

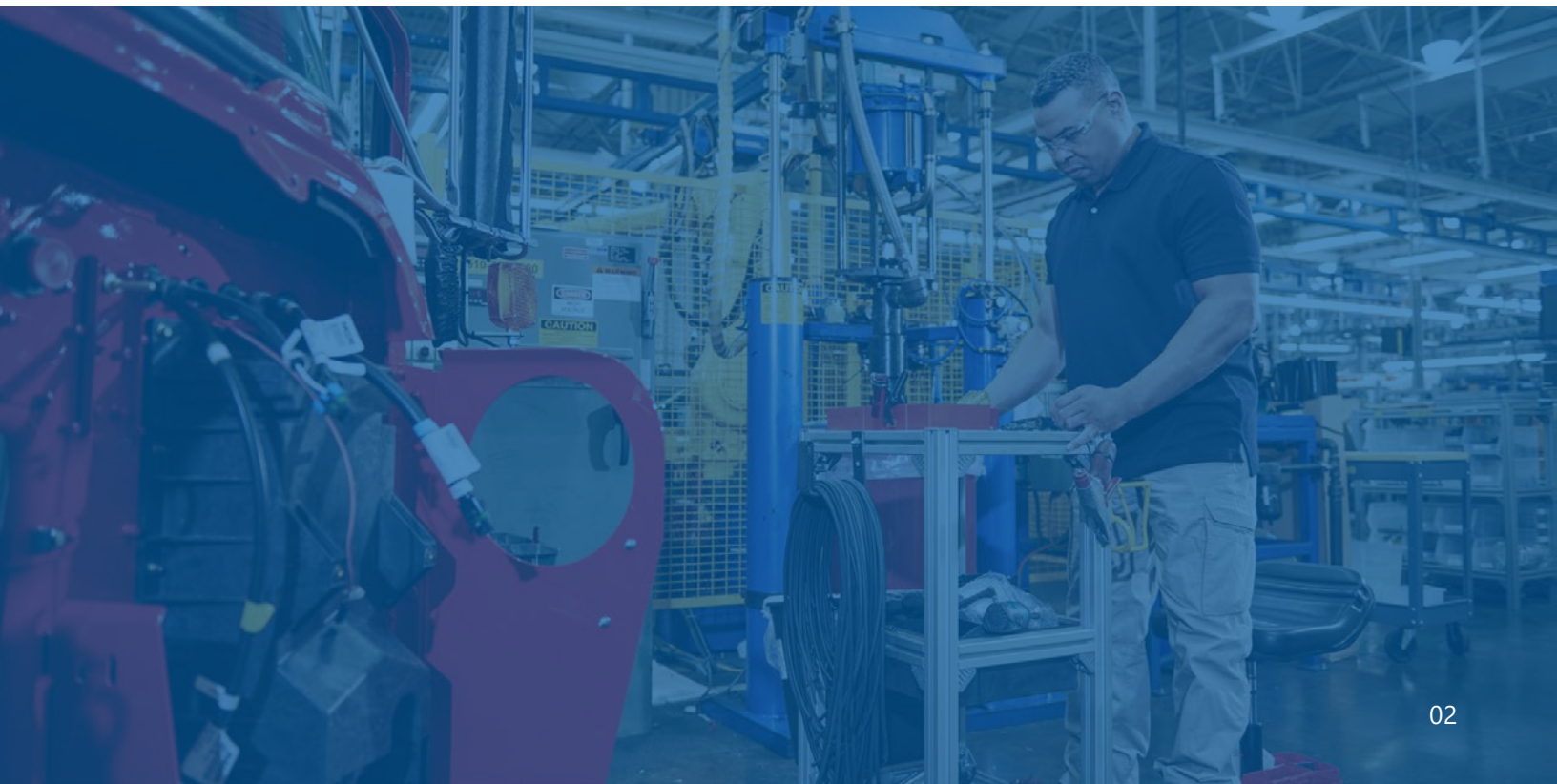
The promise of a digital twin strategy

Best practices for designers and manufacturers of products and industrial equipment



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Introduction

Designers and manufacturers of products are experiencing a major transformation as digital technologies are reshaping what is possible, from achieving new levels of operational efficiency to creating new service offerings and beyond with innovative business models.

