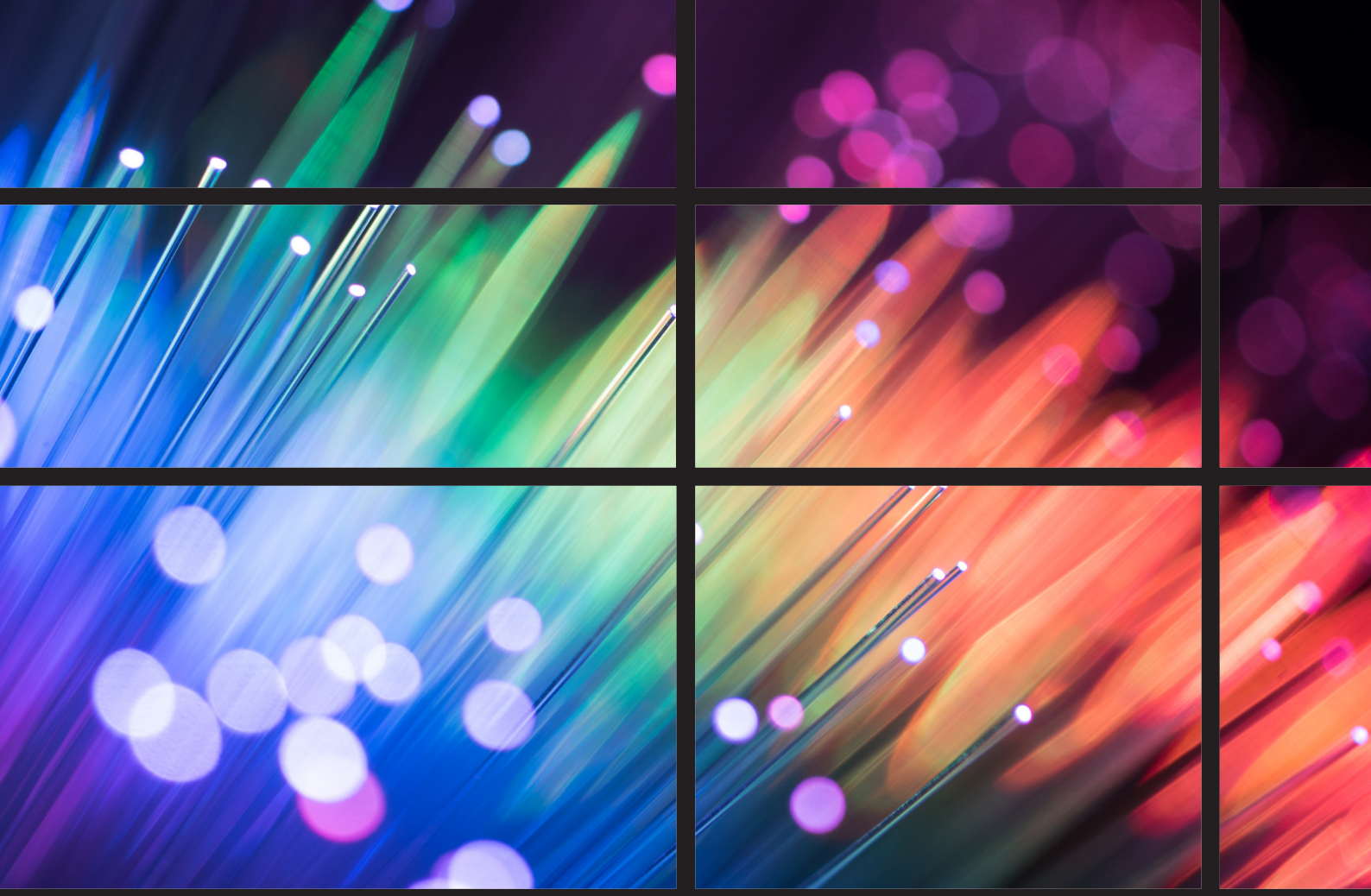


451 Research Vanguard Report

April 2025

Preparing industrial organizations for AI

From assistants to autonomy

S&P Global
Market Intelligence

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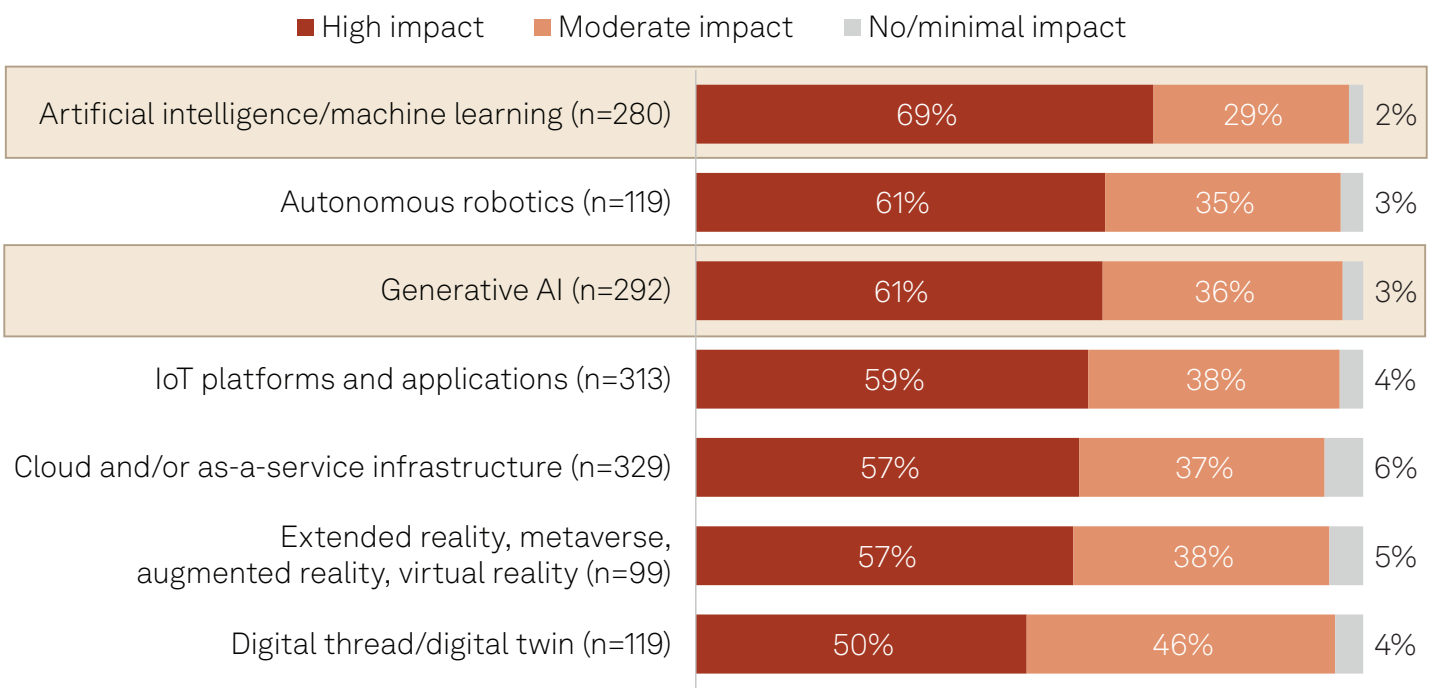
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Introduction

In today's rapidly evolving industrial landscape, AI is emerging as a transformative force, with applications progressing from AI-powered chatbots and assistants to the delivery of a data and insight fabric that can enable increasingly autonomous operations. This evolution necessitates careful strategic planning, proactive change management, investments in appropriate infrastructure, and the implementation of best practices in data management and the integration of IT and operational technology (OT) systems. When implemented effectively, industrial AI offers benefits such as enhanced performance, optimized talent management and improved sustainability practices. The transition begins with using AI-powered assistants to augment human capabilities, with a strategic progression toward higher levels of operational autonomy. Ultimately, AI can be a transformative force with the potential to significantly bolster competitiveness and foster innovation in process industries (see Figure 1).

Figure 1: Industrial enterprises have high expectations for AI, ML and GenAI



Q. Overall, how much of an impact do you expect each of the following technologies your organization has adopted/plans to adopt on your organization's IoT and/or operational technology (OT) initiatives and ongoing operations?
Base: Have deployed or expect to deploy indicated technology.
Source: 451 Research's Voice of the Enterprise: Internet of Things, the OT Perspective, Technology Decisions 2024.

