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Smart Manufacturing in Automotive: Deployment and impact

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Executive summary

The automotive industry is entering a new phase of AI/machine learning (ML) and automation. The question for manufacturers serving the automotive, tire, and battery markets is no longer whether to adopt, but how quickly and where to put smart manufacturing to work, according to Center for Automotive Research (CAR) analysis.

Automakers and suppliers already operate with industry-leading automation, particularly in body, paint, and welding. What is changing is where it's applied. Manufacturers globally are moving into areas that have historically been harder to automate, including electronics assembly, validation, production coordination, and logistics. AI/ML is simultaneously improving predictive maintenance, inspection accuracy, and system performance across existing operations.

The drivers are clear: more complex production environments, persistent warranty issues, rising commodity costs, and global competition are leaving less room for late-stage fixes and reactive management. Automation is also enabling onshoring by supporting cost-competitive production under tight labor market conditions.

The results are measurable. Manufacturers reported reductions in unplanned downtime of up to 50% in select applications, overall equipment effectiveness (OEE) improvements of approximately 5%, and throughput gains of 5-7% from real-time production analytics. Autoliv's productivity acceleration, from roughly 4% in 2023 to over 9% in 2025, is one of the more concrete indicators of what sustained investment can deliver, in CAR's view. Putting this into perspective, Durable Goods Manufacturing averaged just 2.7% productivity growth in 2025, while Motor Vehicle Parts (NAICS 3363) data through 2024 ranged from 2.6% to 5.9% annually.

The impact is already visible on the plant floor. Teams using advanced AI/ML technologies are identifying issues earlier, reducing downtime, and improving process consistency across plants. These gains, however, are not uniform. Differences in how companies embrace smart manufacturing, particularly in quality, uptime, and process controls, are beginning to separate higher and lower-performing manufacturers and suppliers, according to CAR research.

Leading companies are extending these capabilities across plants and process functions, and they are increasingly expecting the same of their suppliers. The industry and supply base are also developing gaps that carry strategic implications for sourcing, program execution and long-term competitiveness.

Automotive: Industry-leading Smart Manufacturing

The 2026 Rockwell Automation State of Smart Manufacturing survey places automotive alongside high-performing, hi-tech and life sciences in overall deployment and future investment intent. The matrix below maps industries by current deployment level and planned investment; automotive sits in the leading quadrant on both dimensions.

