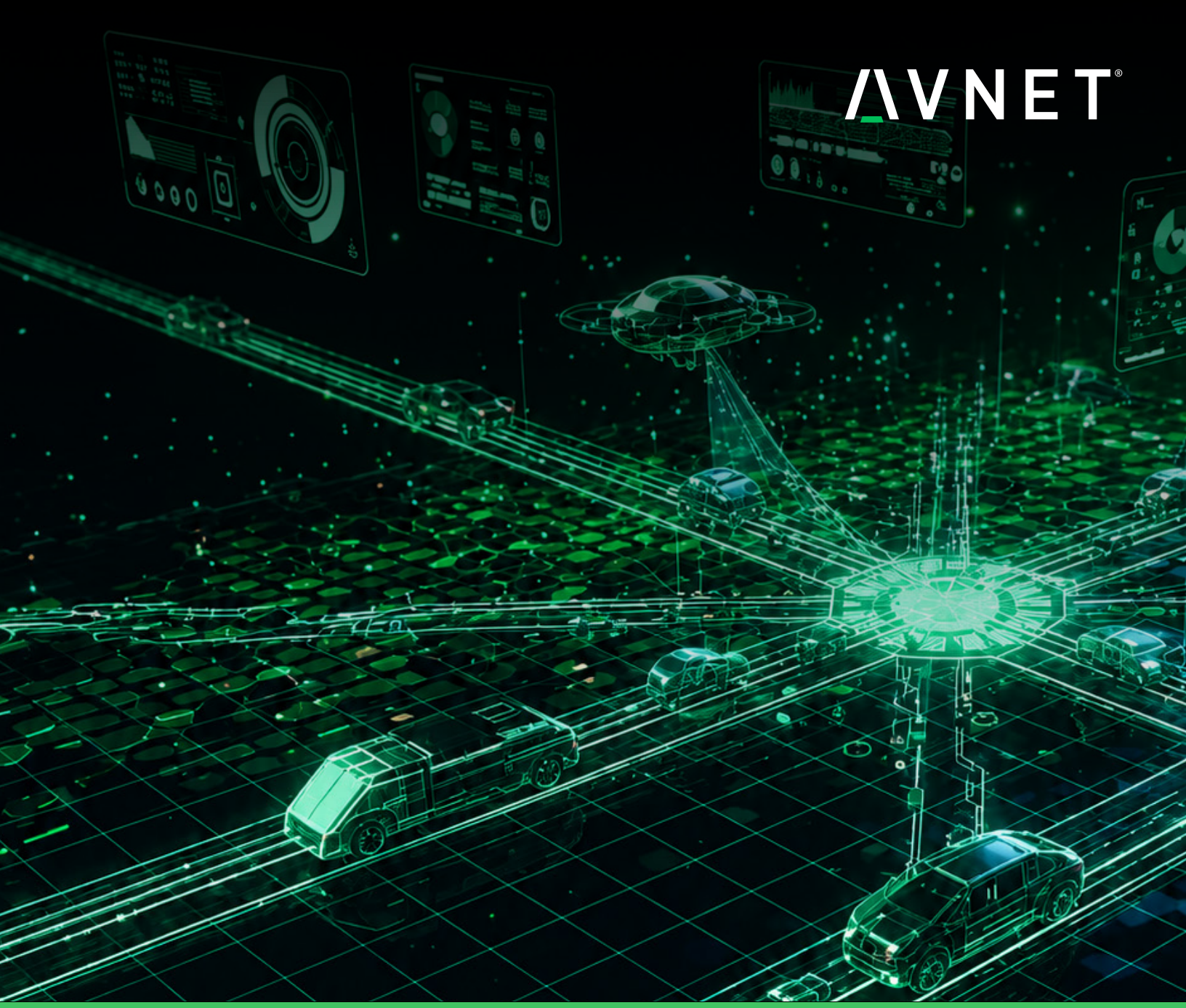


ENGINEERING FOR CONVERGENCE IN NEXT-GENERATION TRANSPORTATION SYSTEMS

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INTRODUCTION

The assumption that subsystems can be optimized one at a time and integrated later no longer holds.

Transportation systems are being shaped by a broader set of technical dependencies than in the past. Electrification, advanced driver assistance, autonomy, connectivity, and more centralized compute are forcing architecture, sensing, communications, power, and control into closer coordination. Engineering domains that could once be managed separately now have to perform more like a unified platform. Avnet's own transportation materials reflect this shift, pointing to rapid change in electrification and Advanced Driver Assistance Systems (ADAS), accelerated further by growing demands from AI, advanced connectivity, and new compute platforms.

The design challenge is directly affected by this shift. The assumption that subsystems can be optimized one at a time and integrated later no longer holds. Decisions around zonal compute architecture directly affect sensor strategy, data flow, thermal behavior, power delivery, software performance, and future upgrade paths. Autonomy adds even more pressure here, because higher levels of perception and decision-making require more sensor input, more processing, and more communication across the system. In practice, this means transportation teams have to think earlier about whether a platform will hold up under validation, production, lifecycle support, and long-term scalability.

