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Whitepaper:
Digital Twins Are the Next Evolution of BIM

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DIGITAL TWINS ARE THE NEXT EVOLUTION OF BIM

Digital twins have emerged as the digital tool-de-jour in many industries. But what is a digital twin? In the architecture, engineering and construction (AEC) industry, BIM and digital twins work in conjunction with one another, but they shouldn't be confused with one another. In fact, a digital twin is far more than just a model; it is a changing, adapting digital mirror of an actual object or system.

Definitions of a digital twin abound. Here is one by IBM: "A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making."

In basic terms, a digital twin is a digital version of a real-life object or system. It acts and reacts the same as the real object or system using an array of data to keep both the physical and digital objects functioning the same.

Digital twins are emerging as the new necessity for everything from simplifying utilities field service to creating more efficiency on factory floors, and even future-proofing machine tools. In fact, in a way manufacturing has been taking the lead. As the industrial Internet of things (IIoT) has become more practical and less of a buzzword, sensors and information gathering have rapidly increased. Now, those manufacturers are discovering and understanding how to put that data to use. Using digital twins, manufacturers and industrial businesses have been able to predict machine maintenance and downtime more accurately, as well as find ways to mitigate the challenges of having that downtime.

But leveraging data in a manufacturing environment is generally limited to making things and the tools that do the making. To that end, it is limited to making things with the tools, equipment and facilities that are currently available.

The world of AEC has started to embrace Building Information Modeling (BIM), much like manufacturers adopted the use of parametric models. Digital twins can change the way AEC firms operate by leveraging BIM data for not only modeling new builds, but also calculating the lifecycle of systems and elements within an existing building or structure.

"We have seen an influx of design customers looking to U.S. CAD to assist them to streamline and freshen up their approach to BIM," says Teresa Martin, Technical Consultant at U.S. CAD. "Ultimately, the designers and architects will be tasked with adding the asset information within their deliverables to meet or exceed BIM Execution Plans. Implementing that now can ensure they are proactively out in front of any requirements from their clients."

According to IBM, there are four different types of digital twins:

- Component twins, which are the smallest example of a functioning component.
- Asset twins, which are essentially two or more components working together.
- System twins, which enable you to see how different assets come together.
- Process twins, which mirror how systems work together, as in a production facility.

Manufacturers function in all four of these spaces, but most of their digital twin concentration at this point has been in component and asset twins. The AEC industry's focus has been, and will continue to be, on system and process twins. While they are somewhat relegated to their own categories of digital twins at the moment, manufacturers and AEC businesses alike will see some expansion into the other types of twins as the technology becomes more approachable and accessible.

