Audi Smart Factories Accelerate the Transformation of the Global Automotive Industry

Audi is one of the world's leading manufacturers of premium cars. The Audi Group includes the Bentley, Lamborghini and Ducati brands. Revenues for 2024 were EUR €64 billion, with around 1.7 million vehicles sold. The group has 88,000 employees worldwide.

Industry
Automotive

VMware footprint
- VMware® Cloud Foundation®
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The automotive industry is advancing for many reasons, including the role technology plays in reshaping how customers configure, buy and power their cars. Audi is leveraging IT to fundamentally change how the cars of the future will be built. Audi is using VMware Cloud Foundation to build the Edge Cloud for Production (EC4P). This private cloud platform is designed to scale and is already helping to streamline production and minimize factory-floor downtime while allowing for the future integration of IoT and AI applications.

Rethinking how cars are designed and built

Audi is one of the world's leading premium car brands. For more than 100 years, the German business has led the industry in terms of technological innovations. For the next-generation of Audi vehicles, the business is creating a production environment that is not only efficient and cost-effective, but also meets the highest quality standards and provides the best possible support for its employees. Its 360factory is Audi's production strategy for fully connected, innovative and sustainable manufacturing.

> "Our motto is software, not hardware. VMware Cloud Foundation underpins our EC4P project, virtualizing our production environment with an on-premises infrastructure platform."
>
> Sven Mueller, Project Lead, Edge Cloud for Production, Audi

Connecting processes to eliminate costly production downtime

Audi has one of the most iconic slogans in the automotive industry, and perhaps the most recognizable snippet of the German language. *Vorsprung durch Technik*. Progress through Technology.

Audi first included the phrase in a magazine ad in 1971. More than 50 years on, the mantra remains the same, but the scope has broadened exponentially to leverage technology improvements.

As a result, technological innovations now steer the automotive industry. IT enables buyers to configure their new cars, banks to create new financing options and cities to plan new charging infrastructure. For Audi, technology is enabling the business to completely rethink how cars are made.

In a production line that is increasingly dependent on computers to manage and monitor dozens of individual processes, eliminating downtime is crucial for streamlined production. Every second counts. Outage prevention and rapid recovery are essential, as every delay adds cost and disrupts delivery.

In a modern production line, downtime is less about mechanical failure and more focused on patching individual machines. A typical production line will comprise industrial PCs, each one running Windows, which is installed individually on each PC.

"Modern IT is becoming increasingly complex," says Sven Mueller, project manager for Audi's Edge Cloud for Production (EC4P) project. "As a production team, we need to manage this complexity. We need a simple, functional IT landscape so that we can build vehicles efficiently, now and in the future."

Audi wants to reimagine this entire way of working. Instead of dozens of individual PCs controlling separate elements of the production process, each of which needs updating, securing and regular patching, it is leaning into the latest technology trend: building an on-premises factory.

Creating a new standard in factory automation

With its EC4P project, Audi is pioneering a new era of IT-based factory automation.

"Our motto is software, not hardware," says Mueller. "EC4P enables the quick integration of software and new tools, whether for worker support, bolt control, vehicle diagnostics, predictive maintenance or energy savings."

The company began testing EC4P at its Böllinger Höfe factory in Heilbronn, Germany. The objective was to create a centralized server cluster to manage worker support systems for an entire assembly line.

"What we're doing here is a revolution," says Gerd Walker, member of the Board of Management of Audi AG Production and Logistics, speaking at the launch of the first test phase. "This first application in series production at Böllinger Höfe is a crucial step toward IT-based production."

For EC4P to work, Audi relies on maximum automation. For example, a "golden image" is created just once and then rolled out hundreds of times, instead of managing hundreds of industrial PCs individually. To do this, Audi also needs scalable, low-latency storage, where compute is disaggregated and with the capacity to add new, virtualized PCs when needed.

"We want to bring local cloud solutions to production at our plants and take advantage of advances in digital control systems," says Jörg Spindler, head of Production Planning and Production Technology, Audi.

On-premises infrastructure to deliver a cloud consumption experience

EC4P is built on VMware Cloud Foundation (VCF). This creates an on-premises infrastructure that delivers a cloud consumption experience on-premises, allowing Audi to extract a software management layer across all local PCs.

