MITSUBISHI ELECTRIC

Changes for the Better

Automating the World

FACTORY AUTOMATION

White paper

Industrial AI in Automotive Manufacturing: From Predictive Welding Analytics to Factory-Wide Optimization.

With comments by

Stephen Methogo,

Director of EV & Lithium-Ion Battery Industries EMEA,

and Giuseppe Polimeni,

Automotive Industry Director, GKAM and Japanese End Users, Italy

Contents

Executive Summary

The automotive manufacturing sector is undergoing its most significant transformation since the introduction of assembly lines. As production complexity increases, and as the industry simultaneously shifts toward electric vehicle production, manufacturers face unprecedented challenges in maintaining quality, efficiency, and sustainability. Traditional manufacturing approaches are no longer sufficient in modern automotive plants, where a vehicle may require up to 7,000 welding points, and the production schedule demands a finished car every 60 seconds.

The urgency of this transformation is reflected in market projections[1]: the global automotive artificial intelligence market, valued at USD 3.2 billion in 2023, is expected to reach USD 35.7 billion by 2033.

This paper explores three distinct AI applications in automotive manufacturing, each addressing specific operational challenges:

- **Predictive welding analytics** that enables 100% process control with 97% accuracy
- **Real-time energy optimization** that achieves up to 30% reduction in energy costs
- **Advanced visual inspection** that processes up to 200 parts per minute with 99.8% accuracy
- **Enhanced automated testing** that delivers repeatable and flexible solutions

---

Real-world implementations across major automotive manufacturers demonstrate how these AI applications deliver significant improvements in quality, energy efficiency, and operational reliability, with ROI achievement often within 6–12 months.

[1] Precedence Research - Automotive Artificial Intelligence (AI) Market Size, Share, and Trends 2025 to 2034.

The Evolving Automotive Landscape

Modern automotive manufacturing operates at the intersection of precision, speed, an complexity. The global welding market, valued at $21.15 billion in 2023[2], is expected to grow at a CAGR of 4.2% from 2024 to 2031, with automotive representing 28% of the total demand. This growth occurs within a broader transformation: the global smart manufacturing market[3] is projected to reach USD 741.30 billion by 2030, growing at a CAGR of 13.5% from 2023.

Key Industry Challenges:

- 71% of manufacturers report skilled worker shortages
- Quality defects contribute to 15-20% of production costs
- Energy inefficiencies persist due to inadequate monitoring
- One-third of facilities struggle with process repeatability

The Digital Transformation Imperative

Industry research[4] indicates that by 2025, 75% of large manufacturers will use AI and IoT-enabled manufacturing execution systems. This transition is underway, with 47% of automotive manufacturers[5] implementing AI for quality control and predictive maintenance. Companies implementing AI-driven quality control systems report an average 30% reduction[6] in defect rates.

In 2022, 82% of firms recognized quality control automation as a priority[7]. However, traditional inspection methods can only cover a fraction of critical points. Common defects—from welding to assembly—include[8] particle size deviations, temperature irregularities, color inconsistencies, contamination, and incorrect moisture levels, as well as surface defects, machining or molding imperfections, and assembly errors by inexperienced workers. These subtle variations are especially challenging for human inspectors to detect consistently, particularly at production line speeds.

"Modern manufacturing deals with enormous complexity - from thousands of welding points per car to energy-intensive tire production processes. Traditional quality control and monitoring methods simply can't keep up,"

— Stephen Methogo, Director EV & Lithium-Ion Battery Industries EMEA at Mitsubishi Electric

Predictive Welding Analytics: a Deep Dive

Resistance spot welding is a critical process in automotive manufacturing, determining vehicle safety and durability. Each car may require over 7,000 welding points, and production lines are often completing one car per minute. At this pace, traditional quality control is a statistical gamble —only 4-5% of welding points are typically inspected, with 92% accuracy at best.

> *"When connecting steel or aluminum sheets using high-intensity current, even minor variations can compromise structural integrity. Yet most manufacturers still rely on manually inspecting a tiny fraction of welding points."*
>
> **— Stephen Methogo, Director EV & Lithium-Ion Battery Industries EMEA at Mitsubishi Electric**

[2] Precedence Research - Automotive Artificial Intelligence (AI) Market Size, Share, and Trends 2025 to 2034.