Manufacturing industry Smart Manufacturing matrix

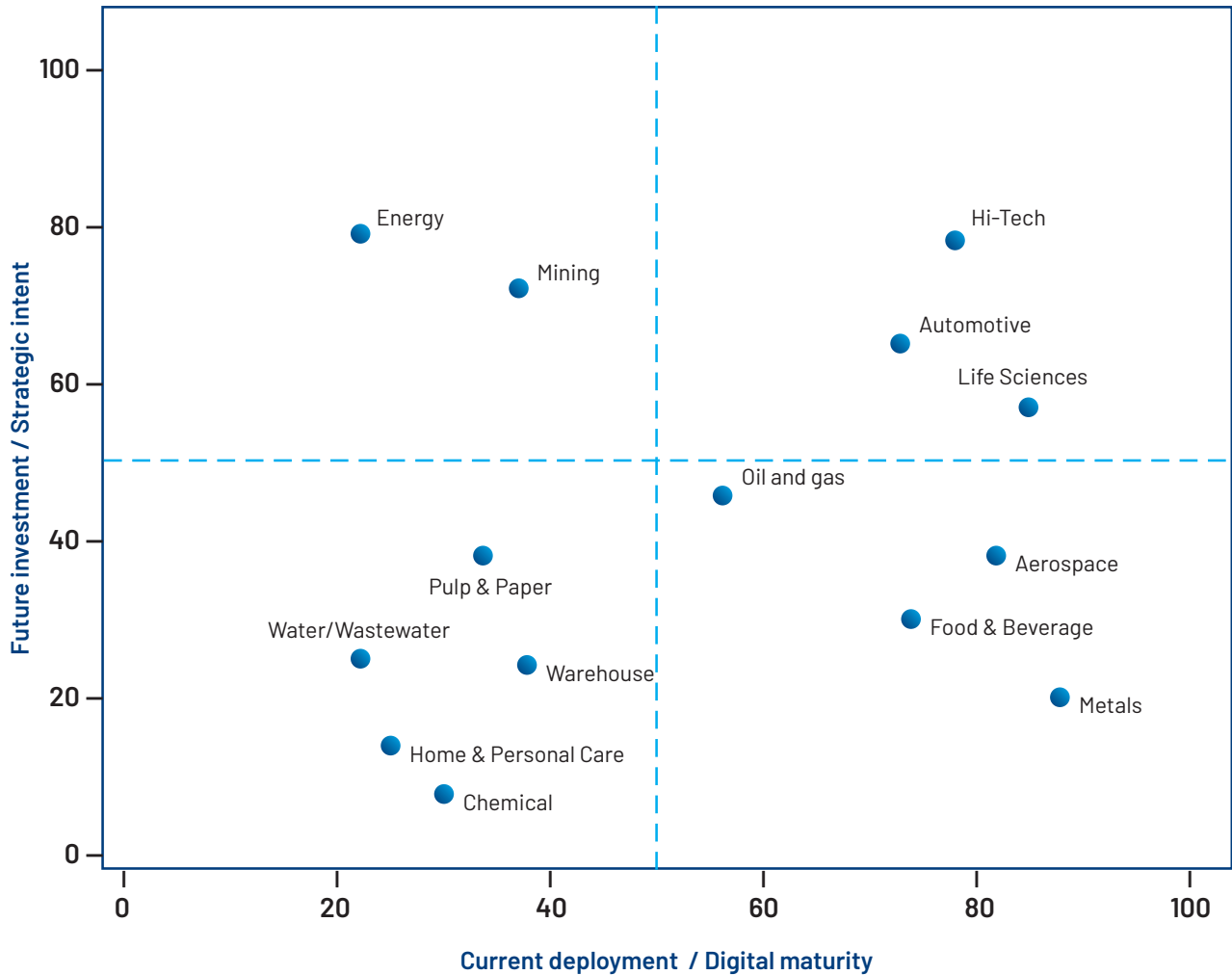


Figure 1. Manufacturing industry smart manufacturing matrix

Source: 11th Annual State of Smart Manufacturing Report, Rockwell Automation

Methodology: The matrix compares industries based on two composite measures aggregated across all smart manufacturing technology categories. The Digital Maturity Index (X-axis) measures current adoption using the percentage of respondents reporting that they have “already invested” in relevant technologies. The Future Intent to Invest Index (Y-axis) measures planned adoption using the combined percentage of respondents planning to invest within the next 12 months and within the next five years.

The automotive industry already operates with extensive automation across stamping, body, paint, welding, and final assembly – built for repeatability, throughput, and precision. What these systems were not originally designed to do, however, is to manage real-time variability, anticipate equipment failures, or coordinate across complex production sequences.

CAR research identifies the next phase for automation systems within automotive as extension – not replacement. AI and expanded automation are reaching into areas for automakers and suppliers that have historically depended on operator experience and judgment. The following illustrates where those gaps persist and what is now possible.

HISTORICAL CHALLENGE	SMART MANUFACTURING PATH FORWARD
<p>Quality & inspection Manual checks and post-process validation create inconsistency at scale</p> <p>Process Control Weld, torque and calibration parameters rely on operator judgement</p>	<p>Inline sensors and vision systems enable continuous, automated defect detection</p> <p>Automated process control replaces operator judgement with defined, measureable standards</p>
<p>Electronics integration Legacy automation was not designed to address new failure modes</p>	<p>AI-assisted validation adapts to evolving vehicle architectures and failure signatures</p>
<p>Production coordination Disruption response depends on manual intervention</p> <p>Maintenance Reactive and schedule-based despite available real-time equipment data</p>	<p>Connected platforms enable dynamic re-sequencing with minimal human input</p> <p>Predictive models shift operations from time-based schedules to condition-based action</p>

Flexible powertrain strategies, where ICE, hybrid, and BEV variants are produced on the same assembly lines, have compounded these challenges. So has the surge in electronic content, which brings greater software complexity, more demanding calibration, and additional validation steps. The net effect is a production environment far more complex than even a decade ago, one that increasingly demands system-level management and smart manufacturing solutions over task-level automation.

