Enhance innovation and agility with Digital Twins

Microsoft

Executive Summary

There's no denying we live in uncertain and rapidly changing times and **companies are looking for every opportunity to become more agile**. Digital twins is a rapidly emerging technology that delivers to this end. Not to be confused as a mere dashboard, a digital twin is a virtual replica of a physical object, machine part, system, process or entire lifecycle. **Digital twin technology enables** real-time monitoring and control, the ability to learn with AI and ML, to autonomously update, self-heal, and even improve systems and designs over time.

This paper seeks to achieve four objectives. **First**, to help the reader understand Digital twin technology and its potential. **Second**, to provide a structured way of looking at the various use cases and applications of this technology. **Third**, to feature Microsoft partners who have differentiated capabilities that bring digital twin visions to life. **Fourth**, to discuss the Azure Digital Twin platform and other investments from Microsoft in this space.
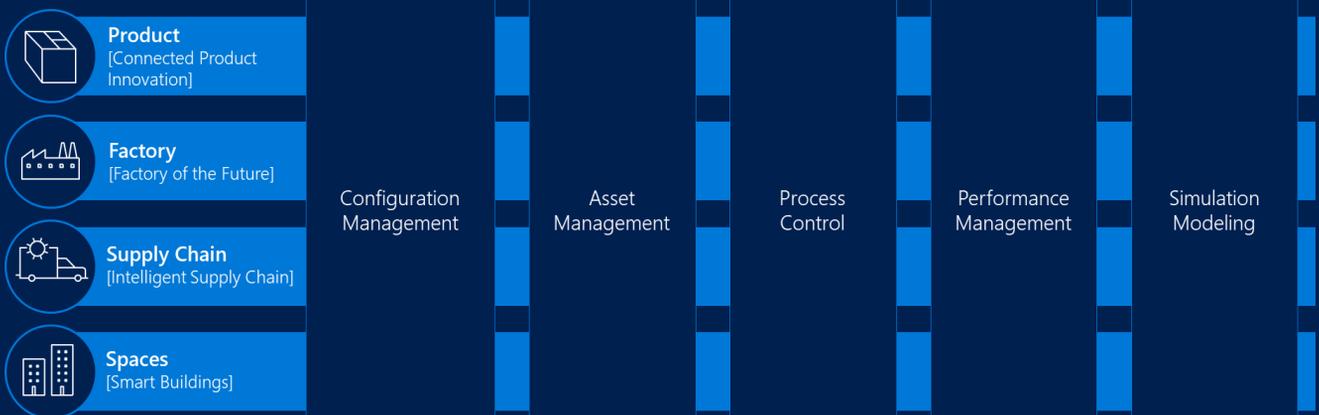
Digital twin technology is commonly applied to manufacturing across key applications that span manufacturing scenarios/use-cases.

The priority scenarios, or use cases, as they relate in Manufacturing are 1) **Product**, 2) **Factory**, 3) **Supply Chain**, and 4) **Spaces**. The top applications include **configuration management**, **asset management**, **process control**, **performance management** and **simulation modeling**.

Configuration management tracks bills of materials, around assets as designed, manufactured, configured, and maintained. E.g. For complex & expensive assets like aircrafts this information is typically maintained by tail number. **Asset management** deals with telemetry of an asset itself and gives insight in to how something is working. E.g. an inlet and outlet pressure of an air compressor might provide visibility into its health & operations. **Process Control** is a bigger application of an end-to-end processes which includes multiple sub systems or sub-components. This could be a chemical processing plant or a manufacturing assembly line. **Performance management** records and surfaces the performance of a process or supply chain. Computed KPIs like Customer service levels, on time deliveries etc. are key indicators of a supply chain performance.

Digital Twin Applications in Manufacturing

Priority Scenarios

Product
[Connected Product Innovation]

Factory
[Factory of the Future]

Supply Chain
[Intelligent Supply Chain]

Spaces
[Smart Buildings]

Configuration Management

Asset Management

Process Control

Performance Management

Simulation Modeling

Executive Summary

Simulation modeling involves creating and analyzing a digital prototype of a physical system to predict its performance. Newer applications in simulation even include an ability to generate telemetry when a physical device does not exist, like in the early stages of prototyping or where a physical sensor cannot be placed E.g. at the center of a molten steel flow where high temperatures make it difficult to place any sensors. The dynamic nature of these technologies means they can be applied in different ways across key scenarios around product, factory, supply chain and spaces.

Microsoft's Azure Digital Twins is a Platform as a Service that manufactures can use to **develop and create comprehensive models** of physical environments, to **model the relationships and interactions** between people, places, devices and more. Azure Digital Twins makes it **simple to query data** from a unified space rather than disparate sensors, **and build reusable**, highly scalable, spatially aware experiences that link streaming data across the physical and digital world.

Microsoft is working with partners and the ecosystem (for example the new Digital Twins Consortium) to help create rich and secure standards for systems collaboration and information interchange in the world of digital twins. Microsoft and its partners offer a broad portfolio of packaged IP for businesses to bring their digital twin vision to life and further digitize their value chain. This paper contains incredible success stories by ISV partners (The Marsden Group, Willow, Aras, Ansys, Bentley, Blue Yonder, Sight Machine, Simio and PTC) along with SI partners (Accenture, Capgemini, EY, Sigma, and Infosys) all of whom have deep expertise in the digital twin space.

Read on to learn more or **connect with Microsoft** or any of the listed partners to learn more about how we can work together to bring your digital twin vision to life.

Microsoft

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A technology paradigm for the future, with roots in the past

Approximately six and a half minutes after a successful television broadcast from the Apollo 13 command module, a routine activity caused a tank explosion, critically damaging the main engine. With repairs required and valuable oxygen leaking into space, both the astronauts onboard and engineers at NASA mission control scrambled to find a solution.
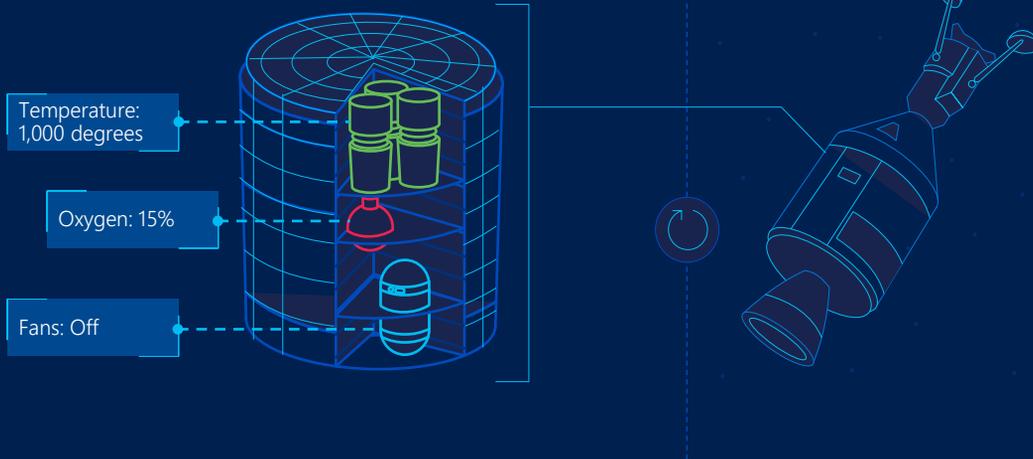
Utilizing machines that were exact replicas of the space craft, in conjunction with computer calculations and analysis, the engineers quickly troubleshot several "what if" scenarios, making modifications, until they felt they had a solution that could bring the astronauts to safety. A process of fixes validated on ground was transmitted to the astronauts who replicated it—or mirrored it—200,000 miles away in space.

