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# A Data-Centric Approach to Infrastructure

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# GOING DATA-CENTRIC IS THE KEY TO A MORE SUSTAINABLE FUTURE AND A COMPETITIVE EDGE FOR A DESIGN, BUILD AND CONSTRUCTION FIRM.

With much of the U.S. infrastructure system barely making the grade and the need for additional infrastructure, the architecture, engineering and construction (AEC) industry faces many challenges. The effects of workforce shortages, supply chain issues and increased costs have put further pressure on this sector, making slow, gradual improvements no longer an option. From concept to completion, the move to making a digital transformation and harnessing the power data holds is the key to solving many of the issues the industry faces.

# WHAT DOES DIGITAL TRANSFORMATION MEAN?

The term “digital transformation” is an evolving term and people may define it differently, but in essence, digital transformation involves integrating digital technology into every aspect of a business. For some smaller companies, the idea of going digital may mean the conversion from paper files to PDFs. A true transformation goes beyond digitization. It requires reimagining and making fundamental changes in how business gets done and value gets delivered to customers, as well as preparing for a cultural change to embrace constantly challenging the status quo.

BIM is vital to a digital transformation for the AEC industry and, along with other technologies and initiatives such as data interoperability, IFC standards, common data environments, reality capture, cloud computing and others, has helped evolve the digital twin. While BIM has been around for decades, advances in technology, compliance requirements, increased project complexity and client expectations have turned it into a must-have tool. It enables taking a holistic approach to manage and create data for a built asset.

Evolving out of BIM, digital twins pushed and continue to push the possibilities of a digital transformation. While seemingly a simple virtual representation of something in the real world, digital twins are much more than that. The virtual replicas not only have the exact measurements and elements of the physical object but also fuse data, including real-time data from IoT (Internet of Things) sensors, with artificial intelligence (AI), analytics and machine learning, allowing the digital model to develop alongside its physical counterpart.

The ability to gain nearly real-time data on the environment, progress, working conditions and more is proving its worth for many AEC companies.

“I think owners are really starting to see the value in the development of models in 3D and bringing them into value engineering analysis,” said Jon Chiglo, WSB chief operating officer. “You can modify the model quickly to look at other alternatives or ideas that may come up, to show what those benefits are. By having it all in the iTwin or a 3D environment, you can start identifying where those impacts are changing and compare the difference between alternatives quickly. It’s speeding up the assessment for projects, which benefits our owners and stakeholders. It allows us to make more well-informed decisions in a shorter period of time which benefits everyone.”

Companies ready to make a move to a digital transformation need to have everyone on board and a solid strategy for moving forward. This involves assessing current processes and systems and researching the best technologies to incorporate. Along with digital twins, many AEC early adopters have benefitted from augmented reality (AR) robotics, reality capture, drones and AI.

As a diverse and fragmented industry, implementing the transition to going digital often comes with a few bumps in the road. From different project owners with different ideas and a plethora of contractors and designers, bringing everyone on the same page requires a collective embrace of the digital transformation.

“One of the most important points is that we can’t do it alone,” said Mark Enzer, Mott MacDonald strategic advisor and visiting professor at the University of Cambridge. “This needs to be done collaboratively across the industry. If, for example, the supply chain comes with all sorts of digital capability, but the client doesn’t want it, then it’s no use. Or, if one party sets up a digital delivery platform, but the other partners on a project can’t interface with it, then it’s useless. Digital transformation needs to be a shared exercise.”

## WHY THE AEC INDUSTRY LAGS BEHIND ADOPTION

While consumer electronics, automotive and aerospace industries have long been steeped in technology and innovation, manufacturing and construction has taken longer to get on board. Then in 2020 came the pandemic. Manufacturing companies were forced into remote or distributed work environments. Designers and engineers had to go digital or risk project delays.

