# Manufacturing Transformation: Journey to the Cloud

*Practical ways to achieve smarter, faster and more responsive operations*

A White Paper by AWS and Frost & Sullivan

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FROST & SULLIVAN

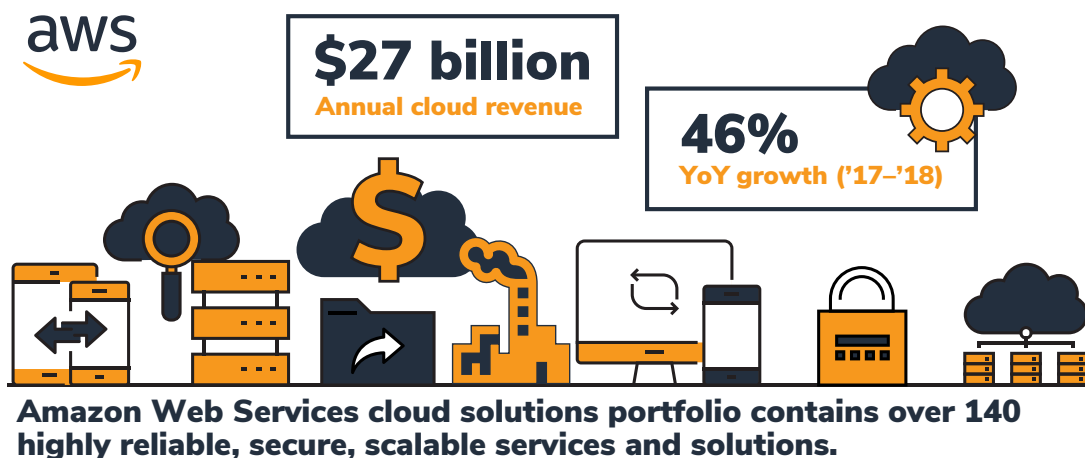*50 Years of Growth, Innovation and Leadership*

**1** EXECUTIVE SUMMARY

A manufacturer's technological progress is typically hamstrung by significant operational challenges. They confront data silos, high operational costs, lack of skilled workforce availability, weak operational technology/ information technology integration, high-speed computing needs, and machine downtime. While manufacturers may take multiple approaches to overcome these obstacles, their overall goal is to achieve enterprise visibility through a single pane of glass. However, most legacy infrastructures are not adequately prepared for this long-term digital transformation journey. Industrial firms are turning to cloud service providers to bridge the widening performance capability gap. The cloud's ability to assist with dynamic scaling in storage and to support cost efficiencies positions it as the linchpin for resolving current and emerging manufacturing challenges.

The market is awash with several cloud platform solution providers, but there is a clear market leader — Amazon Web Services (AWS). AWS has an annual cloud revenue of $27 billion and over 46% in YoY growth ('17–'18). Its cloud solutions portfolio contains over 140 highly reliable, secure, scalable services and solutions — from data warehousing to deployment tools to directories and content delivery. Customers often choose AWS to access a range of differentiated cloud-based capabilities, such as database, compute, security, and storage.

Although cloud computing is one of the critical pivot points of Industry 4.0 and the Industrial Internet of Things (IIoT), a sizeable portion of manufacturers have yet to adopt it. Many delay adoption due to integration challenges, lack of congruence on value derived versus capital investment, data privacy and/or security concerns, and change management anxiety. However, the imperative to embrace cloud and begin their transformational journey is more pronounced now than ever. The purpose of this paper is to explain the eight practical ways (outlined below, but in no particular order) manufacturing organizations can embrace the cloud and achieve smarter, faster, and more responsive operations:

- **Establish Backup & Disaster Recovery**
- **Integrate Cloud**
- **Develop Applications**
- **Enable Streaming Analytics**
- **Develop Data Lakes**
- **Deploy Machine Learning (ML) & Artificial Intelligence (AI)**
- **Deploy Edge Analytics**
- **Replace Industrial Data Centers**



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**$27 billion**
Annual cloud revenue

**46%**
YoY growth ('17–'18)

**Amazon Web Services cloud solutions portfolio contains over 140 highly reliable, secure, scalable services and solutions.**

**2**

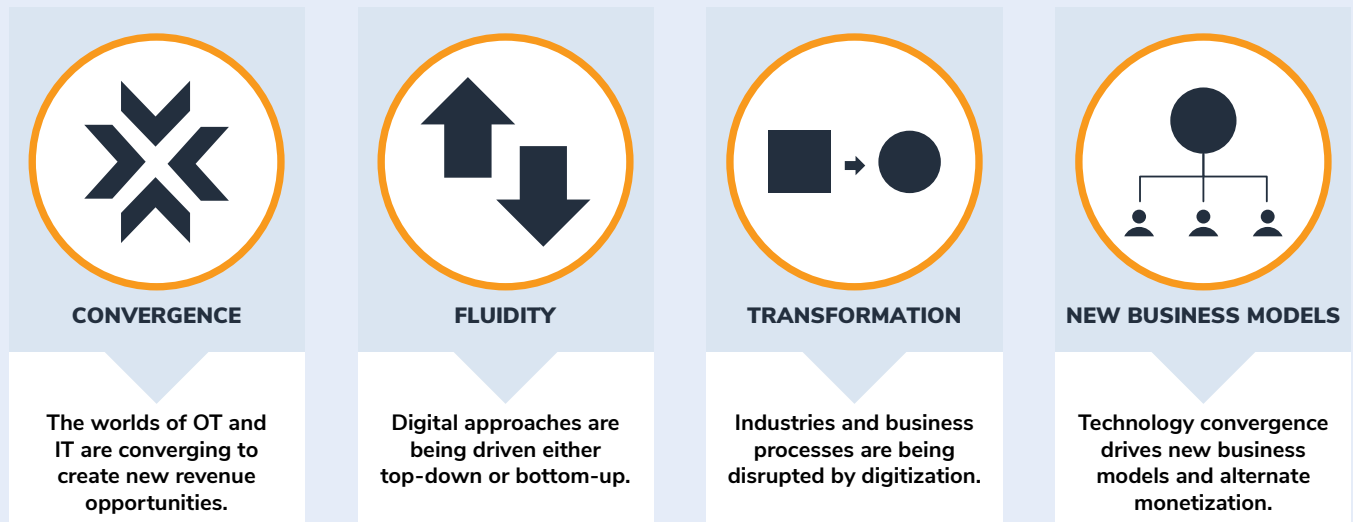# INTRODUCTION: CURRENT STATE OF MANUFACTURING

## *Defining the Digital Era*

The digital era we live in today comprises four key shifts as outlined in Exhibit 1. First, the convergence of OT and IT has created new business opportunities. Second, the fluidity of digital approaches has allowed organizations to decide whether to implement top-down, from the enterprise, or bottom-up, from field devices. Third, digitalization has disrupted industries, processes, and businesses worldwide. Such disruption is inevitable, and changes spurred by it arrive continuously. Fourth, digital disruption is not just about embracing technology but about driving new business models and outcomes through the lens of business operations. Shifts of the digital era have impacted all industries — including manufacturing and its value chain.

