DIGITAL DELIVERY
FASTER SMARTER BETTER
The impact of digital transformation and innovation in recent years on our global built environment has been nothing short of transformative.

With construction needing to be leaner and greener, AECOM is embedding digital solutions into workflows that are key to accelerating the delivery of critical infrastructure that will leave a powerful legacy — a world where infrastructure creates opportunity for everyone.

Technological advancements are bringing about new ways to optimize project delivery, increase productivity and create efficiencies throughout the design and construction process. By rethinking technology’s role in how we design, build and operate built environment assets, we can unlock the best outcomes for our clients and communities — better quality, greater reliability, faster delivery and the highest safety standards.

We are pushing the industry forward through the creative application of existing tools and by inventing new ones. We’re recruiting the brightest talent and helping them develop the right mix of traditional and digital skills to create the built environment of the future. Through our global digital solution networks and industry partnerships we’re connecting our global digital expertise to share best practices and create world-class solutions that are transforming the industry.

Read on to find out how we’re leading the industry’s digital transformation, connecting data and collaborating with key partners to solve our clients’ most complex challenges around the world: from the digital solutions that are transforming design and construction, to automating asset management and harnessing the power of data like never before.
Efficient and automated design + construction

/  Digital workflow
/  4D and 5D BIM
/  Multidisciplinary digital libraries and DFMA
/  Immersive technologies (VR/AR)
/  Digital design review
/  Construction optimization
/  Modular construction
/  3D printing

Data-driven asset management

/  GIS 2.0
/  Digital surveying
/  Predictive failure and analytics
/  Reality Capture

Data management and intelligence

/  Data management
/  I3 – Data science

ARTICLE: TRANSFORMING THE DESIGN PROCESS
Explore how a digital approach can help the industry deliver faster, greener and more efficiently, and tackle long-standing productivity issues.

ARTICLE: DRIVING INNOVATION IN ROAD ASSET MANAGEMENT TO LEVERAGE VALUE
Pavement and digital specialists Dr Bachar Hakim and Diego Gonzalez Pascual discuss the latest innovations available to help road authorities secure better value from their assets.

ARTICLE: IMPROVING INFRASTRUCTURE COST ESTIMATE ACCURACY
See how machine learning and assembly tools can lead to more precise infrastructure cost estimates faster and using fewer resources than traditional approaches.
EFFICIENT AND AUTOMATED DESIGN + CONSTRUCTION

Technology is rapidly transforming how we design and construct. We are embracing fully digital workflows to deliver faster, smarter, better and safer solutions to our clients’ biggest challenges.

Efficient design tools and the use of artificial intelligence and machine learning automate repetitive manual tasks, enabling greater creativity whilst providing more reliable design and construction outcomes.

SOLUTION
DIGITAL WORKFLOW

We know that getting things right from the start makes all the difference.

Our dedicated Digital Project Delivery teams support projects from mobilization to completion, ensuring our clients benefit from digital best practice, workflow establishment, management, execution and governance throughout.

Through our Digital Healthy Start program we ensure projects are set up to take advantage of the best available digital tools from the start. These include:

- Project Playbook: Providing project teams across our global business with a centralized location to easily access global and regional best practices, standards, processes, procedures and templates.

- Productivity-enhancing tools: Collaboration and productivity tools such as Autodesk BIM 360, Dynamo scripts, design anomaly detection through our self-developed AI and machine learning plug-in and model checking dashboards through our ALytics Model Intelligence software.

A digital workflow ensures all asset data is captured effectively during the design phase and can be used beyond — a “running current” of clear and consistent information for stakeholders through all stages of building and operating an asset.
AECOM-designed Pier A, opening in 2019, will help Amsterdam Airport realize its vision of becoming one of Europe’s leading aviation hubs.

The new eight-gate pier and airside facilities will increase the airport’s capacity by 14 million passengers per year. Keen to avoid the challenges typical of projects of this scale and complexity, we implemented an ecosystem of innovative technologies and software to ensure the smooth-running of the project.

With design teams located across Europe, collaborative cloud-based workflows allowed continuous coordination in a live working environment. Digital workflows strengthened communication, dramatically improving the efficiency of information flow between disciplines, improving quality and aiding earlier identification of issues.

By embracing digital workflows, the team successfully challenged traditional design approaches to streamline project delivery and help Amsterdam Airport create a destination that will redefine future airport design.

The team used immersive technology at key project milestones to strengthen client engagement and allow project stakeholders to better visualize their vision throughout the design process. This allowed reviewers to gain a more accurate representation of the design than through traditional presentation methods such as 2D drawings and visual renders.

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Through the early identification of critical elements within a 3D model and the application of relevant attribute information to objects, data enriched models can be expanded to facilitate sequencing / scheduling assessments (4D) and detailed cost analysis (5D). The linking of these additional ‘dimensions’ to models gives an enhanced analytical view into the health, progress and risks associated with a project throughout its lifecycle.

Alignment of model elements with ‘time’ (4D) enables the optimisation of procurement activities, construction planning and site sequencing. Highly constrained sites with traffic restrictions and noise impact limitations can be investigated in far greater detail when compared to more traditional scheduling methods.

The next level of detail involves the alignment of ‘costs’ (5D) to the schedule and the 3D model, which carries the additional benefit of providing stakeholders near-absolute clarity around the quantities, volumes and cost profile for each element within the project scope. 5D analysis also enables operational stakeholders to accurately plan capital expenditure (CAPEX) and operational / maintenance expenditure (OPEX) before construction starts.

SCHIPHOL AIRPORT PIER A
Amsterdam, Netherlands
On the M6 motorway project for Highways England, AECOM has developed and implemented parametric and automated design into the project workflows. With the use of parametric design software, we have been able to reduce design and modelling costs by approximately 20 per cent.

