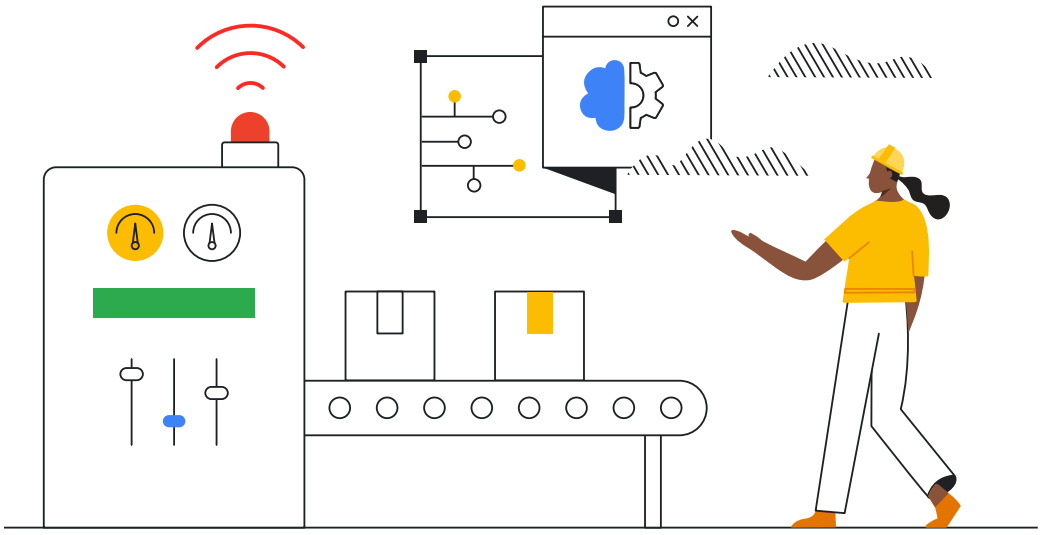
Google Cloud

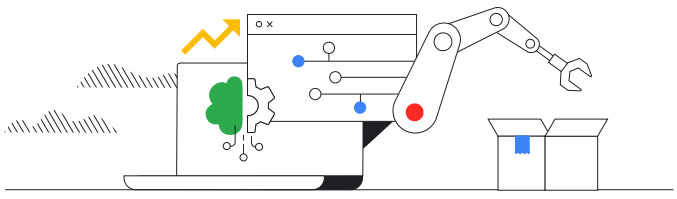
Data and AI:
How the Cloud is helping manufacturers transform at scale



Executive summary

What is helping manufacturers operate more efficiently and make more informed business decisions? Modernizing factory floor operations, and making the gathering and analysis of operational and enterprise data, easier. However, the transformation of data at scale can only happen when the workforce is empowered. Closing the talent gap is important for making new technology work in large and traditional factory setups.

This paper explores some of the ways cloud-based technology is fueling digital transformation across the manufacturing sector, by helping manufacturers modernize operations, reduce costs, and stay competitive—without replacing their existing engineering teams.



1. 2007-2019 total return to shareholder, Watermark Consulting, 2021 Customer Experience ROI Study, October 18, 2021.
2. McKinsey Global Institute, Visualizing the uses and potential impact of AI and other analytics, April 7, 2018.

Data and AI: How the Cloud is helping manufacturers transform at scale

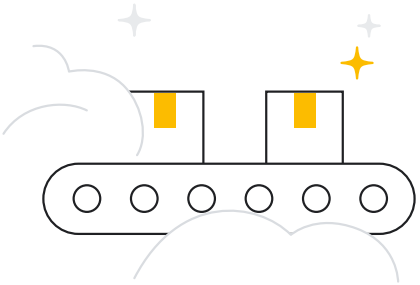
Accessible data and easy-to-use AI are helping organizations overcome scalability hurdles and drive digital transformation.

Like many other industries, the manufacturing industry increased its investment in its data-driven transformation journey in light of the pandemic. For forward-thinking organizations, this has been an opportunity for a "factory reset"—a chance for manufacturers to pause, recover, become more resilient, and learn how to become more resourceful. To do that, they're leaning on data analytics and AI-driven insights, along with valuable human experiences, to streamline and modernize operations, lower costs, and drive better business outcomes.