In April of 1970, the world witnessed the safe splashdown of Apollo 13, and the power and potential of what we know today as a "digital twin" was made manifest. Today, fifty years later, it is that same responsiveness and agile shift from challenge to solution that makes digital twins critical to manufacturers.

A recent survey by Gartner reports that 75 percent of organizations implementing IoT already use digital twins or plan to within a year. The number of organizations using digital twins is expected to triple by 2022. iv

Apollo 13: First application of a Twin, by NASA
April 1970

Temperature: 1,000 degrees

Oxygen: 15%

Fans: Off

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Digital twins deliver agility in manufacturing

A digital twin is...

Digital twins are virtual replicas of physical assets and, even though there are many applications for the technology, twins share a common implementation pattern. Twins are built using computer-aided design (CAD), bill of materials, simulation models, IoT sensors, time-series data, maintenance records, and any other data a manufacturer wishes to bring together. The data is then managed, unified, and modeled to build a high-fidelity digital representation of the physical reality.

Once modeled, a visualization layer provides insights, easy consumption, interaction, and manipulation. This enables users to predicting failures, assess future performance, and provide opportunities for optimization. Digital twins are further able to integrate with artificial intelligence, machine learning, and analytics to create living simulation models that change in tandem with their physical counterparts. [iii]

Greater agility is critical in today's market

Demand uncertainty and disruptions are taxing planning systems to the brink and manufacturers are no longer able to depend on statistical forecasting models and scale economies of mass production. With change the only constant, it is no wonder that a recent report by the United Nations Industrial Development Organization (UNIDO) said it is critical that manufacturers adopt supply-chain wide technology that supports greater agility. [ii]

The term 'digital twin' is believed to be coined by Dr. Michael Grieves during a 2002 presentation on product optimization within Product Lifecycle Management. During his presentation at University of Michigan, he spoke of a "management center" that held insights on real space and virtual space, facilitated the sharing of data and information between the two. [v]

Used in conjunction with IoT, today's digital twins unlock the abilities Grieves envisioned: monitor and manage production remotely, gain invaluable information for both real-time decision-making, strategic planning, and energy cost-savings, time reduction, operational efficiency, and innovation.

By 2022, Gartner expects 85 percent of all IoT platforms will include some digital twin monitoring, and a few cities will take the lead in showing the utility value of digital twin smart city technology. [xvii]

A recent issue of the MIT Sloan Management Review discussed the power of IoT and digital twins, "Supported by an estimated 25 billion connected global sensors by 2021, digital twins will soon exist for millions of things. A jet engine, a human heart, even an entire city can all have a digital twin that mirrors the same physical and biological properties as the real thing. The implications are profound: real-time assessments and diagnostics much more precise than currently possible; repairs literally executed in the moment; and innovation that is faster, cheaper, and more radical." [vi]

The promise of Digital Twins, and the agility they offer, is driving the technology in to the mainstream for manufacturers. Gartner reports that the digital twins market last year (2019) was USD 3.8 billion and is expected to grow to USD 35.8 billion, ~10x increase, by 2025, at a CAGR of 37.8 percent. [Vii]

Microsoft

Digital Twins mean moving faster

Technology has always made it possible to move faster, see things sooner and make better decisions. The potency of an IoT/Digital Twins mix is that it creates a new digital feedback loop for manufacturers. As connections and communication between products, assets and processes become more ubiquitous, the opportunity to use data to further automate, up-level, innovate increases drastically.

Feedback loops foster exponential learning and adaptability. "We see a world in the not-too-distant future where every business is powered by these digital feedback loops and it becomes a normal part of doing business," Sam George, Corporate Vice President of the Azure IoT Engineering Team said in a recent article, "companies that aren't powered by digital feedback loops will find themselves at a competitive disadvantage."

While new technologies often feel out of reach, digital twins are not for most. Believe it or not, many companies actually use applications supported by digital twin-like capabilities to function right now.

"...digital twins give you the power of prescience to re-write the future of your business."

– Çağlayan Arkan, Vice President, Manufacturing Industry, Microsoft

In a recent study Gartner found that, while only 25% of manufacturers recognized Digital Twin as an important emerging technology, many were utilizing digital twin technology without even realizing it.

That's ok and is often the case with emerging technologies, "digital twins give you the power of prescience to re-write the future of your business...from empowering remote, intelligent operations to ensuring business resiliency, to enabling the agility to predict and respond to real-time changes, " says Çağlayan Arkan, Vice President, Manufacturing Industry, Microsoft.

Digital Feedback Loop

Engage customers
Deeper relationships
Customer signal

Optimize operations
More efficient ops
Operational data

Intelligent
Data & AI
Systems & Experiences

Empower people
Employee signal
More effective employees

Transform products
Product telemetry
Better products

Microsoft

The path for every forward-thinking manufacturer is to incrementally transition from sparingly or unknowingly using digital twin-like technology to using it in strategically in different phases of a process or lifecycle. Manufacturers can start in very specific, very limited scenarios that provide the most business value, long- or short-term, that makes sense and then expand as new opportunities become apparent.

Real-world transformation through Digital Twins

The potential of digital twins is only limited by the type of data that is available. It is one thing to talk about it, it is another thing entirely to show it.
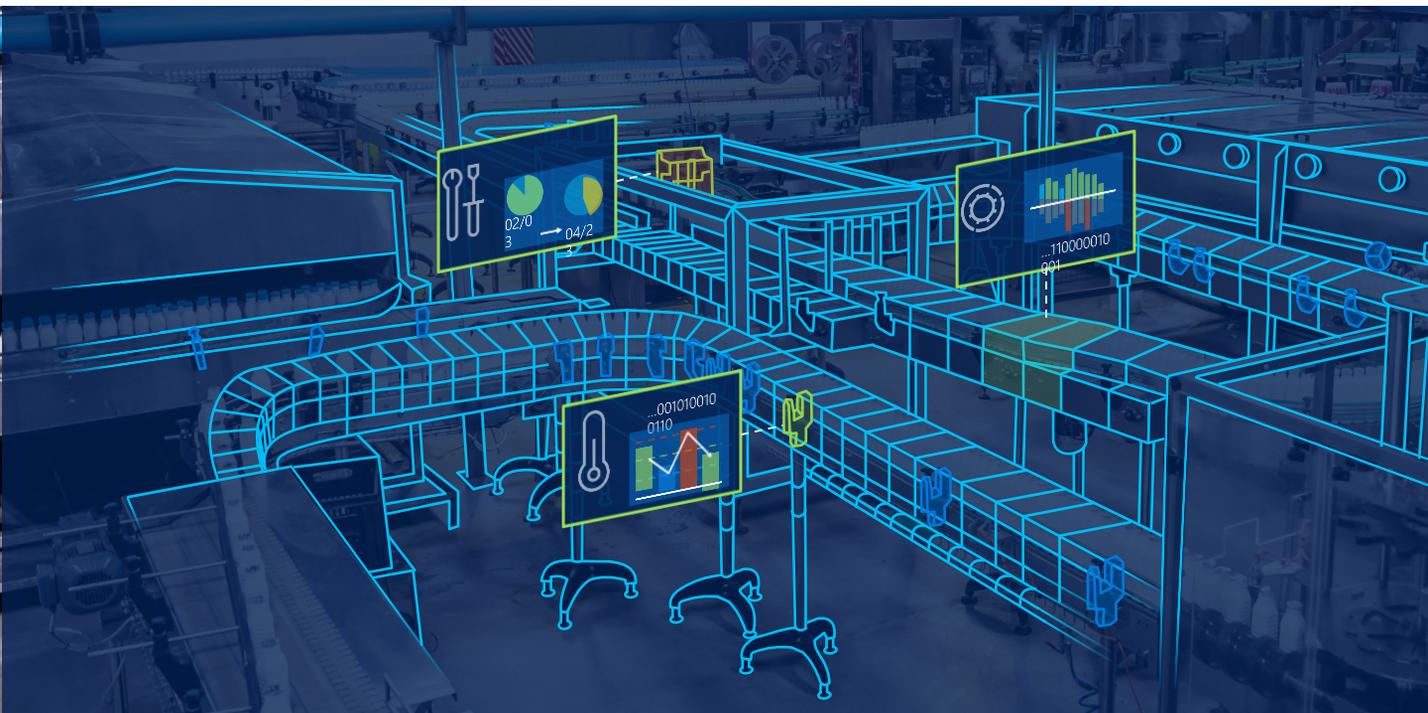
There are many incredible stories in this paper, but the next section highlights four

