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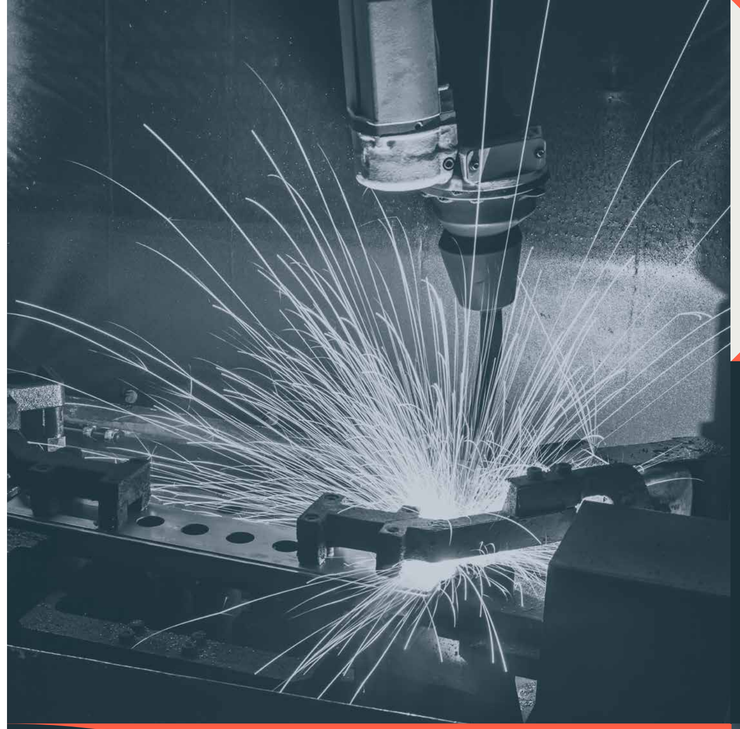
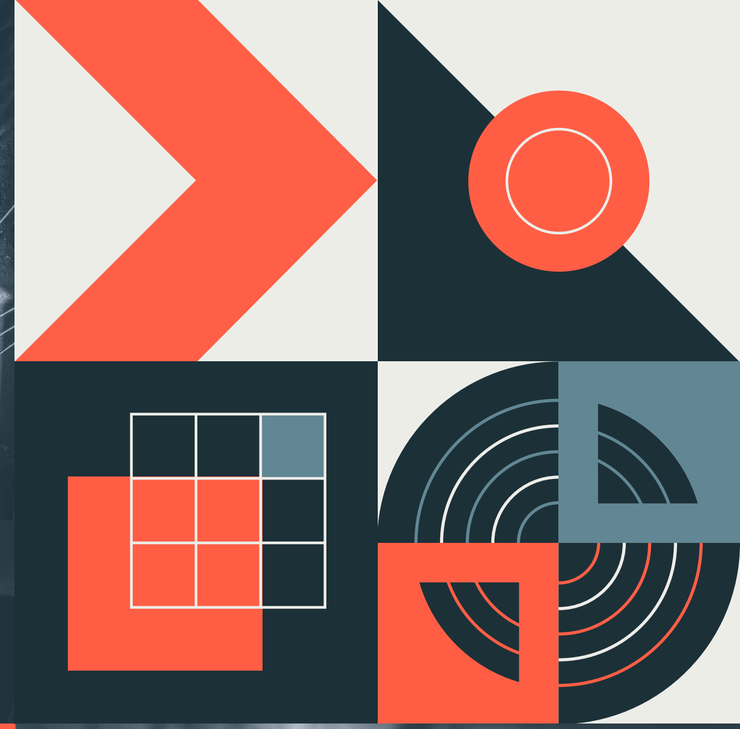
EBOOK

Four Forces Driving Intelligent Manufacturing

A data-driven business built on Lakehouse for Manufacturing





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Introduction

Manufacturing has always been an evolutionary business, grounded upon infrastructure, business processes, and manufacturing operations built over decades in a continuum of successes, insights and learnings. The methods and processes used to approach the development, release and optimization of products and capital spend are the foundation of the industry's evolution.

But today it's data- and AI-driven businesses that are being rewarded because they're using process and product optimization not previously possible, able to forecast and sense supply chain demand, and, crucially, introduce new forms of revenue based upon service rather than product.

The drivers for this evolution will be the emergence of what we refer to as "Intelligent Manufacturing" that has been enabled by the rise of computational power at the Edge and in the Cloud. As well as new levels of connectivity speed enabled by 5G and fiber optic, combined with increased use of advanced analytics and machine learning (ML).

Yet, even with all the technological advances enabling these new data-driven businesses, challenges exist.

McKinsey's recent research with the World Economic Forum estimates the value creation potential of manufacturers and suppliers that implement Industry 4.0 in their operations at USD$37 trillion by 2025. Truly a huge number. But the challenge that most companies still struggle with is the move from piloting point solutions to delivering sustainable impact at scale. Only 30% of companies are capturing value from Industry 4.0 solutions in manufacturing today.