This paper starts from a single premise: **convergence is changing how platforms are engineered.** Readiness, resilience, and scale are shaped early, when architecture decisions still define the boundaries of performance, flexibility, and risk. What follows is an examination of why the shift is happening, how it changes engineering itself, and which dimensions matter most to teams designing transportation systems that can be confidently deployed for long term success.

Convergence changes the engineering challenge altogether.



WHY NOW

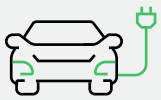
Several forces are arriving at the same time. Electrification raises the stakes around power architecture, energy management, and safety. Connectivity extends system requirements into diagnostics, Over-the-Air updates (OTA), and long-term support. Higher expectations for intelligence increase reliance on software, sensors, compute, and require real-time data handling. Simultaneously, transportation teams are being asked to design with earlier awareness of validation, serviceability, compliance, and regional deployment realities.

Autonomy is accelerating all of it. As platforms take on more perception and decision-making capability, the interdependencies across architecture, compute, communications, and power become more consequential. Thermal management is one clear example. More compute, more sensor input, and higher data throughput place significantly greater demands on the system, which means thermal behavior has to be treated as a platform-level design concern, not a subsystem problem to be solved later.

The result is a shared engineering condition across transportation categories that once looked quite different from one another. Use cases and operating environments still vary widely, of course, but the underlying design pressures are converging.

Architecture decisions now define the boundaries of performance, flexibility, and risk.

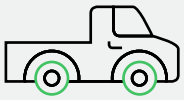
TRANSPORTATION CONVERGENCE, BY THE NUMBERS



More than **17 million electric cars were sold globally in 2024,** representing more than 20% of all new car sales worldwide.



In the United States, electric car sales reached **more than 1 in 10 new cars** sold in 2024.



Global electric medium and heavy-duty truck sales rose to more than 90,000 in 2024, **an increase of almost 80% year over year.**



86% of automotive companies surveyed by KPMG said they are **investing heavily in AI and emerging technologies.**

/ IMPLICATION

Readiness, resilience, and scale are shaped early.

Convergence changes the nature of engineering decisions. As transportation systems take on more sensing, software, connectivity, and compute, design choices expand beyond any single subsystem. A decision made for performance in one area can affect power delivery, thermal behavior, data flow, software responsiveness, validation complexity, and future upgrade paths elsewhere in the platform.

Autonomy brings this into stark contrast. Avnet's ADAS and autonomous-driving materials note that modern vehicles are becoming mobile digital communications platforms, and that the volume of data moving through them has increased dramatically as ADAS and sensor fusion expand. **By 2025, mid-class cars carried more than 200 sensors** for driver-assistance features alone. Those demands shape architecture choices, compute requirements, communication design, and thermal management across the entire platform, and not just the sensing stack.

The practical consequence is that engineering choices carry downstream business implications much earlier in the program lifecycle than before. Teams have to evaluate whether a platform can be sourced, validated, integrated, supported, and scaled with confidence, and that evaluation has to happen while architecture decisions can still be adjusted, not after they've been locked.

WHEN SOFTWARE READINESS DELAYS HARDWARE LAUNCH

A major automaker delayed production of a flagship next-generation vehicle to allow more time for software development and testing, underscoring how tightly launch readiness now depends on coordination across hardware, software, and validation in modern transportation platforms. The company said it needed additional time for software development and testing, and later reporting indicated the launch had been pushed back because of software issues.



FOUR DIMENSIONS OF ENGINEERING FOR CONVERGENCE

Convergence doesn't announce itself as a single problem. It shows up across architecture, sourcing, validation, and ecosystem dependencies, often at different points in a program, and rarely in isolation. To make the complexity easier to evaluate, this paper organizes the engineering challenge around four interconnected dimensions.

INTEGRATED HARDWARE AND SOFTWARE	Compute, sensing, connectivity, and control have to function as a single coordinated environment. System behavior is defined across domains, not restricted to any one component.
CROSS-FUNCTIONAL SYSTEM DESIGN	Electrical, digital, wireless, power, and system architecture decisions carry consequences beyond performance. They affect sourcing flexibility, regional adaptability, and long-term resilience in ways that have to be considered before they become constraints.
DEVELOPMENT-TO-DEPLOYMENT READINESS	A platform has to do more than work in development. It has to support validation, manufacturability, serviceability, compliance, and production ramp without requiring major redesign to get there.
ECOSYSTEM-WIDE ENGINEERING	Transportation systems depend on more than the product itself. Suppliers, software platforms, communications infrastructure, and long-term support networks all have to align for a program to scale viably.

These dimensions are concurrent pressures, and decisions made in one will surface consequences in the others. Together they provide a useful lens for evaluating whether a transportation platform will perform as an integrated system and hold up under the realities of deployment and scale.

Transportation categories may look different on the surface, but many now rely on a more similar technical foundation than before.

ONE ENGINEERING PATTERN, MANY VEHICLE TYPES

Passenger vehicles, drones, heavy machinery, commercial platforms, marine systems, and consumer mobility all share a common reality: architecture decisions now carry wider consequences across the platform. Power, compute, sensing, software, and communications have to function together in ways that support deployment, serviceability, and scale.