[3] Grand View Research - Smart Manufacturing Market Size, 2023-2030

[4] Digital Twins and Industrial Internet of Things: Uncovering operational intelligence in industry 4.0 by Sharmin Attaran, Moshen Attaran and Bilge Gokhan Celik, Decision Analytics Journal Volume 10, March 2024

[5] Global Trade Magazine, Automotive Predictive Maintenance Market: Pioneering Efficiency and Reliability, August 5th 2024

[6] AI-Powered Quality Control Intelligence for Precision & Efficiency, Jesse Anglen - Co-Founder and CEO at Rapid Innovation

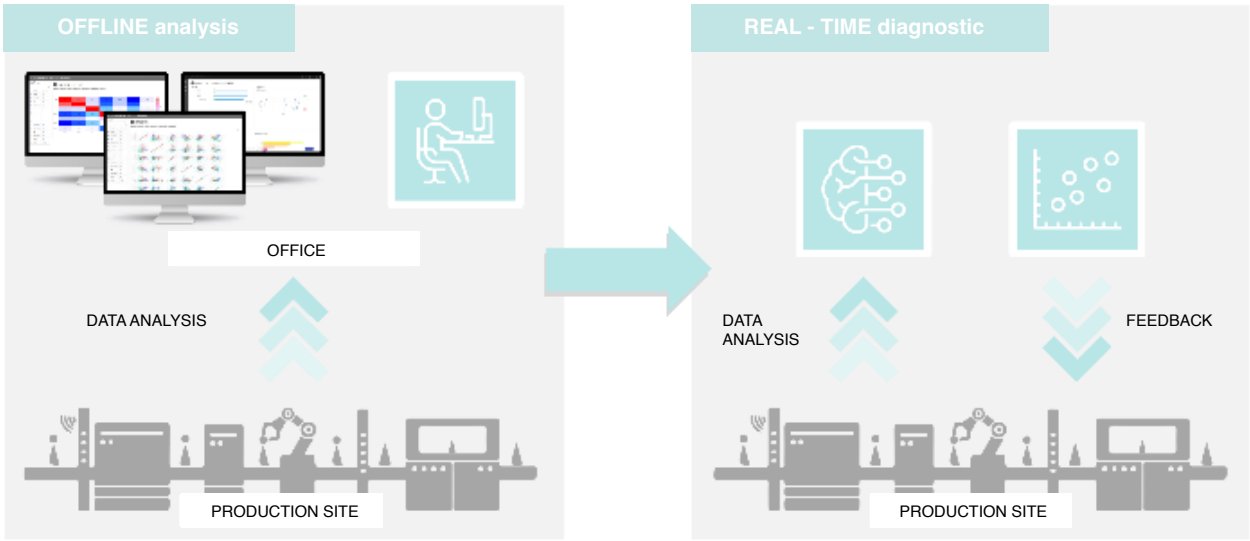
[7] Kofax 2022 Intelligent Automation Benchmark Study

[8] Strategies for Reducing Defect Rates in Commercial Feed Production Using the RCA, FMEA, and 5W+1H Methods in the Feed Industry at PT XYZ, Journal of Artificial Intelligence and Engineering Applications (JAIEA), February 2025

MELSOFT MaiLab: Real-Time Welding Analytics

MaiLab's AI-powered analytics enable continuous monitoring of all welding points, achieving 97% accuracy with 100% process control. By analyzing real-time data, it detects pattern deviations before they become defects—shifting quality control from statistical sampling to full process control.

Find out more about MELSOFT MaiLab



Capabilities

- Real-time monitoring of up to 30 parameters per second
- AI analysis of current, voltage, material properties, and resistance patterns
- Seamless integration with existing welding equipment through standardized interfaces
- Predictive maintenance capabilities with 95% accuracy
- Custom alerts for quality deviations

"MaiLab uniquely transforms existing factory data into real-time insights at the edge level. Unlike cloud-based analysis, which may act too late, MaiLab enables immediate feedback and correction."

— Stephen Methogo, Director EV & Lithium-Ion Battery Industries EMEA at Mitsubishi Electric

Implementation Process:

Following a structured improvement mode—such as the Smart Manufacturing Kaizen Level (SMKL)—can help align stakeholder objectives and provide a systematic framework for implementation.

The process typically begins with collecting data directly from the products or leveraging existing historical datasets. This step is crucial, as MaiLab requires specific parameters to function effectively. Once the data is gathered, the next phase involves creating and validating the AI model offline. This ensures that the model is robust and reliable.