This significant saving was achieved by developing a set of standard parametrically coded templates, along with generative component scripts, which are facilitating the foundation of a digital twin model. These techniques provide more accurate and consistent design information and remove unnecessary and repetitive processes. The development of highly detailed models at earlier stages in the design process also enabled enhanced levels of value engineering.

Designing in this way allowed us to link directly into 4D and 5D BIM — highly accurate programming and costing. Having linked the model to time and cost, we started to integrate the life cycle parameters of an asset into the design. This dynamic connection leverages the power of digital information and provides our clients with insight into information once lost within countless reports.

With the use of parametric and automated design techniques and processes, the biggest time saving occurs within the change management control aspect of engineering design. By configuring and coding our programmes we can handle design changes faster, with greater quality and higher accuracy, all aligned to the project criteria outlined by the project requirements.

SOLUTION
MULTIDISCIPLINARY DIGITAL LIBRARIES AND DFMA

With standard design components that can be used on multiple projects, our fabrication-ready digital libraries are streamlining project delivery.

Our digital library approach eliminates costly re-work by capturing design decisions in construction-ready “mini-models”, providing consistency from one project to the next and dramatically reducing the time needed to design a building. Residual decisions can be built into configurators enabling client choice on individual projects.

The use of digital libraries continues to create efficiencies in the construction phase. Standardized components, specifications and tutorials stored within the model help speed up construction and procurement and, where required, facilitate Design for Manufacture and Assembly, modular and off-site construction.
In 2015, Her Majesty’s Revenue and Customs (HMRC) announced its plans to bring its employees together in new large, modern regional centres to drive collaboration and flexible working. AECOM is working with HMRC to deliver the new future-proof workspaces — the largest office transformation programme in the UK.

The first of HMRC’s new regional centres, 1 Ruskin Square in Croydon, and one transitional site in Canary Wharf, have been completed. We are using our experience on these projects to set up dedicated digital libraries for future projects in the programme that respond directly to HMRC’s preferred design and finishes.

All projects are being 3D modelled in REVIT to BIM Level 2 standards with specification documents directly linked to the 3D model. This single platform approach has significantly increased efficiency, enabling us to complete RIBA Stage 3, Developed Design, to a level of detail that is unparalleled for workplace fit-out, in just eight weeks.

Through our pioneering use of digital libraries, we are delivering faster, smarter better workplaces of the future for HMRC.
DIGITAL DELIVERY
TRANSFORMING THE DESIGN PROCESS

In response to increasing economic, social and environmental pressures, private and public sector developers are challenging the design and construction industry to deliver faster, greener and more efficient infrastructure solutions. Digital expert Dale Sinclair explores how a new digital approach can help the industry meet this challenge, and tackle its own long-standing productivity issues.
The UK Government has big ambitions for the country’s infrastructure, with a national infrastructure programme target to deliver £650 billion worth of projects by 2025. The pipeline comprises millions of affordable homes built in multi-use communities, more efficient, sustainable transport networks and solutions, and energy infrastructure to secure low-carbon success.

Across both public and private sector developments, this vision calls for better-performing, greener buildings and infrastructure delivered faster and more cost-effectively. And, the Construction Sector Deal commits the industry to: reduce the cost of construction and the whole life costs of assets by 33 per cent; half the time taken from inception to completion of new build; and decrease greenhouse gas emissions in the built environment by 50 per cent, supporting the Industrial Strategy’s Clean Growth Grand Challenge.¹²

Failure to launch

Yet, despite this urgency and national focus, the UK’s infrastructure ambitions continue to outpace supply — the lag exacerbated by long-standing issues in the UK design and construction industry. This includes a persistently low productivity growth rate, averaging just 0.4 per cent per year, the ongoing prioritisation of costs over climate-change risks in some areas, and continued delays to the delivery of major infrastructure projects.³ Reflecting this, only 1 per cent of housebuilders think that the target of 300,000 homes a year can be achieved by 2022.⁴

That’s, perhaps, no surprise given that the vast majority of building projects still follow the generations-old linear process of briefing, design, construction and, finally, occupation — with maintenance considerations frequently an afterthought.

Typically, project teams start afresh with every project, drawing on a new client brief and site context, alongside local regulatory drivers, to shape their plan, and find it difficult with the analogue tools available to learn and apply lessons from previous successes and failures in a systematic way.

The complexities and constraints of the UK’s national and local planning systems also increase project pressures as councils look to developers to help them build the major infrastructure that communities need to thrive, urgently and cost-effectively. To do this, developers need to ensure a robust business plan and delivery model from the outset. Yet too many projects still run late and over budget.

To change the outcome, we must change the process

For some, the answer is to standardise within the traditional design process, replicating deliverables, gateways and scopes of service across multiple projects, to save time and resources.

But the industry needs to be bolder, to go further. Digital innovation gives teams the chance to access and benefit from the latest innovations in advanced manufacturing, design and construction, and facilitate the industry’s shift to a circular economy approach and creating net-zero adaptive buildings more rapidly.

Informed by our work with clients and digital expertise, AECOM has developed a new digital ecosystem to help teams realise that potential now. The platform — which brings together the latest digital tools for use across disciplines, including design for manufacture and assembly solutions — is built around a central digital library that enables knowledge capture, supports interdisciplinary workflows and applies lessons learnt to deliver smarter, greener buildings faster.★
Here are three ways in which an integrated digital delivery approach like this can transform processes and improve outcomes across the entire project lifecycle and wider industry.