Automotive Industry – Smart Manufacturing: Why now

The push to expand automation and deploy AI/ML is being driven by a convergence of operational and competitive pressures, which have intensified over the past several years:

Production complexity

Mixed powertrain production has increased the number of variables that must be managed during daily vehicle assembly operations. Where a single-powertrain line might require managing dozens of process parameters, a mixed-line producing ICE, hybrid, and BEV variants simultaneously requires managing several times that number. Higher electronics content adds additional complexity, too, that is, more calibration steps, more validation requirements, more potential failure points.

Flexible manufacturing systems introduce additional variability. Each configuration adds parameters to monitor, thresholds to set, and decisions to make. This is where AI/ML is most useful: identifying patterns in high-dimensional process data that operators and engineers cannot monitor continuously.

Operational cost pressure

Commodity inflation, vehicle affordability constraints, and persistent margin (cost) pressure have increased focus on yield, scrap, throughput, and unplanned downtime. In this environment, late-stage quality fixes, emergency maintenance calls, and production disruptions that could have been anticipated carry potentially severe financial consequences. For example, a single production stoppage can cost tens to hundreds of thousands of dollars per hour at high-volume assembly facilities. Predictive maintenance systems that reduce unplanned downtime by even a few percent can deliver meaningful cost improvement.

Global competition

Competition from China is increasing expectations around speed, cost, and manufacturing integration. Furthermore, Chinese OEMs are reporting faster development cycles and tighter cost structures in part because of highly integrated, automated production environments. The expectation that domestic manufacturers can match these cost structures while producing more complex vehicles and simultaneously improving quality, is increasing pressure on both OEMs and suppliers to improve manufacturing performance.

Onshoring and labor

Automakers' onshoring (reshoring) commitments are running directly into persistent labor shortages across parts of the supply base. Automation is enabling cost-competitive production under conditions where labor supply is constrained. The jobs that return from reshoring will be more automated than the jobs that left, requiring a different skill set and a different manufacturing model. System-guided processes reduce dependence on experienced operators and can maintain production consistency even when experienced personnel are unavailable.

Limits of existing systems

Existing automation is strong in repeatability but less effective in managing variation, disruption, and complexity. The automotive industry may be pressing the limits of what task-level automation can deliver. The next phase of performance improvement, in quality, uptime, productivity and responsiveness, requires systems that can learn, adapt, and support decisions in real time rather than executing fixed instructions.

Smart Manufacturing within the Automotive Industry

Figure 2 below, maps automotive technology deployment and future investment against the industry average, using 2026 Rockwell Automation survey data. Automotive investment intent is so far concentrated in quality, analytics, and automation systems, consistent with the operational priorities described in this paper.