80% of manufacturers see smart manufacturing as key to their future success

57% of manufacturing leaders feel their organization lacks skilled workers to support their smart manufacturing plans

A lack of supply chain integration could stall smart factory initiatives for **3 in 5 manufacturers by 2025**

The four driving forces of change

Over the last two years, demand imbalances and supply chain swings have added a sense of urgency for manufacturers to digitally transform. But in truth, the main challenges facing the industry have existed, and will continue to exist, outside these recent exceptional circumstances. Manufacturers will always strive for greater levels of visibility across their supply chain, always seek to optimize and streamline operations to improve margins. In the continuing quest for improved efficiency, productivity, adaptability and resilience, manufacturers are commonly tackling these major challenges:

Skills and production gaps

The rise of the digital economy is demanding a new set of skills. For today's Intelligent Manufacturing organizations, there's a fundamental need for computer and programming skills for automation, along with critical-thinking abilities. Also important is the ability to use collaboration systems and new advanced assistance tools, such as automation, virtual reality (VR) and augmented reality (AR). The deficit of workers with these skills is of critical concern to manufacturers.

In addition, the industry dynamics are pushing companies to increase and refine both partner/supplier relationships, optimize internal operations and build robust supply chains that do not rely upon safety stock to weather supply chain swings. Historical focus on operational use cases is now extending to building agile supply chains.

Supply chain volatility

If the events of the last few years proved anything, it's that supply chains need to be robust and resilient. Historically, supply chain volatility was smoothed by holding "safety stock," which added costs without financial value. Then the pendulum swung to "just in time delivery," where efficient use of working capital disregarded demand risks.

Recent experiences have highlighted that demand sensing is needed in addition to safety stock for high-risk parts or raw materials. The ability to monitor, predict and respond to external factors – including natural disasters, shipping and warehouse constraints, and geopolitical disruption – is vital to reduce risk and promote agility. Many of these external data sources leverage unstructured data (news, social posts, videos and images), and being able to manage both structured and unstructured data available to measure and analyze this volatility is key.

Need for new and additional sources of revenue

Manufacturers' growth historically has been limited to new product introduction rate or expansion into new geographies. The emergence of "equipment as-a-service" is changing that dynamic. It's pivoting the business from product-centric growth to one leveraging added services, which are not slaves to the product development introduction cycle and can be highly differentiated depending on the market segment and types of products. Real-time data plays an outsize role, as now businesses are in unison with use cases such as predictive maintenance, stock replenishment and worker safety.

An increased focus on sustainability

Manufacturers have always focused on efficiency, but they're increasingly seeing the value chain as circular. It's no longer enough to consider an organization's own carbon footprint – it needs to also include indirect emissions and other environmental impacts from the activities it doesn't own or control. This requires a 360-degree view of sustainability, which includes both internal and external factors in measuring compliance with ESG programs.

This eBook will look closer at these four key challenges and their associated use cases, as well as some of the most effective technologies and solutions that can be implemented to respond to them.

Digital transformation is not a destination, it's a journey

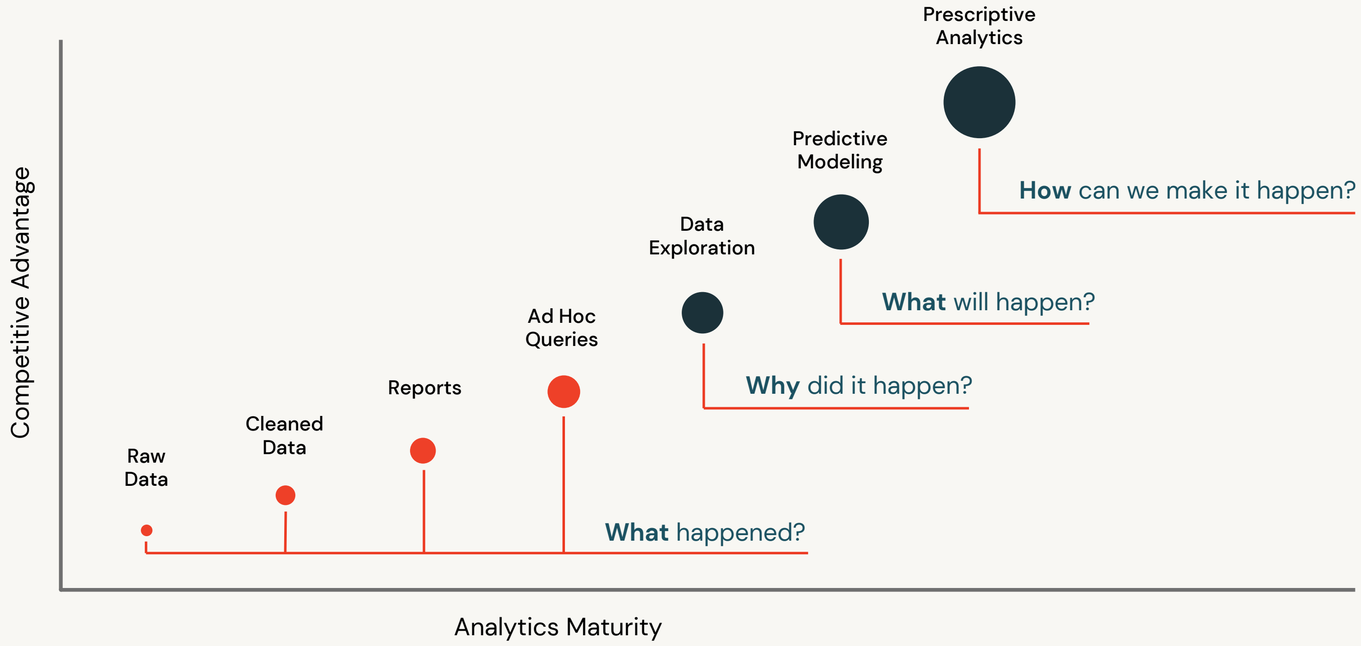
Digitalization is reshaping many areas of manufacturing and logistics, product design, production and quality of goods as well as sustainability and energy output.