1/ INFORMING DECISION-MAKING FROM START TO FINISH

A building is only ever as good as the quality of the spaces within it and the success of its vision to form a coherent, adaptable whole. Yet the reality is that in the earliest stages of a project, those involved don’t generally have the spatial information they need to fully understand the impact of the decisions they’re making on their building. Using the project detail and sector knowledge stored in digital libraries, teams can generate 3D models to visualise their design in practice and give them that insight.

It means that, well before construction, they can assess the planned use of space, products, materials, light and colour and how the operation of their building will work. Ideas and changes can be tested in the virtual world and spaces (such as those designed by sector, i.e. residential, healthcare and workplace) quickly adapted to suit new circumstances or project conditions, without losing embedded knowledge and intelligence.

With access to interdisciplinary data, teams can also see detailed information on sockets, lights, grilles and other building services from day one — limiting the potential for costly, last-minute changes down the line.

2/ MAXIMISING VALUE ACROSS SPECIFICATIONS

While a building’s spaces determine its look and feel, its systems — ranging from structural to business services and internal wall systems — form its engine room. The building-system components of digital libraries provide fabrication and construction-ready information that enables teams to optimise these elements from an aesthetic and whole-life perspective by selecting the products, materials and solutions that can deliver the best long-term value for the project.

In addition, this better quality, more detailed design content makes it possible to repeat best-practice and well-designed spaces across programmes of projects, replacing the design standards typically used. And AECOM teams are now using digital design libraries, consisting of construction-ready spaces and systems to drive residential developments, repeatable retail plans, high-performance workplaces and adaptive healthcare and higher education buildings.

3/ BLENDING INNOVATION AND TRADITION, STRENGTHENING COLLABORATION

By having the latest tools, software and solutions in one place and ready to deploy via a digital ecosystem, including design for manufacture and assembly (DFMA) techniques, such as modular construction, teams can help to eliminate waste, reduce costs and save resources across the project lifecycle. For example, the adoption of off-site modular solutions — which use advanced manufacturing technologies and processes in construction — can deliver high-performing, precision-engineered buildings equipped to lower running costs, adapt to changing needs and save energy.

In cases where modular approaches are not suitable, such as commercial offices or airport terminals, digitally integrated platforms can bring together manufacturing and construction software tools to help multidisciplinary teams and supply chain partners collaborate more efficiently, reducing downstream costs and delays and making these complex, often global, programmes simpler to manage. For example, by linking an architect’s model to engineering software, you can limit the need for multiple design iterations and ensure early design decisions are as robust as possible.

Delivering for the future

Digital delivery is truly transformative, giving project teams the opportunity to not only transform the way we design and create our built environment, tackling long-standing productivity challenges in the design and construction industry, but also crucially deliver the faster, smarter, better buildings that our communities and the future demand.
CASE STUDY
DURLEIGH WATER TREATMENT CENTRE
Bridgwater, UK

Wessex Water’s project to reconstruct Durleigh water treatment centre shows how the water industry is harnessing the use of digital technology to deliver projects faster, smarter and more safely. Wessex worked with AECOM to bring together a range of tools and technologies and form a comprehensive digital engineering approach to the scheme.

COMMON DATA ENVIRONMENT
enabling collaboration across the supply chain and Wessex Water’s business (project management, engineering, procurement, operations), this has supported Wessex Water’s integrated delivery team approach.

DIGITAL ENGINEERING AND VISUALISATION:
the digital model fully integrates all civil, mechanical and electrical and process design. Ground penetrating radar, drone survey and laser scan data are used to ensure existing assets are accurately modelled. They create a seamless interface with the design of new plant. Automated clash detection has allowed more than 100 structural clashes to be eliminated during the design process, reducing the risk of change during construction.

The model has been a powerful tool as part of value engineering; for example, the visualisation has helped rationalise layouts in the wastewater treatment and low lift pumping areas with a potential £300,000 saving.

DIGITAL DESIGN REVIEWS:
the ability to visualise the scheme in 3D allows the delivery team to quickly understand how the proposed works will look and function, leading to sound and timely decision making.

DESIGN FOR MANUFACTURE AND ASSEMBLY (DFMA):
A DFMA approach has sought to maximise opportunities for off-site build, helping to de-risk the programme and ensure the scheme is delivered within the duration of the planned site outage. The federated model has been used to identify DFMA opportunities, providing equipment suppliers with an immediate understanding of the project. 3D supplier fabrication details are inputted into the design model to give confidence that the off-site manufactured components — stainless steel tanks, access platforms and process pipework — will integrate into the construction when delivered to site ready-made.

THE IGLOO:
The data rich 3D model is combined with collaboration software “Revizto” to create a virtual reality model. This virtual world is hosted in an “igloo”, a fully immersive cylinder with 360°degree model projection enabling teams to stand within, and walk around, the proposed water treatment centre. This aids design coordination, stakeholder buy-in and plant construction and operability review.

Simon Osborne from Wessex Water praised AECOM for “helping to shape our future approach to digital technology.”
Blurring the lines between physical and digital worlds, virtual reality (VR) and augmented reality (AR) are helping us visualize projects like never before. Whether supporting public consultation or engaging stakeholders in the design process, immersive technology is helping our clients make better-informed decisions, with confidence.

**SOLUTION**

**VIRTUAL AND AUGMENTED REALITY**

VR and AR are highly effective communication methods for any project. Visualization is particularly powerful for engaging project stakeholders and is increasingly being used as an invaluable communication tool on AECOM projects from exquisite pavilions to 50,000-seat stadiums across the world.

Because 2D plans can be hard to interpret, local communities are often anxious about the impacts of large construction projects. High quality visualizations in an immersive environment allow people to experience complex schemes and better understand proposals, often changing perceptions.

While traditional visualizations and fly-throughs follow a pre-defined camera path, VR provides the possibility to explore; interacting with a development from different angles, at different times of day, providing an instant sense of scale.