Afterward, the AI model is tested against new samples from the production line to confirm its prediction accuracy under real-world conditions. Once validated, the system is configured for in-line deployment, including the visualization of results through dashboards and alerts.

This setup allows AI to act as a support tool for line-side operators, providing real-time insights that help optimize the production process with maximum efficiency.

A systematic approach may proceed as follows:

- Data quality verification (2-3 days)
- System configuration and parameter setting (2 days)
- Equipment integration (1-2 days)
- Operator training and system optimization (2-3 days)

Typical MaiLab Performance Metrics

- 97% defect detection accuracy
- 100% process control
- 65% reduction in manual inspection time
- 40% decrease in welding-related defects
- ROI in 6–12 months

"Recent implementations in major European automotive plants highlight MaiLab's transformative capabilities. At one facility in Poland, the system monitors every welding point across multiple production lines, ensuring instant quality verification without disrupting production. A similar success has been realized at an Italian plant, where MaiLab's pattern recognition has significantly reduced defect rates."

"What sets MaiLab apart is its ability to analyze existing factory data and convert it into actionable insights in real-time. The system integrates seamlessly with the existing infrastructure, requiring minimal adjustments to current workflows. Its true strength lies in edge-level hot data processing at the edge level—allowing real-time AI creation and validation. While cloud computing can analyze historical data to draw conclusions, this process often comes too late, after defects have already occurred. MaiLab bridges this gap, enabling immediate AI-driven responses, as close as possible to the machines on the production line."

— Stephen Methogo, Director EV & Lithium-Ion Battery Industries EMEA at Mitsubishi Electric

Energy Optimization in Automotive Manufacturing

Energy consumption, particularly in EV production, is a major cost and environmental issue—EV manufacturing can consume up to 80% more electricity than conventional vehicles. The increased energy intensity makes advanced monitoring and optimization systems essential, as traditional systems often offer limited visibility into energy patterns, rendering optimization efforts reactive rather than proactive.

EcoAdvisor: Understanding Energy Use

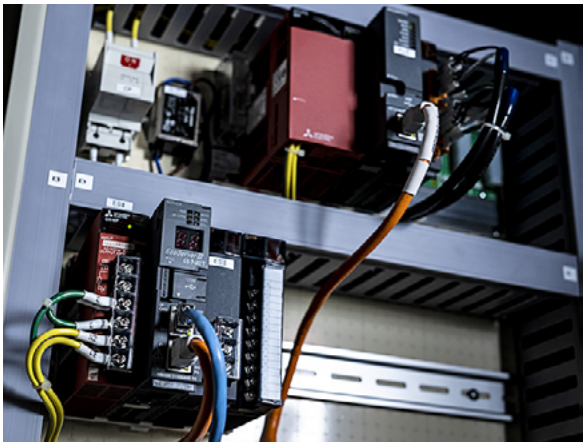
By combining sophisticated energy data collection, through local EcoWebServer III units with the advanced AI analysis capabilities of EcoAdvisor, real-time energy optimization becomes possible, along with the identification of potential causes of energy losses across complex manufacturing processes. In some early use cases, up to 30% reduction in energy costs has been realized, while supporting sustainability initiatives.

FIND OUT MORE ABOUT ECOADVISOR

[9] "Are electric vehicles definitely better for the climate than gas-powered cars?", MIT Climate Portal, October 13th 2022

Case Study: Yokohama Rubber's Onomichi Plant

The Onomichi Plant, specializing in large industrial tires, faced significant energy demands due to its complex manufacturing processes. As part of its carbon-neutral manufacturing initiative, Yokohama Rubber set a goal to reduce greenhouse gas emissions by 28% by 2030, compared to 2019 levels.



With EcoAdvisor, the facility was able to:

- Identify and reduce standby consumption (e.g., constant power consumption during low production periods, particularly in water pump operations)
- Optimized compressor usage during off-hours (e.g., night shifts and non-production periods)
- Achieve zero standby power consumption for inactive equipment
- Increase energy visibility at the department level
- Foster an inter-department energy-saving competition

"Previously, we could only describe the results rather than quantify them. EcoWebServer III and EcoAdvisor have made it possible to visualize the effects of actions like turning off wasteful lighting in a way that everyone can understand. Showing the actual power-saving figures really motivates each department."

— Takeshi Matsushita, Engineering and Maintenance Section, Onomichi Plant, The Yokohama Rubber Company.