This transition from manual operations to automated solutions is enhancing and optimizing operational efficiency and decision-making, while also making supply chains more frictionless and reliable, as well as enabling organizations to become more responsive and adaptable to market and customer needs.

This disruption has been driven by a rush of new technologies including artificial intelligence, machine learning, advanced analytics, digital twins, Internet of Things (IoT), and automation. These, in turn, have been enabled by the greater network capabilities of 5G. Industry 4.0 is well underway. Intelligent Manufacturing isn't the future, it's what competitive organizations have established today.

The data and AI maturity curve

From descriptive to prescriptive



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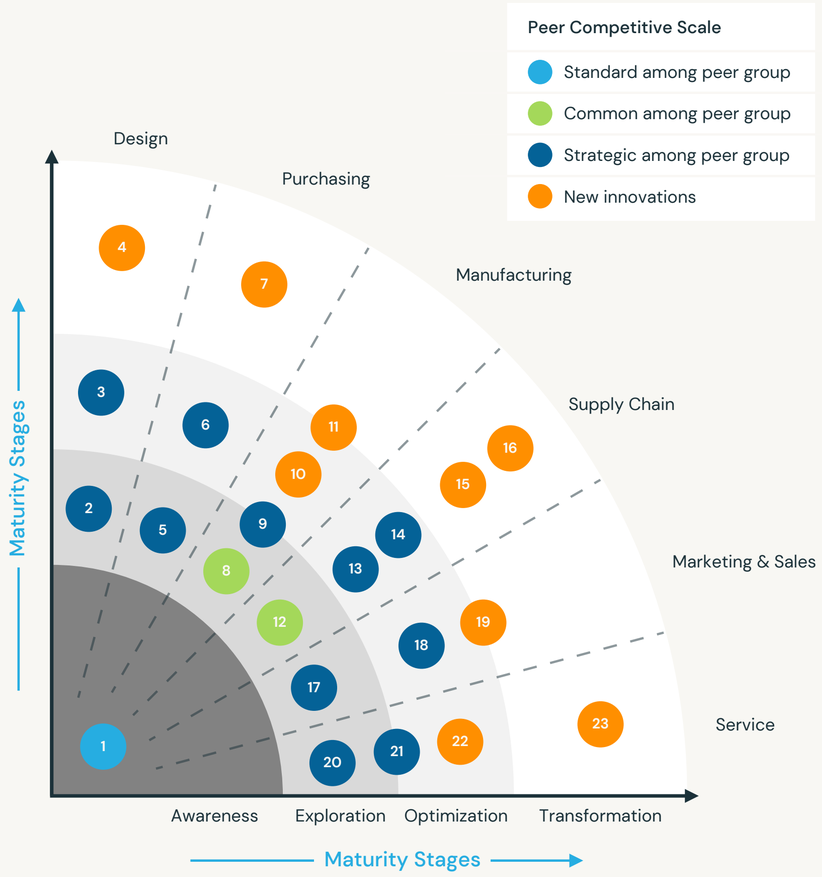
Manufacturing – use case maturity matrix

No	Use case name
1	EDW offload
2	Product 360
3	Voice of customer insights
4	Testing & simulation optimization
5	Supplier 360
6	Spend analytics
7	Sourcing event optimization
8	Process & quality monitoring
9	Process 360
10	Equipment predictive maintenance
11	Quality & yield optimization
12	Supply chain 360
13	Demand analytics
14	Inventory visibility & tracking
15	Inventory optimization
16	Logistics route optimization
17	Customer 360
18	Marketing & sales personalization
19	Recommendation engine
20	Asset/Vehicle 360
21	Connected asset & value-added services
22	Quality event detection & traceability
23	Asset predictive maintenance



That is not to say that the digital transformation journey is simple. Replacing legacy systems, breaking down data and organizational silos, bridging the gap between operational technology (OT) and informational technology (IT), reskilling workforces, and much more requires a clear and determined digitalization strategy, and to reach new levels of IT and data maturity.