**DIGITAL DESIGN REVIEW**

As VR and AR become more commonplace in changing how stakeholders visualize projects, we’re looking to the future. Advances in immersive technology mean we are now able to pioneer the use of immersive technologies as an integral part of the design process.

Immersive technology is bringing digital models to life, allowing all stakeholders from architects, engineers and contractors to non-technical owners and end-users, to intuitively interact with a design in real time. Our clients can now interact with their final project throughout the process, transforming how they engage with designs. On complex projects with multiple stakeholders, clients can now engage with designs differently as they understand more about the product they are getting.

And, through our partnerships with industry-leading solutions providers we’re working towards being able to live edit designs in the virtual environment meaning the digital model gets updated in real time.

Effective communication is key to the success of any project. We’ve implemented digital design reviews to improve coordination on large, complex projects and facilitate collaboration between design teams and project stakeholders. Digital reviews bring together BIM models from different design disciplines to facilitate clash detection and interdisciplinary coordination.
The Serpentine Pavilion is one of the most exciting projects in London’s cultural calendar, and one of the top ten most-visited architectural and design exhibitions in the world.

With only 24 weeks to deliver the 2018 Pavilion, digital technologies were fundamental to driving the creative problem solving needed to complete the structure on time and turn Architect Frida Escobedo’s vision into a reality.

In 2018, the Pavilion took the form of an enclosed courtyard formed of celosias — traditional breeze walls common to Mexican architecture. Virtual prototyping enabled the whole team to experiment around the architect’s vision before physical testing and fabrication started, and communicated technical developments to all stakeholders, fostering collaboration and strengthening the trust between disciplines that was so crucial to delivering the project on time. Parametric models of the Pavilion’s tile spacing, canopy sizes and lighting schemes were transferred into 3D VR and AR environments, immersing the team in full-scale simulations of the design.

Accelerating the design process through the use of digital modelling tools, VR and digital design reviews allowed us to develop full-scale mock-ups with the contractor to finalise each visible detail of the highly experimental wall structures. The walls’ modular design enabled off-site fabrication, essential to delivering the Pavilion within the seven-week build period and on such a highly constrained site in the Royal Parks.

AECOM has provided engineering and technical design services for the annual Serpentine Pavilion, alongside technical advisor David Glover and creative construction company Stage One, since 2013.
On a rural greenfield site, north of Mozambique’s capital Maputo, AECOM is helping Heineken design its new US$100 million (£76 million), 800,000-hectolitre capacity brewery plant. Recognizing the potential for BIM to reduce unplanned design and coordination issues on site, the project is Heineken’s first plant to be modelled entirely in 3D. AECOM is leading development of the BIM process using a suite of digital tools including Autodesk Revit, BIM 360 and Navisworks.

The ability to interrogate designs in a virtual environment has been key to enhancing quality and meeting challenging project deadlines. 4D simulations and virtual reality immersive design reviews were used to improve construction schedule planning and help stakeholders visualize the design from the early stages, walking through their building in a virtual environment from their Netherlands HQ.
Rail improvement projects are necessary to upgrade services. But they can cause delays and interruptions for passengers. And because 2D plans for large construction projects can be hard to interpret, those impacted by the works are often sceptical of how they will benefit in the long term.

To get passengers on board with Network Rail’s £800 million (around US$10.5 million) improvement works at Waterloo Station, which included rebuilding the former Eurostar international terminal to bring disused platforms back into use and increasing the station’s capacity by 30 percent, we created a fly-through experience of the finished building, digitally recreating the whole station using photorealistic textures, materials and lighting. Virtual reality (VR) headsets were then given to passengers on the station concourse, allowing them to ‘experience’ what the station would be like once completed. The response was impressive with most expressing excitement and support for the upgrade.
Technologies and processes such as AECOM’s Construction Scheduler, off-site modular construction and 3D printing have the potential to fundamentally change the way we build.

**SOLUTION**

**CONSTRUCTION OPTIMIZATION**

While construction planning programs can assist with scheduling, the intelligence of determining the optimum program sits with planners. Until now. We’re harnessing the processing power of machines to transform scheduling with a construction optimization tool that will automate construction sequencing.

Our new construction scheduler links Building Information Modelling (BIM) to a simulation engine that allows us to model and test the different variants of the construction process and generate solutions in seconds. The tool allows design and construction teams to rigorously and rapidly evaluate options, with high levels of sophistication, reducing traditional construction schedules by 10 percent on average.

Through enhanced understanding of the BIM components, the spatial requirements of individual work tasks and the dependencies between them, the tool helps planners quickly identify the optimal construction sequence.

**SOLUTION**

**MODULAR IN CONSTRUCTION**

With the potential to speed up the construction process, provide better, higher quality buildings and reduce program and costs, modular, factory-made, buildings are an important part of our industry.

We are applying the technique to housing, education, healthcare and commercial buildings: creating manufacturing spaces for developing and testing prefabrication solutions, and through our integrated design, fabrication and construction approach, delivering volumetric modular systems.

By optimizing off-site processes, we know we can deliver better buildings. Material components adopted in the upfront design to ensure precision-engineered high-quality performance, and deliver sustainable, energy efficient buildings. And in a controlled environment many risks can be removed, so safety standards are raised, quality procedures can be enforced, and design intent met.
A temporary housing scheme for 24 homeless families, PLACE/Ladywell is the result of a partnership with Lewisham Council, Rogers Stirk Harbour + Partners (RSHP) and AECOM. Adopting an off-site volumetric modular solution, the project was delivered to a faster program, compared to traditional construction, and is now a benchmark for the delivery of modular housing across London.