"Azure Digital Twins gives you the ability to model anything, create a live digital replica to control the present, track the past, simulate possibilities and predict the future."

– Sam George, Corporate Vice President, Azure IoT, Microsoft

particularly compelling transformational stories in different areas of manufacturing.

1. Remote control and communication at Unilever
2. Rewind and Replay for "What If?" Scenarios with thyssenkrupp
3. Serialized Asset Tracking and Monitoring with Rolls-Royce
4. Digital Verification and Validation with V4i

Microsoft

Remote Control and Communication with Unilever

The Marsden Group, a Microsoft Partner, delivered this key capability to Unilever, the manufacturer of products like Dove, Vaseline, and Ben & Jerry's.

Using Azure IoT Edge and Azure Industrial IoT Platform capabilities, Marsden's TwinIQ solution provides Digital Twin and Optimiser accelerator frameworks for the rapid discovery and enablement of digital transformation.

The twin leverages huge volumes of data from factory equipment to build a digital model. It learns and improves in real-time with AI and ML capabilities while enabling real-time data intelligence sharing, conversation, and collaboration.

Remote connectivity gives Unilever employees the ability to hand over control of specific operations to the digital twin optimiser.

In fact, operators on the floor now trust the twin more than themselves to monitor settings like soap moisture levels and batch process efficiency for optimal productivity.
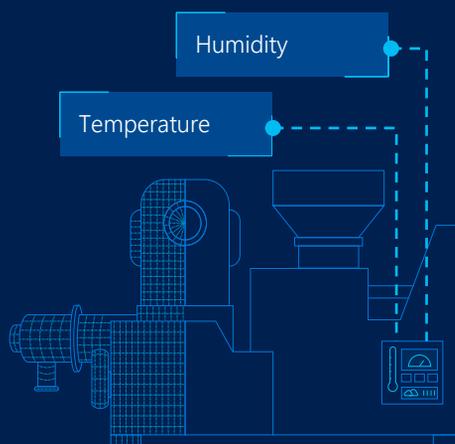
Unilever Chief Engineer Dave Penrith says "The more data it gets, the more it learns. The more it learns, the faster it learns, and it starts to learn at an increasingly exponential rate."

As a result, Unilever has digitized their factories to a point where not only are they able to run them lights out, but also pivot production almost immediately from making ice-cream to making hand sanitizers. This is a remarkable example
of a customer experiencing the benefits of end-to-end digital transformation.

THE MARSDEN GROUP

Link to Partner

Link to full story

Unilever uses digital twins to monitor, optimize, and control production processes

Humidity

Temperature

Microsoft

Rewind and Replay for "What If?" Scenarios with thyssenkrupp

thyssenkrupp collaborated with Willow and Microsoft to create a digital twin of thyssenkrupp's 246-meter Innovations Test Tower. Part of the project was to experiment with elevator technology, creating a building design that reduces space lost to traditional rope elevators to free up more livable real estate. The other part was to help real estate owners and managers reduce costs and increase tenant satisfaction.

With that in mind, the team created "Willow Twin," a digital replica of the building supported by Microsoft Azure. This is a twin of an entire building. It generates analytics on the elevator around different use scenarios and collects real-time data on the ways both staff and guests utilize not just the elevator, but the entire building space over the course of a day. Digital twin analytics and intelligence replay enables real-time connectivity of both people and data-driven systems across the building to monitor processes and patterns, and rapidly identify problems using 'what if' simulations for fire evacuation and other emergency management scenarios.
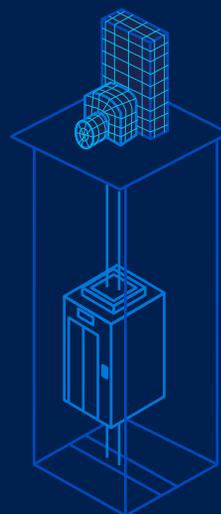
These critical insights help thyssenkrupp improve elevator maintenance and be proactively responsive to critical emergencies. From a building maintenance perspective, the same twin can provide visibility into maintenance needs and the capability to rewind and replay if something goes wrong in the building infrastructure. The Willow Twin, and projects like it, promise to open new possibilities for smart architecture and for remedying social challenges like overcrowding.

willow
know your world

[Link to Partner](#)
[Link to full story](#)

The digital twin enables thyssenkrupp to do emergency evacuation scenarios

Microsoft

Serialized Asset Tracking and Monitoring with Rolls-Royce

Rolls-Royce has more than 13,000 commercial aircraft engines in service around the world. Within these engines Rolls-Royce has embedded hundreds of sensors for Engine Health Management. The onboard sensors provide serialized telemetry for each engine and provide accurate insight into engine health, performance, fuel usage, service needs and more.

The massive amount of disparate data is continuously collected, monitored, and aggregated via a digital solution built on Microsoft Azure. The digital twin enables a digital feedback loop that not only drives product updates and informs and optimizes maintenance processes but also enables Roll-Royce to monitor the entire fleet of these engines in flight and assure their availability and uptime.
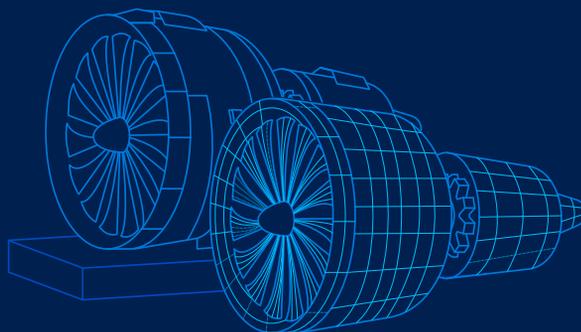
Rolls-Royce is also able to model a myriad of scenarios virtually, often with complex calculations to generate optimal fuel recommendations and flight routes and bring significant operational cost savings for their airline customers.

Because they can monitor engines on-wing, they were able to create new business models and offer their product-as-a-service well known in the industry as "Power by the Hour."