Much of the aforementioned transformation requires a foundation of effective data management and architecture to be in place. Without this ability to control the vast amounts of structured data (highly organized and easily decipherable) and unstructured data (qualitative, no predefined data model), manufacturers cannot generate actionable insights from their data, derive value from machine learning, monitor and analyze supply chains, or coordinate decisions across the business.

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The foundations for data-driven manufacturing

Cloud-native platforms

Improve data management, enhance data analytics and expand the use of enterprise data, including streaming structured and unstructured data

Technology-enabled collaboration

Democratize analytics and ML capabilities – ensure the right users have access to the right data driving business value

The ability to scale machine learning use cases

A central place to store and discover ML models and enabling greater collaboration between ML, data and business users

Open standards and open data architectures

Leverage open source standards and open data formats to accelerate innovation and enable the integration of best-of-breed, third-party tools and services

95% agree that digital transformation in manufacturing is essential to their company's future success

Global spending on digital transformation is forecast to reach **USD$2.8 trillion by 2025**

85% have accelerated their digital transformation strategies since 2020

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Driving Force No. 1

The shift from manufacturing to Intelligent Manufacturing

If left unaddressed, a Deloitte study calculates that the manufacturing skills gap will leave 2.1 million jobs unfilled by 2030, costing the U.S. economy up to $1 trillion. The immediate response would be to point the finger at the pandemic. Indeed, the same study found that approximately 1.4 million positions were lost at the start of the pandemic, and only 63% of those have since been recouped.

Yet the reasons for the lack of manufacturing talent today are manifold, and COVID-19 has only contributed to an existing problem. For instance, many highly experienced baby boomers are retiring from the workforce, leaving fewer people with the in-depth knowledge of custom equipment and machines. Meanwhile, younger generations have a poor perception of what manufacturing jobs are like and are reluctant to step into the industry. Meaning not only a problem with retaining skills, but also attracting them.

And, of course, there is a growing gap between the current capabilities of industrial workers and the skill sets needed for today's data-driven, sensor-filled, 5G-enabled Intelligent Manufacturing.

With the drive to optimize operations, stabilize supply chains and reinvent business models through equipment-as-a-service, the skill sets have radically changed from even a decade ago.

Intelligent Manufacturing's use cases are placing a high demand on robotics programmers and technicians, cybersecurity experts, digital twin architects, supply network analysts, and people who can leverage AI and machine learning algorithms because deployment of these common use cases is producing multiples of returns for those embracing Intelligent Manufacturing.

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Those manufacturers with a strategy for upskilling existing talent, while also changing the perception of the incoming workforce, need to take advantage of the following use cases:

Digital twins

Ingesting information from sensors and other data sources, these virtual replicas of physical assets create models to which a layer of visualization can be applied. This enables users to predict failures, assess performance and reveal opportunities for optimization. Digital twins unlock the ability for manufacturers to monitor and manage production remotely, as well as explore "what-if" scenarios.

Process and quality optimization

Process and quality optimization generally covers the optimization of equipment, operating procedures, and control loops. It requires access to accurate, up-to-date data about conditions, collected through IoT devices to monitor every aspect. The introduction of deep learning architectures is enabling manufacturing machinery to identify visual clues that are indicative of quality issues in manufactured goods, while digital twins can be used to spot inefficiencies without the need to pause production.

Throughput optimization

Increasing throughput is critical for meeting delivery schedules, and manufacturers are always looking for ways to identify and eliminate bottlenecks, reduce inventory and increase the utilization of assets. Throughput optimization makes use of data-driven algorithms to identify, rank and resolve labor, equipment or inventory bottlenecks.

Equipment predictive maintenance

Rather than wait for a piece of equipment to fail or stick to a fixed schedule, predictive maintenance adopts a predictive approach to equipment maintenance. By monitoring real-time data collected from hundreds of IoT sensors, machine learning techniques can detect anomalies in operations and possible defects in equipment and processes. Predictive maintenance correlates data across many more dimensions than traditional inspection techniques, to anticipate failures and prevent costly breakdowns.

Quality and yield optimization (with computer vision)

Quality assurance focuses on the use of data analytics, AI and machine learning to identify and prevent defects during the manufacturing process. This type of edge AI is an approach that can increase productivity by 50% and detection rates by up to 90%. Making use of image recognition and machine learning, computer vision can automate visual inspections, detecting faults and imperfections faster and more cost effectively than manual approaches.