Arranged in three four-storey blocks, PLACE/Ladywell is intended to remain on site for between one and four years. The key objective was the delivery of housing to support Lewisham’s housing needs, however the design and delivery of the project has provided much wider benefits. Internally, the spaces exceed current local authority standards by 10 percent; community and retail use at ground level enable the community to thrive; and with the manufacturing and assembly process inherent in the modular solution, control over quality, finish and programme enabled over 95 percent of the project to be delivered off-site, and has reduced running costs, in use, by up to 50 percent.

“This scheme offers a solution to an all too common problem that plagues many development sites, which often sit unused while complex regeneration plans are put together.”

— Sir Steve Bullock, Mayor of Lewisham
CASE STUDY

STUDIO H

Indianapolis, Ind, United States

Faster, less expensive and improved delivery of patient care is not only life-changing, but life-saving. That's why AECOM Hunt's healthcare group created Studio H, a laboratory for testing and refining prefabrication and modular construction techniques for healthcare facilities.

Located within a warehouse in Indianapolis, Studio H is a collaborative space where AECOM construction and design professionals work with cutting-edge manufacturers to understand how different prefabricated elements fit together to improve the constructability of healthcare spaces. It's also a showroom where clients can see first-hand how modular and prefabricated construction benefits their projects, and a training facility for AECOM employees to learn how to optimize the installation of these components.

The benefits of prefabrication include reduced cost, better quality, improved construction schedules, enhanced safety performance and expedited delivery.
AECOM is developing one of the UK’s first 3D printed commercial products designed to transform the digitisation of transport networks. The 3D printed arch, CNCTArch, is made from graphene-reinforced polymer and was designed to reduce the time and cost of installing digital signalling systems to ultimately deliver a better service for rail passengers.

Currently being tested on an outdoor track at Network Rail’s workforce development centre in Bristol, the graphene arch supports Data Communication Systems (DCS) units required for railway communication systems. The 4.5 metre high, lightweight arch sits over rail tracks and eliminates the need to attach new digital equipment to existing infrastructure. The CNCTArch can be used in both tunnels and open environments and has the potential to transform the deployment of digital traffic management systems.

AECOM looked at replacing the traditional bolt and screws method of deploying digital systems in tunnels, which currently takes four shifts to install. The patent-pending arch, on which the digital technology is attached, is designed to reduce the installation time to only one shift.
DATA-DRIVEN ASSET MANAGEMENT

We’re developing technologies to automate asset identification and condition assessment; improving health and safety, communication with stakeholders, design efficiency and optimizing operations and maintenance to reduce whole life costs.

SOLUTION
GIS 2.0

Web- and mobile-based maps and apps have become an integral part of our daily lives, helping us navigate through a complex world of decision making.

Most of us are familiar with Geographic Information Systems (GIS), relying on the location-based solutions on our mobile devices and desktops to navigate from A to B, or to make decisions based on our surroundings. But GIS technology has numerous technical applications, from assisting remote information gathering on site, to assessing damage after a disaster.

Digital map solutions are a valuable tool for improving project communications, better informing project stakeholders and providing critical information in a spatial context. From standard mapping portals to custom web solutions, we use our flexible array of mobile and web GIS 2.0 solutions to develop a tailored approach for each project.
Combining reports, spatial data and visualisations, the digital environmental statement integrates hundreds of documents to create an interactive and intuitive platform that allows the user to navigate their own way through the full package of environmental information. It makes large amounts of complex project information more accessible and easier to navigate and understand.

AECOM developed the UK’s first purpose-built digital environmental statement for Highways England’s A303 Amesbury to Berwick Down (Stonehenge) project. It has transformed the way complex environmental data, information and assessments are presented and shared with stakeholders.
AECOM’s Environment team was commissioned to carry out a site conditions due diligence assessment of 241 Total petrol stations in Saudi Arabia. Our proposal of using the AECOM GIS 2.0 platform was key in both securing the commission and completing the work in just six weeks. Carrying out the same assessment using traditional methods would have taken 12 weeks. We were also able to complete the work remotely from the UK.

The GIS 2.0 platform is global and transcends how AECOM projects are executed digitally. It places our projects into a real world context and fosters interactive collaboration and sharing of information across desktop, web and mobile devices.
SOLUTION

PREDICTIVE FAILURE AND ANALYTICS

For built environment asset owners, the ability to predict the future is becoming a reality — and it’s making a significant difference to the operations and maintenance of critical assets.

Internet connectivity failure, emergency repairs and unplanned outages are major costs for asset owners. But predictive asset management can help operators keep their assets operational — facilitating planned maintenance activities and avoiding the significant financial implications of reactive maintenance works.

In the age of ‘big data’ there is now a wealth of information available on the performance of assets. It is the ability to interpret and optimize the use of this data that is making the difference for our clients.

AECOM’s Predictive Failure platform empowers asset owners and operators to make data-driven decisions to better manage their assets and forecast asset deterioration more effectively.

Through visualising the geo-referenced data, the tool supports engineering insight to determine the underlying factors that contribute to asset performance problems. It is able to amalgamate and process a vast amount of information from disparate datasets and uses algorithms to analyse performance data. This allows us to accurately model the deterioration and failure of assets, leading to more effective maintenance and the ability to spot issues earlier, helping keep assets operational.

CASE STUDY

PREDICTIVE FAILURE

UK

AECOM is currently using the Predictive Failure platform to analyse water pipes and model deterioration patterns, helping UK water companies develop more effective renewal programs. Modelling drain deterioration in this way increases the efficiency of costly survey work and has improved pipe defect detection rates from 20 to 50 percent.
Old Oak Common is the largest parcel of undeveloped land in inner London. With Crossrail, a planned High Speed 2 (HS2) station and access to three tube lines, yet only 10 minutes from Heathrow Airport, this is London’s next big transformational development project. The arrival of HS2 will cement Old Oak’s position as the best-connected development site in Europe, delivering an additional 10,000 homes and 8,000 jobs plus cultural and educational uses. An AECOM-led team is developing the masterplan for the site, creating a bold yet deliverable redevelopment program that will create a thriving new area in the city.

