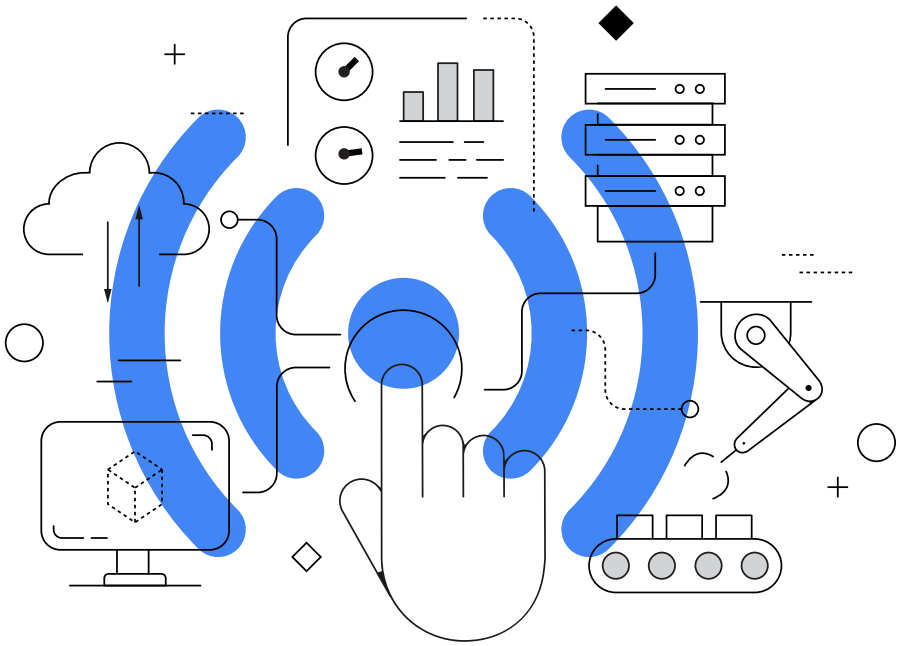
SAP on Google Cloud for manufacturing



Google Cloud

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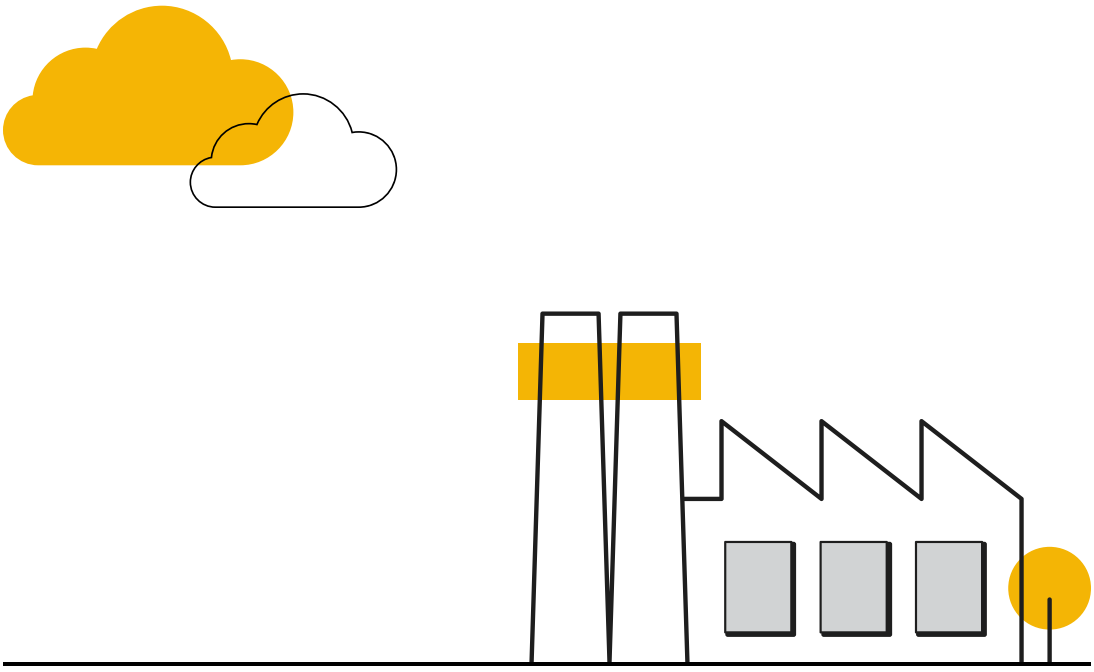
Introduction