Manufacturing industry Smart Manufacturing matrix

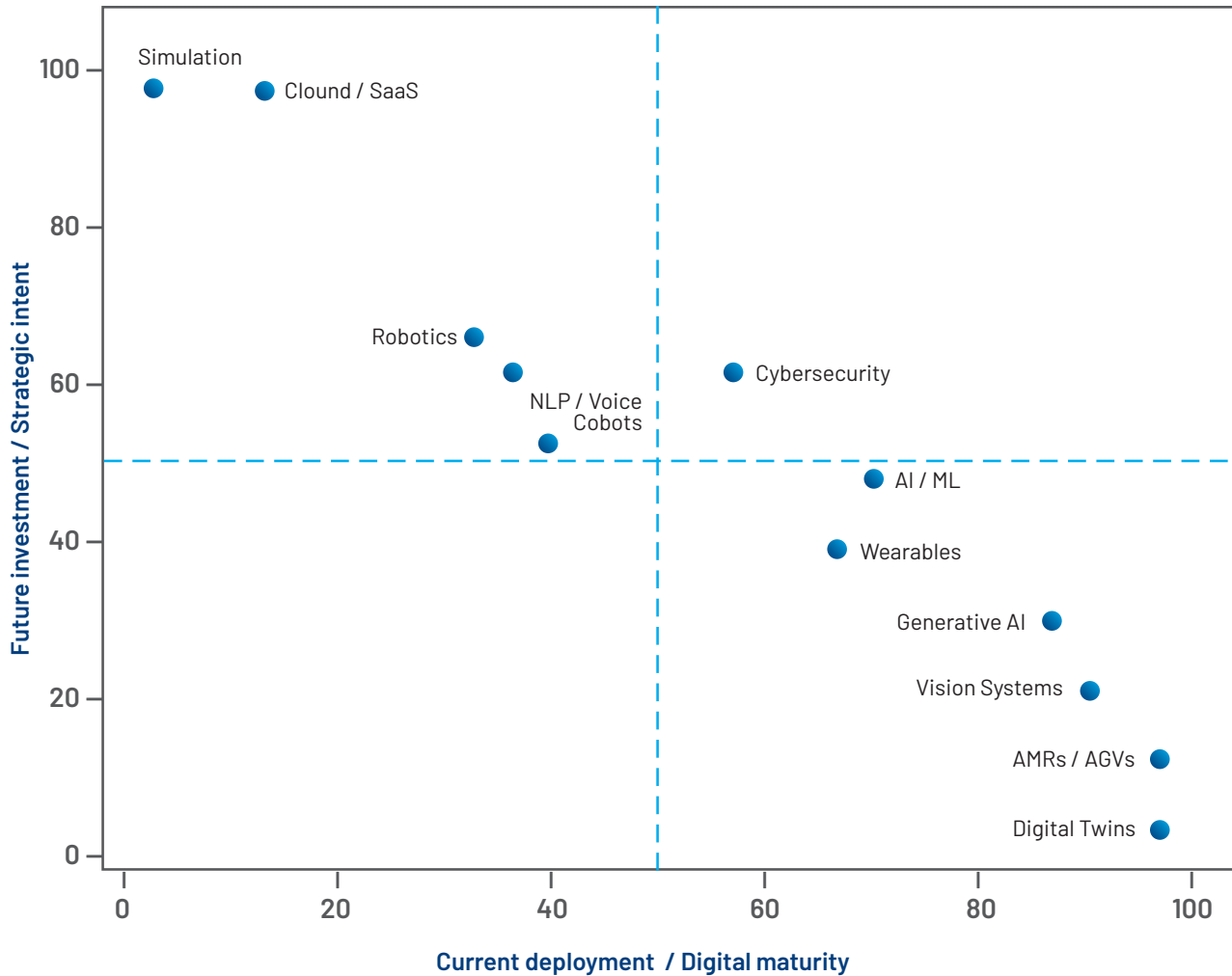


Figure 2. Automotive technology deployment and future investment matrix
 Source: 11th Annual State of Smart Manufacturing Report, Rockwell Automation

Methodology: The matrix compares smart manufacturing technology categories within the automotive industry using two composite measures. The Digital Maturity Index (X-axis) measures current adoption using the percentage of automotive respondents reporting that they have “already invested” in each technology category. The Future Intent to Invest Index (Y-axis) measures planned adoption using the combined percentage of respondents planning to invest in each technology category within the next 12 months and within the next five years.

Quality processes

Inspection has historically included manual checks and post-process validation. Automation is expanding into in-line inspection and anomaly identification during production. AI/ML supports detection and classification, but the primary shift is moving quality processes closer to the point of production, that is, catching problems before they propagate through assembly.

Examples include AI-enabled vision systems for paint and surface inspection, automated electronics validation, in-line anomaly detection on body panels, and traceability systems that link process parameters to specific vehicle or component builds. According to CAR research, when a field quality issue appears, manufacturers with full traceability can identify the root cause and affected population in hours rather than weeks.

Process monitoring and adjustment

Core processes are automated but monitoring and adjustment have often relied on operators and engineers reviewing data after the fact. Systems are increasingly being deployed to standardize monitoring and automate parameter adjustments, reducing reliance on shift-to-shift judgment and improving repeatability across facilities.

Examples include automated adjustment of weld parameters when process drift is detected, torque setting verification and correction during assembly, calibration routine automation for electronics-intensive vehicles, and paint application parameter adjustment based on real-time environmental conditions. These adjustments happen continuously and systematically in advanced operations, not episodically based on operator observation.

Equipment diagnostics and maintenance

Maintenance decisions have traditionally been schedule-based or reactive. Automation is expanding into continuous diagnostics and condition-based maintenance workflows. AI/ML supports earlier identification of equipment issues and helps reduce unplanned downtime by identifying developing problems before they cause failures.

Applications include welding robots, stamping presses, paint line conveyors, and assembly robots, equipment categories where unplanned failure has high production cost. Manufacturers using real-time monitoring and predictive analytics have reported reductions in unplanned downtime of up to 50% in select applications, along with improvements in overall equipment effectiveness (OEE) of approximately 5% and measurably faster bottleneck identification.