As part of the original site decommissioning, AECOM deployed drones to deliver a ground-breaking site survey of an old rail depot in just two days. The drones collected 3,000 photographs at the 11-hectare site that will form part of the Old Oak Common development — a task that would have taken eight weeks using traditional data capture techniques — minimizing disruption to operations and reducing the need to place people in positions of risk in a live rail environment.

The data collected was so accurate the team used it to create the project 3D BIM model. Early placemaking work celebrates the unique qualities of Old Oak and sets the tone for future stages of London’s most ambitious regeneration project.
SOLUTION
DIGITAL SURVEYING
We’re pushing the boundaries of digital surveying using the latest laser scanning and drone equipment across brownfield and construction sites to infrastructure and built assets to capture data that can be processed and analyzed to create detailed 3D models for design, construction and asset management.

Using digital surveying techniques, data can be captured faster and with more accuracy compared to traditional surveying methods. The technology also facilitates surveys of large and complex sites quickly and safely — reducing the need to work in hazardous or difficult to access environments.

Digital surveying tools include:
- Terrestrial or tripod-based laser scanning
- Mobile laser scanning (handheld and cart based)
- UAS/drones
- Traditional surveying
- Tablet based data collection
- Close range photogrammetry: Bentley and Autodesk
- Aerial and vehicle mounted LiDAR processing capabilities
- Subsurface utility engineering (SUE)
- 3D modelling: scan/drone to BIM

SOLUTION
REALITY CAPTURE
Using the AECOM-developed Reality Capture tool, comprising a mobile phone, 360-degree camera and Cloud app, we’re able to take 360-degree images of projects that are automatically uploaded and stored on a secure cloud server quickly and easily, visually documenting construction-site progress throughout a project’s lifecycle. The tool allows us to document site progress faster, with stakeholders able to assess the information at any time and from anywhere. The images can be easily retrieved as the app logs their location and capture times; this is in stark contrast to traditional photograph repositories, which either rely on extensive tagging or renaming. The 360-degree images provide a more ubiquitous view of projects, which would traditionally involve taking dozens of photographs at multiple locations.
DRIVING INNOVATION IN ROAD ASSET MANAGEMENT TO LEVERAGE VALUE

With road authorities across the world increasingly asked to do more — such as adapt to new technologies, futureproof and maintain the systems effectively, and mitigate environmental impact — for less, pavement and digital specialists Dr Bachar Hakim and Diego Gonzalez Pascual discuss the latest innovations available to help them secure value.

As transport modes, systems and usage continues to evolve rapidly, road authorities must work to optimise their road networks, reducing accidents, congestion, noise and pollution, and maintain high-quality infrastructure, in response to rising user expectations of network availability, performance, safety and security. And do it all with increasingly limited resources.

Furthermore, they need to ensure that the infrastructure they provide is equipped to adapt to the use and demands of emerging, smart technologies, such as Connected and Autonomous Vehicles (CAV), electric car charging, energy generation and harvesting, in-vehicle sensors, and data communication management for route and condition optimisation.

In response to these new pressures, the industry must find new ways to provide smarter, better and increased services for less, generating value from innovative materials, technologies, and industry approaches, especially in the performance and management of road pavement infrastructure.

SECURING THE BEST-POSSIBLE RETURN

The international standard for asset management, ISO 55000 provides a strategic framework to support organisations in generating the “best possible net return from assets”, while also reducing costs. Drawing on this standard, as well as our pavement management expertise and work with clients, here are four key ways in which asset owners can incorporate smarter technologies into their asset management plans and systems — leveraging whole life costs, improving performance and minimising risks.
1/ ENSURING HEALTHIER, SAFER ROAD PAVEMENTS

As a result of traffic loading and environmental variations, pavements deteriorate with time and rehabilitation is required to maintain serviceability throughout their life. Typically, the condition of road pavements is monitored using visual inspection and annual surveys to assess surface defects, skid resistance and bearing capacity. This approach is reactive, however, highlighting visible surface defects rather than predicting deterioration to aid maintenance planning.

Digital tools offer road authorities the opportunity to transform the process and implement digital health monitoring of the whole pavement system. Using a combination of smart pavement sensors, machine surveys and in-vehicle technologies, it’s possible to develop a system that enables real-time measurement of stresses and strains, temperature and moisture to generate continuous, remote data that can be compared with the material thresholds for planning maintenance.

For authorities, this kind of system can improve lifecycle management and reduce the risks of pavement failure, preventing the unexpected repairs and subsequent traffic delays that negatively impact on an authority’s costs and reputation.

2/ IMPROVING SAFETY THROUGH AUTOMATION

Building on this, by using automated technologies — many of which are already available to the construction industry — authorities can remove and/or mitigate the exposure of site technicians to the safety risks inherent in conventional methods of testing and monitoring asphalt pavements.

These technologies can facilitate a complete and seamless process to ensure the compliance and quality of a construction site, as well as integrate automated, digital data collection (via smart sensors) with cloud-based solutions to oversee performance in service and promote more effective digital asset management (see figure 2, for details).

3/ LEVERAGING THE VALUE OF BIM

A BIM model is not only a 3D representation of an asset, but also a repository for a full set of information about that asset. This includes data covering dimensions, condition, performance, function and classifications.