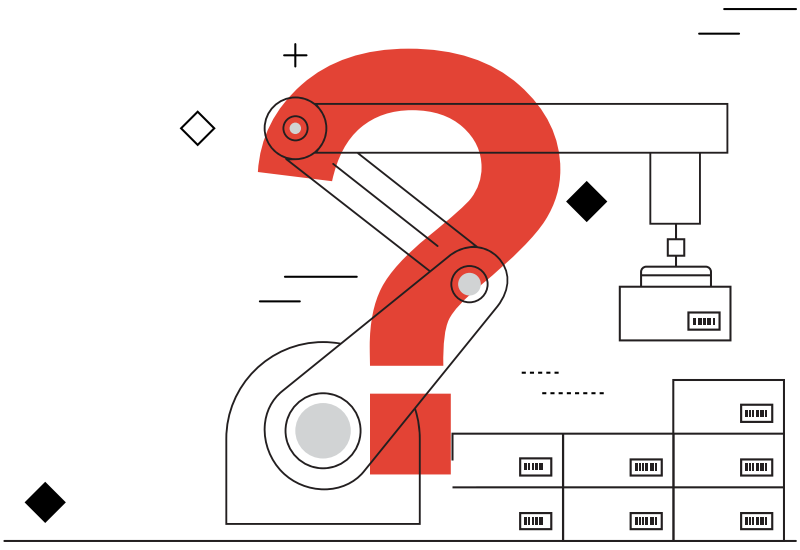
Current manufacturing and technology trends are driving the need for transformation in the manufacturing industry. This document provides an understanding of the current trends and highlights Google Cloud's ability to help manufacturers enable a digital factory. It also demonstrates the value of implementing SAP applications on Google Cloud and explores the differentiators in Google Cloud's offering. The use case examples provided at the end highlight how SAP on Google Cloud can provide advanced solutions to mitigate the challenges faced by manufacturers today.



What's happening in manufacturing?

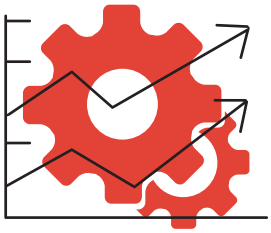
Manufacturers today face the challenges of changing customer expectations, an evolving workforce, and increasingly urgent sustainability imperatives. At the same time, significant advancements in the Industrial Internet of Things (IIoT) and cloud technologies in recent years are reducing the cost of adopting new manufacturing technologies and broadening the spectrum of what is available.

Notably, costs associated with data storage, networking, and computing have dropped drastically with the innovation of cloud technologies. The cost of sensors and other internet-connected devices has also dropped significantly (as much as 60% in the last 15 years), making IIoT solutions more affordable at scale for manufacturers. Modern cloud-based solutions are also cost effective and require little-to-no physical infrastructure setup for new features and capabilities, enabling faster adoption of new technologies.



The areas having the most transformational impact in the manufacturing space as they grow in adoption are artificial intelligence (AI) and analytics, security and the convergence of information technology (IT) and operational technology (OT), hybrid/multi-cloud environments, connectivity and 5G, edge and cloud architectures, and self-service/no-code app building.

The challenge for manufacturers is to leverage the power of technology solutions to become more agile. They must do this to address the changing needs of their customers, workforce, and planet – all while increasing uptime, reducing costs, and improving quality.



Manufacturing trends

Changing customer expectations

Modern consumers demand more personalization, customization, and sustainability of products, driving the manufacturing industry to create more agile supply chains. These demands often lead to SKU expansion, placing additional strain on manufacturers to track and manage thousands of different product types. Customer orders now come in lower order quantities with shorter lead times, leading to frequent changeovers and more production stoppages.

To meet increasing customer demands, gain better control of the supply chain, and reduce costs, companies are now looking to re-shore some manufacturing operations. These continuously changing demands placed on manufacturers require companies to embrace change and strengthen solutions that best support agile manufacturing. Integrated enterprise resource planning (ERP) systems and plant applications, such as those offered by SAP, can together enable manufacturing flexibility by helping manufacturers adapt quickly to the demands of the market. In addition to supporting consumer needs, agile manufacturing provides other operational benefits such as improving asset utilization and increasing process efficiency. Streamlining the flow of operations from order to execution allows manufacturers to adapt easily to change, reduce operational cost, and meet ever-changing customer demands.

Evolving workforce

The current manufacturing workforce is aging. Many companies are facing a situation where their experienced workers, who hold the most knowledge and expertise at their plants, are nearing retirement. Additionally, rising automation and technology in manufacturing processes are increasing the required technical skills of plant workers. As the current workforce moves towards retirement, the newer generation must be equipped to learn existing processes while quickly adopting new digital technologies.

To combat skill gaps, manufacturers are focusing on the use of new tools and technical capabilities to digitalize existing processes and help employees learn new skills quickly. Connected worker technologies – such as tablets and augmented reality (AR) headsets – allow plant workers to access instructions easily and upskill quickly. Additionally, real-time dashboarding and mobility technologies enable workers to become skilled operators with the data needed to make real-time decisions.

Sustainability

Regulations increasingly place the responsibility on manufacturers to sustainably source and process materials while driving towards a lower carbon footprint and improving plant efficiency. Manufacturers can improve plant efficiency by tracking and optimizing utilities usage. They can reduce energy consumption by over 10% and reduce their carbon footprint by over 10% by utilizing analytics to optimize usage.[1] Asset-rich manufacturing companies are prioritizing sustainability and decarbonization initiatives for the coming years. Additionally, some manufacturers are tracking process yield closely to determine waste reduction opportunities, lower costs, and minimize their environmental impact. They are also prioritizing product quality to limit waste generation from product rework and recalls. Lastly, manufacturing companies use sustainable data platforms and solutions to help identify improvement opportunities and encourage decarbonization.