Although a world changing and tragic event, COVID also forced the acceleration of a digital transformation in the AEC space. Bringing disruptive technologies into the mix has given construction manufacturers a leg up when it comes to cost savings, a competitive advantage, improved operations and enhanced quality. A recent study by the Manufacturing Leadership Council found that 75 percent of manufacturing respondents already use AI and machine learning.

For these fast-paced, customer-driven industries, not making a digital transformation no longer makes sense. AEC, on the other hand, has a more complex and unique nature. Instead of focusing on creating a line of products or parts, this industry focuses on one-off designs or bespoke projects of the largest economic scale. Every project, which is often massive and complex, requires a tremendous amount of different assets, from the designers to the workers to the materials and equipment. That becomes a time-consuming process that largely lacks efficiency and

standardization.—though data centric can help even large, complex one-off projects with digital design delivery and component reuse. On a larger scale, an institutional knowledge of similar projects stored digitally is helpful in applying similarity, if not an exact template, for the next project.

AEC projects consider safety even more than other industries, and AEC firms strive to comply with every safety regulation. Since a project typically involves the owner, designer, general contractor and multiple subcontractors, managing a project while staying compliant and building things correctly can become problematic. Each project has different people focused on different silos and with different specializations, compacting the efficiency issue.

“They need to use new tools and think differently about the lifecycle of a project,” said Tom Coleman, vice president of visualization and data intelligence at WSP. “Typically, a designer, when they start a project, may only think about their silo of building the geometry to meet the client requirements or whatever tests they have. They’re not concerned about the lifecycle at the start of the project because they know that somebody else will do that down the road. But that thinking is changing.”

Knowing these challenges and the possible solutions brings up the question of why this transformation has taken so long to take hold. While every company has its reasons for approaching digitalization slowly, a few key reasons stick out.

Change comes slow. Everything has been done on paper for centuries. Although in this day and age, nearly every company has embraced communication technologies and computers, taking that next step can feel overwhelming and not worth the effort. But relying on old methods creates a scenario for miscommunication and a loss of data and details for stakeholders. A reliance on traditional methods has only succeeded in making things take longer.

“The whole problem in our industry has been the time it takes to go from concept to conceptual design to 30 percent designed to contracting to construction,” Coleman said. “Typical mega projects in the U.S. can take upwards of 20 years to build because of all those processes. Every time in those processes, somebody else does the work and it happens over and over again. There’s replication and siloization at work that adds costs over 10, 15, 20 years of work.”

Another factor that some businesses find a hindrance are the tools themselves. Especially for smaller companies, digital investments often only happen when a client requires them for projects. While one tool may work for one client, it may not work for the next. These short-term investments create waste that often leads to the avoidance of researching and investing in the right long-term technologies.

Many AEC businesses are not set up for training people on the new tools. They see it as wasted effort and often expect training to happen off the clock. Considering that more than half of construction firms do not have a dedicated research and development budget, the lack of technical staff to provide the needed support becomes a limiting factor.

Like with any aspect of business, cost is a top concern. When the old ways are considered good enough, making a big investment in something new quickly gets lower on the list of things to do. In reality, the standard way of doing things is rife with wasted time and money. Since the bulk of costs associated with a project happen in the field, a lack of transparency and inefficiencies slowly but surely increase the cost of a project. McKinsey & Company analyzed $1 trillion worth of capital projects and found that enhanced basic project management offered the biggest potential in increasing job site performance.

“We can advance the technology to a certain extent. However, to get the full value, owners need to be willing to adopt and embrace it,” Chiglo said. “The owners have an opportunity to take the design we’ve developed and carry it forward incorporating our 3D models into and throughout the project lifecycle.  This allows us to help them develop their machine control models, manage their construction operations and ultimately roll them into the asset management realm. We’re always looking at operationalizing the 3D model to get the strongest return on investment of everyone’s time and resources.”