READ MORE ABOUT THIS CASE STUDY HERE

Advanced Quality Inspection Systems

In general, manual inspection is limited by human attention spans, with peak concentration typically lasting for only 15–20 minutes, while production lines operate continuously. Traditional methods are not only challenging from a human resources perspective, due to fatigue-related errors, but also struggle as manufacturing parts become more complex and are produced at higher speeds and volumes.
To illustrate this point, consider the case of inspecting a battery tray assembly. With more than 500 rivets and 100 welds, all of which must meet stringent water-ingress requirements to prevent potential battery failures and ensure safety, traditional inspection processes may struggle to meet such demands.

MELSOFT VIXIO: Visual Inspection at Scale

MELSOFT VIXIO uses AI-powered pattern recognition to inspect up to 200 parts per minute with 99.8% accuracy. Unlike rule-based systems that typically detect only predefined defects, VIXIO can also use examples of “good” parts to identify a broader range of abnormalities such as random scratches and color shading variations. The system requires minimal setup and no programming expertise, generating inspection models within seconds.

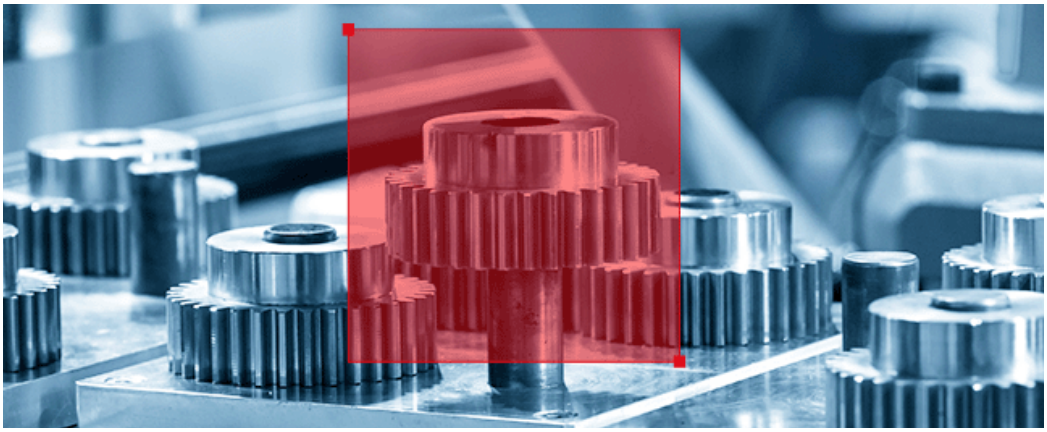
The system benefits:

- High-speed, high-precision AI inspection
- Code-free operation
- Flexible hardware integration
- Full batch traceability
- Standard camera compatibility

FIND OUT MORE ABOUT MELSOFT VIXIO

Typical Results

- Faster inspections
- 99.8% accuracy
- Zero missed defects due to human fatigue
- Fewer false positives
- Rapid ROI

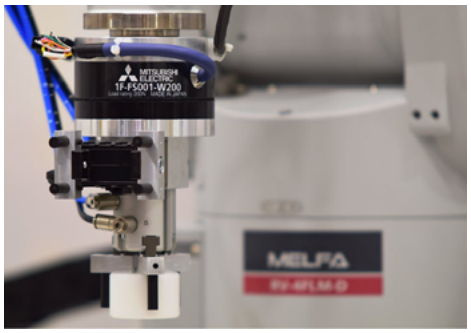


Enhanced Haptic Testing

While visual inspection systems like MELSOFT VIXIO are highly effective at identifying visible defects, certain automotive components—particularly human-interface elements such as door handles, buttons and levers—require more than visual analysis. These parts must also be evaluated for tactile quality and mechanical performance, which traditional and visual inspection methods often fail to address. In one example, Minebea Access Solutions, a Tier 1 supplier specializing in automotive access systems, required comprehensive testing of pre-assembled door handles, detecting subtle force variations as low as 5N. In addition, rapid testing cycles, intuitive operation, and automated logging for complete quality traceability were also required.

Traditional manual test methods introduced human variability, while conventional automated systems lacked the sensitivity to replicate authentic human interactions. To overcome these limitations, Minebea turned to AI-enhanced force-sensing technology—offering both the consistency of automation and the refined sensitivity of human touch. This approach aligns perfectly with Minebea's "INTEGRATION" strategy, which combines mechanical, electronic, and software technologies to advance automotive innovation and enhance user experiences.