Technology trends

AI and analytics

The power of cloud computing has made it possible to analyze massive data sets quickly so manufacturers can predict outcomes or events before they occur and proactively prevent negative impacts. Using AI and machine learning (ML) models, manufacturers can analyze machine operation data, production plans, and demand levels to know in advance if a critical machine or tool is going to fail. Then they can schedule maintenance or replace parts before a failure happens to prevent expensive downtime.

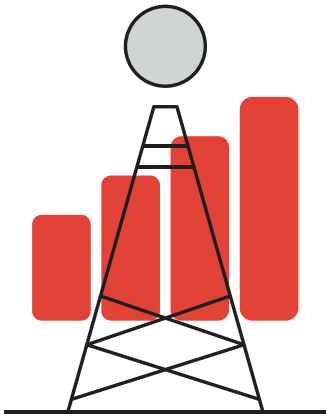
IT/OT convergence and security

IT and OT functions will converge to enable new digital ways of working in manufacturing. This has broad implications for manufacturers in terms of organizational design, role definitions, and task management. When adopting new technologies, manufacturers must expand security perspectives to better understand their real vulnerabilities when converging IT and OT infrastructure. Manufacturers need to prioritize security to prepare themselves for the growing ecosystem-driven threats in an increasingly digital world.

Hybrid/multi-cloud environments

It is common to find multiple cloud environments in most companies. Business functions such as marketing, sales, or finance may have already adopted various cloud technologies that run alongside on-premises legacy systems, which can be challenging to shift to the cloud. Rarely do all of these initiatives line up under one cloud provider. It's important to have a primary manufacturing cloud solution that can effectively coordinate data and applications across multiple cloud (or on-premises) environments.

Connectivity and 5G



Many advanced manufacturing use cases require data from sources that have limited connectivity or limited current plant networks. It is critical to build a comprehensive connectivity strategy that uses next-generation technologies like 5G and ultra-broadband to enable reliable, high-performance communications at scale. Additionally, manufacturers can use 5G to enhance their digital security by creating private networks and securing production lines from external internet access. Where network infrastructure is limited, 5G could hold the answer to rapidly connecting machines and sensors, without requiring extensive new investments in wired networks.

Edge and cloud architectures

The evolution of cloud technologies has unlocked new functionality and features that can impact manufacturing; however, real value is found through quick reaction to the physical environment. Relying solely on the cloud can introduce latency in processes. An edge architecture can reduce latency by acting quickly on data at the edge. By combining new-age cloud computing capabilities with edge infrastructure located within the plant, manufacturers can take advantage of the scale of the cloud while still being able to react quickly to changes on the plant floor.

Self-service/no-code app building

Manufacturing operations are inherently complex and require a vast number of specific scenarios for process improvement, digitalizing operations, gaining insights, or adding specific context. New tools from cloud platform providers offer the ability for end users to create new, lightweight applications using little-to-no code. This democratizes app development and data insights at manufacturing locations – reducing dependency on developers and giving plant workers the ability to solve their own business challenges with data.

Creating a digital factory

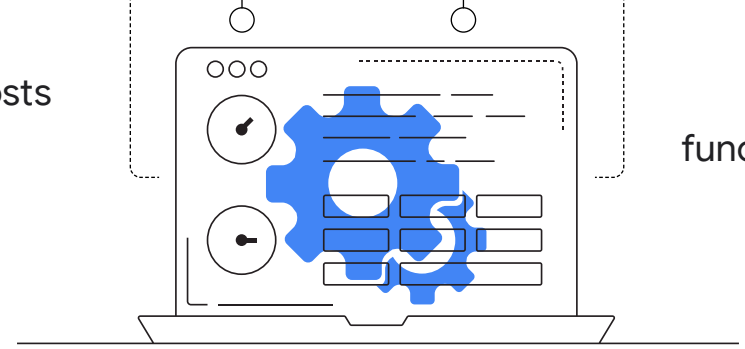
A digital factory is created when manufacturers use advanced technology to enable new business processes and unlock value in many areas:

5-10%
improvement in production volume/ direct production

20-30%
savings in logistics-related costs

10-20%
savings in energy costs

10-30%
reduction in support function costs



Together, these often result in a 10-20% improvement in production efficiency for most manufacturers.[2]

Creating a digital factory impacts everyone in a manufacturing organization. Capturing the full potential of digital manufacturing is largely dependent on utilizing advances in technology to enable new ways of working. Roles and responsibilities for all employees, from the C-suite to machine operators and quality technicians, will shift in the digital manufacturing journey.

How digitalization impacts key roles in manufacturing

C-suite executives

By optimizing manufacturing operations, a digital factory unlocks new capacity from existing assets, allowing companies to pursue new growth opportunities. On the cost side, more efficient manufacturing will lower operational costs, releasing more capital to be invested either back into manufacturing or elsewhere in the organization.

