DIGITAL TWIN:
A PRIMER FOR INDUSTRIAL ENTERPRISES

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In recent years there has been a great deal of buzz around the concept of Digital Twins, gaining prominent placement in analyst predictions such as Gartner's Top 10 Strategic Technologies Trends of 2019.

According to IDC's 2019 Digital Transformation FutureScape, 30% of G2000 companies will have implemented 'advanced digital twins' to optimize their operations by 2020, the vast majority of which will be industrial enterprises. While discussions of digital twin have framed this technology as a modern business imperative, the first mention can be dated back to NASA in the 60s with the Apollo 13 mission. For enterprises deep in multitudes of digital transformation initiatives, digital twins can be convenient to lump into the category of nice to haves to add to the end of the to-do list. The truth is, digital twin technology is available today – and if you're an industrial enterprise, it's very likely that your existing technology can start compounding additional value unified through a digital twin strategy. In doing so, enterprises can expect to achieve outcomes like differentiation for their products, improved operational effectiveness across processes, and optimized productivity for their people.

But guidance for enterprises looking to develop digital twin strategies has been sparse in the market – with most conversations occurring at the conceptual level. Complicating matters, there has not been a consensus in the market as to what a digital twin is, creating confusion and barriers to widespread adoption. In this whitepaper, we will unravel the concept for business leaders looking to bring their digital twin strategy from vision to value.

WE'LL ANSWER QUESTIONS LIKE:

> What is a digital twin and why is the time right to develop a digital twin strategy?

> What is the digital thread and what business outcomes does it deliver?

> What use cases are creating value for industrial enterprises today?

> What is a practical approach for defining or assessing a digital twin initiative?

> How can enterprises act today to begin their digital twin journey?

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Why is the time right to develop a digital twin strategy?

Industrial enterprises are feeling more pressure than ever before to deliver results and react to constantly changing market landscapes. Competitive and disruptive threats are reshaping product and service expectations to demand higher quality and greater flexibility. Global trade and cost pressures are presenting new risks that are demanding ruthless efficiency and lean, agile operational processes for industrial enterprises to compete at blazing speed. A looming skilled labor shortage is forcing companies to rethink the way they empower their front-line workers to remain productive and agile. Companies are undergoing digital transformation and applying technology to try to address these challenges – and they're generating an incredible amount of data in the process, giving way to a new set of technology-based business challenges.
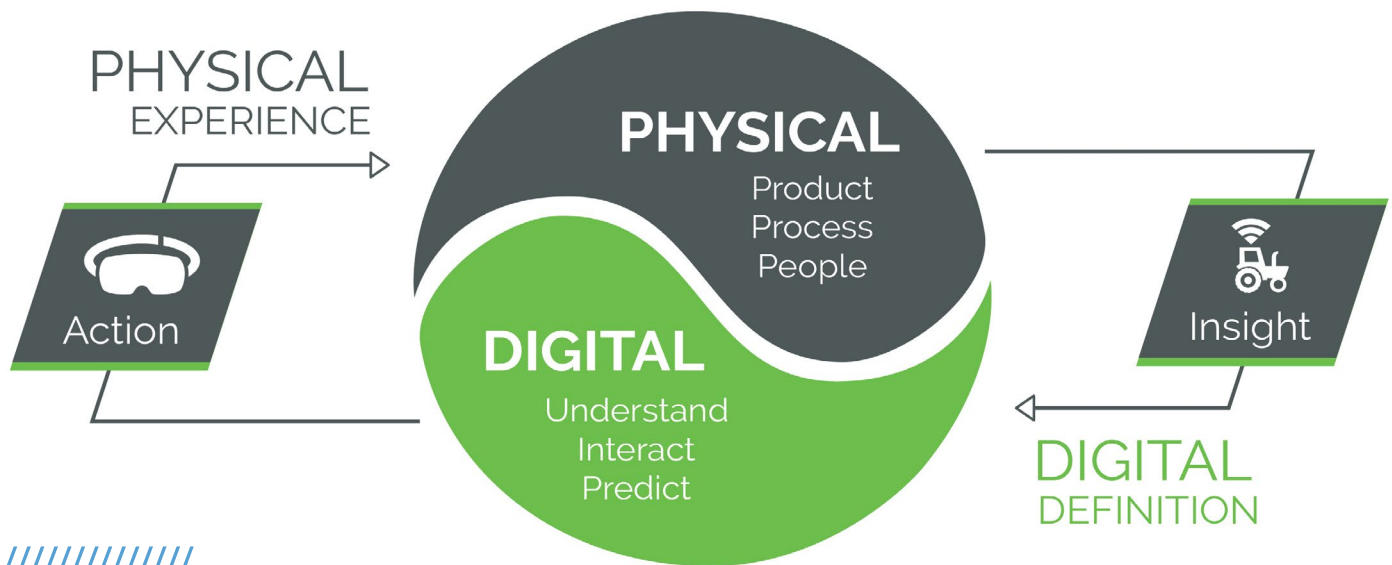
What Is a Digital Twin?