## SMART PROPONENTS, GOVERNMENT PUSHING FOR DIGITALIZATION

Staying behind the times is becoming harder for AEC companies. From smart cities to smart buildings, no industry can escape meeting the increased demands of modern times. As societal demands change, especially focused on safety, sustainability and well-being, any new infrastructure needs to incorporate the latest technologies to make that happen. No longer a new innovation, infrastructure with a digital heart is becoming a necessity.

To meet the demands of a data-centric environment, infrastructure needs to incorporate various digital components. From operational data, such as energy consumption and temperature control, to bridges and roadways with sensors, many vendors are innovating with new materials and technologies and partnering with AEC companies to provide training and certification programs.

Infrastructure additions and improvements are a worldwide phenomenon. Europe spent €315 billion in three years fiscal period with its “EU Infrastructure Investment Plan.” China’s massive Belt and Road initiative may cost $1.8 trillion. The U.S. has given the AEC a shove toward digital transformation with the recent Infrastructure Investment and Jobs Act

(IIJA). The all-encompassing $1.2 trillion bill includes a section encouraging Departments of Transportation (DoTs) to embrace advanced digital construction management systems (ADCMS). These systems fall into three categories: virtual construction planning and scheduling, digital project management and controls and model-based project delivery.

“Effectively, a handover should be much simpler with a common data environment because all the relevant information should be there,” Enzer said. “It’s not the end of the issue though. More often than not, delivery generates a lot of information that isn’t necessarily useful in operation. So, there is a very discernible barrier between delivery and operation, which needs to be transcended.”

Every region in the world with a building standard has developed them with local concerns in mind, and the United States is no different. The U.S. has 50 different DoTs with 50 different standards. Considering how nearly every U.S. bridge needs to be replaced, the thousands of miles of roads need to be upgraded or rebuilt and the fact that infrastructure built decades ago are approaching their end of life, even those newly allocated funds likely will not cover all the work that needs to be done. While there is a push for DoTs to quickly adapt digital workflows, many do not have the in-house staff to get everyone on board. The software itself also presents an issue, but that is changing.

“Software developers build their product to as if one size fits all, but individual clients have many different size feet,” Coleman said. “Bentley is developing software that will allow us to essentially divvy up those models so the structures people can digitally sign the structures, the roadways can digitally sign the roadways, the drainage people digitally sign the drainage and so forth. And so, every DoT now is working on procedures for electronically or digitally signing and sealing digital products.”

# BENEFITS OF A DATA-CENTRIC APPROACH

For AEC companies still trying to resist change, the nitty-gritty benefits of incorporating data-centric, digital systems are proving to speak for themselves.

## SITE MONITORING AND SCANNING

The use of drones and laser scanners turns the once difficult task of surveying and assessing construction sites into a faster, easier and more accurate process. These technologies also capture details that once were impossible to get. Once the data is collected, it can be seamlessly integrated into the digital twin.

“As you get into a 3D world, your base mapping data has to be your foundational piece,” Chiglo said. “If that’s off, everything else will be off. For most of our projects, we fly drones through the site with LiDAR and update the base mapping we get from the client. Regardless of the time of the year, we’ll fly and at least collect the hard surfaces and that’s just the supplemental data for the base mapping. You also get some topography. You might have new buildings or new landscaping that you can pick up and make sure those types of details are in your base mapping so that everyone can have access to it. We have done progress updates after construction started, as well. We’re using drones to fly over construction sites and read quantities and productivity rates.”

3D scanners feature object recognition algorithms that are able to recognize objects from the 3D mesh made from point clouds, to create fast and accurate deliverables. Capturing existing conditions of an as-built model can reveal when building or equipment is not as specified.

“Reality capture is becoming more typical as you can do a scan every day and see progress,” Enzer said. “It’s not just at the end of the job. You can do multiple scans in multiple parts of the project and compare that to the schedule that is built into the model to see whether the progress is where it should be.”