Manufacturing executives

In a digital factory, regional managers, business unit leaders, and other manufacturing executives are empowered with real-time, accurate data on manufacturing operations to help make more informed decisions. Knowing where to make which products, deciding where to expand or reduce capacity, and identifying lower or higher performing facilities will all be possible with the right information, made available through the digital factory.

Business leaders

Other business leaders, in research and development (R&D) or supply chain for example, will find their interactions with manufacturing more responsive and flexible. Flexibility allows for more successful R&D trials, shorter planning lead times for supply chain activities, and more insight into real-time performance on in-progress initiatives.

- **Plant managers**
  Plant managers become aware of plant operations in real time, thanks to advanced decision-making models. Their teams will spend less time sifting through and cleaning data and reports, and will have actionable insights to drive decision making at the plant.

- **Supervisors and plant functional leaders**
  In the digital factory, real-time performance metrics are at the fingertips of all supervisors. Proactive alerts and predictions eliminate much of the firefighting and scrambling to respond to unplanned production events. Schedules are generated automatically based on demand plans, vastly simplifying the planning process. Predictive maintenance takes the guesswork out of scheduling maintenance.

- **Line operators, team members, technicians**
  Today, manufacturing operations are run by workers who have decades of experiential knowledge. New employees may need months or years of training to gain the skills that come from experience. In the digital factory, operators utilize new digital tools to improve workforce efficiency, decrease dependency on experiential knowledge, and improve worker safety. Connected worker platforms put information in the hands of operators, allowing them to own their operational processes without depending on word-of-mouth instructions. Operators are given actionable recommendations on machine settings, process parameters, or expected downtime, giving even new employees an opportunity to manage complex processes.

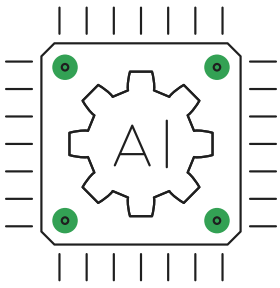
Challenges to creating a digital factory

As manufacturers begin their journey to creating a digital factory, they face a number of technical and business challenges that solution providers must be prepared to address.

Data management
Manufacturers are challenged by the sheer volume of data collected and must determine how to use this data for business insights. Additionally, manufacturing data is often unstructured and disconnected, requiring cleanup and connection before any analytics can be performed. Increased volumes of low-quality data are encouraging companies to pursue digital initiatives to unlock additional enterprise value.

Initiative prioritization
Due to innovations and the pace at which technology is evolving, executives struggle to prioritize projects and investments. Lack of prioritization and innovation governance, paired with low investment budgets, can often lead to competing projects and a divided perspective amongst leadership. Many of these projects require collaboration of both IT and OT resources, so both business groups must coordinate strategies, governance, and roadmaps efficiently to realize anticipated value.

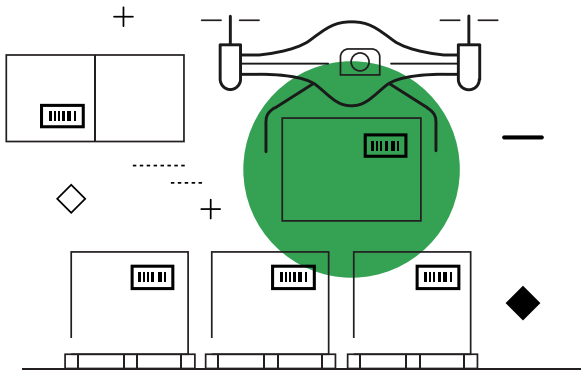
Change management
Another challenge faced by manufacturing companies is the varying level of digital maturity and acceptance across the plant network. Adopting advanced technologies has wide-reaching implications, so it is imperative that companies assess their maturity and readiness for change. Enterprises are challenged to upskill their people and develop the flexibility to change. It is anticipated that by 2022, 54% of employees will require reskilling.[3] A successful transformation will require all members of an organization – from C-suite executives to line-level operators – to increase their digital acumen to realize the full potential of newly implemented technologies.



Vendor landscape

Manufacturers are challenged with selecting vendors to partner with when shaping their transformation journeys. Companies are often overwhelmed by the variety of solutions in the marketplace and must be thorough in the selection of vendor partners. At the same time, they are looking to build a comprehensive digital ecosystem with solutions that work well together without complex integrations. New vendors are offering niche, but critical capabilities, such as detailed line-level scheduling, product simulation, and digital twins. Additionally, established market players are expanding their product suites to meet these capabilities by acquiring companies or building new solutions. Despite these market changes, both new and established vendors face challenges in offering a full interconnected suite of capabilities. Specialized vendors are unable to scale to meet ecosystem needs on their own, while established players sometimes lack targeted industry expertise to build relevant solutions for manufacturing.