Digital twins are digital models that virtually represent their physical counterparts. This virtual representation of a physical product, an operational process, or a person's task is used to understand or predict the physical counterpart by leveraging both the business system data that defines it and its physical world experience captured through sensors.

PHYSICAL EXPERIENCE

Action

PHYSICAL
Product
Process
People

DIGITAL
Understand
Interact
Predict

Insight

DIGITAL DEFINITION

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What started out with the capture and storage of enterprise data has slowly crept out of the server closet. Sensors are everywhere, and telemetry data is being created by not only Smart, Connected Products, but for entire enterprise processes and systems, and with augmented reality and other people-centered technologies being adopted, there are even digital connections to people. The result is that today this data exists in siloes across organizations, each possessing limited context which in turn limits its value. Enterprises have recognized the need to integrate this new data but have been struggling with the strategy to do so in a scalable and effective way. Systems integration spending is growing rapidly year over year, and accounts for increasingly large portions of industrial companies' spend. One key objective of this spending is to map data from currently isolated technology siloes as companies recognize the value of centralizing and simplifying the process of information discovery and analysis. In addition to providing universal data access, enterprises also recognize that exploring the relationship between interrelated data sets offers higher order insights than any one set alone. This data unification is a necessary pre-requisite to building a digital twin, and is often referred to as a digital thread.

With new technologies like augmented reality and IoT creating and demanding vast amounts of data from disparate sources, it is more important than ever that companies have a clear strategy as to how and why they will integrate their various operational and information technology. The digital thread is the essential groundwork that can turn the common dilemma of spiraling cost and complexity of digital transformation into an opportunity to enable faster time to value, greater agility in change management, and more data-driven decision making. A digital twin is a model for contextualizing, analyzing, and realizing the value of the digital thread in a way that enables it to be acted upon and scaled across multiple solutions and front-end applications. In other words, the value of a digital thread is manifest through the discrete use cases served by digital twins.

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What enterprise outcomes does the digital thread deliver?

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Defining the Product and Service Experience: Customers of industrial product manufacturers are feeling pressures to ensure maximum return on their investments. It is an imperative that product and service providers become proactive in their contribution to customer success. Yet defining the customer journey end to end has proven to be a challenging and costly endeavor for enterprises of all kinds. For example, sales organizations often analyze customer purchasing history to understand new market opportunity. Separately, R&D may analyze smart, connected product usage data to identify utilization of specific features for future development. Both seek to define the characteristics of successful customers, yet each is working with limited data sets. By mapping these streams of value rich insight under a digital thread of the product or customer experience, transparency is created across roles and opportunities are unlocked to develop digital twins that proactively strengthen the customer relationship, improve the quality and value of products, and tap in to new sources of service revenue.

