The New AI Imperative in Manufacturing

How the new wave of AI is disrupting manufacturing operations, and how to benefit from it

Capgemini | Microsoft

The AI imperative in manufacturing

As digital technologies, and particularly artificial intelligence (AI) evolve at unprecedented pace, the shift toward AI-driven manufacturing is now a pressing reality. This transition is reshaping how plants are designed, operated, and maintained.

From **Capgemini's** perspective, AI in manufacturing represents a transformative convergence of technologies, involving:

Data Standards | **Generative and Agentic AI** | **Edge capabilities** | **High-speed connectivity** | **Simulation** | **Robotic advancements**

It embodies a profound rethinking of processes, operations, and collaboration. It aims to build factories that are more efficient, worker-centric, sustainable, and flexible to adapt to disruptions. This revolution is reshaping the role of people—assisted by AI agents, empowered with the right insights to deliver innovation at speed—while more repetitive tasks get automated.

Capgemini's unique approach, leveraged by our strategic alliance with **Microsoft,** plays a pivotal role in how we help organizations embrace AI-driven manufacturing at scale. This collaboration combines our deep industry expertise and transformation capabilities with **Microsoft's** cutting-edge technologies to deliver agile, secure, and scalable solutions, tailored to our clients' needs. Together with our clients, we accelerate digital transformation, unlock real-time data intelligence, and build connected, adaptative production environments.

Together with Microsoft, Capgemini helps manufacturers reimagine what is possible, empowering our clients to move faster, operate smarter, and build a more sustainable future. The time to act is now.

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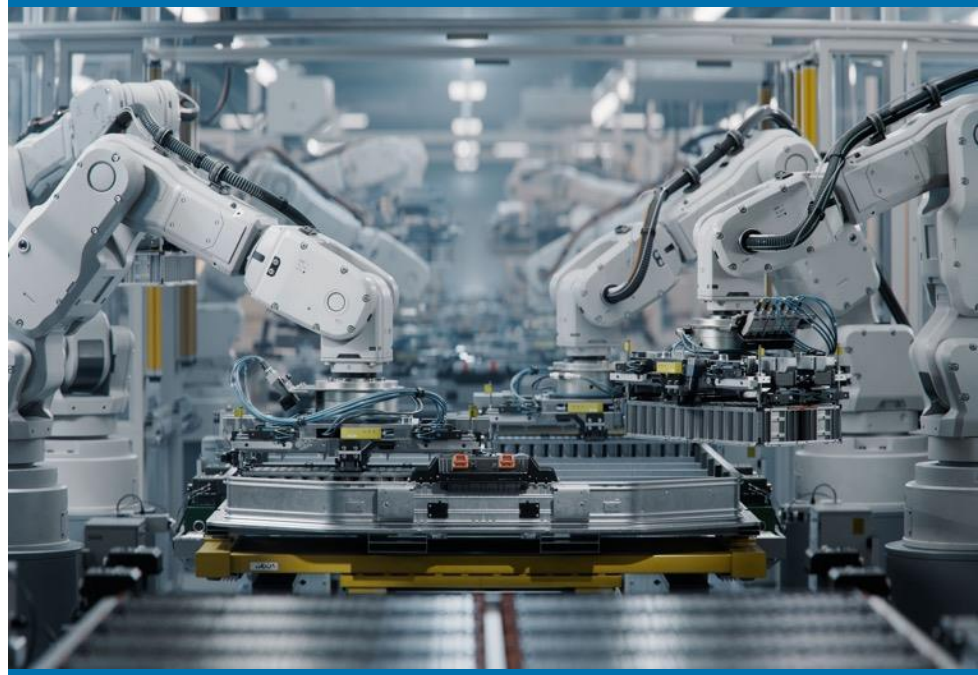


AI-driven manufacturing is unleashing the power of Intelligence, at scale!

Discover how **Capgemini** and **Microsoft** are helping manufacturers adopt the next generation of AI, by combining deep operational expertise, cutting-edge solutions driven by the latest advancements in AI, scalable cloud infrastructure services, and proven transformation frameworks.

Contents

01 The pressure to transform

A challenging global landscape

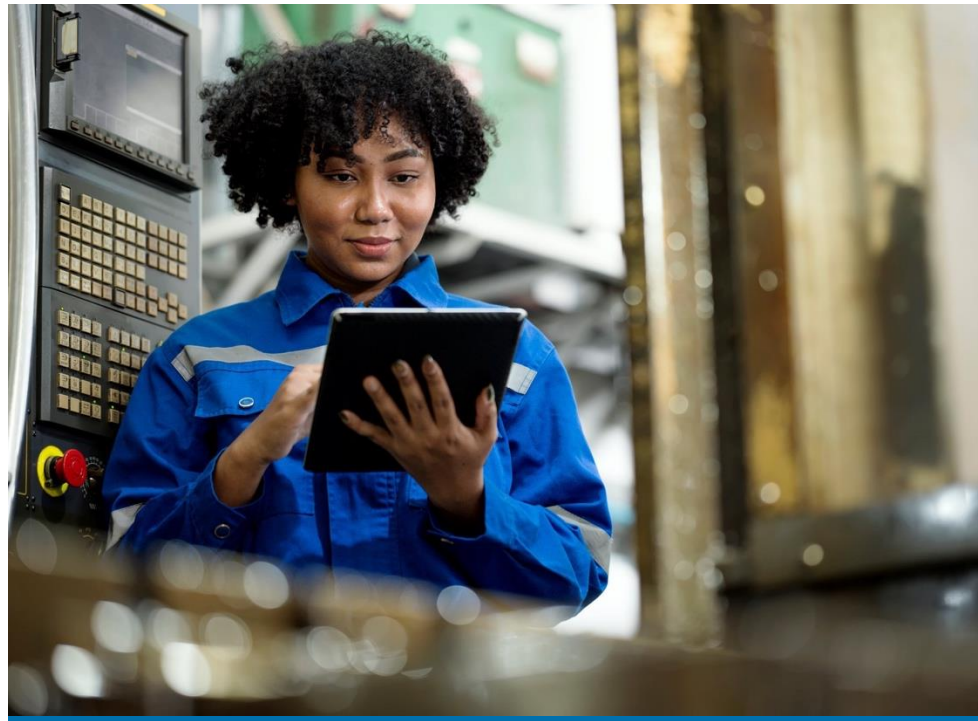
Across the globe, industrial stakeholders are navigating a convergence of powerful trends and disruptive forces, giving rise to an increasingly complex and volatile operating environment.

Geopolitical tensions, fluctuating tariffs, and energy prices are prompting a rethink of supply chains and a move to relocate production closer to home. This shift is fueling a global wave of **reindustrialization**, with over $3.4 trillion* in planned investments and a growing emphasis on reducing dependency and strengthening local manufacturing capabilities. In addition, there are continued issues and political sensitivities around data sovereignty, regulatory compliance, data residency, confidential computing, cybersecurity, and data control.

Additional pressure is also mounting. On one side, ambitious **sustainability targets**—such as achieving net zero emissions by 2050—are driving the need for a fundamental rethinking of both products and production systems, with **circularity** becoming a central design and operational principle. On the other side, **cost pressure** is intensifying, particularly in energy.

Furthermore, in many regions, **industrial know-how** has eroded. As experienced staff retire, it becomes increasingly difficult to attract new talent to manufacturing roles. The attractiveness of the sector is declining, and industries face increasing difficulty in attracting **digitally skilled talent**, with studies showing that 87% of manufacturing organizations foresee significant **labor shortages**.

At the same time, **competition** has intensified across all sectors. Entire industries are being disrupted—either by assertive global powers or agile new entrants. Meanwhile, **consumer expectations** continue to rise, with growing demands for shorter lead times, higher quality, and stronger environmental and ethical commitments.



Manufacturing companies are now being forced to undertake **radical transformations** to ensure both long-term resilience and competitiveness.

The resurgence of Manufacturing (Reindustrialization strategies in Europe and the US – 2025). Capgemini, CRI Report, 2025.

Companies that strategically leverage digital manufacturing and intelligent data systems are achieving significant gains in efficiency, agility, and sustainability.

Manufacturing is at a turning point

To deliver innovation at speed, it is critical to empower people with new ways of working, the right tools, and actionable insights.

By leveraging rapidly evolving digital technologies and AI, manufacturers can now tackle both traditional operating challenges—such as quality, cost control, and lead time management—and the four major objectives facing the industry today:

1. Reducing costs by an additional **20–30%**, without quality degradation
2. Designing more **resilient** supply chains and more **flexible** production systems
3. Being an **attractive employer** for both conventional and digital talent, because **93% of employees** consider their wellbeing to be equally important as their salary
4. Achieving net zero by 2050, and driving **sustainable** transformation of the industry that produces **over 35% of global GHG emissions**

The scale of this change will not be small. Most manufacturing companies have multiple global sites with hundreds of plants. Yet over the past decade, **Industry 4.0** has started to reshape manufacturing by embedding digital technologies, data, and AI into the heart of operations.

What lessons can be learnt from 10 years of Industry 4.0 transformation?

The resurgence of Manufacturing (Reindustrialization strategies in Europe and the US – 2025), Capgemini, CRI Report, 2025.

01 A decade of Industry 4.0: Key lessons learnt

Industry 4.0: The first wave

Key technologies and enablers include:

- **Interoperability standards and protocols** (ISA 95, OPC UA, MQTT, etc.) to facilitate seamless communication, data exchange, and integration among diverse manufacturing systems and devices
- **Connectivity, industrial IoT, and data management** to standardize and facilitate data collection from the shopfloor
- **Manufacturing Execution Systems (MES)** and other execution systems (quality management systems, etc.) to support shopfloor performance, operational transparency, and traceability
- **Data and AI-driven use cases** to leverage machine learning, deep learning and other algorithms to develop use cases such as control tower, manufacturing intelligence, predictive maintenance and quality, or dynamic scheduling

Operational efficiency and an improvement in quality or maintenance costs helped connect machines, harvest data and use AI, leading to notable gains:

OEE	↑	15%	Cycle time	↓	20%
Labor productivity	↑	25%	Product quality	↑	10%

These have been achieved thanks to a seamless integration of business vision, digital organization and operating model, and a sound choice of use technologies and use cases integrated into an architecture approach.

Figures are average values derived both from our client cases and from recent publications : The resurgence of Manufacturing (Reindustrialization strategies in Europe and the US – 2025). Capgemini, CRI Report, 2025. Making brownfield factories Smarter and Greener (A business case for Digital Manufacturing in brownfield factories), Capgemini / Everest Group, 2024. Global Lighthouse Network: The Mindset Shifts Driving Impact and Scale in Digital Transformation. World Economic Forum, 2025.

Implementation: Differing adoption levels

Industry 4.0 digital transformation has optimized operations and delivered significant value. But while some use cases have been broadly adopted, such as using digital solutions to manage work orders and quality controls and report operational KPIs, other use cases are progressing more slowly, such as digital solutions for dynamic scheduling or predictive quality as they require more robust technical and organizational foundations.

