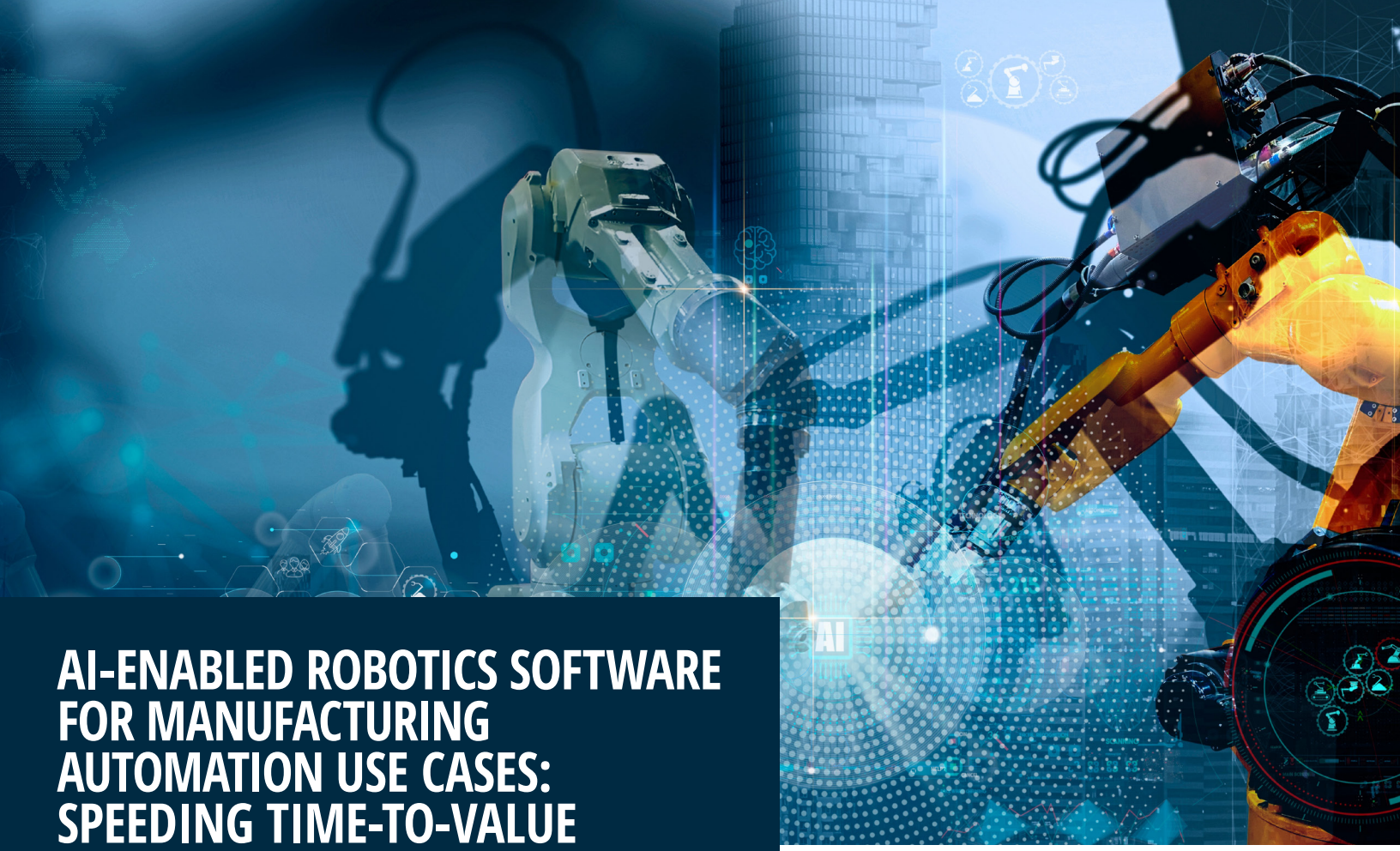

AI-ENABLED ROBOTICS SOFTWARE FOR MANUFACTURING AUTOMATION USE CASES: SPEEDING TIME-TO-VALUE

Ryan Martin, Senior Research Director

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EXECUTIVE SUMMARY

The number of robots in use will more than double in the next 5 years, from 6.3 million in 2025 to 15.2 million in 2030. At the same time, deploying new technologies is the number one challenge facing manufacturers with 86% of firms saying that staff do not have the skills to utilize new technologies and 90% of firms saying they simply do not have sufficient time to conduct the necessary planning to scale innovations.

