eBook

Making Your Digital Twin Come to Life

With the Lakehouse for Manufacturing and Tredence

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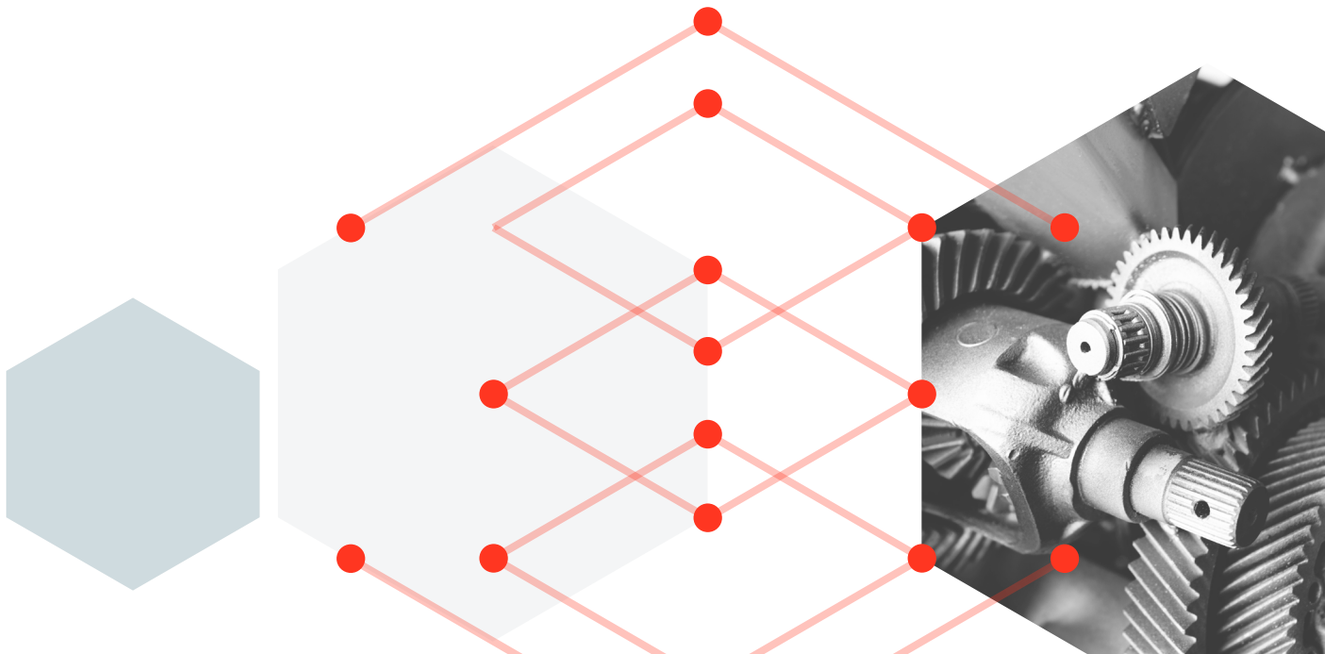

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Introduction

The concept of digital twins is not new. In fact, it is reported that the first application was over 25 years ago, during the early phases of foundation and cofferdam construction for the London Heathrow Express facilities, to monitor and predict foundation borehole grouting. In the years since this first application, edge computing, AI, data connectivity, 5G connectivity and the improvements of the Internet of Things (IoT) have enabled digital twins to become cost-effective and are now an imperative in today's data-driven businesses.

Today's manufacturing industries are expected to streamline and optimize all the processes in their value chain from product development and design, through operations and supply chain optimization to obtaining feedback to reflect and respond to rapidly growing customer demands. The digital twins category is broad and is addressing a multitude of challenges within manufacturing, logistics and transportation.

Digital twins accelerate potential revenue increase up to
10%

Time to market accelerated by
50%

Product quality improvement up to
25%

> "In a case study published in MIT Technology Review, "profit margins increased and manufacturing time was reduced when digital-twin technology was implemented. Automobile manufacturing profit margins increased by 41% to 54% per model. The estimated average automobile manufacturing time was reduced to approximately 10 hours."