Operational Process Visibility: Enterprises are struggling to keep pace and manage the necessary rate of change in their operational processes. By the time information becomes available to the necessary stakeholders in upstream and downstream functions in the value chain, risk has escalated, placing companies in a reactive state that is costly, wasteful, and inefficient. Mapping operational process data utilizing a digital thread for asset and process-related data, companies can develop digital twins to gain the transparency and operational predictability to simulate and orchestrate change or optimize operational processes across the value chain with high speed and accuracy.

Data-Driven People: Studies that show that employees spend upwards of 35% of their workday looking for and consolidating information. When you build, for instance, a digital thread of a production process, that thread can centralize data about asset utilization and health, overall throughput, to provide workers with a holistic view of end-to-end operations. Analyzing this data either in real-time or in retrospect through a digtial twin can improve decision making not only at the management or total system level, but for the individual workers involved in that process. With the emergence of augmented reality, front-line workers can experience this value for the first time. The concept that digital twins centralize and present data in an actionable format is a key characteristic of their value.

A digital thread is the connection synchronizing related upstream and downstream information. A digital thread creates continuity and accessibility to a common set of data, defining the product, process, or people that it relates to across the enterprise functions. It solves a few key challenges of its own:

> **360 views:** By mapping related data sets through a common platform, true 360 degree views of products and processes become available, unlocking the opportunity for higher order insights delivered through a digital twin.

> **Single Source of Truth:** Visibility is achieved upstream and downstream across roles by delivering real-time updates and channels for communication, driving a culture of agility and innovation.

> **Scalability:** New products, processes, and technologies are coming online every day. With a digital thread architecture, data is interoperable from the start – enabling scalable gains in efficiency and change management.

What use cases are creating value for industrial enterprises today?

Opportunities to create value from digital twins exist across industries, but their deployment is delivering most significant early impact in industrial enterprises. This is due to the prevalence of connected products as well as connected-operational environments, and even the emergence of connected workers through augmented reality. Industrial enterprises may also have much of the requisite technology deployed today. The impetus for connecting the dots between this technology to create a functioning twin is driven by functional business challenges and opportunities.

Once a twin is established, we see examples of digital twins driving value across the enterprise, and nucleating around a few key use cases led by functional champions in engineering, manufacturing and operations, and maintenance and service. While a unique product, process, or person may have a common digital twin, use cases are delivered through 'lenses' into this digital twin that are specific to the role and task. Multiple twins can also be combined to create system-wide visibility that provide broader insight for a total business function or system of twins.