### EXHIBIT 1: FOUR SHIFTS OF THE DIGITAL ERA

**Four Shifts of the Digital Era**
**Convergence, Fluidity, Transformation, & New Business Models**

| CONVERGENCE | FLUIDITY | TRANSFORMATION | NEW BUSINESS MODELS |
|---|---|---|---|
| The worlds of OT and IT are converging to create new revenue opportunities. | Digital approaches are being driven either top-down or bottom-up. | Industries and business processes are being disrupted by digitization. | Technology convergence drives new business models and alternate monetization. |

*Source: Frost & Sullivan*

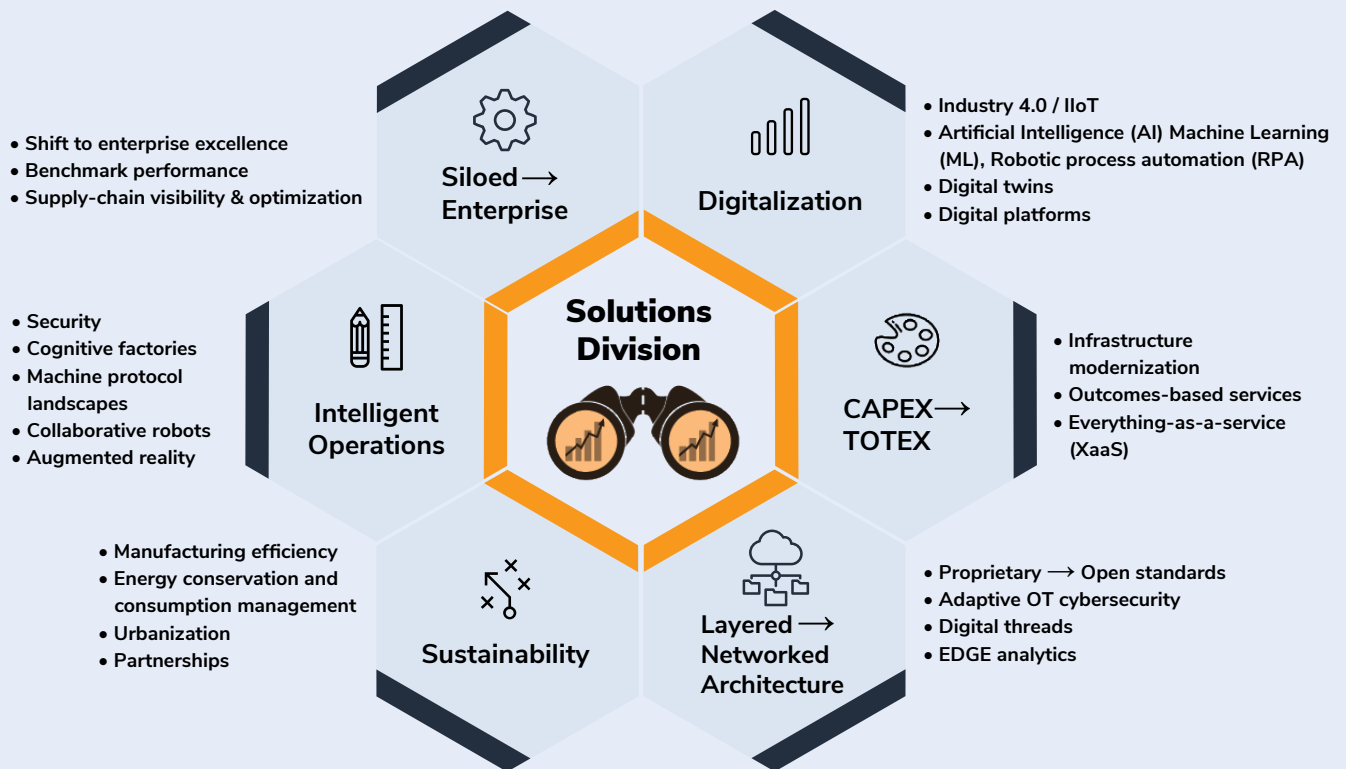## *Critical Issues in Manufacturing*

The manufacturing industry faces several issues critical to its progress **(summarized in Exhibit 2)**. Digital transformation is a source of uncertainty for most companies. Some may find it difficult to navigate the new technology landscape and position themselves within it. The requirements of Industry 4.0 and IIoT mandate the implementation of innovative, highly scalable IT solutions to support I/O-intensive applications. Often times, there is an amalgam of transactions from different database-enabled applications. The mixture of application requirements and the broad array of sensors on production equipment allow manufacturers to generate massive amounts of data. Improper data management leads to under-utilized operational capacity and scattered resource utilization. Frost & Sullivan market research indicates less than 5% of manufacturing data is converted to actionable recommendations. In response to the changing world, industrial firms have a new

> *Frost & Sullivan market research indicates less than 5% of manufacturing data is converted to actionable recommendations.*

strategic imperative - adopt innovative technologies to capture and distribute data for large-scale processing. However, aging machines are generally not cloud-ready, and data is often trapped within them. IIoT data from the factory floor is valuable and its worth is substantially magnified when IIoT systems and processes are leveraged by operations throughout the organization. The progression to an integrated architecture is gradual, but there are material benefits to modernization. For example, properly implemented equipment refreshes improve quality, reduce defects, minimize unplanned downtime, increase equipment utilization, and maximize throughput. Modernization also limits "rip and replace" actions as much as possible.

**EXHIBIT 2: CRITICAL ISSUES IN MANUFACTURING**



**Critical Manufacturing Issues**
**Across Industrial markets of the future**

- Shift to enterprise excellence
- Benchmark performance
- Supply-chain visibility & optimization

**Siloed → Enterprise**

**Digitalization**

- Industry 4.0 / IIoT
- Artificial Intelligence (AI) Machine Learning (ML), Robotic process automation (RPA)
- Digital twins
- Digital platforms

- Security
- Cognitive factories
- Machine protocol landscapes
- Collaborative robots
- Augmented reality

**Intelligent Operations**

**Solutions Division**

**CAPEX → TOTEX**

- Infrastructure modernization
- Outcomes-based services
- Everything-as-a-service (XaaS)

- Manufacturing efficiency
- Energy conservation and consumption management
- Urbanization
- Partnerships

**Sustainability**

**Layered → Networked Architecture**

- Proprietary → Open standards
- Adaptive OT cybersecurity
- Digital threads
- EDGE analytics

*Source: Frost & Sullivan*

Manufacturers also encounter compounding pressures outside the organization. Globalization has created more competition from factories, vendors, and customers distributed across borders. Regulatory pressures are forcing manufacturers to refresh their energy-efficiency and emission-reduction targets. As such, operations must be optimized in order to meet competitive pressures, respond to customer needs, properly allocate resources, and potentially reduce environmental impacts.

## *Enabling Technologies*

A manufacturer's products and services will be defined by the new technologies developed in the digital era. Organizations need a digital tapestry which covers the manufacturing value chain end-to-end. The cloud best supports a digital tapestry because it enables connectivity, scalability, availability, and reliability. Ultimately, an

> **'Data analytics can help car manufacturers increase availability of machines. For instance, "if the availability of machines increases by 1 min/day, they could build one additional car."'**

organization's goals are to lower costs and to achieve higher production output with greater accuracy and insight. Based on current digital implementations and industry interactions, Frost & Sullivan has observed the meaningful degree to which digital technologies are helping manufacturers. Most companies have improved their competitive edge, increased their operational uptime, balanced their conflicting business priorities, and boosted their overall business profitability. For instance, a leading car manufacturer stated how data analytics helped them increase availability of machines because "if the availability of machines increases by 1 min/day, they could build one additional car." Exhibit 3 illustrates the thirteen pivotal technologies enabling transformation for manufacturers. Cloud holds an interesting position; it will be the central driver to peripheral technologies and subsequent innovation.