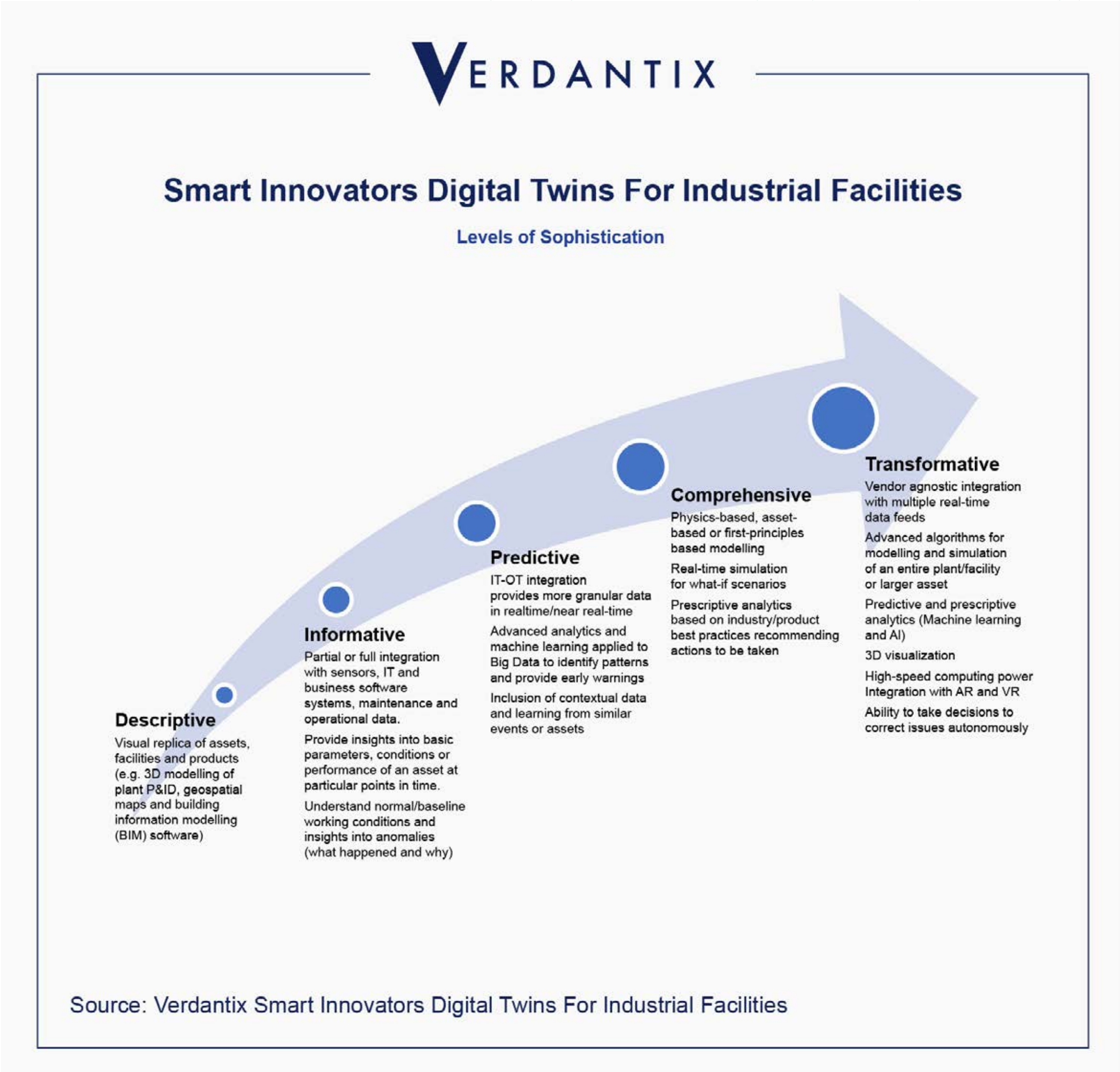
Autodesk said in their eBook Demystifying Digital Twin, "For the AEC industry, a digital twin is in the form of the built asset. Take, for example, an office building and its digital twin. At the end of design and construction, there is an exact, digital replica of the entire building, from the roof to the HVAC system and MEP. The actual, physical building is mirrored as a "twin" in a digital, dynamic format."

Verdantix, which is an independent research and consulting firm in the world of AEC, explained that there are five levels of sophistication when it comes to digital twins.

As technology and adoption advances, the higher levels of sophistication are sure to grow and expand. The world of BIM is heavily based on the lowest levels of sophistication, 'Descriptive' and 'Informative.' Manufacturers and other industrial spaces have been leading the way into the next levels of sophistication ('Predictive' and 'Comprehensive') where users are beginning to utilize the information and analyze it for real-time adjustments, predictive maintenance and what-if scenarios.

Malavika Tohani, Principal Analyst at Verdantix, explained, "When digital twins possess the ability to identify issues before they actually occur, they start moving up the sophistication curve. As the majority of APM software already has this capability, we're now seeing most vendors in this category developing digital twin product plans."

As we progress into higher levels of sophistication of digital twins, there is much more value to be squeezed from the concept, but also an expanding importance of healthy, data-rich models.



In this same sense, as the sophistication of these digital twins increases, their value will increase to more stakeholders. Knowing and understanding more data provides greater insight into not only design and construction, but also predictive maintenance and even lifecycle management. More stakeholders will continue to be involved, and with their involvement, greater sophistication on both the digital twin side of things and robust BIM data collection.

