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The architecture, engineering, construction, and operations industry has experienced tremendous transformations over the past decade, and advances made in digital-twin technology is part of that. A digital twin in the AEC/O industry is a virtual replica of all associated physical buildings, technologies, systems, equipment, and sensors.

But the industry still has a way to go in embracing and utilizing that technology to its full potential.

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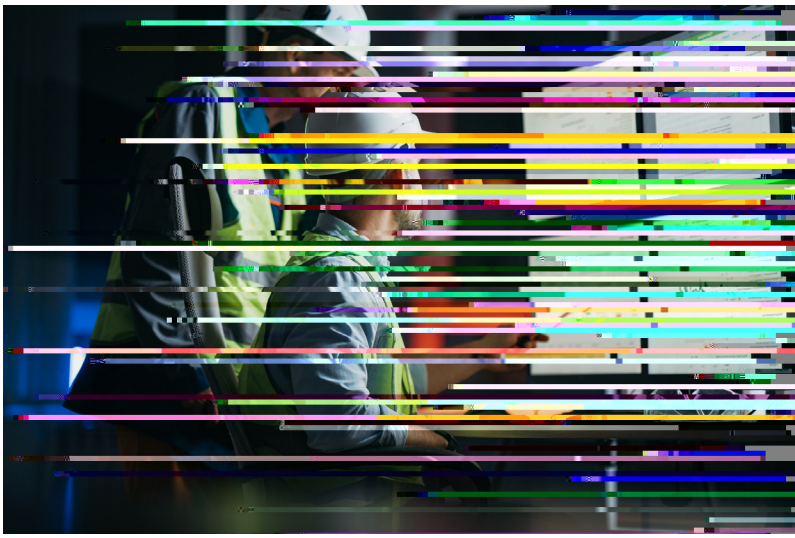
The AEC/O industry, with its multidisciplinary nature, is riddled with fragmented models that often lack synchrony and consistency. The heart of that issue lies in the industry's current model-driven approaches, which inadvertently promote data silos instead of centralized, coordinated data management. From planning through construction to the operation of a building, there are enormous amounts of data created by multiple stakeholders. However, since this valuable information resides mostly in silos, it becomes inaccessible throughout a building's lifecycle.

The complexity and continuous increase of data, ultimately impacting project/object performance, have created the perfect storm for AEC/O companies, resulting in major inefficiencies and massive loss of time. Outdated and incomplete information — bad data — leads to poor and error-filled decisions which ultimately impact the performance of buildings and the increased operational costs. This bad data leads to operational



roadblocks, undermines the quality and longevity of project-critical information, and ultimately hampers the realization of the full benefits of digital twin technology.

To better utilize data, breakdown silos, and ultimately optimize digital-twin technology, there needs to be a shift in how AEC/O organizations approach their data – one that optimizes data management and amplifes the value of the technology.

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While data and data-centric strategies are undeniably the driving force behind digital-twin technology's value creation, the AEC/O industry has yet to effectively master data utilization across all disciplines. To expedite the creation and adoption of true digital twins and maximize value for stakeholders, the

focus needs to be directed towards data-based strategies and solutions. Connectivity becomes a crucial part of the equation. Organizations must aim to establish smooth connectivity and intelligent relationships between their numerous sources of complex information.

The critical questions become: just how vital is it to address interoperability to augment and optimize the data-based capabilities of digital twins? And: how can an open standard approach to BIM offer a multitude of benefits for the creation, processing, and transfer of intelligent data among stakeholders throughout a building project's lifecycle?

Often, in the design phase, the emphasis falls on the model itself, not the underlying data it contains. Most stakeholders tend to underestimate the complexity involved in linking and managing vast amounts of project-critical data, leading to isolated data creation and integration, which is often prone to loss or erosion at every handover between different people. Considering that the efficient use and management of data is fundamental to successful digital twins and most BIM-related processes, it is pivotal to focus on optimizing data and data-centric capabilities right from the onset of the design phase.

Enter building lifecycle intelligence (BLI), a data-driven approach to designing, managing, and optimizing processes across all disciplines and phases of a building's lifecycle. BLI unifies relevant data to provide a comprehensive view of all systems, processes, and assets within the built environment. With BLI, a digital twin isn't merely a visualization, a 3D drawing, or a captured point cloud, but a crucial tool that enhances collaboration, optimizes performance monitoring, and informs better decision-making.

Let's look at an example: In Bergen, Norway, Europe, digital-twin technology was used when building a new 50,000-square-meter hospital for children. By capitalizing on an open cloud-based planning and data management, the teams were able to implement a completely digital working method to maximize collaboration and efficiency.

The project was exclusively digital, with no printed drawings used at any stage. Using a digital twin enabled all parties to work in the same environment, improving collaboration, and cross-discipline coordination. Responsibilities for different element data were able to be assigned in the consultants' models, and these updates were shared with the entire project team. This provided significant cost savings, better project control, and substantially better outcomes for all project stakeholders.

Artificial intelligence (AI) can help close the performance/simulation gap and expedite the transformation towards more sustainable and cost-efficient solutions across the project lifecycle. AI requires the right data in the appropriate context, guided by a clearly defined strategy.

In addition to broadening access and streamlining adoption, the use of AI and AI-powered automation and analysis has the potential to significantly improve the overall capabilities of digital twins and expand on the advantages of their utilization. The introduction of AI-based technologies and solutions often helps fast-track the widespread adoption of digital twins, as well as maximize and extend their various benefits and use cases throughout the AEC/O industry.

For example, digital twins and AI could be utilized beyond informing a building's initial construction; they can simulate and assess various retrofitting scenarios to ease the identification of optimal material choices for longevity and reuse. Likewise, during operation, these technologies could help optimize energy use and occupant comfort for the existing structure and its tenants. This would be designed to consider long-term cost-savings and sustainable renovation scenarios.

after a train crash. With a proper digital twin in place, the building itself can prepare for that, too, just like the people are preparing for all the casualties they expect. Things like heat maps, the volume of footsteps, etc. will automatically indicate to the building that more lights need to be turned on, or that the heat or AC needs to be turned on in certain areas. A digital twin can be much more than just a replica — it can truly react to external factors.

As AEC/O companies are increasingly using virtual environments to support various phases of the design, construction, and operation of buildings and infrastructure, the need to implement automated technology and bridge the gap between design, construction, and operations remains critical in maintaining a competitive advantage in today's market. A single source of truth that prevents data silos and ensures a data-driven approach will provide value across a built asset's complete lifecycle.

The journey toward digital transformation is undoubtedly long-term, marked by diverse challenges and setbacks. Yet, the benefits of this approach have the potential to transform every part of the industry for the better.

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