**EXHIBIT 3: ENABLING TECHNOLOGIES DRIVING MANUFACTURING TRANSFORMATION**

### Enabling Technologies Driving Manufacturing Transformation
**Adoption of innovations across industrial markets**



Ubiquitous Sensing

Artificial Intelligence + Machine Learning

In-memory Computing, Digital Twin

Block Chain

Predictive Analytics

Edge Devices

Cloud Computing

5G

Automation

Additive Manufacturing

Drones

Robotics

Wearable Computing

*Source: Frost & Sullivan*

Another strategic driver of digital adoption is the progressive transformation of traditional plant information architectures. Typically, manufacturing industries have adopted the ISA-95/Purdue model for their operations. The practice comes with a number of disadvantages; its architecture is unnecessarily complex with a myriad of industrial communication protocols.

This chapter outlined how the combination of global shifts, critical issues, and enabling technologies creates gaps between manufacturing business objectives and operational capabilities. In Chapter 3, the strategic rationale for cloud adoption will be explored alongside key benefits and implementation focus areas.

**3**

# ROADMAP TO THE CLOUD: STRATEGIC BENEFITS & FOCUS AREAS

### Strategic Importance of Cloud

The manufacturing industry is undergoing a transition toward smart manufacturing in which business and operational processes become digitized. Smart deployment of IIoT is essential to a firm's plans to win, service, and sustain stickiness with customers. As manufacturers increasingly turn to IIoT, the cloud becomes an essential part of the industry's IT and OT infrastructure. "Cloud" simply means a firm's software, data, and related infrastructure is hosted remotely via the internet. The cloud makes it easier and more cost-effective for manufacturers to store, transmit, compute, and protect mission-critical data. Manufacturers frequently store data in on-premises systems, which are generally considered a capital expenditure and require large upfront investments. If data volumes or computer-power needs increase, organizations must scale their compute and storage capacities to meet demand. To do so, additional servers are procured — delaying time-to-market and creating additional expenditures for variable capacity needs.

The pace of technology refresh cycles has halved in recent times – a drastic difference from the last decade; currently, IT refreshes once every four to seven years. In communications with Frost & Sullivan, manufacturers describe their struggles as twofold. First, they are challenged to keep up with the pace of innovation, and second, they are tasked to find a viable partner who is at the forefront of change. Cloud plays an important role in bridging these divides. Frost & Sullivan research indicates digital technologies for asset management alone yield uptime improvements of more than 10% in a given year, in comparison to baseline measured values. To realize such operational gains, it is recommended to start small, realize return on investment (ROI), scale quickly, and drive enterprise-wide adoption. A typical digital roadmap lasts for five to seven years, and an average manufacturer likely began their manufacturing transformation journey approximately 14 to 16 months ago. In essence, the industrial markets are primed for digital adoption over the next three to five years.

### Key Benefits of Cloud Adoption

Cloud computing entails a virtualized architecture of computing resources, storage and other services. With cloud, manufacturers are empowered to accomplish the following improvements:

- **Optimize Production:** Manufacturers need to have access to secure data lakes that can be leveraged to securely store, categorize, and analyze data. Subsequent application of AI/ML capabilities can help identify areas for process optimization in real time. Previously, local in-house experts could only optimize in response to problems which already occurred. Now, industrial and manufacturing software providers offer real-time and predictive analytics. This improves overall equipment effectiveness (OEE), service levels, product quality, and supply chain efficiency.

- **Eliminate Silos:** Data silos restrain operational performance. Cloud helps in breaking these silos while driving transparency, visibility, and collaboration.

- **Onboard Fleets Quickly:** Maintaining asset inventories is critical for manufacturers. It enables organizations to be better prepared for disruptions by 1) onboarding millions of new device types quickly,

> *As manufacturers increasingly turn to IIoT, the cloud becomes an essential part of the industry's IT and OT infrastructure. The cloud makes it easier and more cost-effective for manufacturers to store, transmit, compute, and protect mission-critical data.*

and 2) establishing a catalogue of device information – for both static states (e.g. serial number) and dynamic states (e.g. current temperature).

- **Swap Capital Expenses for Variable Expenses:** With cloud, industrial firms only pay for the computing resources used — avoiding heavy and upfront investments in data centers and servers.

- **Realize Cost Savings from Massive Economies of Scale:** A cloud service provider generates economies of scale by aggregating a massive amount of customers on the cloud. This translates to lower prices offered to customers for computing resources used.

- **Eliminate Capacity Guesswork:** Customers can access as much or as little capacity as needed to scale up or down – with only a few minutes notice.

- **Ramp up Speed and Agility:** Cloud computing resources are available to developers in minutes. Organizational agility dramatically increases because the cost and time required to experiment and develop is significantly lowered.

- **Refocus Resources:** By utilizing cloud computing, infrastructure efficiencies become optimized. The organization does not have to perform the heavy lifting of racking, stacking, and powering servers. It can focus on customers instead.

- **Lower Latency:** Because applications can be easily deployed worldwide with just a few clicks, manufacturers are able to provide lower latency and a better experience for customers at minimal cost.

The overarching benefits of cloud can be boiled down to four important outcomes **(Exhibit 4)**. First, it allows improved overall equipment effectiveness — from asset and process efficiency to product flow. Next, the cloud creates organizational agility by cultivating resource efficiency, data flow, and the ability to scale up or down quickly. Then, cloud services help organizations to develop new revenue streams and cost savings via optimizing capital efficiency, mitigating efficiency restraints, and discovering new ways to monetize their services. Lastly, cloud computing enables manufacturers to securely store, transfer, and analyze their valuable data.

**EXHIBIT 4: OUTCOMES FOR SMART MANUFACTURING**

## Cloud Benefits: Smart Manufacturing
Security, incredible cost savings, virtually limitless storage and compute power, at a very low price

| Improve Overall Equipment Effectiveness | Create Agility: Scale Up or Down Quickly | Develop New Revenue Streams | Stengthen Security: Protect Valuable Data |
|---|---|---|---|

*Source: Amazon Web Services; Frost & Sullivan*

**Although the strategic value of cloud implementation is clear, adoption rates among manufacturers vary. The subsequent section outlines how manufacturers can begin their manufacturing transformation and journey to the cloud.**
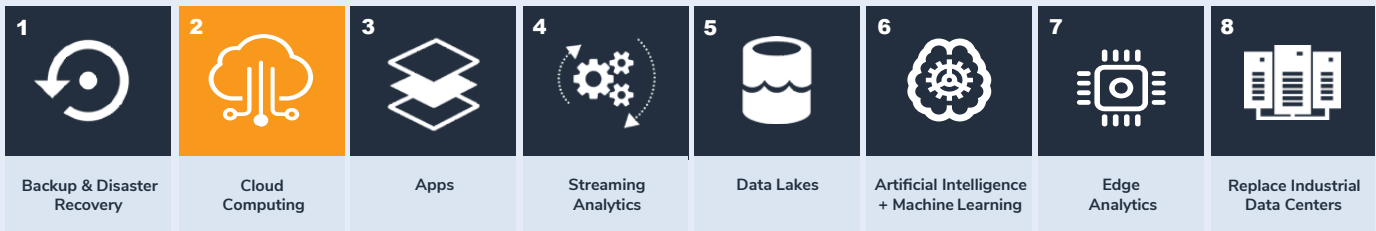
# Focus Areas: Eight Ways to Manufacturing Transformation with Cloud

Organizational transformation is often a challenging and slow-moving process. However, the benefits of the cloud largely outweigh the implementation costs and organizational inertia. To fully adopt the cloud, manufacturers must focus on the following eight practical focus areas **(Exhibit 5)**.

