Microsoft Azure

Beyond predictive maintenance

How prescriptive maintenance mitigates future failures through explanation and solution

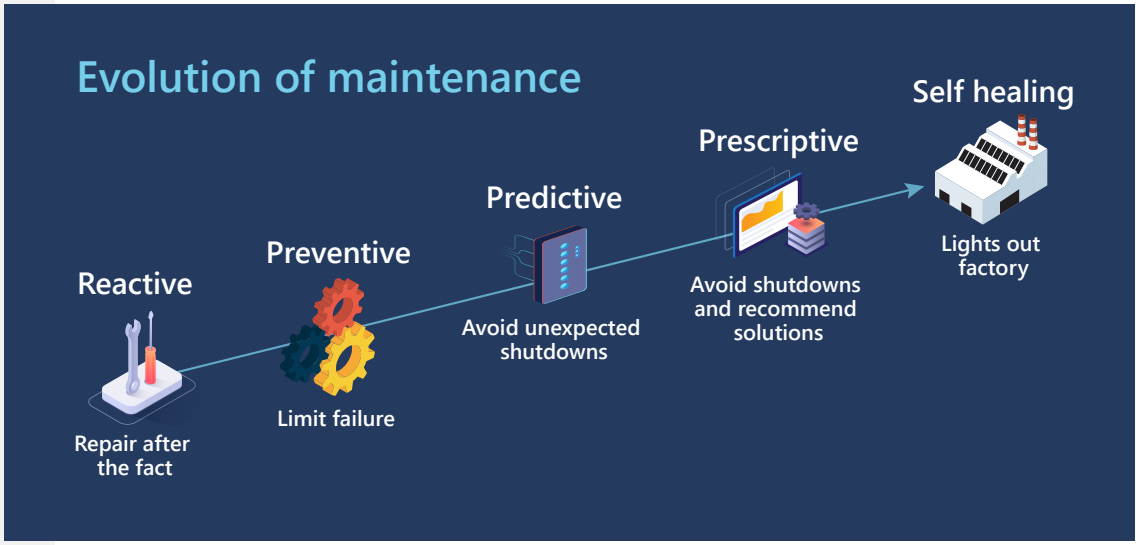
White Paper

Table of Contents

Preventative, predictive, and prescriptive maintenance provide answers to questions surrounding timing, probability, failure cause, and risk-level ranking issues

Preventative maintenance refers to the routine maintenance of assets and equipment to prevent unplanned hiccups, failures, or downtimes. Part of preventative maintenance involves a proactive maintenance strategy in which manufacturers strategically plan and schedule maintenance assessments and tune-ups apropos of indication of premature breakdowns.

For decades, the classic preventative and predictive maintenance models have been based on scheduled maintenance, historical data, and operator know-how. Predictive maintenance leverages sensors to reschedule services ahead of time to prevent temporary lapses in production and ensure that manufacturers are following regulations; it marks the first wave of taking costly reactivity out of service maintenance.



While preventative and predictive maintenance are useful in mitigating expensive downtimes, they don't provide context on why failures occur in the first place. Predictive maintenance, for instance, focuses on only one asset at a given time. It concentrates on operationalization or subscription services for single assets rather than holistic solutions that meet the requirements of maintaining a system of assets that work as intended.

Prescriptive maintenance, on the other hand, takes a more comprehensive view. Instead of waiting for machines, equipment, or products to break, or focusing on a singular asset, prescriptive maintenance runs devices on a single lifecycle (regardless of how old they are) and deals with assets in aggregate. Prescriptive maintenance marks the first electronic approach to setting context around data.

The benefits help manufacturers understand the "why" behind a failure, and they explore and present numerous solutions to solve for failures. Prescriptive technologies realize the vision required to maintain uptime, extend service

cycles, and ensure that companies obtain more yield out of their assets—all while achieving lower operational costs in service of maintenance.

A process-driven approach to both predictive and prescriptive maintenance technologies—in that order—is necessary to realizing the benefits offered by both analyses.

Prescriptive maintenance goes beyond predictive maintenance; it extends the lifecycle of machines and products, preventing downtimes, increasing operational efficiency, and saving on operational costs.

Why prescriptive maintenance?

Tried-and-true predictive standards of operation have already established their value, which raises the question: why should manufacturers adopt prescriptive maintenance?

The optimal response to any given asset challenge will depend on more than just the operational posture of a single asset in isolation. To that end, context matters when evaluating a failure. Prescriptive maintenance provides answers to questions such as: is it the right time to bring the line down? Are there spare parts available, or is this machine set to retire? Do we lose more throughput stopping the work to fix it or shifting the work to other machines? Each decision requires insight and context that the basics of predictive maintenance don't provide.

Prescriptive maintenance goes beyond predictive maintenance and one-time use cases; it extends the lifecycle of machines and products, preventing scheduled (or unscheduled) downtimes, increasing operational efficiency, and saving on operational costs.

Operational excellence and increased cost savings are the primary drivers behind prescriptive maintenance. Shifting from a fixed schedule to a more flexible one will reduce costs exponentially. An end-to-end product journey for every product or machine offers more predictable pricing per asset once it's fully integrated into the company's business model.

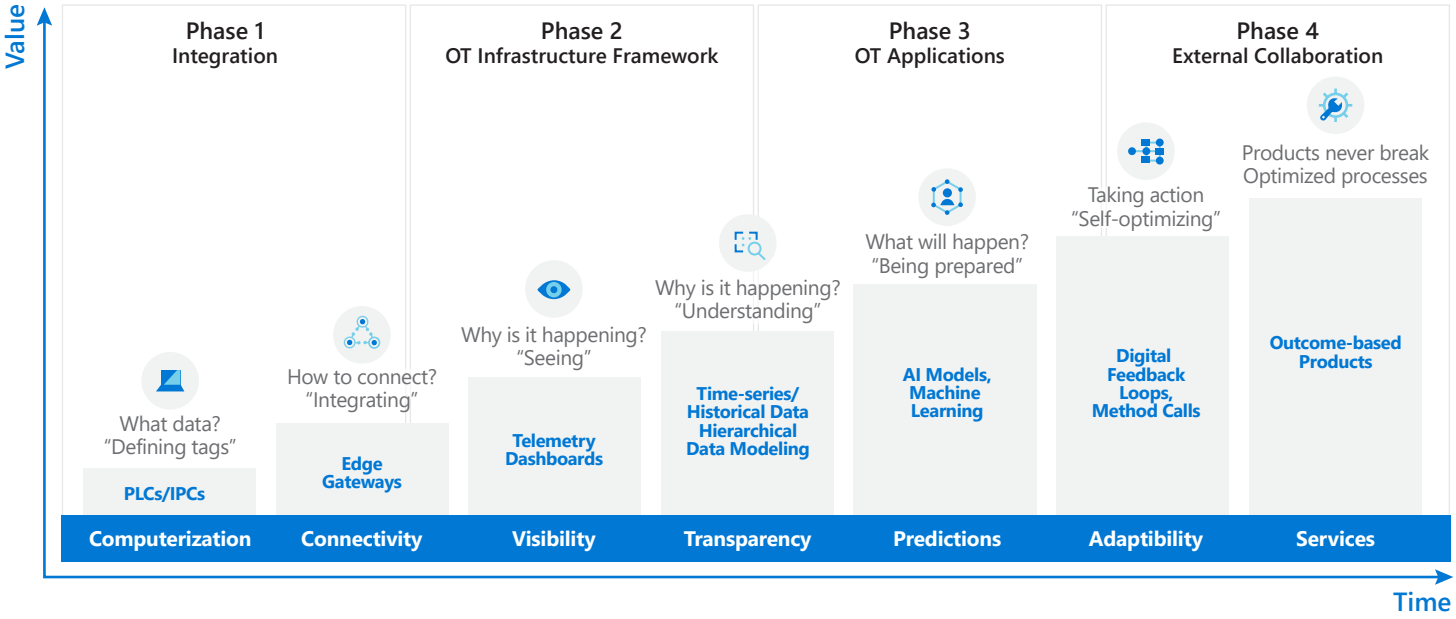
It is then that manufacturers can extend their asset lifecycles and adopt future-facing, progressive operational standards, as well as self-learning machines and lights out factories (to name a few).