Use case adoption in Industry, based on Capgemini benchmark

Low ○○○
●○○
●●○
Strong ●●●

Operations Control Tower

●◐○

Real-time control towers limited to parts of the line, not full line or cross-plant levels

Digital Safety

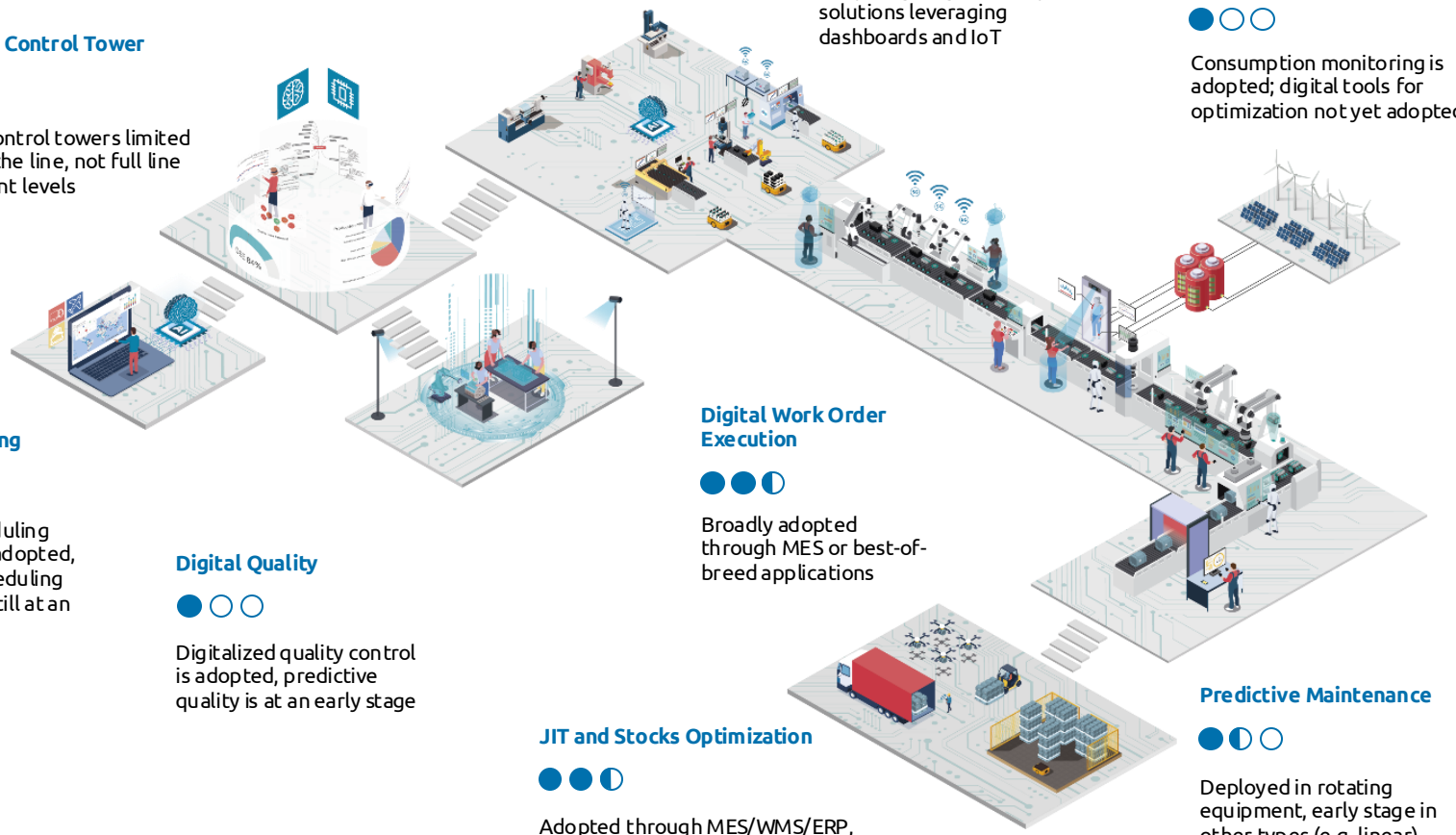
●○○

Early-stage digital safety solutions leveraging dashboards and IoT

Digital-Energy and Waste Tracking

●○○

Consumption monitoring is adopted; digital tools for optimization not yet adopted



Digital Scheduling

●○○

Digitalized scheduling management is adopted, but dynamic scheduling optimization is still at an early stage

Digital Quality

●○○

Digitalized quality control is adopted, predictive quality is at an early stage

Digital Work Order Execution

●●◐

Broadly adopted through MES or best-of-breed applications

JIT and Stocks Optimization

●●◐

Adopted through MES/WMS/ERP, optimization still early-stage

Predictive Maintenance

●◐○

Deployed in rotating equipment, early stage in other types (e.g. linear)

Data foundations remain a core enabler

Few manufacturers have truly scaled their digital transformation. When many have launched promising AI pilots, 25%* are partially advanced, still facing silos and heterogeneity, 45%* are in first implementation phases, and **only 5%*** have reached industrialized, end-to-end digital operations. Research consistently shows that companies in this category continue to invest in their transformation efforts, aiming to further consolidate their competitive edge.

The gap between ambition and execution is especially visible in brownfield factories, where legacy systems heterogeneity, processes diversity, operational interdependencies and risk aversion slow down transformation. Despite growing investments—reaching nearly $110 billion in 2023*—most initiatives remain siloed or exploratory.

According to Capgemini research, a core reason to explain that gap remains the lack of **data centricity and foundations.** Manufacturers struggle with legacy IT/OT not built for connectivity, heterogeneity of data standards across factories, the lack of robust data engineering standards, and more complex data security and compliance requirements. It is more urgent than ever to build and strengthen data foundations and standards, in order to both scale existing use cases, and enable novel AI technologies.

Only 5%

of industrial companies have deployed AI in manufacturing at scale*

80%

of industrial data and AI initiatives require investment / on technical foundations*

*Making brownfield factories smarter and Greener
A business case for Digital Manufacturing in brownfield factories. Capgemini / Everest Group, 2024.
**The Root Causes of Failure for Artificial Intelligence Projects and How They Can Succeed
Avoiding the Anti-Patterns of AI. James Ryseff, Brandon F. De Bruhl, Sydne J. Newberry. RAND, 2024.

03 The tech that unlocks intelligence

Manufacturers seek to identify the key applications that will bring the best return on investment and competitive advantage to their operations.

What is the next wave of AI in manufacturing about?

New technologies are defining a new paradigm in manufacturing. Factories have to be "software-defined" to improve agility, customization, and upgradability. They must also be "data-powered" to enhance decision making, improve operational efficiency, and augment operators.

But the deployment of additional intelligence—combining **Generative AI, Agentic AI, Edge AI, Physical AI, and advanced robotics**—is unlocking even greater levels of performance.

Key questions are:

- What will my future plant look like?
- What are the most valuable use cases and technologies "beyond the hype"?
- What's new in AI value propositions that was not possible, technically or economically, five years ago?
- What is the difference between Generative AI and Agentic AI capabilities compared to traditional IT/OT, IIoT and classical AI transformation?
- How do you design a simple roadmap addressing technical, data and people challenges, and how will it impact my people?

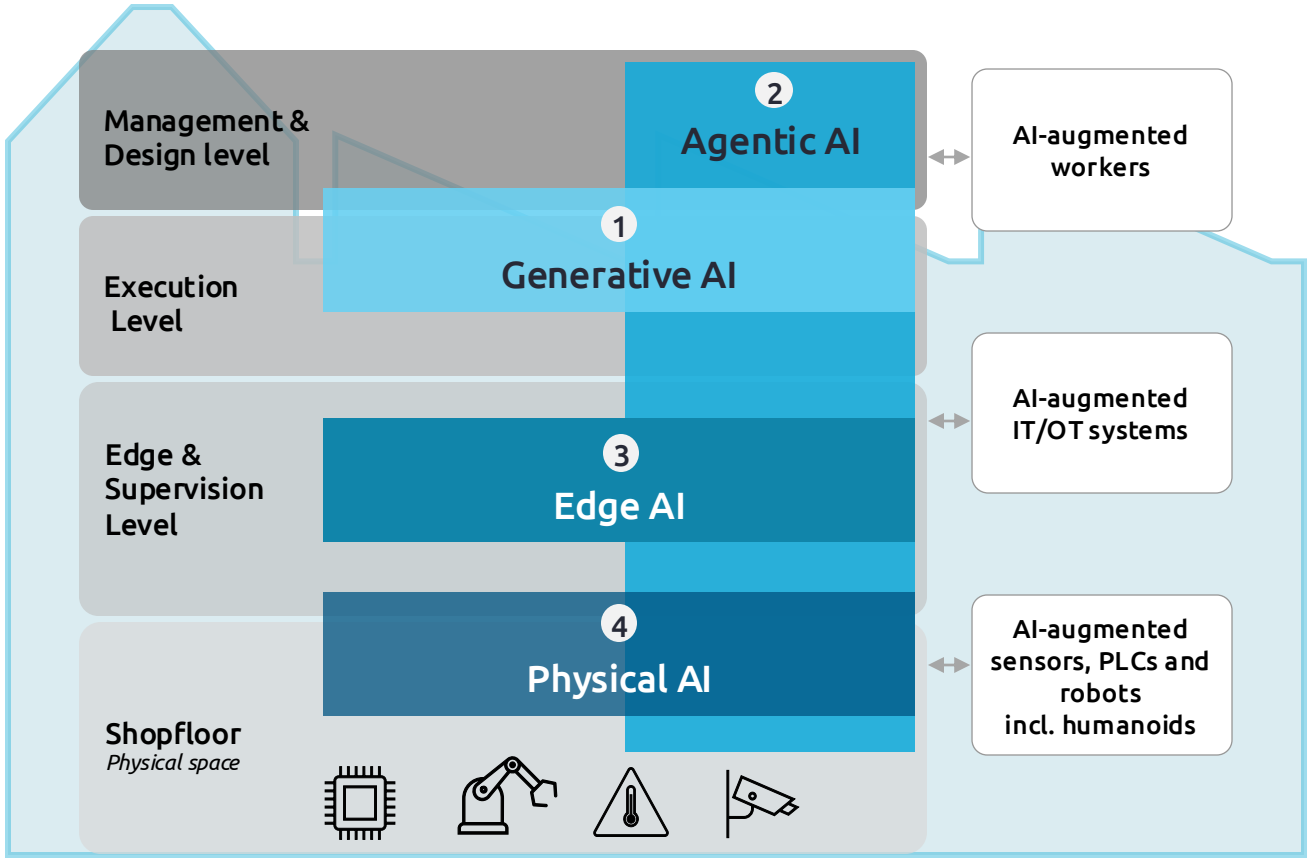
As demonstrated by front-runners, new AI capabilities promise significant benefits, including:

- **Workers' knowledge and efficiency**: Addressing the workers' scarcity and turnover by capitalizing the factory knowledge in virtual assistant agents and enabling quicker root cause analysis and problem solving
- **Productivity**: Shifting from reactive to predictive and prescriptive operations, with agents capable of providing real-time insights, but also acting on machine set up and alerting workers. The combination of new types of AI is leading to the possibility of progressively transforming and then automating certain processes
- **Flexibility**: Reaching higher manufacturing flexibility by adapting production configuration and scheduling in real time according to customer demand and events on the shopfloor
- **Sustainability**: Leveraging AI, combined with advanced connectivity to better identify energy, material and water waste hot spots and prioritize actions for optimization

Let us now offer a clear and concise definition of these strong waves of AI in manufacturing.