**EXHIBIT 5: FOCUS AREAS - EIGHT WAYS TO MANUFACTURING TRANSFORMATION WITH CLOUD**

## Focus Areas:
### Eight ways to manufacturing transformation with cloud

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Backup & Disaster Recovery | Cloud Computing | Apps | Streaming Analytics | Data Lakes | Artificial Intelligence + Machine Learning | Edge Analytics | Replace Industrial Data Centers |

*Source: Amazon Web Services; Frost & Sullivan*

**Establish Backup & Disaster Recovery:** Manufacturing companies create and store a tremendous amount of mission-critical data. It must be backed up and recoverable. Data loss can be caused by a number of sources, such as database corruption, hardware failures, employee mistakes, and even natural disasters. The top three concerns in determining which data backup solution suits organizational needs are capacity, speed, and extensibility. However, a backup solution is meaningless without a reliable method of recovering data. Once a backup solution is in place, it should be routinely tested to ensure data is restorable.

**Integrate Cloud:** There are three deployment configurations common to cloud computing: private cloud, public cloud, or hybrid cloud. When cloud computing is setup to be used exclusively by one organization (either with single or multiple business units on-site or off-site), it is a private cloud. Large capital investments, concerns about utilization, and scalability are some of the disadvantages of the private cloud model. Public clouds, on the other hand, are not exclusive and can be used by the general public. A third-party cloud service provider (e.g. AWS) typically establishes and operates a public cloud through data centers. The final configuration – hybrid cloud – entails the deployment of applications and services over a myriad of cloud computing infrastructures. Once cloud configuration is established, manufacturers can then decide where its application generates the greatest value. For example, product and production design are astute cloud application areas. They use high performance computing resources (e.g., computational fluid dynamics, finite element modeling, etc.), which can be pushed to cloud as a cost saving measure to otherwise invest in on-premises compute resources. Running an SAP environment in the cloud can also help manufacturers move faster, operate more securely, and save substantial costs. The execution leverages all of the scale and performance benefits of the cloud in parallel. Similarly, a variety of product design tools (e.g. electronic design automation or EDA) can be impractical and costly on-premises. The computing power and infrastructure requirements to design, test, validate, and build these systems have also grown remarkably in recent years. Running product design workloads in the cloud enables faster innovation and improves collaboration, all while lowering costs.

**Develop Applications:** Manufacturing firms can develop highly valuable cloud-computing applications with the capacity to impact nearly every aspect of their business. Application development at the enterprise level allows manufacturers to rethink how they manage operations across business units across the value-chain. Applications allow data to become traceable and mobile throughout the organization.

**Enable Streaming Analytics:** Streaming analytics refers to the processing of live streaming data. The capability is now a prerequisite for the effective implementation of IIoT solutions. Manufacturing processes are both fast-paced and reliant on mixed yet inter-dependent variables. Streaming analytics monitors real-time performance and provides on-the-fly, real-time optimization. Its benefits for manufacturers include increased operational efficiency, lowered costs, balanced inter-dependency, and diminished risk. The emergence of smart products, which are powerhouses of data, will need a reliable conduit to connect with smart manufacturing. The ideal channel can be developed comprehensively through cloud and a streaming analytics platform.

**Develop Data Lakes:** A data lake is a centralized repository which stores data at any scale. Data can be stored as-is, with or without structure, and run through different types of analytics — from dashboards and visualizations to big data processing to real-time analytics — to guide informed decisions. In today's manufacturing world of diversity and heterogeneity, pushing all plant-level data to a single data lake will structure a clear view of complex enterprises. Further, the data lake can orchestrate, collect, ingest, store, and compute at scale to cost-efficiently drive operational performance.

**Deploy Machine Learning & Artificial Intelligence:** ML and AI programs have the ability to perform functions and recognize patterns beyond the scope of human ability. Such capabilities are important for manufacturers who aim to improve intricate production processes and predict machine malfunctions before they occur. The Georgia Pacific example on page 17 illustrates how the company optimized its process with ML and AI.

**Deploy Edge Analytics (EA):** Analytics models are typically trained by cloud servers. However, with edge analytics, the sensors or tags embedded within products or devices take immediate action on data at the source. Information generated by micro-data centers and connected devices can be aggregated, sorted, and processed at the 'edge' in a highly responsive manner. Data is managed at the point of incorporation and leveraged immediately. Irrelevant information is accurately removed from consideration – which allows critical remedial alerts to be produced instantaneously.

**Replace Industrial Data Centers:** The cost-effectiveness of cloud computing will eventually lead manufacturers to consolidate their data centers. The increasing need for data storage could potentially require data centers to reconfigure their server farms to handle wider and more diverse data flows. Many might consider security a major threat in moving to the cloud, but in anticipating this need, cloud solution providers have invested in powerful security standards. Their performance is already resonating with extremely regulated industries, such as healthcare and financial services.

> *The Georgia Pacific example on page 17 illustrates how the company optimized its process with ML and AI.*

In summary, the aforementioned OT workloads are compute-intensive and can be moved to cloud-ready partners. The recommended areas of focus will help manufacturers save costs and drive efficiency at scale. Digital platforms and manufacturing functions can fit together to create direct, bidirectional communication **(Exhibit 6)**. The service components shown will be detailed further in Chapter 4.