## RESOURCE SUPPLY ISSUES

Supply chain issues have always existed, but COVID-19 created a new wave of issues for businesses in every industry. Emerging technologies and digitalization make it easier to make sound business decisions and better monitor the supply chain. From sensors in the field to the use of QR codes and blockchain ledger technology, AEC firms can gain instant access to material information and share supply information, as well as reduce waste, increase labor productivity and work toward a more efficient work process.

Materials management also plays a key role. Digital technologies provide accessibility to fact sheets that can provide the smallest of details. AEC companies can keep track of the supplier for raw materials throughout the process, from when the material was made, ordered, sent and delivered. In some cases, the information will include testing reports and quality records. When it comes to capital expenditures, a digital inventory captures all historical information while gaining real-time visibility of inventory activities. This makes it easier to minimize lead times and ensure the proper velocity of supplies.

## CONTROL COSTS

"The reason we want to go digital and why we want to create models is to control costs, become more efficient and understand the lifecycle of our components," Coleman said. "If I know what type of guardrail it is, then I can work with an engineer to say that because that guardrail has a specific gauge of thickness and strength elasticity, it may be 10 years before you know it degrades to a point where it can't do its job anymore."

BIM technology provides 5D visualization that can boost cost estimation. This enables companies to more easily analyze and gauge potential costs during the design process and predict any expense changes once construction begins. High-fidelity visuals also allow for the detection of possible risks that could add cost to the project. Instead of being surprised, key stakeholders know what is coming and can make decisions to avoid those added expenses.

## IMPROVED DECISION-MAKING CAPABILITIES

Anyone in the AEC industry knows how labor-intensive and time-consuming infrastructure and construction projects are. Prior to a project starting, modeling, drawings, testing and much more need to happen. The constant back and forth continues once the physical work starts, sometimes leaving uncertainty as the project progresses.

Digital twins offer a way to change all of that. It provides a fast, risk-free way to simulate a construction project, which enables achieving an optimal design full of vital data. As construction gets underway, constant monitoring provides real-time visualization, enabling the collaborative team to make the right changes when needed and to make them quickly.

The technology also results in the creation of asset descriptions, which can be reused for other applications.

"Now that we have iTwins and 3D modeling, we can create a virtual model at the forefront of a project, like we're doing on the WSP projects globally" Coleman said. "That model becomes the as-built model through the life cycle. Once you have a 3D model, the Bentley tools allow the identification of an element ID in that model. So, a curb is a curb, and a stop sign is a stop sign. I can code those in the software and give it an asset description. If you have an asset description, you know what the material is. We can do carbon analysis of those materials in real-time from the models or costing from those models because you get geometry from a 3D model. In essence, the real meaning of digital twin or digital project delivery is essentially building a visual data model of your project from the start and then continuing that model through the lifecycle construction implementation and operations."

## LABOR ISSUES

A firm's ability to use the latest technology is challenged with a labor shortage in the AEC industry created by experienced workers retiring while younger generations move toward other types of jobs. It behooves the firm to work more efficiently with the high-quality employees they have.

A data-centric approach can help a firm upgrade the quality and sophistication of its workforce. Being data centric and availing itself of the latest digital technologies, a firm will be a more appealing place to work for the most talented and tech-savvy workers. Also, the standardization that being data-centric affords allows new workers with little experience to get up to speed quickly.

Building and construction is seen as unsafe, which prevents many from entering work sites and others from staying on the job. Here, modern technology can help. Use of VR minimizes safety risks on hazardous job sites, for example. Off-site stakeholders can virtually take a walk through the construction, further enabling the speed at which any changes can be made. VR allows for monitoring to help reduce the number of workers needed onsite. AI tools can analyze different datasets to help make processes more efficient. The ability to find new ways to complete injury-prone, repetitive tasks provides a way to reduce employee turnover issues.