Transforming the factory: From operations management to the shopfloor

In addition to the "classical" AI-driven systems already in use, four AI transformations are reshaping manufacturing, by bringing a higher level of automation at every level (robotic programming, process automation, etc.) and revolutionizing the role of workers and managers on the shopfloor.



1 Generative AI

Focuses on creating new content, reasoning or problem solving based on patterns learnt from existing data. Its manufacturing applications include the creation of new process designs, process and machine setting optimization, robots programming, defects root cause analysis or production reports automation.

2 Agentic AI

Refers to AI systems that can near-autonomously learn, analyze, make decisions and eventually take actions, without direct human intervention. Its manufacturing applications include predicting maintenance needs and adjusting plans, rescheduling production depending on conditions, and sending anomaly reports to supervisors.

3 Edge AI

Refers to AI systems deployed at the line edge network—such as on local servers or sensors—to bring computation to where the data is, and process data and algorithms even in high-frequency environments. Its applications enable acting in real time, such as adjusting machine settings, detecting and removing anomalies in production, or responding to safety threats.

4 Physical AI

Is about AI systems embedded in physical systems (PLC/automates, robots, etc.) that can use sensors to read their environment (cameras, radar, operators, logs, production metrics, etc.) and interact with dynamic and complex movements. This enables enhanced automation capabilities, such as manipulating complex shapes, handling unstructured environments, or addressing unforeseen events.

1 – Generative AI: What is it?

Generative AI refers to creating intelligent systems capable of performing **content development, reasoning, and problem solving.** This unleashes a new productivity frontier, estimated to add the equivalent of $2.6 trillion to $4.4 trillion annually across all business functions use cases.*

Its manufacturing applications span across multiple capabilities, including:

Content development:

- Automated reports generation (e.g., life sciences reports with heavy compliance requirements)
- Work instructions and training generation
- Manufacturing process or tooling design
- Machine programming

Reasoning for workers' assistance:

- Assistance in machine set-up and workflows
- Defects recognition, root cause analysis and correction assistance

Problem solving:

- Classification, summary, search and analysis of quality and maintenance incidents
- Process analysis and identification of inefficiencies
- Scenarios analysis and comparison (e.g. production, workflow or scheduling scenarios)

Natural language interfaces are shaping an entirely new relationship between humans, AI, and machines.

GenAI for Intelligent Industry, a new revolution for R&D and operations. Capgemini 2024.
*The economic potential of generative AI The next productivity frontier. McKinsey & Company 2023.

1 – Generative AI: Why does it matter compared to today's Industry 4.0?

While traditional digital solutions (e.g. digital work instructions, MES, analytics reports, etc.) require extensive levels of coding, configuration and information structuring, Generative AI can **extract, synthesize, and classify massive amounts of information in a comprehensive way**, thanks to unstructured information processing (tech documentation, historian, sensors, camera images, etc.) including natural language processing.

This leads to significant benefits, including:

- **Enhanced human-machine-AI interaction**, facilitated through natural language interaction
- **Optimized efficiency** with reduced, non-added-value activities (reports generation, workflows, etc.)
- **Data-driven decision-making** with workers able to dialogue with multiple systems to search for insights and assistance in real time
- **Enhanced predictions** of OEE losses (breakdowns, product defects, plannings, etc.) as Generative AI can read production history, compare with real-time conditions and raise defects predictions and prescript actions
- **Accelerated process design** prototyping and automation, thanks to natural-language-based design
- **Improved sustainability** with combined optimization scenarios for productivity, energy and waste, e.g. requesting best time to produce with regards to equipment consumption, energy systems, and weather forecast

1 – Generative AI: Field stories in manufacturing

Aluminum manufacturer

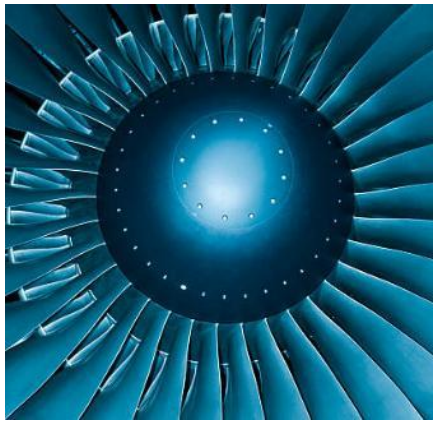
SafetyGPT for the safety team and employees

An aluminum company uses Generative AI-based SafetyGPT to help field workers with the required safety information for specified work area/activity and hazards by processing information from various systems like EHS apps, ERP and intranet. It also enables the safety team to accelerate incidents investigations on information gathering, analysis and reporting.

Pharmaceutical manufacturer

Generative AI-driven line inspection

A global leader in pharmaceuticals uses Generative AI to create synthetic image datasets that help train machine learning models to detect manufacturing defects, allowing them to reduce overall false rejects across various product lines by more than 50%.



Aircraft engines manufacturer

Generative AI-based inspection and defect detection

A leading manufacturer of aircraft engines uses Generative AI in its defect detection process during manufacturing. It enables the inspection process to focus on specific areas of the cooling channels and holes, which has resulted in increased machine utilization by 30%, reduced scrap and accelerated fault detection in near-real time.

Electronics manufacturing

Generative AI powered shopfloor Copilot

For an electronics manufacturing company, a Generative AI-powered assistant is helping understand the error codes of machines to operators and engineers by translating their messages in natural language. It also provides solutions based on machine details and history by searching through its manuals or spare parts lists. This has resulted in a ~25% reactive maintenance time.

Steel producer

Generative AI to improve maintenance efficiency

A steel company deployed a Generative AI-powered tool that allows maintenance teams to ask questions about equipment maintenance, receive summarized answers, and visualize complex diagrams showing the exact steps for repairs. The tool also incorporates a validity score for information accuracy, ensuring confidence in the suggested solutions. The result was a ~20% reduction in maintenance orders.

2 – Agentic AI: What is it?

AI agents are systems that replicate human intelligence by learning from an evolving context and taking appropriate actions. They perceive their physical and digital environment, process information, decide on actions to achieve a goal, and execute those actions. Agentic AI turns manual processes into autonomous workflows. "Multi-agent" systems combine the expertise of specialist agents and orchestrate workflows and maximize output quality.

LLMs and reasoning models are bringing AI agents new capabilities and placing them at the heart of core transformation.

Key applications in manufacturing include:

- **Machine control/"self-healing"**: Automatically readjusting machine parameters according to real-time conditions
- **Prescriptive maintenance and quality**: Analyzing real-time data, and scheduling maintenance plans and additional quality tasks autonomously to avoid failures
- **Production plan adaptation**: Regenerating schedules—up to multiple times per day—including operational instructions, and resource allocation according to actual production events (e.g. machine breakdown, urgent order, missing part, etc.) to optimize cycle time, quality, safety, and sustainability

We project that AI agents could generate up to $450 billion in economic by 2028.*

*Rise of agentic AI: How trust is the key to human-AI collaboration, Capgemini, CRI Report, 2025.

2 – Agentic AI: Why does it matter compared to today's Industry 4.0?

AI agents are about to become the operational backbone of intelligent factories, where critical decisions are made much faster. Being autonomous, task-oriented and context-aware, Agentic AI complements traditional AI by adding adaptability and automation to the stability and performance of traditional AI systems: agents can "augment" humans, systems, and machines.

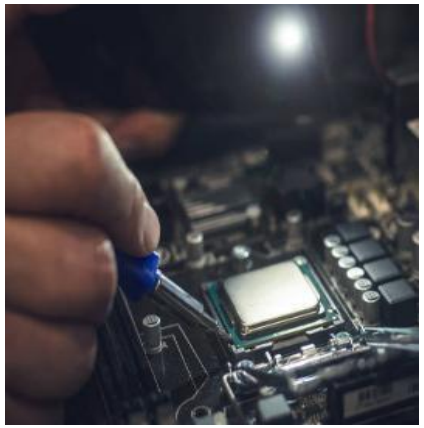
Key benefits from AI agents in manufacturing include:

- **Enhanced production performance**, by analyzing real-time data and production history and adjusting controls and action plans accordingly
- **Human-AI-machine collaboration**, by introducing the concept of an "Agentic Workforce" where AI agents work alongside humans, augmenting their responsibility, expertise, and decision-making. This may require a redesign of roles, processes, and team structures
- **Adaptive, self-learning systems** through plan-execute agents, perception-layer agents, and DRL agents (e.g. an AI agent system can learn to replicate the fine-tuning settings of a piece of equipment—those that a human operator applies based on the context)

2 – Agentic AI: Field stories in manufacturing

Food & beverage processor
Industrial co-pilot agent for predictive maintenance

A dairy company created a maintenance co-pilot agent that monitors real-time data, such as temperature, vibration and frequency for predicting specific failure scenarios. The agent autonomously prepares and triggers early maintenance requirements prior to plant shutdowns based on AI algorithm-based machine performance analysis. The pilot project yielded a low six-figure saving in repair costs.



Electronics manufacturer
Autonomous QC agent

An electronics manufacturing company developed an autonomous quality control AI agent that assists employees in correctly setting up the solder paste printer for the first production using maps. Later models continuously learn and optimize the unknown behaviors of the solder printing process for parameter recommendations.

Results show that high quality was achieved with about a 50% reduction in cycle time.

Steel Manufacturer
Autonomous control agent for steel production

A steel manufacturer developed a deep learning model that creates what-if scenarios on furnace control settings based on control patterns. The deployed solution initially acted as an adviser to the operator for optimal control settings, and was later converted to a partially autonomous operating system with agent outputs directly fed into the furnace control system. The agent has decreased LNG consumption by approximately 2%.

Tire manufacturer
Agentic AI for productivity improvement

A tire manufacturer wanted to reduce the time of production bottlenecks' manual assessment and root cause analysis by experts. The solution: a primary agent queried in natural language that extracts the context of the request, and launches a root cause analysis agent. Combining the outputs from this agent with the explainer and visualization agents, the main agent responds to the query in 88% lesser analysis time.

