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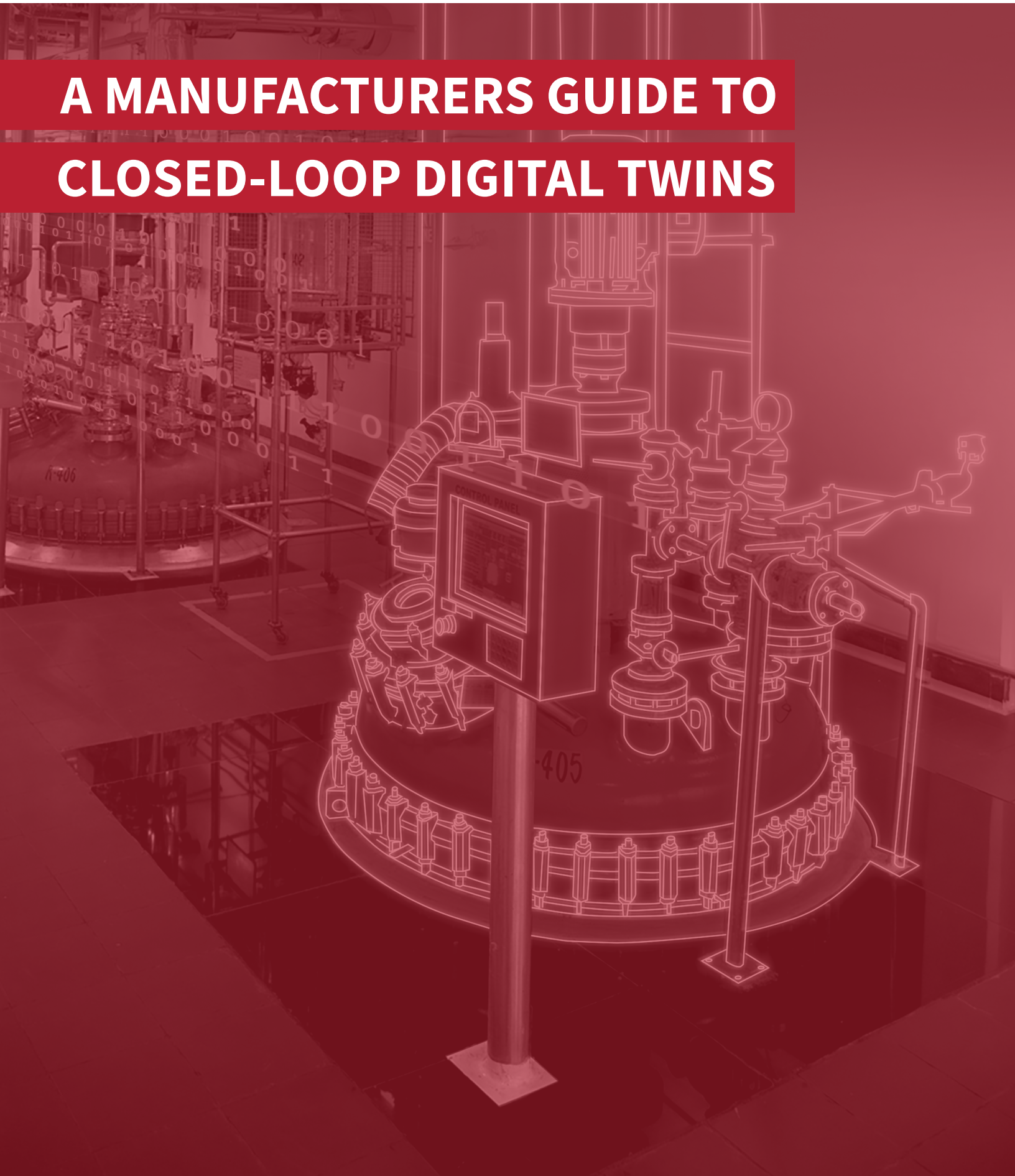
A MANUFACTURERS GUIDE TO CLOSED-LOOP DIGITAL TWINS



Internet of Things (IoT) enabled digital twins of product, production and performance, present manufacturers with unparalleled opportunities to continuously optimize every step of manufacturing. Leveraging IoT data in digital twins creates a closed-loop environment and the ability for manufacturers to realize new efficiencies, avoid production issues, improve development and design cycles as well as open the door to new revenue streams. This ebook covers best practices to get the most out of IoT- enabled digital twins.