**EXHIBIT 6: MANUFACTURING USE CASE — TRACEABILITY & MOBILITY**
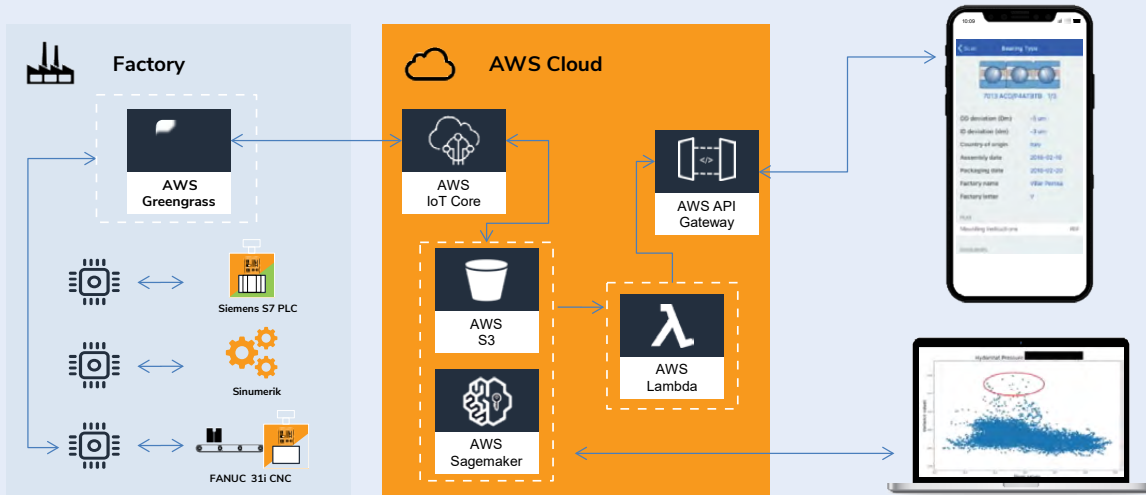


Source: SKF; Amazon Web Services re:Invent 2018; Frost & Sullivan

In Chapter 3, the strategic value and benefits of cloud manufacturing were explained at the organizational, process, product, and data level. Chapter 4 will dive into the cloud platform services of the market leader – Amazon Web Services.
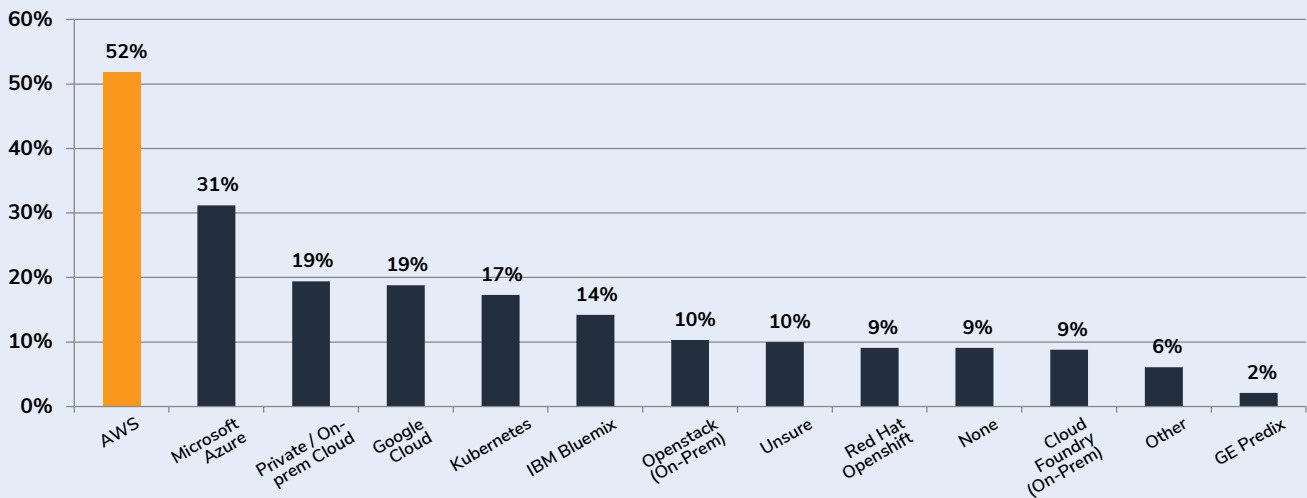
*Amazon Web Services manages a highly orchestrated set of 140 services which work in unison to build sophisticated and scalable applications. Its low-cost infrastructure platform in the cloud powers hundreds of thousands of businesses across 190 countries.*

## 4 AWS PORTFOLIO: ENABLING MANUFACTURING TRANSFORMATION

### AWS Portfolio: Market Positioning

Amazon Web Services manages a highly orchestrated set of 140 services which work in unison to build sophisticated and scalable applications. Its low-cost infrastructure platform in the cloud powers hundreds of thousands of businesses across 190 countries. AWS applications and services are customizable and easily tailored to meet organizational needs or industry vertical requirements. By working with AWS, manufacturers have access to highly available storage, low-cost compute, high-performance databases, smart provisioning tools, and more. Cloud does not require considerable up-front capital investment, and its billing cycles are flexible, based on a pay-per-use basis.

The strength of AWS market position is reflected in a recent survey of IIoT developers **(Exhibit 7)**. A clear majority of respondents (52%) were either using or planning to use AWS cloud service offerings to implement their IIoT solutions.

#### EXHIBIT 7: INDUSTRIAL IOT DEVELOPER PLATFORM PREFERENCES
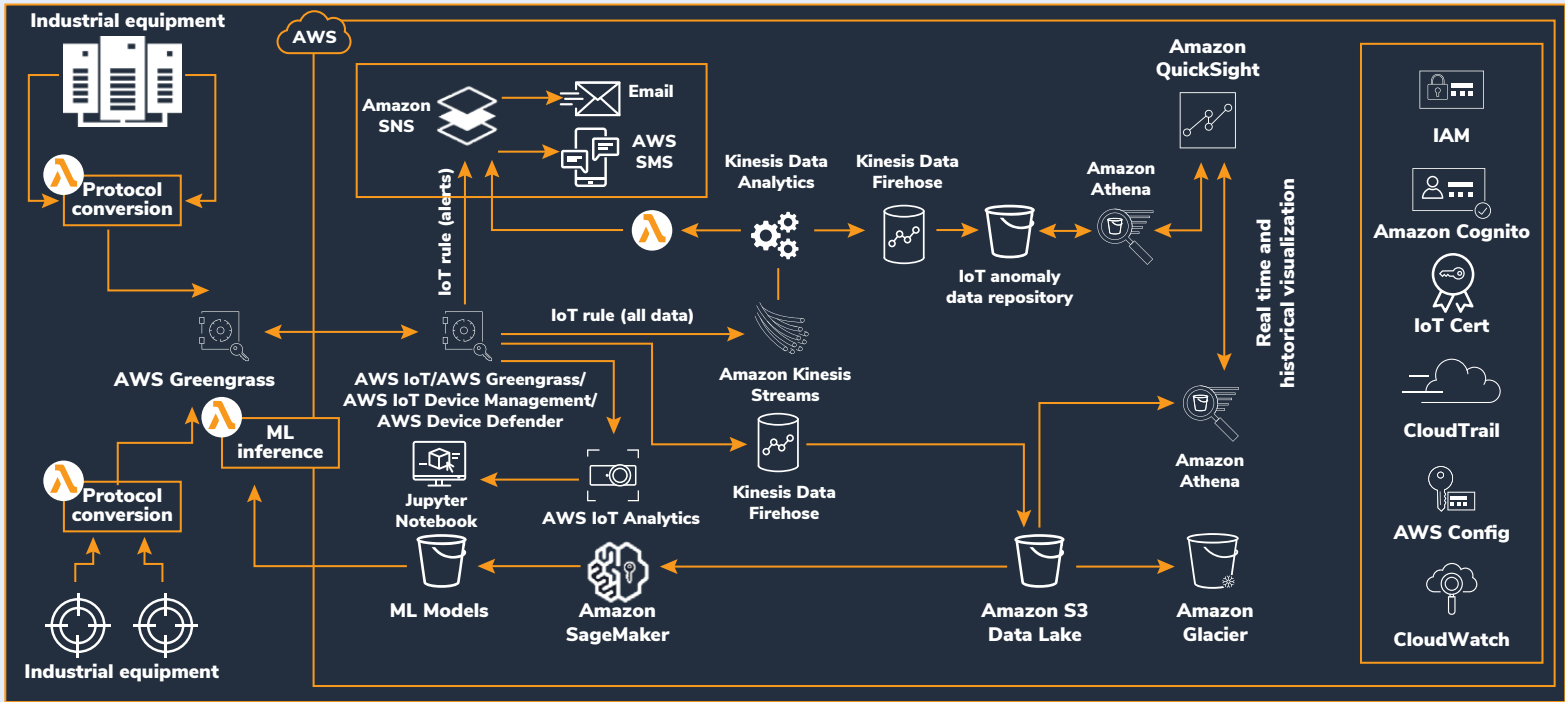


**Cloud Services for IIoT**
**Do you use, or plan to use, any of the following cloud service offerings for implementing your IIoT solution?**