Pharmaceutical manufacturer
Agentic QC sidekick in labs

A pharmaceutical company developed a companion app for the Quality Control Laboratory that helps analyze past LIRs to summarize trends and root causes of using a particular method in natural language. This helps reduce incidents and take preventive actions. When combined with planning tools, this agent will enable the right method for QC analysis in the labs and can be helpful in training QC analysts.

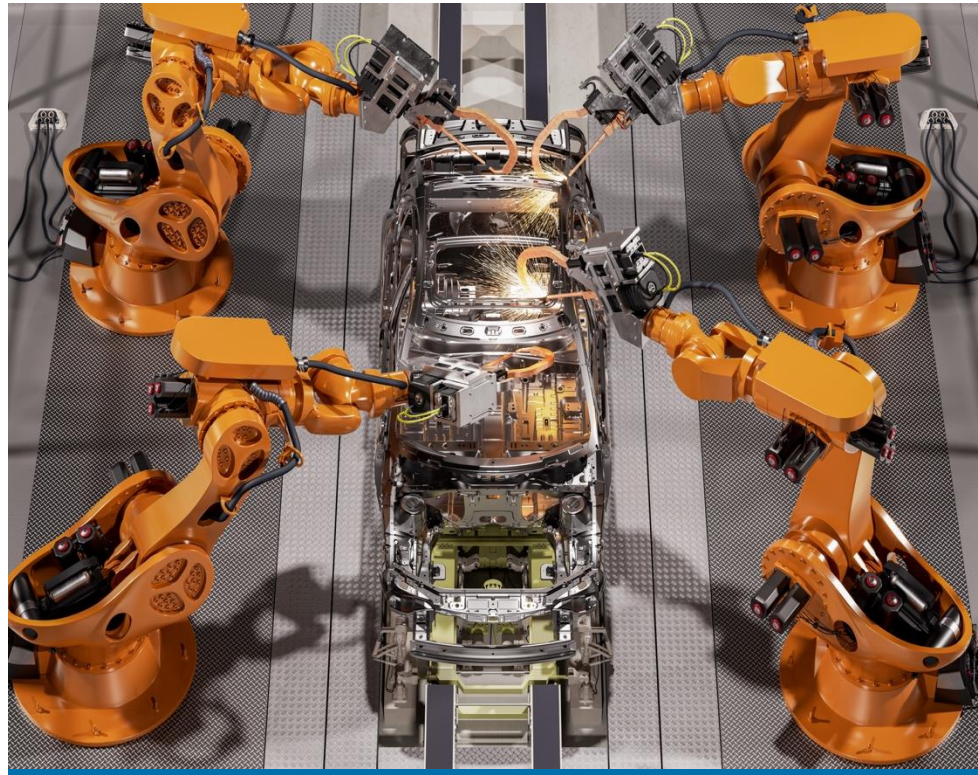
3 – Edge AI: What is it?

Edge AI makes sensors, cameras and local software smart. It leverages data from devices on a network—such as sensors, cameras, or local servers—and uses AI algorithms to process data and make decisions in real time. It reduces reliance on centralized cloud systems and brings computation closer to the data source, enabling faster responses, lower bandwidth usage, and greater privacy.

This decentralized intelligence allows systems to identify defects and risks on the shopfloor, identify causes, and act all in real time—even in disconnected or latency-sensitive environments.

The market for AI at the edge is expected to grow from ~$27 billion in 2024 to ~$269.82 billion in 2032*, representing an approximate CAGR of 33%.

Its applications are mentioned in the Generative AI and Agentic AI slides, with enhanced real-time capabilities when working at the edge—e.g. adjusting machine settings, detecting and removing defected parts in production, or responding to safety threats in real time.



There is a projected shift where 95% of new IoT deployments will include Edge AI capabilities in the near future.

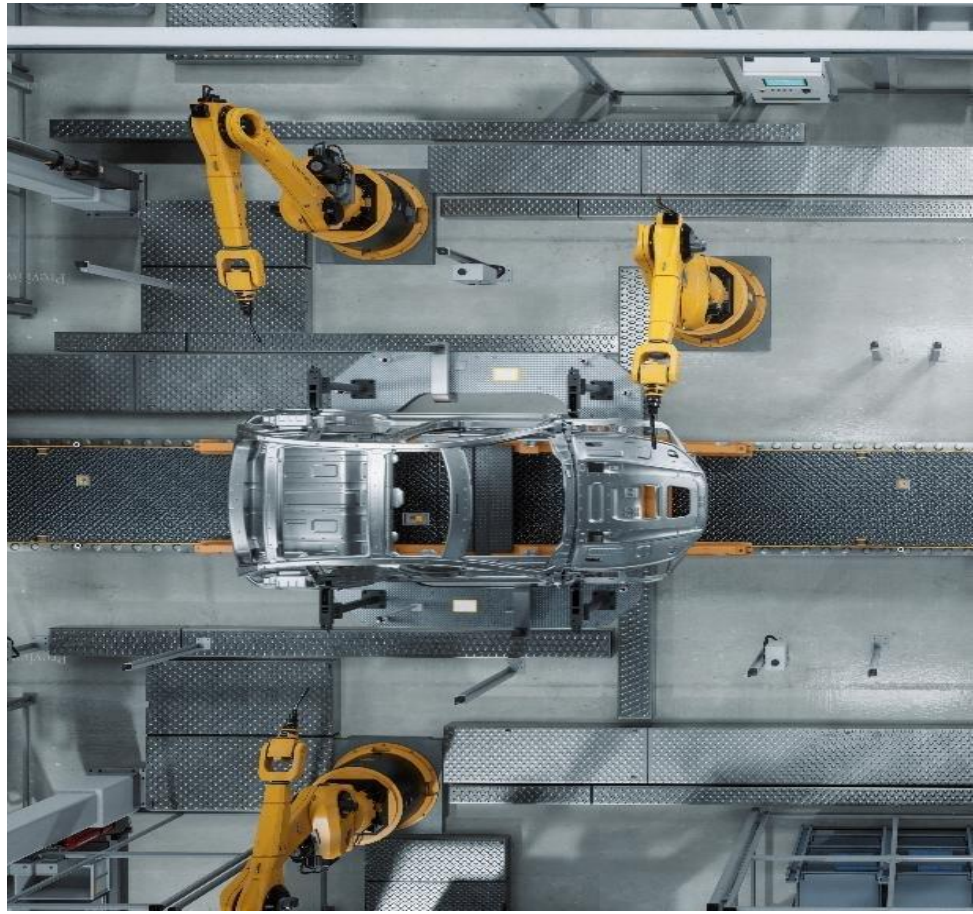
* Fortunebusinessinsights report

3 – Edge AI: Why does it matter compared to today's Industry 4.0?

Manufacturers have needed to process data produced at the edge for a long time. Edge Intelligence brings computation and AI directly to the data source, in an economically and technically viable way, while safeguarding cybersecurity.

The benefits of using AI at the edge for manufacturers include:

- **Workplace safety and security** by using Edge AI for real-time surveillance, detecting hazards, and preventing unauthorized access
- **Downtime reduction** using real-time local analysis and optimization of equipment data
- **Optimized energy consumption** derived from the benefits of accelerated local monitoring and control capabilities rather than cloud-based surveillance methods
- **Automated defect detections** using AI-powered vision systems and the possibility of immediate corrective actions that follow



3 – Edge AI: Field stories in manufacturing

Cement manufacturer

Optimize clinker-kiln operations with AI at Edge

A cement company developed real-time machine learning algorithms deployed on the edge of clinker kilns to optimize fuel consumption and process control during the pyro process. The result was ~$0.2 million savings in fuel costs, with a replicable application for all sites leveraging an edge platform.

Medical device manufacturer

Edge AI-powered monitoring device development

A global medical device company wanted more accurate models of users' blood glucose levels and sensor performance using their existing clinical trials data. The solution was an on-device, AI-based sensing algorithm. The solution developed is more robust for the patient and outperforms existing methods, also increasing sensor life.

Anode manufacture

Edge AI-driven anode inspection management

An anode production company is deploying Edge AI capabilities to inspect the surface defects of anodes during green and baked anode processes to avoid defective anodes moving forward in production. This involves image processing at the edge and an AI cloud model.

Automotive manufacturer

Edge AI-driven defect inspection for crankshaft

A leading automotive company used multiple data generated during crankshaft production for Edge AI systems to determine if the crankshaft is of the necessary quality. This reduced the cost by ~20% as the defective crankshafts were identified proactively along with production and not at the end of the production cycle, reducing waste/rejects.

Beverage bottler

Edge AI-based manufacturing workplace safety

A major beverage bottler uses an Edge AI-based machine vision system to monitor safety in operations. It operates ~1000 supervision points, recording and analyzing safety anomalies such as failure to wear protective gear and unsafe movements, and generates alarms for serious issues automatically.

4 – Physical AI: What is it?

Physical AI refers to AI embedded in machines that interact with the physical world, manipulating products of the line (robots, automates/PLCs, etc.). They are capable of reading their environment (cameras, radar, lidar, operators, logs, production metrics, etc.) and operate using complex movements and actions, such as manipulating complex shapes, moving in unstructured spaces, or addressing unforeseen events.

The convergence of Edge AI (including Generative and Agentic AI) and **advanced robotics**, combined with advanced sensors and broadband connectivity, is setting a new frontier in the world of robotics. By enabling real-time, on-device intelligence, AI empowers robots to operate semi-autonomously, adaptively, and securely within dynamic industrial environments **providing on-device intelligence in a physical environment**.

These robots—categorized as humanoids, autonomous robots, cobots, and modular robots—combine mobility, perception, and decision-making to adapt to dynamic environments with minimal human intervention.

Physical AI-embedded robots are not just tools—they are seen as **intelligent collaborators** reshaping industrial operations.

For Physical AI complete point of view, please refer to our paper: Physical AI, where Intelligence meets the real world, Synapse 2025.

4 – Physical AI: Why does it matter compared to today's Industry 4.0?

Physical AI is redefining automation. Powered by AI, advanced sensors and modular mechanics, it performs diverse tasks across industries—from manufacturing to healthcare—with precision and adaptability. The ability to deliver specific functions makes it key to driving productivity, safety, and cost-efficiency in dynamic environments.

The benefits of Physical AI in Industry include:

Human-centric design: Humanoids and cobots operate safely in shared spaces, reducing the need for factory reconfiguration

Collaboration: Polyfunctional robots, for example, can deliver specific tasks—welding, inspection, assembly—without reprogramming or downtime

Operational resilience: Edge AI enables robots to function even in low-connectivity environments, ensuring uptime and responsiveness

4 – Physical AI: Field stories in manufacturing

Military logistics

Autonomous robots for military logistics

A defense company wanted to increase its logistical capabilities across maritime, land and air domains. The solution was to develop an autonomous behavioral engine powered by AI that enables fast and safe unmanned logistics in congested, dynamic environments. It is using the capabilities of AI-based vision and predictive human behaviors by robot engine.