For some companies, risk management is the number one goal when it comes to both predictive and prescriptive maintenance. For others, it's mitigating the regulatory and auditing load that customers will incur and manage. Another crucial consideration includes the likelihood of prescriptive technologies extending the life cycles of assets and bolstering operational efficiency.

Companies want to invest in a solution that's an improvement from their existing solution, saves money, and doesn't require a high learning curve. Prescriptive maintenance provides an informed context so companies can execute business decisions in advance of upcoming maintenance windows.

Prescriptive maintenance as a principal component of business models

Forward-thinking organizations draw on a variety of analytics to inform their decision-making. For manufacturers to leverage prescriptive maintenance successfully, we recommend they embed it into their operational playbook.



Integration allows companies to align their servicing decisions to wider business goals through incremental changes to systems and maintenance processes. As a result, companies can make continuous improvements informed by insights from advanced analytics. Advanced analytics are composed of artificial intelligence (AI) and machine learning (ML).

The effective digital platform enables informed decision-making sensitive to the needs of the line operations, as well as business requirements. It is through a secure digital platform that businesses can better monitor equipment and processes and draw data and insights from historical data to improve upon existing processes. Business decision makers, as well as analysts, operational technology (OT) managers, and operators, can benefit from the solutions that prescriptive maintenance offers.

Business models that prioritize digitalization yield improved operational efficiency because industrial internet of things (IIoT) capabilities like prescriptive maintenance give companies full visibility and the ability to analyze operations. Companies that embrace such models go beyond merely connecting processes and devices, and as a result, have a fuller range of available responses to business challenges.

Asset acquisition, installation, and deployment costs typically count against capital expenditure (CapEx) budgets, while maintenance and servicing count against operating expenses (OpEx). Both budgets operate in different directions at various times, often leading with CapEx at the beginning of a new project or facility and sitting more heavily on OpEx as equipment ages and companies try to extract additional value out of their sunk-cost assets.

While predictive and prescriptive maintenance may forestall large CapEx investments, manufacturers that invest in such technologies maximize their overall returns across both regimes; optimizing the repair versus replace calculus considering its impact on different kinds of budgets, efficiency, and customer requirements as demonstrated in the case studies below.

Avoided Cost as a KPI for prescriptive investment

When deploying a maintenance solution in your facility, it's helpful to have a metric of success for the work you're doing to validate and warrant the deployment of such solution. When evaluating predictive or prescriptive maintenance solutions,

Avoided Cost = Assumed Repair Cost + Production Losses − Preventative Maintenance Cost

for instance, manufacturers typically track the Avoided Cost as a key performance indicator (KPI) to indicate the impact of the proactive investment.

To clearly evaluate the successful implementation of descriptive, preventative, and prescriptive maintenance, it's important for companies to understand the difference between reactive costs and proactive costs—and how to measure the impact of proactive investment. Reactive costs such as unplanned downtime and emergency technician visits lead to real consequences in OpEx and product delivery deadlines.

All this to say, while waiting until machines break will minimize the cost of the repair itself, it'll typically maximize the cost of the repair incident, creating a disruptive impact on the facility and product delivery schedule.

In instances with well-known or long-serving hardware, anticipating a replacement cycle partway through a multi-year period of continuous operation allows your company to perform maintenance well ahead of the indicators of part catastrophic failure and batch downtime into previously existing downtime windows.

An avoided cost still qualifies as a cost saving; avoided costs account for future costs by mitigating—or avoiding—costly repairs down the line. An avoided cost is the equivalent to the assumed repair cost combined with the production losses from unplanned downtime minus preventative maintenance cost.

Predictive maintenance detects an issue; prescriptive maintenance diagnoses and mitigates it

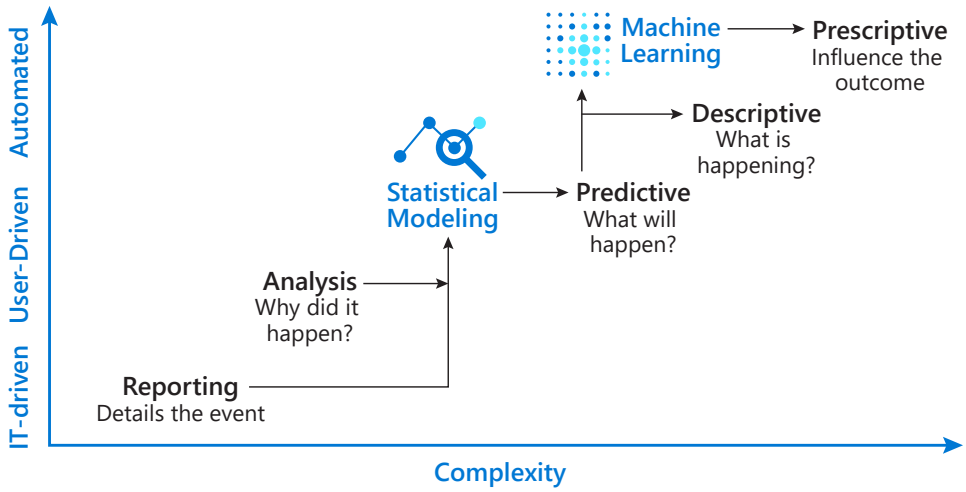
Predictive maintenance analytics forecast what will most likely happen in the future using various methods that analyze current and historical facts to generate future outcomes. Predictive maintenance technology alerts companies when there's an error or malfunction within a process; predictive maintenance prevents catastrophes before they occur.

Thanks to machine learning, when applied to real-time streaming data, companies can analyze data in conditions that mirror the physical world. Predictive modeling allows companies to pinpoint conditions that inevitably lead to equipment issues down the line. With this information, operators can tweak processes and systems to enable preventative actions whenever those conditions arise. This allows companies to aggregate insights from predictive models into real-time operational changes that result in significant business value.

At a minimum, predictive maintenance, better data resolution, and more effective models allow operators to run machines longer without encountering unexpected breakdowns. Predictive maintenance uses or leverages data from a single asset to predict values for other assets. An integral part of accurate prediction hinges on measuring the right and necessary variables. These models predict which independent variables caused each outcome.

Prescriptive maintenance, on the other hand, changes processes altogether to mitigate risks from ever becoming a potential outcome. Prescriptive maintenance explains why the error or malfunction occurred in the first place, and it offers the capability to warn operators of future failures. Prescriptive maintenance formulates the foundation for a well-built predictive model by collecting

The progression of analytics



information on predictable and expected behavior, as well as a catalog of all failures or malfunctions. Once it recognizes unusual behavior or patterns, condition monitoring and bottleneck analysis signal an anomaly outcome.

Prescriptive analytics propose various solution-driven actions to take by feeding historical data into a machine learning model that analyzes patterns and trends. Using this model, prescriptive maintenance then applies this to current data to predict future outcomes for each solution.

An everyday example illustrating this progression is when you get into a car and the dashboard light comes on indicating that you've run out of wiper fluid. Predictive maintenance represents your scheduled service appointment: every 5,000 miles or so

the technician checks the wiper fluid while proactively changing the lubricants in the motor. Prescriptive maintenance would skip the manual check. By including a sensor in the fluid level, the car could tell the technician if fluid was required or not at the time of the next service—or even change the default amount of fluid used each time as the fill-line threshold approaches. As a result, the car would continue to function properly without the driver ever knowing an error condition was mitigated.