A highly organised information structure is needed from the first stage of the design, so a rich and detailed asset data collection can be leveraged during the whole lifecycle of the object. This structure is based on the early implementation of the construction and asset management needs and starts from the conceptual design stage.

The data structure (shaped by attributes), which includes a core information structure (or tracking identification), gets an increasing amount of information that grows with the certainty of the design (Concept design => Detailed design => As built design) and with the scale.

This information is gathered across the whole lifecycle and may include an interaction of GIS and BIM data. Figure 3 Asset breakdown from GIS to BIM scales (BuildingSmart and Open GeoSpatial), (AECOM)

The data extraction spreadsheet (data-drop) and the IFC files (BIM models) allow for migration of the Project Information Model (PIM) information to the Asset Information Model (AIM), which will be used during the operations and maintenance phase.

The AIM can be created from scratch. But, it’s likely that the asset data/knowledge produced through this approach will be less than that gathered across the complete lifecycle.

Where next for automation?

Funded by Highways England, Mineral Products Associations and Eurobitume UK, AECOM recently completed collaborative research projects, to review and explore the possibility of incorporating recent technological advancements and automation in quality monitoring equipment, as an alternative to the conventional testing and monitoring of asphalt pavements to help improve safety.

The research projects covered two main issues: firstly, automation in controlling surface regularity and macro-texture, assessing contactless 3D laser-based technologies; and, secondly, automation in managing quality during installation, with three suites of technologies to monitor asphalt temperatures and compaction requirements.

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The integration of complete lifecycle asset information, from conception to operation and maintenance, passing through design and construction, and gathering asset information stage by stage, can reinforce authorities’ confidence in their asset data and enhance data-driven decision making.

By using BIM documentation as the base for their asset management inventory, owners can also avoid the extra work required to recreate asset information, following construction commissioning, and secure 2D and 3D information for their asset management system at no extra cost.

This, in turn, provides the capacity to supplement their asset management with 2D and 3D models.

There’s no limit

Innovative materials and techniques can provide durable, sustainable low-maintenance pavement solutions to improve whole life cost as a part of asset management strategy.

AECOM’s pavement specialists are currently leading projects to develop and trial next-generation asphalt surfacing and whole-life surfacing solutions to mitigate the risk of reflective cracking.
Increasingly reliant on smart technologies in our lives and work, we create 2.5 quintillion bytes of data every day. That’s 90 percent of the world’s data produced in the past two years alone. From finance and feasibility to design, construction, operations and maintenance, we’re harnessing the data explosion, using cutting-edge techniques to collect, process and analyze project information to improve accuracy, safety and efficiency.

**SOLUTION**

**DATA MANAGEMENT**

AECOM’s Digital Project Delivery team in EMEA are working with our clients to transform organisations and complex long-term programmes by managing their data more effectively.

Our data management offer combines best-in-class cloud-based software solutions with a developed governance framework to establish, implement, manage and operate seamless projects and programs. We work closely with our clients, providing them with the appropriate technical solutions to meet their needs and provide training for their teams.

Our integrated digital platform provides clients with clarity at executive and contract level through clear, up-to-the-minute dashboard reporting, ensuring measured outputs are monitored and managed to deliver optimal outcomes.

**SOLUTION**

**I3 — DATA SCIENCE**

The age of life cycle data science is here. We’re helping clients make sense of terabytes of structured and unstructured data produced across an asset’s life cycle.

I3 by AECOM has the connected expertise and the global capacity to help clients manage, comprehend and interpret mountains of data — as it’s developed — and at each stage of the design, build, finance and operate process. AECOM’s data science approach makes use of advances in information management technology to create a holistic picture of our client’s data through advanced analytics, virtual design and construction techniques, and the creation of custom dashboards. The results are impressive. Our data-driven insight assists in sound decision making while reducing risk and increasing our clients’ competitive advantage — saving time and money.

[www.aecom.com/services/i3-aecom](http://www.aecom.com/services/i3-aecom)
CASE STUDY

LINKEDIN PROJECT DELIVERY OPTIMISATION (PDO)

Global

Following our successful management of the project and programme to deliver LinkedIn’s Europe, Middle East and Africa (EMEA) headquarters in Dublin in 2017, we were asked to set up a Project Delivery Optimisation (PDO) team to apply this process across LinkedIn’s growing portfolio of global workplaces.

To facilitate this, our PDO team is developing a bespoke digital ‘Project Management Playbook’. The Playbook, which is to be used in the onboarding of external project managers, design teams and general contractors, will provide guidance on LinkedIn’s project processes, reporting and document management as well help upskill team members to use the latest digital tools for efficient delivery.

Our unique offer provides the LinkedIn Design & Build team with centralised support for external teams as well as internal stakeholders. In addition, our experts are performing ongoing project health checks to ensure the information available — in near real-time —to the GWS team is accurate and up-to-date. We are driving smarter, faster and better project delivery to build out high-quality LinkedIn offices around the world.

CASE STUDY

HEALTH FACILITIES SCOTLAND DIGITAL ESTATE

Scotland, UK

AECOM is helping Health Facilities Scotland (HFS) create a digital estate framework and methodology for NHS Scotland’s Boards to digitise their portfolio of buildings. A key element of this framework is the concept of digital twinning to link physical healthcare built assets to a digital representation using data from sensors and analysing condition, efficiency and real-time status.

The framework will help boards plan and prepare for their digital twin where connectivity coupled with data analytics will not only reform levels of operational effectiveness of facilities but extra insights from the digital twin will help to reshape and improve services, support person-centred care, and improve outcomes.
Cost intelligence leads Ed Day and Tristan Harvey-Rice explain how using machine learning and assembly tools can lead to more precise cost estimates, which are arrived at faster and using fewer resources than traditional cost modelling approaches.
Large infrastructure projects are notorious for costing more than originally planned, with industry research suggesting overruns can be as high as 45% for rail projects, 34% for bridges and 20% for road projects.