Automotive manufacturer

Context-based humanoid AI robots for assembly

An automotive manufacturing company developed a pilot project that used humanoid robots for assembly preparation in its production plant and the fully autonomous execution of two-handed tasks requiring varied and dynamic manipulation, complex grasping, and coordination of both hands in unison. This resulted in support to the humans working in ergonomically awkward positions on the shopfloor and reuse of the existing workstations.

Major retailer

Robotic agent for order picking

A retail company developed AI-controlled robots in its fulfillment center to handle the order-picking and unloading process. Thanks to its AI capabilities, the robot can process a wide variety of shapes, colors and quantities, which previously required human hand-eye coordination. Unloading robots can operate autonomously to grasp cartons and place them on conveyor belts, relieving workers of heavy physical work.

Metals and mining company

Autonomous trucks for mining

A mining company has deployed a fleet of 100 autonomous electric mining trucks that are powered by a 5G-Advanced network and AI algorithms for precise sensing and collaboration of fleet vehicles. These trucks provide 20% more efficiency than manual trucks despite working in extremely cold temperatures of -40°C during open pit mining.

Agro-food company

Robotic automation and vision for fruit picking

The agro-food company designed a robot to pick and sort irregular organic items like fruit. The solution was a robotic automation system that uses machine vision and AI for identifying the fruit on top, translating it into co-ordinates so that the "hand" picks only the targeted fruit without damaging it or touching any other object.

04 Main enablers of next-generation AI transformation

Identifying and removing the obstacles

Building on the lessons learnt from a decade of Industry 4.0, AI deployment begins with identifying and removing the obstacles to that transformation: technical, organizational, and human. Some obstacles are linked to the very nature of AI transformation.

Technical:

Legacy IT/OT complexity and heterogeneity

Brownfield sites weren't built for connectivity or AI. Heterogeneity of culture, processes and IT systems legacy across plants and geographies creates silos that complexify standardization.

Data quality, security and compliance

Without a robust data engineering strategy, companies struggle to extract actionable insights from data. As connectivity increases, so do cybersecurity and data confidentiality threats.

Generative and Agentic AI maturity

While significant progress has been made, there is still a lack of guarantee against generating incorrect, irrelevant, out-of-context, or hallucinated responses.

AI performance and reliability

The average performance and accuracy levels remain insufficient for fully autonomous use in critical applications. Current systems also fall short of meeting MLOps standards for scalable and reliable deployment.

Organizational/human:

Lack of a unified AI strategy

Many companies lack a unified digital manufacturing roadmap—versus site-level initiatives. At the same time, it is complex to demonstrate ROI of robust and scalable digital systems.

Lack of digital continuity

Continuity between product engineering and production is lacking, with siloed processes, tools, and data. Model-Based Systems Engineering is poorly used, while collaboration between business and IT departments is not fluid.

Scalability challenge

Most digital solutions are implemented as isolated pilots, with limited interoperability across plants or systems. There is a lack of a "scalable by design" approach at the pilot phases.

Cultural resistance

Both leadership and shopfloor workers often resist change—due to perceived risks (financial, technical), lack of digital skills, or fear of job displacement.

How to remove those obstacles and accelerate next-generation AI transformation?

Two core enablers pave the way

Developing the new generation of AI systems in manufacturing is a journey, starting from building a strong vision, engaging top sponsors, designing an outcome-based roadmap, and preparing the necessary technical foundations. It requires testing and learning through Proof of Concepts, while at the same time building the foundations for scaling. We have identified two critical enablers for success in this transformation:

A. Building an adaptive manufacturing platform:

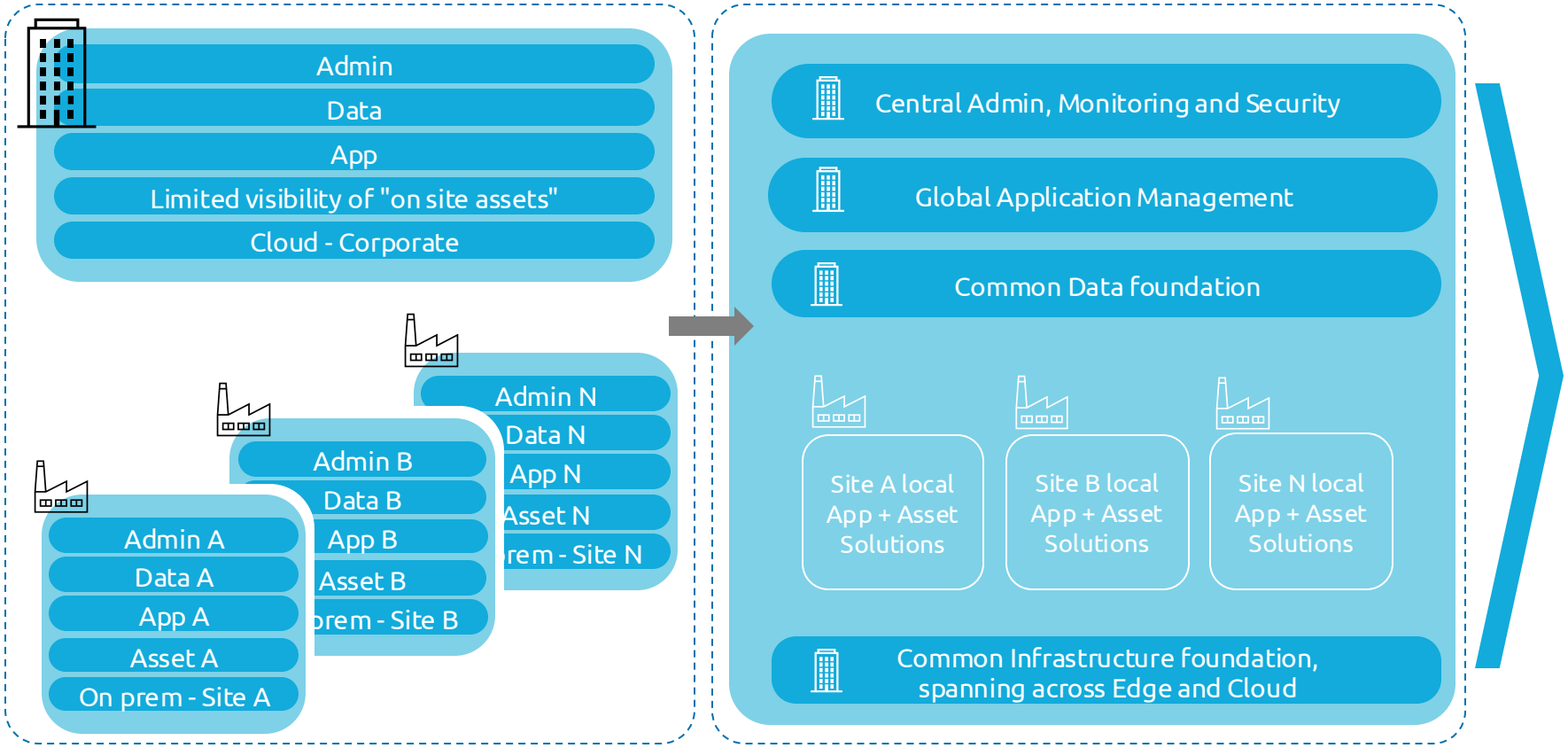
- Unlocking standardization and modeling
- Enabling performance and scalability
- Building upon strong data foundations for products, processes, and resources
- Leveraging key features based on Microsoft solutions

B. Driving a value-led transformation:

- Starting from shopfloor organization, processes and people
- Anticipating the transformation of shopfloor operators' and managers' work and skills
- Establishing trust in AI solutions, creating value from a new relationship between humans, robots and AI

An adaptive manufacturing platform: Unlocking standardization and modeling

Our **adaptive manufacturing platform** concept is a set of architecture patterns, design principles, technologies and technical approaches that enables **common standardization of data, apps, and infrastructure across the organization**. Data is made available to the people and places where it is needed, collaboration and better decision-making are made, optimizing processes and products.



Key benefits of the adaptive manufacturing platform

- A **common** data foundation enables a **holistic view** of your entire data estate from IT to OT, **reducing quality issues across systems**. Data professionals can build and deploy data product where it makes the most sense
- Consistency in IT and OT tools leads to **scalability and repeatability**. IT uses familiar tools for centralized, repeatable, and secure systems management across the enterprise
- Developers can build cloud-native apps that can also be **deployed repeatably across locations**
- Open standards across OT and IT facilitate **seamless technical integration and lifecycle management**

Moving from siloed solutions, tools and approaches to unified, standardized and centralized ones

An adaptive manufacturing platform: Enabling performance and scalability

Creating an adaptive manufacturing platform relies on designing an **IT/OT/data architecture** that follows key principles as outlined below. Such principles aim to create an integrated and scalable system, enabling the convergence of IT and OT, and relying on robust data foundations. When built, such architectures can enable factories to benefit from globalized use cases or autonomously develop robust and reliable local AI tools, bringing value to the shopfloor while being compliant with global IT/OT standards.

1. Business knowledge as the core model

A design principle where business knowledge is taken as its foundation

- Decoupling IT-OT apps from business knowledge
- Reduce the impact of applications lifecycle management
- Ensure the sustainability of the architecture

2. Data and semantics-driven architecture

A design principle where data structure and modeling are at the core of any application

- Encourage a unified data architecture
- Increase interoperability
- Enable Generative AI by providing all the necessary context (Context Engineering)

3. Event-driven architecture

A design principle where the program flow is determined by dynamic events (e.g. part flow, shopfloor disruption, etc.)

