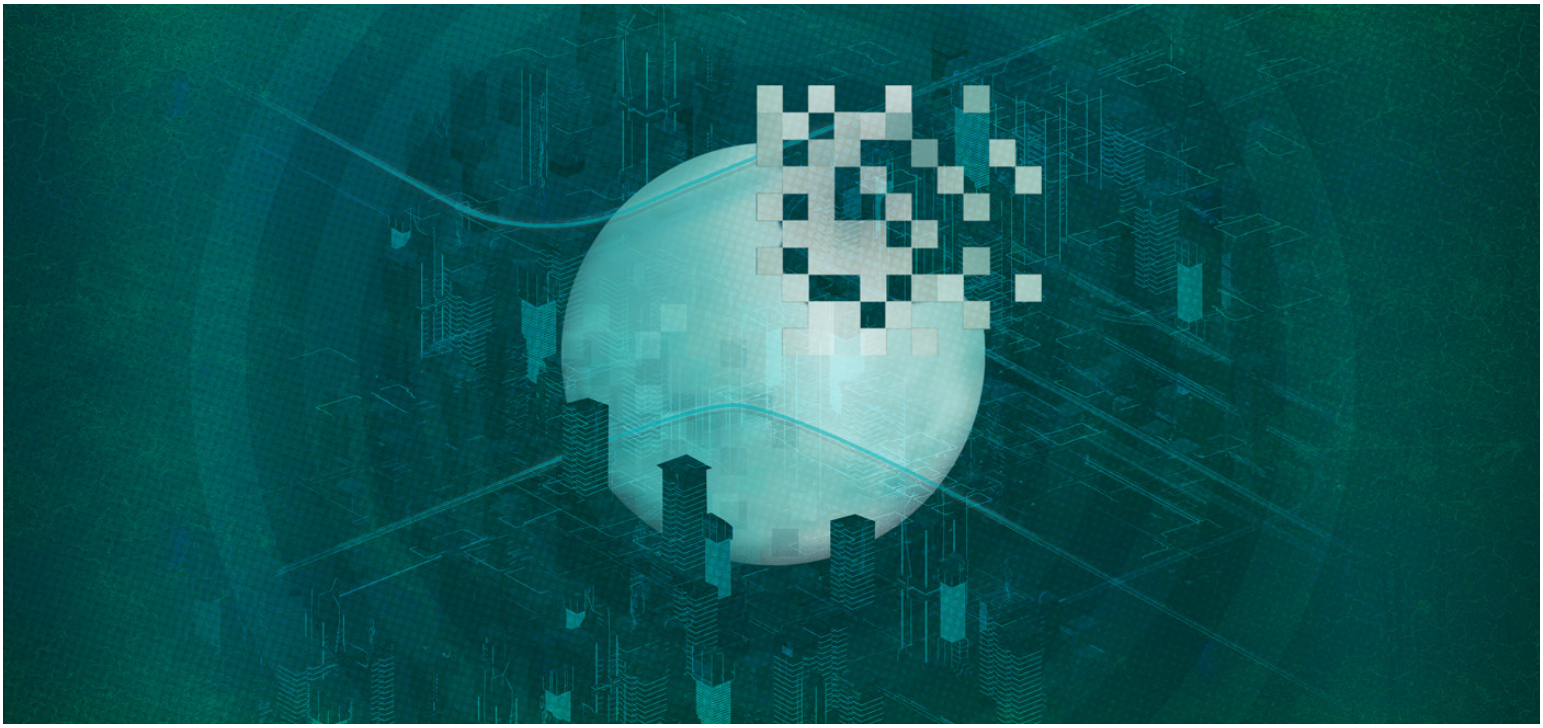

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Signals for Strategists

Expecting digital twins

Adoption of these versatile avatars is spreading across industries

By: Adam Mussomeli, Brian Meeker, Steven Shepley, and David Schatsky

EXACT digital replicas of physical objects and processes are becoming an important tool in business. Companies are using these "digital twins" in a growing number of industries, making it easier to design and operate complex products and processes ranging from wind turbines to supermarket aisles. Digital twins are accelerating product and process development, optimizing performance, and enabling predictive maintenance. The results that companies are targeting: increasing efficiency, reducing costs, and building better products. Organizations seeking to boost innovation and business performance should explore the transformative insights that digital twins can deliver.