Artificial Intelligence (AI) software is hyper relevant in this context because the world of robotics automation programming has been anything but smooth and efficient. Until recently, projects were expensive, rigid, and clunky to implement, with optimization tuned for a specific or narrow set of tasks. Additionally, because of the heavy lift to deploy new automation workflows, many repeatable tasks that companies wanted to automate were avoided due to the complexity, time, and cost of doing so.

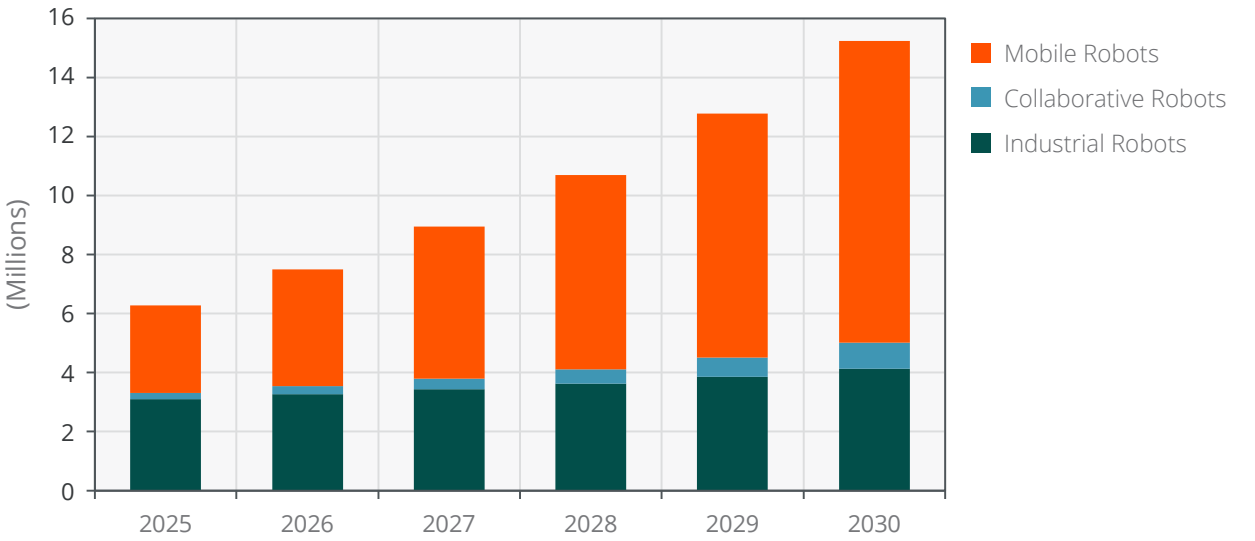
AI-enabled robotics software alleviates such issues by offering a low-code environment for a wide array of users to instantiate automation workflows rapidly, speeding time-to-value. Not only that, but full-stack, closed-loop systems that process data at the edge use real-time sensor inputs to facilitate actions that are adaptive to changing environmental conditions. This new cohort of solutions means that automation projects once considered unattainable become the new best choice.

Programmers, engineers, and frontline workers will all have a say in these new automation deployments. First, employees with practical knowledge will provide important validation as part of workflow automation. Over time, it may make sense for higher degrees of autonomy that see people monitoring an implementation, and, eventually, being entirely hands-off—or "out-of-the-loop"—for true, adaptable automation.

Low-code, AI-enabled software that operates in a closed-loop fashion at the edge is a key enabler for this new era of automation.