- Aligned with dynamic workflows
- Enables near real-time processing with minimum time lag
- Supports a high volume and high velocity of data

4. Adaptive cloud-native

A design principle where both cloud and edge infrastructure are leveraged depending on conditions and needs

- Increase performance agility
- Support distribution of workload and data processing
- Leverage both on-premise and cloud resources for optimal scalability

5. Future-proof thanks to standards use

A design principle where best-in-class IT, OT and data international standards are leveraged

- An open, standards-based and loosely coupled architecture for better replicability across sites (ISA 95, 88, 99, OPC-UA, MQTT, Unified Namespace, etc.)
- A versatile architecture ready for new tech implementation

6. Modular, flexible and scalable

A design principle advocating the use of reusable IT-OT-data components, enabling quick reconfiguration and scalability

- Facilitate flexible design
- Increase component interchangeability and systems decoupling
- Implement small features in a “short-lived” manner

7. Industrial-grade reliability

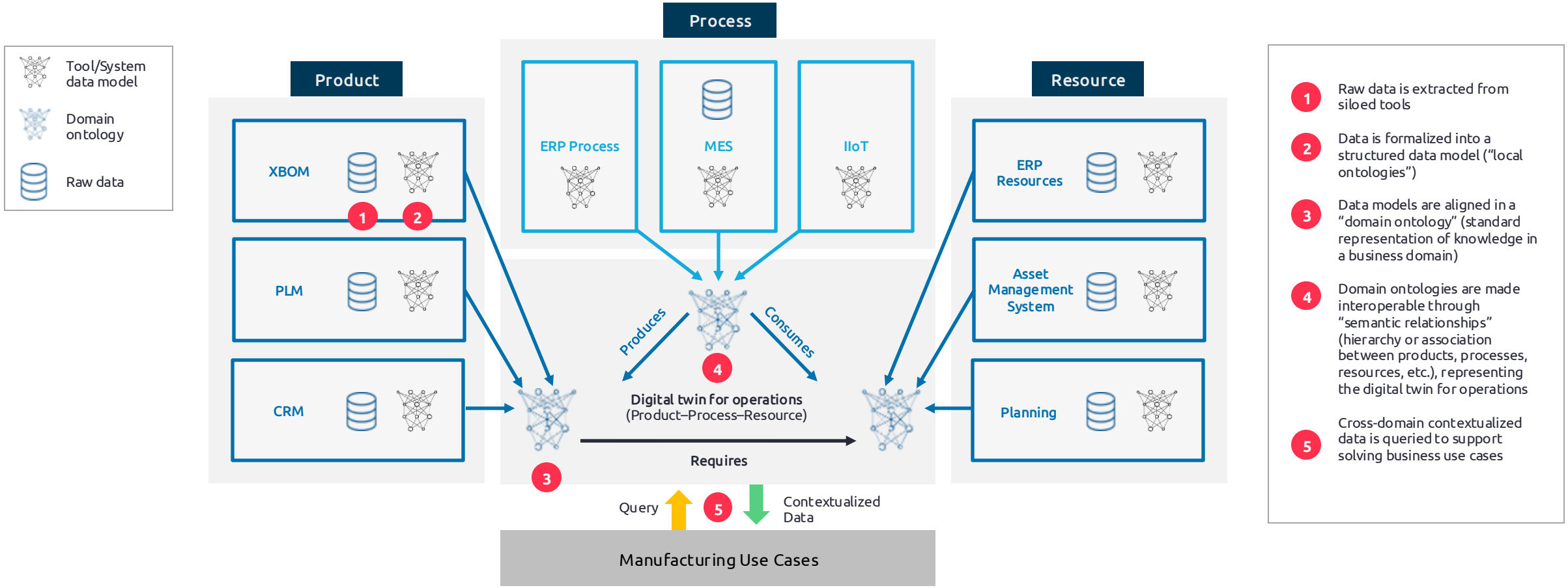
A design principle where high availability and performance of systems are guaranteed under demanding industrial conditions

- Endure harsh operational environments
- Ensure smooth operations and rapid recovery from disruptions

The **adaptive manufacturing platform** brings a differentiating value, as it enables not only building on legacy IT and OT systems—as core data sources—without disrupting them; it also enables **reconsidering the make or buy strategy**. The modular architecture enables keeping data ownership and **easier in-house applications development**.

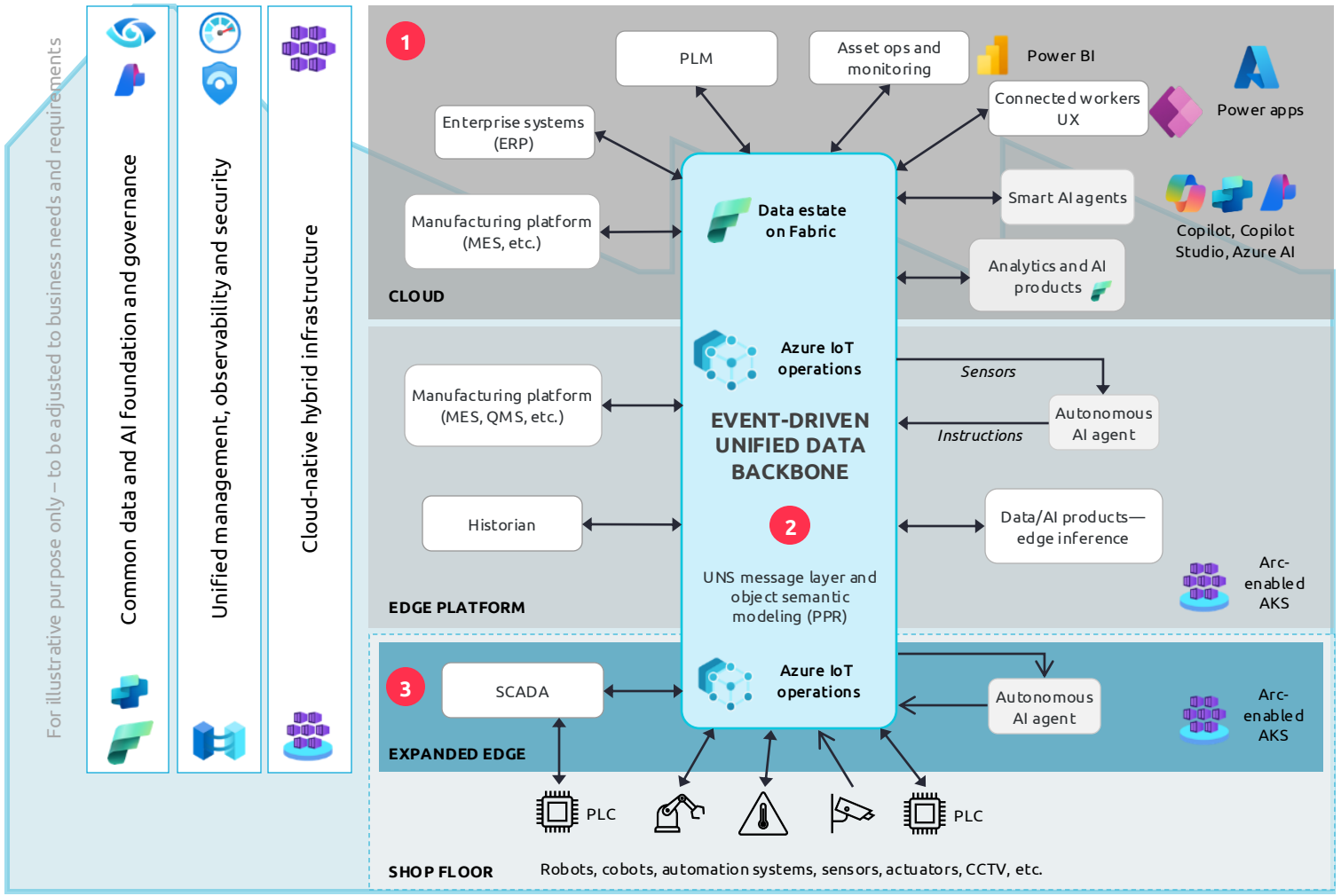
An adaptive manufacturing platform: Building upon robust data foundations for products, processes and resources

Strong data foundation is based on a **semantic representation of the Product-Process-Resource (PPR) configurations** possible within the organization and aims to become the **"single source of truth"** for the company. This **core semantic model** is the source of the **digital twin for operations**, providing a common language across the company, facilitating interoperability across domains and systems and sourcing data/AI use cases. The following diagram illustrates its core principles:



1. Raw data is extracted from siloed tools
2. Data is formalized into a structured data model ("local ontologies")
3. Data models are aligned in a "domain ontology" (standard representation of knowledge in a business domain)
4. Domain ontologies are made interoperable through "semantic relationships" (hierarchy or association between products, processes, resources, etc.), representing the digital twin for operations
5. Cross-domain contextualized data is queried to support solving business use cases

An adaptive manufacturing platform: Leveraging key features based on Microsoft solutions



Key Features

1. **An edge/cloud hybrid architecture** relying on cloud-native technologies enabling AI workloads where it makes more sense, managed in a unified and centralized way. Systems can be hosted in the cloud versus edge platform depending on business needs, and financial and technical constraints. The key benefit is **flexibility.**

2. **An event-driven data backbone,** based on a unified manufacturing semantic model and ontology hosted as a digital twin for seamless OT and IT data integration at all levels of the enterprise. "Everyone speaks the same language and gets the **relevant data they need, at the right time, right place, right quality."**

3. **A strong edge platform** managed/monitored centrally, enabling data and AI workloads locally for **real-time or closed-loop decision-making.**

Did you know?

margo

Together with ABB, Rockwell Automation, Schneider Electric and Siemens, **Capgemini** and **Microsoft** are founding members of Margo, an initiative that defines mechanisms for interoperable orchestration at scale for edge applications and workloads and devices. It delivers the interoperability promise through an open standard, a reference implementation, and a comprehensive compliance testing toolkit. Margo unlocks barriers to innovation in complex multi-vendor environments and accelerates digital transformation for organizations of all sizes.

B. Value-led transformation

The overarching principle of data and AI-driven transformation of manufacturing can be defined as: the ability of people and processes to use data and AI to create value across the production system.

Research highlights some **best practices from front-runners** of AI in manufacturing programs:

- They moved beyond the "pilot purgatory" to achieve **ROI of 2–3x** over three years and 4–5x over five years*
- They have unlocked **step changes in performance**—averaging improvements of more than 50% in conversion cost, cycle times, and defect rates
- They stay focused on "**value back**"

Because the investment in building data foundations for manufacturing is substantial, complex and time-consuming, it is essential to foster **a value-driven execution.**

Global Lighthouse Network: The Mindset Shifts Driving Impact and Scale in Digital Transformation. World Economic Forum, 2025.

A value-led transformation: Starting from the shopfloor organization, processes and people

Align stakeholders on opportunities brought by new AI capabilities

Embarking **top-level sponsors** at CEO, CFO and COO levels on the new AI capabilities (Agentic AI, Edge AI, Physical AI) will be key to ensuring sponsorship and prioritization of areas to explore.

Aligning business, IT and OT stakeholders will be fundamental to ensuring that **both technical foundations and business values** are properly addressed.

Defining a **business and technical North Star vision** for plants, targeting the most replicable use cases and at the same time the most important technical assets will be key.

Balance long-term foundations and short-term quick wins

It is essential to embark stakeholders on both **building the technical foundations**—not having a straightforward business case—while developing short-term, **value-driven business use cases**.

To fully capture the value of AI, Generative AI or Agentic AI, it is crucial to **assess business operational processes** (both manual and automated ones) to identify the most valuable ones to "augment" through AI capabilities—those can be built incrementally. To quantify AI impact, it is key to develop metrics to measure productivity gains from AI augmentation (e.g., sprint compression, support efficiency, faster resolution of inefficiencies and improve downtime, etc.).