## SUSTAINABILITY AND ACHIEVING NET ZERO

Across the globe, corporations and countries are working toward making net zero a reality. The AEC industry has started to feel the pressure to reduce carbon emissions. BIM, generative design, AI and digital twins have tools to help make that happen before and during a project. Conducting an analysis of a site provides a way to mitigate against the urban heat island effect, detect potential problem areas and simulate projects to incorporate sustainable changes.

Digitalization lets companies build with sustainability in mind. Any construction project requires a massive amount of material. Unfortunately, nearly a third of it goes to waste. Data from digital technologies provides an easier way to develop and meet waste-reduction goals, as well as preserve surrounding areas.

"We have a service for sustainability," Chiglo said. "We can reduce the amount of waste that comes off a project by leveraging 3D design. The 3D environment we're working in creates a much clearer picture. In a 3D realm, it allows you to see the potential impacts. We can avoid sensitive environmental areas, contaminated property and additional right of way. It's balancing earthwork to reduce the amount of truck traffic on the roads and the trips the trucks make. There are significant and real sustainability benefits of using 3D design."

## RESILIENCE

After going through a pandemic, businesses quickly realized that resilience is more than a buzzword. Changes in how people work and live are fueling changes in how cities and infrastructure are built. Committing to a digital transformation allows AEC companies to future-proof their business and projects.

Implementing technology and improving processes enhances an organization's ability to better handle unexpected disruptions without losing out on productivity. These tools also help builders create infrastructure that is more resilient to the changing environment.

## ENHANCED DATA AND PORTFOLIO MANAGEMENT

Once a sequential process, digitalization provides a way for a holistic design and build process. The available technologies enable companies to determine the data they want, get it fast and use it to make the best decisions.

"One of the key things that we say about digital twins is that they should be driven by 'purpose'," Enzer said. "The first thing to consider is, what do you want to achieve? What's your purpose? And then you can create your digital twin to do that. If, for example, you want to use a digital twin for a building to help make it more livable, then you would focus on what decisions would have to be made about the temperature, humidity and air quality... that sort of thing. So then, you could identify what sensors you need and what modeling would be required to generate the insights for managing the building more effectively. But the purpose drives everything: the data refresh rate, the fidelity of the model, whether to have a 'human in the loop'.... everything."

As companies obtain vast amounts of data, they need strategies to manage it and keep it secure. Cloud data management systems continue to improve the way that happens while minimizing data loss. These systems use high-precision analytics to bring together diverse data from different applications into a federated, single-source environment without disrupting processes. Having access to detailed, organized data in one location enhances workflow agility, improves internal and external collaboration, reduces time spent on low-value tasks and minimizes errors.

“We can imagine many different digital twins for many different purposes,” Enzer said. “What becomes really important, though, is interoperability between them. I think that the current debate about interoperability is very helpful. And I feel that it’s the way we have to go. You can have lots of different providers of different digital twins, but they have to be able to talk to each other.”