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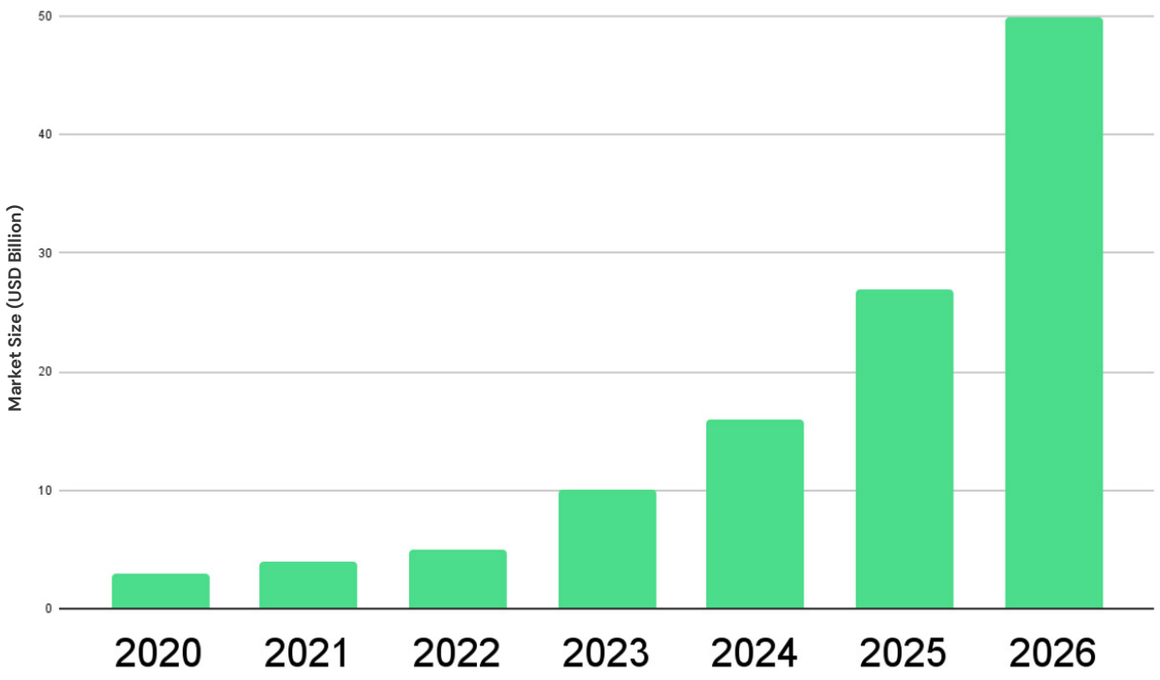
Introduction (continued)

Digital twin market growth rate accelerates

Digital twins are now so ingrained in manufacturing that the global industry market is forecasted to reach $48 billion in 2026. This figure is up from $3.1 billion in 2020 at a CAGR of 58%, riding on the wave of Industry 4.0.



The growth rate for digital twins is staggering with common adoption reported to be in the 25-40% CAGR growth rate.

But challenges remain

The most common challenges faced by the manufacturing industry that digital twins are addressing include:

- Product designs are more complex, resulting in higher cost and increasingly longer development times
- The supply chain is opaque
- Production lines are not optimized – performance variations, unknown defects and the projection of operating cost is obscure
- Poor quality management – overreliance on theory, managed by individual departments
- Reactive maintenance costs are too high, resulting in excessive downtime or process disruptions
- Incongruous collaborations between the departments
- Invisibility of customer demand for gathering real-time feedback

Digital Twins Bring Broad Benefits to Manufacturing

Industry 4.0 and subsequent intelligent supply chain efforts have made significant strides in improving operations and building agile supply chains, efforts that would have come at significant costs without digital twin technology.

