Reconciling the Irreconcilable

How technology is helping to make the impossible builds possible

A white paper by Microsoft

Microsoft

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Executive summary

Governments, industries and businesses worldwide have long aimed to improve efficiency while driving digital transformation. But as the UK Construction and Built Environment (CBE) sector also squares up to the ever-sharpening challenge and opportunity of sustainable development, how should it best address today's increasingly exacting requirements?

This paper makes the case that the industry has started on the road to transformation and sustainability, but that – although there are no easy answers – key shortfalls can be addressed through the practical application of real-time, joined-up data.

Hopes for "easy answers" were set back by COVID-19, which appeared while this paper was in preparation. At the time of writing (May 2020), governments continue to lock down businesses and social life. Yet our central tenet – that digital transformation in the CBE sector is crucial to accelerate business resilience, collaboration, safety, and cyber-security – applies all the more.

To set the scene, we discuss sustainability goals and then look at new "irreconcilable" requirements in action, briefly reviewing the ambitions and tribulations of two recent construction initiatives: a third runway at Heathrow Airport and the High Speed 2 (HS2) rail project. With the growing demand for energy-intensive datacentres in mind, we also look for inspiration to the groundbreaking Project Natick.

After surveying solutions that are already helping CBE stakeholders make smarter decisions, we turn to the connected Microsoft approach, outlining interoperable solutions that can help realise an entire "digital building lifecycle":

1. Intelligent design
2. Connected sites and workers
3. Smart lifecycle management
4. Intelligent asset management

In each case, we illustrate tangible results delivered by these solutions in a recent construction project, and highlight the Microsoft difference.

Finally, the paper identifies a key threat to sustainable industry development in the UK – the skills gap – and juxtaposes new opportunities presented by government investment at home with an inspiring "connected construction" project overseas.

02

New plans for UK digital construction

02

It's a truism to observe that today's increasingly urgent focus on sustainable development is changing the face of industry across the world. At the global level, the United Nations General Assembly crystallised 17 goals in its landmark 2015 document, *2030 Agenda for Sustainable Development*[1], conceived as a "blueprint to achieve a better and more sustainable future for all". By including specific targets for Sustainable Cities and Communities[2] and for Industries, Innovation and Infrastructure[3], the UN situated industry and the built environment at the centre of its global development vision. Explicitly recognising the disproportionate concentration of energy-consuming resources in cities, the targets aimed to make industries sustainable

> **"with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes[4]"**

"Sustainable" often describes an activity that doesn't deplete resources or cause other harmful environmental effects. By contrast, this paper will understand sustainable construction in terms of its social and economic, as well as its environmental, impacts. For example, when a sustainable physical or digital environment is delivered, the people who use it can be empowered – a social impact. And when building owners require sustainable environments, they encourage the creation of innovations to meet those requirements – an economic impact. Digitisation can help promote sustainability in all senses, in ways that will be explored below.

National governments have on the whole followed the UN's lead on sustainability-focused development, setting out increasingly detailed and exacting targets.

In the UK, for example, the government built on the existing Climate Change Act by putting the 2017 *Clean Growth*[5] initiative at the heart of its industrial strategy. By cutting carbon emissions, this sought to protect the climate and environment for current and future generations while enabling the sustainable growth of productivity, employment and income nationwide. Meanwhile, the *Greening Government*[6] commitments, updated in 2018, applied similar principles to the government's own technology use – moving it towards "clean and green digital and technology services and practices". The theme was developed in the 2020 UKAuthority white paper on local government, digital infrastructure and sustainability, *How Green is our Digital?*[7] , which noted the intimate and growing interrelationship between sustainability, efficiency and digital transformation.

At every level, global and national, the challenge grows: improve efficiencies at the micro- and macro-economic level while driving digital transformation and meeting increasingly tough environmental and social sustainability targets. Consideration of factors like the world's rapid urbanisation along with expanding populations in many regions has led to a sharp focus on the waste created in construction projects, which simultaneously over-consume resources for building.

Far from the sustainability drive being confined to the global and national stage, disruptive concepts like the "circular economy" have also been actively championed by industry itself, with the business sector supporting initiatives like the Circular Economy 100 network.[8] Set up by UK charity the Ellen MacArthur Foundation, the CE100 aims to develop and implement an economic model that avoids consuming finite resources, and works to design waste out of the system – not least by moving towards renewable energy sources. Members and partners include major businesses like BASF, Philips, Renault, Unilever, The Coca-Cola Company and Microsoft.

02

Construction opportunities in the UK

The Construction and Built Environment industry is the second-largest sector in the UK and a key engine of national prosperity: every £1 spent on UK construction creates £2.92 of value for the UK economy.[9] However, there remain many opportunities for growth and development, and the impact of COVID-19 has only highlighted the need to improve resilience, connect workers, implement safety measures, and strengthen data security.

Unfortunately, use of digital across the sector is second-to-last – just ahead of agriculture – and a 2017 McKinsey study[10] showed this low level of digitisation had contributed to an annual productivity increase of just 1% over the past 20 years. Moreover, the same study found that the sector could boost its productivity globally by up to 60% through implementing best practices, including those in areas such as technology, collaboration and supply chain management (see Figure (i), 'Potential global productivity improvement from implementation of best practices'). Yet few technology companies focus on supporting the sector. It's crucial, therefore, to consider ways in which new technologies could contribute to positive change, looking at specific solutions that have novel applications and advantages in real-life contexts.

The government's own *Construction 2025* report, published as long ago as 2013, hoped for new forms of industrial partnership that would "put Britain at the forefront of global construction".[11] Recognising the country's "world-class expertise in architecture, design and engineering", the report nevertheless challenged the sector to significantly improve its overall performance by reducing project costs, schedules and emissions and closing the trade gap. The "long-term" ambitions, to be achieved over 12 years, included:

33% lower costs

50% lower emissions

50% faster delivery

50% improvements in exports

On top of these severe targets, *Construction 2025* also identified areas for improvement in the sector's sustainability, use of technology and supply chain that remain strikingly relevant – seven years after its publication.

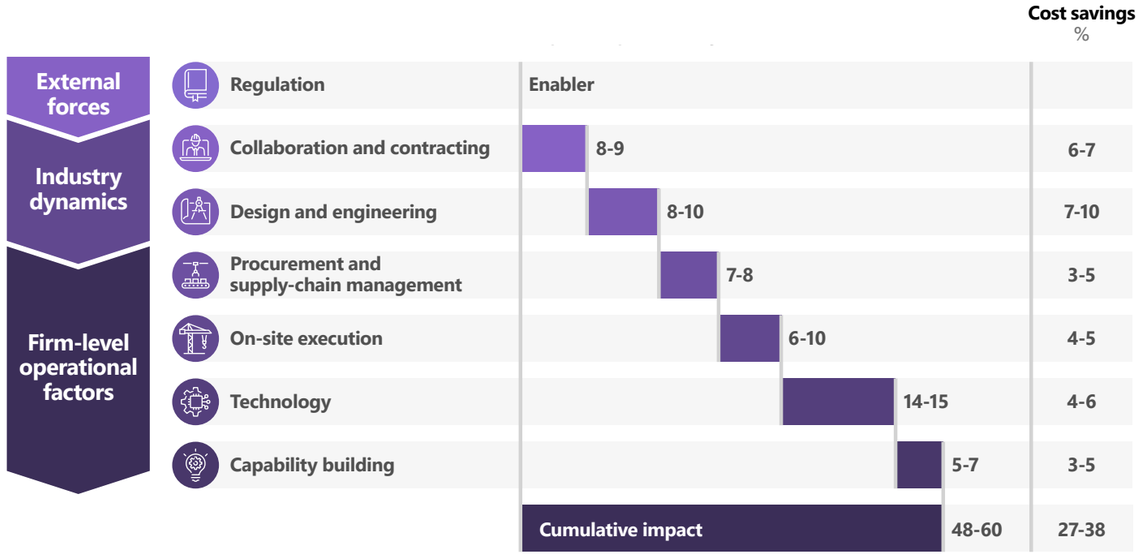


Figure i, Potential global productivity improvement from implementation of best practices.
Source: McKinsey Global Institute analysis.