Though helpful, the cumulative answers that predictive maintenance technology bring are ephemeral when it comes to a holistic view of operational processes. In other words, knowing of a system failure or glitch through IIoT technology is only useful if that same IIoT technology can identify why the failure occurred in the first place, fix it, and predict the likelihood of it occurring again in the future.

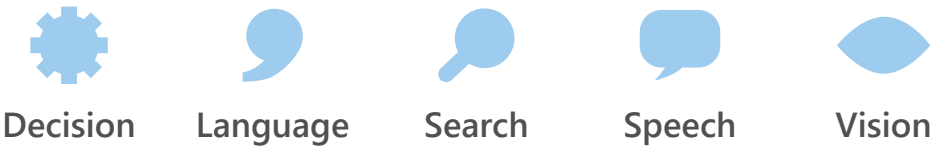
The zenith of success in adopting IIoT technologies lies in utilizing prescriptive maintenance—not just predictive maintenance. Prescriptive maintenance triggers cascading changes down the value chain that can motivate companies to optimize repair schedules or alter approaches to machine or spare part purchasing decisions—all of which empower businesses to evolve.

Cognitive Services, Machine Learning, and Anomaly Detector make predictive and prescriptive maintenance possible

Azure services and machine learning both apply artificial intelligence (AI) to improve, supplement, and increase efficiency within business operations. Machine learning provides companies with the predictive intelligence they need to stay viable in an increasingly competitive and digitizing market. AI detects problems before systems or customers are negatively impacted.

Azure services represents a group of services with each one supporting different prediction capabilities via machine learning. Companies can use Azure services to draw solutions from a representational state transfer application programming interface (REST API) or software development kit (SDK). Azure was designed with a zero-learning curve in mind, so no specialty machine learning or data science knowledge is required to access its benefits—or deploy it.

Azure services' predictive capabilities can be divided into five categories:



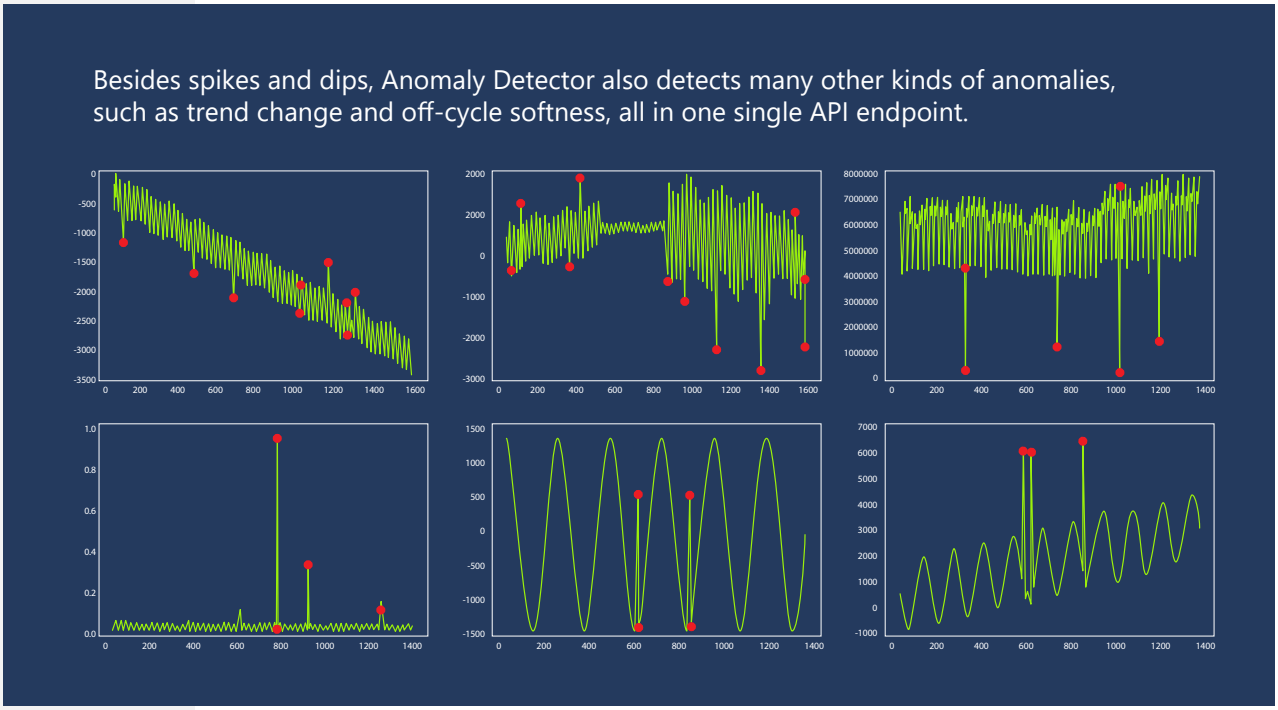
The service category decision is intended to help customers build apps that present recommendations for efficient decision-making. The language category helps these apps process various languages using sentiment evaluation technologies, as well as pre-build scripts. Search application programming interfaces (APIs), when added to Bing, allow customers to comb through billions of webpages and web content with a single API call.

Using Azure services' speech service, users can translate speech into text and text into speech. It also possesses the capability to convert one language into another language and process speech recognition. Lastly, Azure services' vision category recognizes, identifies, captions, indexes, and moderates everything from videos and pictures to files and digital content.

Cognitive Services can be used in any application that can make REST API(s) or SDK calls (e.g., bots, desktop, or mobile applications, mixed or virtual reality, etc.). Azure Cognitive Search is a separate cloud search service that optionally uses Cognitive Services to bake in image and natural language processing to indexing workloads.

Anomaly Detector API is one example of data models within Cognitive Services. Anomaly Detector API allows businesses to monitor and detect abnormalities within their time series data by applying the best-fitting models for each new data set for any scenario, data volume, or industry.

Through analyzing time series data, Anomaly Detector can pinpoint which data points are anomalies and establish boundaries for anomaly detection and expected values based on sensitivity to data anomalies that the user controls.



Anomaly Detector API works by comparing real-time data points to previous data points to evaluate if the current data point is abnormal. From here, it constructs a model based on the time series data points sent by the user with each point analyzed using the same mode.

As part of Cognitive Services, this API comes with zero learning curve as well. The RESTful API allows companies to seamlessly incorporate API into business processes.

For specific data sets, companies can deploy machine-learning solutions. Machine learning solutions involve computing data and establishing an algorithm to solve specific business needs. Once companies train the data and algorithm to their liking,

they can yield new insights on new data in the future. However, unlike Azure services, the process of building a machine learning system requires some knowledge of machine learning or data science.

Azure Machine Learning presents solutions for issues related to slow training of models and complex deployments by empowering data scientists and developers to create, deploy, and train machine learning models while accelerating and supporting end-to-end lifecycle support. Industry learning continuous development practice and development operations (DevOps) for machine learning enable companies to increase the pace at which they can bring products to market.

Azure Machine Learning boasts a myriad of solutions and benefits. To start, it can easily scale from across cloud or edge resource pools, and its simple drag and drop interface enables quicker and smarter model prototyping. Furthermore, it supports open-source frameworks, allows companies to build pipelines that facilitate the sharing of end-to-end data science experiments to optimize workflows, and speeds up solution deployment.