# DIGITAL TRANSFORMATION IN ACTION

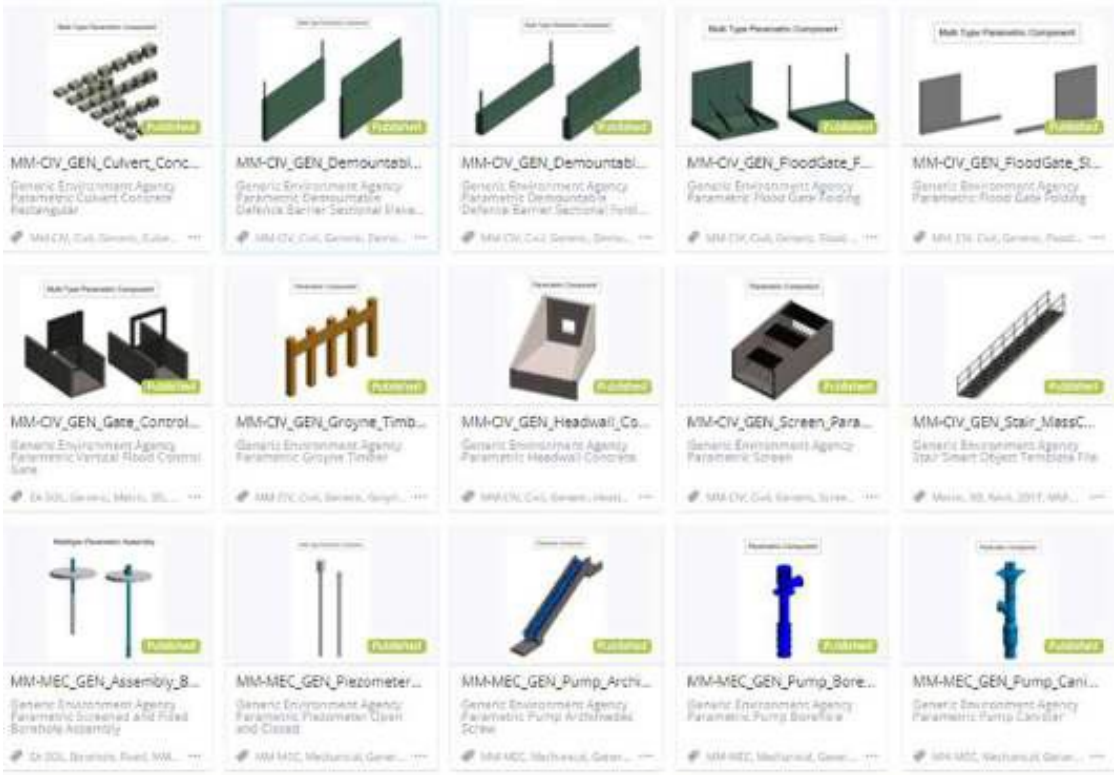
As the AEC industry considers embracing digitalization, some firms have already pushed the boundaries to design and complete data-centric projects.

## UNITED KINGDOM ENVIRONMENTAL AGENCY OF ENGLAND AND WALES (EA) OBJECT LIBRARY

Guarding against coastal erosion and flooding risks fueled the EA to invest GBP 2.5 billion in capital projects during the next 10 years. Since most of the projects involved construction, the EA quickly gravitated toward digitalization to increase efficiency, have digital prototypes and streamline data. The digital process developed also needed to reuse existing data and provide a way to standardize design content for collaboration within the organization and with supply chain vendors.

To make that happen, the EA turned to Mott MacDonald to help develop a standard object library (SOL). This library features standardized 3D asset information that users can drop into models, making it easier to design, visualize and analyze a project.

Initially, the EA requested 15 asset types with the goal of growing the library over time using Mott MacDonald's Moata Intelligent Content, a content creation service, as well as directly creating assets during projects. The EA required the assets to meet compliance standards and its format standards,




**The U.K.'s EA contracted Mott MacDonald to create a smart object library (SOL) accessible to the EA and across all suppliers.** (Image courtesy of Mott MacDonald.)

as well as provide accessibility, compatibility and return-on-investment metrics. Another challenge was ensuring the library could handle diverse data from different industries and allow for adding components, filtering and quick searches.

Faced with challenges for cross-collaboration, MacDonald discovered that the Bentley ProjectWise Components Center could provide the comprehensive solution needed. It allowed the MacDonald team to host different file formats while ensuring accessibility for different suppliers and disciplines of the project. During the three-month pilot, the EA saved 4,767 hours by reusing content and GBP 224,000, achieving a three-time return on investment.

## XI'AN-SHIYAN HIGH-SPEED RAILWAY PROJECT

A high-speed rail project in China's Hubei and Shaanxi provinces is seeing the benefits of digitalization. The 255.75 kilometers Xi'an-Shiyan section of the rail serves as a vital connection between cities between the Guanzhong Plain and the Yangtze River while also revitalizing rural areas and alleviating poverty in the Qinba mountainous area.