First, it challenged the industry to develop "greater clarity and certainty around sustainable and low-carbon construction opportunities". This would give businesses the confidence to invest in these new markets. Second, the industry would need to become more efficient and technologically advanced, positioning itself "at the forefront of smart construction and digital design" by driving forward the *Digital Built Britain* agenda.[12] If it failed in this, the paper flatly added, "the UK will be left behind". A third area of concern was the industry's "fragmented" supply chain. Large UK building projects – defined as those in the £20–£25 million range – typically involved managing around 70 sub-contracts, many of them small, which inevitably increased the risk of project inefficiencies and communication, supply-chain and delivery problems. To rectify this, the report challenged the industry to build more integrated supply chains that would focus closely on the end-product and customer value.

02

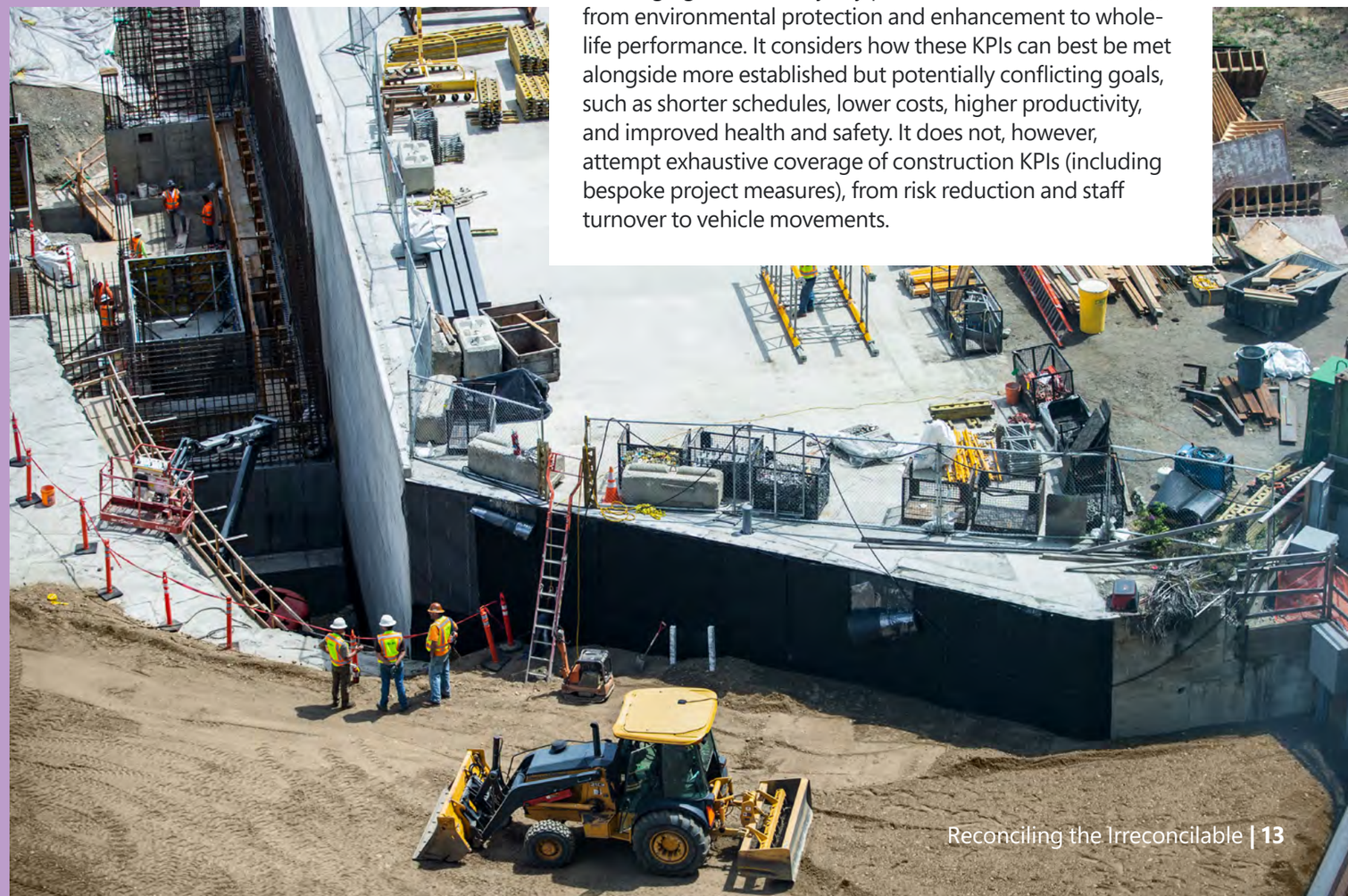
This paper will make the case that these key goals, identified back in 2013 – namely, that the industry becomes more sustainable, technologically advanced and integrated in its supply chain – have started to be tackled, but that they can be further addressed through the practical application of real-time, joined-up, interoperable data.

An immediate concern is that the current norm for how the industry uses data is obsolete. It tends to be locked in role-, department- or project-based silos rather than being connected in ways that could provide meaningful insights to multiple stakeholders throughout a project lifecycle. Nor is this just a matter of how projects are run; the project data itself is siloed. There is an urgent need to improve the level and quality of data, to consolidate and index it, and finally to connect it to project processes.

By contrast, the new era, heralded by new technology, empowers all stakeholders to exchange transoperable data on open digital platforms via the cloud – and in real time. This enables more productive workflows in delivering profitable and sustainable projects.

Other industry standards

This paper focuses on the construction industry's increasingly challenging sustainability key performance indicators (KPIs), from environmental protection and enhancement to whole-life performance. It considers how these KPIs can best be met alongside more established but potentially conflicting goals, such as shorter schedules, lower costs, higher productivity, and improved health and safety. It does not, however, attempt exhaustive coverage of construction KPIs (including bespoke project measures), from risk reduction and staff turnover to vehicle movements.



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“Irreconcilables” in action

New performance expectations – adding to traditional KPIs regarding safety, quality, productivity, and staff – present us with almost insurmountable challenges: to design, supply, implement and maintain vast construction projects while delivering highly sustainable outcomes.

Infrastructure projects are a prime example. On top of the traditional measures mentioned above, they are increasingly commissioned on the basis of explicit outcomes such as flow of cars on motorways, volume of passengers on rail lines and baggage-handling times in airports. Meanwhile, sustainability requirements range ever more widely, from using low-impact materials and achieving zero or negative carbon emissions to creating environments that encourage well-being.

As regulations and KPIs become more exacting, we can illustrate the sharpening challenge by briefly considering the progress of some recent major construction projects – and the conflicts that beset them.

Heathrow Airport

Heathrow was severely affected by the impact of COVID-19, especially after the Civil Aviation Authority's advice against "all but essential" travel. This followed decades of appeals for a demand-led expansion to Europe's busiest airport.

The proposals to increase Heathrow's capacity by building a third runway and new terminal had been intensely debated for at least 14 years.

This project had to contend with detailed requirements relating to regional economic growth, local employment prospects and infrastructure connections, while also meeting objections about environmental impacts (including carbon emissions), community destruction, noise and air pollution, property values, and more. The development was eventually ruled unlawful in February 2020 on the grounds that the UK government's Paris Agreement commitments to combat climate change had not been taken into account.

In short, more traditional considerations based on economics, capacity and growth clashed with newer environment and sustainability commitments – and the latter prevailed.

> “Air quality standards ‘went beyond anything attempted on previous major UK infrastructure projects’ ”

Source: **HS2 Ltd, Annual Report and Accounts 2017-18**

HS2

The glacial progress of the High Speed 2 (HS2) rail project is partly a consequence of its complex ambitions. The railway is planned to link London, Birmingham, Manchester and Leeds, with services extending further north.