Azure Sentinel is another cloud-native platform that utilizes AI to collect large volumes of data across on-premises and cloud-based deployments. A key component of Azure Sentinel is its built-in security information and event manager (SIEM) platform, which stops threats in their tracks before they can cause harm. Threats that previously went undetected are now brought to light while false detections are minimized. AI technologies chase down threats and automated tasks squash unexpected threats automatically.

Azure Sentinel and Azure Defender bring best-in-class security to protect every company's data and safeguard data sharing for increased collaboration.

Azure Defender Azure Sentinel

thyssenkrupp

ThyssenKrupp safely tests reimagined elevators through Willow Twin

ThyssenKrupp Elevator, the German worldwide leader in elevator technology, created the Willow Twin, in partnership with Willow, to increase overall customer satisfaction. Leveraging digital twin technology, ThyssenKrupp can calculate usage and machinery patterns, identify current and future failures, test hardware, and as a result, reimagine its customer satisfaction approach altogether.

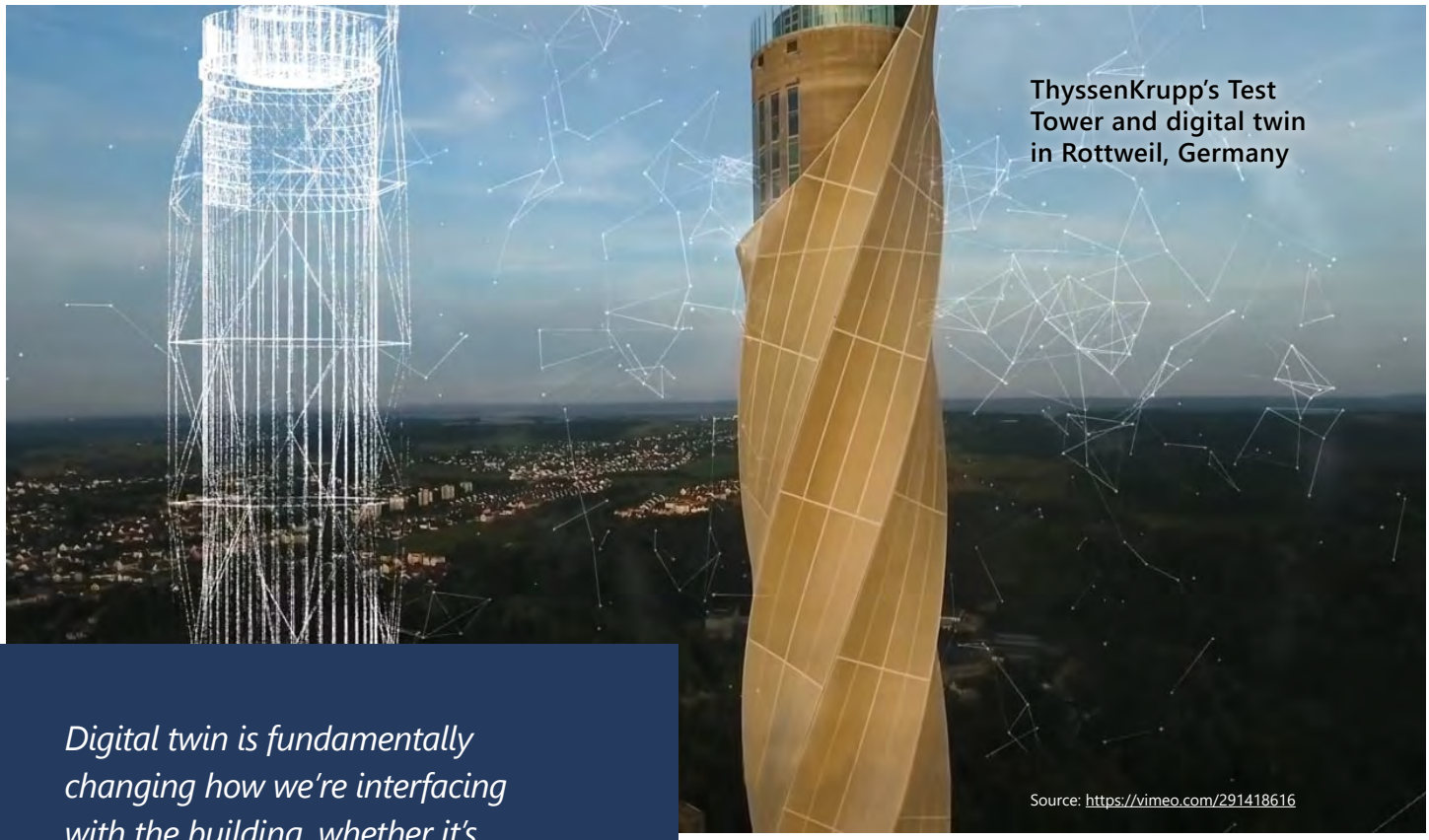
Willow Twin utilizes MULTI elevators—which are made possible by linear motors—to move vertically and horizontally, enabling multiple cabins to travel up and down various shafts at a given time.

The benefits of MULTI elevators are threefold: tenants and visitors can navigate more easily and quickly through large buildings, height and structure requirements and limitations for elevators are decreased, and the MULTI elevator uses fewer shafts compared to more traditional elevators.

Ultimately, Willow Twin will accomplish several goals:

- Manage and reduce costs for real estate owners and managers
- Improve overall interactions for tenants and customers
- Increase operational efficiency
- Provide greater insights on occupant and visitor usage and experience for facility management

ThyssenKrupp tested the Willow elevator at its Test Tower in Rottweil, Germany. The Test Tower, which has been dubbed the village of towers, allows ThyssenKrupp to simulate people, coordinates, walls, devices, and more within a building through Digital Twin.



ThyssenKrupp's Test Tower and digital twin in Rottweil, Germany

Source: https://vimeo.com/291418616

Digital twin is fundamentally changing how we're interfacing with the building, whether it's the occupant, the owner, or the operator. It won't be very long before every single building construction process ends with a requirement to have a digital twin of the asset.

– Shaun Klann, President, US and Europe Operations, Willow Inc.

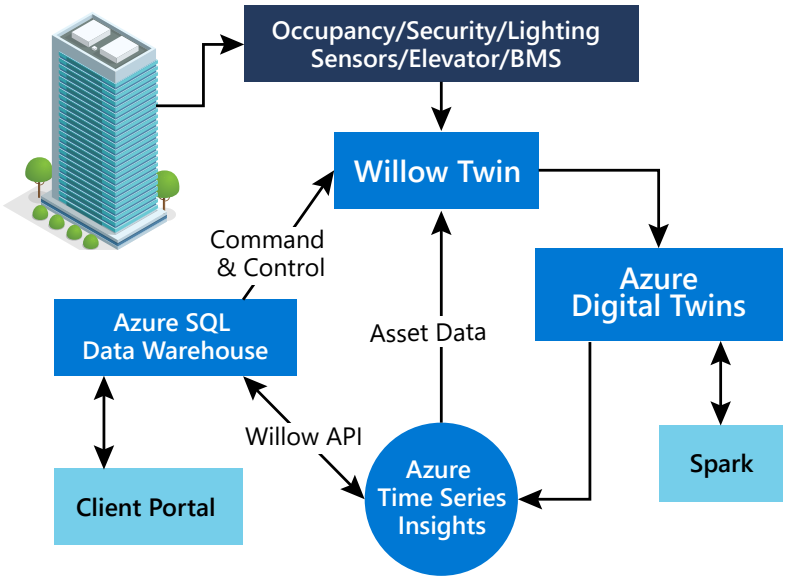
Since ThyssenKrupp works in the business of the transportation of people, it was imperative that the company could safely trial Willow Twin. Willow creates a digital twin replica of each building to conjoin static data produced during every stage of construction of each building. In addition to status data, Willow provides insights into live dynamic information.