[Link to full story](#)

Rolls-Royce has enabled serialized tracking of assets in-flight

Microsoft

Digital Verification and Validation with V4i

Reducing or removing the need to prototype is would be a game-changer for most, if not all, manufacturers. V4i is a private-public consortium managed by the National Center for Defense Manufacturing and Machining (NCDMM) and is on a mission to provide advanced assurance in product development and manufacturing.

As a founding member of the consortium, Microsoft enables a cloud-based, high-performance computing and collaborative design environment for manufacturers to conduct multi-physics simulations and systems modeling across the value-chain.
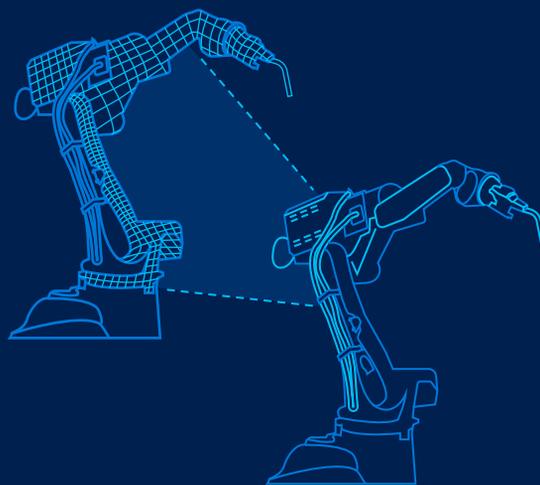
By leveraging the Azure platform, Microsoft and V4i helps manufacturers develop trust in their digital models and enable virtual verification and validation of their designs.

With design cycle times and prototyping costs being what they are, digital twins offer a sound alternative to better physical testing and validation while cutting cost. Digital twins also provide a protected way to mitigate risk and verify the safety and functionality of autonomous functions. Digital verification and validation saves both time and money and creates new opportunities for agility in future product design processes.

[Link to Organization](#)

Microsoft and V4i help manufacturers develop trust in their digital models and enable virtual verification and validation of their designs.

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Common patterns and Use Cases in Manufacturing

These incredible stories clearly demonstrate the power of digital twin technology. As manufacturers imagine building with this new technology, they will need to bring together various dimensions of data, build a graphical relationship across the data elements and ingest massive amounts of timeseries and other data from IoT devices and multiple other business systems. They will also need to build intelligent mechanisms to query the data to generate insights and for users to interact with the digital twin.

Before these decisions can be made thoughtfully, it is important to understand the intersection between critical use cases, the digital twin applications that are relevant in those cases, and the Microsoft partners with IP that can drive those transformative efforts.

Let's walk through the top use cases and explain where these applications for digital twin typically operate in the areas of:

1. **Product design** – Design and lifecycle of an asset. The extent a digital twin technology can replicate an entire product cannot be overstated. All physical parts, mechanical pieces, software, electrical systems, etc.,
   can all be brought into a twin.

2. **Factory optimization** – Production of an asset. In factory optimization, digital twin technology is used to experiment with best production practices, optimize production quality and efficiency, test what if scenarios related to changes in demand, design, or other parameters, troubleshoot, and find the most operationally efficient approaches to producing their product or products.

3. **Supply Chain management** – Insight from raw materials to distribution. Digital twins can replicate entire, often multi-enterprise,

supply chains. Manufacturers can model horizontally and vertically across the value chain at each facility and phase of operation.

4. **Spaces scenario** – Simulation of buildings from construction to maintenance. When digital twins are applied in a space scenario, engineers use them to construct every detail of a large environment virtually. This data can inform both construction during the building process and can help monitor and control the actual physical space once it is built.

Priority Scenarios

Product
[Connected Product Innovation]

Factory
[Factory of the Future]

Supply Chain
[Intelligent Supply Chain]

Spaces
[Smart Buildings]

Within these top use cases, there are key applications that are most relevant to manufacturing, including 1) Configuration Management, 2) Asset Management, 3) Process Control, 4) Performance Management and 5) Simulation Modeling

Throughout this next section, there will be mentions of and links to partner stories features later in the document. These partners own specific IP that uniquely drive transformational efforts in a particular area. Follow the links to click down on a particular story.

Microsoft

Configuration management

Configuration management is the ability to have an exact digital representation of a physical product or asset as it presently exists. It mirrors a specific unit in operation such as an individual vehicle by VIN or unique aircraft engine as seen in the Rolls Royce story. As the real-world asset gets maintained, updated or retrofitted, manufacturers see those changes and accurately understand the current status. Configuration management provides the necessary context for interpretation and analysis of sensor data streaming back from a specific asset in the field.

Featured partner story:

Aras was brought in to help Microsoft's devices business unify product data from multiple business lines into a single system on Azure. As a result, Microsoft is in a better position to get devices to market faster with better PLM processes.

Asset management

Asset management makes it possibly to see live-streaming telemetry from a device, asset, or product and allow you to remotely control the device or asset. It can also use real-time data to accurately assess scenario implications for other aspects of an asset or process.

Featured partner story:

PTC worked with Howden to create a twin of globally-dispersed products and broadcast it to front-line workers standing in front of the physical product for use cases like procedural guidance and parts identification through mixed reality.

Process control

Process control applications provide a virtual representation of every aspect of a process like what happens in a factory or a plant floor. These applications improve productivity by creating a robust data pipeline and a foundation for exploring variances and correlations in both batch and streaming production data, in real-time. Manufacturers can capture interactions between multiple digital devices, production systems and even ERP and environmental sources across operations for an end-to-end process view, real-time management, continuous productivity improvement and autonomous forward-looking decision making. By contextualizing these data sources, these productivity platforms provide end-to-end visibility into higher level manufacturing processes and enable bi-directional control.

Featured partner stories:

Sight Machine worked with a global paper manufacturer to create a twin of all production (15,000+ tags, 24 hours a day) that now maps detailed process, quality, and downtime data to specific production batches; transforming the business' ability to solve production problems.

Featured partner stories:

Simio collaborated with a >$10B global ETO industrial equipment manufacturer to create a simulation-based process digital twin fully integrated into SAP, built and driven entirely from their data to improve on time delivery while reducing costs.

Microsoft

Performance management

Performance management supplies visibility and control to a system's key performance metrics. For example, it connects components within a supply chain and continuously generate real-time insights from data it receives from the value chain and each stage of the production process.

This level of insight helps manufacturers predict patterns before they happen, sense disruptions, understand the consequences of different options, and provide prescriptive recommendations for optimal performance along the entire value chain

Featured partner story: ⁘ BlueYonder

Blue Yonder uses their Luminate Control Tower, a digital twin of an enterprise supply chain, to find bottle necks, test supply chain designs, proactively detect risk and deliver prescriptive guidance to manufacturing companies.

Featured partner story: 🅱 Bentley®
Advancing Infrastructure

Bentley Systems worked with Microsoft and Schnieder Electric to create a digital twin of Microsoft Asia Pacific headquarters in Singapore using their OpenCities planner service.

Simulation modeling

Simulation modeling enables the creation of a digital entity even before the physical assets are made, or where gathering telemetry from a sensor is not an option, by using a library of simulation models and capabilities. The interesting evolution of this technology is its extension into the world of operations, for example as a simulated proxy for a physical sensor where for example due to environmental conditions like very high temperatures a sensor cannot be placed, e.g. at the core of a molten steel flow or the center of a jet exhaust. The result is ultrafast modeling, the ability to perform a myriad "what-if" analyses and build, validate and deploy complex systems more easily. This modeling capability also facilitates real-time data transfer and support the creation of reusable components.