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Digital Twin Checklist

When properly utilized, a digital twin can have benefits for any type of manufacturer by improving production performance, refining the development of new products or iterations, and establishing service-centric relationships with customers.

The following checklist provides some key focus areas to consider when putting the digital twin to work for your organization.

1

Digitalize the environment.

Digitalization is a prerequisite to survive in Industry 4.0. IDC reports that 85 percent of enterprise decision-makers say they have a time frame of two years to make significant progress with their digital transformation or they will fall behind their competitors and suffer financially.

Having the seamless real-time access to data that digitalization provides is crucial when building a fully operational digital twin. With numerous sensors and the ability to access data from modern programmable logic controllers (PLCs), the IoT understandably plays a pivotal role in extending digitalization beyond office systems. By introducing additional software-based capabilities such as data analytics, edge processing, machine learning and artificial intelligence, digital twins have the ability to leverage the IoT environment for maximum efficiency, as well as help engineering and design teams fine tune configurations before any physical deployment.

The key to success with digital twins is to leverage industrial IoT as a service with extensive communication capabilities to ensure that you are capturing everything needed to create a complete digital representation of a physical product, production or performance.

2

Establish a clear goal.

What are you hoping to accomplish by leveraging a digital twin? For instance, are you looking to reduce design time, improve production quality or eliminate an ongoing customer frustration? While the potential exists to address each of these issues, each type of digital twin serves a specific purpose. Knowing what you hope to accomplish helps determine what type of digital twin is needed.

The digital twin of product provides a virtual-physical connection enabling organizations to analyze how a product performs under various conditions such as in the market or in conjunction with other products. The results are used to make adjustments in the virtual world to ensure that the next iteration of a physical product will perform exactly as planned in the field. The digital twin of production can help validate how well a manufacturing process will work on the shop floor before anything actually goes into production. The digital twin of performance comprises the performances of both the production and product digital twins and is constantly fed with real time data from the product and the production facilities to keep the digital twin current.

3

Invest in strengthening your team's skill set.

While the technologies powering today's various digital twin offerings continues to mature, the reality is that specific skills are necessary for organizations to get the most out of digital twins. Teams often need new skills to enhance their data science, modeling and next generation configuration management skills.

Working with the right strategic partners to build out the digital twin can be of great benefit and alleviate the need to add new employees while existing team members get up to speed with utilizing virtual technology.

4

Maintain a journey perspective.

Effectively leveraging a digital twin is more of a journey than a destination. By using this perspective, organizations have the ability to leverage their experiences when expanding the digital twin to address various goals across the enterprise. Remember that starting with smaller, easier deployments can help build confidence while scaling to larger, more complex deployments.

Simply put, the digital twin technology is always evolving. And even after deployment, a digital twin should continue to constantly learn from its environment. As an organization expands its digital twin journey to include the product, production and performance versions, the ability to create a digital thread further expands the digital twin's usefulness across the board. The digital thread links together product data and organizations with an end-to-end digital process — spanning design, manufacturing and product support.