The Take

The integration of AI is reshaping process industries, emerging as a significant driver of competitive advantage, performance, talent management and sustainability. On the technology front, the journey toward full autonomy is a phased process that involves the development of more sophisticated models and deployment of multi-agent architectures. It requires a robust data management strategy, effective data governance policies, strong security measures, and seamless IT and OT integration.

A strategic and well-planned approach that adheres to best practices is essential for effective AI adoption. To succeed, industrial organizations must:

- Assess current maturity to identify gaps and create an implementation roadmap
- Involve process owners to ensure alignment with business objectives
- Foster collaboration between OT and IT teams for infrastructure and data management
- Engage HR for change management and training
- Address legal considerations related to data, intellectual property and responsible AI
- Secure executive buy-in and leadership commitment

To successfully navigate the AI landscape and unlock its full potential, organizations must embrace such a strategic approach while fostering collaboration, prioritizing continuous learning and focusing on tangible value creation. This is not a one-time project but an ongoing journey of adaptation and innovation.

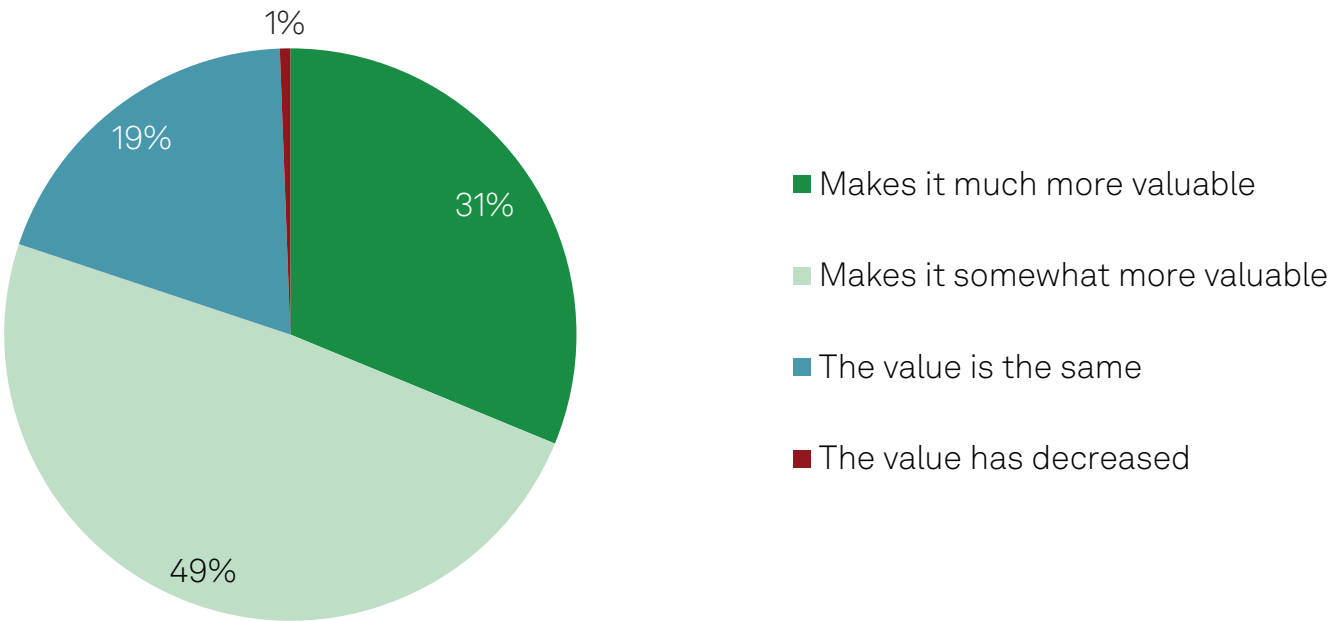
The evolution of AI in process industries