Key Digital Twin Use Cases
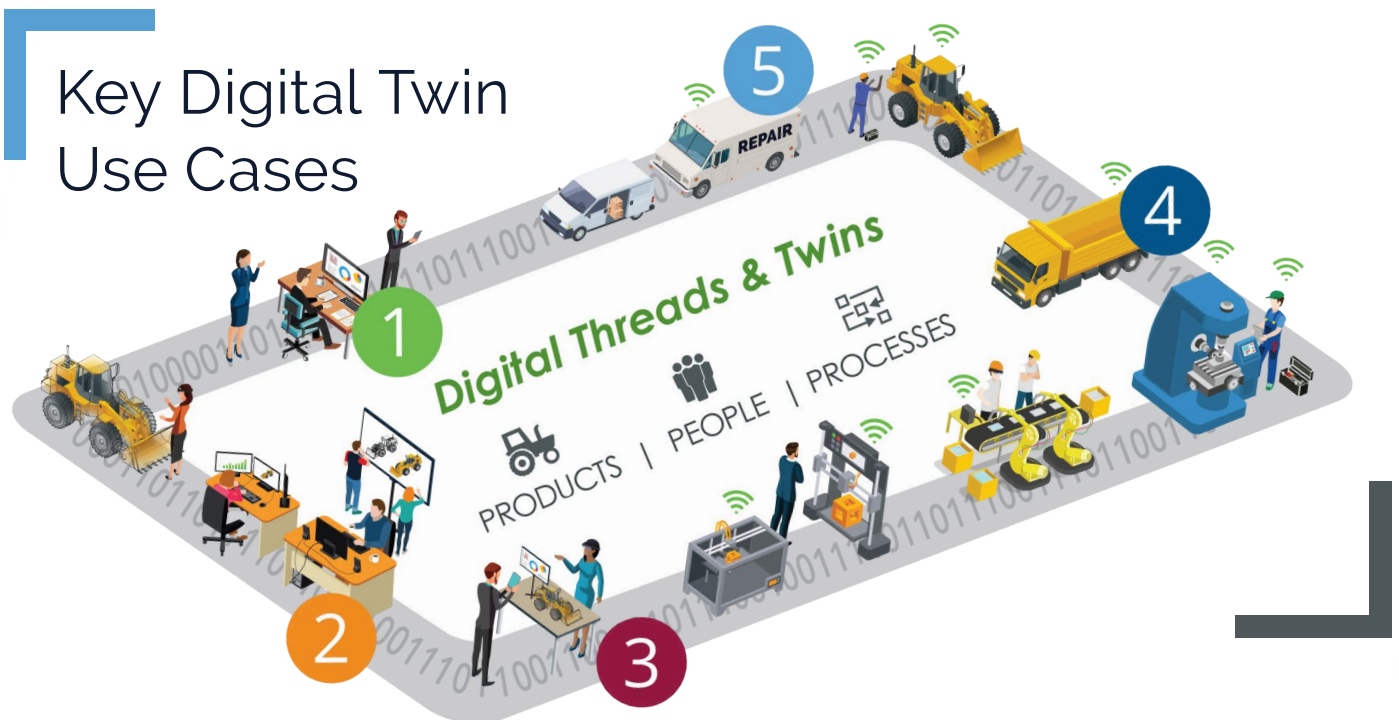
1
Corporate/CXO
Unlock new outcome and usage-based business models that increase customer lifetime value and profitability

2
Product Engineering
For discrete manufacturers, enables "Voice of the Product" that replaces usage assumptions with facts, accelerating time to market with optimized features and designs

3
Sales & Marketing
Develop customer transparency and alignment that reduces cycle and lead times and provides opportunities for up-sell, cross-sell, and relationship building

4
Manufacturing & Operations
Gain production visibility and planning that improves operational agility, increases throughput, and optimizes process efficiency throughout the supply chain

5
Customer & Technician Service
Create enhanced service delivery and offerings that improve customer satisfaction through increased uptime and quicker time-to-resolution

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A Product Lens for Engineering

Engineers have been discussing the concept of closed-loop product lifecycle management for decades. Until relatively recently with the advent of smart, connected products this has been limited to academic discussions. Now, with the new real-world data created by these smart, connected products, the opportunity exists for the first time to understand product usage and behavioral characteristics of individual products or systems of products, for example a fleet, after they leave the factory. As companies seek to leverage this new source of product insight, they are discovering that digital twin architectures are the best way to create meaningful value from the data. By bringing in real-world data and analyzing it in the context of physics-based engineering simulation, product designs and user experiences can be improved according to real-world facts, rather than assumptions.

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KEY BUSINESS OUTCOMES

> **Engineering Excellence:** Real world usage data combined with product simulation enables engineers to adapt to changing markets and to optimize future product designs for higher quality, and reduce engineering costs while accelerating time to market.

> **Downstream Efficiency:** Extend the digital thread to downstream stakeholders to enhance cross-functional collaboration, enabling efficient change management in manufacturing and service processes, eliminating scrap and rework, and reducing lead times. The twin can also be adapted to generate manufacturing and service instructions that can be paired with the product inside and outside the organization.

> **Success-Driven Design:** Analyze the as-designed versus as-used product data to optimize product requirements to better fit customer needs and bring differentiated product enhancements to market before the competition.

CASE STUDY | Whirlpool

Whirlpool is combining the real-world insights from smart, connected products with the product definition through a digital thread, and applying simulation capabilities through a digital twin to test low-fidelity prototypes with minimal investment. Through the digital twin, Whirlpool is able to minimize the time it takes to test new concepts – using facts instead of assumptions to drive ideation. This increases the speed of innovation and accelerates the introduction of new products to the field.