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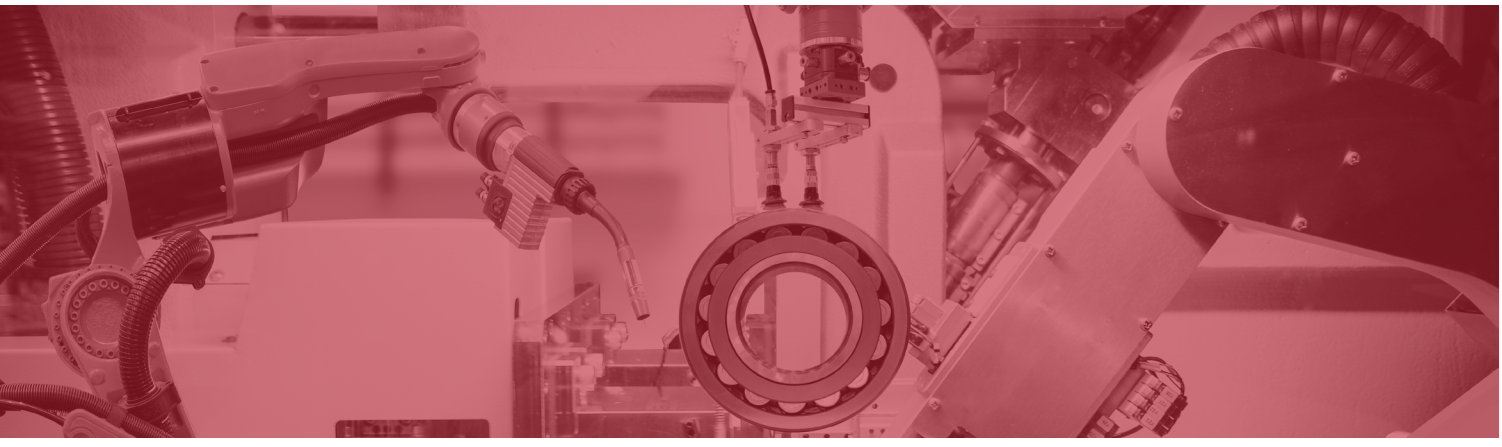
How the IoT Enables the Best Performance Digital Twin

As the race to capitalize on the latest digital technologies accelerates, the trend to watch is the convergence of the digital twin with other components of the IoT. While most companies are familiar with product and production digital twins, more advanced companies already are pushing toward adopting the latest type of digital twin—the digital twin of performance. Of those, the most advanced are leveraging the digital thread to supercharge their performance twins. Beyond that, a host of opportunities are available to further enhance a digital twin strategy by integrating other IoT components.

With digital twins of product and production, manufacturers gain the capability to virtually test, validate and analyze products and processes before they are put into production. By digitally simulating designs and process steps, manufacturers save the time and expense associated with physical prototyping or the risk of performing tests during live production.

The performance digital twin takes these capabilities a step further. It uses the performance data of the product and production machines to see if the virtual simulations match the output. With the performance digital twin, manufacturers can capture and analyze real-time operational data from connected products and plants to gain insights for refining virtual models and improving the performance of systems in production.



The Closed-Loop Digital Twin

The effectiveness of the performance digital twin is dependent upon live data, which requires a digital strategy, including an IoT-based approach. For instance, with industrial IoT as a service, you can connect your physical machinery and infrastructure to the digital world via a digital thread–a framework that enables real-time data flow between the digital twin components. This thread establishes a complete closed-loop digital twin that allows you to take real-time data from product and production performance and immediately apply it back into the performance digital twin to optimize product and performance health. The collected data allows you to validate product and process designs earlier, test their configuration and understand the impact of countless variables such as design changes, usage scenarios, environmental changes and more.

For example, production lines collect an enormous amount of data on a second-by-second basis from every sensor on every device on every machine. This data is combined with data about environmental conditions, such as temperature, humidity, etc. Without the IoT-enabled digital thread, manufacturers can only collect a limited amount of this data and analyze it infrequently, perhaps monthly or quarterly. With limited data points and frequent intervals between analyses, manufacturers miss the opportunities to reduce costs, accelerate development times and refine processes.