The line would pass through the Chiltern Hills, an Area of Outstanding Natural Beauty. To mitigate this, the government announced two million trees would be planted. Similarly, 108 ancient woodlands would allegedly be harmed or lost, along with rare species of flaura and fauna. In response, HS2 Ltd pledged that it would plant seven million trees and shrubs during Phase One.

Arguments about future HS2 carbon emissions and noise pollution continue today, while estimated costs balloon.

High Speed 2 (HS2) Limited’s *Annual Report and Accounts 2017-18*[13] provides a snapshot of the company’s sustainability performance in 2016-17 and 2017-18. Of the 17 environment-related KPIs listed, only one (Gross Direct Emissions, tonnes CO_2e) reveals a declining performance from 2017 to 2018; all other performance figures show improvements.[14] The company holds environmental credentials like ISO 14001 (for its environmental management system), and its Phase One project was certified under the BREEAM Infrastructure pilot scheme, a sustainability assessment methodology.

HS2 Ltd also pledged to create (or had already at the time of the report created) new ecological habitats, restored existing ancient woodlands, created new native woodlands, built climate resilience into its processes, worked to air quality standards that were “beyond anything attempted on previous major infrastructure projects in the UK”, preserved biodiverse habitats from net losses, minimised carbon emissions, reused excavated material and adopted environmental mitigation measures.

It’s a measure of the industry’s tougher sustainability KPIs that, in 2019, the government ordered a review of the project in response to *criticism* of its environmental and financial sustainability.

Design of the proposed High Speed North (previously HS3) network is now under way. The exact route remains under consideration.

Project Natick

Clearly, IT tools and data can be used to improve the design of new offices, deliver construction projects more efficiently and manage buildings more economically. But if IT is to be part of the solution to sustainability and efficiency challenges, how can this be reconciled with its own significant carbon footprint, including the energy-intensive datacentres needed to store and process our ever-increasing data loads?

There are no easy answers, and large technology companies must be part of the solution. Microsoft, for example, has ensured that, since 2012, its operations have been carbon-neutral. In January 2020, it announced its commitment as a global company to become carbon-negative by 2030[15] – and to remove all the carbon emitted directly or by electrical consumption since its beginnings in 1975.

Meanwhile, the company's Global Real Estate & Security organization actively promotes its "digital building lifecycle" model, with the goal of furthering its own digital transformation as well as that of the industry. One benefit of the model is that, as private sector real-estate owner-investors and the public sector work more closely together, "digital twins" of buildings and the surrounding communities start to provide a bigger-picture understanding of the causes and effects of real estate phenomena. And the industry no longer has to make do with drawings and renderings that give a highly detailed but incomplete picture of the built environment. Instead, it can tap into the continuous feed of data and refined information.

These advantages help reduce energy waste and control emissions throughout the digital building lifecycle.

But more needs to be done, and the company has been working with submarine technology and marine-energy specialists to research the possibilities. For example, Project Natick is exploring the potential of environmentally sustainable, pre-packaged datacentre units that can be ordered to size, rapidly deployed and left to run on the seafloor, lights off, for years.

This solution could satisfy multiple potentially conflicting requirements.

By submerging datacentres near coastal cities, data can reach coastal communities rapidly and meet their exponential growth in demand for cloud computing infrastructure, enabling fast, smooth user experiences. Traditional construction KPIs relating to quality assurance, costs and schedules could be more effectively met through a simplified, easily scalable, prefabricated design-build process. And at the same time, crucially, environmental impact would be kept to a minimum, preserving precious coastal terrain for residential, commercial or agricultural development, or simply conservation initiatives.

As Peter Lee, corporate VP of Microsoft AI and Research who leads the New Experiences and Technologies (NExT) group, observes: "That is kind of a crazy set of demands to make. Natick is trying to get there."

> "Microsoft operations have been carbon-neutral since 2012"

04

Smarter decision-making for smarter cities

04

Digital technologies are no panacea for solving the world's sustainability challenges. The decision-makers – those who own and use the data collected as a foundation for informed choices and action – remain ultimately accountable for the decisions taken.

> **"More courageous leadership is needed from stakeholders, including government"**

It follows from this that, to drive fundamental industry change, more courageous leadership is needed from wider industry stakeholders, such as clients and sponsors, including government. While new directives, reports and projects feature ever more complex KPIs, contractors inevitably continue to struggle with traditional pressures like schedules and costs. Supporting business and digital transformation across the industry will also, therefore, depend on fresh thinking from government and asset-owners, too.

That said, technology has its part to play in bringing today's global, national and industry-specific development goals within reach, not to mention enabling compliance with new health-related strictures. So this chapter will review digital tools that can help the construction process reconcile its "irreconcilables", end-to-end. They enable key stakeholders to schematise, create, design, represent, plan, analyse, monitor, supervise, interact with, and manage buildings and projects – while communicating and making smarter decisions – all through connected data.

So what are these solutions and tools? They include Internet of Things (IoT) and Internet of Actions (IoA) platforms, the "Digital Twin" platform, intelligent business-application platforms, AI platform, mixed reality (MR), and building information modelling (BIM). Ultimately, they can help untether decision-makers from physical-only constraints and enable smarter decisions through flexible and holistic experiences that unify the physical and the virtual.

04

IoT and IoA platforms

This cloud-hosted service enables construction and facilities managers to monitor the health and efficiency of equipment by tracking events, operational data, device failures and other connections. Facilities managers can also connect, monitor and manage sensor-enabled assets with two-way communication.

In the wake of COVID-19, IoT wearables and sensors can help keep workers safely distanced, monitoring and reporting in real-time to ensure guidelines are being followed. These smart devices can even support post-hoc compliance reviews.

IoT will be joined in time by a counterpart Internet of Actions (IoA) platform, which will enable intelligent devices to "explain" to users the import of IoT events like those above, that is, *why* they are happening.

"Digital Twin" platform

A Digital Twin is a high-fidelity digital replica of a physical asset or process, often based on data from automated-sensor technology. The construction industry can benefit from creating Digital Twin warehouses, office buildings or even a city. This technology offers new spatial intelligence information to model how spaces and infrastructures are used, allowing designers to make more informed decisions based on this input.

A Digital Twin can also be used to compare a planned schedule against actual project progress and represent the differences visually. This can help project managers get a quick idea of on-site progress and take corrective action as needed, shifting from reactive mode to proactive.

Intelligent business-application platforms

As mentioned on page 14, today's projects often run on and generate numerous data sources that are siloed in different systems. For project decision-makers to make more informed and timely decisions, these sources must be integrated and connected with stakeholders and processes, end-to-end. An intelligent business application platform can unify data from multiple sources and augment it with AI to make predictions about project schedules, supply chain issues, materials and more.

AI platform

By bringing together and rapidly analysing numerous information streams, AI can provide predictive intelligence about the probability of multiple plausible scenarios happening on-site. Decision-makers can then prioritise those they see as most critical, and act pre-emptively.

This real-time tracking of the interactions of workers, machinery and objects can help managers improve productivity, efficiency, and health and safety on sites. In practical terms, real-time alerts can be sent to supervisors about health issues, such as a worker accidentally breaching social distancing guidelines; construction errors, such as machinery being moved to the wrong site area; and productivity issues, such as concrete-pouring that's not progressing to schedule.

04

Mixed reality (MR)

Instead of working with 2D technical drawings and other static documentation (still all-too-familiar in the CBE sector), designers can now benefit from machine-readable, transoperable, non-siloed data.

MR tools allow designers and engineers to interact with holograms in a real physical environment, and stakeholders can review 3D models, visualise layouts and create other experiential designs at scale and in context. Being able to experience a project digitally at 1:1 scale changes perceptions, opening up critical early discussions about constructability, safety, installation sequencing, quality and need for support.

MR devices also equip designers to iterate in real time. A building's Digital Twin can also be communicated via MR devices to demonstrate to prospective customers, saving time and money and empowering customers by helping them visualise a proposed building.

Finally, remote-assist MR tools can enable on-site employees to collaborate with experts in different locations (and, in the context of COVID-19, at a safe distance). They can even help in upskilling employees with new processes.