Signals

- The global market for digital twins is expected to grow 38 percent annually to reach $16 billion by 2023[1]
- The technologies that enable digital twins are proliferating. Internet of Things (IoT) and machine learning deployments are each expected to almost double by 2020; analysts forecast the markets for public cloud and simulation and analytics software to grow briskly during this period[2]
- A growing number of enterprises in asset-heavy sectors, such as oil and gas, aerospace, automotive, and industrial products, are leveraging digital twins to transform production[3]
- Beyond the industrial sector, organizations are piloting digital twins in the retail, health care, and smart city domains[4]
- In the last two years, several enterprise technology vendors such as IBM, Oracle, and SAP have launched digital twin offerings; various IoT and engineering simulation software providers such as Dassault Systèmes, GE, PTC, and Siemens have made acquisitions to build or advance digital twin capabilities[5]

Defining digital twins

A digital twin, as we've written elsewhere, is "an evolving digital profile of the historical and current behavior of a physical object or process that helps optimize business performance."[6] It is the exact digital replica of a physical entity. The resulting digital avatar combines modeling and simulation with sensors and big data. For example, the digital twin of an automobile prototype is a digital, 3D representation of every part of the vehicle, replicating the physical world so accurately that a human could virtually operate the car exactly as he or she would in the physical world and get the same responses, digitally simulated.

Processes can also be digitally twinned. For instance, a manufacturing plant could be modeled so that a digital equal replicates each piece of equipment and element of operation, allowing someone at a computer or console to simulate the entire manufacturing process and get accurate results. Even urban areas, with their complex and interdependent infrastructure systems and large populations, can potentially be twinned, making possible better planning of infrastructure projects and the rollout and allocation of city services. Digital twins can support the goal of designing urban systems to make cities more resilient.[7]

Sophisticated digital twins continuously pull real-time sensor and system data to provide accurate snapshots of the physical twin's current state. This information can be integrated with historical data and predictive analytics to inform human operators—who may be remotely located—of potential issues and suggest solutions. Imagine if a remote mechanic could instantly diagnose an engine problem by consulting your car engine's digital twin and recommend that you drive to the nearest repair shop—or drive your car himself remotely—just ahead of an imminent breakdown.

Digital twins can profoundly enhance an enterprise's ability to make proactive, data-driven decisions, increasing efficiency and avoiding potential issues. And they can make it possible to "experiment with the future" by exploring what-if scenarios safely and economically.

Multiplying applications for digital twins

The high cost and significant effort required to implement digital twins initially confined their use to industries creating or maintaining expensive, large-scale machinery. As the technologies that enable digital twins become more cost-effective, enterprises today are finding more ways to benefit from these connected digital avatars:

- **Wider variety of entities represented.** Once reserved for equipment and machinery, digital twins are now being used to represent more complex entities or even networks of con-

nected entities, such as assembly line processes, warehouses, transportation networks, and grocery stores, and, with the availability of data from wearable devices, even people.

- **More sectors affected.** Digital twins continue to be used in Industry 4.0[8] sectors in connected factories[9] and oil rigs.[10] But companies are also implementing them in consumer goods and retail,[11] facility management,[12] and health care.[13] We are helping clients in the public sector explore this technology as well.
- **Fuller scope of product life cycle modeled.** Initially finding value in product maintenance, industries are finding more applications for digital twins throughout the development of product or process: design, testing, and day-to-day operation.

Improvements in underlying technology

Recent increases in adoption of digital twins are due in part to advances in the technologies upon which they are built.

Collecting operational data is getting cheaper and easier. IoT sensors continue to decline in cost and proliferate in type, lowering the cost of capturing and transmitting operational and environmental data from the physical twin.

Analytics and simulation can produce richer insights. Ever-improving cloud offerings and progress in machine learning are making it easier to gain insights from large volumes of IoT and contextual data to predict risks and simulate solutions.[14]

Human-computer interfaces are increasing ease of use. Chatbots, speech recognition, virtual assistants, and augmented reality are making it easier for workers to engage with digital twins.