Featured partner story: /Ansys

Ansys collaborated with Volkswagen to develop a simulation-based digital twin of an electric car battery pack and deployed a six-step multi-physics simulation approach using their Ansys Twin Builder. This enabled virtual prototyping that increased the quality of design while also vastly accelerated the time-to-delivery.

These incredible partners stories are powered by investments and technology that Microsoft has built over the last few years. Let us dive into these investments next.

■■ Microsoft
■■

Transformative partnerships powered by Microsoft

Azure Digital Twins

Azure Digital Twins is a service that gives manufacturers a platform to develop and create these comprehensive models of physical environments, to model the relationships and interactions between people, places, devices and more. Manufacturers can query data from a unified space rather than disparate sensors, and build reusable, highly scalable, spatially aware experiences that link streaming data across the physical and digital world. It is currently in being piloted by a broad set of customers and partners from a wide range of industries.

As part of this effort, Microsoft has been developing a Digital Twin definition language (DTDL) to better facilitate communication across different digital twin technologies.
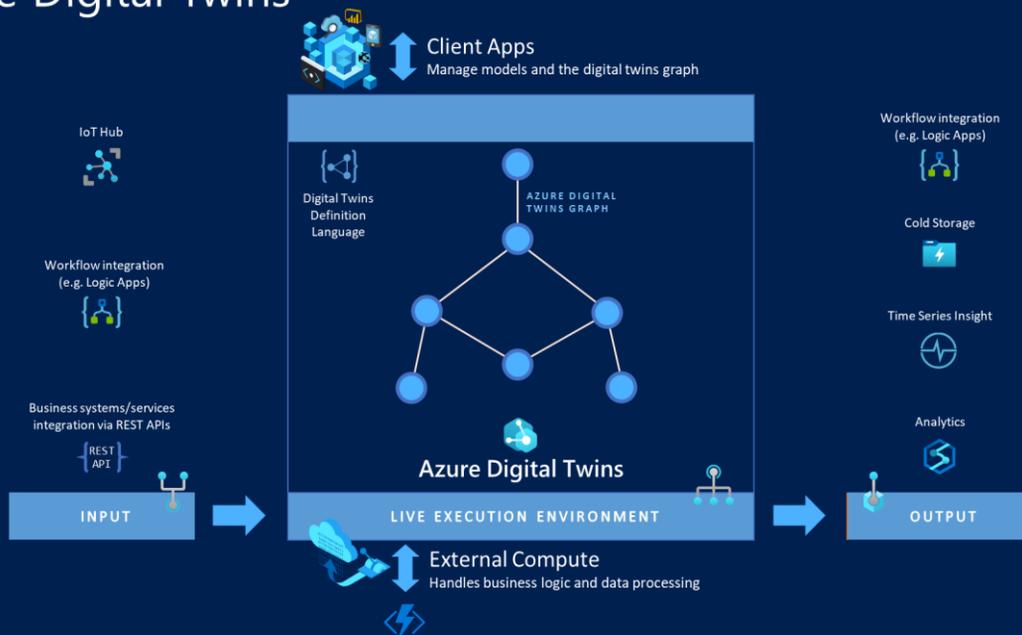
DTDL, enables the creation of a device capability model to describe the parts of a device to enable clear and accurate transmission of device data throughout the digital ecosystem.

Of course, Azure is the world's first cloud offering to deliver an end-to-end, unified approach to IoT security. Digital twins in and of themselves virtually eliminate blind spots with unified security monitoring and respond to incidents quickly with integrated threat intelligence.

Beyond that Azure Digital Twins provide security through access control and Azure Active Directory (AAD). Role-Based Access Control and Azure Active Directory serve as automated gatekeepers for people or devices, specifying what actions are allowed—and helping to ensure security, data privacy, and compliance.

By removing these layers of complexity and accelerating the creation of innovative spatial intelligence solutions, Azure Digital Twin supplies what manufacturers need to become more agile and responsive as they create the next wave of innovation in IoT.

Mixed reality and AI

Just as the current existence of IoT technology makes digital twins powerful, the opportunities to augment digital twins with mixed reality or AI are significant.

It is through the combination of observational, transactional, and behavioral data that humans are providing the blueprint to interact with machines, train the machines and to take informed action based upon specific kinds of data. Gathering "behavioral data" via digital twin technology in conjunction with compute-intensive AI and simulation solutions is posed poised to fuel immersive visual experiences via mixed reality devices like HoloLens.

The benefits of Digital Twins, Mixed Reality and AI to manufacturers include the ability to:

- Unlock immediate value through quick digital twin construction and integration with ERP data.

- Bring digital twin insights to first-line workers to collect second order insights as part of a behavioral data feedback loop.

- Connect data with AI to determine solutions for specific use cases.

- Increase operational efficiency.

- Secure consistency in packaging and shipping.

- Build trust with supply chain partners and customers with an optimized fulfillment process.

Microsoft is currently working with such technologies on a variety of projects. Once such project is within the Microsoft Operations Applications Group where a team is building a digital twin of a warehouse and enabling Microsoft Dynamics 365 Operations to consume digital twin insights through the lens of mixed reality.

A warehouse digital twin supports the "always-on" operational needs of warehouses that are essential in the manufacturing supply chain. What happens in the warehouse can impact quality, shipping, and customer loyalty.

When used in conjunction with mixed reality technology, the aim is to facilitate the collection and injection of both digital and behavioral data back into Dynamics 365 digital twin. This combination of visualizing, collecting, and parsing forms the feedback loop that fuels effective and insightful AI, that can ultimately be configured to control certain aspects of the warehouse operations.

Embracing open standards

"As manufacturers think about building agility into their supply chains, there is increasing realization that these efforts cannot occur in isolation," states Deloitte's 2020 Manufacturing Industry Outlook. "The need to cultivate a strong ecosystem is a trend that has emerged, and our research shows that it is an increasingly effective strategy for manufacturers, especially as it relates to digital momentum."

In line with that, Microsoft has been taking part in a multi-year collaboration of industry leaders (e.g. OPC Foundation) and has adopted an open standard for exchanging information in a rich, object-oriented, and secure way. OPC Unified Architecture (OPC UA) is the industrial interoperability standard that scales from sensor to cloud. ■ Microsoft

It facilitates the creation of semantically rich information models and provides secure data exchange between industrial equipment and systems, including discovery as well as command & control. It is open source, cross-platform, vendor-neutral, and supports companion specifications/ extensions to other industrial standards like BACnet, MTP or MT Connect.

Conclusion

Digital transformation, together

Digital twin technology gives you an opportunity to not just stay abreast of today's unprecedented pace of data flow, connectivity, and collaboration but use it to fuel advantages for your business.

And there is no doubt business will be entering new frontiers in the coming months and years.

A new, broader evolution of enterprise-level twins is already evolving, and with that we'll likely see even more uses for digital twins in manufacturing in robotics, the development of remote command centers, the enablement of new capabilities with Over-The-Air updates, more immersive integration with Mixed Reality, and even deeper, more connected monitoring and insights. Digital twins will seamlessly integrate with the Internet of Things and open it to countless new possibilities.

Microsoft and its ISV and SI partners offer an invaluable ecosystem for business like yours to further digitize your supply chain.

There are many incredible success stories by ISV partners like The Marsden Group, Willow, Aras, Ansys, Bentley, Blue Yonder, Sight Machine, Simio, Siemens, AVEVA, Iconics, Hexagon and PTC, many of which have been mentioned.