Prepare people and skills

To mitigate risk of rejection, business teams have to be **onboarded from the beginning**, prioritizing opportunities that augment local capabilities. These involve deep collaboration among IT/OT/business teams and partners. Leveraging Copilot AI and internal Basic AI Academy to scale usage is part of the solution.

Developing advanced AI also requires a **broad set of skills and expertise** such as prompt engineering, agent development, and robotics enhancement. **Upskilling and reskilling** workers to adopt and codevelop those tools is crucial to allow broad adoption.

Think asset portfolio

Treating a solved business use case as a product, not a project, is key. **Assetization** is a systematic approach to developing, managing, and deploying reusable assets for scalable digital transformations across an organization.

Assets at Centers of Excellence for AI can serve to upskill frontline site operations and technology leaders, who take on the responsibility of **deploying** these new technologies in localized contexts.

Ensure local adoption and trust in AI solutions

Building **adoption programs** to make digital stick: AI-driven solutions aren't just for the workforce, they are with the workforce.

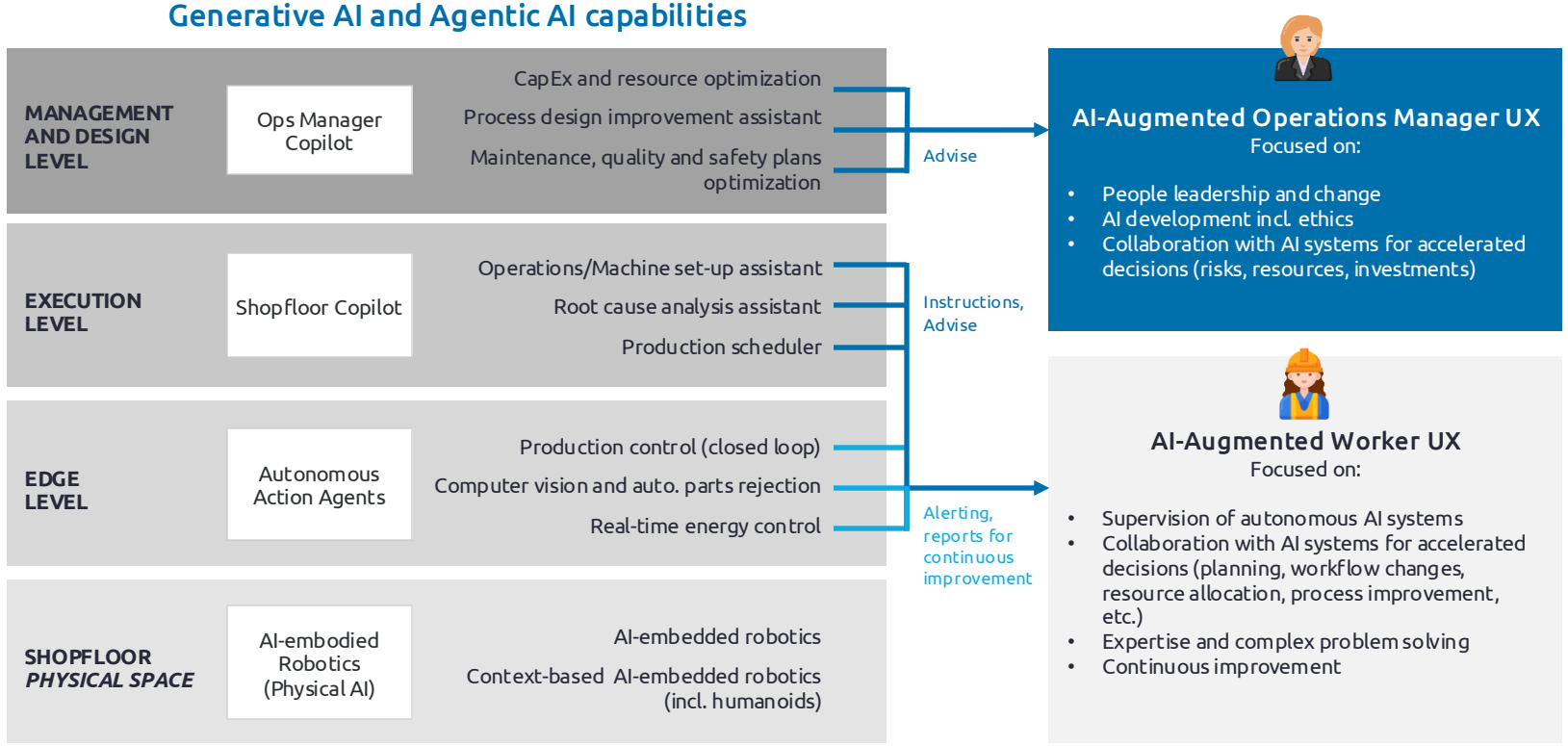
Therefore, it is key to encourage **frontline ownership to get involved**, as well as prioritizing a human-centric approach to design, deployment, and change.

Establishing a **relationship of trust between individuals and AI**, as well as confidence in the outcomes or solutions it delivers, is a critical driver of success (see our trusted AI framework on slide 36).

Operators' and managers' work and skills will be crucial

As AI has enabled higher levels of automation on the shopfloor, workers are to play a key role in enabling, co-developing, supervising, and collaborating with AI systems—both physical and virtual. Here are the areas of transformation:

Generative AI and Agentic AI capabilities



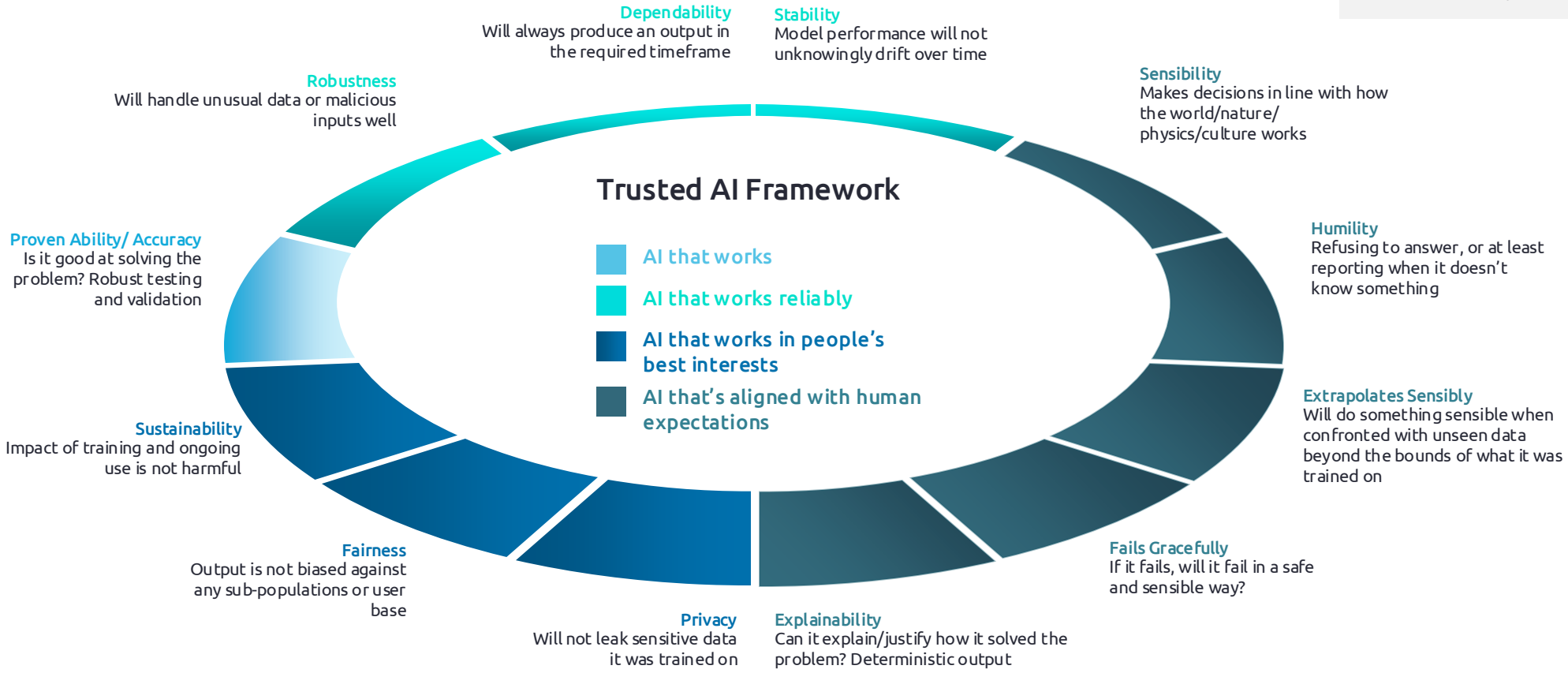
What are the key changes to anticipate for people in operations?

- **Upskilling to adopt AI:** Deploying AI means preparing employees in understanding and leveraging AI systems in their day-to-day work. Upskilling workers to use AI, interpret outputs, provide feedback, and effectively collaborate will be key.
- **Codeveloping AI agents:** AI agents are only relevant if they address the local shopfloor context, including product, process and equipment knowledge. Experienced workers are to play a key role in collaborating with AI project teams and capitalizing on that knowledge.
- **Collaborating with AI agents:** Agentic AI promises more integrated workflows and enhanced human-AI-machine interactions. Workers will collaborate with AI in natural language to get insights, accelerate decision-making, and react more effectively on the shopfloor.
- **Supervising autonomous AI agents:** When it comes to autonomous AI agents, workers will move from monitoring machine performance to supervising how AI systems operate, monitor their performance and outcomes, and ensure overall plant performance goals are achieved.
- **Enhancing expertise and focusing on complex anomalies:** Autonomous AI promises workers to focus on fewer repetitive tasks (e.g. quality control) and more value-added activities (e.g. complex problem solving, exceptions, and anomalies). At the same time, AI will provide workers with enhanced data analysis and predictive capabilities, enabling them to make better decisions, improve processes, and innovate on the shopfloor.

Scaling up requires establishing trust in AI solutions

Establishing a relationship of trust with individuals impacted by AI, as well as confidence in the outcomes or solutions it delivers, is a critical driver of success. Capgemini has developed a strong AI governance framework to deliver a trustworthy AI implementation. All the principles are fully applicable to manufacturing environments.

Microsoft AI solutions are supported by a broad security product portfolio, allowing a holistic approach to security, identity, privacy, safety, compliance, and data sovereignty simultaneously. Security Copilot is now working with Microsoft Security.