MELFA Robots: AI-Enhanced Force Sensing Solution



By combining Mitsubishi Electric's RV Series MELFA robots with a high-resolution force sensor and AI-enhanced force control algorithms, it is possible to create a system that mimics human interaction with robotic precision.

The system employs AI to dynamically optimize testing parameters based on real-time feedback. Unlike conventional equipment that applies fixed forces, this solution can continuously adjust applied pressure to replicate variable force patterns typical of human touch.

Furthermore, by utilizing a multi-robot-station design, the operator can load components while the robots perform testing, maximizing throughput without compromising quality. This set-up, leveraging high-precision sensors, can accurately simulate both finger and full-hand interactions.

Benefits

- High test coverage and accuracy
- Reduced set-up time (from one month to a few days)
- ROI within months

"Our AI and robotic technology bridges mechanical testing with human perception. The system autonomously optimizes force, speed, and position with minimal input. The net effect is to deliver repeatable premium quality—especially critical for luxury brands.

— Giuseppe Polimeni, Automotive Industry Director, GKAM & Japanese End Users, Mitsubishi Electric

Strategic Implications and future outlook

The topics and real-world examples discussed in this white paper highlight the growing importance of AI-enhanced manufacturing. They also demonstrate the symbiotic relationship between the human workforce and advanced technology—whether through collaboration with robots, AI-driven decision support, or the augmentation of human skill and knowledge. By integrating these elements, automotive manufacturers can enhance their production processes and flexibly respond to evolving market demands.

According to Deloitte 93 percent of manufacturing companies believe AI will be a main technology that drives growth and innovation in the sector. McKinsey projects that AI-driven quality management can cut defect rates by up to 50% in automotive production. These forecasts underscore a broader trend that is already gaining traction across the industry.

The case studies presented, from predictive welding analytics and real-time energy optimization to advanced visual inspection and haptic-style force-sensitive testing, demonstrate how AI is already transforming manufacturing processes. These implementations deliver measurable gains in quality, efficiency, and sustainability.

Edge-level analytics, in particular, empower manufacturers to address specific production challenges directly on the shop floor. This bottom-up approach to AI deployment allows for focused, high-impact solutions that evolve into broader factory-wide transformation. By starting small, with targeted use cases whether in welding quality, energy management, or inspection, companies lay the foundation for scalable, enterprise-wide AI integration.

Integrating AI into automotive manufacturing is not simply a technological upgrade; it represents a fundamental shift in how quality, efficiency, and sustainability are achieved. Through real-time monitoring, predictive analytics, and seamless data integration, manufacturers can realize tangible improvements in defect reduction, energy usage, and operational performance.

The transformation of automotive manufacturing through AI is no longer a future vision — it is a present-day reality, unfolding one process at a time. As these case studies show, the path to success lies not in wholesale change, but in the strategic deployment of AI exactly where it matters most: at the point of production.

[10] AI Enablement on the Way Smart Manufacturing.
Deloitte Survey on AI Adoption in Manufacturing

Automating the World

About Mitsubishi Electric Factory Automation Systems Division

Offering a vast range of automation and processing technologies, including controllers, drive products, power distribution and control products, electrical discharge machines, electron beam machines, laser processing machines, computerized numerical controllers, and industrial robots, Mitsubishi Electric helps bring higher productivity – and quality – to the factory floor. Its digital manufacturing portfolio is constantly expanding, providing cutting-edge digital twin solutions such as Gemini, AI-powered quality control like MELSOFT VIXIO, data analytics platforms like MaiLab, complemented by visualization and historian solutions, such as Genesis64, from its subsidiary Mitsubishi Electric Iconics Digital Solutions. In addition, its extensive service networks around the globe provide direct communication and comprehensive support to customers. The global slogan “Automating the World” shows the company’s approach to leveraging automation for the betterment of society, through the application of advanced technology, sharing know-how, and supporting customers as a trusted partner.

For more about the story behind “Automating the World” please visit:

https://www.MitsubishiElectric.com/fa/about-us/automating-the-world/index.html

e-F@ctory

Mitsubishi Electric's e-F@ctory concept utilizes both FA and IT technologies, to reduce the total cost of development, production and maintenance, with the aim of achieving manufacturing that is a "step ahead of the times". It is supported by the e-F@ctory Alliance Partners covering software, devices, and system integration, creating the optimal e-F@ctory architecture to meet the end users needs and investment plans.

e-F@ctory Alliance

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BLDG., 2-7-3 MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

www.mitsubishielectric.com/fa

New publication, effective ?