Value >>>

> Cross-functional collaboration between product and service groups, reducing redundant information systems and analysis, and providing greater enterprise agility across their global operations.

> Product development cost are reduced by replacing assumptions with facts and enabling more cost effective digital simulation and prototyping.

> Improving customer success by reducing documentation search time and mapping sensor and customer data into intuitive, contextualized views.

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A Process Lens for Manufacturing and Operations

Operational transparency is a costly endeavor exacerbated by the proliferation of information systems. Insights often go undetected due to the inability to connect the dots between disparate information systems. After building a digital thread of an operational work-flow, a process lens can be deployed to combine, analyze, and deliver operational insights that blend real-time updates from connected assets and workers with production expectations. The process lens often leverages multiple digital twins to provide a system-wide view of a total operations or manufacturing environments. Through analysis, businesses can adapt and orchestrate operational processes for greater forecasting accuracy and improved operational effectiveness.

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KEY BUSINESS OUTCOMES

> Agile Change Management: Access customer order and supply chain data and analyze against current operational configurations to adapt processes to develop production plans optimized for speed and agility. These plans can also be shared upstream and downstream to improve efficiency across the supply chain.

> Reduced Operational Risk: Enable predictive analytics to simulate the impact of unplanned operational changes, reducing risk.

> Optimized Production: Combine KPIs and operational insights across production environments, creating enterprise-wide reporting consistency, and benchmarking best in class processes to ensure lean operational excellence.

CASE STUDY | WOODWARD

Woodward, one of the worlds largest providers of controllers and components for industrial and aerospace markets has developed a digital twin of their operations – from design, to manufacturing, and service. Their goal was to gain agility and improved decision making from the abundance of product, operational, and process data across their engineering systems, enterprise and manufacturing execution systems, and deployed connected assets. By taking a single-platform approach to unifying these systems, and developing an intuitive front-end UI for various roles, Woodward was able to better understand the end-to-end process flow, yielding greater throughput, visibility, and agility in their operations.

Value >>>

> Cost savings and scalability for their systems integration needs, with greater future agility and flexibility to deploy new assets and systems with ease.

> Lower manufacturing costs and improved production quality through proactive process improvement and predictive asset maintenance.

> Role-based visualization of end-to-end operations, providing 'just in time' information and visibility for workers and improving collaboration across the value chain.

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PROCESSING INPUT

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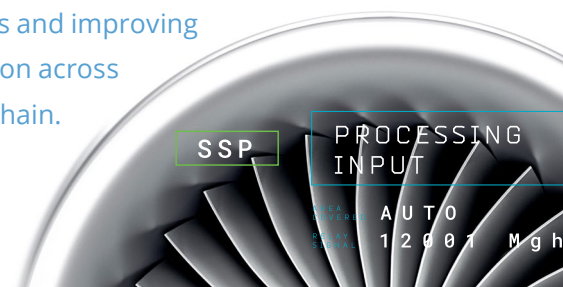
A Customer Success Lens for Service

The cost of downtime and production delays can absolutely cripple industrial enterprises' relationships with their customers and severely harm their bottom line – both for producers of industrial equipment as well as users. It is no secret that downtime costs global industries millions of dollars in lost revenue every year. Combining the digital thread, and real-time sensor data from connected products, digital twins for service and customer experience help enterprises move from reactive to prescriptive in the way they deliver experiences and outcomes to customers. Machine learning, remote diagnostic capabilties, and physics-based simulation all help to drive a greater level of understanding of how a product or service and expected outcomes are experienced by the customer. A digital twin of a product or service procedure in a customer environment unlocks new revenue opportunities and strengthens customer relationships.

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KEY BUSINESS OUTCOMES

> Technician Success: Consolidating enterprise, engineering, and service-network data into role-based views enables providers of products and services to optimize service process experiences and deliver new self-service capabilities to their customers.