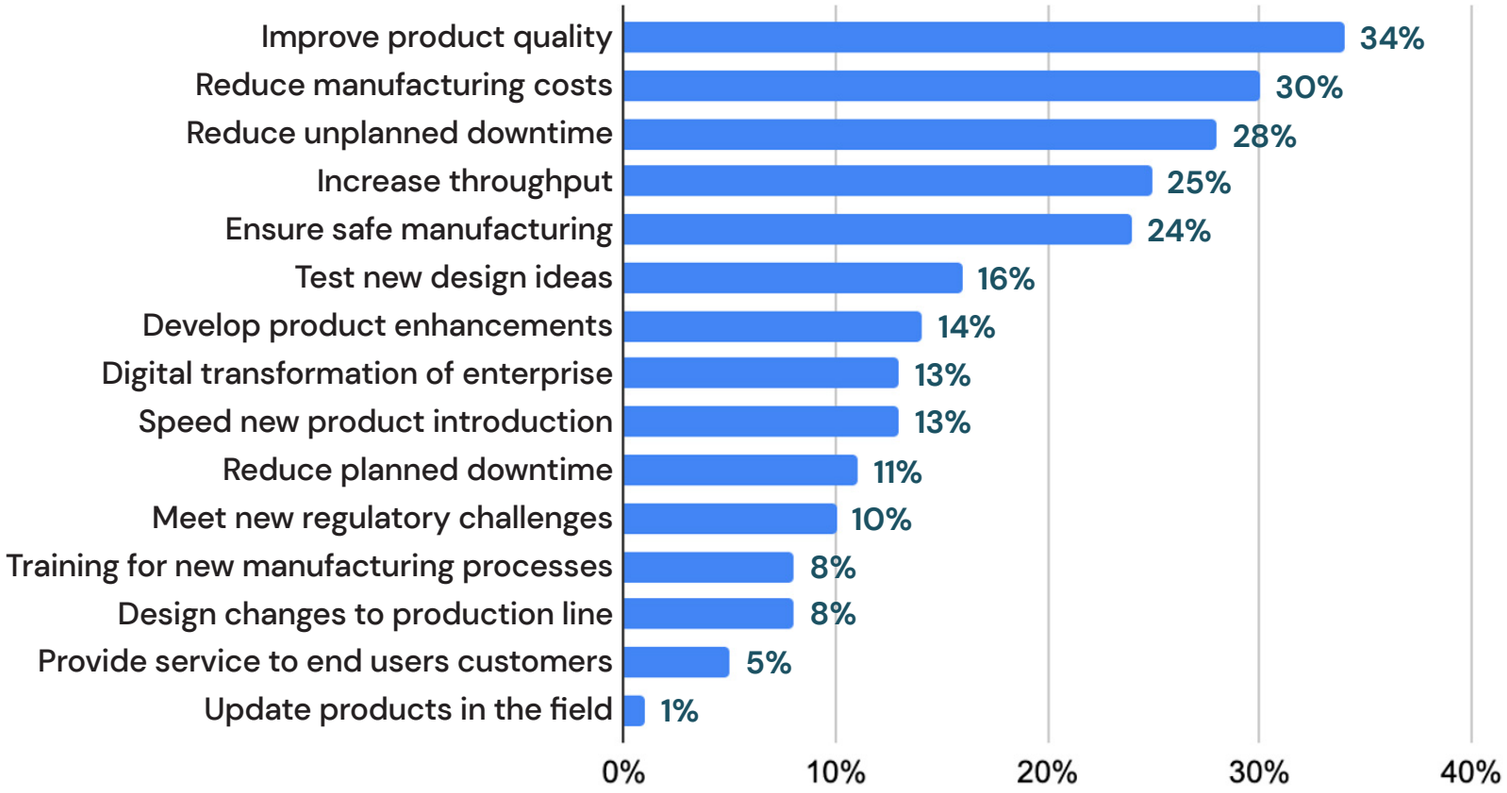
Let's look at the benefits that digital twins deliver to the manufacturing sector:

- Product design and development is performed with less cost and is completed in less time as iterative simulations, using multiple constraints, deliver the best or most optimized design. All commercial aircraft are designed using digital twins.
- Digital twins provide the awareness of how long inventory will last, when to replenish and how to minimize the supply chain disruptions. The oil and gas industry, for example, uses supply chain—oriented digital twins to reduce supply chain bottlenecks in storage and midstream delivery, schedule tanker off-loads and model demand with externalities.
- Continuous quality checks on produced items with ML/AI generated feedback pre-emptively assuring improved product quality. Final paint inspection in the automotive industry, for example, is performed with computer vision built on top of digital twin technology.
- Striking the sweet spot between when to replace a part before the process degrades or breaks down and utilizing the components to their fullest, digital twins provide manufacturers with real-time feedback. Digital twins are the backbone of building an asset performance management suite.
- Digital twins create the opportunity to have multiple departments in sync by providing necessary instructions modularly to attain a required throughput. Digital twins are the backbone of kaizen events that optimize manufacturing process flow.
- Customer feedback loops can be modeled through inputs, from point of sale customer behavior, buying preferences, or product performance and then integrated into the product development process, forming a closed loop providing an improved product design.

Digital Twins Bring Broad Benefits to Manufacturing (continued)

The top four use cases are heavily focused on operational processes and are typically the first to be deployed in manufacturing by a majority of companies. Those that have a lower adoption rate are more complex in deployment, but typically offer higher and longer-lasting value.

Digital Twin Use Case Deployment



> Can you imagine the cost to change an oil refinery's crude distillation unit process conditions to improve the output of diesel one week and gasoline the next to address changes in demand and ensure maximum economic value? Can you imagine how to replicate an even simple supply chain to model risk?

What Are Digital Twins?

Now knowing the business challenges and benefits digital twins deliver, let's turn to the basics and explore what digital twins are and how a modern data stack is necessary to build effective and timely digital twins. The classic definition of digital twin is: "A virtual model designed to accurately reflect a physical object."

For a discrete or continuous manufacturing process, a digital twin gathers system and processes state data with the help of various IoT sensors [operational technology data (OT)] and enterprise data [informational technology (IT)] to form a virtual model which is then used to run simulations, study performance issues and generate possible insights.

Types of Digital Twins

Product/asset twins

Product or asset twins are used to analyze the connectivity, interdependence and interaction of the components in a product to analyze and predict performance in operation.

System/ unit twins

System or unit twins are twins of a fully functioning system. The system is made up of individual products and components, so it is used to monitor the interaction of products in operation. System twins are useful for predicting unexpected downtime.

Process twins

Process twins work beyond a single system, e.g., it encompasses the entire production, supply chain or shop floor process. Process twins monitor and enhance the entire manufacturing and supply chain process to maximize utilization, improve operational effectiveness or reduce risk.