| Category | Value |
|---|---|
| AWS | 52% |
| Microsoft Azure | 31% |
| Private / On-prem Cloud | 19% |
| Google Cloud | 19% |
| Kubernetes | 17% |
| IBM Bluemix | 14% |
| Openstack (On-Prem) | 10% |
| Unsure | 10% |
| Red Hat Openshift | 9% |
| None | 9% |
| Cloud Foundry (On-Prem) | 9% |
| Other | 6% |
| GE Predix | 2% |

*Source: Copyright © 2018 Eclipse Foundation, Inc. Made available under a Creative Commons Attribution 4.0 International License (CC NY4.0).*

Of the available AWS services, this paper will concentrate on IIoT services empowering organizations to become smarter, move faster, lower IT costs, and scale **(Exhibit 8)**. The strategic importance of AWS services, solutions, and "so what?" implications for its manufacturing customers are subsequently outlined.

**EXHIBIT 8: AWS MANUFACTURING REFERENCE ARCHITECTURE**



*Source: Amazon Web Services*

# Key AWS IIoT Services & Solutions

**AWS IoT Core:** AWS IoT Core is managed cloud service. It enables connected devices to simply and securely link to cloud applications and related devices. The service has the ability to support billons of devices and trillions of messages. AWS IoT Core reliably and securely processes and routes messages to AWS endpoints and devices. Once AWS IoT Core is in place, it constantly tracks and communicates with all of the organizations devices – regardless of their connectivity status. The service also serves as a bridge for the simple connection and integration of other AWS Services, including: AWS Lamba, Amazon Kinesis, Amazon S3, Amazon SageMaker, Amazon DynamoDB, Amazon CloudWatch, AWS CloudTrail, and Amazon QuickSight. The preceding applications require no infrastructure management and facilitate the gathering, processing, analyzing of data generated by connected devices.

**AWS Lambda:** A revolutionary operations solution, AWS Lambda allows manufacturers to run code without provisioning or managing servers. They are only charged for consumed compute time. The event-driven, server-less computing platform executes functions in response to pre-determined events/scenarios. With Lambda, code can be run for virtually any type of application or backend service — all with zero administration. Once a manufacturer's code is uploaded, Lambda runs and scales the code with high availability and automatic triggers alerts linked to other AWS services. The solution is also accessible directly via the web or mobile application.

**AWS Greengrass/Edge:** Greengrass expands AWS seamlessly to field devices by pulling data from sensors and control systems in industrial plants. Greengrass-connected devices act upon locally generated data and simultaneously use the cloud for management, analytics, and durable storage. Lambda functions also run on Greengrass devices, which allow the execution of predictions based on machine learning models. Device data remains synced, and devices communicate with other devices securely — with or without Internet. AWS IoT Greengrass can be programmed to filter device data and only transmit necessary information back to the cloud.

> *Greengrass-connected devices act upon locally generated data and simultaneously use the cloud for management, analytics, and durable storage. Device data remains synced, and devices communicate with other devices securely — with or without Internet.*

AWS has partnerships with leading automation systems providers, which allows Greengrass agents to be run on the hardware platform/edge and perform near-real-time analysis on the production data.

**AWS SageMaker:** Amazon SageMaker is a fully-managed machine learning deployment platform. It enables developers and data scientists to quickly and easily build, train, and deploy ML models at any scale. Amazon SageMaker removes all the barriers which traditionally hamstring developers from leveraging ML. The platform features modules which may be used together or independently to build, train, and deploy ML models.

**AWS Batch:** Multiple disciplines, including developers, scientists, engineers, use this service to quickly and practically run massive scale batch computing jobs on AWS. The optimal quantity and compute resource type are rapidly provisioned by AWS Batch – depending on the scale and specific resource requirements of the given batch jobs. AWS Batch eliminates the need for batch computing software or server clusters in order to run jobs. The service frees up organizational resources to focus on more pressing needs, such as analyzing results and solving problems.

**Amazon CloudWatch:** Amazon CloudWatch is a supervisory and administration service which turns manufacturing data into actionable insights. It is designed to be an effective cloud tool for a range of industrial job functions – developers, system operators, site reliability engineers (SRE), & IT managers. By implementing Amazon Cloudwatch, manufacturers can get a view of the operational health of AWS resources, applications and services that run on AWS, and on-premises servers. The service collects monitoring and operational data (e.g. resources, applications, and services) and sorts it into logs, metrics, and events. The end result is holistic view of system-wide performance changes – which enables a rich and deep understanding of the operational landscape and ability to take timely actions.

**Amazon EC2:** Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, scalable compute capacity in the cloud. It was created to simplify web-scale computing for developers. The Amazon EC2 interface allows organizations to obtain and configure capacity with minimal friction. Manufacturers receive complete control of computing resources. Amazon EC2 reduces time requirements for new server instances to minutes. The time savings allows capacity to be quickly scaled up and down. Servers can be commissioned simultaneously at a variety of levels – from one to thousands. The entire process is controlled with web service APIs, and the application can automatically scale depending on needs.

**AWS IoT SiteWise:** AWS IoT SiteWise is a managed service which amasses and classifies data from industrial equipment at scale. IoT SiteWise screens operations across facilities, quickly calculates common industrial performance metrics, develops applications to analyze industrial equipment data, thwarts costly equipment issues, and lessens production inefficiencies. With IoT SiteWise, manufacturers focus on analyzing and optimizing their operations and avoid creating costly in-house data collection and management applications.

**Amazon Managed Blockchain:** Customers are looking to drive secure, de-centralized transaction execution across applications such as supply chain, product traceability, and documentation. Amazon Managed Blockchain enables a fully managed service that creates and manages scalable blockchain networks. Popular open source frameworks such as Hyperledger Fabric and Ethereum are also used in-step with Amazon Managed Blockchain. The service eliminates the overhead required to create the network, and systematically scales to meet application demands by running millions of transactions.

**Amazon Timestream:** Accessing and collecting stranded data is a critical challenge for manufacturers. The lack of data leverage prompted Amazon to introduce Amazon Timestream — a fast, scalable, serverless, fully managed time series database service for IoT and operational applications. The service has the ability to store and process trillions of events per day, with up to 1,000x faster query performance at one-tenth the cost of relational databases. Organizations use Timestream to rapidly organize and analyze time-series data with built-in functionality for analytics, including smoothing, approximation, and interpolation.