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It enables Audi to merge IT and Operational Technology (OT), with shop floor operations based on IT principles. And software-based infrastructure delivers high availability and more reliability over hardware-based infrastructure.

"With VMware Cloud Foundation, we have an all-in-one solution that we can use for various use cases and applications," says Christopher Kolb, domain architect for the EC4P project. "VMware Cloud Foundation enables us to centralize these systems and move away from a distributed approach towards more streamlined processes. By focusing on the 'golden image,' we can install once and then roll out to the hundreds of stations we operate in production."

In addition, Virtual Desktop Infrastructure (VDI) workloads run on a hyperconverged infrastructure (HCI). User session data and a vSAN storage cluster are mounted to the HCI clusters to gather data, which keeps the organization's manufacturing facility running without interruption. The VMware vSAN storage clusters are deployed in a stretched cluster topology, which provides synchronously replicated storage across two sites. In the event of a site-level failure, Audi can rapidly failover to a secondary site and recover in just minutes. Data protection through VMware vSAN enables Audi to protect its persistent data, closing security vulnerabilities.

The adoption of VCF, including vSAN, was conducted alongside VCF Professional Services. A close working relationship was critical in gaining momentum for such a strategically significant project:

"All failover scenarios were tested successfully, ensuring that our systems are robust and can handle any unexpected issues without disruption," says Kolb.

"Broadcom is an expert in virtualization, and the involvement of VCF Professional Services was crucial. We share the same mindset for innovation, enabling us to successfully push this project across the finish line."

Accelerating the delivery of next-gen applications

Böllinger Höfe moved into series production with EC4P in July 2023, after initial testing showed a marked improvement. A local server cluster now controls worker support systems across 36 production cycles on the Audi e-tron GT assembly line.

The immediate impact is reduced costs due to the consolidation of multiple IPCs, a smaller hardware footprint and lower hardware maintenance costs. Centralized operations and remote management improve IT efficiency and achieve standardization across the shop floor, while a smaller hardware footprint also lowers the environmental impact, consuming less energy and generating less heat.

For teams on the production line, there are no changes to the process. The only discernible difference, with consistent patching, is fewer interruptions. Through intelligent workload and network telemetry, engineers can proactively flag, diagnose and remediate issues during planned maintenance windows thus leading to less downtime. Thanks to faster, automated updates, maintenance and application deployments have improved operational efficiency with IPC upgrade time reduced from more than 20 minutes to just a few minutes.

EC4P, powered by VCF, provides infrastructure standardization through a unified private cloud platform for applications on the shop floor. The platform allows Audi to rethink the way applications are developed and shorten application delivery times. The transformation drives centralization, standardization and automation.

"The partnership between Audi and Broadcom sets a milestone in the evolution of production IT," Kolb explains. "The things we have jointly implemented here serve as the standard for production IT at Audi and possibly even in the future for the wider industry."

The Böllinger Höfe factory in Heilbronn, Germany.

The architecture of the server clusters, and the use of VCF, is designed to enable rapid scaling of EC4P in large-scale production environments. Audi sees Böllinger Höfe as a learning environment to roll out IT-based factory automation at much larger production facilities such as Ingolstadt and Neckarsulm.

"The EC4P platform is provided by production, for production," says Kolb. "It runs across the entire production process, from operator guidance systems to robotic controllers, ensuring all systems work together smoothly."

The successful delivery of EC4P represents a paradigm shift in car production and a reset for the culture of IT.

"With EC4P, we are merging the fields of OT and IT to advance our shopfloor to the next level," says Mueller. "This development will also create new employee roles between production and IT. The platform, network and application components represent an entirely new way of working."

Simplifying the integration of IoT and enabling AI

EC4P is foundational. The platform will allow Audi to accelerate the integration of new IoT applications in the production line. New data-gathering opportunities will multiply, providing a richer content feed for new AI-powered applications. Audi is adapting EC4P for new use cases in the Audi Production Lab (P-Lab), its research and development facility in Ingolstadt charged with identifying new technologies, and reliably integrating them into production sequences.

EC4P is progress through technology, at speed.

"Audi EC4P is unique because it has managed to change things in a large company on a timescale that others didn't believe possible," says Kolb.