Figure 1: Commercial & Industrial Robot Installed Base

Source: ABI Research



WORKFLOW AUTOMATION: HUMAN-IN-THE-LOOP TO HUMAN-ON-THE-LOOP

WORKFLOW AUTOMATION

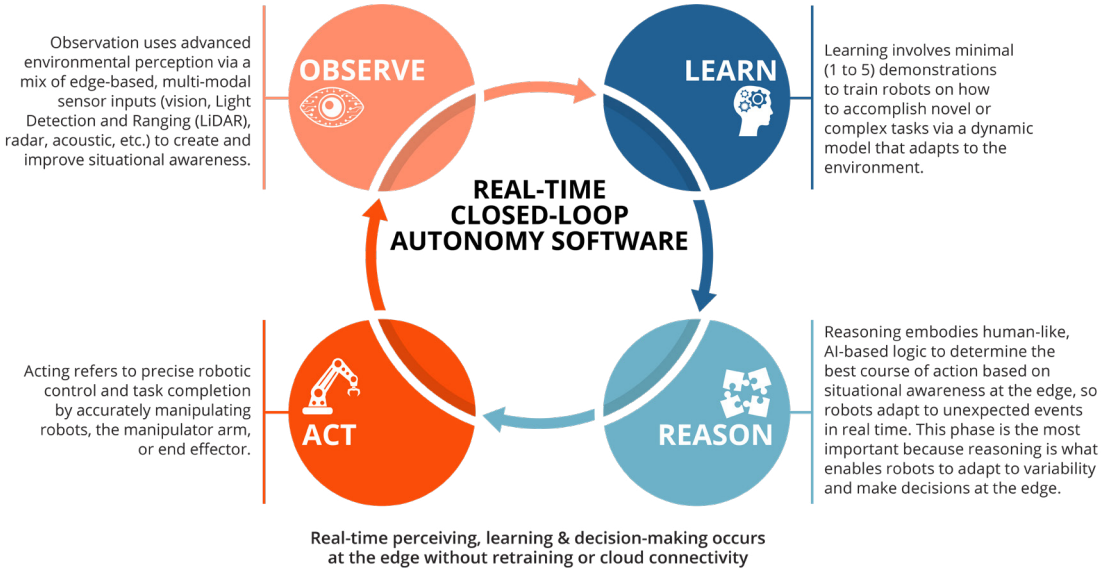
Workflow automation involves a series of steps or actions that operate in sequence to achieve an intended result. Historically, approaches to automation were rigid and expensive, requiring significant internal resources, the help of suppliers, or employing third-party consultants any time a change needed to be made. For these reasons, many automation workflows were considered uneconomical and avoided altogether.

AI software completely changes this dynamic by democratizing workflow automation to its users and enabling workflows that previously could not be automated due to the complexity of the process or environment. The most modern and capable solutions take a full-stack, closed-loop approach to not only enable new use cases for robotics automation, but also to drive more autonomy into implementations.

Full-stack, closed-loop autonomy allows automation to operate more like humans in terms of flexibility and responsiveness to changes, but with the reliability and repeatability of equipment that makes workflow automation desirable.

Full-stack solutions use vision systems and sensors for real-time, edge-based observation; holistic software for learning and reasoning based on data inputs; and executable hardware (robotics) that act to complete the desired task. The loop from observing, learning, reasoning, and acting is closed by feeding information between these tenets at the edge, so adjustments can be made in real time.

Figure 2: Closed-Loop AI Software Automation
(Source: ABI Research)



THE HUMAN FACTOR

People are an important part of the equation. For initial robotics automation implementations, and potentially for some time, a human is likely to be in-the-loop (Human-in-the-Loop (HITL)) to validate the reasoning and actions taken by the robot(s) as part of a workflow. This scenario caters especially well to situations where there is high safety concern, such as spot welding, grinding and sanding of componentry, or the cage-free assembly of heavy equipment.