44% report difficulty hiring manufacturing talent with the required digital expertise

83% of manufacturing workers are interested in learning new digital skills

56% of Gen Z say that the pandemic has changed their perception of manufacturing. 77% now view it as more important

Proof through customer success

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Driving Force No. 2

Transparency, visibility, data: optimizing the supply chain

Over the last few years, organizations have experienced the biggest disruption to their supply chains since the 1940s. In the short term, this meant having to adapt to global lockdowns and restrictions, material shortages and compromised workforces. Longer term, there will be economic downturns and new consumer and customer demands and habits to contend with. Resilience and end-to-end visibility are key, with manufacturers given a harsh reminder of how important it is to be able to forecast and respond to disruption.

Such resiliency requires a combination of technologies and solutions. For example, decision support tools with predictive capabilities – to monitor the supply chain and analyze what-if scenarios. Demand sensing and forecasting in combination with enterprise critical systems (ERP) needs to combine data from a wide variety of sources.

Working together, combining millions of data points from across organizations' operations along with other external sources, these technologies can be used to optimize supply chains, reduce costs and improve customer service and loyalty. However, achieving this – embracing the latest in AI, machine learning and predictive analytics – means being able to manage and maintain a flow of accurate, relevant data and to be able to translate this data into actionable insights.

Successful supply chain optimization depends on up-to-the-minute, end-to-end visibility that can be applied across all stages of the supply chain, from design to planning to execution. This will incorporate a range of solutions that can include:

Purchasing

Spend analytics: Most obviously, transparency and insight into where cash is spent is vital for identifying opportunities to reduce external spending across supply markets, suppliers and locations. However, spend analytics are also hugely important to supply chain agility and resilience. This requires a single source of data truth for finance and procurement departments. For example, integrating purchase order, invoice, accounts payable, and general-ledger account data to create a level of transparency, visibility and consistency to inform supplier discussions and deploy strategies to manage cash better during times of disruption.

Cross supply chain collaboration

Supply chain 360: With real-time insights and aggregated supply chain data in a single business intelligence dashboard, manufacturers are empowered with greater levels of visibility, transparency and insights for more informed decision-making. This dashboard can be used to identify risks and take corrective steps, assess suppliers, control costs and more.

Supply chain network design: By building and modeling the supply chain, it enables manufacturers to understand the costs and time to bring goods and services to market. Supply chain network design helps to evaluate delivery at the lowest possible cost, optimal sources and inventory deployment, as well as define distribution strategies.

Demand, inventory, logistics

Demand analytics: By collecting and analyzing millions – if not billions – of data points about market and customer behavior and product performance, manufacturers can use this understanding to improve operations and support strategic decisions that affect the demand of products and services. Around 80% say that using this form of data analysis has improved decision-making, while 26% say having this level of know-how to predict, shape and meet demands has increased their profits.

Inventory visibility and tracking: Inventory visibility is the ability to view and track inventory in real time, with insights into SKU stock levels and which warehouse or fulfillment center it is stored at. With complete oversight of inventory across multiple channels, this helps improve supply chain efficiency, demand forecasting and order accuracy, while ultimately enhancing the customer experience.

Inventory optimization: The practice of having the right amount of available inventory to meet demand, both in the present and the future, enables manufacturers to address demand expectations, and reduce the costs of common inventory issues. Inventory optimization incorporates data for demand forecasting, inventory strategy and stock replenishment. With the addition of AI reinforced learning models, this can help improve demand prediction, recommend stock levels, and automatically order raw materials to fulfill orders, while also detecting and responding to shifts in demand.

Logistics route optimization: Using AI, route optimization can help manufacturers go beyond normal route planning and include parameters to further drive logistics efficiency. What-if scenarios present route options that help cut transportation costs, boost productivity and execute on-time deliveries.

Successfully implementing AI-enabled supply chain management has enabled early adopters to **improve logistics costs by 15%, inventory levels by 35%, and service levels by 65%**

Only 6% of companies believe they've achieved full supply chain visibility

57% believe that supply chain management gives them a competitive edge that enables them to further develop their business

Supply chain optimization case study

▶ Watch our case study

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Driving Force No. 3

Future opportunities for manufacturing business models

When looking at the rapid evolution and growth of e-commerce, manufacturers have some catching up to do. Particularly when it comes to embracing new and customer-centric business models. For example, when shifting from a product to a service mindset, the product lifecycle becomes more holistic and the client relationship is maintained beyond the point of purchase.

These new opportunities are forming part of a longer-term industry shift from the sale of goods (CapEx) to recurring revenue streams, such as through Equipment-as-a-Service (EaaS) models. While this approach is not new to many (Rolls-Royce's "Power-by-the-Hour" engine subscription model has been around since 1962), customer demand, advances in industrial IoT technology, and a continuing decline in sales and margins have seen EaaS emerge as an imperative for manufacturers.