The highest adoption rate of innovative manufacturing technologies has been in the automotive, aerospace, and food and beverage industries, with some manufacturers even beginning to list their AI initiatives on patents. In fact, according to research from Google, 66% of manufacturers that use AI in their day-to-day operations report their reliance on AI is increasing.[3]

Manufacturing makes up about 11% of the U.S. Gross Domestic Product (GDP) and employs about 9% of the private sector workforce.[1]

According to Macrotrends, global manufacturing accounted for 16% of the global GDP in 2020.[2]



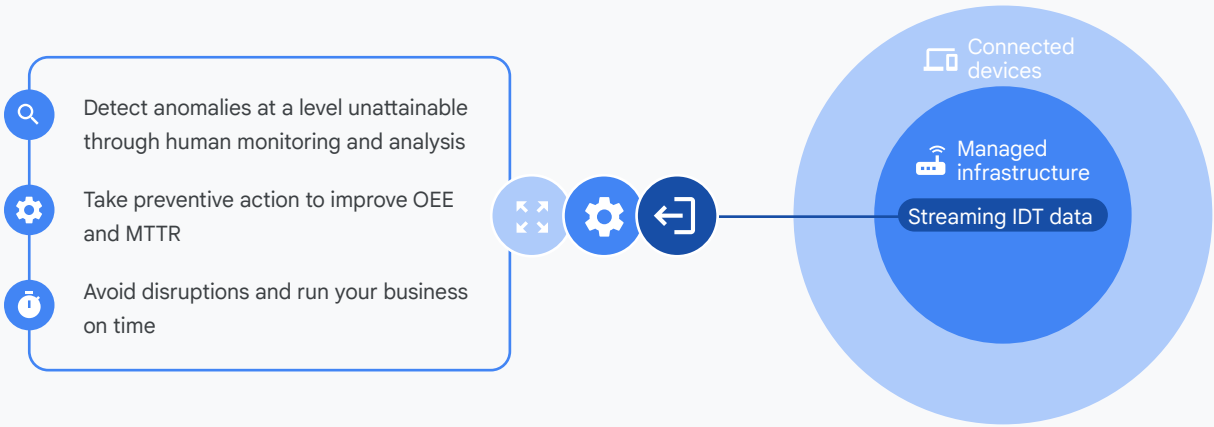
1. Federal Reserve Bank of St. Louis https://fred.stlouisfed.org/series/VAPGDPMA
2. UN Dept of Economic and Social Affairs. https://unstats.un.org/sdgs/report/2021/goal-09/
3. https://cloud.google.com/blog/products/ai-machine-learning/research-on-ai-trends-in-manufacturing

Cloud technology is helping to transform the value chain, from beginning to end

AI is behind the shift to intelligent manufacturing. How? By being leveraged in the field and in factories for product design, real-time performance monitoring, predictive maintenance, quality assurance, worker safety improvement, cost reduction, and hitting sustainability goals.

Operational improvement

Big data and machine learning unlock operational improvements to create competitive advantage



Product design and development

Semiconductor manufacturers are training algorithms to design semiconductor chips faster, with Google using reinforcement learning to decide where components should be laid out on a chip. This approach is reducing chip design times from weeks to hours.

Dutch manufacturer, ASML, sped up both engineering and time to market by adding Google Cloud to its on-premises machine learning (ML) solutions. This meant:

- Product release cycles were shortened from monthly to biweekly
- Encryption, build, and test times were reduced from hours to just 10 minutes

Production operations

AI can help improve production operations in many areas like quality, asset utilization, and predicting maintenance cycles. The cost of quality can be significant, largely because of defect correction. Reducing rework, repair, and scrap has a major impact on manufacturing operations, and visual inspection solutions help achieve this.

Electronics manufacturing use cases center around material and cosmetic defect detection and assembly inspection. In the automotive space, surface quality control is important throughout the manufacturing process. Presence checks identify missing parts, while detecting welding defects and analyzing cable tree paths are also vital.

Doosan Heavy Industry & Construction tapped into the power of Google Cloud's Compute Engine to run its innovative defect discovery process with a non-destructive testing model that's flexible, scalable and continuously learning. By doing so, they produced a:

98%

accuracy rate in finding areas requiring further analysis

96%–98%

accuracy rate in detecting defective welds

Business transformation

Transform your business with machine learning

Active asset monitoring

Facility-level employees dedicated to monitoring machine health and anticipating downtimes

Automated anomaly detection

Staff freed up to focus on value-added work, while machine learning watches out for anomalous behavior indicating downtime

Alerting on symptoms

Alarms surrounding symptoms of machine failure without a line of sight into underlying causes