No company has emerged as a market leader with a complete end-to-end solution, so vendor relationships, solution flexibility, and solution modularity are more important than ever. Vendors will need to build and support application programming interface (API)-led connections to flexibly integrate their technology with legacy systems within a manufacturer's architecture. As IT and OT layers begin to blend, vendors will need to plan for the convergence by preparing for intelligent devices, machines, and platforms to enhance the traditional programmable logic controller (PLC) and supervisory control and data acquisition (SCADA) layers. Finally, new solutions will need to be flexible and modular to allow manufacturers to rapidly develop and deploy proofs of concept, realize value quickly at a low cost, and then expand with more functionality later. Manufacturers must be thorough in the selection of vendor partners to meet their specific needs.



Selecting the right vendor

When evaluating solution vendors, executives and decision makers should account for the specific needs of the organization. The below criteria are used by manufacturing companies to evaluate solution vendors.

Data management

- Data management, governance, and handling services plus ability to support diverse data types from various sources.
- Potential to unlock insights from structured and unstructured data and connect previously siloed data sources.

Platform security

- Capacity to secure data and protect the enterprise from threats.
- Potential to protect the enterprise without inhibiting innovation and further solution development.

Market reputation

- Place in the market according to peers and research.
- Provision of strong solutions that enable innovation in the business and its processes.

Solution portfolio

- Portfolio of services, technical expertise, and additional applications that can be integrated into a core solution.
- Toolkit and expertise that will support and encourage innovation.

Flexible integration with legacy systems

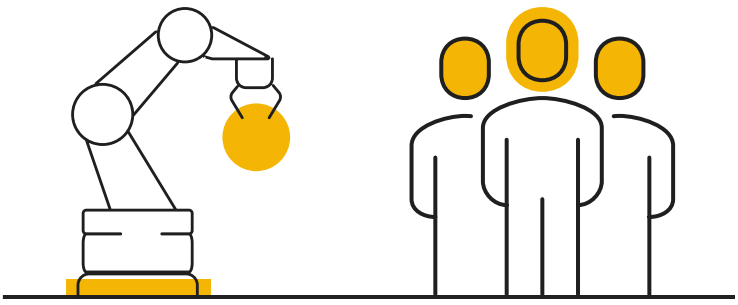
- Flexible integration with business functions and legacy systems and ease of customization.
- Ease of use and ability to run seamlessly with current systems as well as new technologies that may be part of future initiatives.

How SAP on Google Cloud can help manufacturers

For manufacturers that run SAP, Google Cloud is ideally suited for cloud hosting of manufacturing applications. Google Cloud makes SAP deployments easy and offers a suite of applications to integrate with and enhance SAP functionality. By integrating SAP on Google Cloud, manufacturers can take advantage of Google Cloud's extensive data management, AI and ML analytics, and hybrid/multi-cloud capabilities. They can also benefit from:

Ease of migration

SAP deployments and migrations can be complex, and Google Cloud offers the tools and services to help simplify and streamline the process. Google Cloud offers industry-leading security capabilities with migration options for high availability – leading to a secure migration experience. Additionally, automated templates can be used to deploy applications faster, consolidate SAP data within the cloud, and begin drawing on AI and ML powered insights. The Cloud Acceleration Program from Google Cloud takes full advantage of Google Cloud's network of partners and uses pre-built migration solutions and applications. These offer the risk mitigation and operational efficiency strategies needed to transition to the cloud.



Data management and storage

Running SAP on Google Cloud's platform allows manufacturers to take advantage of cloud-hosted data storage capabilities without incurring significant operating costs. Google Cloud connects data hosted in a variety of locations across a global network, allowing manufacturers to gain insight from historic data, production data, quality data, and key SAP business data. Traditionally hard to access SAP data can be retrieved and utilized with ease through Google Cloud storage capabilities and streamlined access through API calls.

Hybrid/multi-cloud capabilities

Google Cloud has the advantage of being able to integrate with legacy, on-premises systems and other cloud platforms. Google Cloud's hybrid and multi-cloud capabilities allow manufacturing companies to bring together the strengths of multiple cloud platforms, on-premises solutions, legacy providers, and a diversity of hardware. Once SAP on Google Cloud is integrated, manufacturers can take advantage of Google's secure public cloud, encouraging open source innovation with limited long-term risk.

External data sources

Once an SAP on Cloud foundation is established, Google Cloud's toolkit enables manufacturers to begin building their digital factory. With an established SAP on Google Cloud solution, manufacturers realize value throughout the supply chain, from planning through production to customer satisfaction. Manufacturers can leverage Google Cloud's extensive data signals from various Google portfolio tools, such as Web search data, weather, maps, shopping, and more. Combined with valuable customer and industry data from outside the enterprise and their SAP system, they can drive insight into production planning, customer needs, and other business processes.

Data analytics capabilities

Industry leaders are taking advantage of increased amounts of data collected through the consolidation of production data and SAP business data. Google Cloud's simplified capabilities allow business leaders to rapidly make effective data-driven decisions. Google Cloud's query performance allows for insights across previously siloed business units. Enhanced processing speeds combined with Google Cloud's AI and ML capabilities enable insights to be obtained at a rapid pace. Google Cloud's AI and ML capabilities can also leverage data from SAP systems and enhance them using its extensive application suite, making the system and the business more intelligent.