With a closed-loop digital twin, production line machines are evaluated in real time to determine if the line works as intended. Also, a product's performance is tracked after it leaves the production line. The product is monitored to analyze its expected use and performance against its actual use and performance. The on-going monitoring of the product is achieved with the digital twin of performance, which gathers real-time data from the individual assets and overall production plant. This data then feeds back into the current production line and new design iterations, allowing for real-time adjustments.

Integrating More IoT Components

By using the broad capabilities of the IoT, manufacturers can further their performance twins, which in turn can be used to enhance the benefits they get from product and production twins. When using industrial IoT as a service, other IoT components can be integrated to evolve your digital twins to collect more data and for advanced analytics. For example:

Big data analytics leverage real-time product or process health data to derive meaningful insights that will enable you to detect issues earlier and optimize performance.

Artificial intelligence (AI) enables rapid review of data sets so large that it's impossible to manually analyze. Further, AI leverages big data and supports machine learning.

Machine learning (ML) enables the ability to build predictive models to reduce downtime and maintenance costs.

Generative design offers opportunities to create lighter components quicker, resulting in material savings and lower shipping costs.

Further, you can integrate the product and production twins into advanced production systems that are capable of building products that either couldn't be built at all or produced cost-effectively using traditional production technologies. These include:

Additive Manufacturing: By integrating design, simulation and digital additive manufacturing systems, you will be able to more easily design and print parts that can't be made using traditional manufacturing techniques.

Advanced Robotics: With automated industrial robot programming, manufacturers will save time and money building higher-quality products that will get to market faster.

New Business Opportunities

By integrating each new IoT component into the closed-loop digital twin, the benefits compound—but that's just the beginning. With new capabilities, manufacturers can develop new business opportunities and models that drive revenue and create a competitive advantage. Business models made possible by IoT-enabled digital twins include:

Product as a Service (PaaS): With connected sensors and devices added to the machines you sell, you can track how much time a machine is used

in real time. With this capability, you can start leasing your machines and charging based on usage. For example, Rolls Royce, an early adopter and a maker of airplane engines, no longer sells only engines. Instead, the company sells its customers the thrust generated by the engines on a power-by-the-hour basis.

Maintenance as a Service (MaaS): Similarly, with the machines you sell connected to digital twins via the IoT, you will be able to provide customers with ongoing value by helping them maintain the asset's health and performance. For example, you can offer your customers predictive maintenance on their product that runs through the end of its lifecycle.

Finally, by connecting your digital twins to web- and enterprise-based systems, such as enterprise resource planning (ERP) and customer relationship management (CRM), and to your physical assets, you will be able to push the value of your digital twin into business functions. For example, when inventory systems talk with production lines and suppliers, you can automate restocking and dramatically reduce inventory overhead.

The IoT Advantage

As manufacturers move forward with their digital strategies, they're learning that integrating systems, such as digital twins and other IoT components, builds more tightly connected end-to-end digital systems in which the whole is greater than the sum of the parts. With this approach, business and operational systems become more transparent and optimized, which leads to gains in productivity, reduced risk and the development of new business models.