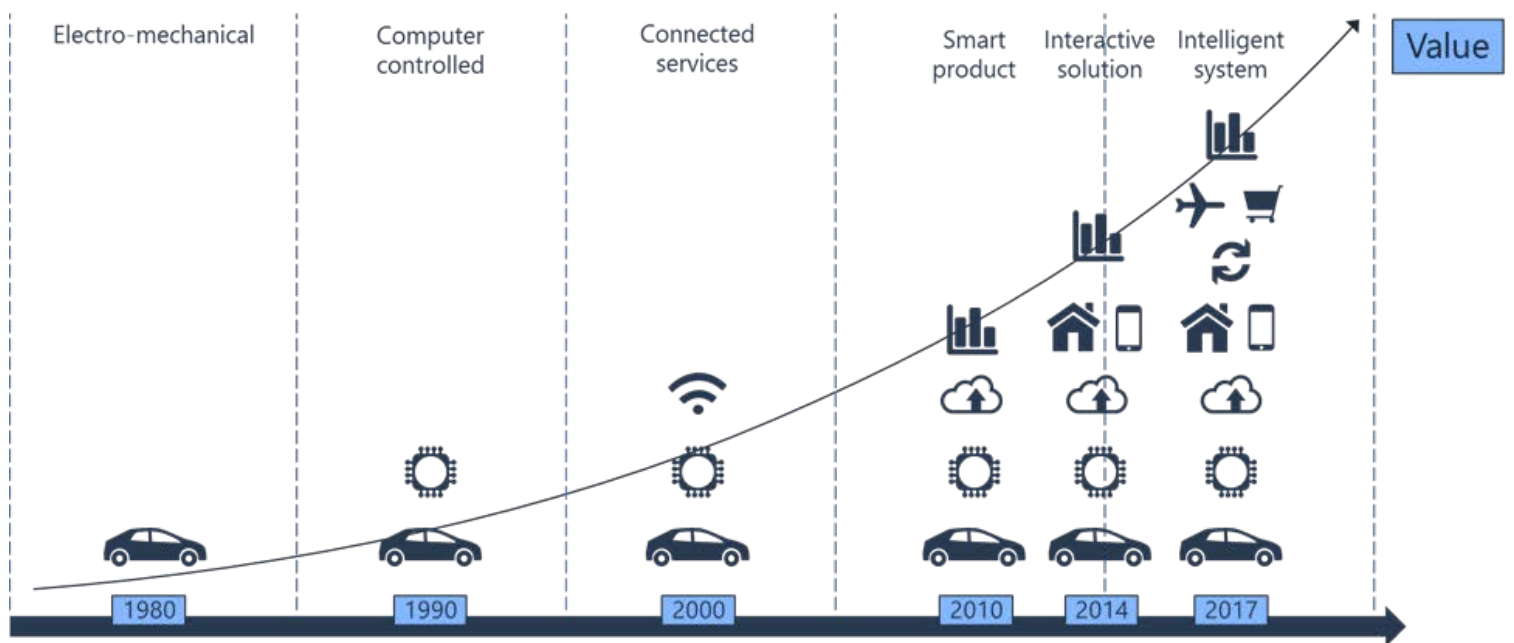
At Microsoft, we believe designers and manufacturers can benefit from creating a **digital twin strategy and platform** for the business to host innovative new offerings and achieve a holistic approach to transformation.

In this paper, we define the scenarios that will have the biggest impact on your business and show you how Microsoft is uniquely positioned to help you plan and execute a digital twin strategy.

Digital transformation: An imperative

Today's digital transformation is changing the priorities of nearly every enterprise. In the future, all companies will be digital companies—not only creating smart connected products, but building services to capture new business opportunities and engage with the value chain differently to meet their evolving expectations.

This kind of transformation can be incredibly difficult, particularly as traditional businesses move from tried-and-true product design strategies and manufacturing processes that have worked for decades. The definition of a product today is vastly different from one created 3-4 years ago. There is a growing expectation that products will not solve for only a discrete business or lifestyle issue but rather will add and derive value from the ecosystem where it exists and functions.



The challenge extends beyond just designing a product that combines the best attributes of physical and digital worlds. Product lifecycles are changing. Products must not only get to market faster and at the right time, they must also evolve and improve to sustain value for both the designer/manufacturer and owner/operator. As a consequence, many manufacturers are challenged to keep pace. This means that the transformation is not limited just to product design and definition, but rather significantly impacts the way products are manufactured, assembled, delivered and maintained.

Digital transformation: An imperative

Continued

In reality, Industry 4.0 is a journey. Many manufacturers have to work with equipment that spans decades of investment, remain at the forefront of cybersecurity practices, and develop and attract the skilled workforce of the future. This doesn't happen overnight; digital transformation is an investment and commitment to constant evolution.

To get ahead of the curve, organizations are making digital transformation a priority as CEOs expect digital revenue to double in the next five years. IDC says that by 2020, 70% of manufacturers will put operations at the forefront of these projects¹. The intelligent factory is quickly becoming a reality as 40% of operational processes will be self-healing and self-learning by 2022². At the same time, IoT-based sensing and cognitive situational awareness will continue to improve the speed of operations. IDC estimates this will create 30% improvements in the cycle times of impacted critical processes by 2018³.

Designers and manufacturers that can achieve digital excellence will thrive in this new world. To do so, they must create a consistent digital information thread throughout the enterprise and value chain. This founding principle is enabled and enhanced by cloud- and edge-based technologies and capabilities that can facilitate potential for gains in engineering, supply chain, manufacturing, final assembly and test. The digital twin is strategy that can turn this digital information thread into real value.

The digital twin revolution

One of **Gartner's Top 10 Strategic Technology Trends for 2017**⁴, a digital twin is a virtual model of a process, product, production asset or service. Sensor-enabled and IoT-connected machines and devices, combined with machine learning and advanced analytics can be used to view the device's state in real time. When combined with both 2D and 3D design information, a digital twin can visualize the physical world and provide a method to simulate electronic, mechanical, and combined system outcomes.

This pairing of virtual and physical worlds allows monitoring of systems and analysis or simulation of data to head off problems to prevent downtime, optimize overall operations to increase uptime, and even develop new services for the future. These can be unique to each customer but can also be used to intelligently record and compare a global fleet view of insights that can improve internal processes such as design engineering, supply chain management, quality processes, manufacturing operations and field services. To be successful, a digital twin must be intelligent, collaborative, interactive, immersive, and fully contextual within the OEM's enterprise.