> "MR allows designers to interact with holograms in a real physical environment"

Building information modelling (BIM)

BIM is a key tool to use in the design development phase of a project. It lets designers build a digital representation of the physical and functional characteristics of a facility – information that is often used to create a Digital Twin.

Working from a common data environment with BIM lets teams operate from a single model. Design doesn't get ahead of what's practical for construction. All parties are informed about construction and operational cost implications earlier, for more informed decision-making. Fewer final decisions are pushed to the construction phase when the cost to change them is high, and no final decision is slipped into an afterthought when the cost of changing it is highest.

Recent developments in BIM offer a sixth dimension (6D) that represents facilities management and even a seventh dimension (7D) for environmental and sustainability analysis. Embracing these exciting technologies will help stakeholders even more effectively meet the exacting requirements of tomorrow's construction industry.

> "BIM now even offers 7D for environmental and sustainability analysis"

05

Reconciling the “irreconcilables”

The Microsoft way

The previous chapter provided an overview of the digital solutions that can help the CBE sector reconcile the "irreconcilable" – to meet or exceed traditional performance metrics while demonstrating ever more stringent sustainability and environmental credentials.

To repeat a cautionary note made above: digital transformation cannot be a panacea for all industry challenges. But this chapter will explain how Microsoft digital solutions can bring AI, cloud data, and analytics together to tackle long-standing ills by fixing the digital supply chain, boosting employee collaboration and productivity, and enabling the smart management of buildings both during and after construction. It will also illustrate how each solution has delivered tangible results in a recent construction project.

Figure (ii) shows where Microsoft technology can play a key role throughout the construction process, with the overall effect of helping you drive more resilient and agile operations. Microsoft and its partners' solutions are able to solve problems right across the supply chain, from tendering and design through to construction and ongoing management. Because they are built on a single platform and open architecture, they enable the industry to develop a common data environment and join up traditional silos.

Figure ii, How Microsoft Solutions help fix the supply chain. Source: Microsoft.

Intelligent Design

Innovate in design
Bring your ideas to life and create ground-breaking, sustainable designs swiftly and efficiently, powered by state-of-the-art mixed reality, AI and the cloud.

Connected Sites & Workers

Empower your workforce
Connect and protect your employees with proactive site management and real-time, IoT-powered solutions that deliver better health and safety and cross-site collaboration.

Smart Lifecycle Management

Fix your supply chain
Leverage Microsoft's IT and Operational Technology systems to create autonomous supply chains built to predict and manage issues before they arise.

Intelligent Asset Management

Revolutionise asset management
Use Azure Digital Twins, a virtual representation of your physical environment, to gain total visibility and improved efficiency across all your sites.

Connecting with construction solutions

A. Intelligent design

How can designers create buildings that satisfy traditional requirements like delivery schedules, cost and quality, while simultaneously satisfying increasingly complex sustainability metrics?

The principles of building construction can be applied to any design-build process, in which an idea must be translated into physical reality. The traditional craft of draughtsmanship enabled elaborate structural details, including measurements, to be captured on paper – but this was a painstaking and time-consuming process that became increasingly burdensome as new iterations and version increments were required.

With Microsoft Azure AI and HoloLens smart design automation and visualisation via the cloud, designers are empowered to create innovative, highly precise, sustainable solutions, delivered in an agile, flexible off-premises environment. Detailed walk-throughs are generated using advanced 4D visualisations and HoloLens mixed reality, enabling new structures to be viewed in detail – with a ceiling or mechanical installation removed, for example – before they're built.

A breakthrough feature is the option for voice commands. Users can speak with their team naturally, and the natural voice recognition script will know what to do if a specific command is embedded into the user's sentence structure. Here's a practical example from a command script:

> **"So, we're standing here in the hallway connecting the reception area with the lobby area. A lot of the MEP systems will be installed behind the ceiling tiles, but if we "Hide ceiling" for a moment, we can see how all the different systems fit in an installation rack. To evaluate how the finished room will look, we can "Show ceiling" with the latest ceiling tile option the architect has chosen."**

Following this stage, designers can turn their ideas into reality with Smart Facilities technologies, all offered as a service.

Powerful Microsoft cloud and high-performance computing applications also enable designers to enhance their simulations and generate higher quality data. This allows customers to automate repetitive design tasks using Azure AI-driven processes that build on existing design capabilities.

By integrating Microsoft 365 with building information modelling (BIM) applications, companies can also rapidly improve team collaboration on design projects. They can also reduce their reliance on costly on-premises solutions and high-end desktop machines.

Airbus

Reaching new heights with Microsoft mixed reality

It took Airbus 40 years to build its first 10,000 aircraft. Over the next 20 years, the aerospace giant aims to build 20,000 more – a major construction challenge that will require cutting-edge innovation, including intelligent design.

Holographic technology from Microsoft, known as "mixed reality" because it combines physical and digital worlds, will be key to helping Airbus reach its goal.

Mixed reality takes digital information beyond 2D screens to a 3D experience by using holograms, which are images made of light and sound. It allows people to interact with holograms in physical space, meaning they can view and manipulate holographic images on their own in the air or in combination with real physical objects.

Airbus has seen impressive results in its trials and deployments of Microsoft mixed reality technology in training, design and manufacturing. In fact, the company has identified more than 300 use cases for Microsoft mixed reality. For example, it can help designers quickly and virtually test designs to see if they're suitable for production, improving efficiency, saving money and simplifying workstreams by enabling rapid iteration. The shift from old-school paper drafts to virtual files represents a net contribution to project sustainability. Production-line workers can now access information hands-free, and Microsoft mixed reality also supports hands-on virtual training without tying up expensive equipment.

The new HoloLens 2 headset also offers eye tracking that can sense when a user's eyes fix on a particular location and produce relevant digital information, as well as automatic scrolling as the user reads. Users can log in via iris recognition, making sharing among multiple users easy and highly secure.

"Mixed reality and HoloLens 2 are key assets for Airbus"

Jean-Brice Dumont, Executive Vice President of Engineering, Airbus

Leading in real life

The first new solution offered under Microsoft's partnership with Airbus was a mixed reality training programme first released with Japan Airlines (JAL). It helped maintenance operators and cabin crews learn in a 3D holographic environment and access instructions, heads-up and hands-free, while on the job.

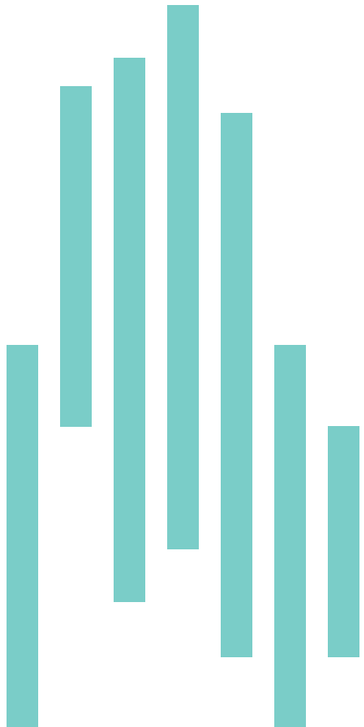
But the company's collaboration with Microsoft on mixed reality goes beyond helping Airbus reach its internal goals. Such technological innovation is crucial to Airbus' larger objective to become a world leader in digital services for the aerospace industry.

"We are very optimistic about this future collaboration with Microsoft based on what we've done in the last four years," says Jean-Brice Dumont, Executive Vice President of Engineering at Airbus. "This is really a way for us to lead our digital transformation. It's multi-fold, but the use of mixed reality and HoloLens 2 is one of the key assets for Airbus in the future."

Connecting with construction solutions

B. Connected sites and workers

How can construction managers boost operational efficiency and team collaboration while delivering improved health and safety compliance across multiple sites?



Microsoft Dynamics 365 and Microsoft Power Platform enable managers to boost operational efficiency and create a more accessible, collaborative workforce. Management and optimisation of projects can be carried out in real time via one consistent, user-friendly interface across all business functions. All of this is instantly available via a mobile device.