As a result, the company can test—through simulations—everything from people flows analytics and machine behavior to worst-case scenarios and real-time malfunctions.

Willow Twin provides ThyssenKrupp with hundreds of thousands of data points; it can simulate what will happen during an emergency and pinpoint the cause of such emergency, offering the company full visibility into how to make operations safer, smoother, and more efficient.

Thanks to the agility and scalability offered for data storage and embedded security features that Azure Digital Twins boast, ThyssenKrupp and Willow were able to create a single, robust, and secure solution through IoT, cloud, and AI. Willow Twin draws on its predictive maintenance solution, MAX, to gain data (e.g., elevator data, sensors, security, occupancy, etc.) from buildings.

This data funnels into Willow Twin, which is then transferred into Azure Digital Twins. Azure Time Series Insights records the data within Azure Digital Twins, and the data from within the Time Series Insights feeds into Spark. From here, data flows directly into Willow API. Within Willow API, Willow API and AUTH API inform Azure Digital Twins by feeding it asset data. The data from the Azure SQL Data Warehouse is then transferred to the client portal before becoming directly accessible by the client.



Through a powerhouse trio of AI technologies, digitalization, and IoT, building owners and managers can enhance data and energy usage to manage their operational costs. Through Digital Twin, live data from IoT sensors that monitor each buildings' energy and power systems (i.e., heating, air conditioning, ventilation, etc.), owners and office or building managers can see where errors occur, where energy is used superfluously, and more.

The innovation at play at ThyssenKrupp won't stop at Rottweil. Ultimately, the enterprise solution created will make elevators, buildings, and cities safer and smarter worldwide.

FESTO

Through AI and ML Festo has more transparency into its maintenance process

Festo, a family-owned worldwide kingpin in the automation technology and technical education space based out of Esslingen, Germany, pursued full adoption of smart production and digital automation. Before this, AI and ML allowed Festo to service over 300,000 customers solely through pneumatic and electric-driven solutions.

Through the full-fledged implementation of smart production and digital automation, Festo could realize minimal downtimes and increase overall productivity through accurate forecasts of plant maintenance. Festo's goal was to accurately predict its plant's maintenance requirements before it encountered failures, experienced lulls in productivity, and accrued costs down the line.

By networking machines and visualizing data across the value chain, Festo gained more transparency within the maintenance process, as well as preventative and predictive maintenance solutions during non-productive times.

> *Thanks to Microsoft's services, we can focus on our core competencies, generate smart data from big data, and offer our customers digital value-added services to remain optimally positioned in the market.*
>
> **– Dirk Zitzmann, Product Management and Business Development, Festo**

To achieve this, Festo relied on the data availability and Azure security properties. Over the years, the company has continuously improved its products as software as a service (SaaS). Without SaaS offerings, Festo didn't have the capability to offer new products, such as customer licensing models or individualized digital products, to its customers.

To combat unplanned downtimes and achieve greater productivity, Festo launched three products:

- Festo Dashboards
- Smartenance
- Festo Projects

Festo Dashboards provides Festo with the foundation of preventative maintenance, as it provides a panoramic overview of component status. Through the dashboard, operators can diagnose glitches, errors, and faults, which increases productivity and allows plants to test their products more thoroughly before shipping them off to customers.

Thanks to cloud-connected devices, Festo can send extensive information directly from Azure using a standardized communication protocol to retrieve data on the status of production plants.

To simplify factory data and make the digitization process more approachable, Festo devised the Smartenance digital maintenance management app. Smartenance serves as an app for plant operators and maintenance managers and is tailored to each Festo factory. Azure hosts the app on two different interfaces: the mobile application and a web-based application.

Smartenance gives Festo visibility into tasks, instructions, details, photos, measurements, readings, texts, and more. In practice, maintenance workers can check the status of various pieces of equipment anytime, anywhere.

Within the app, links to company-wide dashboards signal machine failures while simultaneously diagnosing them. Through these dashboards, historical energy consumption, and overall factory and equipment data, operators can determine the root causes of problems and draw insights from past and current irregularities.

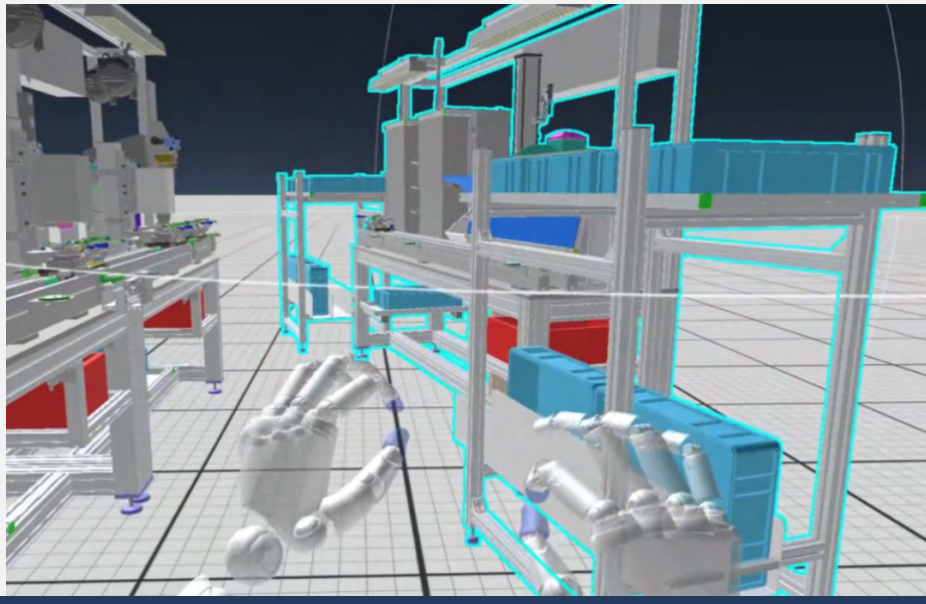
Source: Design News, You Can Use VR to Optimize Your Plant

Additionally, plant operators and maintenance managers can use the Smartenance app to assign tasks and see an overview of completed and in-progress tasks. Energy consumption and historical data are illustrated through graphical information, making it easily understandable for any production manager or operator.

All of Festo's past, current, and future data are documented through Azure cloud, making it widely available by any production manager or plant operator. Festo Projects presents an added layer of organization and insight, by detailing and documenting information regarding plant components, past, current, and future repairs, and providing frequent updates.

Moreover, Festo Projects can duplicate a physical machine virtually on a computer, allowing Festo to deconstruct the machine, and understand what work is required to repair and rebuild it piece by piece before physically deconstructing it.

Festo has also rolled out additional cloud-based digital services that boast status updates and malfunction diagnosis capabilities such as product-specific dashboards. Through Azure Cloud, Festo can more easily manage every piece of data within its company and offer software solutions to its customers. More importantly, thanks to Azure's scalable, secure platform, Festo doesn't have to manage its assets or fully digitalize on its own.



ZF established a Digital Manufacturing Program, Maintenance Intelligence, further realizing Industry 4.0

Based out of Friedrichshafen, Germany, ZF is a supplier of commercial vehicle systems, industrial technology systems, and passenger car systems. ZF is considered a leader within the automobile market, and as such, an enabler of the fourth generation of mobility.

To remain competitive in an increasingly demanding market, ZF rolled out a Digital Manufacturing Program (DMP) in coordination with Microsoft and PwC Germany. The DMP was trialed in ZF's northern German factory, Diepholz, as that facility boasts the following capabilities:

- Is small-sized
- Is profitable
- Boasts key personnel
- Has high potential for digital optimization
- Faces cost pressure due to low margin products
- Has 350+ employees

Improvement opportunities, coupled with the plant's willingness to transform, made ZF Diepholz the perfect candidate to become the pilot plant to trial new digital use cases. Before the trial, the plant navigated issues surrounding data silos, paper-based data collection, slow progress in digitalization, and high efforts to measure ZF's overall equipment effectiveness (OEE).