DIGITAL TWIN DURING DESIGN

Much like other parts of the design process, creating and incorporating a digital twin into design is all about data.

Let's be honest, at the moment a digital model isn't an exact replica of a real-world object or building—but the more data that is available, the closer the real-world and the digital twin can get to being replicas of each other. Leveraging more data means you can create a model that is truer to life, which adds more value to the digital twin as a predictive and testing asset.

The process of developing a quality digital twin starts at the design phase. Troy Gates, Director of Technology at U.S. CAD, said, "A digital twin is a visual and data representation, in [U.S. CAD's] case, of a building that spans the lifecycle of that building from design to construction to ownership. It's really targeted towards real time information, especially when it gets into ownership, and you start looking at things like IoT and other sensors and devices that can feed back into there. But I think the goal of a digital twin is to be able to have predictive information for an owner. To be able to accumulate and visualize data so that as the project progresses from design to construction into operation, they can predict what's going to happen in that building. By collecting data through all of those phases of the design, construction and ownership phases, hopefully that data is rich enough that they can predict what's going to happen with that building in the future."

Incorporating data-rich models from the outset, especially during the design phase, is essential for making sure all stakeholders can leverage the digital twin properly, no matter what level of sophistication. Gates continued, "I think construction and design is data collection and model creation, as well as being able to document why during construction, so that you don't build a model and apply the data after the fact. With a digital twin, you're instead applying the data while you're building."

DIGITAL TWIN DURING CONSTRUCTION

While the idea of a digital twin in manufacturing is being used heavily on the design end and the operations end, AEC can also benefit from the technology during construction.

The initial concept of BIM is often static, but incorporating BIM data as a digital twin makes it a living model that provides insight at the design phase, the construction phase and beyond.

“Things like terrestrial scanners, where you can actually do an on-site scan of what phase the construction is on, you can do a comparative analysis of the digital model,” says Martin. “It can show things like, ‘at this phase of construction we should have these things installed’ and then you could compare it to something like a point cloud scan that captures the data in real time. Then you can say, ‘Okay, I can see that the mechanical people are behind, or the structural people are on time’ when based on the digital twin model.”

There are two main benefits in this concept during the construction phase. The first is just as Martin laid out, that the digital twin can be used to make a comparison and calculation about where construction is versus where it should be. With this comparison information, decisions can be made on pivoting or changing plans or even something as basic as adjusting the scheduling of contractors for various elements of the build.

The second is a bit more revolutionary and still somewhat conceptual: giving all stakeholders real-time access to the progress of construction. When properly implemented, a digital twin could act as a tool to give designers, contractors and owners or clients access to the construction process. There are a number of benefits to having open-ended communication in this manner, and many traditional BIM users will immediately see the perks to transparency with a client.

DIGITAL TWIN FOR MAINTENANCE AND OPERATION

Using a digital twin and IoT for maintenance and operations is where manufacturers have really gotten ahead of the AEC industry. Manufacturing has a lot of focus on specific assets (read as machine tools) and leveraging digital twins to not only lay out a factory floor more efficiently, but also when developing predictive maintenance strategies. In the future, machine learning and AI may even be able to help a machinist take time off of cycles to improve efficiency.

The AEC industry has taken a heavy nod from its manufacturing brethren. According to Gates, "Currently, the AEC industry is mostly focusing on assets, as well. So, equipment, MEP systems, security devices, especially in the healthcare spaces. We're seeing these assets being such an entry point to digital twin because it's an easy thing to implement. There is already lots of data, there are lots of sensors and all of that is easy to track throughout an entire lifecycle."

But there is an area where the AEC industry could benefit differently than the manufacturing industries: lifecycle management. While calculating the lifecycle of a machine tool is important, often manufacturers have more interest in just getting stuff made. If a machine that produces a steady product needs to be replaced, it gets replaced. When you're dealing with buildings and architecture, as well as the systems within them, the lifecycle of said building can be complex and contingent on many varying factors. With a digital twin, not only can regular maintenance be streamlined and improve the longevity of a structure and its systems, but that facility or building can even be modernized faster as technology quickly changes.