Key Google Cloud portfolio differentiators

- **BigQuery** allows businesses to quickly process large amounts of data from a variety of data sources, including production facilities, data lakes, historians, sensors, SAP systems, and more.

  BigQuery Omni allows BigQuery tools to run seamlessly on a variety of cloud platforms. This brings multi-cloud analytics to SAP data, allowing manufacturers to cost-effectively access and securely analyze data across Google Cloud, Amazon Web Services (AWS), and Microsoft Azure (coming soon), without leaving the familiar BigQuery user interface (UI).

- **Google Kubernetes Engine** (GKE) allows simple deployment of workloads and applications, which removes the complexity of scaling across the enterprise, and modernizes SAP systems and applications.

- **Apigee**, Google Cloud's API Management tool, allows easy connection of enterprise systems and empowers line-of-business employees to create apps and automation without having to write code.

- **Cloud AutoML** is an advanced ML toolset that allows for training of customized ML models for efficiency and accurate predictions.

  AutoML Vision and Auto ML Vision Edge enable the development of ML models to identify and classify images or objects in real-time; and enable the deployment of Cloud AutoML models to the edge.

- **Looker** is Google Cloud's business integration tool that drives insights from data with effective visualization technologies.

- **AppSheet** is a suite of tools that allows non-developers to build applications and automate processes without coding.

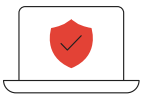
- **Cloud IoT Core** is a scalable solution that connects and manages IoT devices, so downstream solutions are controlled and fully secured within Google Cloud.

- **Cloud Data Fusion** is Google Cloud's low code data integration service that manages extract, transform, and load (ETL) pipelines to increase productivity and speed up data access.

- **Anthos** allows users to easily move legacy applications to the cloud while deploying new applications with the latest organizational policies and security requirements.

Digital manufacturing use cases

To create a digital factory, manufacturers are applying new cloud technologies to address their business challenges with a variety of use cases.

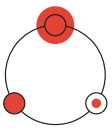


Reliable operations

- Production line visibility
- Real time asset health monitoring
- Prescriptive asset maintenance
- Real time operations performance visibility
- Predictive asset maintenance
- Dynamic adaptive scheduling

Inventory tracking and management

- Material track and trace
- Returnable containers and toolkit tracking
- Intelligent inbound shipment acceptance
- Inventory level optimization



Supply chain optimization

- End-to-end supply chain visibility
- Automated production planning and scheduling
- Blockchain-enabled trusted transactions

Intelligent production control

- Yield optimization
- Digital machine setup
- Digital twin
- Intelligent process control
- Sense and respond closed-loop production

Digital quality

- Digital quality inspection
- Inline quality monitoring
- Visual quality inspection
- Quality issue root-cause analysis
- Digital thread for quality

Workforce productivity and safety

- Digital work instructions
- Smart alerts and notifications
- Over-the-shoulder coaching
- Intelligent shift turnover and management
- Knowledge capture and management
- Digital training and skills management
- Intelligent work order management

Energy management

- Utilities consumption monitoring dashboards
- Energy usage analytics
- Smart building management and optimization

Manufacturing companies invest in new technologies for use cases that are impactful and can deliver business value. Google Cloud computing and hosting has enabled greater insight into business challenges, allowing more digital manufacturing use cases to be identified. Use cases provide even greater impact when process data is shared across the entire value chain from customers to vendors. Google Cloud technology enables goals and anticipated value for each use case to be achieved faster. Three use cases that are driving significant value for manufacturing companies using best-of-breed cloud capabilities are:

Use case 01: Yield optimization
Use case 02: Predictive asset maintenance
Use case 03: Real-time quality inspection

Use case 01: Yield optimization

Yield optimization allows manufacturers to increase the overall output of the conversion process.

In manufacturing processes, yield loss is one of the biggest costs – and often top of mind for companies as they try to utilize digital technologies to impact their bottom line. Yield optimization starts with a comprehensive view of the material inputs, the conversion process, machine performance, and worker capabilities. Manufacturers can capture process characteristics, monitor changes in the production output, and quantify the waste generated during the process. By organizing and analyzing these inputs and outputs, it is possible to understand the sources of yield loss and determine the root cause of these losses.

With these insights, manufacturers can optimize the process to maximize overall efficiency. Using sensors and quality measurements, processes can be tracked for quality, yield loss and waste at every step of the production process.

Up to 30%

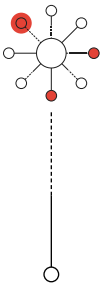
increase in production throughput by optimizing processing

Up to 10%

reduction in raw ingredient costs by reducing overconsumption

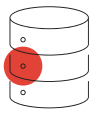
Yield optimization unlocks tremendous value for manufacturers by increasing throughput and reducing overconsumption. Unlocking yield data also leads to better visibility in supplier quality and can help improve supplier quality service level agreement (SLA) adherence.[4,5,6,7]

Google Cloud enables yield optimization with industry-leading analytics capabilities



Capture real time data

- **Cloud Pub/Sub** performs real-time data ingestion.
- **Apigee** consolidates data by connecting previously disparate systems.
- **Cloud IoT Core** collects data from multiple edge devices.
- **Cloud Dataflow** processes and streams analytics on collected data.