ZF Diepholz improved upon its process of machine data acquisition and data evaluation. It also gained visualization and prediction tools for detailed planning processes, and as a result, experienced cost savings and more efficient manual labor. Additionally, ZF Diepholz enhanced its root cause analysis for product quality. Prediction analysis also improved overall process and product quality.

Among a host of reasons, ZF Diepholz sought to enable condition monitoring of production assets and machines to analyze historical and real-time data. The plant also saw a need for better transparency into maintenance needs and analysis of parameter dependencies and optimization of maintenance cycles and quality.

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To solve all of these problems, Microsoft and PwC produced various levels of solutions. One level explains what happens within a plant, and is comprised of a planning dashboard, production worker cockpit, parts traceability, maintenance dashboard, and condition monitoring. Another level, which explains the "why" behind various equipment maintenance needs, comprises of the following:

- Measure tracking dashboard
- Shift planner
- Digital value stream mapping
- Parts cost calculator
- System based on preventative maintenance
- Paperless maintenance documentation

Payback time is expected to be around a little over eighteen months for ZF Diepholz **— a clear incentive for ZF plants to invest in the global rollout of digital solutions.**

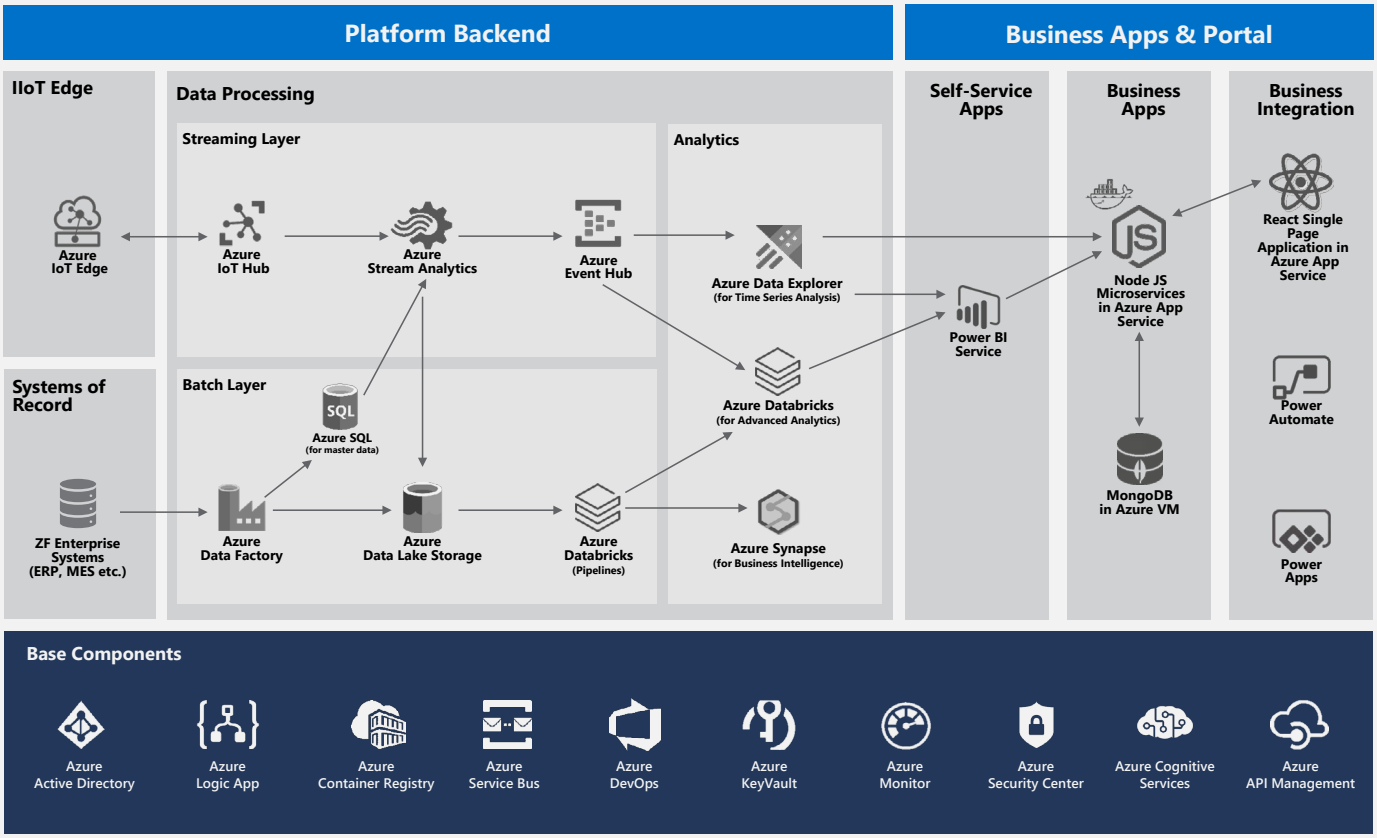
The solution tackles the predictive capacity that IIoT has to offer and provides predictions for what will happen in the future. Within this level are five systems: a planning deviation alerting device, machine stop-and-go analyzer, process parameter analyzer, root-cause analyzer, and predictive maintenance system.

Lastly, level six, otherwise known as the adaptability level, is made up of the prescriptive quality and adaptive maintenance scheduling programs, both of which pinpoint which actions need to be taken moving forward.

As a result of implementing each level of technology, ZF Diepholz realized fully automated production transparency, faster and improved reaction times on production performance, improved planning efficiency and effectiveness, and a deepened understanding and steering through analytics.

ZF took advantage of production control tower technologies, which provide transparency of production performance from the plant to each machine, as well as maintenance intelligence, which enhances maintenance operations through machine monitoring and fault prediction.

Overall, each benefit boasted the potential to reduce conversion cost, reduce required inventory, improve overall plant performance, enhance overall output quality, and make the plant's workforce more efficient.



PwC Intelligence Architecture

AB InBev embraces seed to sip concept using Azure Digital Twins

Headquartered in Leven, Belgium, Anheuser-Busch InBev, best known as AB InBev, is both a beverage and technology company and a figurehead in the world of manufacturing innovation. With over 500 beer brands worldwide, 200 breweries, and over 150,000 employees, AB InBev is the largest brewer in the world—and a major figurehead within the process manufacturing industry.

AB InBev has been on a mission dubbed "seed to sip." As part of the initiative, AB InBev wants to trace every bottle opened back to its origin—from wheat fields, through the manufacturing processing, and to store shelfs. On top of that, the company is dedicated to achieving the highest standards of quality and consistency, which incentivized AB InBev to dramatically transform its operations using Azure Digital Twins.

To achieve both goals, AB InBev utilized Azure Digital Twins to create a complete digital twin of its breweries, supply chain, and distribution network. The digital twin is synchronized with each physical brewery and provides live and up-to-date data on brewery sites around the globe 24 hours a day, 7 days a week.

Through digital twin capabilities, AB InBev is able to adjust its brewing processes based on conditions that impact natural ingredients, maintain uptimes on machines involved in its packaging process, track supply chain data to reduce emissions, and deepen its understanding of the complex relationship between equipment and natural ingredients.

Azure AI and Microsoft Bonsai's deep reinforced learning works with the digital twin to provide an autonomous system that helps AB InBev packing line operators detect and automatically compensate for bottlenecks within complex operations. For added quality assurance, efficiency, visibility, and control, AB InBev paired mixed reality and remote assistance with the digital twin technology, too.