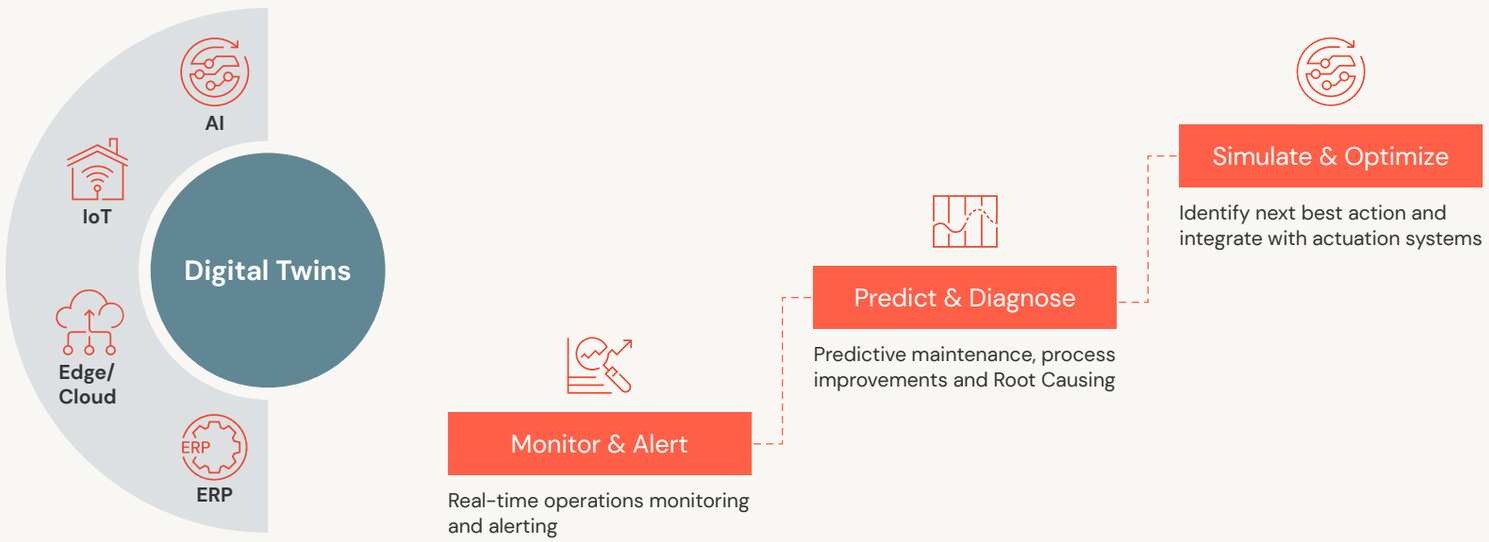
Digital Twin Architectures

Classic digital twins have been physics-based models of specific systems. More recently, **data-driven digital twins which work on the real-time system data are gaining prominence**.

These twins provide the opportunity to not just monitor and simulate system performance under specific conditions, but also provide the platform to further embed AI-based predictive and prescriptive solutions into the industrial environment.

Digital twins undergo a series of changes during their lifecycle to become completely autonomous.

Data-Driven Operational Digital Twins: Maturity Journey



Digital twins have reduced automotive product design lifecycle from

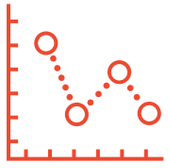
6–8 years to 18–24 months

Digital warehouse design lets companies test and learn using a digital twin, which can improve efficiency by

