The Road Ahead

Five Strategies that will Define
Next-Gen Industrial Vehicles

2025

1. How Platform Engineering Boosts Efficiency

Platform engineering is a cornerstone of modern industrial vehicle (IV) development—and of software development across all industries. It enables manufacturers to meet the growing demands for quality, functionality, and scalability with time and cost efficiency.

Building on the idea of standardization and reusability, platform engineering aims to provide developers with a self-service infrastructure of highly optimized, ready-made software components that can be easily fetched, customized, and deployed to different devices. Atomic platform components for base functions can be easily composed into larger molecules or templates, delivering ready-made functionality and a customizable look and feel for a variety of use cases.

Cross-platform capabilities, like those offered by the Qt Framework, reduce duplicate work. The same code can be used on different devices while offering rapid adaptation and deployment for a variety of systems.

Additionally, by abstracting over the underlying hardware and OS requirements, a cross-platform framework provides the necessary abstraction to develop and maintain software for a wide range of devices with a single software stack. This unifies these devices within a single, cohesive software framework and allows them to operate harmoniously.

Such flexibility and cohesiveness allow development teams to respond swiftly to changing requirements and optimize the software stack across different vehicle types without having to rebuild the entire system for every new product.

Five Core Elements of Platform Engineering

Unified Framework

Use a cohesive software development platform to manage all components and functions efficiently, ensuring seamless interoperability.

Middleware Integration

Implement middleware to bridge components, simplifying communication and integration across systems.
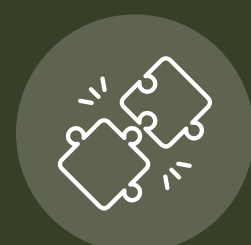
Modular, Cross-Platform Design

Enable quick customization and scalability to meet changing operational and market demands.

Model/View Programming

Decouple UI appearance from logic to simplify customization in look-and-feel while preserving the underlying functionality across products.

Standardization and Flexibility

Use standardized building blocks and third-party integrations to port consistent, quality-assured functionality efficiently across products.

By adopting a configure-to-order approach, standardizing features, and automating GUI mimic generation with a GUI editor tool, we've reduced delivery time by 2-3 times, depending on system requirements. This accelerates delivery, improves product quality, and reduces the need for engineers. Read More ➤

– Espen Skjong, Technical Director, Blue Ctrl

Image courtesy of Blue Ctrl

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2. Why Great UI/UX Drives Success in Embedded Systems

The consumerization of UI/UX is transforming industrial vehicle operator interfaces, prioritizing productivity and ease of use. While industries demand smartphone-like experiences, creating these interfaces on embedded devices presents a strategic challenge, requiring efficient resource management and the simplification of data.

Meeting these demands requires thoughtful design choices, optimized performance, and strategic use of embedded system resources, all of which are highlighted by the following key themes listed opposite.

Intuitive Access
UI design should provide clear-to-follow performance data and situational awareness while using subtle feedback, such as visual, auditory, or tactile insight, to support operators without demanding full attention.

Perfect Synchronization of 2D & 3D
Leveraging a framework that offers seamless integration of 2D and 3D graphics ensures a smooth, responsive experience with no lags, delivering a level of responsiveness and reliability that is difficult to achieve otherwise.

Simplified Navigation
Using simple 2D controls for complex 3D navigation allows operators to manage sophisticated systems effortlessly, maintaining control with ease and precision.

Cognitive Load Reduction
Minimizing unnecessary interactions, streamlining workflows, and simplifying complex data from sensors, cameras, and other sources help operators focus on critical tasks, reduce training time, and build a more confident workforce.

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3. The Role of Digital Twins in Industrial Vehicle Innovation

Digital twin technology offers functional virtual representations of equipment, serving as transformative tools for industrial vehicles in diagnostics, predictive maintenance, and operator safety and training. By simulating real-world systems, digital twins simplify the understanding and management of complex machinery, improving usability and productivity.

These virtual models play a crucial role in vehicle design and testing, enabling simulation and refinement of functionality before physical production begins. While not all digital twins include visual representations, integrated graphical capabilities—such as real-time 2D and 3D visualizations—greatly enhance usability and provide critical support for operators in real-world scenarios.

For example, a Collision Management System (CMS) application can generate a 360-degree aerial view by combining multiple camera streams.

Enhanced with AI for object recognition and obstacle detection, such visual systems offer drivers detailed situational awareness, increasing comfort and safety during operation. Sensors further contribute by creating comprehensive environmental maps, identifying hazards like rocks or pedestrians, and flagging them for immediate attention.

This technology also enables semi-autonomous operations, where vehicles can intelligently detect obstacles and navigate paths. Visual integration within digital twins enhances situational awareness, allowing operators to engage with the vehicle in its actual environment, whether on-site or at a distance. In training scenarios, the ability to view and interact with a digital twin in real time simplifies the learning process, equipping operators to handle complex systems more effectively. These capabilities translate into safer, more efficient operations and better-prepared personnel.

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Digital Twins Cut Development Costs by up to 60%* while also Offering Other Benefits such as

Advanced Diagnostics

Delivers detailed analysis of equipment performance and potential issues.

Predictive Maintenance

Proactively identifies maintenance needs to reduce downtime.

Enhanced Operator Training

Offers interactive, real-time simulations for skill-building and familiarization.

360-Degree Awareness

Improves safety with AI-enhanced visualizations that identify and flag obstacles.