Physical asset operational in the field



Virtual asset and services in digital space

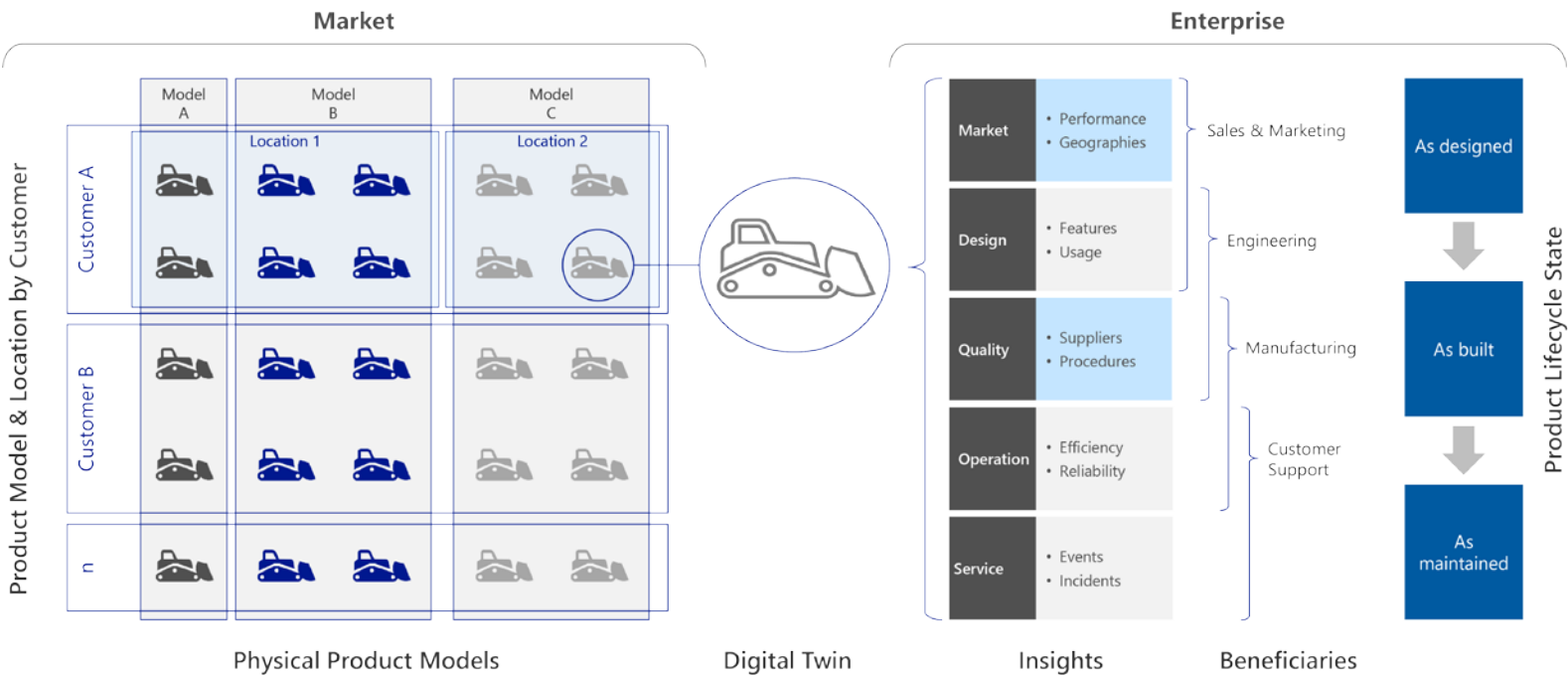


Real-world,
real-time operating
data and diagnostics

Performance
optimization and
enhancements

* Image source: https://www.cat.com/en_US/products/new/equipment/dozers/medium-dozers/1000000223.html

The digital twin revolution Continued



The digital twin model is not new. NASA was the first to experiment with the precursor to a digital twin—pairing technology—in the early days of space exploration. The formal concept of a digital twin was first introduced in 2002 as an information mirroring model by Dr. Michael Grieves⁵. In 2013, Eric Tuegel, AFRL/RQVS, of the United States Airforce Research Laboratory, progressed the definition of Digital Twin with “Airframe Digital Twin.”⁶ The definition included an integrated architecture spanning design, test and evaluation, manufacturing and assembly, sustainment and maintenance, repair and overhaul, and the creation of a lifecycle-wide probabilistic support system for decision making.

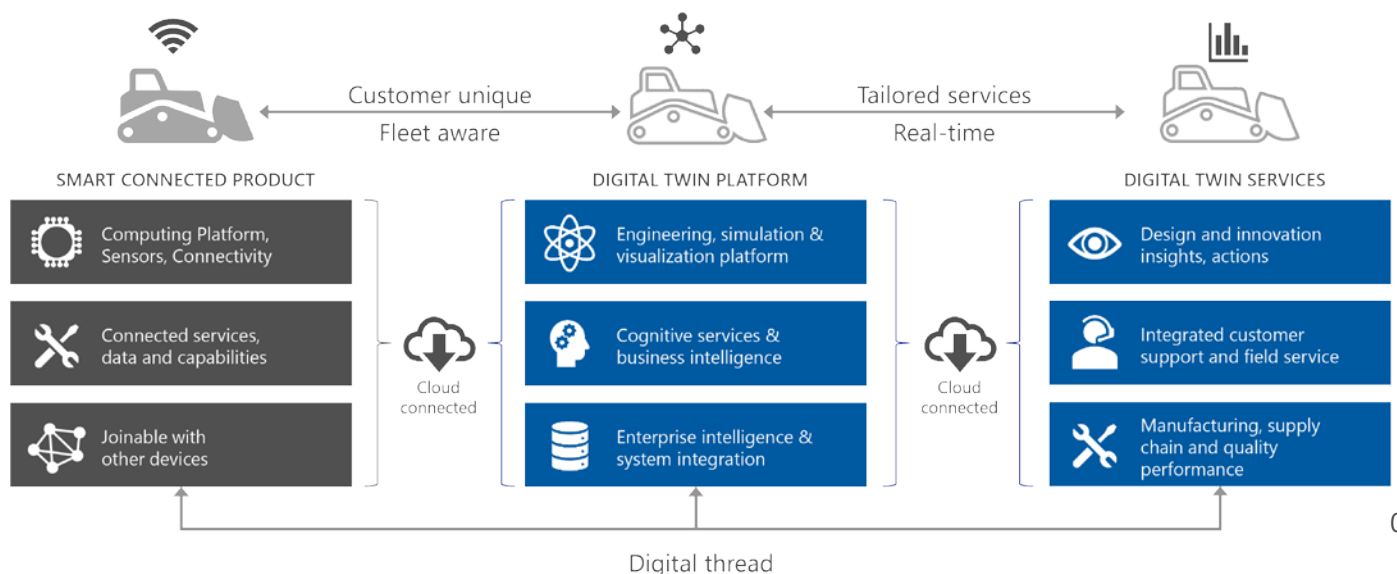
What is new today is the method by which you can facilitate a digital twin strategy based on advanced technologies like IoT, cognitive services and cloud computing to form the basis to develop and deploy dynamic applications and services that cater to enterprise and customer needs. Within the last decade, the concept of a digital twin has been mostly used for product design and simulation by utilizing a data-driven 3D digital companion. Most recently, data and advanced analytics have enabled digital twin technology to do more than simply mirror key processes within physical assets. Now a digital twin strategy can use machine learning to predict outcomes based on historical data and algorithms specific to parts, systems, subassemblies and assemblies that further consider lifecycle states from as-designed to as-manufactured to as-maintained. Today predictive analytics and advanced visualization allow us to explore or identify new opportunities and business models.