Uncover root cause

Machine learning works to detect downtime indicators too subtle for human detection

Facility level perspective

Machine health monitored facility-by-facility, with KPIs sent to corporate HQ on a daily/weekly basis

Global view on machine health

Leverage the scale of the cloud and generate awareness on machine health at a global level

Sustainability

This sits at the top of the list for many manufacturers. On the shop floor, it means reducing energy consumption. In data centers, Google Cloud has achieved a 30% energy reduction by applying an AI method called reinforcement learning. This can be applied in the paint shop of an automotive manufacturer, for example, which consumes a significant amount of electrical energy. Taking into account different process parameters, adaptive control algorithms can significantly help to reduce energy consumption.

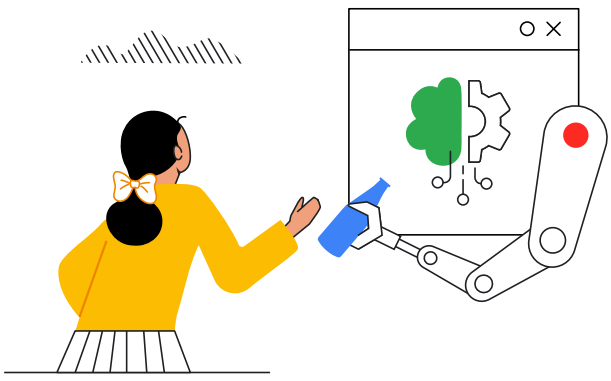
Successful large-scale adoption depends on people and data

The majority of transformation efforts are centered around Industry 4.0— the fourth Industrial Revolution—where adopting new technologies helps manufacturers optimize and manage factory operations, and expand them throughout the supply chain. By making decisions led by AI and real-time insights, manufacturers can increase efficiency and drive revenue.

Manufacturers typically run a proof-of-concept (POC) and pilot implementation to make the case for Industry 4.0 technologies and gain approval for wider adoption. This ongoing experimentation hasn't yet led to widespread business benefits. Manufacturers remain in "pilot purgatory," with Gartner reporting that only 21% of companies in the industry have active AI initiatives in production.[5]

Tighter integration of suppliers and supply chain transparency is estimated to boost forecasting accuracy by **33%**.

Sharing of real-time production data across the supply chain is projected to reduce inventory-holding costs by 20% and lead times by up to **15 weeks**.[4]



4. McKinsey & Company. https://www.mckinsey.com/business-functions/operations/our-insights/operations-blog/imperatives-for-chinas-factories-of-the-future
5. Gartner. https://www.gartner.com/en/newsroom/press-releases/2020-10-01-gartner-survey-revels-66-percent-of-orgnizations-increased-or-did-not-change-ai-investments-since-the-onset-of-covid-19

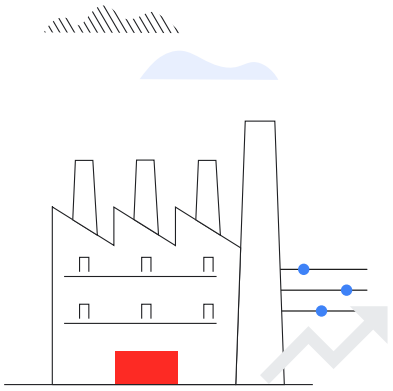
The primary challenges manufacturers face when looking to adopt AI at scale are:

Closing the talent gap

AI solutions are designed to be used by data scientists or other highly skilled experts, making it difficult for manufacturing and production engineers to use and maintain. Even in cases where manufacturers have data scientists on staff, they see lengthy implementation timelines.

Providing data access

While data from disparate systems may be manually collected and prepared for applying AI and analytics during a pilot, the appropriate data infrastructure must support those efforts at production scale. Siloed and disparate data sets need to be combined and accessible in real-time by the teams responsible for developing and deploying the solutions.