> Reduced Downtime: Proactively identifying machine service and maintenance needs by simulating historical patterns or design expectations of machine performance against real-time sensor data to reduce unplanned downtime and maximize asset utilization and customer value.

> New Business Models: Unlock new usage or outcome-based service contracts that leverage usage, availability, and operational data to simulate and orchestrate product parameters and deliver remote updates and value-add services.

CASE STUDY | Howden

Global air and gas handling equipment provider Howden has rolled out its connected field maintenance program 'Uptime' that delivers digital twins of their products to customers and service technicians through augmented reality. The application enables customers to predict and optimize equipment performance and reduce unplanned downtime, improving customer success and optimizing service and maintenance outcomes.

Value Metrics >>>

> Enabling proactive and pre-emptive performance analysis to optimize maintenance scheduling and reduce downtime.

> Instant data access for Howden service networks to understand and drive resolution for customers remotely.

> Unified view of sensor and simulation data for customers to have visibility and a greater understanding of asset performance.
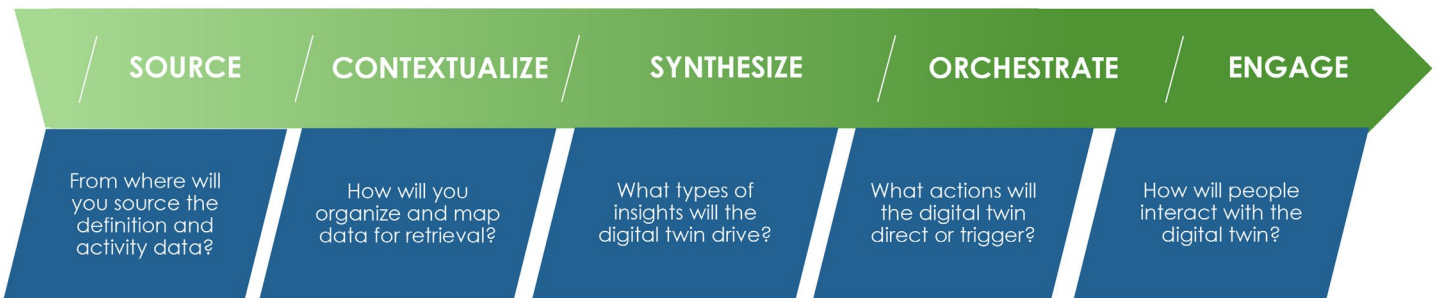
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Building Your Digital Twin

As we've seen, there are no shortage of opportunities across the value chain to develop digital twins to improve business outcomes and decision making. While identifying opportunities can be overwhelming, the aforementioned use cases are proven in the market to be the most simple and straightforward to stand up, delivering a quick return on investment. From there, these use cases can be adapted and extended to further differentiate product and service offerings and drive operational effectiveness in your processes.

The time is now for industrial enterprises to build out their

digital twin strategies. With the maturity of the enabling technologies and digital thread initiatives reaching critical mass, many companies are taking stock of their current capabilities and moving quickly to fill the gaps. The way digital twins are delivered through various lenses can vary greatly based on the specific use case being pursued, but core considerations should be addressed based on necessary capabilities. Companies seeking to advance their digital twin strategy will benefit from organizing current and future capabilities into the following framework. From there, specific use cases can be plotted to organize requirements and develop a plan of action.

SOURCE	CONTEXTUALIZE	SYNTHESIZE	ORCHESTRATE	ENGAGE
From where will you source the definition and activity data?	How will you organize and map data for retrieval?	What types of insights will the digital twin drive?	What actions will the digital twin direct or trigger?	How will people interact with the digital twin?

Source

A digital twin requires you to combine the digital definition from related business systems with real-world data and insights from the physical world via sensors. Companies must decide what source data they will include, for example manufacturing process plans or operating procedures that define a process combined with the real-world telemetry and sensor data from manufacturing and production environments. Adding additional sources to its definition, for example supply chain data from an MES system, can drive increased overall context for the twin as well as unlock additional use cases without rework. Additional technologies continue to add to potential sources of insight. In the future, with the bounty of sensor data coming online through AR devices, people and the spaces they inhabit (factories, buildings, etc.) will be defined and integrated into twins as well.