Infrastructure contractors and operators need to establish cost estimates early on in a project to determine project feasibility, secure funding, meet regulations and demonstrate value for money. Water companies, for example, undergo a price control every five years for the water regulator, Ofwat, whereby they provide projected costs for future works.

While public-funded projects that go over budget can negatively impact on people’s perception of the project, making it harder for the project to progress, the macro-economic consequences of project overruns are even more serious. Projects that steer completely off budget can end up being cancelled.

At the outset of a project’s lifecycle, less is known about the specific details of what actually needs to be built and a site’s unique characteristics and how they will affect the final cost. Typically, contractors and infrastructure organisations will create early stage project estimates manually, using models derived from data based on projects they’ve previously delivered. They then amend the costs as a project progresses and the actual project scope and associated costs become known. However, this modelling approach typically considers just one or two variables or characteristics of each asset/cost, such as the diameter of a piece of pipe and the surface it is being installed into. This is because traditional modelling techniques are largely carried out manually with analysts inspecting data ‘by eye’ to identify correlations. This leads to models that use only a few cost drivers to create estimates.

Additionally, while some organisations have a lot of historical project data, many don’t have the tools, people or time to crunch the data to get the most accurate costs out of it. On the other hand, some organisations don’t have enough historical data to generate accurate estimates from in the first place.

We’ve developed two smart ways to produce more accurate cost estimates more quickly with fewer resources than traditional methods.
ESTIMATING INFRASTRUCTURE COSTS IS A VITAL ASPECT OF ANY PROJECT. WE ARE INDUSTRY LEADERS IN PROVIDING A RANGE OF TOOLS, TECHNIQUES AND SOFTWARE TO ENHANCE OUR CLIENT’S ESTIMATING ACCURACY AND VISUALISATION OF POTENTIAL EFFICIENCIES.

TOO MUCH DATA?

Machine learning approach¹
Our machine learning (ML) cost model approach uses algorithms to detect relationships between many different project variables or characteristics and their cost, as opposed to just one or two variables covered by more traditional methods. This leads to greater certainty of costs because it allows more sophisticated relationships between the variables to be discovered, removes subjectivity and uses more of the available project scope detail. Organisations with a lot of good quality historical data therefore benefit most from using the ML approach.

We've trialled the approach to derive and train an algorithm that can estimate costs using all available asset characteristics, using AECOM historical data for several hundred pipe laying projects with actual costs. We've analysed the project cost characteristics such as the length, diameter and ground condition of pipes, using the traditional manual modelling approach, followed by our ML approach. While the traditional approach estimate was eight percent out from the total actual cost, our ML estimate was less than four percent out, an increase in accuracy of 50 percent.

Leveraging ML in this manner allows thousands of cost datapoints to be extracted and analysed in a few days by just one suitably experienced data scientist, achieving results that outperform those that would previously be produced by an entire team of analysts using traditional methods.

Our machine learning tools can be applied to any infrastructure sector including transit, aviation, water, buildings and power projects, helping improve cost estimating by increasing accuracy, lowering resource requirements and delivering faster results.
As a project progresses and actual design and cost information becomes available, asset details and actual costs can be added to the model, updating the bill of quantities produced and providing fully-detailed cost breakdowns. These can be compared throughout all project gateways, showing reasons for budget changes and providing an early warning that budgets may be exceeded, giving greater time for challenge or mitigation.

We’ve built several assemblies for High Speed 2 which form part of a suite of estimating tools being used to validate that the project is achieving value for money.

**HS2 Phase 1 Structures Assemblies**

AECOM developed 25 assemblies for a variety of above- and below-ground structures identified as key cost drivers on the Phase 1 programme of works. Working closely with HS2’s design team to establish standard designs and parameters, estimating logic was developed and combined with a centralised rates library to derive a full bill of quantities at any stage of design maturity.

**NOT ENOUGH DATA?**

Assemblies tools

Being able to track cost changes throughout a project gives a better understanding of the reasons why budgets may be exceeded and therefore where to target efficiencies. It also improves overall learning about specific costs for future estimating and allows greater management over change events and the contractual disputes that can arise from them. However, more traditional cost estimating methods provide very little visibility of why a cost changes from initial estimates to actual costs. In an effort to move away from obscure budget figures that are not based on any asset breakdown or scope build up, we have developed asset assemblies tools, which use high-level design parameters or characteristics to assemble a full bottom up bill of quantities estimate at unit or resource level.

Our assemblies tools:

/ Are helpful for organisations with little of their own information to base estimates on
/ Use Excel as a platform
/ Can also be embedded into existing cost estimating systems
/ Provide generic asset models based on agreed defined specifications taken from assets previously built by an organisation, and on the organisation’s own standard design specifications
/ Provides a fully detailed estimated asset cost using the bare minimum of information, such as basic asset dimensions, using design assumptions to ‘fill in’ scope detail that was initially absent
/ Allows teams to explore procurement strategies with little effort
/ Can be used to quantify carbon and construction duration

Separately, we’re producing assemblies for the Environment Agency as part of its ongoing internal estimating system development and have been commissioned by Gatwick Airport to produce asset assemblies to benchmark tender returns.

Through development of new techniques such as machine learning and asset assemblies, AECOM is re-defining best practice in estimating and benchmarking, helping organisations improve their investment decision making and ultimately secure value for money for their customers and shareholders.
About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate critical infrastructure assets for governments, businesses and organizations. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM had revenue of approximately $20.2 billion during fiscal year 2018. See how we deliver what others can only imagine at aecom.com and @AECOM.