants along the value chain and throughout the project lifecycle is imperative to and should form the foundation of digital transformation.

A widely accepted first step to digitization is the consolidation of existing data; though a tedious task, it will set the foundation for more sophisticated data collection and analytical techniques down the line.[48] This report proposes that this process should be extrapolated globally to abate the issue of fragmentation and create the foundation for the transformation of the global industry.

It is evident that not all regions are at the same level of transformation or stage of digitization and digitalization; however, the industry as a whole can benefit from the sharing of information and knowledge between projects and organizations. That said, global open interoperability standards are crucial to extracting actionable insights from this data.

Ultimately, the ability to freely share data and insights, as well as interpret them, will create the optimal conditions for digital engineering to transform the AEC sector. Therefore, the development of an open integrated global platform that can be easily interpreted by both software and users across regions will allow us to capitalize on the existing data and reap the benefits of digital engineering.

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43 Nawi et al.
44 Kennedys
45 McKinsey
46 World Economic Forum
47 National Infrastructure Commission
48 McKinsey

ABOUT ASITE

Asite's vision is to connect people and help the world build better.

Asite's platform enables organizations working on large capital projects to come together, plan, design, and build with seamless information sharing across the entire supply chain.

Asite SCM is our Supply Chain Management solution, which helps capital project owners and Tier-1 contractors to integrate and manage their extended supply chain for delivering on capital projects. Asite PPM is our Project Portfolio Management solution, which gives you and your extended supply chain shared visibility of your capital projects. Asite APM is our Asset Performance Management solution, which allows you to keep track of your complex, ever-changing register of capital assets. Together they enable organizations to build digital engineering teams that can deliver digital twins and just plain build better.

The company is headquartered in London's Tech City and has regional offices in New York, Houston, Ft. Lauderdale, Dubai, Sydney, Hong Kong, and Ahmedabad (India).

For more information about Asite, please contact sales@asite.com

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CONTACT US

Tom Coleing
Marketing & Communications Manager

E: tcoleing@asite.com

Lola Dabota Omo-Ikerodah
Senior Communications & Content Executive

E: lIkerodah@asite.com

Rachel Carey
Senior Communications & Content Executive

E: rcarey@asite.com

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