AI implementation in process industries has evolved significantly. Initially, AI took the form of straightforward machine learning algorithms embedded in vendor-provided software applications. Over time, enterprises began building their own AI capabilities, deploying custom models, hiring data scientists and adopting foundational tools such as Python and Jupyter Notebook. The introduction of large language models (LLMs), generative AI tools and modern machine learning frameworks such as TensorFlow and PyTorch has dramatically accelerated and expanded the role of AI in industry. These tools have lowered the barrier to entry for AI development, enabling faster experimentation, more accessible model training and scalable deployment, helping organizations move from pilot projects to production-grade AI solutions. The potential of agentic AI — systems that coordinate multiple models for operational insight as well as real-time decision-making and action — brings industrial organizations significantly closer to autonomous operations, albeit initially with strong human-in-the-loop interactions.

To support this trajectory, enterprises must mature their data management and governance practices. What began with the harvesting of IoT data from individual machines and sensors must evolve into an enterprise-wide knowledge graph or fabric capable of training models and supporting intelligent, mission-critical AI inferencing. Public models such as OpenAI's GPT or Google's Gemini can be used as a base capability. However, organizations and their software partners must then leverage unique — and likely proprietary — operational insights and data to build models suited to their specific requirements.

Training AI models on process data presents unique challenges. Key data in process industries often consists of time series data, illustrating the evolution of specific variables over time. These processes tend to be multivariate and complex, and they often operate under strict safety constraints. Unlike sectors such as retail and telecommunications, process industries face a scarcity of public data, which makes the creation of comprehensive AI models more difficult. To combat these limitations and address data quality issues such as gaps and inconsistencies, enterprises can use AI to create and train models on synthetic data — artificially generated data that mimics real-world data — when real data is scarce, sensitive or difficult to obtain. By training AI models on synthetic data, organizations can improve model performance, validate algorithms and conduct experiments without the constraints associated with real data. Regardless of how data is gathered or created, AI training and inferencing significantly increases the value of collected operational data (see Figure 2).

Figure 2: Industrial AI enhances the value of collected machine and sensor data



Q. Overall, how does the recent rise in interest in AI, including generative AI, impact the data you collect via your organization's IoT projects?
Base: Organizations with plans to use AI (n=679).
Source: 451 Research's Voice of the Enterprise: Internet of Things, the OT Perspective, Use Cases and Outcomes 2024.

Getting started: GenAI and workforce assistants

The transition to AI and autonomy is marked by the increasing role of both large and small language models, which enable software-based chatbots and assistants to enhance workforce performance. This initial application of GenAI in organizations provides significant benefits while preserving operator oversight — delivering higher levels of autonomous efficiency while keeping humans in the loop. Automating repetitive tasks can enable engineers to focus on more complex problems, both speeding and improving operations. Systems that communicate using natural language can facilitate collaboration and improve overall productivity. These AI augmentations can address workforce challenges and help navigate cultural issues. At more advanced stages, individual AI models may be strung together in agentic AI systems that can handle complex tasks autonomously.

Supporting AI assistants and advancing toward higher levels of AI-enabled autonomy requires careful attention to several key areas. Change management is essential to train personnel to interact effectively with AI models and ensure they understand how AI affects their work processes. Prompt engineering is crucial for eliciting better results from AI assistants, enhancing the quality and relevance of their outputs. Adopting AI models necessitates investment in infrastructure, whether cloud-based or internal, with thorough planning to ensure a strong return on investment. Technology adoption should begin on a small scale, with specific use cases to prove value before expanding.

Moving toward autonomous operations

The transition from chatbots to full autonomy involves developing richer models and knowledge graphs, and ultimately multi-agent deployments. This progression follows defined stages of autonomy, from control and process automation to fully autonomous operation. Each stage involves sensorization, control loops and digitalization. Multi-agent architectures represent a significant evolution in AI deployment. It involves transitioning from front-end agents that interact with users to background agents that perform tasks automatically. Autonomous agents can react to environmental changes and perform specific tasks, such as asset performance management, thereby optimizing operations and reducing the need for human intervention. Although challenging to implement, multi-agent AI can bring many benefits, and it is a critical step toward more autonomous operations. Benefits include the insight-driven automation of increasingly complex tasks, significant cost reductions, improved asset management and the removal of humans from hazardous working conditions, ultimately contributing to enhanced safety and sustainability.