Our SI partners like Accenture, Capgemini, EY, Sigma, and Infosys also have deep expertise in the digital twin space. Microsoft also actively partners with emerging companies and niche startups in this space like Majik, Jitsuin, Datanomix, Supply Chain Wizard and DeviceTone.

Of course, there are many others who are ready to support your digital transformation no matter what stage or region you're in. Together, we can unlock entirely new business models that support continuous agility, advanced productivity, and ongoing innovation.

Next steps

Take a moment to explore Microsoft Azure Digital Twins and the Microsoft partners creating innovative digital twin solutions for manufacturing companies like yours around the globe.

Connect with Microsoft or any of the listed partners to learn more about how we can work together to bring your digital twin vision to life.

Learn more about:
Microsoft Azure Digital Twins
Visit the Azure Marketplace
See digital twin results on App Source
For more information, visit aka.ms/DTforMfg

■■ Microsoft

Appendix: Customer Stories

Microsoft

Simulation modeling: Customer Story

Featured Partner: Ansys

Volkswagen Motorsport had only nine months to design, test, and build their electric car entry for the Pikes Peak International Hill Climb. Also known as The Race to the Clouds, this annual invitational is a race to the summit of Pikes Peak. With a goal to beat the previous electric vehicle record,

Volkswagen Motorsport engaged Microsoft partner Ansys and its simulation solution the Ansys Twin Builder. Volkswagen engineers needed an electric car battery pack that could get the team up Pikes Peak with power to spare. But it needed to fit the given chassis and target weight. This required a series of simulations, to determine the cell selection, battery pack size, battery cooling and charging efficiency.

Volkswagen Motorsport and Ansys developed a simulation-based digital twin and deployed a six-step multi-physics simulation approach using Ansys Twin Builder. The simulations perfected, tested, and validated the electric car battery pack's electrical and thermal properties.
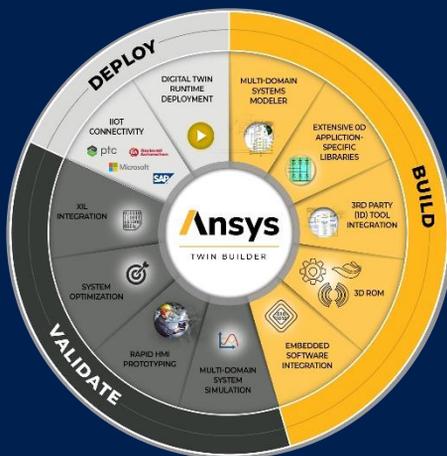
Result: Volkswagen Motorsport's car ran the course faster than any other car ever had.

Ansys Twin Builder can help manufacturers:

- Simulate baseline and failure data resulting in accurate, physics-based digital twin models.
- Use physics-based predictive models to increase accuracy and improve ROI from predictive maintenance programs.
- Leverage "what-if analyses" to simulate different solutions before selecting the best one.
- Use virtual sensors to estimate critical quantities through simulation. Simulation models can bring in IoT data into it the Ansys Twin builder for visibility and monitoring.
- Compile simulations into runtime modules that can be automatically integrated into IoT processing systems, reducing the heavy lift of IoT customization.

/\nsys

Ansys Solution architecture

Asset management: Customer Story

Featured Partner: PTC

PTC defines Digital twins as digital models that virtually represent their physical counterparts: industrial assets, processes, people, and places. 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.

Howden, a manufacturer of industrial products, called on Microsoft partner PTC to unify their processes and help them enhance their customer experience across the lifecycle of their products.

With expertise in industrial IoT, digital twin applications, augmented reality, and product lifecycle management, PTC created a twin for Howden's globally dispersed products using digital definitions sourced from Engineering and broadcast to the front-line workers standing in front of the physical product for use cases like procedural guidance and parts identification.

PTC's ThingWorx Industrial IoT platform and Microsoft Azure help streamline real-time collection and response to IoT data, enhancing Howden's customers' experience of owning and maintaining Howde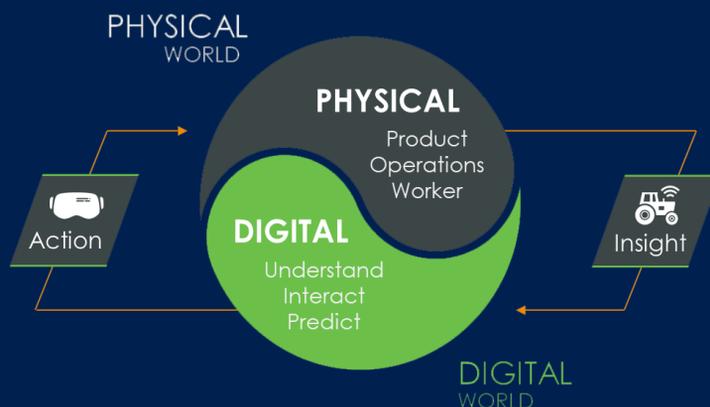n equipment. The information also helps the manufacturer's existing 3D machine models create mixed reality instructions with Vuforia Studio. PTC has also helped Howden transform it's own factory by creating digital twins for factory operations (process) and machine operators (people).

PTC helped Howden:

- Respond more quickly and effectively to customer needs.
- Deliver effective training and reduce downtime by monitoring deployed machines and creating augmented reality experiences. [xii]
- Create predictive and simulation models to assess complex scenarios and forecast failures.
- Remotely troubleshoot, patch, or update software

PTC Solution architecture

Process control: Customer Story

Featured Partner: Sight Machine

A global paper manufacturer wanted to reduce scrap rates, limit changeover inefficiencies, improve consistency of product quality, and reduce high energy costs associated with operations. Gaining accurate insight into data and where breakdowns in production occur was imperative. Sight Machine unifies all data inputs continuously (i.e. 15,000+ tags, 24 hours/ day) within the manufacturer's production process and creates a standard data model and continuously updated digital twin of the entire end-to-end process from pulp to paper. From machine operators to the CEO, everyone can quickly visualize and establish correlations across any set of variables to identify bottlenecks and opportunities for productivity improvements.
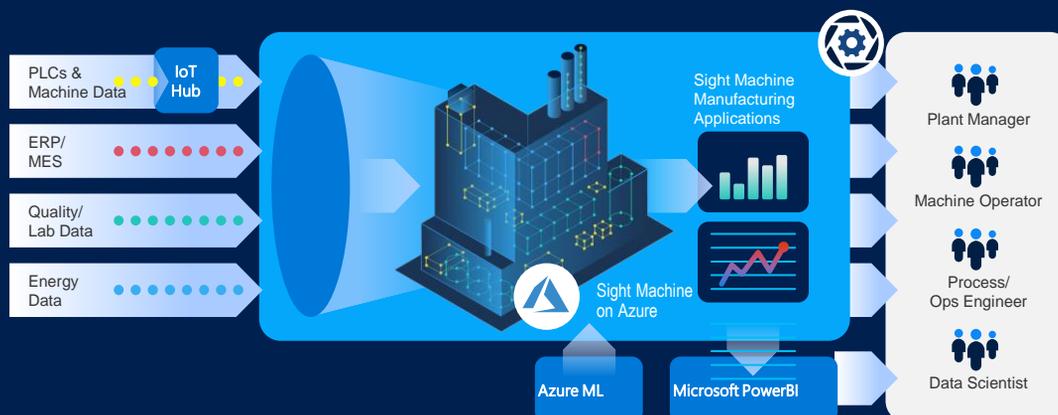
They can now map detailed process, quality and downtime data to specific production batches, transforming it into actionable intelligence. Supported by Azure, Sight Machine's solution enables new levels of insight and action giving the paper manufacturer the ability to solve previously impenetrable problems.