Opening up some of these new revenue streams, of course, demands operational flexibility, but more importantly, digital maturity. This means cloud technologies that allow employees new levels of access to data, the ability to work anywhere, and adapt rapidly to new needs. The introduction of a microservices architecture, to allow the agile development and deployment of new IT services. And the democratization of data, so the entire organization and its ecosystem of partners and suppliers have access to information about market demand, operations, production, logistics and transportation.

This level of visibility and collaboration is not only beneficial to lower maintenance costs, capital expenditure and human capital management, but also in empowering all stakeholders to make smarter and more informed decisions.

Connected assets

The digital connectivity of high-value physical assets is helping to drive a more efficient use of assets and cost savings. Connected assets can provide continuous, real-time data on their operating conditions, even if they are on the other side of the world. Connected assets can also be used as the foundation of as-a-service business models to track the usage of rented machines, and for automakers to use with connected vehicles and electrification strategies.

Quality event detection and traceability

Manufacturers are increasingly seeking end-to-end supply chain traceability — to be able to identify and trace the history, distribution, location and application of products, parts and materials. With event-based traceability, typically using blockchain ledgers, manufacturers can record events along the supply chain. This can help aid legal compliance, support quality assurance and brand trust, and provide full supply chain visibility for better risk management.

Demand-driven manufacturing

Equipment-as-a-Service: Startup organizations without the in-house infrastructure can use a third-party to realize their concepts, while manufacturers with the production capabilities can ensure minimal downtime for their assets. This involves greater risk for the manufacturer, but also the potential for higher and annuitized revenues.

By 2023, 20% of industrial equipment manufacturers will support EaaS with remote Industrial IoT capabilities

In 2025, the global EaaS market is estimated to grow to $131B compared to $22B in 2019

In the U.S., 34% said pay-per-use models represent a big or a very big competitive advantage, while 29% consider it a slight advantage

Equipment as a service case study

Read our case study →

Driving Force No. 4

The focus on sustainability

It's an inescapable truth that Earth's resources are finite, and we need to change our present, linear business models for something that minimizes our use of resources and eliminates waste. Manufacturers need to take a more sustainable approach, where they can limit their negative environmental impacts, while also conserving energy and natural resources.

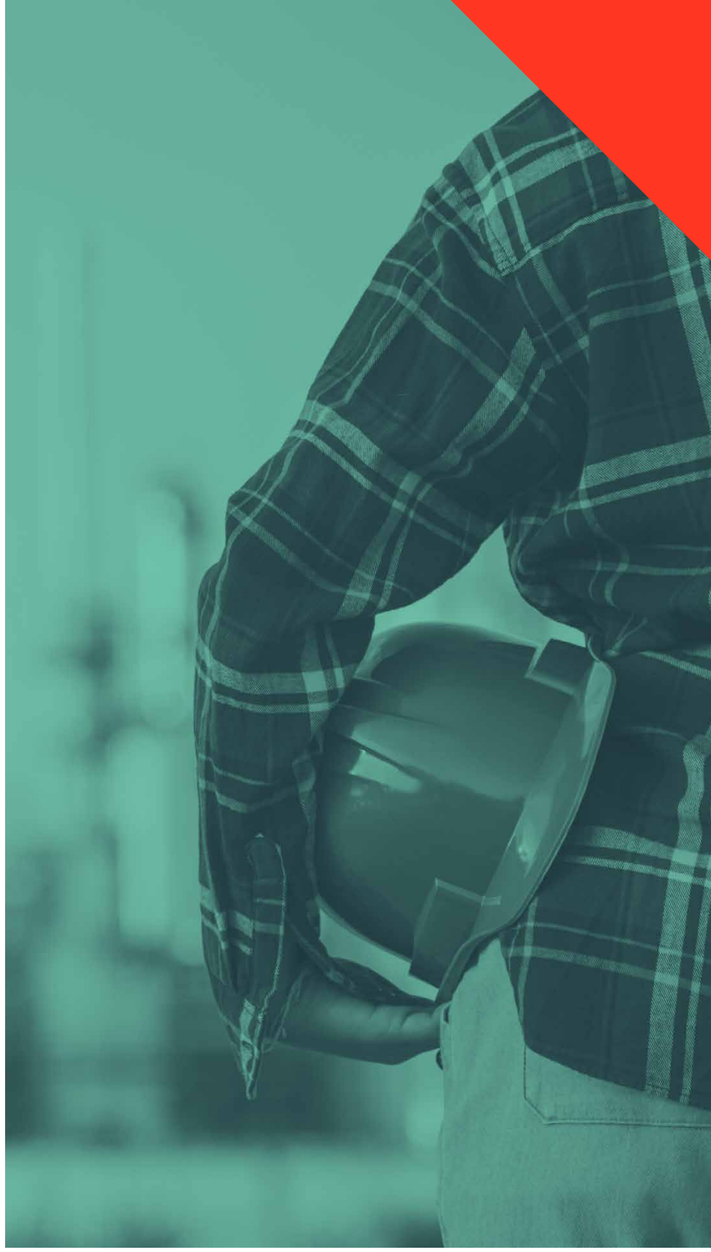
When looking at the entire manufacturing value chain, there are many areas where more sustainable practices can deliver measurable change. Products can be designed in a way that reduces waste and increases their longevity; materials can be selected and sourced in a more ethical way; operational efficiency and green energy can improve production; and the introduction of sustainable practices for transportation and shipping can help reduce carbon footprints. These are part of the move toward more circular business models and establishing what PwC has called the four Rs of the circular economy: Reduce, Refurbish/Reuse, Recycle and Recover.