Process and store data

- **Firestore** collects data insights in real time.
- **Cloud Storage** securely stores unstructured data.
- **Cloud Data Fusion** or **Dataflow** quickly integrate collected data into **BigQuery** and provide insights.
- **BigQuery** data warehousing helps to gain insights quickly.

Perform data analytics

- **AI Platform** is based on **TensorFlow Enterprise** and enables custom ML and deep learning (DL) workflows.
- **AutoML Tables** accelerate ML on structured data.
- **AutoML Vision** provides insights by comparing images.

Drive improvements

- **AI and ML** technology help identify trends in yield data and process improvement opportunities.
- **BigQuery ML** can build ML solutions at scale and provide yield optimization recommendations.
- **Looker** can help users customize data visualizations and query data based on new inputs and added perspectives.
- **AppSheet** helps develop unique apps to associate data from machine tags, sensors, and other inputs, to detect sources of loss.

Use case 02: Predictive asset maintenance

Predictive asset maintenance allows operators and plant management to anticipate machine downtime or tool failures, and schedule maintenance proactively. Performing maintenance only when required, as opposed to traditional time-based maintenance practices, limits machine downtime and encourages effective use of labor.

Implementing predictive asset maintenance allows supervisors to schedule maintenance as needed, based on the true condition of machines, and to effectively coordinate production around planned machine downtime. Effective planning of maintenance reduces machine downtime and limits cycle starts and stops. By limiting these factors, manufacturers see increases in throughput and asset utilization, and reduction in material waste and scrap.

Data from manufacturing execution systems (MES), ERP systems, maintenance systems, operational historians, and sensors are used to train ML models and drive analytics. Implementation of predictive asset maintenance allows for real-time analytics and alerting capabilities to inform plant workers of machine activity.

10-20%

increase in overall equipment effectiveness

5-10%

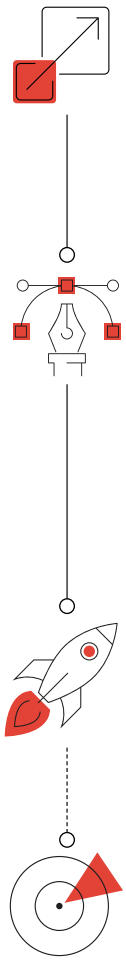
reduction in maintenance costs (labor, spare parts)

Up to 20%

reduced waste due to start up and stopping

Predictive asset maintenance allows manufacturers to avoid unplanned downtime and decrease the amount of time spent on maintenance – both reducing maintenance costs and increasing uptime, which allows for less waste and higher throughputs.[8,9]

Google Cloud enables predictive maintenance with pre-built algorithms and industry-leading analytics capabilities



Collect data

- **Cloud Pub/Sub** performs real-time data ingestion.
- **Apigee** consolidates data by connecting previously disparate systems.
- **Cloud IoT Core** collects data from multiple edge devices.
- **Cloud Dataflow** processes and streams analytics on collected data.

Build out and train models

- **Cloud Bigtable** can store and manage massive amounts of maintenance data in a NoSQL database with low latency.
- **AI Platform**, based on **TensorFlow Enterprise**, enables custom ML/DL workflows for advanced use cases.
- **Cloud AutoML** solution and custom AI solutions enable complex ML models.

Deploy at edge

- **AutoML Tables** accelerate ML on structured data and at the edge.
- **Google Cloud's Edge TPU** runs ML models at the edge in real time to anticipate downtime before it occurs.

Drive business insights

- Obtaining **timely business data** can drive asset maintenance scheduling.
- **BigQuery ML** can build ML solutions at scale and provide predictive maintenance-based recommendations.
- **Looker** can help users customize data visualizations and query data based on new inputs and added perspectives.
- **AppSheet** allows users to create specific, use-case focused applications that address their individual business needs.
- **Apigee** API ensures information is updated to where originally obtained using an established system of connections.
- The combination of **BigQuery ML, Looker, AppSheet, and Apigee** delivers a powerful value-generating framework.

Use case 03: Real-time quality inspection

Real-time quality inspection can monitor quality issues and alert operators when a problem arises. Quality is a big area of focus for manufacturers, and real-time quality monitoring can help in understanding the root cause of an issue. Root cause analysis aids in pre-empting any subsequent quality issues. With faster recognition of quality issues, rework times are limited, and scrap material levels are reduced.

Edge devices, including sensors and cameras, are implemented to run automated inspections and collect product quality data. This data can be leveraged for trending of quality issues and performing quality assurance process optimization. Over time, the data can be used to build algorithms, so that real-time root cause analysis is performed, and automatic action can be taken to resolve the issues proactively.