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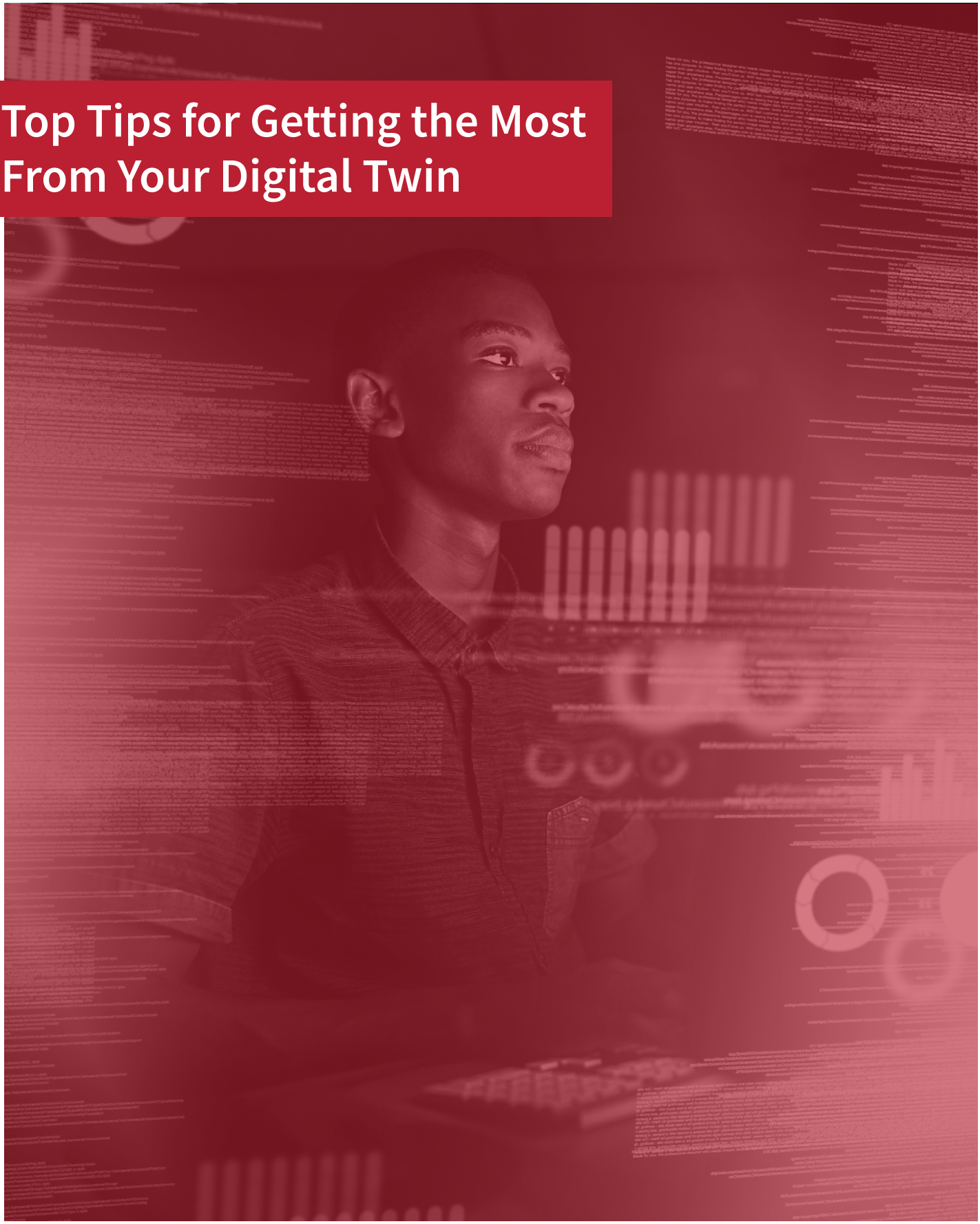
Top Tips for Getting the Most From Your Digital Twin



Increasingly, digital twins are viewed as the technology to which most other IoT components connect to, each enhancing the other. For those seeking to begin or extend their digitalization efforts, these five actions will help realize the full set of benefits that digital twins can deliver.

1

Think big

Most thought leaders and others at the leading edge of the trend toward digitalization advise that you start small but think big as you execute your transformation. They say that digitalization is more than a strategy; it's an entirely new business mindset. Because digital twins are at the core of digitalization, the same is true for your digital twin deployment.

When business leaders think or talk about digital twins, too many are still referring to product and production digital twins—virtual replicas that are used to create digital simulations of product designs and manufacturing setups. While digital simulation delivers powerful benefits such as lower cost, reduced risk, faster time to market, and the ability to introduce new or enhanced products, that's just the beginning of what digital twins can deliver.