05 The path to value with Capgemini and Microsoft

Capgemini and Microsoft: Your best partners for AI in manufacturing

Capgemini

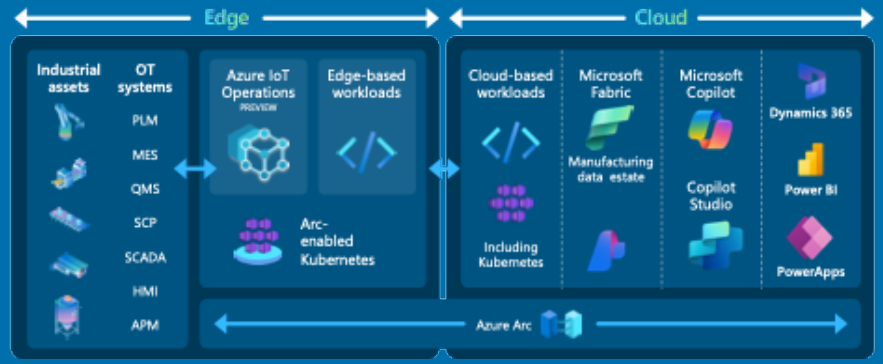
Capgemini services, recognized by leading industry analysts, are covering end-to-end AI-driven manufacturing value chains, bringing together the language of the shopfloor (industrial business stakes and KPIs, manufacturing and process engineering, OT and connectivity, etc.) and the language of agile development methodologies, IT/OT systems development, cloud, data, and AI.

Everest Group	AVASANT FOUNDATION	FORRESTER	IDC
Leader Industry 4.0 Services Peak Matrix® Assessment 2025 (March 2025)	**Leader** Manufacturing Digital Services 2024 RadarView™ (March 2025)	**Leader** Application Modernization & Multicloud Managed Services (The Forrester Wave™, Q1 2025)	**Leader** Worldwide Smart Manufacturing Strategy Service Providers 2023-24 – December 2023

The Resonance AI Framework by Capgemini provides a sequential approach to the conceptualization, structuring, and implementation of successful AI-driven transformation. It helps business leaders realize AI's potential and achieve market leadership.

Microsoft

Microsoft provides the scale, security, and AI power to take insights global, on a digital backbone that will flex in line with business needs. With Azure IoT Operations, Fabric, Factory Operations Agents in Azure AI Foundry, and Copilot templates, Microsoft empowers manufacturers to extract the full value from factory data by unifying their data estate to generate comprehensive insights from AI. And to do it at scale!



Capgemini is **the top Microsoft Solutions Partner-Cloud, with 14 advanced specializations across Azure, modern work, security and business applications**

65k+ Microsoft certified experts
Ranking us amongst the top 3 Microsoft Partners

80k+ Trained FTE in 2024

Accredited with Microsoft Cloud Solution Partner designation for achieving all six Solution Partner designations

Microsoft Solutions Partner
Microsoft Cloud

Microsoft Solutions Partner
Security

Microsoft Solutions Partner
Business Applications

Microsoft Solutions Partner
Modern Work

Microsoft Solutions Partner
Data & AI

Microsoft Solutions Partner
Digital & App Innovation

Microsoft Solutions Partner
Infrastructure

Embracing the new AI wave in Manufacturing: how to get started with Capgemini and Microsoft?

Capgemini and Microsoft can lead you in a practical pathway to transform your operations thanks to the new AI wave. Our action proposals are mixing core design to prepare the right foundations, with practical demos and testing to showcase value. They are not necessarily sequential and can be performed in parallel.

Capgemini Industry Agentic Studio

Industry Agentic Studio combines Capgemini Services and Microsoft Solutions:

Strategy for AI transformation

Transform business for efficiency & innovation (Transformation office): Business Value tracking from new Agentic AI Use Cases, Teams Upskilling, Target Hybrid Operating Model definition (AI & Human Workers), Change Management and adoption of new working practices.

Unlock AI platform capabilities: Understand current platform capabilities and secure existing investments. Configure for AI security, content safety and compliance. Microsoft 365 Copilot, Dynamics 365 Copilot's, Azure AI Foundry, Microsoft Fabric, Microsoft Purview

Implement AI agents at scale: Developing Custom AI Agents on Modern Software Engineering Platform, integrating and Orchestrating AI agents with Enterprise systems. Trusting AI agents: security, privacy and guardrails. GitHub Copilot, Azure APIM GenAI Gateway

Operate AI agents lifecycle: Managing Agent and AI System lifecycle. Human in the Loop. Azure Monitor, Security Copilot, Azure APIM GenAI Gateway

Plant Assessment & Architecture Design

Through our **standard method for shopfloor visit and factory assessment,** we can help identify the **most proven AI opportunities** (incl. Generative AI, Agentic AI, Edge AI, Physical AI) based on benchmark with similar industries.

An **Architecture and Data assessment** will help identify and prioritize the technical foundations to implement, including key actions to take on **data acquisition and data foundations design**.

Pattern Analysis

In parallel with building a vision and technical foundations, Data testing is key. We can propose to **analyze your Data** on your most critical areas and perform correlation analysis. Thanks to the variety of AI systems (including Generative AI), we can **cross-analyse data of different sources** – e.g. equipment performance, operators log, MES and ERP information, IoT and sensors – and identify untapped improvement opportunities. A recent similar exercise enabled to identify **a 12% OEE improvement opportunity** for a major beverage company.

And we can use Capgemini Intelligent Industry Lab as a service to accelerate your journey!

How Capgemini Intelligent Industry Lab accelerates transformation

At the Capgemini Intelligent Industry Lab, located in Cadiz, Spain, we have pre-packaged multiple manufacturing use cases within a full stack Microsoft Platform. We invite our clients to the lab to showcase demos of those use cases, to discuss their core infrastructure, and to co-design and build Minimum Viable Products specific to their individual needs and contexts.

Capgemini Intelligent Industry Lab as a Service offers **unified management via the Azure Arc edge/cloud hybrid platform,** and up-to-date **Microsoft solutions for data and AI-driven manufacturing** (Azure Arc, IoT Operations, Fabric, Copilot Studio, Azure AI and AI Agents):

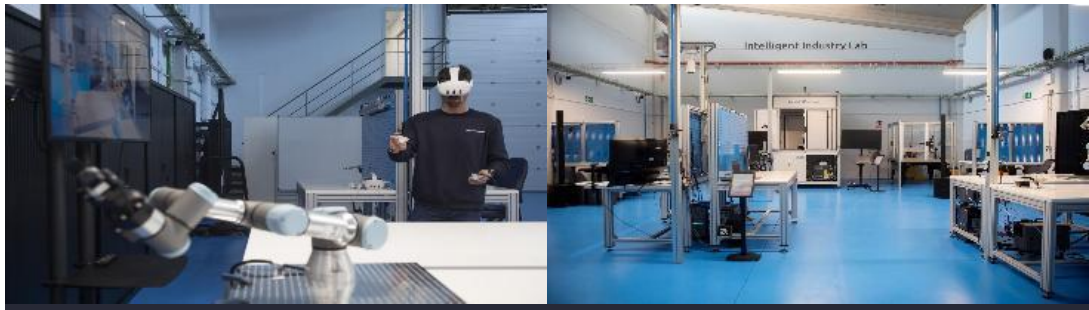
- Modern GitOps deployments with Flux v2
- Modular, scalable architecture tailored for manufacturing
- Seamless data integration into Microsoft Fabric
- Built-in ML and Generative AI directly on Fabric data
- Real-time monitoring with native Power BI
- Low-code apps with Power Apps using live IoT data
- Stronger security and compliance with centralized policies
- Edge processing for low-latency, real-time scenarios

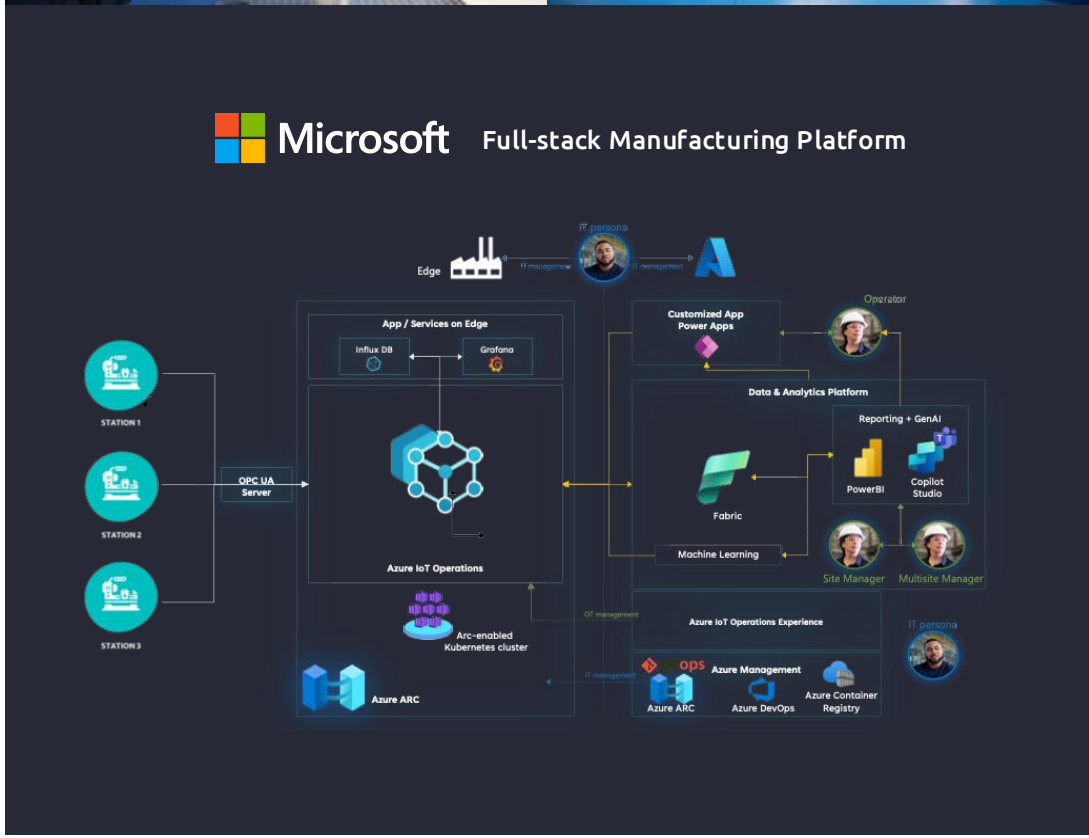
The **Intelligent Industry Lab as a Service** offers a lower TCO and faster innovation through automation and reduced custom development. It has been designed to best fulfill the following missions:

- Emerging technologies evaluation
- Tech days, innovation and North Star workshops organization
- Real environment for use case development and testing
- Innovation at scale platform
- Testing partner for delivery

To achieve these missions, the core assets include:

- Multiskilled squads
- Network of architects and experts
- Connection with Microsoft product engineers
- Industrial operations and environment (robots, PLC, sensors, etc.)
- Full Azure OT-IT-IoT architecture, with partners' ecosystem





Take the next step to AI in manufacturing

Get in touch to schedule a practical discovery session with our teams.

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Acknowledgments:

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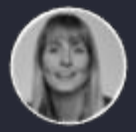

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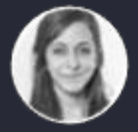

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