20% to 25%

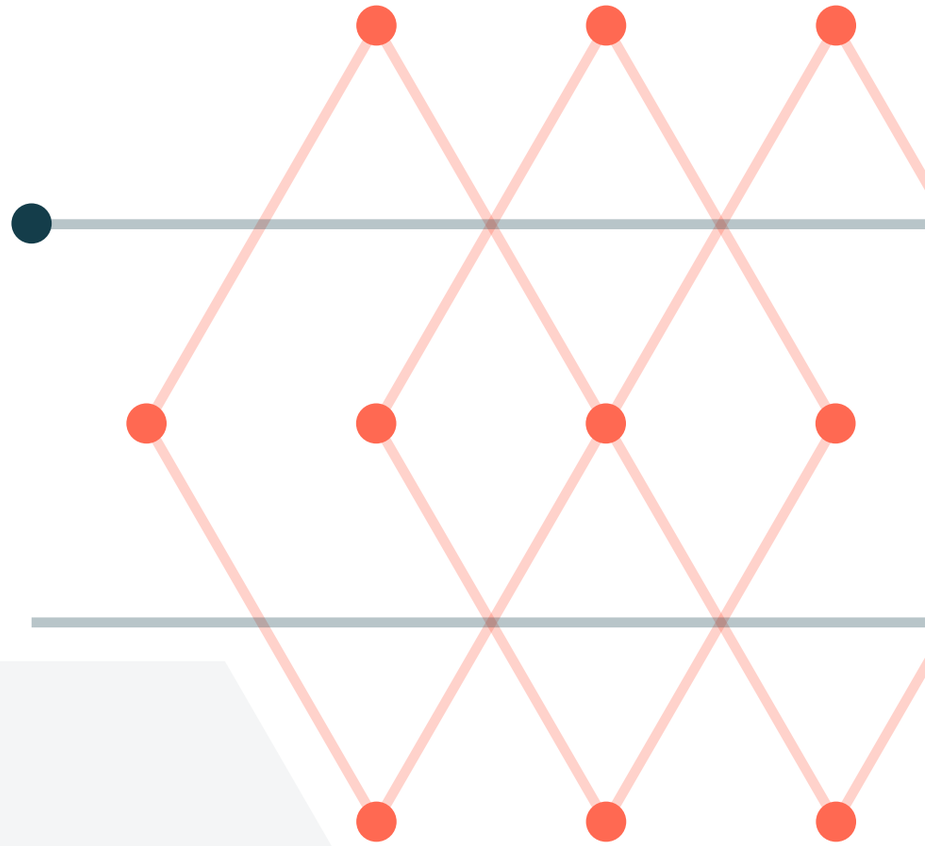
How to Build a Digital Twin

A data architecture capability is needed to capture and collect the ever-expanding volume and variety of data streaming in real time from example protocols, such as ABB Total Flow, Allen Bradley, Emerson, Fanuc, GE, Hitachi and Mitsubishi.



Data collection, data analytics, application enablement and data integration orchestrate the time-series data stream and transfer to the cloud. Azure IoT Hub is used to securely ingest data from edge to cloud.

Cloud infrastructure and analytics capabilities are offered within the flexibility of the cloud. Azure Digital Twin is used to model and visualize process workflows. Databricks MLflow and Delta Lake scale to deliver real-time predictive analytics.



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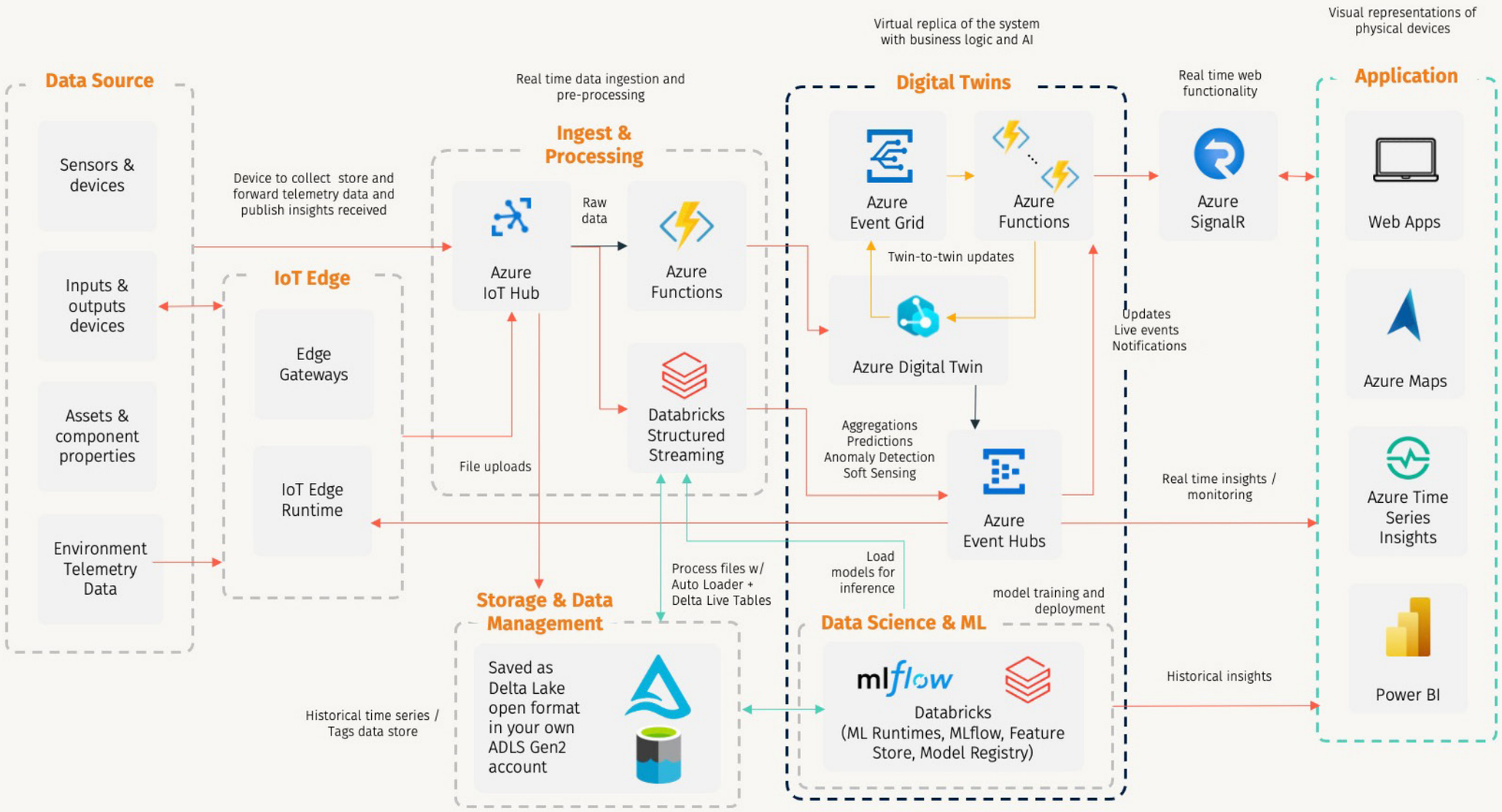
How to Build a Digital Twin (continued)