**AWS Lake Formation:** AWS Lake Formation is a service that quickly and securely creates data lakes. It rapidly moves, stores, catalogs, and cleans organizational data. By pointing Lake Formation at data sources, the service accesses the sources and moves the data into a new Amazon S3 data lake. The service allows manufacturers to centrally define security, governance, and auditing policies in one place. Policies are then enforced for users across analytics applications. The silo-based infrastructure of traditional manufacturing paradigms has restrained customers' ability to perform analytics over mixed forms of data (e.g., process, product, environment, customer, etc.). AWS data lake services help customers overcome this challenge by pulling different forms of data (that are normalized, cleaned, and ready for analysis) and applying advanced analytics on the data sets.

**AWS IoT Things Graph:** AWS IoT Things Graph is a service that visually connects different devices and web services to build IoT applications. Models illustrate devices and web services as well as bridge differences in low-level details such as communication protocols and proprietary interfaces. AWS IoT Things Graph bundles and implements IoT applications within AWS IoT Greengrass-enabled devices.

## AWS Partnership: Achieving Real, Differentiated Value

AWS offers a one-stop-shop suite of cloud applications. Its capabilities allow manufacturers to add AI and machine learning to industrial environments. The company maintains its superior market position by constantly adding and upgrading its already comprehensive offerings.

By partnering with AWS, builders large or small are empowered to become smarter, faster, leaner, and more responsive through their manufacturing transformation journey with the cloud. The differentiated values of AWS are outlined below.

**Breadth and depth of offerings:** The AWS cloud platform is mature and feature-rich with an unparalleled breadth and depth of services, capabilities, and solutions. AWS leads the market because they 1) understand precisely how their customers use cloud and 2) have the ability to help manufacturers take intelligent actions, optimize processes, and improve OEE.

**Hardware agnostic portfolio:** Manufacturing plants are straddled with proprietary and heterogeneous systems. AWS solutions can work with diversity and extract data, immaterial of make, vintage, or protocol.

**Vibrant partner ecosystem:** AWS has focused on building a strong partner ecosystem to meet manufacturing customer needs spanning diverse verticals, heterogeneous processes, and highly variable application complexities. Their full spectrum of partners includes integration services, industrial software organizations, IoT competency partners, application developer tools, independent software vendors (ISVs), management vendors, and security vendors.

**Customer empowerment:** AWS Cloud is highly adaptable and flexible. It empowers customers to build composable cloud applications leveraging the AWS solution portfolio. In line with new trends, AWS also facilitates accelerated deployment of containerized AI and analytics applications.

**Enriched user experience:** As the technology consumption gap widens, there is an acute focus on intuitive user experiences within manufacturing. AWS delivers AI-powered conversational user-interfaces to enable rewarding customer experiences.

**The two subsequent customer use cases illustrate the organizational benefits experienced in working with AWS.**

## AWS Customer Case Study 1: Western Digital

Based in the United States, Western Digital (WD) is a computer hard disk drive manufacturer and data storage company. It develops, manufactures, and sells data technology products, such as storage devices and data center systems. In the past five years, WD has partnered with AWS to transform its design and engineering processes.

**Challenge:** In the electronics and semiconductors industry, speed and time-to-market for new product offerings are critical to achieve sustainable market success and overall business profitability. As a global electronics manufacturer, Western Digital was looking to overcome the following specific challenges around design and engineering:

- Longer lead times for new products
- Reducing cost of quality issues and minimizing business risks
- Inflexible IT systems
- Poorly utilized traditional CAD/CAE infrastructure, with high operational costs

**Solution:** WD worked with AWS to leverage cloud and optimize both its design and engineering operations. In using the AWS cloud platform and associated services, WD has been able to optimize clusters, design chambers, and scale up/down in minutes. The designers used thin clients, which had no local data, and pushed all heavy-end engineering work to the cloud. High-performance computing (HPC) capabilities allowed WD to perform remote rendering while encrypting the data in motion. Collaboration between designers was secure, regardless of their location worldwide.

**Outcome:** Since beginning its partnership with AWS, WD was able to shut down over 20 data centers and eliminate a co-location center, which previously experienced outages. It also created a fully redundant data lake environment on AWS S3 – protecting the company from potential data loss. Its engineering teams, manufacturing teams, and development teams analyzed immense amounts of data and used AWS SageMaker to identify and address process tuning issues. As stated by a WD executive, AWS helped "shape the compute to match the work to be done."

## AWS Customer Case Study 2: Georgia Pacific

Georgia Pacific (GP) is one of the world's biggest manufacturers and distributors of tissue, paper, toilet and paper towels, packaging, building products, and associated chemicals. By working with AWS, GP leveraged key solutions to create a system for capturing and analyzing valuable data, and moved away from site-specific expertise held only by local experts.

**Challenge:** The manufacturing process for many GP products is complex. For example, the delicate nature of tissue paper leads to breaks when converting massive parent tissue rolls into consumer-ready final products. An array of complex factors causes breaks, and the associated product quality can be difficult to correlate. Lack of insight on rolls likely to break causes fear of and/or loss of productivity (which carries a high cost of downtime). Operation of these complex machines was often adjusted manually by seasoned in-house experts based on years of operating experience. GP also faced serious unplanned asset downtime because asset management was quite reactive and human-driven.

**Solution:** GP partnered with AWS to implement a cloud-based analytics solution. Production data was transferred from large paper machines and converting process machines, and then stored on Amazon S3. AWS machine learning solutions analyzed the data and generated the predictions flowing into Amazon SageMaker. Alongside a human machine interface (HMI), SageMaker provided immediate operator feedback on process conditions. Through simple indicators, the operators could recognize what variables to adjust in real time to minimize the risk of web breaks and optimize quality. Thousands of data points were processed to identify central drivers. To reduce the perceived complexity, the drivers were ranked to identify the top three conditions impacting paper machine operations. Using a combination of data from the paper machine process, converting operations were analyzed to identify the "convertibility" of parent rolls. The analysis was used to pinpoint optimal speeds for processing in real time, which were then automated (via APCs as outlined in Exhibit 9).