There are a number of business operating models that employ the four Rs and support the circular economy. Sharing platforms and aaS models help optimize manufacturing capacity and enable businesses to rent rather than buy the machinery and equipment they need. Product use extension helps extend the lifecycle of products through repair and refurbishment, while resource recovery means recovering raw materials from end-of-life products.

Achieving this means establishing a redesigned supply chain that leverages many use cases, technologies and solutions we covered earlier.

It will require greater levels of collaboration between suppliers and vendors. It will require optimizing production lines and transportation. It will require greater levels of customer engagement to extend product lifecycles and close the loop of the supply chain.

But most of all, it will require data, to provide visibility and intelligence across the network, and to be able to make the decisions to improve efficiency in the present, as well as longer-term decisions based on a broad view of sustainability impacts.



The manufacturing industry alone is responsible for **54% of the world's energy consumption** and **20% of carbon emissions**

80% of the world's leading companies are now incorporating sustainability into their operations and goals

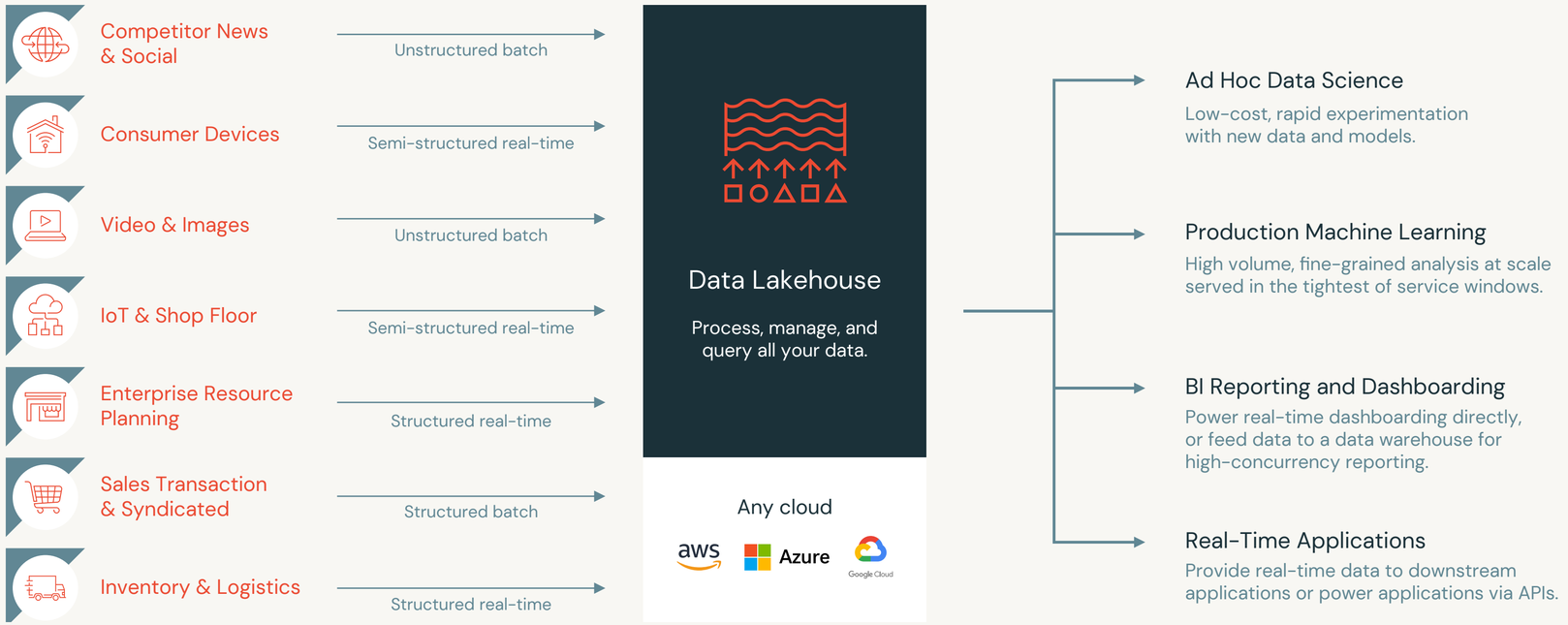
78% of industrial, manufacturing and metals organizations now report on sustainability — up from 68% in 2017

Sustainability Solution Accelerator

Read now →

Leveraging the Databricks Lakehouse for Manufacturing

Our open, simple and collaborative Lakehouse for Manufacturing enables automotive, electronics, industrial, and transportation & logistics organizations to unlock more value and transform how they use data and AI.