Sight Machine helps this manufacturer:

- View how machine parameters impact downtime and quality.

- Conduct fast, accurate root-cause discovery to maximize uniformity.

- Better leverage data to improve operational efficiencies.

- Easily optimize machine settings for each paper grade.

- Gain actionable insights into optimal process settings to reduce energy.

- Maximize the value of their aging assets while minimizing the unit cost of production.

Sight Machine Solution architecture

Performance management: Customer Story

Featured Partner: Blue Yonder

Blue Yonder's Luminate Control Tower is a manifestation of the digital twin for an enterprise's supply chain network. It provides real-time visibility into the enterprise's end-to-end supply chain, predicts exceptions, and provides a framework for stakeholder collaboration and issue resolution. With machine learning based insights, the Luminate Control Tower helps manufacturers and distributors predict patterns before they happen, sense disruptions, understand the business impact of different options, and provide prescriptive recommendations for optimal performance along the entire value chain.

Built on the Microsoft Azure platform, Blue Yonder's Luminate Control Tower helped a **Global multinational home appliance manufacturer,** leverage the power of supply chain digital twins in providing end-to-end visibility along with real-time insights into supply chain dynamics and behavior. With the ability to ingest data from all relevant planning and production resources including ERP, TMS, and WMS, as well as external data
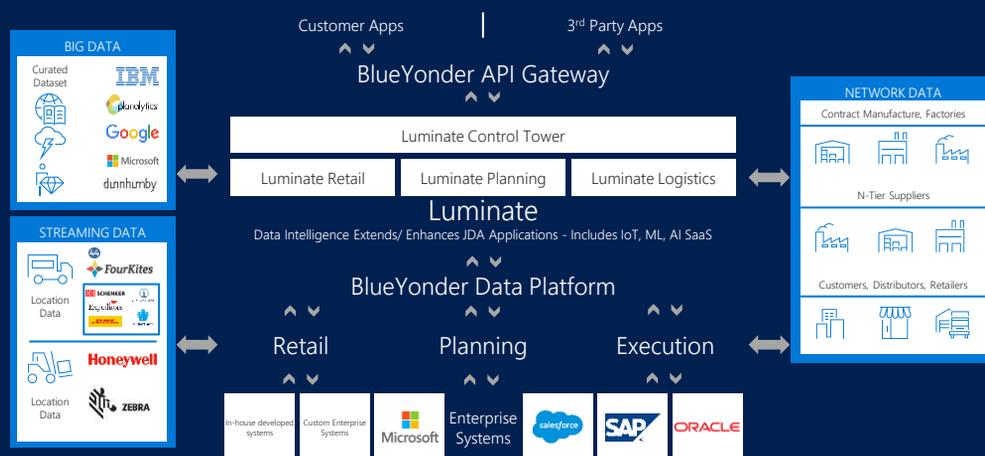
sources from suppliers, customers, and digital sources (like RFID), Blue Yonder's Luminate Control Tower enables the home appliance manufacturer to quickly discover and address bottlenecks, test supply chain design changes, proactively detect risk in real-time and offer prescriptive guidance to supply chain and manufacturing operations.

Blue Yonder can help manufacturers:

- Digitally orchestrate its supply chain without latency: 15 percent increase in operational efficiency and 10 percent decrease in carrying costs.

- Continuously gain insights to discover, interpret, and act on real-time information from the entire digital ecosystem, including third-party data.

- Make informed, optimized decisions in real-time to improve customer delivery performance.

- Actualize better ways to reduce costs, enhance quality, and improve end-to-end performance as the Luminate Control Tower learns from itself.

❖ BlueYonder

Blue Yonder Solution Architecture

Configuration management: Customer Story

Featured Partner: Aras

As a manufacturer of a wide range of electronics and systems, **Microsoft** manages vast amounts of product data. Everything from Surface computers, XBOX consoles and HoloLens headsets to the servers, storage and networking in the Azure data centers around the world. When the Microsoft Device Group needed to unify the product data from multiple business lines into a single system, Microsoft turned to Aras and their Aras Innovator low-code platform.

To achieve the necessary collaboration and remote management required, Aras was deployed on Azure. Aras Innovator has proven to be an open and resilient platform for PLM processes and much more, just what Microsoft was looking for to support its global ecosystem of design partners and contract manufacturers. Aras enabled the rapid delivery of highly flexible, upgradeable solutions to manage the complex product variants for engineering, manufacturing, and supply chain operations.

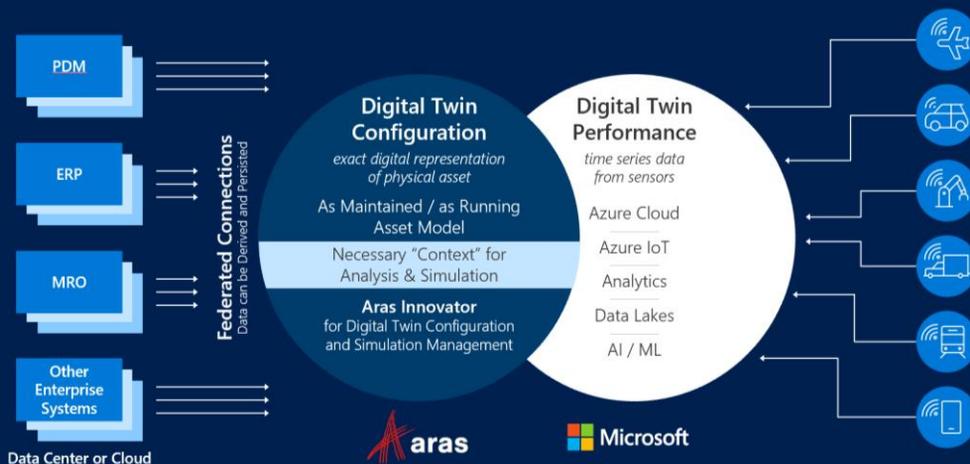Aras helps ensure that critical product information vital to configuration management is correctly represented and has digital thread traceability. Aras Innovator now serves as the global backbone at the heart of Microsoft's PLM implementation. Microsoft is now in a better position to accelerate the latest devices to market due to Aras's innovative approach to PLM.

Aras helped Microsoft:

- Align and unify fragmented systems supporting critical tasks such as the global product development, prototype testing, and supplier quality.

- Connect and trace each product's digital assets – and their revisions over the lifecycle – including versions of BOMs, parts, software, electronics, CAD models, documents, manuals, and more.

- Support complex analysis of configuration management, including variants and options, with "closed-loop" traceability to verify requirements.

Digital Twin Configuration + Digital Twin Performance

Process control: Customer Story

Featured Partner: Simio

A multinational ETO corporation manufacturing robotics, heavy electrical equipment, and automation technology needed to better understand, integrate, and schedule its complex manufacturing operations. They also wanted to improve material availability, reduce the cost of production while improving on-time delivery by removing the disconnect between master planning and detailed production scheduling.

Simio was deployed to create simulation-based process digital twin fully integrated into SAP incorporating all the operational constraints (i.e. equipment, tooling, labor, transportation), business rules (operating requirements, labor requirements, inventory policies, maintenance policies) and detail decision logic (i.e. equipment selection, labor allocation, material allocation). Simio became the engine for creating an optimal schedule for all tasks in the facility, ensuring complete synchronization between all production departments, engineering, and master planning.