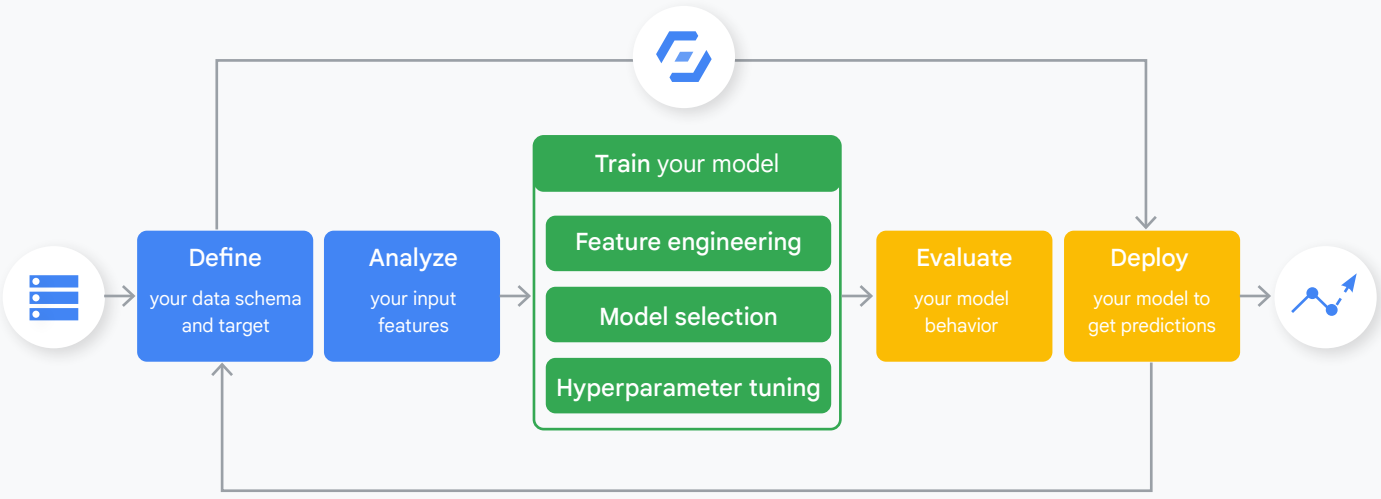


Improve data management, get better AI insights

AI is the backbone of intelligent manufacturing, and high-quality, accurate data empowers AI. Every step of the AI data lifecycle—from gathering and extracting the data to parsing and sorting it, and then analyzing it to gain valuable insights—involves strategic decisions and positioning. This can be particularly challenging in long-standing manufacturing environments.

Managing the ML lifecycle

Guide users through the end-to-end ML lifecycle



There are many steps to driving intelligent manufacturing: organizing the data generated on the factory floor and throughout an organization, making it universally accessible and useful, and optimizing it with AI solutions. To do this, manufacturers must address the three levels of increasing data interoperability:

Technical interoperability

This level enables different systems within the manufacturing automation stack, such as programmable logic controllers, to store data in the cloud using any number of the individual systems' data models.

Syntactic interoperability

This level provides a predefined, declarative structure for a data catalog that stores relevant metadata to help make sense of the insights.

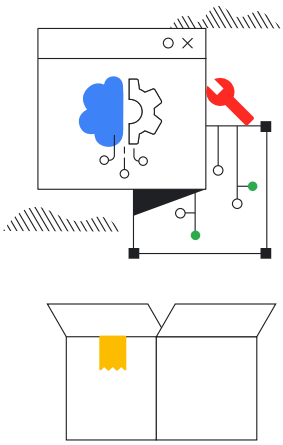
Semantic interoperability

A more advanced level, semantic interoperability provides a "language" to describe the factory with detailed definitions for the meaning of each data field and is referred to as "digital twin modeling."

With each successive level, interoperability increases. The higher the interoperability, the easier it is for manufacturers, their partners, and cloud providers to build and deploy scalable, high-value solutions that tap into advanced AI/ML capabilities. The cloud is critical to fueling AI with quality data.

> To leverage AI and machine learning, data is very important. Extracting the data, and ensuring its quality and contextualization, remains a challenge in many manufacturing environments."

Dominik Wee,
Managing Director, Global Manufacturing, Industrial and Transportation,
Google Cloud



Digital twin modeling can help manufacturers investigate the cause of assembly line incidents. For instance, in the case of a recall, manufacturers are able to trace back through the manufacturing process and understand where the faulty parts were made.

Realizing the full potential of AI-driven manufacturing solutions depends not only on capturing data from all factory assets, but also ensuring its quality.