Production coordination and response

Scheduling, sequencing, and disruption response have historically fallen to experienced production supervisors. AI and ML solutions are now taking on more of that coordination work – automating routing, logistics response, and production recovery in real time.

In one example, a Tier 1 supplier reduced line stoppages by connecting real-time production data to automated resequencing logic, eliminating response delays that previously required supervisor intervention.

Engineering and enterprise functions

AI/ML applications are also expanding beyond the plant floor. Engineering teams are using simulation and digital twin tools to accelerate vehicle development, reduce physical prototype cycles, and evaluate manufacturing process trade offs before tooling is cut. Quality teams are using field-to-plant data linkages to identify warranty root causes earlier in the production cycle. Planning functions are using scenario analysis, enabled by digital twins, to improve production sequencing and logistics coordination under variable demand conditions.

What is changing in practice

The operational effects of expanded automation and AI/ML are increasingly visible and, increasingly, measurable. The pattern across early applications is consistent: more production steps are governed by defined, repeatable systems; problems are detected closer to the point of occurrence; maintenance is shifting from reactive to condition-based; and decisions are becoming more consistent across shifts and plants.

Earlier issue detection

In traditional operations, quality issues often surface during end-of-line inspection, at the customer, or in warranty data. Each of those detection points is expensive. Moving detection upstream, into the production process itself, reduces the cost of containment and the volume of affected vehicles or components.

AI-enabled vision systems identify surface anomalies during paint or body operations that previously required manual inspection. Electronics validation systems catch calibration and software issues during assembly rather than at end-of-line. The practical effect is smaller containment populations, faster root-cause identification, and fewer vehicles affected before a problem is isolated.

Predictive maintenance replacing reactive approaches

Traditional maintenance schedules don't account for how equipment is running. Condition-based maintenance, supported by continuous monitoring and AI/ML pattern recognition, replaces fixed schedules with real-time equipment intelligence.

Early deployments have shown 40–60% reductions in unplanned downtime. For high-utilization equipment like stamping presses and welding robots, that reduction translates directly to production cost and throughput.

Reduced variation across shifts and plants

One of the persistent challenges in manufacturing is maintaining consistent performance across shifts and facilities. Experienced operators and engineers develop judgment over time, and that judgment does not transfer automatically to new hires or different plants. System-guided processes reduce that dependence by encoding best practices into defined, repeatable workflows.

Manufacturers deploying standardized monitoring and automated process adjustment report more consistent quality metrics across shifts. In one body shop application, real-time analytics identified a framing-line bottleneck that had not been isolated, producing a 5...7% improvement in cycle time and a four-jobs-per-hour throughput gain. Launch teams with better visibility into process performance can identify and address variation faster during ramp-up, when the cost of variation is highest.

Operational productivity: The Autoliv example

Autoliv, a leading global producer of safety systems, provides one of the more concrete supplier-level examples of what sustained automation investment can deliver, in CAR's view. The company reported direct labor productivity improvements accelerating from approximately 4% in 2023 to more than 8% in 2024 and over 9% in 2025. Management has since raised its annual productivity guidance to 8%, citing additional automation opportunities in logistics and operations.

Autoliv was already a strong productivity performer as an early-adopter of automation. BLS data put that performance in perspective: Durable Goods Manufacturing as a whole averaged modest or negative direct labor productivity growth over 2020–2024, ranging from 0.8% in 2021 to -1.1% in 2023, before recovering to 2.7% in 2025. Motor Vehicle Parts manufacturers (NAICS 3363) showed more volatility, swinging from

-2.6% in 2020 to a peak of 5.9% in 2022 before moderating to 2.4% in 2024 (2025 data not yet available). Against these benchmarks, Autoliv's 8.1% in 2024 and 9.2% in 2025 reflect the returns from an early and sustained commitment to automation, now extended into AI/ML and digitalization. The company has reached a productivity growth rate roughly three to four times that of the broader durable goods sector, an advantage that compounds year over year in cost structure and manufacturing competitiveness.