Managers can improve health and safety for frontline workers by combining mobile, wearable and sensor technologies with visual recognition systems for real-time activity and personnel location-tracking. They can also deploy AR site-surveying and maintenance guides, limiting the need for additional on-site team members while making social distancing easier.

Microsoft 365 with intelligent cloud services frees construction companies from 2D plans, dusty servers and poor communications. Off-site managers can easily connect to on-site workers to talk health and safety – or just check in. Office 365 with Microsoft Teams gives employees the best-known productivity tools, plus they can instantly talk, message, make video calls and share files between building sites and head office, via any device. Teams also helps reduce needless travel – another sustainability advantage.

Laing O'Rourke

Real-time safety monitoring with IoT

Construction is an inherently dangerous business, but when it's being conducted in some of the most inhospitable regions of the world, the potential dangers take on a more challenging dimension.

For Laing O'Rourke, an international engineering enterprise, the safety of its employees is paramount, especially those operating in the remote regions of Canada, the Middle East and Australia.

That's where the technological possibilities of the Internet of Things (IoT) can deliver tangible benefits.

The company has moved away from paper drawings and towards Digital Engineering. It now designs virtual buildings through 3D, gathering and analysing huge amounts of data.

> "A smart hard hat with sensors and data-collection helps prevent heatstroke"

A hard hat with intelligence

Using Microsoft Azure, services like Infrastructure as a Service (IaaS) and Platform as a Service (PaaS), along with the assistance of software developer and Microsoft partner MOQdigital, Laing O'Rourke in Australia has also been trialling some innovative technology.

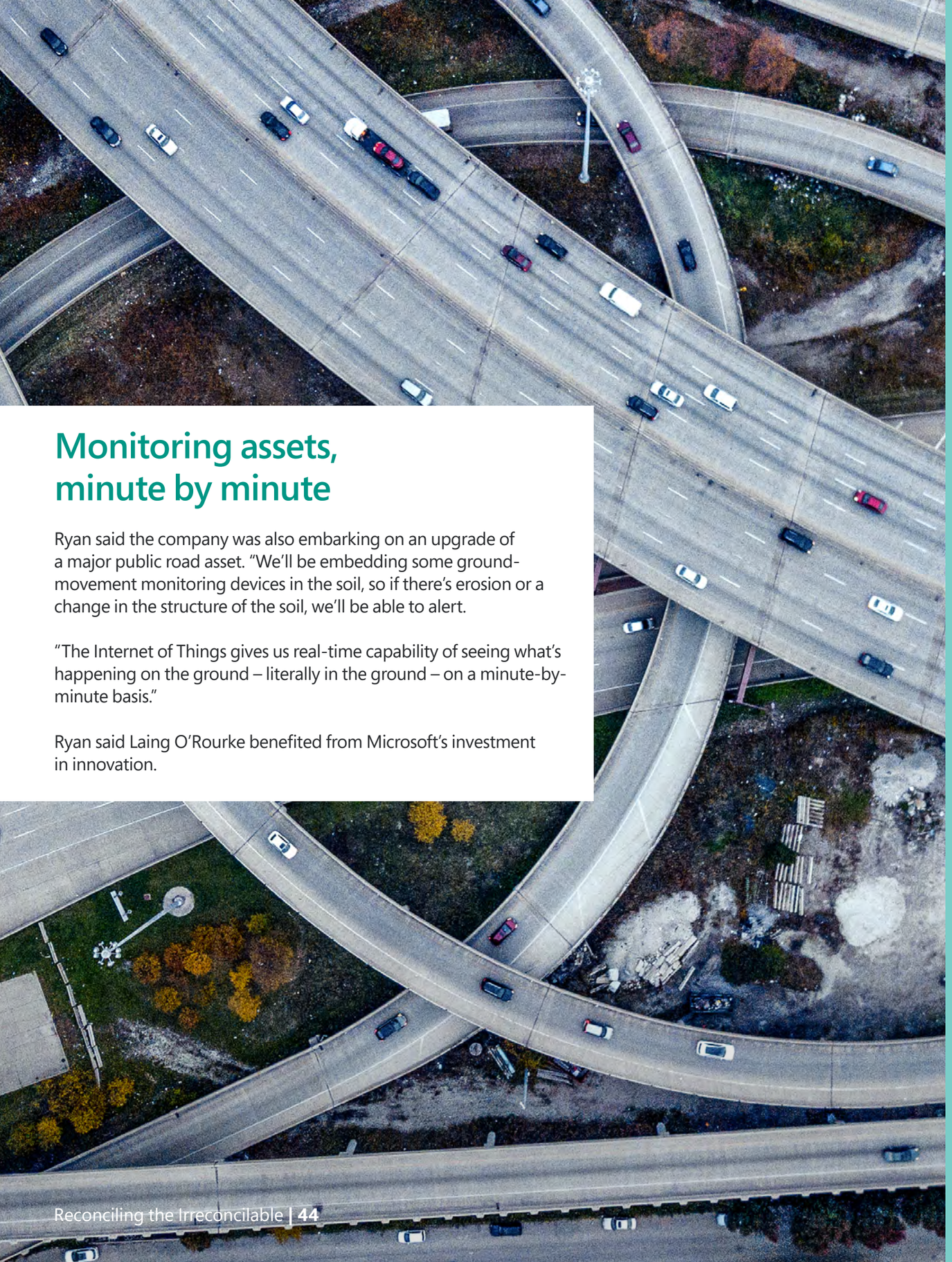
"Because of the climate in Australia, one of the issues we face is heatstroke. The problem is, by the time you feel heatstroke symptoms, you already have it. So you need to have been warned well beforehand," said Ryan Macnamee, the company's global CIO.

The answer is an interactive smart hard hat with sweatband sensor array and data-collection unit, which can be retro-fitted to an existing hard hat. It monitors the temperature and heart-rate of the wearer, plus the external temperature and humidity. It also contains a GPS module and an accelerometer that helps determine orientation and vibration or shock impacts.

Local vibration and sound alerts are delivered to the wearer by the control unit. All data is collected and stored, and the system enables remote access to it, along with the generation of alerts by SMS and email.

"By putting the data in the cloud and leveraging Microsoft's Power BI platform, we can make better informed decisions and projections, and proactively warn people," Ryan said.

Laing O'Rourke is looking into licensing its hard-hat technology once trials are complete. It has also identified IoT opportunities around managing people, plant and infrastructure.



Monitoring assets, minute by minute

Ryan said the company was also embarking on an upgrade of a major public road asset. "We'll be embedding some ground-movement monitoring devices in the soil, so if there's erosion or a change in the structure of the soil, we'll be able to alert.

"The Internet of Things gives us real-time capability of seeing what's happening on the ground – literally in the ground – on a minute-by-minute basis."

Ryan said Laing O'Rourke benefited from Microsoft's investment in innovation.

> "The things that we can do in Azure now would have taken a large team years to complete. By leveraging Microsoft's investment, we don't have to spend the money. To us, it's a nice commodity – we just turn it off and on as we need it"

Connecting with construction solutions

C. Smart lifecycle management

How can construction companies avoid risky tenders and save time and money on projects, while driving efficiencies and productivity throughout the process?

As the sector looks to control cash flow and make cost-savings in the wake of COVID-19, it will be essential to optimise supply chains. Through better use of data across a chain, organisations can adapt to complex scenarios. Microsoft Dynamics 365, Office 365 and Azure work together seamlessly in real time, enabling companies to take control of their supply chain and driving up efficiency and productivity.

Using Azure AI-fuelled mining and analysis of past project data, construction companies can at last avoid risky tenders and project overruns. Sensors, networks and ambient intelligence can be used to intelligently predict and avoid project delays and machinery downtime and to accelerate delivery time. Apart from helping to cut project inefficiencies, these technologies also reduce workforce frustration, incentivising employees and reaping productivity benefits.

Using reliable data, transoperable digital platforms and building information modelling (BIM) to drive the design development phase of the building lifecycle, as shown in figure (iii), will become increasingly important in the construction sector. This will be especially true as technologies continue to improve and refine this phase into a more efficient, more cost-effective stage of the "digital building lifecycle".