Digital Twins: Technical Architecture



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How to Build a Digital Twin (continued)

Building a digital twin doesn't have to be a daunting task. Below are some simplistic steps:

System and use case discovery and blueprinting

- Identify priority plant processes and systems to model, with focused use cases (e.g., asset maintenance, energy management, process monitoring/optimization, etc.)
- Develop a validated process outline, blueprint and key performance indicators
- Develop a set of process variables, control variables and manipulated variables
- Design control loop
- Validate and document process and asset FMEA for all assets and sub-systems

Technology infrastructure requirements

- Technical edge infrastructure onsite — to sense, collect and transmit real-time information
- Clean, reliable data availability in the cloud
- Data processing and analytics platform — to design, develop and implement solutions
- Stream processing and deployment of models for predictions and soft sensing
- Edge platform to orchestrate the data, insights and actions between the cloud and site IT systems
- Cloud to edge integration — to enable seamless monitoring, alerting and integration with plant OT/IT systems

Visualization delivered

- Information communication — visual representation of digital twin along with remote controlling functions (e.g., Power BI dashboards, time series insights, web app-based digital twin portals)
- Closed-loop feedback — to send the insights and actions back to form a closed loop — Azure – Event Grid and Event Hub with connection from IoT Hub to Azure IoT edge devices and control systems is used

Why Is Manufacturing Struggling With Data and AI?

Challenge	Root Cause	Goal
Siloed data across the value chain	Siloed data from systems designed for on-premises 30 years ago	Aggregate high volumes and velocities of structured and unstructured data to power predictive analytics (e.g., images, IoT, ERP/SCM)
Unable to scale enterprise data sets	Legacy architectures such as data historians that can't handle semi-structured or unstructured data	Data architectures that scale for TBs /PBs of enterprise IT and OT data
Lack real-time insights	Batch-oriented data transfer	Address manufacturing issues or track granular supply chain issues in the real world
Can't meet intellectual property requirements	Systems that do not establish data lineage	Data lineage established across organizational silos and disjointed workflows

Data architecture is the root cause for this struggle.