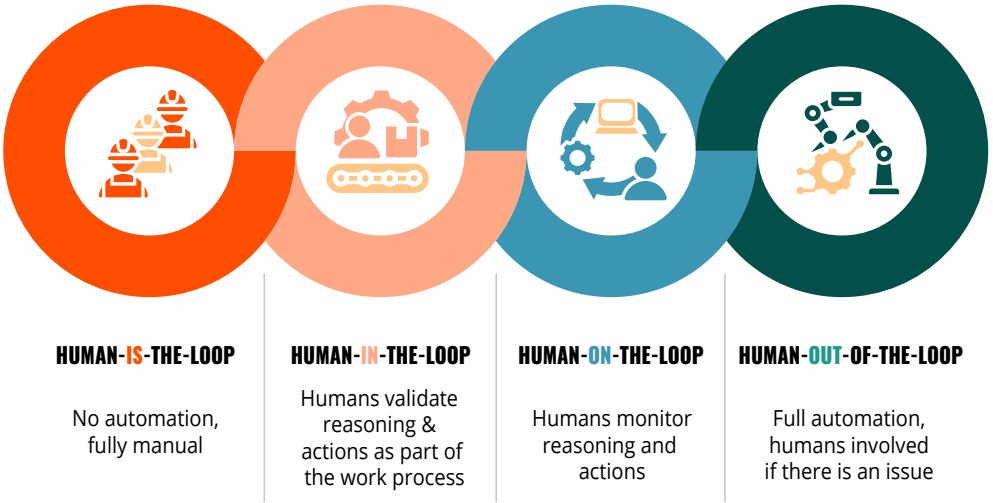
Human involvement can also be on-the-loop to monitor the reasoning and actions taken by robots. Human-on-the-Loop (HOTL) implementations are a step toward higher degrees of autonomy because the role of people is to monitor the processes of the robot, rather than validate actions.

The final stage is for a human to be out-of-the-loop (Human-out-of-the-Loop (HOOTL)), meaning that any involvement or intervention occurs only if there is an issue that cannot be resolved autonomously by the system; the default state is for a fully autonomous workflow.

One phase is not better than another. Rather, the phases present a framework to measure and manage the implementation journey that manufacturers must face.

Figure 3: Phases of the Automation Journey Using AI-Enabled Robotics Software

Source: ABI Research

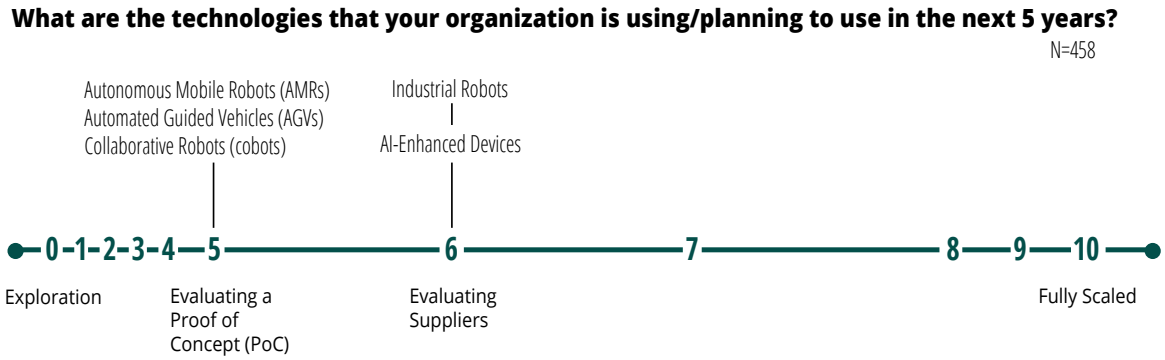


According to ABI Research's 2025 Survey of Manufacturers, most firms are evaluating proofs of concept for Autonomous Mobile Robots (AMRs), Automated Guided Vehicles (AGVs), and Collaborative Robots (cobots), while, for industrial robots, they are evaluating suppliers.

AI-enabled robotics automation software uplevels these endpoints by allowing them to be used for automation tasks previously untenable, recognizing that the role of humans will evolve depending on the use case, level of automation, and maturity of the deployment.

Figure 4: Manufacturing Technology Adoption

Source: ABI Research's 2025 Survey of Manufacturers



MANUFACTURING AUTOMATION CASE STUDY: SURFACE PREPARATION & QUALITY ASSURANCE

75% of manufacturers believe that AI is important if not essential for new solutions, and 71% emphasize the criticality of coming to grips with new solutions in a matter of hours.