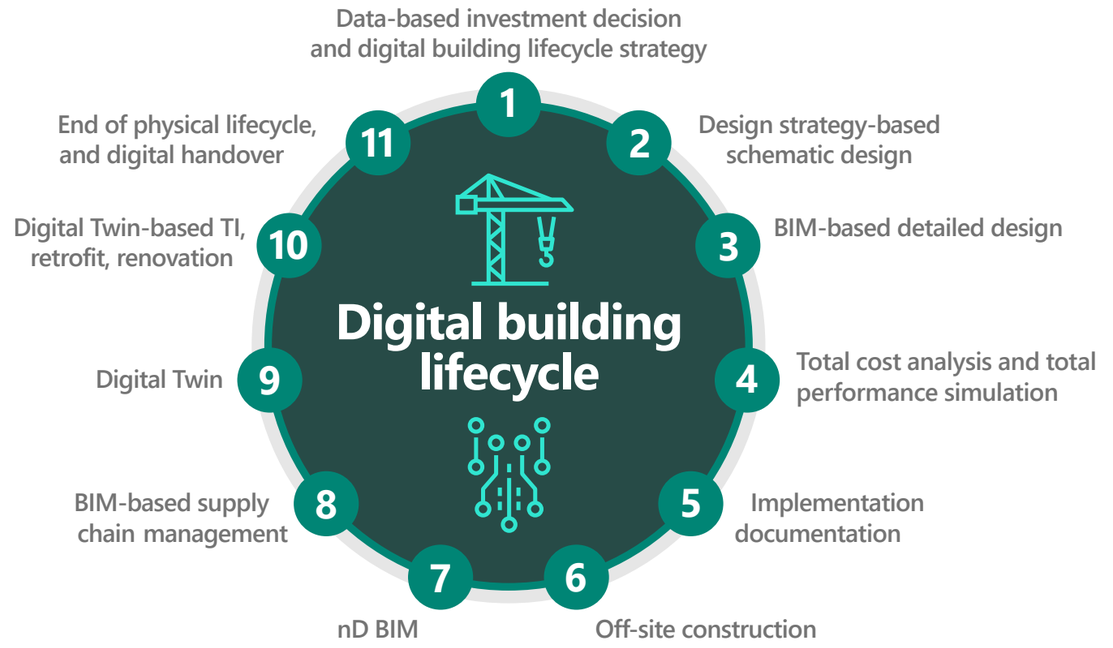


Figure iii, How technology drives the design development phase of the construction process. Source: Microsoft.

PCL Construction

Smarter construction from smarter insights

Based in Edmonton, Canada, PCL Construction is turning the centuries-old construction industry on its head with a push towards digital technology and cloud services. Five years ago, the company implemented an initiative based on cloud, mobility, analytics and integration.

"Becoming a cloud-first business was the core of our strategy, and Microsoft Azure was our platform of choice," explains Mark Bryant, Chief Information Officer at PCL. "We moved most of our traditional IT processes and infrastructure to the cloud. We also rewrote and migrated our own applications to optimise them for the cloud and embraced SaaS, PaaS, and IaaS. As a result, we've increased productivity, decreased risk and sped time-to-market."

For building owners, smart buildings are a way to differentiate themselves from other developers. They need to drive down energy and maintenance costs while driving up tenant satisfaction and retention – and equip buildings to accommodate a modern workforce.

By enabling real-time data access and analytics delivered by IoT, PCL can also increase job-site safety, operational efficiencies and worker productivity.

"A lot of money goes into environmental control at job sites – whether it's maintaining the right temperature and humidity for concrete to set, or keeping workers comfortable," says Chris Palmer, Senior Manager for Advanced Technology Services at PCL. "By using IoT to monitor environmental conditions around the clock, we can reduce our environmental footprint and make the industry more sustainable – an important goal for us."

Finding the right platform

PCL chose Microsoft Azure and Azure IoT technologies as the foundation for its smart construction push. This was the first step towards developing Job Site Insights™, a construction management app that provides a single-pane view into all aspects of work at a job site.

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The app is built on Azure and accessible through a desktop PC, tablet or mobile device. It uses Microsoft Power BI dashboards and data visualisations that show everything from costs to quality metrics, schedules and inspections. It connects the productivity tools in Microsoft Office 365 and uses a wide variety of Azure services, including Azure Digital Twins, to uncover deep insights into the data.

Transforming decision-making with data

Since moving to the cloud and using IoT data to generate business intelligence, the company's IT teams no longer focus on managing server and storage infrastructure. Job-site workers also have more time for value-added tasks.

The company is now using Microsoft HoloLens for planning and modelling residential interiors. "We use HoloLens to mock up a complete suite floor with all the furnishings in it," says Senior Project Manager for Stantec Tower and SKY Residences, Myke Badry. "Within that mock-up, we can peel back layers of construction and plan the intricacies of the work behind the walls."

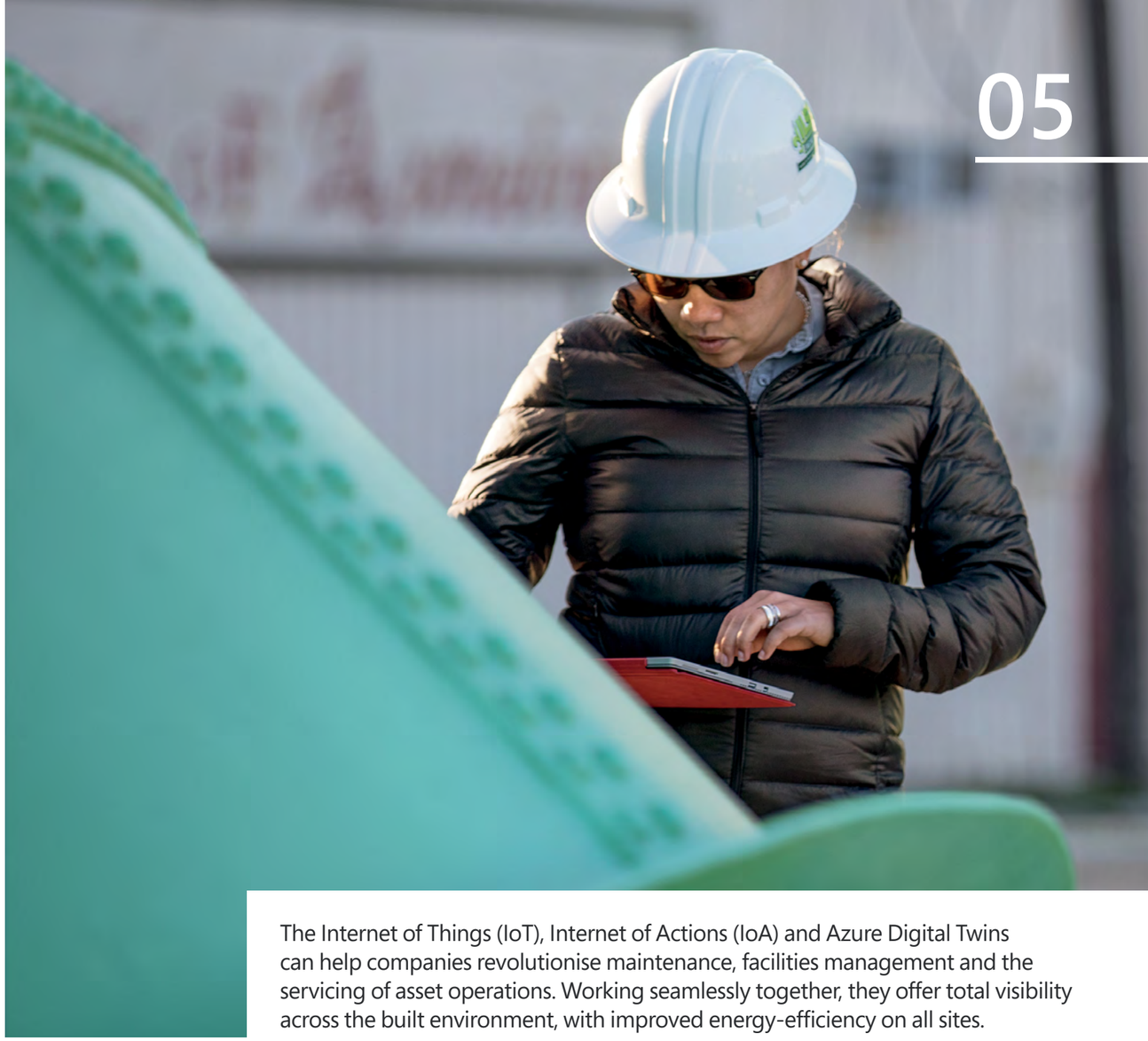
"It's great to see the construction industry evolving, adapting, and embracing technology," adds Badry. "These advances make our jobs easier every day."