Why Databricks for Digital Twins?

Lakehouse for Manufacturing's simple, open and collaborative data platform consolidates and enhances data from across the organization and turns it into accessible, actionable insights. Scalable machine learning powers digital twins with predictive insights across the value chain from product development to optimizing operations to building agile supply chains to robust customer insights.

Supports Real-Time Decisions

Lakehouse for Manufacturing leverages any enterprise data source — from business critical ERP data to edge sensor data in one integrated platform, making it easy to automate and secure data with fast, real-time performance.

Faster and More Accurate Analysis

The true benefits of digital twins are not the business intelligence dashboards, but machine learning insights generated from incorporating real-time data. Scalable and shareable notebook-based machine learning accelerates ROI.

Open Data Sharing and Collaboration

Drive stronger customer insights and greater service with partners leveraging open and secure data collaboration between departments or your supply chain delivering faster ROI.

> Databricks open Lakehouse Platform has shown time and again that it is the foundational enabling technology to power digital twins for manufacturing. But the real power is the Databricks partnership with Tredence that speeds implementation for tailored use cases that deliver superior ROI in less time."
>
> **Dr. Bala Amavasai**,
> Manufacturing CTO, Databricks

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Why Tredence for Digital Twins?

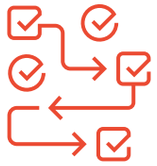
Over the last few years, Tredence's unique Manufacturing and Supply Chain practice has coupled functional expertise with cutting edge AI driven solutions to create measurable business impact for their customers. Now, Tredence's partnership with Databricks is all set to unlock the power of real time analytics and actions, to further strengthen their "last mile impact" vision.

Global Reach

Tredence offers a global team with the subject matter expertise that delivers practitioner and user-oriented solutions to identify and solve for challenges in digital transformation design and implementation.

Purpose-Built Solutions

Adopt contextual edge to cloud, purpose-built AIoT solutions that unify your ecosystems with connected insights and enhance productivity, while enabling efficient cost structures.



Focused Dedication

A dedicated centre of excellence (CoE) for AIoT and smart manufacturing solutions — serving the entire manufacturing value chain from product development to manufacturing and downstream operations.

> Tredence is excited to co-innovate with Databricks to deliver the solutions required for enterprises to create digital twins from the ground up and implement them swiftly to maximize their ROI. Our partnership enables clients to get the most out of Tredence's data science capabilities to build decision intelligence around manufacturing processes and Databricks' Lakehouse Platform to realize the full promise of digital twins."
>
> **Naresh Agarwal**,
> Head of Industrials, Tredence

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Using Digital Twins to Drive Insights

Rolls-Royce uses Databricks to drive insights around predictive maintenance, improving airframe reliability and reducing carbon emissions.

Use Case

Predictive Maintenance

- Rolls-Royce sought to use real-time engine data to reduce unplanned maintenance and downtime
- Legacy systems were unable to scale data ingestion of engine sensor data in real time for ML

Why Databricks?

- The Lakehouse Platform on Azure unifies in-flight data streams with external environmental conditions data to predict engine performance issues
- Delta Lake underpins ETL pipelines that feed ML workloads across use cases
- MLflow speeds deployment of new models and reduces incidents of grounded planes

Impact

22 million tons
of carbon emissions saved

5% reduction
in unplanned airplane groundings

Millions of pounds
in inventory cost savings from a 50% improvement in maintenance efficiency

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About Databricks

Databricks is the data and AI company. More than 7,000 organizations worldwide — including Comcast, Condé Nast, Acosta and over 40% of the Fortune 500 — rely on the Databricks Lakehouse Platform to unify their data, analytics and AI. Databricks is headquartered in San Francisco, with offices around the globe. Founded by the original creators of Apache Spark,™ Delta Lake and MLflow, Databricks is on a mission to help data teams solve the world's toughest problems. To learn more, follow Databricks on Twitter, LinkedIn and Facebook.

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