### EXHIBIT 9: GEORGIA PACIFIC DATA LAKE ARCHITECTURE
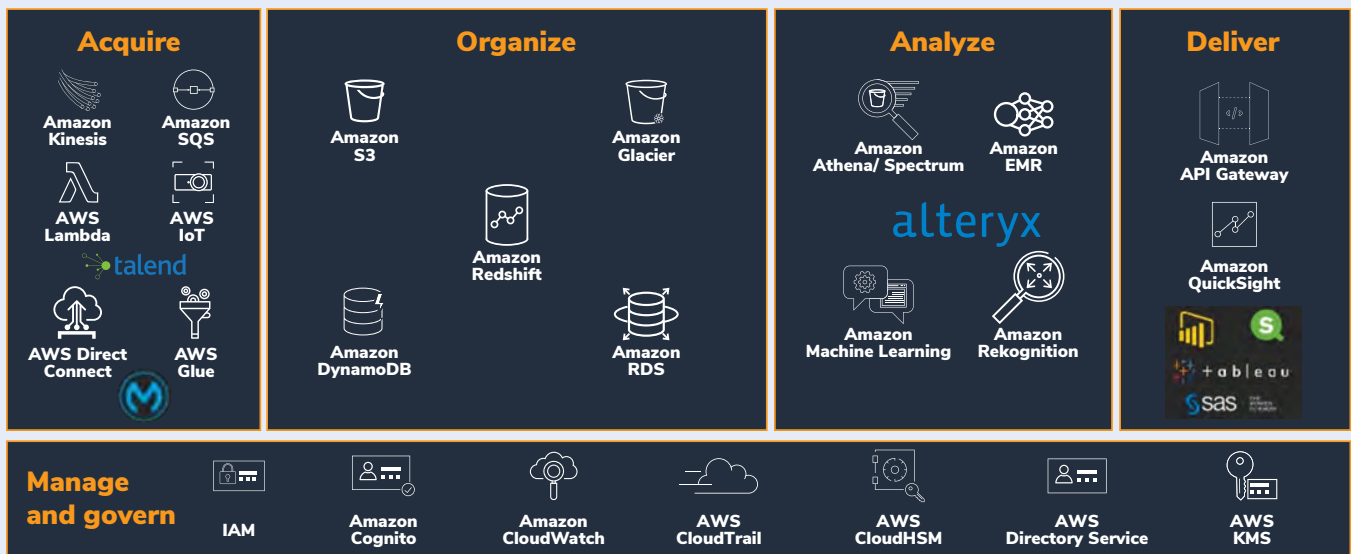


*Source: Georgia Pacific; Amazon Web Services re:Invent 2018; Frost & Sullivan*

**Outcome:** Major improvements were realized in asset reliability involving lube systems, vibration analyses, and prognostics for rotating equipment. The partnership with AWS radically advanced GP's ability to remotely monitor and diagnose issues by comparing equipment across facilities and processes. Processes were also optimized, including utilities, power, pulping, bleaching, paper machine sheet break, parent roll converting, material consumption, waste elimination, and lumber pricing. A 10% improvement in uptime and yield was achieved for converting lines. The company was able to effectively establish a dedicated core capability of data citizens and then set its priorities by deploying resources based on key use cases. By taking a technology augmentation approach, instead of full automation, GP was able to eliminate some of the risk and uncertainty involved with rolling out such critical new production process enhancements. GP also quickly moved from a traditional "point to point" architecture to a "data lake-based hub and spoke" architecture to take advantage of single data lake and low-cost storage options available in AWS. Moving forward, GP will need to focus on data governance, data quality, context, and enrichment. An advanced analytics platform and edge computing will also be core to GP's manufacturing transformation journey.

**5**

# STRATEGIC CONCLUSION

## *Migration to the Cloud: Practical Steps and Core Value Drivers*

To effectively migrate to the cloud, manufacturers would do well to consider the following practical approaches. First, start small. The entire organization may not be ready to adopt the cloud immediately. By starting small, with a specific, defined use case, manufacturers can test services and develop the proper mix. In doing so, they take the next practical step: realize value. Once a solution proves to maximize cost savings or generate efficiencies, it must then be applied quickly at scale. The speed of adoption will likely drive enterprise adoption.

Amazon Web Services summarizes the aforementioned practical steps within its professional services model **(Exhibit 10)**. The cloud adoption framework guides customers through exactly how AWS implementation helps in their journey to the cloud.

## AWS Professional Services Model

- Stage 1: Align. Align customers with business objectives and hold workshops to illustrate how efficiencies will increase and costs will decrease.

- Stage 2: Launch. Generate proofs of concept with customers.

- Stage 3: Scale. Expand services throughout organization to maximize value.

- Stage 4: Optimize. Evolve operations by optimizing the computing power using the elasticity model.

**EXHIBIT 10: AWS PROSERV MODEL**

## AWS PROSERV Model
**Manufacturing Transformation:  Journey to the Cloud through 4 implementation stages**

| Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---------|---------|---------|---------|
| Align | Launch | Scale | Optimize |
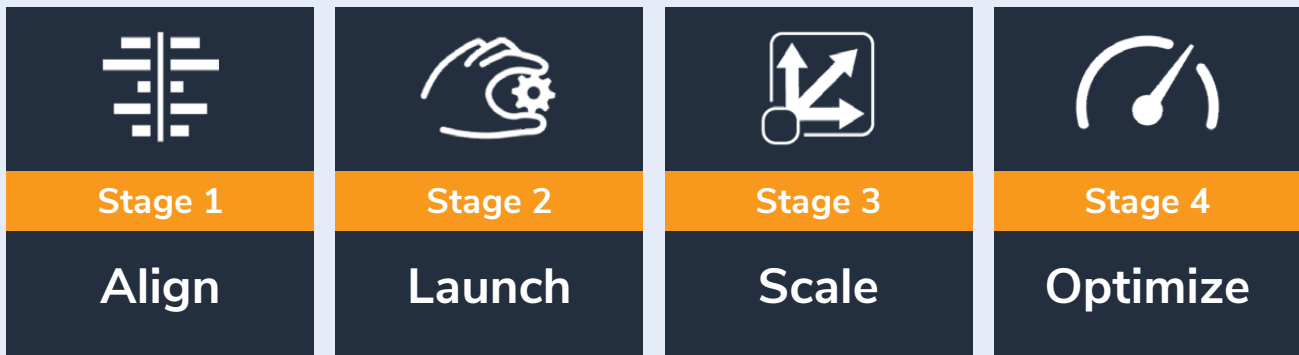
*Source: Amazon Web Services*

## Shop Floor to Top Floor: Achieve Smarter, Faster, More Responsive Operations

With downtime and profitability at stake, industrial firms today must become adaptable and responsive to meet the varying demands and needs of their customers. Manufacturers can become more agile and cost-effective than ever through effective implementation of cloud computing services and solutions, and AWS is the ideal partner. As the market leader, AWS guides manufacturing organizations confidently through their journey to achieve operational transformation and simultaneously reduce strategic risk. AWS solutions provide affordable storage for backup and disaster recovery, reduce operational expense costs, spin up resources quickly, drive enterprise collaboration, unlock visibility restraints, and achieve faster time to market.

AWS has the largest suite of services and the broadest ecosystem of partners. The company is present in 18 geographic regions, and each AWS data center, regardless of location, meets strict regulatory, security, and compliance standards. The scope and scale of its services allows AWS to serve customers at an unprecedented level. AWS works with customers across all instances and stages of maturity, from those who are unsure of connecting their shop floor assets to the cloud to those who find it difficult to pull data from legacy systems. AWS has also invested in human capital. Its teams feature individuals with real manufacturing experience from a broad range of verticals.

AWS is not simply an information technology company connecting industrial devices to the Internet; it is the cloud market leader with a 360-degree understanding of the manufacturing industry and its critical issues. AWS has the expertise to lay out a viable roadmap for manufacturing transformation. The customer-centricity of AWS is echoed from the organization's penchant for constant innovation. Customer feedback is continuously infused into its products and released to the market in record time. AWS learns alongside its customers and allows manufacturers to climb the digital learning curve at a significantly faster clip.

Break down your silos and join the cloud-led transformation journey with AWS to unlock your ability to become smarter, faster, leaner, and more responsive in your manufacturing operations!

# **NEXT** STEPS ›

> **Schedule a meeting with our global team** to experience our thought leadership and to integrate your ideas, opportunities and challenges into the discussion.

> Interested in learning more about the topics covered in this white paper? Call us at 877.GoFrost and reference the paper you're interested in. We'll have an analyst get in touch with you.

> Attend one of our **Growth Innovation & Leadership (GIL)** events to unearth hidden growth opportunities.

> Learn more about how AWS is helping manufacturers transform and reach new operational heights by visiting **AWS**.

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