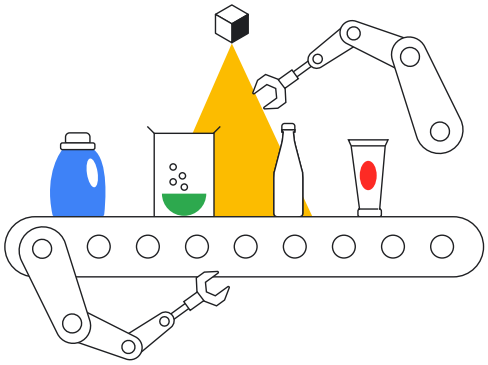
There are several critical factors involved in dealing with data, including:

- Data standardization (labeling, parsing, and normalizing data)
- Data contextualization
- Performing analytics at scale

Manufacturers need help parsing, normalizing, and contextualizing their data to make it universally accessible and useful, and to ensure it's the best possible data to drive their AI algorithms.

> When you elevate your machine-level data into the cloud, then you can start merging machine-level data with additional data sets–for example, product quality data enabling deeper insight into factory operations and product quality. The end game is a complete digital twin representation of your overall factory machines and product quality indicators."

Charlie Sheridan,
Technology Director, Global Manufacturing, Industrial and Transportation, Google Cloud



Remove technological barriers, empower engineers

Staffing, training, and easy-to-use technology are front and center in helping to drive intelligent manufacturing, but the limited availability of specialized engineers is making the staffing challenge more evident.

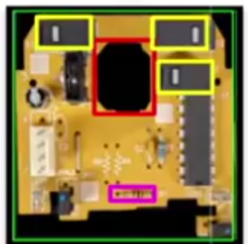
The pandemic amplified supply chain disruptions, shifts in product demand, and staffing shortages; increasing the importance to bridge the gap. This has made optimizing product development and operations and continuing to digitize the customer journey vital parts of this initiative. AI solutions, like Google Cloud Visual Inspection AI, are created to help engineers every step of the way.

> In some cases, you're dealing with really old infrastructure and people who understand the machine side, but they don't understand the IT side."
>
> **Charlie Sheridan,**
> Technology Director, Global Manufacturing, Industrial and Transportation, Google Cloud

An AI solution lifecycle that's low touch

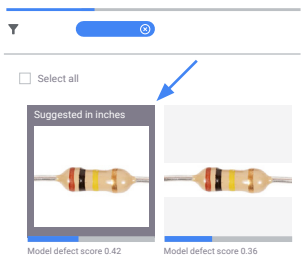
Automatic preprocessing

Powerful preprocessing of images, auto **alignment, cropping,** and **finding similar components** in complex products



Active learning

Works hand-in-hand with Domain expert at shop-floor and **suggests** suspicious images that **should be labelled to improve model**



Unsupervised learning

Best-in-class ML algorithms based on latest ML research

Google Brain

DeepMind

Device connectivity issues and data barriers can be prevented by ubiquitous connectivity solutions, particularly for operational technology (OT). Manufacturers recognize that some of their workloads can't move to the public cloud entirely or right away. Why? Because:

- Of industry or region-specific compliance and data sovereignty needs
- Of low latency or local data-processing requirements
- They need to run close to other services

But these workloads can still tap into the power of the cloud.

A recent report found that the "edge cloud construct is increasingly viewed as a key enabler for the '4th Industrial Revolution,' which will increase zero marginal cost manufacturing to deliver unprecedented communication-driven opportunities with massive economies of scale."[6]

With solutions such as Google Distributed Cloud, manufacturers can extend their infrastructure and services to the edge and to data centers, helping them migrate and modernize applications and process data locally. Which Google Cloud services can help? Databases, ML, data analytics, container management services, and third-party services.

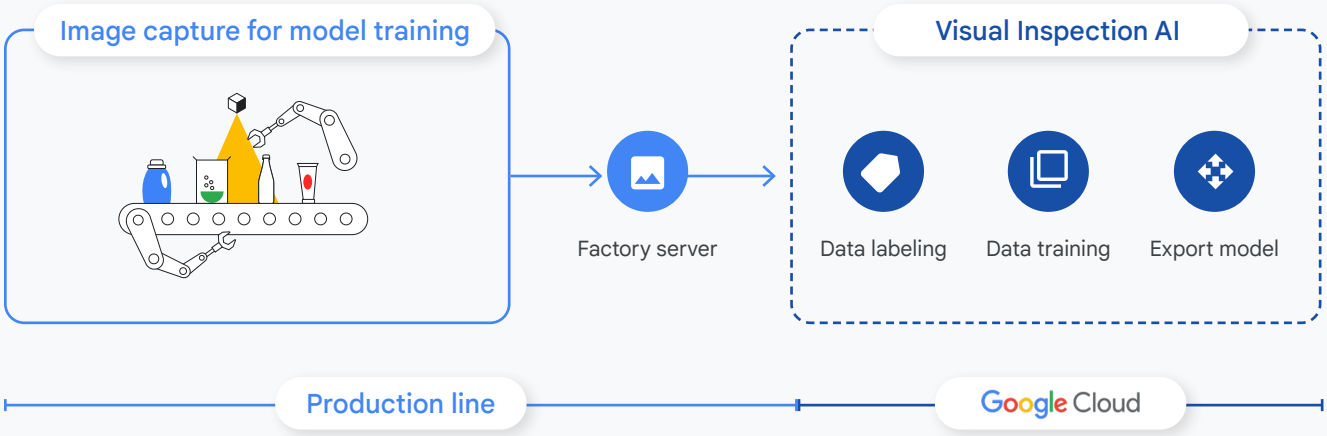
According to the Linux Foundation's 2021 State of the Edge[7] report, the foundation expects cumulative capital expenditures of as much as $800 billion between 2019 and 2028 on IT server equipment and edge computing facilities to support cloud operations.