Digital twin architecture for an integrated enterprise offering

Developing a digital twin strategy should always begin with the intended business benefits, outcomes, and impact on people, practices, and processes. It is not simply enough to validate that the technology functions. Often many digital strategies fail to meet expectations because they are focused on proof-of-technology versus proof-of-value. Once value is well articulated, the technology can be proven through use cases with measurable results. As an example, if the goal of a digital twin strategy is to increase equipment availability in the field, the scope of the use case can span equipment health insights through to optimal scheduling of parts and field engineers. The measurement of success can then take the form of total availability sustained validated by the number of maintenance incidents mitigated, elapsed time for replacement part availability, and reduction in time taken to deploy resources in the field.

The approach to this use case can be the analysis of equipment telemetry such as onboard diagnostics or analytical processing of historical performance data, but represented as a relative health measurement easily identifiable by a field engineer. This representation could be purely data driven and displayed through a dashboard or a holographic indicator shown within the context of the actual equipment as it operates.

The manifestation of value could be the creation of a customer facing digital twin service that manages availability of their equipment through automated insights and expert assistance from the manufacturer.



The impact of a digital twin strategy

What would it mean to your organization if you could mitigate equipment failure, streamline your factory operations and processes, increase operational efficiency, and perform enhanced product development? A digital twin strategy offers you exceptional ways to achieve these objectives, allowing you to transform your business by applying virtual lessons to the physical world to uncover new opportunities and business models.

A digital twin strategy is most effective when applied to low-volume, highly-configured products where you need detailed information to quickly respond to changing conditions, particularly for things like asset optimization and preventive maintenance. The insights you gain will enable you to operate at peak performance because you can maintain your equipment in such a way where it never fails. The end result? You can lower operating expenses and increase efficiencies as you extend the life of your equipment and optimize its daily performance.

Another effective approach is to expand the scope of your digital twin strategy from a single object or piece of equipment to build a digital twin model of your supply chain or entire factory. This will allow you to have complete visibility across all levels of your plant operations and processes—all the way down to how individual machines and people are interconnecting in real time and even external factors. The combination of this information gives you very personalized, actionable information.



The impact of a digital twin strategy

Continued

As you bring in this kind of intelligence, you can drive significant levels of growth and efficiency across your manufacturing organization by:

1 Creating new customer and enterprise value through personalized service. A digital twin strategy serves as the ultimate customer service application for your business. Real-time data shows you how your customers are operating and maintaining their products. These insights allow you to further optimize equipment operation and ensure improved uptime and availability. This has the potential to completely change the way your business manages customer support today as you move to more personalized service, versus a one-size-fits-all approach. New value-added digital services and revenue streams are also now possible as you transform the products you take to market and create new customer experiences by leveraging digital twin insights. You can extend capabilities such as customer support and field service, as well as develop upgradable opportunities for customers tailored for optimal performance of their specific equipment. This can drive unique revenue opportunities for OEMs and resellers as well.

2 Driving product quality and innovation. Digital twin simulations, using real-world data learned from how existing equipment, processes, and products perform over time, allow you to experiment with design iterations, make more informed design and engineering decisions, and enhance the overall product roadmap. For example, by simulating the outcome of changing different components within a specific product, you could determine if that change will allow you to meet your quality goal or will merely increase the cost of the product with no other measurable gains. This data allows you to influence and validate new prototypes and bring better, more innovative products to market faster. Pioneering breakthroughs are more achievable and cost-effective, as well as better aligned with the full product life cycle.

The impact of a digital twin strategy

Continued

3 Preventing breakdowns before they occur. You can reduce production costs and downtime by using a digital twin simulation to adjust product performance, safely postpone non-regulated maintenance events if needed, or even eliminate problems before they occur. Service technicians can manipulate equipment digitally in real-time, or visualize problems ahead of a job to optimize the operation of existing equipment and perform preventative maintenance. Experts can support technicians in remote locations by using immersive and rich virtual, augmented or Windows Holographic experiences to help troubleshoot more complex issues by visualizing complete systems including hidden or obstructed parts and assemblies. Ultimately, a digital twin strategy allows you to reduce or mitigate devastating failures and have more operational flexibility and efficiency.

4 Reinventing knowledge-sharing for employees. Your digital twin strategy can allow your experts to explain complex scenarios visually, with 3D and 2D representations of real-world operational parameters and characteristics. These types of tools are essential for manufacturers to democratize skills and knowledge-sharing when facing an aging workforce and an approaching skills gap between new or less experienced employees. A digital twin strategy also enables employees in both professional and trade roles to build skills while at work, opening up new possibilities through advanced and contextual knowledge sharing. Digital twin capabilities can have a significant impact in terms of providing proactive guidance that can span the enterprise by increasing innovation during the design phase through to improving field service personnel safety during maintenance procedures. Together with Windows Holographic devices such as HoloLens, your workforce can be more efficient and will always have the right knowledge and right skills in the right place, at the right time.