“Power BI shows project costs, quality metrics, schedules and inspections”

Connecting with construction solutions

D. Intelligent asset management

How can construction and facilities managers cut the costs of managing maintenance, facilities and asset operations, while improving building efficiency and freeing up time for other pressing tasks?



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The Internet of Things (IoT), Internet of Actions (IoA) and Azure Digital Twins can help companies revolutionise maintenance, facilities management and the servicing of asset operations. Working seamlessly together, they offer total visibility across the built environment, with improved energy-efficiency on all sites.

Where IoT conveys *what* is happening, the less well-known Internet of Actions conveys *why* it's happening. Enabled by artificial intelligence, IoA can act as a kind of partner to human agents, providing invaluable support to those navigating a mixed reality environment.

Azure Digital Twin is another revolution in building management. It allows contractors to create "smart spaces" that enable maintenance and facilities to be managed remotely in real-time, improving building efficiency and automating tasks using device and sensor-tracking.

Mitie

Building intelligence into asset management

Mitie is the number one facilities management company in the UK, employing 50,000 people and supporting services touched by about five million people a day.

To remain at the forefront of its industry, Mitie embarked on an industry-disrupting digitisation journey. Using artificial intelligence and machine learning to analyse data collected from intelligent buildings and Internet of Things (IoT) sensors, Mitie is providing a range of cutting-edge solutions to its clients, employees and end-users alike.

The company's new facilities management approach, Connected Workspace, is delivered in partnership with Microsoft. It enables managers to improve energy-efficiency and to predict – rather than react to – facility maintenance needs, saving time and money.

With data informing maintenance regimes, Mitie is able to build Digital Twins of client facilities and set operating parameters for critical items of plant and equipment. It then uses automated monitoring to track the performance of each item against these parameters, providing early warning of any future issues.

Managing Director of Professional Services, Chris Rowley explains: "Fundamentally, it's about capturing the data at the right time and moving towards demand-led cleaning and proactive equipment maintenance. We can even ensure our clients' environment remains within its comfort policy all of the time. This provides a hard financial benefit to our clients and a better experience for the end-users of the buildings."

Maintaining a biophilic environment, including heating always set to optimal temperatures, also has a positive effect on employee well-being. "We've had a huge positive impact on employee engagement and the new technology enables us to do that. People are 20% more productive and 38% more calm on a daily basis," said Jo Davis, Group HR Director.

Big data provides critical insights that are turned into business benefits. "Millions of records flow in every 10 minutes through our IoT sensors installed under the desk or around the meeting rooms," said Cijo Joseph, Director of Strategy and Solutions. "We apply AI and machine learning to the data, convert the insights into a feature, and then give it back to our clients. That's the critical stuff."

The collaboration with Microsoft runs across all Mitie roles, from CEO and CIO to engineers and architects. The partners operate as one unified team, as Cijo Joseph notes: "We're all in it together – it's a mutual success and a mutual win-win. And that's a game changer."

The Microsoft differentiator: a connected portfolio

Microsoft offers the CBE sector a key overarching advantage: a unique platform of joined-up solutions that connects devices, data, insights and people with the sustainable built environment itself. These solutions – along with solutions from the partner ecosystem, built on the Microsoft platform – help drive efficiencies throughout a construction project, rethinking the supply chain, improving company-wide collaboration and driving productivity.

A single platform with broad solutions based on an open architecture delivers another major advantage. This can help accelerate the entire industry's digital transformation by opening the data gates and enabling data to flow friction-free through Azure, integrating different software via a single, consolidated reservoir of data.

> "A platform that connects devices, data, insights and people with the built environment"

Other distinctive Microsoft benefits include:

A connected "digital building lifecycle"

Conceptual and detailed design, supply-chain efficiency, and health and safety on construction sites can all be significantly improved by leveraging the Azure cloud, connected devices, IoT, IoA, data and AI. Azure can also simplify a key challenge of complex, multi-partner projects, by enabling the rapid set-up of a scalable, tagged, joint-venture IT environment in the cloud.

Partnership approach to IoT and Digital Twin

Microsoft's integrated common platform approach uses the power of partnership to develop breakthrough innovations. This platform brings together partners, products and process expertise to create reusable, highly scalable, spatially aware experiences.

Open business platforms

Construction partners can augment their existing IT solutions with Microsoft's open business-application platforms (Dynamics 365), collaboration tools (Microsoft 365 and Office 365, including Microsoft Teams) and industry-leading cloud platforms (PowerApps, Power BI, common data services).

World-class R&D

Microsoft continues to make large investments in a wide range of technologies, tools and platforms, including IoT, AI, quantum computing, intelligent edge and cloud IoT infrastructure. Its market-leading mixed reality tools offer the construction sector unique solutions to long-standing challenges.

06

Envisioning the future

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This paper has briefly reviewed the urgent global, national and commercial trends towards sustainable development – trends that are certain to continue. It has noted that the UK CBE sector has started to respond to the new requirements, now complicated by unforeseen COVID-19 health guidelines. It has also cautioned that, without more fundamental change, the sector will struggle to accelerate a historically sluggish growth rate and drive efficiencies while meeting tomorrow's more exacting KPIs.

These performance indicators require, among other measures, an increasingly sharp reduction in the industry's carbon and environmental footprint. Digital transformation can help realise such targets and, as illustrated by the case studies in chapter 4, tomorrow's successful companies will champion greener technological and industrial innovations.

However, technology alone can't solve all the sector's challenges. Moreover, as Ibrahim S. Odeh notes in his *introduction to Shaping the Future of Construction, Insights to redesign the industry* (World Economic Forum, 2017), one of those challenges is the pace of "continuous and rapid transformation" itself:

> "… projects are getting bigger; public budget is becoming more challenging to secure; [there are] advancements in technological innovation (3D printing, big data analytics, virtual and augmented reality, drones, etc.) … and the rise of ineffective or inexperienced management teams in such a rapidly changing environment[17]"

By linking technological advancement with management inexperience and the "rapidly changing environment", Odeh manages to highlight a different kind of threat to sustainable development – the skills gap.

With experts proclaiming that a fourth industrial revolution is under way, and with fast-evolving technologies transforming how businesses run and buildings are created, industrial skills shortages should come as no surprise. To make the most of the opportunities enabled by technology – higher standards of productivity, quality and safety; increased efficiency and collaboration; more sustainable projects – the construction industry must work more closely with government and other institutions to train users of this technology. Many skills predictions are stark:

"We will need to reskill over 600,000 construction employees over the next two decades, from trades vulnerable to technological change to new roles created by technology … To meet the expected output to 2021, the industry [also] needs to recruit 5,240 employees every year in the occupation category defined as 'non-construction professional, technical, IT and other office-based staff', [which is] almost twice as many as any other job specification."[18]

A recent CITB report[19], along with others, broadly agree with MACE's analysis above that, as the Industry 4.0 revolution continues, the technology skills shortfall could become the sector's Achilles' heel. The scale of reskilling and upskilling needed urgently demands a new mindset of lifelong learning, with new training programmes and courses that prioritise hands-on use of new technologies.