Thanks to these technologies, settings can automatically optimize based on available raw materials and required recipes that AB InBev controls. The set of recipe parameters are adjusted for each brew, which inform control systems. During the brew process, inline sensors measure haze, turbidity, dissolved oxygen, and alcohol to predict brew quality. Thanks to enterprise resource planning (ERP) integration, InBev also decreased cycle time by automating its packaging line.

As a result of implementing Azure Digital Twins, AB InBev decreased water consumption, reduced cycle time, increased its fermentation process, and optimized operations yield potential. Additionally, AB InBev empowered its frontline workers through digital bottleneck detection, and digitally assisted remediation and remote assistance offers real-time, hands-on support around the clock.

HoloLens and Teams connect BASF's experts with on-site operators and technicians to reduce downtime and save on costs

Headquartered in Ludwigshafen, Germany, BASF, one of the world's leading chemical producers, draws upon state-of-the-art technology to facilitate collaboration among over 122,000 globally-dispersed employees. HoloLens, a mixed reality device created by Microsoft, fosters teamwork and enables collaboration by making complex design and troubleshooting tasks more efficient.

HoloLens allows on-site engineers at BASF to view prototypes in the three-dimension version of the actual physical space to visualize fast-track solutions and enact changes. If a plant in say, Germany, is dealing with a piece of machinery or equipment they're not as familiar with, instead of flying out an operator who is well-versed in that machinery or equipment who lives in Asia, they can connect instantly with that operator in a virtual environment.

As the operator in Germany dons HoloLens and scans the machinery in question, no matter where the operator in Asia is, they can take the call from their mobile device via Teams and begin to instruct the on-site operator in Germany on how to fix the problem step by step. HoloLens has mitigated expensive multi-day downtimes, and it has helped companies save on travel, since they no longer need to quickly figure out how to get operators with more equipment-specific experience from point A to point B in a matter of hours.

Using HoloLens in combination with Microsoft Teams, BASF has figured out how to successfully draw on remote assistance to perfect global collaboration. In addition to the imaging that remote experts can see via HoloLens, Teams also allows each party to send pictures, take video calls, and provide in-text instructions for increased context and smooth correspondence.

Source: Digitalization at BASF: HoloLens https://www.youtube.com/watch?v=-co30255Vbs

Plant managers contact experts in Europe through Teams and share HoloLens images to review and help with problems in plants as far away as China. The combination of HoloLens and Teams is a seamless experience and offers unprecedented visual access to help experts prepare for maintenance or support trips. They can pre-order parts even before they leave to travel to a site, saving time and money.

– Konstantin Belasik, Manager of Engineering, Innovation and Prototypes, BASF Group

Beyond routine maintenance checks and fixes, HoloLens and Teams have allowed BASF team members around the world to share ideas on equipment upgrades, swap prototype designs, and signal manufacturers for help at production time. In addition, since HoloLens provides a three-dimensional view of real environments, designers can see parts of plants and equipment with which they may not have been previously familiar. In turn, this allows for increased innovation down the line, so designers can incorporate existing beneficial assets of plants.

HoloLens also solves scalability issues. Through a mixed reality approach, designers can visualize large designs in real space rather than smaller-sized physical 3D models. For BASF, HoloLens has been extremely successful at reducing failure rates, simplifying planning, innovation, and manufacturing, and achieving time and cost savings.

Tetra Pak

Tetra Pak uses cloud-connected machines to improve maintenance repairs and scheduling

Unplanned shutdowns mean massive productivity losses and costs for every company, but in the liquid food industry, products and money quite literally go to waste. Tetra Pak, the Swedish giant in the food packaging and processing industry, relies on the aseptic process, which involves short heating and cooling times to eradicate harmful microorganisms, to sterilize its milk and milk cartons before they're shipped off.

Tetra Pak continually evaluates and improves its machines for its customers, so that, for instance, issues within production, packaging, or aseptic processes only further incentivize the company to find solutions for the same problems that its customers experience.

Milk, one of Tetra Pak's products, can be an especially difficult product to work with for several reasons. In general, cows produce up to six gallons of milk per day. If a single operation within a milk-packaging line goes down, that offline operation will result in thousands of gallons of spoiled milk. Cows still continue to produce milk daily during multi-day outages in operations, meaning even greater losses for Tetra Pak's customers.

To mitigate breakdowns from the outset, Tetra Pak enabled cloud-connected machines to more concretely detect when equipment needs maintenance to avert interruptions. Knowing when to maintain aseptic equipment that runs day-in and day-out is a delicate dance; servicing machinery too late can result in offline productions while replacing machinery too soon can result in inflated costs.

To predict informed maintenance timing, Tetra Pak connected its packaging lines to the Microsoft Azure Cloud to collect operational data. The company placed sensors on more than 5,000 carton-filling machines to study data patterns in multiple factories. Data from each machine provided Tetra Pak insight on operations and answers to questions surrounding time, specificity, origin, and other details related to plant data. Through analysis of multiple pieces of machinery, within the first six months Tetra Pak successfully predicted the future breakdown of five lines, which resulted in more than $30,000[1] in savings for its customers.

Furthermore, when Tetra Pak does repair its machines, it uses HoloLens to diagnose the root cause of problems and fix it quickly. Like BASF, this results in more machines up and running faster and savings on travel costs.

Customers have many pieces of equipment, so you have to know a lot of about a lot. That's often difficult. This helps us to do that. This is how we take the global expertise that we have available somewhere in Tetra Pak and bring it to the fingertips of the engineer in the countryside in Chile or Pakistan.

Factors to consider when implementing prescriptive maintenance technologies

When it comes to integrating prescriptive maintenance capabilities into operations, broader implementation necessitates a myriad of operational changes, such as adjusted repair schedules or reprioritized repairs. Given these changes, we've observed that companies that incrementally phase into these changes at the optimal rate for their business experience the smoothest transition.

While companies face challenges such as IT/OT integration, build versus buy decisions, and integration of solutions across the technology stack, more companies are finding a path forward as IIoT has become a more familiar fixture in the manufacturing space. Instead, they're shifting focus to other critical issues, such as creating long-term scalable architecture for their future needs and data reuse, which is necessary for the implementation of new use cases and the continued deployment of new IIoT capabilities.

IIoT achieves the most for your business when it reaches across the organization and connects disparate areas, recalibrating operational models, rewiring processes, and augmenting and contextualizing existing technical and domain expertise. Whether it's collaboration with other employees, tapping into domain expertise, sharing data, or co-developing technical solutions, companies can benefit in a myriad of ways.

Many successful companies utilize an entire ecosystem to support and accelerate their IIoT initiatives, but developing such an ecosystem poses challenges. Successful companies recognize the difficulty and devote sufficient attention to fostering and managing the myriad partnerships they need.

Microsoft services that enable and share prescriptive maintenance

Moving froward, Microsoft continues to prioritize the development of user-centric technologies: self-service, end-to-end process support, pay-per-use models, and easy and secure data sharing.

When it comes to IT design principles, Microsoft prioritizes the development of high availability and service level agreements (SLAs), high performance and scalability, data security and privacy, asynchronous messaging for loose coupling of services, and resiliency through fast failure detection and recovery.

To improve machine efficiency while minimizing costs by optimizing operations, manufacturers can connect assets to the cloud using OPC UA (Open Platform Communication Unified Architecture) and the Industrial Components. Through the application of advanced analytics, manufacturers can plan for future disruptions.

IIoT devices that possess the capability to natively communicate OPC UA can directly connect to IoT Edge, the computing power of manufacturers' on-premises network. IoT Edge allows companies to focus on insights instead of data management by taking on the legwork of moving cloud analytics and custom business logic to devices. From here, Azure IoT Hub connects devices to the cloud by enabling security-enhanced bidirectional communication between IIoT and IoT applications and devices.