The impact of a digital twin strategy

Continued

In all cases, products and processes are fixed faster, equipment stays working longer, manufacturers can develop better products, and the workforce is more efficient. The key is the ability to use real-world operational data to make smart, informed changes that provide the best resolution in real time or scheduled—whether data is captured from just one customer or many. The digital interface of the twin allows you to simulate many different scenarios—eliminating costly physical trial and error—before you put the final change in place.

Implementing a digital twin strategy will soon be non-negotiable for most manufacturers. As the foundation for your connected products and services, it is a critical path to enabling asset or process lifecycle management, intercompany collaboration, flexible vertical integration, and end-to-end re-engineering. Manufacturers that do not keep up with this innovation will be quickly left behind.

Next, let's look at how you can get started with a digital twin strategy today, best practices for driving innovation, and examples from leading enterprises that are differentiating their business with a digital twin strategy.



Three stages of the digital twin journey

The digital twin journey begins with a data-centric strategy that can evolve to three stages of maturity. You can start realizing the benefits of a digital twin strategy at the very first stage. As you continue your evolution, your business will be transformed as you use a digital twin strategy as a competitive advantage to meet the changing needs of customers, achieve new levels of operational efficiency, drive product innovation, and capture new business opportunities. As your business evolves, so will your digital twin strategy.

Stage 1: Remote monitoring of smart, connected products with predictive analytics

For many businesses, the journey to a digital twin strategy starts with the basics: smart connected products and remote monitoring. A digital twin strategy allows you to store and monitor product configuration details and performance information unique to each customer, all while being fleet-aware.

Having access to this device data provides a significant amount of value, with no requirement to connect to any visual content such as 3D or 2D computer aided design (CAD) content. You can leverage interactive data visualization dashboards such as those found in Microsoft Power BI. In this first step, you have still accomplished a digital twin environment because the data is unique to the customer, however there remains opportunity to expand and enhance capabilities by extending into predictive analytics, connected field service, and ultimately into engineering.

This is where Microsoft's cloud platform provides a comprehensive set of capabilities that span device to service to application, essentially creating a unique bond between the customer and the enterprise.



[Rolls-Royce and Microsoft collaborate to offer advanced operational intelligence to airlines](#)

Rolls-Royce is leading the industry by merging physical and digital worlds to gain insights into maintenance planning, fuel management, and overall fleet health—ultimately helping airlines run at reduced costs with longer lifespans for their aircraft. The company's Trent XWB turbofan jet engine is a significant data provider in the overall airline 'data platform' that uses predictive analytics and customized intelligence to help airlines operate at peak performance and utmost safety, as well as ensure the highest level of cost savings. This is a new level of predictive intelligence that could not be realized previously due to lack of access to either the right information or tools to process the information efficiently. Rolls-Royce can achieve these impressive results by using historical and real-time data feeds—without contextual 3D engineering model visualization capabilities.



Three stages of the digital twin journey

Continued

Stage 2: A platform for deep insights

After remote monitoring is in place, the next step is to build a platform to facilitate your digital twin strategy, one that gives you the actual virtual representation of the physical product or system, with a deep view into the mechanical, electrical, and digital components. Windows Holographic devices such as Microsoft HoloLens give you a powerful way to visualize this data and interact with the functionality and performance of the product and components.

It is this platform that gives you a complete picture of your equipment's genealogy. You will not only be able to see the physical view of the product as it is operating, but you can also see factors such as how it was designed, how it was manufactured, and how it is actually being maintained. This data gives you a completely new level of insight to accelerate innovation, increasing the overall value of the product through the development of new services for customers, improved operations of the current product, and new functionality for future product versions.



[Sandvik Coromant uses predictive analytics to optimize service](#)

To take its services to the next level, Microsoft helped Sandvik Coromant develop a scalable service model that integrates all elements of the production flow—people, machines, tools and data—to deliver an unprecedented level of field service. The model was developed with a predictive analytics solution that leverages Azure IoT Suite, Cortana Intelligence, and Dynamics 365, allowing the company to scale its expertise to its global customer base without the need to add manpower or reduce quality of service. With this technology, Sandvik Coromant can now provide services that help customers make more informed decisions and more easily calculate the financial return on a new machining tool. That translates to additional revenue, more satisfied customers, and greater flexibility in how its technical experts connect with customers.



Three stages of the digital twin journey

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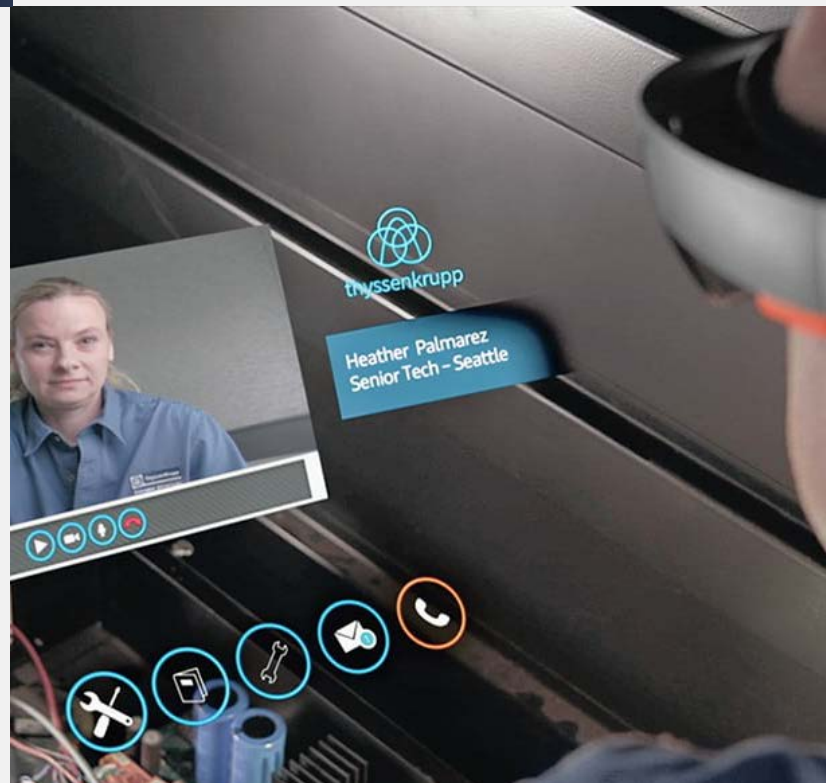
[Tetra Pak's technology keeps food and drink flowing safely from farm to table](#)