Contextualize

Digital twins give unified insight into the data connected by the digital thread. Once a use case is understood, unique identification and organization of data surrounding an individual product, process, or person can be mapped and organized to inform the twin model. It could be contextualized into an overall process, enhanced with behavioral data, or used to align to desired KPIs. Understanding the over-arching goals of the twin will help to contextualize it into the type of digital twin model that makes the most sense.

Synthesize

Analytics can be used to add value for certain use cases to inform business decisions with greater accuracy and unlock hidden insights, or the value can be self-evident. Analytics

could be applied on the mapped data to answer questions along common frameworks, for example descriptive answers to questions like how a product is performing, to diagnostic questions around cause of failure, and predictive or prescriptive questions that simulate potential scenarios and optimize performance outcomes.

Orchestrate

Orchestration is where these insights are put to task. Triggers can be created that automate or direct actions based on the result of the answer or analysis. For example, a process trigger could be put into place to dispatch a technician or create a customer service ticket for a product failure. You could automatically propose remote configuration updates based on performance characteristics. It is also possible to deliver updated KPIs and worker priorities based on customer or supply chain activities. Whatever questions you seek to answer, a corresponding action can be orchestrated to react, and measurable KPIs and outcomes can be captured.

Engage

Digital twins are delivered or interacted with through a front-end UI or 'lens' that is role or task-based and specific to a given use case. They can be delivered through interfaces such as desktop and mobile devices, and emerging technologies like augmented reality are provide additional options. In fact, augmented reality provides the capabilities to capture spatial data related to environments and workers to eventually develop digital twins of these previously undefined spaces and processes. These technologies also offer enhancements to the fidelity and user experience of digital twins and make use cases accessible to new stakeholders such as deskless workers.

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Getting started: Where to begin your Digital Twin journey

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Many business leaders may be surprised to learn that if you're already gathering data from your products, processes, or people little additional investment is needed to stand up a basic digital twin model. In addition to the requisite digital thread connecting siloes of interrelated data, you may even have the enhanced front-ends and analytical capabilities in place. For companies looking to extract real-world insights to improve product design, for instance, they need only to securely deliver that product sensor data back to product engineering systems in a compatible format for simulation. Below are a few practical actions to take today to advance your digital twin strategy:

1 > Assemble cross-functional tiger teams to understand pain points or use cases that will break down silos and deliver value to multiple teams, producing the greatest ROI and enabling the greatest flexibility to adapt and mature the digital twin over time.

2 > Inventory your technology initiatives and the goals they seek to achieve to determine where digital twin use cases can be enabled with minimal investment and pre-defined success metrics.

3 > Identify business partners whose technology ecosystem integrates easily across your entire technology footprint and who possess the requisite capabilities. Consider not only what can be done today, but how your twin might evolve over time to avoid costly and challenging integration projects down the line.

Gone are the days of digital twins being a concept to daydream about in the future. Many industrial enterprises are deploying digital twins and reporting significant benefits today. Many more have the building blocks in place and are missing out on untapped value – all they require is the unified vision and partnerships to construct the model that fits best to solve their unique challenges. Successful implementations will require executive-level buy-in, the right mix of technology capabilities, and domain expertise often stemming from partner ecosystems.

The confusion surrounding digital twins is rooted in their nearly unlimited potential coupled with varying, and often narrow, schools of thought in industry. The time is now for industrial enterprises to create a digital twin strategy, to take a step back to view the mosaic of technology initiatives that exist today and to connect them to executive-level business objectives.

Contact an Expert to learn more about how PTC's network of strategists and partners as well as our unique technology portfolio can help you unlock the value created at the convergence of the physical and digital worlds through the use of digital twins.

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