Automotive supplier productivity comparison

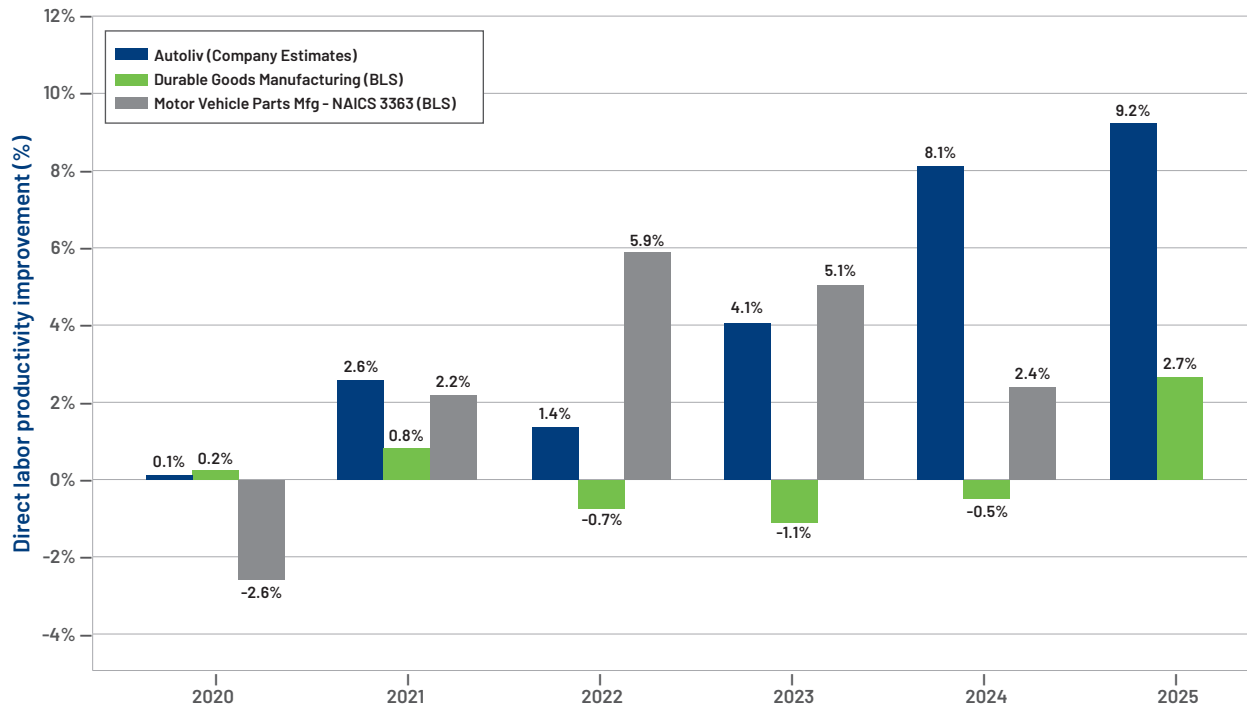


Figure 3. Automotive supplier productivity comparison, 2020-2025
 Source: BLS/BEA; Autoliv company estimates; CAR Analysis|* 2025 data not yet available for NAICS 3363

What this means: Strategic implications for the Automotive Industry

A performance divide is emerging

Early-adopters are reporting measurable gains in quality, uptime, productivity, and launch execution. Companies that have not yet made comparable investments are competing against those results with legacy systems and manual processes. That gap widens each year, and CAR interviews indicate it is beginning to influence sourcing and contract award decisions.

Uneven adoption across the supply base

Large Tier 1 suppliers with global operations and dedicated manufacturing engineering resources are generally further along in deployment. Mid-sized and smaller suppliers face a more difficult path, with fewer resources and less institutional bandwidth. The gap between what leading OEMs expect and what many suppliers can currently deliver is observable and growing. OEMs are increasingly weighing automation capability alongside cost, quality history, and capacity in future program assessments.

Rising expectations from automakers

As automakers extend smart manufacturing across production, engineering, and quality operations, they are raising expectations for their supply base. Greater responsiveness, more consistent quality, and better production visibility are becoming baseline expectations rather than differentiators.

Some automakers are explicitly communicating automation requirements in select commodity categories, with direct consequences in sourcing decisions.

Onshoring will be more automated than before

Increased domestic production commitments, driven by tariffs and trade policy, supply chain resilience, and customer requirements, are materializing against persistent labor constraints across parts of the supply base. Production that returns will not look like the production that left: it will be more automated, more data-intensive, and require a different workforce skill set.

Future operations will rely more heavily on system oversight and process engineering than on direct labor in traditional assembly roles. Manufacturers planning those moves must account for workforce development, facility design, and capital investment accordingly.