The use of digital twins in manufacturing is also getting a boost from the integration of digital design and manufacturing systems, such as lifecycle management, manufacturing execution systems, and enterprise resource planning (ERP), and the use of

"bills of process" that list key process steps, machine settings, variables, and manufacturing methods.[15]

Evolved digital twin, extended benefits

As digital twins get more capable, they are being applied to a growing number of uses, from designing and testing products and processes to monitoring day-to-day operation and conducting maintenance.

ACCELERATING INNOVATIVE PRODUCT DESIGN

Using realistic digital models, product designers can quickly and inexpensively prototype new ideas and simulate a variety of what-if scenarios involving system interactions, product testing, and customer experience. For example, automaker Maserati has used virtual modeling and simulation to reduce the number of expensive, real-world prototypes, wind tunnel tests, and test drives, cutting vehicle development time by 30 percent.[16] French supermarket chain Intermarché uses data from IoT-enabled shelves and sales systems to create a digital twin of

a brick-and-mortar store, enabling managers to get real-time insight on stocks and test the efficacy of different store layouts before implementing.[17]

DESIGNING MORE EFFICIENT PROCESSES

Using digital twins to model complex processes allows companies to identify inefficiencies and ways to address them. GE created digital models of supply chain and factory processes at its Nevada facility that improve inventory management by helping leadership make thousands of data-informed decisions.[18] Maserati digitally modeled its production line to improve the positioning of factory robots and eliminate inefficient movement, improving facility throughput by a factor of three.[19] In health care, Dassault Systems is building a "library" of realistic human heart simulations that physicians can consult to better understand a patient's condition in real time and compare reactions to different treatments.[20]

OPTIMIZING DAY-TO-DAY PERFORMANCE

By continuously capturing vital operational metrics, enterprises can monitor and optimize product or process performance in real time. Digital twins of the medical facilities of 50 hospitals, for example, are expected to improve patient experience by identifying the busiest areas and times of day in each hospital and simulating solutions to resolve congestion.[21]

ENABLING PREDICTIVE MAINTENANCE

Digital twins can watch for imminent risks such as equipment breakdown, enabling operators to proactively mitigate issues and reduce both unexpected maintenance shutdowns and scheduled but unnecessary maintenance procedures. For example, GE's aircraft engines' digital twins combine sensor, performance, and environmental data with insights from similar engines. The digital twin can then predict the life span of various engine components under different scenarios. This enables teams to make informed maintenance decisions, resulting in reduced turnaround time. By using these digital twinned engines in their fleet, one airline was able to reduce the number of maintenance shop visits, saving millions of dollars in unnecessary service overhauls.[22]

PLANNING FOR LARGE-SCALE INFRASTRUCTURE CHANGES

Digital twins can help with planning for the impact of changes in urban infrastructure. Modeling the behavior of individual people or vehicles, for instance, can make it possible to predict the emergence of collective behavior arising from cascading effects due to disasters or infrastructure failures. They can also help visualize and understand the impact of large-scale infrastructure or other projects such as wireless rollouts, the construction of stadiums, or the redevelopment of city neighborhoods. For example, this could make it possible to design better emergency response systems or more resilient infrastructure.

Implications for enterprises

Enterprises with high-value capital assets, intricate processes, and/or a focus on expensive product innovation could reap the greatest advantage from digital twins. Implementation, however, remains a complex affair. At the extreme, it could require certain enterprisewide changes. Adopting digital twins, therefore, calls for considerable investment, collaboration, and sustained commitment on the part of leaders from all of the business functions affected.

Operations leaders will need to reimagine workflows, including revising criteria, timelines, and feedback loops for decision-making. Technology leaders will need to establish the required technology infrastructure—robust IoT deployments, simulation platforms, and integrated data sources—across departments and across IoT and contextual systems. They will need to tackle data-sharing, security, and governance concerns as well.

DIGITAL TWINS ON THE HORIZON

Digital twins can be thought of as a way of integrating a host of technologies into a package

designed to improve business operations and outcomes, from design, to production, to maintenance, to marketing and merchandising and operations. Vanguard organizations in numerous industries are already realizing benefits from digital twins. We expect a growing number of companies to invest in this technology in the coming years as part of digital transformation programs; Gartner predicts that "billions of things in the near future" will be represented by their digital avatars.[23] Firms that are not already using or evaluating digital twins may want to make plans to investigate the technology's potential.

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