Gates used the example of HVAC engineers. "They can compare built performance of systems against designed intent of that performance. In the case of an HVAC engineer, they can take what they assumed the design would be able to output, and be able to actually measure it against that digital twin once it's complete. Then they are able to adjust it and say, 'we're getting more airflow or the temperatures are more adjustable,' and so they can start affecting that digital model with that new data versus the design data."

In this way, using a digital twin can also be leveraged to control the system it is mirroring. Essentially, this means making the digital twin a virtual dashboard for controlling aspects of a building. For instance, you could use the data provided in the digital model to make determinations on how to operate the building's environmental systems, and then control the environmental systems in the physical building using the digital twin. It is a complicated way to turn down the thermostat, but it could lead to more efficient use of an HVAC system and finding cost-saving ways to use building utilities.

HOW DIGITAL TWINS WILL CHANGE BIM

BIM has already changed how the AEC world operates. Digital twins will only advance the capabilities and value of what BIM provides.

Autodesk says, “BIM already generates the foundational data for a digital twin during project planning and design. Many firms are familiar with different teams sharing data in a connected way. A digital twin requires the integration of systems and data across workflows, between stakeholders, with multi-disciplinary models at the core, making BIM the most logical and path to high-value digital twins.”

Designers and contractors have embraced the power of BIM, but there is still a lot of value that can be derived from BIM for those stakeholders with the help of a digital twin. What’s more, a digital twin provides a much more approachable interface with data and analysis for owners of the buildings that are the clientele of the contractors and designers.

Gates explained, “The designers and contractors actually have something that gives more value to that BIM, which is now the digital twin, because they can start doing that predictive analysis and looking at how the building performs. I think this is the next evolution of BIM.”

One of the biggest challenges with completing the circle of value for BIM will be providing something usable for an owner. “Autodesk’s Tandem product is very focused on assets right now, because that’s where an owner really has the ability to control it after it’s built,” Gates explained.

But platforms are growing, and software such as Autodesk’s Tandem are working to find ways to normalize the data from BIM. That normalization is what will drive access to functioning digital twins that are not only replicas of physical objects and buildings, but also can function as predictive analytical engines and even control panels for those physical counterparts. Digital twins will start to complete the circle from design to construction to customers and back again.

CONCLUSION

The digitization of our physical world is happening more every day. Machine learning and data leveraging are not just terms for academic pondering or high-end enterprise. Digital twins have arrived, and their value will only increase with time.

IBM said, "Technologies and techniques such as Natural Language Processing (NLP), machine learning, object/visual recognition, acoustic analytics and signal processing are just a few of features augmenting traditional engineering skills. For example, using cognitive to improve testing a digital twin can determine which product tests should be run more frequently. It can also help decide which should be retired. Cognitive digital twins can take us beyond human intuition to design and refine future machines. No more 'one-size-fits-all' model. Instead, machines are individually customized. That's because cognitive digital twin is not just about what we are building, but for whom."

The manufacturing and industrial industries have already started to recognize the need to create high-mix, low-volume techniques to compete in a changing market and use digital twins to make that kind of production profitable. While the AEC industry has adopted BIM, the expansion into using that data paired with IoT and other sensor systems to create a digital twin has started.

Gates said, "Car manufacturers are already doing this. They have had digital twins for a few years. They test the performance of a digital twin car or a model or an engine, and then they actually build it. I don't think we're quite there yet with the AEC industry, but it's coming."

What makes the AEC industry different is the value that the different stakeholders have with a digital twin. In manufacturing, the end-user has little interest in the digital twin of their producer's machine tools or factory, but in AEC, designers and builders and owners can all leverage a digital twin in a number of different ways.

Traditionally, BIM has been used for design and construction, but all that data without insight or applicability is of little use to an owner. As we progress into this new era of digitization, using a digital twin allows an owner to do everything from monitor the building process to predictively maintain parts of their facility to leveraging the data from a current building for developing another facility or a campus.

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