—2H 2024/1Q 2025 Industrial and Manufacturing Survey

Surface preparation and component cleaning are critical aspects of many industrial applications, including general manufacturing, Maintenance, Repair, and Overhaul (MRO), and re-manufacturing processes. Traditionally, these activities have been labor-intensive and difficult or impossible to automate due to the complexity and variability of products, tasks, and the environment.

For the people who do these jobs, the processes are often dirty, demanding, and sometimes hazardous, making it difficult to keep workers for more than a few months. Then, when people rotate to a different job, there is extra time and cost not only for training new employees, but also performing quality inspections.

AI-enabled robotics software alters the fundamentals of this situation by making automation workflows the most logical choice, rather than an impossibility. For example, by using the Palladyne IQ software on a cobot arm, frontline workers can create automation workflows that incorporate multiple steps, cleaning tools, and varying component types—all in a single shift.

The AI software leverages the observe, learn, reason, and act closed-loop framework to allow frontline robots to operate like humans with real-time perception and decision-making for complex tasks that are beyond the scope of traditional, hard-coded programmable robots.

This means that cobots can autonomously identify the component model and perform a visual inspection of it, select the right cleaning tools (wire brush, drill bit, hydro-blasting, etc.) based on the surface characteristics, and use the tool to clean any imperfections. After initial cleaning, the cobot can perform a visual inspection to identify any issues that require attention.

The Palladyne IQ software not only democratizes implementations for those with practical knowledge by virtue of its low-code environment, but also alleviates the need for constant

employee retraining by making automation tasks such as surface prep and Quality Assurance (QA) both attainable and cost-effective. Such workflow automation means greater accuracy and traceability through a reduction in human error/involvement, and closed-loop sensing/reasoning/execution at the edge allows the implementation to be adaptable to changing components and conditions.

ADOPTION BEST PRACTICES

The selection of a human-in-the-loop versus human-on-the-loop implementation is predicated on the level of digital maturity, task set, and scale. Value comes from easier programming, the ability to automate tasks previously considered too complex or costly, and a vision of what "good" looks like. Consequently, the following three steps will help you get the most value from AI-enabled robotics software in the manufacturing automation journey.

IDENTIFY CORE ISSUE/PAIN

Defining the problem to be solved is the most important first step. This stage is where you determine the scope, efficacy, and desired impact of the solution. Often, the target task(s) will be considered historically difficult to automate, hazardous, time consuming, and/or labor-intensive. Analyzing the current situation before implementation will provide a baseline for comparison to measure success.

DEFINE YOUR LOOP

Defining the feedback loop and ensuring a full-stack approach that enables robots to execute tasks at the edge with real-time information is critical. The role of humans in relation to the feedback loop—how involved they are for validating versus monitoring actions—may change over time, and this second step is the right opportunity for such considerations.

It is very likely that humans will start out in-the-loop to ensure the intended Key Performance Indicators (KPIs) are achieved. Over time, users may aim for higher degrees of autonomy by transitioning humans to a role of monitoring, rather than validating, actions.

Eventually, a human might be taken out of the loop due to the inherent trust established by workflows that are not only automated, but also adaptable for unconstrained, changing conditions. This final phase allows employees to triage issues, rather than be an embedded/required part of the workflow for action to occur.

START SMALL, SCALE FAST

Start with a couple of deployments that focus on solving a single set of problems to justify the business case for implementation. Use the early phases of deployments to democratize familiarity with the new solution so more people are empowered to apply similar capabilities to additional problems/areas. As more users get up to speed on the potential for AI-enabled robotics software automation, solicit input on other business problems that have the potential to be addressed by your company's newfound capabilities. For example, robotics automation solutions have relevance beyond the production line that should be assessed, such as for raw material sorting prior to manufacturing, assembly operations after parts are made, and quality assurance throughout the production process. From here, rinse and repeat steps one (issue identification) and two (define your loop).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