Streamlined Vehicle Design

Simulates and refines functionality before physical production, saving time and resources.

*Compared to traditional IoT platforms, excluding digital twin IoT platforms *(Source)*.

The 10.5" touchscreen gives farmers insight into the performance of their equipment during planting and harvest. It handles the telematics and does near real-time command and control of all the embedded microcontrollers that run on the mechanical elements that are out actually planting crops into the ground. Read More ➤

– **Dave Wilcoxson,** Senior Manager, Product Engineering, Precision Planting

Image courtesy of Precision Planting

4. Unlocking Opportunities with IoT-Powered Automation

IoT-enabled remote monitoring and automation systems provide transformative real-time insights into equipment health and performance. These systems leverage sensors, constant and reliable connectivity, and automated alerts to streamline operations, implement predictive maintenance, reduce downtime, and enhance safety. While traditional IoT platforms focus on connecting devices and collecting data, advanced solutions like digital twins build on this foundation by enabling dynamic simulations, predictive analytics, and real-time optimization, unlocking even greater operational efficiencies.

How IoT-Powered Automation Helps

Reliable Connectivity across Devices

For seamless operation, connectivity must be constant and lag-free. Whether it's cloud-based, M2M, or sensor-enabled, uninterrupted communication ensures timely data collection and action execution. This is critical in environments where delays can compromise efficiency or safety.

Cross-Platform Frameworks

Solutions are best developed using cross-platform frameworks, as they greatly simplify handling data from diverse devices, such as desktops, SCADA systems, and rugged tablets designed for field use while ensuring consistent functionality. The software framework provides a unified environment for consistent data visualization and interaction across all devices, saving time and ensuring operational harmony.

Predictive Maintenance and Automated Alerts

By integrating AI capabilities into a framework that supports a wide variety of third-party services and APIs, systems can process complex data in real-time. Predictive maintenance tools use these models to anticipate failures before they occur, while automated alerts ensure rapid response to emerging issues.

Functional Safety with Safe Rendering

In highly automated industrial environments, safety-critical data must be displayed reliably under any circumstance—including possible failure of the main UI. Safe rendering addresses this by creating a redundant, independent subsystem for critical alerts. This ensures that vital warnings and indicators remain accessible, bolstering safety and trust in automated systems.

5. How AI and XR are Redefining Industrial Operations

Emerging technologies like AI and extended reality (XR) are revolutionizing industrial vehicles, driving efficiencies in industries such as farming, mining, and logistics. These innovations simplify operations, reduce physical strain, and enhance decision-making through intuitive, immersive experiences.

Autonomous systems enable seamless transitions between manual control and automated modes, allowing users to interact with the vehicle as needed. This fluidity simplifies complex tasks like navigating challenging environments or managing heavy loads, improving productivity while reducing operator fatigue.

Advancements in Human-Machine Interfaces (HMIs) include the use of augmented reality (AR) and spatial displays to project critical information directly into the user's surroundings. AR can overlay cues, such as directional arrows or warnings, onto real-world environments, minimizing cognitive load and improving safety.

AI further enhances industrial vehicle performance by enabling predictive maintenance and improving performance. AI-driven systems analyze sensor data to anticipate issues before they arise, reducing downtime and increasing reliability. In farming, for example, AI enables precision planting by optimizing seed placement for optimal conditions, distance, and depth while also supporting separate efforts in water, fuel, and fertilizer optimization to enhance overall efficiency.

These advancements are supported by flexible software frameworks, allowing easy integration of machine learning and deep learning resources. To maintain safety and reliability, these technologies are built on resilient, adaptable software architectures that ensure smooth operation even as system complexity grows.

By combining AI-driven optimization with immersive XR interfaces, industrial vehicles are becoming smarter, safer, and more efficient, paving the way for the future of automation in industries like farming, mining, and logistics.

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Applications of Advanced Tech in Industrial Vehicles
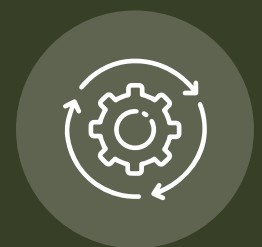
Task Automation

Smart systems precisely handle repetitive tasks like digging, lifting, and plowing, streamlining operations and boosting productivity.

Load Optimization

Intelligent systems balance loads and maximize payload efficiency to get the most out of every trip.

Agriculture

AI powers autonomous tractors for precise planting, fertilizing, and harvesting, optimizing every acre for better results.

Construction

Autonomous earthmovers, cranes, and loaders use AI to keep projects on track by accelerating site work and cutting downtime.

Mining

Self-navigating AI-powered haul trucks take on rough terrains, delivering safer, more efficient mining operations.

Data-driven decision support systems require accurate models and intuitive user interfaces to be trusted and accepted by users. This is what Ekkono and Qt bring to the fingertips of embedded developers in an accessible format. Read More ➤

- Simon Hedström, Machine Learning Engineer, Ekkono Solutions

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Qt Group offers cross-platform solutions for the entire software development lifecycle.

Qt Group (Nasdaq Helsinki:QTCOM) is a global software company, trusted by industry leaders and over 1.5 million developers worldwide to create applications and smart devices that users love. We help our customers to increase productivity through the entire product development lifecycle - from UI design and software development to quality management and deployment.

Our customers are in more than 70 different industries in over 180 countries. Qt Group is headquartered in Espoo, Finland, and employs over 800 people globally.

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