What comes next

For manufacturers already well along in automation deployment, the next phase is about leveraging AI/ML alongside automation rather than simply deploying new systems. The emphasis is shifting toward combining these tools to generate measurable gains in throughput, productivity, and process consistency. AI/ML is increasingly how manufacturers are unlocking the full value of their automation investments.

Throughput and productivity

Many manufacturers have deployed monitoring, analytics, and automation systems that are not yet fully integrated or fully used. Closing those gaps is the next phase of improvement. Better integration across quality, maintenance, and production coordination tools can deliver throughput gains without additional capital investment. In many operations, the bottleneck is not hardware capacity but information latency: the time between when a problem develops and when the right person can act on it.

Faster detection and response

Shorter response cycles are the operational objective that ties together quality, maintenance, and production coordination. A system that identifies a developing equipment issue ten hours before it causes a failure is more valuable than one that identifies it ten minutes before. A quality system that catches a process excursion before it affects ten vehicles is more valuable than one that catches it at end-of-line. The competitive advantage of AI/ML in manufacturing is fundamentally about speed: reducing the time between problem onset and resolution.

Closer alignment between design, manufacturing, and operations

The longer-term direction is more integrated systems that connect engineering, manufacturing, and field operations in ways that current architectures do not support. Field quality data informing engineering design in near real time. Manufacturing process parameters linked to vehicle performance in the field. Production planning systems that incorporate actual manufacturing capability constraints rather than theoretical capacity.

This integration is not trivial to achieve – it requires data infrastructure, organizational alignment, and process discipline that most manufacturers are still building. But the companies that get there first will have a structural advantage in product development speed, quality performance, and cost that is difficult to replicate quickly.

The supplier transition

For suppliers that have not yet made significant investments in automation and AI/ML, the window for catching up without consequences is narrowing. OEM expectations are rising, sourcing criteria are evolving, and the operational gap between leading and lagging suppliers is widening. For most mid-sized suppliers, the right starting point is not a comprehensive digital transformation program but identifying two or three high-impact applications where investment can deliver measurable results quickly, and building from there, according to CAR interviews.

Key takeaways

- Automotive starts from an already industry-leading automation levels. The current shift is about where and how automation and AI/ML are applied, not necessarily building a foundation from scratch.
- The expansion is into areas that have historically been manual, variable, or operator-dependent: electronics assembly and validation, in-line quality processes, equipment diagnostics, and production coordination.
- AI/ML is enabling and supporting this expansion. Its primary value is improving how automated and manual systems identify issues, support maintenance decisions, improve quality processes, and manage complexity from mixed powertrains and higher electronics content.
- Early results are measurable. Manufacturers reported reductions in unplanned downtime of up to 50% in select applications, Overall equipment effectiveness (OEE) improvements of approximately 5%, and throughput gains of 5...7% from real-time production analytics. Autoliv's productivity acceleration, from roughly 4% in 2023 to over 9% in 2025, is one of the more concrete indicators of what sustained investment can deliver, in CAR's view. For context, Durable Goods Manufacturing averaged just 2.7% productivity growth in 2025, while Motor Vehicle Parts (NAICS 3363) data through 2024 has ranged from -2.6% to 5.9% annually.
- A performance divide is emerging. Differences in automation deployment and AI/ML use are producing measurable gaps in quality, uptime, and cost performance between leading and lagging manufacturers and suppliers.
- Gaps across the supply base have strategic implications. Sourcing decisions for select commodities are increasingly incorporating assessments of automation capability and manufacturing consistency alongside traditional cost and quality criteria.
- Onshoring will require more automation. Production returning to domestic facilities must be cost-competitive under tight labor market conditions, which means more AI/ML applications as well.
- The next phase for leading companies is performance improvement, not simply more deployment. The focus is shifting from implementing automation and AI/ML tools to extracting measurable throughput, productivity, and responsiveness gains from what is already in place.

This whitepaper was prepared by the Center for Automotive Research (CAR) along with contributions from Ted Mabley, UHY Consulting. Smart manufacturing survey data sourced from the 11th Annual State of Smart Manufacturing Report from Rockwell Automation. Company performance data sourced from public filings and CAR interviews. Productivity comparison data sourced from U.S. Bureau of Labor Statistics and Bureau of Economic Analysis.



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