Moving toward agentic and multi-agent AI presents challenges that organizations must address. Companies will need to evolve their infrastructure to support more complex AI deployments. Change management and training programs are crucial to ensure personnel can work effectively with AI agents and adapt to automated workflows. Furthermore, the deployment of interconnected autonomous agents amplifies the importance of robust data management, stringent data governance policies and strong security measures to protect sensitive information and operational systems. Legal teams can help navigate the complexities surrounding data ownership, intellectual property and use of proprietary data in multi-agent systems. To prepare for this evolution, companies should start with small-scale, specific use cases to prove value and build internal expertise before wider deployment.

Key infrastructure concepts for AI deployment

Successful AI deployment in industrial organizations requires a strong foundation. Robust data management strategies are crucial because they provide the framework for effectively organizing and handling the vast amounts of operational and process data generated in these environments. This includes establishing clear processes for data collection, storage and accessibility to ensure that the right data is available for training and deploying AI models. Data governance — implementing policies and procedures to guarantee data quality, accuracy, reliability and compliance with regulatory standards — is equally important. High-quality data is essential for building trustworthy and effective AI solutions. Further, strong security measures are indispensable to protect sensitive data and critical infrastructure from escalating cyberthreats in an increasingly connected industrial landscape, safeguarding both IT and OT systems.

Effective integration of IT and OT systems is another cornerstone of successful AI adoption, bridging the gap between the plant floor and the cloud. This convergence facilitates the flow of data between these historically siloed domains, enabling a holistic view of operations and unlocking new opportunities for AI-driven insights and optimization. Leveraging cloud technologies offers significant advantages in scalability, flexibility and access to advanced computing resources. As the divide between IT and OT continues to fade, industrial organizations are increasingly open to cloud adoption to harness these benefits. But this must be carefully balanced with critical requirements for safety and real-time performance in industrial processes, which calls for infrastructure deployed at the edge, on-premises or near where data is generated. This is especially true considering large language models are best run by hyperscale cloud providers, while smaller, industry-specific and proprietary models are more suited for controlled, private environments. Most organizations will require infrastructure spanning from edge to cloud, and this hybrid approach to IT systems and venues presents its own challenges. To that end, collaboration is key, bringing OT and IT stakeholders to the table to inform critical decisions.

Conclusion

Effective AI adoption requires a strategic approach and adherence to best practices. Companies should begin by assessing their maturity level to identify gaps and create a detailed implementation roadmap. Involving process owners is critical to ensure that AI solutions align with company objectives. Collaboration between OT and IT teams is essential for planning infrastructure and managing data effectively. HR plays a key role in change management and developing training programs to prepare the workforce. Legal considerations are important, particularly in managing data, intellectual property and proprietary information. Organizations must enact policies for responsible AI to ensure proper use of the technology and manage impacts on partners and customers. Finally, executive buy-in and leadership commitment are vital for the success of AI programs, as the ultimate driver for deploying AI systems will likely be the same as for any Industry 4.0 project: providing an industrial organization with significant competitive advantage.

Honeywell

Honeywell's Industrial Autonomous solutions leverage advanced digital and AI technologies to help increase plant performance through closed-loop operations with minimal human intervention. This approach directly addresses key challenges in the process industry, including the need for sustained optimization and skilled worker shortages. By moving towards autonomous operations, industrial plants have the opportunity to make every day their best day of production and elevate every personnel to perform at their highest potential.

Learn more: Industrial Autonomous Solutions

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Rich Karpinski is principal analyst and lead for the 451 Research Internet of Things and Applied Infrastructure & DevOps channels within S&P Global Market Intelligence. Rich tracks, analyzes and anticipates the pace and direction of IoT adoption, as well as the use of IoT to enable vertical industry transformation. As part of that work, he oversees a quarterly survey of IoT adopters and a twice-annual survey of operations technology (OT) professionals.

Rich's recent areas of concentration include IoT connectivity and managed platform services, IoT edge computing, IT/OT collaboration, IoT market sizing and data flow analysis, IoT digital maturity analysis, and the adoption of IoT use cases across a variety of sectors.

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