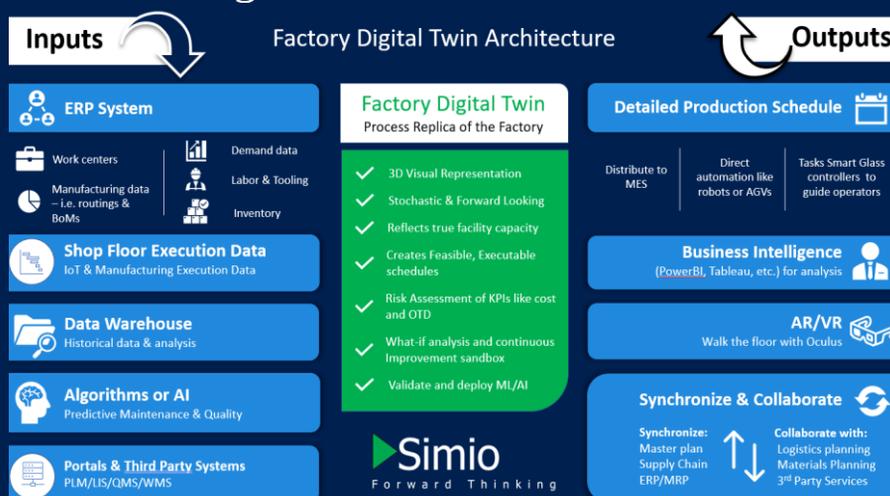The results and schedule are distributed via a cloud platform to all stakeholders and operating departments for instant access and displayed on large electronic display boards installed in each work area across the factory, updated whenever a re-schedule occurs due to real-time changes in demand priorities or shop floor events.

Simio helped the corporation:

- Deploy a cloud-based digital twin of the factory to autonomously schedule all tasks in the facility
- Drive significant improvement in throughput and on-time delivery resulting in a substantial ROI
- Analyze and understand manufacturing constraints – gaining total transparency into all tasks from equipment design through shipping
- Align the master plan with the detailed production schedule to ensure material availability and on-time delivery.
- Evaluate the impact of additional demand to easily and confidently respond faster around cost and timeline for competitive bids.

▶Simio
Forward Thinking

The Simio Process Digital Twin

Process control: Customer Story

Featured Partner: Bentley

With the vision of creating the workplace of the future, Microsoft partnered with software company Bentley Systems and automation specialist Schneider Electric to create a digital twin of **Microsoft's Asia Pacific headquarters** in Singapore.

The digital twin – a virtual replica of the facility – was developed using Bentley's OpenCities Planner and Microsoft's Azure IoT Hub and Power BI analytics service. OpenCities Planner is a cloud-based service that enables visualization of 2D, 3D, and GIS data in a "single pane of glass" accessible from anywhere 24/7.

The team implemented sensors and telemetry throughout the building to create a connected workplace. These sensors collect data about lighting, air quality and temperature enabling the real estate group to monitor and adjust the usage, energy and utilities of the facility. They also enable modelling of the relationships between people, places, and devices. By correlating data across the physical and digital worlds Microsoft can easily adapt the space to suit specific tastes or needs, and unlock new efficiencies, improvements, and opportunities.
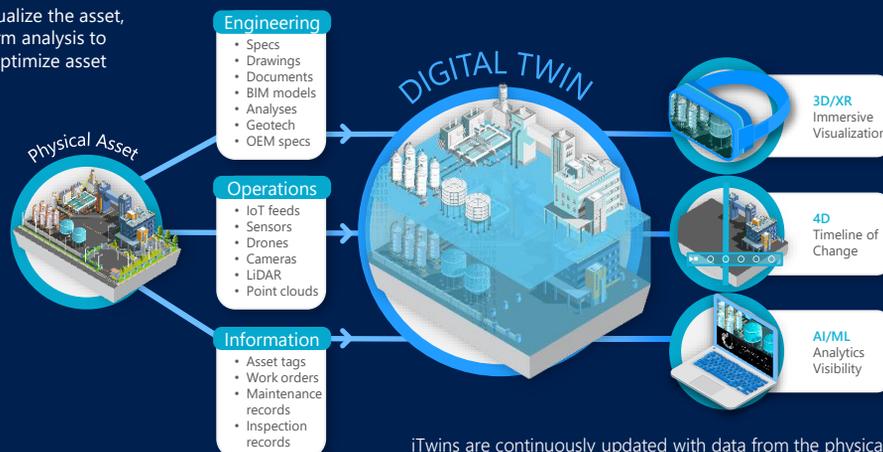
Bentley's OpenCities Planner helps customers:

- Design, visualize, and communicate projects of all types from signature buildings to city-scale developments and smart cities.

- Better manage energy consumption.

- Streamline facilities management and performance.

- Simulate and plan for the impact of extreme weather events and workplace security incidents.

Bentley®
Advancing Infrastructure

Bentley iTwins Digital Twin

iTwins enable you to visualize the asset, track change, and perform analysis to better understand and optimize asset performance.

Physical Asset

Engineering
- Specs
- Drawings
- Documents
- BIM models
- Analyses
- Geotech
- OEM specs

Operations
- IoT feeds
- Sensors
- Drones
- Cameras
- LiDAR
- Point clouds

Information
- Asset tags
- Work orders
- Maintenance records
- Inspection records

DIGITAL TWIN

3D/XR
Immersive Visualization

4D
Timeline of Change

AI/ML
Analytics Visibility

iTwins are continuously updated with data from the physical asset. This data is used to understand and model the asset's performance.

References

- [ii] https://www.forbes.com/sites/lanceeliot/2020/04/14/apollo-13-has-its-50th-anniversary-and-divulges-hidden-warning-signs-applicable-to-todays-ai-systems-including-self-driving-cars/#7219f6be554c

- [iii] https://www.aiscorp.com/en/blog/entry/overcoming-the-top-5-manufacturing-productivity-pain-points#_ftn1

- [iv] https://info.microsoft.com/rs/157-GQE-382/images/Microsoft%27s%20Digital%20Twin%20%27How-To%27%20Whitepaper.pdf

- [v] https://www.gartner.com/en/newsroom/press-releases/2019-02-20-gartner-survey-reveals-digital-twins-are-entering-mai

- [vi] https://www.challenge.org/insights/digital-twin-history/

- [vii] https://sloanreview.mit.edu/article/how-digital-twins-are-reinventing-innovation/

- [ix] https://www.howden.com/en-gb/digital-solutions

- [x] https://www.ansys.com/blog/designing-electric-car-battery-pack-pikes-peak-world-record

- [xi] https://azure.microsoft.com/en-us/blog/microsoft-partner-ansys-extends-ability-of-azure-digital-twins-platform/

- [xii] https://www.ptc.com/en/product-lifecycle-report/digital-twin-howden-demo

- [xiv] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/manufacturing-industry-outlook.html

- [xv] https://www.mtconnect.org/

- [xvi] https://thenewstack.io/the-digital-feedback-loop-powering-next-generation-businesses/

- [xvii] https://futuristspeaker.com/technology-trends/seven-ways-digital-twins-will-affect-your-life-in-2028-and-beyond/

- [xviii] https://www.challenge.org/insights/digital-twin-and-iot-platforms/

Microsoft