Packaging pioneer Tetra Pak is using a digital twin strategy to advance its services operations. Having started with the utilization of remote monitoring capabilities, the company is now employing new digital tools that enable its cloud-connected machines to predict exactly when equipment needs maintenance, averting many breakdowns. Tetra Pak is also leveraging the power of HoloLens to develop a virtual service business which allows senior technicians to guide remote technicians for more than 8,000 packaging machines in plants across the globe, even when a project is thousands of miles away.



[thyssenkrupp innovates with Microsoft HoloLens and Skype](#)

thyssenkrupp has integrated Microsoft HoloLens and [Skype](#) into its operations to improve efficiency for service technicians. These workers can now visualize potential causes of issues before they go to a job site, work hands-free while on the job, and engage with remote experts who can virtually walk them through solutions to fix potentially very complex problems. Work that used to take one to two hours is now taking less than 20 minutes. thyssenkrupp is also using HoloLens and [Azure](#) to [design and deliver custom-built stair lift home solutions](#) with an even higher standard of customer experience, and at a faster pace than ever before.



Three stages of the digital twin journey

Continued

Stage 3: Smarter machines for a smarter business

The final and most innovative stage is a fully integrated system that couples a real-time simulation platform with natural human interaction. By applying advanced artificial intelligence technologies such as cognitive services to your digital twin strategy, you now have a value-added layer of insight that could not be achieved from sensor data alone. These capabilities can automatically identify and report an issue, simulate numerous possible outcomes, and recommend the best resolution.

Using [Microsoft Cognitive Services](#), you can also add voice interface capabilities that allow you to talk to your machine's digital twin environment. You can ask for a status report or request a performance change, and then visualize all possible outcomes to determine final action. Furthermore, advanced audio and visual processing can identify conditions and interpret specific outcomes. For example, a resonant frequency may be identified as irregular deterioration of bearings or warping of a spindle. Additionally, by processing images from still frames or video, foreign object intrusion may be identified at its source or human movement can be detected to prevent accidents. These advanced methods of learning from machine, audio, and visual data can form the basis for self-diagnosing and self-healing capabilities as well as smart human-machine collaboration.

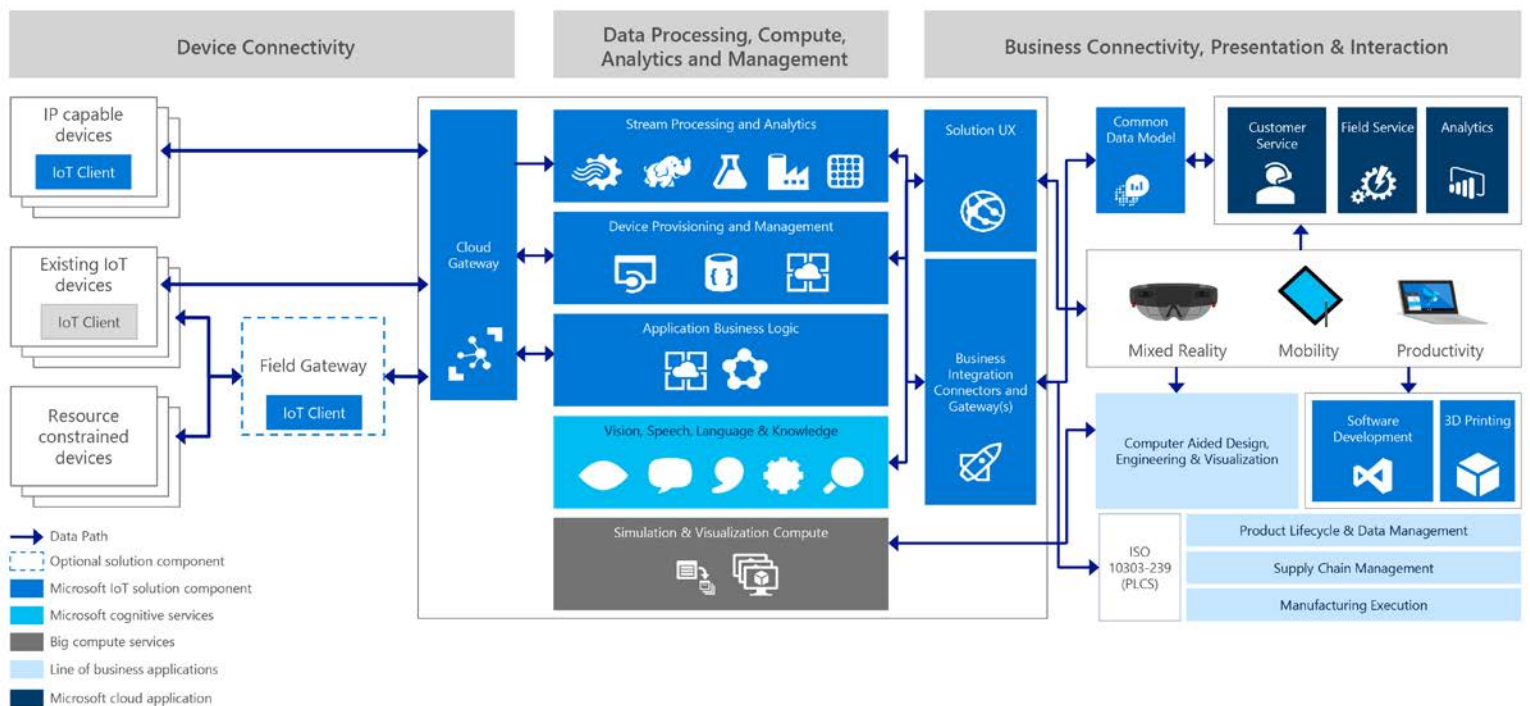
A value-added strategy is to factor in additional information pieces critical to understanding the customer environment, such as call center logs, maintenance events, and reports that are not stored or recorded by a smart, connected product. This assimilates all of the machine-based and human-based data and circumstances around what the customer is reporting within their specific environment in order to see the complete picture.