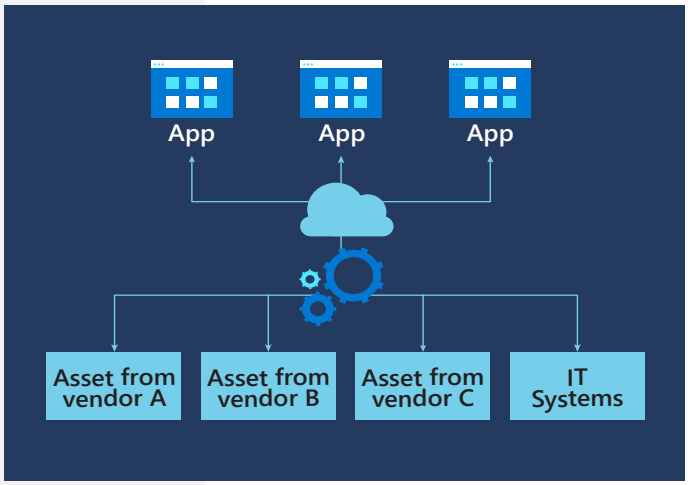
Azure Event Hub stores data through a stream processing platform that involves low-latency and seamless integration. Once data has reached the Azure Event Hub they've arrived in the cloud and the data are subsequently made available within the Azure Data Lake. The Azure Data Lake solves traditional scalability issues that prevent companies from augmenting the utility of data assets. Companies can easily sift through and manage high volumes of data through a user-friendly, one-click interface, and data insights are readily achieved with purpose built industrial solutions of general analysis through Azure Data Explorer, Azure Synapse, or directly with Power BI.

Traditional industrial modules that run inside Azure IoT Edge serve as the liaison between the factory floor and business management. OPC Twin enables registration, remote control, and discovery of devices through REST APIs.

Azure Databricks delivers streamlined workflows and an interactive workspace conducive to collaboration. Azure Databricks utilizes Apache Spark as an Azure service offering so companies can amalgamate with open-source libraries.

Lastly, Microsoft uses the business intelligence of Power BI to integrate with other tools, which allows companies to understand their data via visualized reports and dashboards.

Microsoft partners with the open industrial standards bodies and consortia, such as the Open Manufacturing Platform, that are important for your business to ensure you have control over your data and avoid lock in. By fostering open frameworks and community contribution models solutions are more easily shared and developed across sectors, allowing you to focus on your business instead of treating common challenges across manufacturing as special projects in need of bespoke solutions.



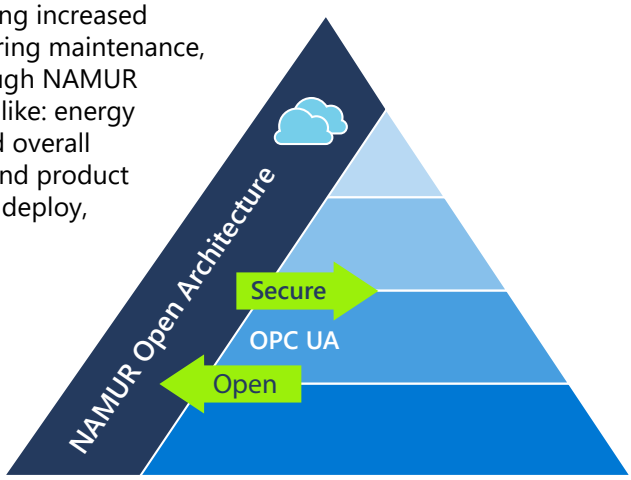
Microsoft offers pre-built solutions for manufacturers that provide baked-in extensibility of Microsoft partnerships, in addition to system interoperability and openness benefits. With these benefits, manufacturing companies can deploy prescriptive maintenance technologies with a global partnership ecosystem to rely on.

To further foster secure collaboration, companies can adopt the most flexible communication model and a best-in-class standard by overlaying NAMUR open architecture (NOA). In doing so, companies can trial new projects more easily and simply without jeopardizing the safety of their existing systems.

NOA seeks to ensure that production goes off without a hitch more easily and more efficiently—and that production data are securely available for monitoring and optimization of assets and plant data. NOA provides for a secure entry and exit point for data and feedback into the automation pyramid—without punching a hole through the layer-to-layer isolation one expects between the systems. By brokering those communications, the isolation layers are preserved while supporting the flow of data that may otherwise overwhelm hierarchical systems.

Once out of the automation pyramid, the data are free to join with data from other layers, providing cross business insights without increasing traffic in operationally constrained pathways inside the automation pyramid. NOA makes data from IT equipment, the plant floor, and the business tools more accessible.

NOA facilitates communications between the shop floor and corporate floor—which would have otherwise been impaired due to inflexible scaffolding. This valuable technique facilitates successfully realizing increased operational excellence, regular monitoring maintenance, and reliable, efficient operations. Through NAMUR Open Architecture, industrial solutions like: energy consumption, sporadic downtimes, and overall maintenance is reduced, and process and product equality and plant output are easier to deploy, maintain, and manage.



Learn more at: https://www.namur.net/en/index.html.

The NOA secure and open platform is comprised of the following: NOA M+O (magneto-optical) sensors, NOA Security Gateway, NOA Information model, and NOA Verification of Request. Manufacturers can

benefit from NOA gateways for data contextualization and aggregation, additional OT components, and sensors for monitoring and optimization—values that were previously untapped.

Additionally, M+O Apps offer process optimization, asset management, field device monitoring, and predictive maintenance solutions.

Through the joint efforts of NOA and OPC UA, communications are standardized, and companies receive valuable guidance as they cloudify traditional cloud permits traditionally on-premise systems that are not yet cloud-ready.

We're here to help you during your company's transition—and protect your company's data

Digital automation provides a solution to efficiency lags. IoT/ industrial IoT fundamentally shapes the way enterprises execute business processes, and prescriptive maintenance capabilities intrinsically enable businesses to achieve operational excellence. As companies have become more familiar with predictive maintenance and its benefits, they've leveraged it to increase profit and reimagine how they interact with materials, processes, products, and the physical world.

Data is all but meaningless if manufacturers can't draw insights that lead to better informed decision making, which is why companies have every motivation to improve this component of their operations.

Integrating predictive, preventative, and prescriptive maintenance is a vital step of digitalization, as it will yield increased operational efficiency and create more streams of revenue. That said, implementing predictive and prescriptive technologies can catalyze a flurry of wholesale operational process changes.

To ease your transition and mitigate risk, Microsoft is here to help you adjust, shape, and customize your technology solution to address your business needs, based on each client, product, or scenario.

Microsoft has committed more than one billion USD annually in cybersecurity research and development to help protect your digitalization investment. Not only is Microsoft committed to pursuing cyber criminals, shutting down their operations, and working to harden the services that our customers rely on, Microsoft has embraced the work of improving customer security posture and maturity.

Microsoft employs over 1,500 data security and privacy experts, and Azure services has more cybersecurity certifications than any other leading cloud provider on the market.

Azure security services, such as Azure Sentinel and Azure Defender, provide protection for hybrid cloud workloads against threats from the likes of SQL injections, brute-force attacks, and more. As your business embraces and adopts prescriptive maintenance technologies, you can feel secure about the livelihood, safety, and security of all your assets with Microsoft Azure.

To learn more, visit http://azure.microsoft.com.

For additional analysis and insights on how IIoT can improve other aspects of your business, read our other relevant white papers:

[1] Microsoft, "The total package: Tetra Pak's technology keeps food and drink flowing safely from farm to table | Transform (microsoft.com)"

Microsoft