With its long-established and comprehensive Enterprise Skills Initiative (ESI), Microsoft has been doing its part. ESI helps trainees at all levels build the digital skills they need to succeed in tomorrow's economy, and the company partners with non-profit organizations, governments, educators and businesses to promote skills-based training – ranging from everyday digital literacy to vital cloud technology skills – and hiring practices.

An enduring, open partnership between the corporate sector, the education system, the construction industry and other major players will be the most effective way to plug the gap.

06

Creating opportunities, home and away

If the industry can arm itself with the technology skills needed for tomorrow's digital building projects while fixing other barriers to progress, exciting opportunities lie ahead.

In its 2020 budget, for example, the UK government announced a plan to "get Britain building" by investing over £680 billion in large-scale national infrastructure projects over the coming decade.[20] And in May 2020, despite massive COVID-19 Treasury spending, Transport Minister Grant Shapps was still able to confirm a £1 billion A66 Trans-Pennine dual carriageway upgrade.

As a long-standing partner of Highways England (which uses the Azure cloud platform), Microsoft recognises that infrastructure investments also represent investment in and opportunities for the CBE industry.

But it's not just UK infrastructure development that presents new opportunities. Inspiration can come from anywhere in the world – such as from New Zealand's first "connected construction site", a collaboration between AsBUILT, Microsoft, Spark and Kiwi construction company, NZ Strong.

The project draws together some key themes of this paper, and the following snapshot illustrates the transformative potential of the "digital building lifecycle".

A digital building experience: Wynyard 100

The Wynyard 100 project, located in Auckland's upmarket Wynyard Quarter, is a large, six-building development. Building One alone will feature seven levels of retail, hospitality, offices and parking, with a 154-room Travelodge hotel.

Simplifying communications with connected data
This is a complex project, with many partners and inputs. So, by connecting Internet of Things (IoT) devices with motion sensors, environmental monitoring capability and a platform that lets all project stakeholders collaborate, AsBUILT and NZ Strong created an intelligent site.

Safety first in the age of COVID-19
To ensure safety, the team created a Digital Twin of the building, hosted by AsBUILT. The platform runs on Azure and is accessible to the entire Wynyard 100 team, from design to supply and project management.

3D cameras provide a live feed of the site that's mapped onto the virtual building, incorporating facial and object recognition technology, enabling site managers to see who is working where. On-screen tags flag when workers aren't wearing safety equipment or are entering hazardous zones, and warn people about dangers on their own devices.

Meanwhile, IoT devices monitor temperature, humidity, light and sound on-site, enabling informed decisions to be taken about worker safety. This data also enables compliance with council building regulations.

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3D mapping for precision location

The geolocation capability also means components can be placed in exactly the right location on the 3D map. This prevents errors, saving time and money.

An open platform that drives efficiency

All team members can order equipment such as cranes and goods lifts or components, saving paperwork and downtime.

Real-time insights that help avoid waste

Being able to oversee all site workers also provides real-time insights into productivity that can be fed back to the procurement team and supply chain, helping to avoid waste.

Cost savings for facilities management

Once the build is finished, the Digital Twin and smart sensors will continue to provide control and cost-efficiencies for the owner.

Using IoT early in the process makes for easier management of the completed building – not least because the source of any issues that appear later can be quickly pinpointed.

Ongoing support via the BIM platform

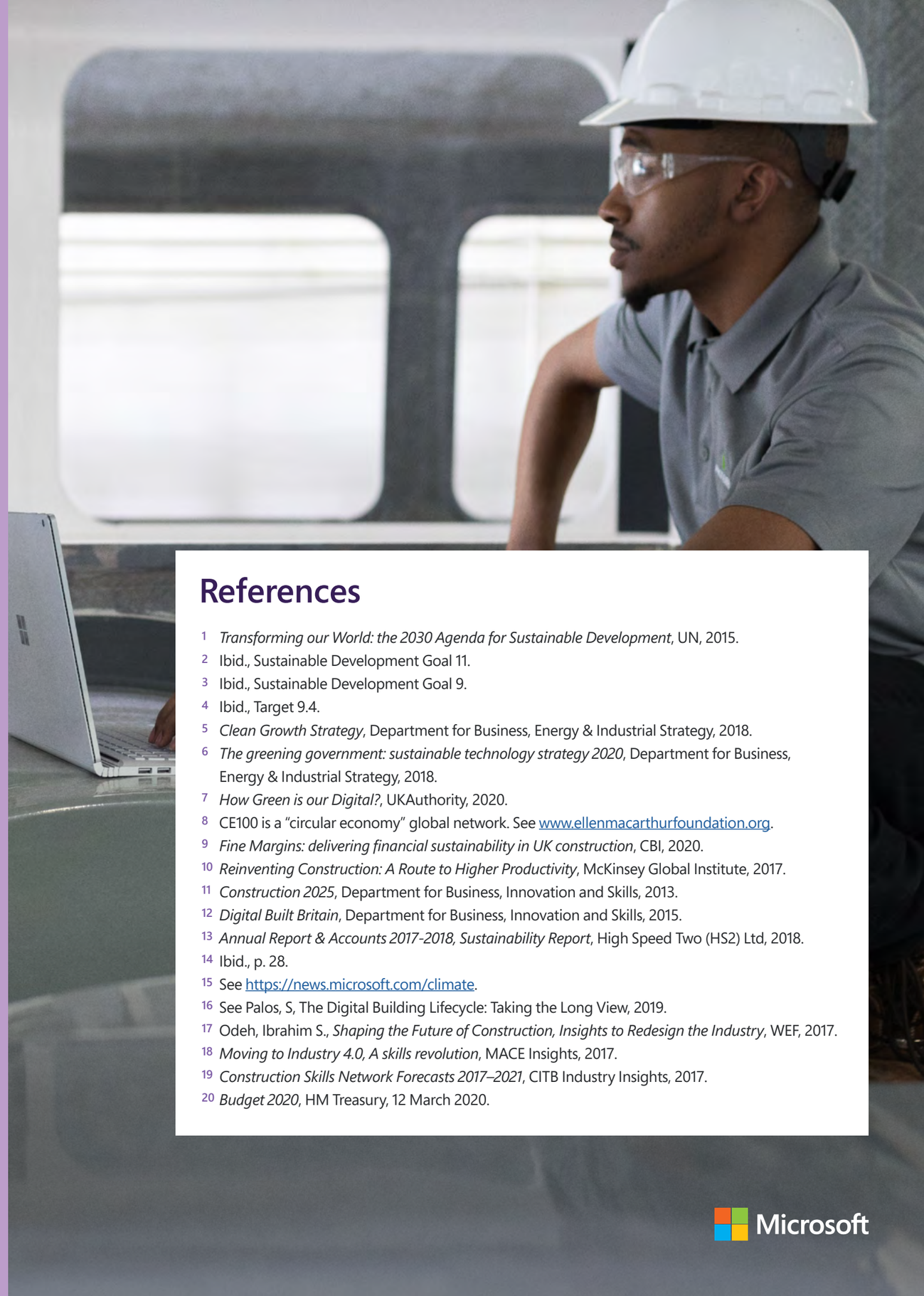
The building information modelling (BIM) platform created for Wynyard 100 even contains information on asset warranties. This means it can auto-send reminders to building owners about replacing worn-out components as they near the end of their lives.

06

This paper set out to consider how the construction industry's increasingly tough sustainability KPIs might be met alongside more established but potentially conflicting goals, including revenue, cost and profit.

The Wynyard 100 development seems to herald a way forward. It frees data to run transoperably across Microsoft and partner technologies, seamlessly connecting processes, people and the built environment. Throughout the "digital building lifecycle", from design to completion to estate management, smart technology helps to drive safety and compliance, save time and money, promote efficiency and productivity – all while minimising carbon emissions, on-site consumption, plant location errors and waste.

It offers a glimpse into our future of sustainable construction. And with support from the government and asset-owners in helping to drive digital transformation, while addressing critical issues like the skills gap, the UK industry can hope to maintain its world-class credentials.



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Microsoft