6. Linux Foundation's 2021 State of the Edge Report. https://stateoftheedge.com/reports/state-of-the-edge-report-2021/
7. Ibid

Google Cloud: the foundation for AI

To fully support AI algorithms and solutions, manufacturers need state-of-the-art data platforms. For what? To perform data contextualization, processing, and hosting. This is where cloud platforms functioning as a centralized, normalized data repository can provide support.

Intelligent manufacturing setting with Visual Inspection AI



To implement this type of data repository, manufacturing companies must adopt a four-step operational process:

1. Assess (define and evaluate resources)
2. Plan (develop a strategic plan)
3. Migrate (adopt a phased approach)
4. Optimize (monitor and adjust as required)

As manufacturers start to successfully gather, parse, and mine their data to enable AI-based analytical solutions, they'll need a cloud partner. One that provides a platform that can store, manage, and access their data.

By partnering with Google Cloud, many leading manufacturers have been able to:

- Handle huge amounts of unstructured data
- Apply advanced analytics capabilities using AI and ML
- Optimize factory floor operations and product development
- Apply real time insights to make data-driven decisions
- Use AI/ML as a strategic technology
- Embed AI within existing products
- Unlock the business value of true digital transformation

Although efficiency and quality can be extended past factory operations and production, to the entire supply chain, the work starts inside the factory. By focusing on key metrics like availability, uptime, and quality, AI/ML can really help manufacturers transform their operations today, and in the future.

The Road Ahead

The push to intelligent manufacturing will continue to grow. With a 41% compound annual growth rate, the market for AI in manufacturing is expected to reach $18.8 billion by 2027, according to Analytics Insight.[8]

Certain challenges, however, will remain evident. Challenges like removing technological barriers, making AI solutions compatible with existing staffing resources, aligning OT with IT, and parsing and contextualizing data.

But the benefits of Google Cloud for manufacturers will continue to grow. Benefits like more efficient operations, greater competitive advantage, reduced costs, and the significant potential of cloud-based AI to keep the modernization momentum up.

Cloud innovation is the foundation for utilizing the power of AI. It is the key to unlocking Moore's Law for manufacturers, linking it to AI and data transformation. To fully realize the benefits and advantages AI brings to manufacturing and crossing the POC chasm, manufacturers must remain mindful of two things—how to gather and manage the data intended to fuel AI solutions, and the ease of use of those AI technologies.

To learn more about how Google Cloud manufacturing solutions can help your organization move into the future of intelligent manufacturing, visit:

Manufacturing solutions

8. https://www.analyticsinsight.net/ai-in-the-manufacturing-market-is-predicted-to-reach-us18-8-billion-by-2027/

Intelligent manufacturing worksheet

Please complete this self assessment of your organization's progress toward intelligent manufacturing. Answer each question with the option that most closely matches your opinion.

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
We have a clear and accurate picture of the manufacturing data we generate.	☐	☐	☐	☐	☐
We have a streamlined process for effectively moving AI projects from pilot to production.	☐	☐	☐	☐	☐
Lack of skilled AI/ML talent is one of the top reasons why scaling AI remains a challenge.	☐	☐	☐	☐	☐
We have achieved significant levels of AI-enabled process automation to improve efficiency and reduce costs.	☐	☐	☐	☐	☐
We are using cloud-based platforms to store, manage, and analyze our data.	☐	☐	☐	☐	☐
We are successfully transforming into the new AI-enabled world of intelligent manufacturing.	☐	☐	☐	☐	☐