China Railway First Survey and Design Institute Group (FSDI), a company founded in 1953, led the design effort. Although the company is steeped in railway knowledge, both research and construction, it had not crossed over into the realm of digitalization. Ready to start the transformation, the company chose this project as its first digital one.

**Bentley applications streamlined contributions from all disciplines, improving collaboration and efficiency by 50 percent on the Xi'an-Shiyan High-Speed Railway project in China.** (Image courtesy of Bentley.)

The technologies they selected needed to ensure the unification of 19 disciplines, allow the use of 66 design and modeling applications and accommodate the challenging and unfavorable land environment of this project. The planned lengthy stretch of railway had to account for varying alignments, five 10-km tunnels and nine bridges. Additionally, the project required compliance with 13 BIM standards set by the China Railway BIM Alliance.

While the applications available enabled the different disciplines to design the elements, it was quickly determined that transferring that data would be difficult. FSDI sought an open solution designed for unification and the elimination of bottlenecks and found that Bentley's open and integrated applications met its needs.

The first step was using ProjectWise to create a single source of truth for easily accessible data. Once established, MicroStation was used for creating different designs for the project, such as the track and tunnels and models for structural elements. The different disciplines were then able to optimize elements using various other Bentley applications, such as OpenRail Designer for track and drainage design and OpenRoads Designer for road relocation.

Using a data-centric approach, FSDI achieved a 50 percent improvement in collaboration efficiency, resolved 286 initial design problems and reduced on-site surveys by 10 percent. The different applications also allowed the FSDI teams to design engineering for signals, barriers, earthworks and the electrical system. Thanks to going digital, the project was completed in four months instead of the projected eight months.

## GWINNETT COUNTY ADVANCED WASTEWATER TREATMENT PLANT

The Gwinnett County Department of Water Resources (GCDWR) in Atlanta, Georgia, ensures the 950,000 citizens in the area receive safe services. Its water treatment plant, constructed in 2000, was outfitted with advanced technologies, such as using advanced ozone and membrane treatment processes, to meet water requirements and return clean, high-quality water to Lake Lanier and the Chattahoochee River.

While the plant has received numerous awards and never a water violation, the vastly growing population has created water challenges. Although it has a 60-million-gallon maximum daily flow, the plant was dealing with flow issues. Along with finding a solution for that problem, the GCDWR needed better capacity for its membrane treatment.

Jacobs Engineering was selected to head the renovation project, which includes improvements to the Membrane Building and East Chemical Building. As a retrofit, challenges included creating a design and equipment that the older buildings could accommodate. This meant having detailed, thorough knowledge of the existing structures. Unfortunately, the project was during COVID-19, limiting the team's access to gain as-built conditions.