20-30%

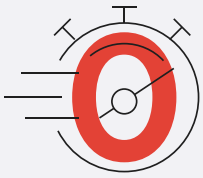
reduction in rework and scrap material waste

14-18%

increase in first pass yield

14-24%

improved overall customer satisfaction

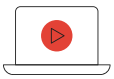


Real-time quality inspection has a significant impact on reducing quality events at the plant and in overall quality delivered to customers. Increased customer confidence in quality has a measurable effect on customer satisfaction.[10,11]

Google Cloud enhances real-time quality inspection with powerful ML for vision algorithms

Capture real-time data

- **Cloud Pub/Sub** performs real-time data ingestion.
- **Apigee** consolidates data by connecting previously disparate systems.
- **Cloud IoT Core** collects data from multiple edge devices.
- **Cloud Dataflow** processes and streams analytics on collected data.

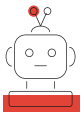


Train models

- **AI Platform** is based on **TensorFlow Enterprise** and enables custom ML and DL workflows.
- **Cloud AutoML** and custom AI solutions enable complex ML models that can be trained with as few as 30 images.

Run models at edge

- Models built using **AI Platform**, **AutoML Vision** and **AutoML Video** allow users to gain insights from images and videos and compare them to appropriate quality measures.
- **Edge TPU** and **Anthos** run ML models at the edge to instantly identify quality issues and prevent recalls.



Data feedback

- **Looker** helps operators and quality leaders target issues in operations using specific analysis.
- **AppSheet** enables development of purpose-built apps that target specific business problems within their operations.
- **Apigee** updates impacted systems in real time and is easy to deploy for inspection-specific APIs for multi-cloud environments.

Why SAP on Google Cloud is the right choice for manufacturers

Cloud capability is important for manufacturers in lowering operational costs, accomplishing sustainability goals, and enabling new digital use cases. Google Cloud can help deliver all of those objectives.

Hosting SAP on Google Cloud can reduce IT infrastructure costs by over 30%, while also improving the efficiency of IT teams by 56%.[12]

↑56%

Google Cloud's cost-effective infrastructure and reliable performance means that Google's average cloud operating cost to run SAP workloads is 46% less than competing cloud solutions.[12]

↓46%

Google Cloud today runs on 100% sustainable energy and aims to run every cloud workload on carbon-free energy by 2030.

100%

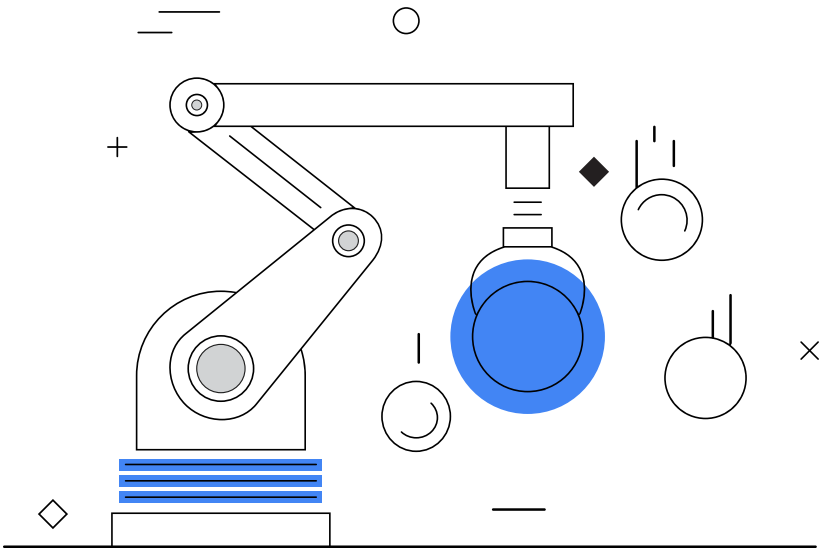
Google Cloud is ideally suited for cloud hosting of SAP and other manufacturing applications due to its expansive network, native SAP integrations, and ease of data transfer and migration. Google Cloud's global fiber is a world-scale private network and ensures low-latency and reliable connections between manufacturing facilities and the cloud. Near zero planned downtime of SAP workloads with Google Cloud Live Migration keeps virtual machines running through planned hypervisor or hardware updates.

Digital manufacturers are seeing bottom and top-line impacts by implementing new digital use cases. Google Cloud has developed tools and templates to help accelerate this adoption. Google Cloud has pre-built ML algorithms to help tackle visual analytics and predictive use cases.

Google Cloud has a comprehensive suite of applications for data integration, storage, visualization, query, analytics (including AI and ML), and security. These solutions also include edge components and connections alongside the core cloud applications, which are very important for manufacturing operations. The key differentiators of these applications are outlined on page 17.

Google puts cloud and cloud security at the center of its strategy. According to The Forrester Wave™, capabilities from Google Cloud Platform, G Suite, Cloud Security Command Center, G Suite Security Center, BeyondCorp, and more are a part of Google's overall portfolio.[13]

As showcased in this document, Google Cloud has a strong ability to deliver predictive asset maintenance, yield optimization, and real-time quality inspection use cases for manufacturing companies.



To learn more about Google Cloud offerings for manufacturers, please visit cloud.google.com/solutions/manufacturing.

Discover more about SAP on Google Cloud at cloud.google.com/solutions/sap.

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