Lakehouse enables a real-time data-driven business with the ability to ingest structured, semi-structured and unstructured data from ERP, SCM, IoT, social or other sources in your value chain so that predictive AI and ML insights can be realized. This enables them to operate their business in real time, deliver more accurate analytics that leverage all their data, and drive collaboration and innovation across their value chain. Most important for capital intensive manufacturing business, it enables them to move quickly from proof-of-concept (PoC) ideation to ROI quickly.

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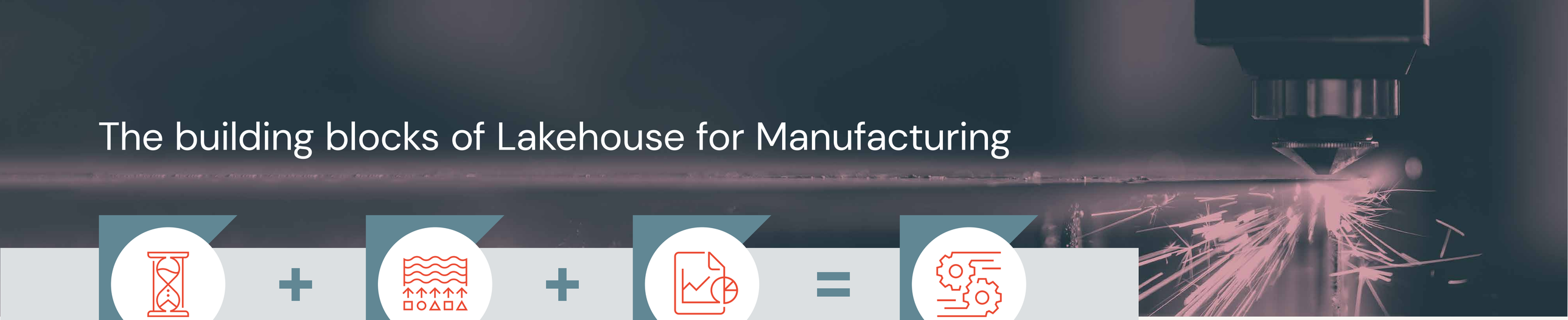

The building blocks of Lakehouse for Manufacturing

Real Time

Make data-informed decisions

Solution Accelerators

Accelerate the possibilities of capabilities

Partner Solutions

Accelerate the creation of insights

Speed

Delivering fast ROI

Real-time data to make informed decisions: The Lakehouse Platform streamlines data ingestion and management in a way that makes it easy to automate and secure data with fast, real-time performance. This means you can consolidate and enhance data from across the organization and turn it into accessible, actionable insights.

Solution Accelerators for new capabilities: Through our Solution Accelerators, manufacturers can easily access and deploy common and high-impact use cases. For manufacturers restricted by time and resources, these accelerators provide the tools and pre-built code to deliver PoCs in less than two weeks.

Pre-built applications to deliver solutions faster: We make it easy for you to discover data, analytics and AI tools, using pre-built integrations to connect with partner solutions, integrating them (and existing solutions) into the Lakehouse Platform to rapidly expand capabilities in a few clicks.

The speed to deliver fast ROI: With faster data ingestion and access to insights combined with easier, quicker deployments, this means accelerated digital transformation and higher ROI.

Manufacturers' end goals

Intelligent Manufacturing leaders leverage a combination of familiar manufacturing techniques and recent value producing and differentiating use of data-led use cases.

This means making use of IIoT, cloud computing, data analytics, machine learning and more to create an end-to-end digital ecosystem across the entire value chain and build scalable architectures that take data from edge to AI. It means embracing automation and robotics, optimizing how organizations use assets and augmenting the capabilities of workforces, and introducing new levels of connectivity to accelerate performance. Not to mention open the door to new platform and as-a-service business models with the potential to generate new revenue streams.

Also key to the data-driven transformation of manufacturing is visibility: a 360-degree, end-end-to view of the supply chain. Not only is this critical for the efficiency, optimization and profitability of operations, it is needed to be able to take new strides in sustainability.

Of course, better data management is not only about unlocking insight, empowering AI, and enabling decision-making. It's also about governance: acknowledging format issues, adhering to compliance, protecting IP, ensuring data security. All this needs to be taken into consideration when bringing onboard an ISV to establish a modern, unified architecture for data and AI.

About Databricks

Databricks is the data and AI company. More than 7,000 organizations worldwide — including Comcast, Condé Nast, H&M 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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