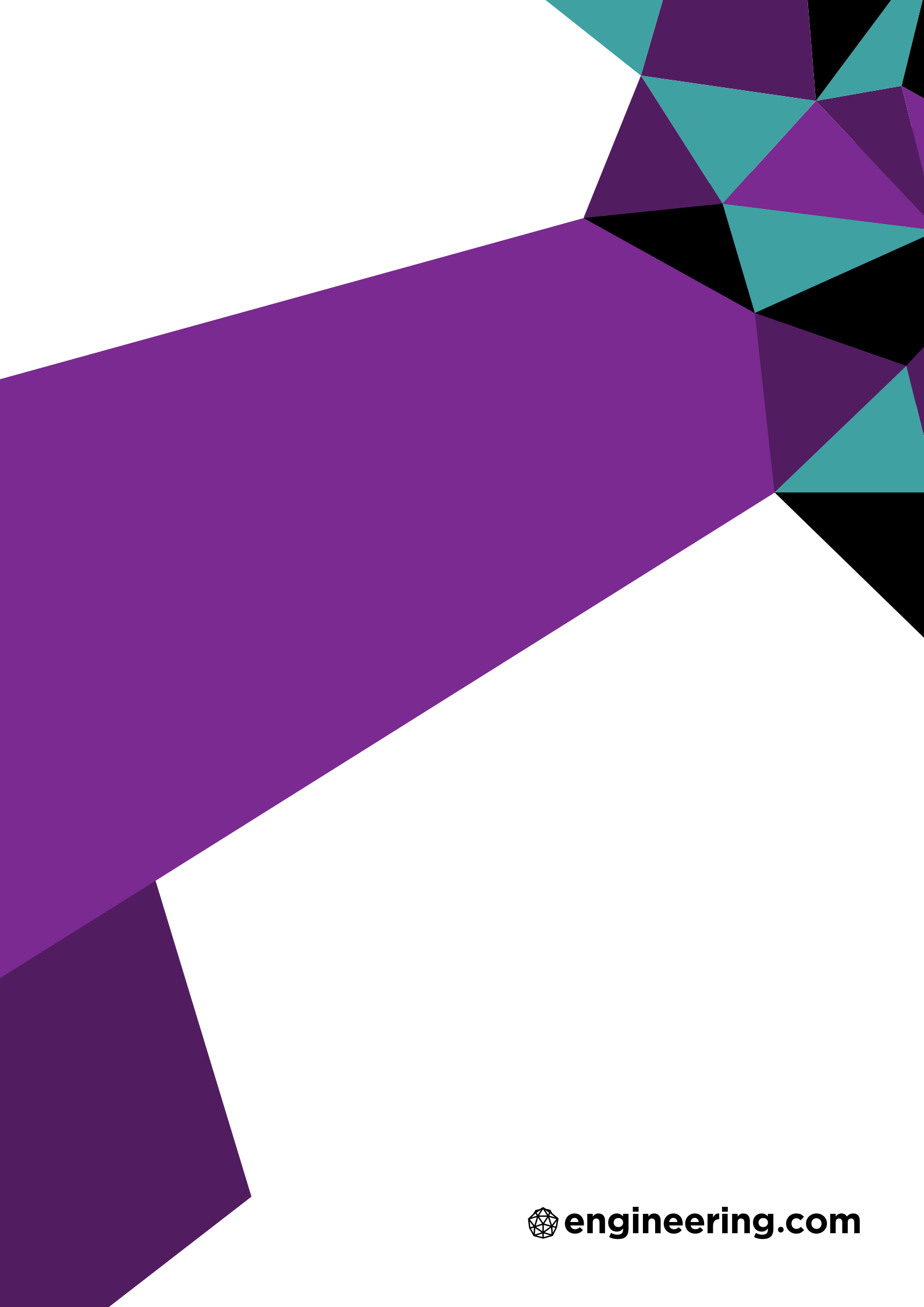
**The reality mesh provided a detailed representation of every area and angle of the wastewater treatment plant, eliminating the need to travel to the worksite.** (Image courtesy of Jacobs Engineering.)

Bentley applications provided a solution to create a federated digital model that fused the data for the new and the old. After laser scanning the buildings and site, the data was entered into the point cloud data using ContextCapture, providing a reality model. ProjectWise enabled the creation of a connected data environment for the new designs and physical model, which allowed design review to happen remotely yet in a central location.

Combining the design improvements, legacy plant data and as-built conditions in a reality mesh resulted in a full representation of the project, eliminating time on the worksite and reducing the associated environmental impacts of transportation. As the process continued, other open and interoperable applications were used to incorporate and update older 3D models and created new elements that allowed the team to see the impact the design would have on the structure and its components. The ability to work in a federated model resulted in 20 design decisions that eliminated 300 hours of time spent modeling.

# CONCLUSION

While the AEC has long faced challenges, many in the industry have turned to old solutions that no longer deliver the efficiency, cost-effectiveness or sustainability needed to successfully thrive in the modern world. Following the suit of other industries and embracing the current data-driven world has and continues to prove that incorporating data-centric technologies is no longer something to try but a necessity.



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