As you increase the quality of interactions between machines and humans, your machines learn and become more intelligent. They can perform such functions as self-optimization based on a learning system and report that back to help you enhance future design or improve customer services. You can also learn about potential quality issues or procedural problems in the way the product was built. As your machines become smarter, your business becomes smarter.

The concept of an artificially intelligent product is now within reach for manufacturers, made possible by catalysts such as cognitive services, which will help to drive the next wave of innovation.

Microsoft solutions and technologies for your digital twin strategy

Microsoft has the solutions and technologies that work together seamlessly to deliver a comprehensive and connected digital twin platform: for the physical product, for your customer, and for your enterprise in an end-to-end manner.



We offer Windows Holographic devices that can visualize digital virtual worlds, augment the real world with camera-based imaging, or place 3D and 2D content in the real world with holograms via Microsoft HoloLens, which all enable visualization of 3D product data in the real world. Our [Microsoft Azure Big Compute cloud platform and services](#) can seamlessly simulate design choices by running Finite Element Analysis (FEA) or Simulation Program with Integrated Circuit Emphasis (SPICE) applications. Our Microsoft Azure IoT Suite can collect data from connected devices and feed parameters into any simulation application together with real-world conditions. Additionally, with [Windows 10](#), applications can easily send 3D data to 3D printers to create parts on-demand. This can be extremely helpful for prototyping solutions for a customer or mitigating any supply chain delays by printing temporary part replacements quickly. Our cloud-based services can also connect devices to use machine learning to correct and sharpen analytics. Our rich cognitive services such as BOTs and language and image processing train equipment to progressively learn from its own use.

Microsoft solutions and technologies for your digital twin strategy

Continued

Our ready solutions can help you get started today –

Connected Field Service

The Microsoft Connected Field Service solution allows manufacturers to learn about problems before the customer does and solve them at the smallest cost to the organization. In a simple scenario, where an abnormality is detected, a sensor sends an alert off to an Azure IoT Hub. This triggers a configurable workflow process within Dynamics 365 for Field Service, ensuring a first-time fix. This proactive approach improves customer satisfaction and resource productivity by catching issues and troubleshooting them remotely—before they significantly impact your business.

Predictive Maintenance

The Microsoft Predictive Maintenance solution gives you better visibility into equipment status, letting you resolve issues before they disrupt your business. Monitor your assets in near-real time by collecting data through Azure IoT Suite. This allows you to create automatic alerts and actions, such as remote diagnostics, maintenance requests, and other workflows. Then perform historical analysis of your data and predict when you need to service equipment.

Remote Monitoring

With the Microsoft Remote Monitoring solution, you can monitor assets located nearly anywhere from afar. The solution helps you understand equipment conditions, enabling you to provide over-the-wire updates and fine-tune processes. To optimize business processes over the long term, the solution applies analytics techniques, like machine learning, to your data. The smart system performs in-operation analysis to find correlations across multiple data streams, letting you improve costs, uptime, and product quality. You can also leverage new predictive maintenance programs to perform historical analysis of your data and resolve issues before they disrupt your business.

Big Compute for Visualization & Simulation

Using Microsoft Azure, you can increase the frequency and speed of engineering simulations, analyses, and visualizations to optimize product designs for performance, safety, and manufacturing using hyper-scalability in the cloud. Quickly provision high-performance computing clusters in the cloud to replace or scale up capacity as either the primary resource or as an on-demand, burst capability.

Microsoft solutions and technologies for your digital twin strategy

Continued

Digital Twin

Microsoft's digital twin approach brings the power of immersive, holographic capabilities to deepen and accelerate interactivity across the value network and help make your digital transformation a reality. Learn how new value networks can be created that multiply the potential for gains in operational efficiency and the development of new business models.

Connected Operations

With Microsoft Connected Operations, you can empower your employees to engage with your customers, so you can transform your products, optimize your operations, and find new sources of revenue.



Microsoft HoloLens brings your digital twin strategy to life

With Windows Holographic devices, the digital twin environment takes on an expanded role in manufacturing: the ability to blend physical and digital into 3D. It's one thing to create a digital prototype, it's another to see a holographic hologram of equipment digitally brought to life by incorporating physical and digital worlds.

[Microsoft HoloLens](#) is a powerful visualization tool that takes your digital twin strategy to this new level by allowing you to do things that were previously impractical or even impossible. You now have an entirely new way to visualize relevant data in the context of the real world, solve complex tasks, not to mention save costs and downtime in factories or plants.



Get started today



Your digital twin strategy is more than just about technology. No longer is it an engineering overhead for your organization; it is a powerful business strategy that can accelerate your digital transformation. To be truly successful, you must thread digital twin capabilities into your business as a strategic asset to enable new opportunities.