As you plan and prioritize your digital journey, maintain a focus on the entire value chain of your future digital enterprise, from ideation to realization and utilization. Explore the plethora of integrated industrial software and automation components, and consider how integrating them with digital twins creates a more effective end-to-end digitalized business system. Examples include predictive learning, big data analytics, advanced robotics, additive manufacturing and generative design.

2

Seek Industrial IoT as a service Solutions

Once you've adopted an IoT business mindset, you'll realize that neither you—nor anyone—will be able to predict where digitalization will lead far into the future. Technologies, business strategies and models are evolving rapidly. An industrial IoT as a service solution will ensure that you'll be able to integrate existing and future systems with IoT technologies.

For example, manufacturers can combine computer-aided design (CAD), computer-aided manufacturing (CAM), product lifecycle management (PLM) and IoT technologies to build powerful closed-loop digital twins of product, production and performance. With a closed-loop digital twin, organizations have the ability to make use of valuable, real-world insights that can help improve production processes and fine-tune product iterations.

3

Improve business processes and create new business models

With this change in mindset as you link digital systems, you'll discover how digital twins are central to building more effective business processes. Digital twins enable or enhance critical systems such as condition monitoring, predictive and prescriptive maintenance, asset performance management, inventory management and fleet management, among others. For example, a digital-twin-enabled fleet manager can monitor the location of hundreds of delivery trucks, gathering and analyzing up-to-the-minute data on mechanical wear-and-tear, speed and fuel consumption.

Additionally, digital twins are central to enabling a wide array of service-based business models central to competing in Industry 4.0. For instance, a compressed air provider selling hours of service rather than the physical compressors. Whenever a business is able to improve its service offering, it opens the door for stronger customer relationship opportunities.

4

Integrate with other emerging technologies

With an industrial IoT as a service solution and a digital mindset, opportunities abound to integrate other emerging technologies with digital twins. In product design, for example, connecting generative design capabilities to your digital twins will, among other things, enable you to design lighter components more rapidly, resulting in material savings and lower shipping costs. Also, you'll be able to build intelligent models of, for example, 3D computer aided design (CAD) models and bill-of-materials (BOM) needed to optimize the construction and performance of products and processes over time. Finally, you'll be able to integrate your virtual product definitions and production execution to create smart products that generate massive amounts of data that can be leveraged to help you optimize the efficiency of your entire production operation, from ideation to utilization.

Other emerging technologies include predictive learning, big data analytics, additive manufacturing and advanced robotics. In every case, the digital twin will enable you to virtually test, validate and predict the performance and health of the products and processes before production.

Of course, cloud technology will support your digital twin implementations with up-to-date, flexible, cost-efficient cloud-based IT infrastructure that enables quicker innovation and time-to-market.

5

Improve production processes

Most of the excitement about digital twins centers on innovation, whether product or process. However, it's important to remember how digital twins can be deployed to increase manufacturing efficiency and effectiveness. An emerging trend is to use digital twins to enhance predictive maintenance. Though a recent Information Week survey found that only 4 percent of respondents consider digital twin an enabler of predictive maintenance, the value of supercharging predictive maintenance with a digital twin can come with many benefits: downtime reduction, reduced maintenance costs, improved equipment performance and reliability, extended asset life span, better inventory management, enhanced fleet management and more.

Increasingly more detailed parametric data is required to refine the production process and ensure that products are built at the highest quality, fastest speed and lowest cost. Continually and consistently improving production quality and speed requires close, automated monitoring that compares machine performance against established key performance indicators (KPIs). By using digital twins to conduct second-by-second audits, any deviation can be identified and corrected before any products are made below standards.

It's critical to understand that digital twins are transforming every phase of production and enhancing most—if not all—other Industry 4.0 technologies. Just as the conveyor belt was central to the era of mass production in the First Industrial Revolution, the digital twin is central to cyber-physical systems in the Fourth Industrial Revolution. Working from that premise will enable manufacturers to recognize the magnitude of digital twins' potential.

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