Most businesses are already at the first stage of their digital twin strategy with smart, connected products and remote monitoring. As you continue your evolution, work with Microsoft to extend and develop a strategy that can transform your business today. We understand the business opportunity and offer the critical technology to enable a digital twin strategy that meets your business needs—whether that's improving your supply chain operations, or innovating with product design, or enhancing the customer experience with new services.

We have the largest ecosystem of industry-leading partners that can help you take advantage of your existing technology investments and give you the flexibility to select the best solutions for your business. Our partners design and deploy innovative, industry-focused solutions built on a Microsoft foundation, so manufacturers get best-in-class technology coupled with deep industry expertise.

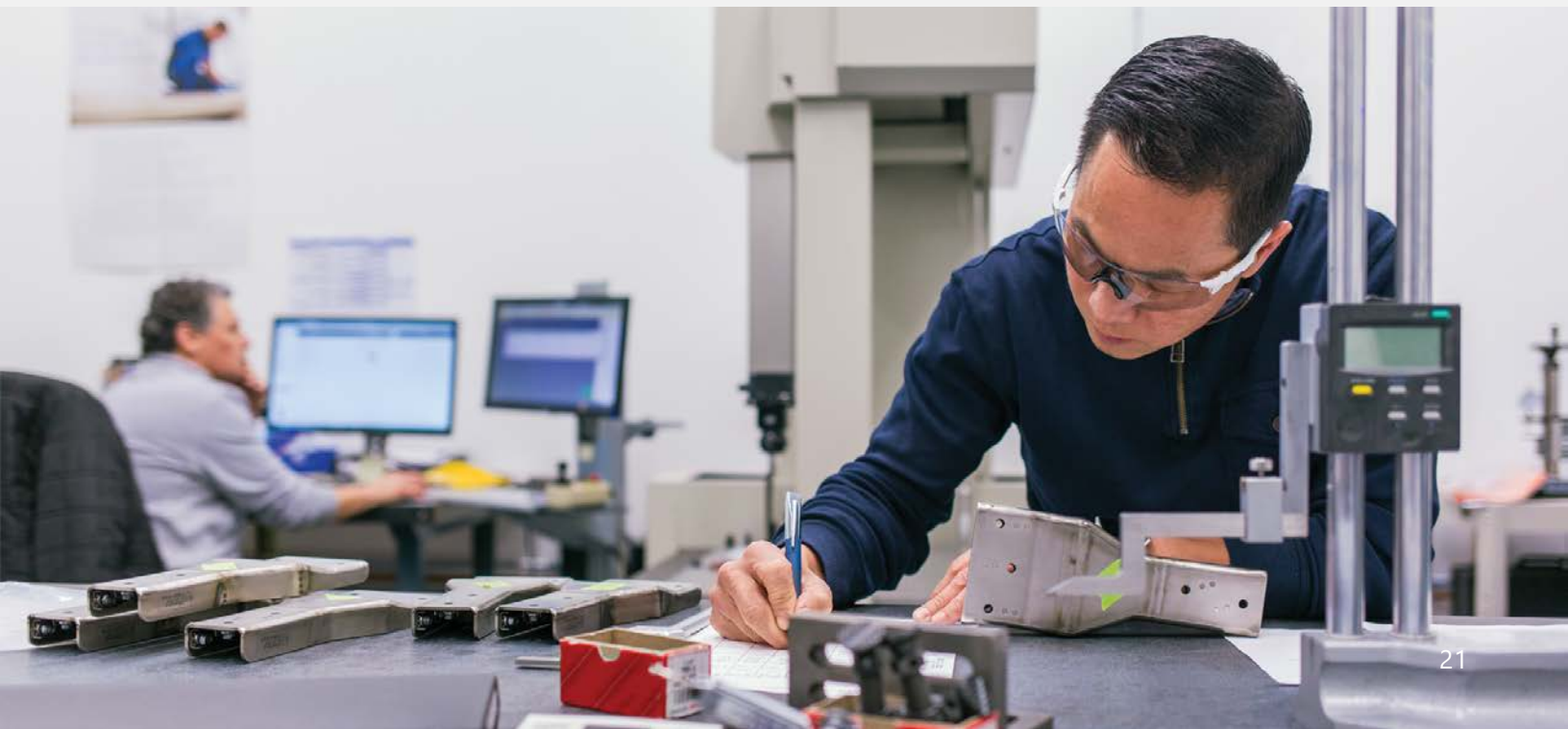
Get started today Continued

Our worldwide Microsoft Services team of architects, engineers, consultants and support professionals can help you gain more value from your digital twin journey. While our 22,600+ consultants, digital advisors and support and sales professionals live and work across 191 countries, we speak 46 different languages and engage with our customers and partners on-premise or by phone, web, community and automated tools. With our expertise in the Microsoft portfolio, technology integration and digital transformation capabilities, we are committed to helping you get the most from your technology investments through strategy, planning, deployment and support services.

No other technology provider offers a comparable end-to-end portfolio as well as an open and flexible approach. Together, it's this unique perspective that helps Microsoft drive digital transformation across all aspects of your business, helping you optimize operations, empower employees, transform products and services, and engage with your customers.

Use our knowledge and expertise in a solution strategy workshop, solution design session, or develop a proof-of-concept or pilot to start your journey towards a digital twin strategy, solution or offering.

For more information about digital transformation services with Microsoft, [learn more here.](#)



^{1, 2, 3} [IDC FutureScape: Worldwide Operations Technology 2017 Predictions, November 2016.](#)

⁴ [Gartner's Top 10 Strategic Technology Trends for 2017, October 2016.](#)

⁵ Dr. Michael Grieves and John Vickers – University of Michigan, "[Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems \(Excerpt\)](#)," August 2016.

⁶ Eric Tuegel, AFRL/RQVS, Air Force Research Laboratory, [ADT 101: Introduction to the Airframe Digital Twin Concept](#), February 2013.

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