What changes from category to category is context. One platform may prioritize ruggedization and long operating life. Another is shaped by weight, energy efficiency, or real-time communications requirements. Another by fleet uptime, service access, or regional infrastructure. Across all of them, architecture decisions carry broader consequences for validation, deployment, support, and scale than they did even a few years ago.

Automotive is the clearest large-scale example, which is why it tends to lead the discussion. The same system pressures are spreading across the broader transportation landscape and that is what makes convergence strategically significant. It is a broader engineering condition that shapes and informs how transportation platforms are designed and how successfully they can be deployed over time.

Transportation type	Likely engineering focus	What that often drives
Autonomous vehicles	Compute, sensing, software/control, communications, thermals	Sensor fusion, real-time decision-making, higher data throughput, thermal management, validation complexity
Heavy machinery / agriculture	Power, ruggedization, durability, connectivity, serviceability	Long operating life, harsh environments, uptime, remote diagnostics, platform reliability
Last-mile delivery ground	Power efficiency, connectivity, compute, fleet management, modularity	Battery life, route optimization, telematics, compact architecture, maintainability at scale
Last-mile delivery drones	Weight, power efficiency, sensing, connectivity, real-time control	Lightweight systems, constrained power budgets, reliable communications, autonomy support, flight stability
Consumer vehicles / e-bikes	Power, cost efficiency, compact electronics, connectivity, control	Battery management, size/weight constraints, cost-sensitive integration, app connectivity, service simplicity
Commercial vehicles / fleets	Uptime, diagnostics, power, connectivity, lifecycle support	Fleet management, predictive maintenance, durability, service access, operational continuity
Marine / watercraft	Connectivity, durability, power management, environmental resilience	Harsh operating conditions, long service cycles, remote monitoring, corrosion/environmental protection
Utility / off-road / all-terrain vehicles	Durability, power, control, sensing, serviceability	Variable terrain performance, ruggedized electronics, simplified maintenance, sustained field operation
Smart wheelchairs / mobility aids	Reliability, power efficiency, compact control systems, safety	Battery life, lightweight design, intuitive control, dependable operation, user safety

CHALLENGE

Technical success is not the same as deployment readiness.

Designing a transportation platform is one challenge. Scaling it is another. As a program moves beyond the conceptual stage, the engineering burden expands exponentially. Validation requirements tighten. Manufacturing realities become more visible. Supplier limitations show up in practical ways. Serviceability, diagnostics, and long-term support stop being secondary concerns and start shaping what the platform can realistically become.

This the the point at which teams discover that technical success and deployment readiness are not the same thing. A prototype may prove that a concept works, without surfacing thermal issues, integration complexity, sourcing constraints, or service burdens that become harder to solve later. The closer a program gets to production, the more expensive those corrections become. In converged systems, that risk is amplified because architecture, compute, sensing, software, communications, and support decisions are more tightly linked than before.

A promising prototype can still conceal thermal issues, sourcing constraints, or service burdens that surface later.

For teams trying to scale programs, the real challenge is whether the platform can answer a set of critical questions early enough:

- Can it be validated under real operating conditions?
- Can it be manufactured predictably at scale?
- Can it absorb sourcing changes without destabilizing the design?
- Can it manage thermal, power, and communication demands as system complexity grows?
- Can it be updated, serviced, and supported over time?
- Can it move from prototype success to durable deployment without major redesign?

A QUICK READINESS CHECK FOR TRANSPORTATION TEAMS

- ☑ Have architecture choices been evaluated against thermal, power, and data-flow demands?
- ☑ Can the platform be validated under real operating conditions?
- ☑ Does the design preserve enough sourcing flexibility to absorb change?
- ☑ Have manufacturability and serviceability been considered early enough?
- ☑ Can the system be updated, diagnosed, and supported over time?
- ☑ Are partner, infrastructure, and software dependencies clear?

These questions will determine whether a transportation system remains a promising concept or can be evolved into a durable product.

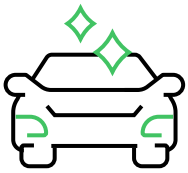
CONCLUSION

Convergence is not just a trend to monitor. It is a design condition.

The reality is that transportation teams can’t design around convergence anymore. Platforms have become more intelligent, connected, electrified, and software-defined. Architecture decisions made early in a program determine whether it can be validated, manufactured, supported, and scaled with confidence, or whether it will stall under the weight of the corrections that should have been made upstream.

The gap between programs that deploy successfully and those that don't is created earlier than most teams expect. Not in production. Not in validation. In design. Power strategy, compute architecture, communications design, thermal behavior, software integration, and support assumptions all set boundaries that become harder and more expensive to move as programs approach the launch stage.

The organizations that will lead the next-generation transportation wave are the ones that treat convergence as a design requirement from the start and not an integration challenge to solve later. That means evaluating architecture decisions against the full system. It means building sourcing flexibility and serviceability into the design before they become constraints. And it means recognizing that readiness, resilience, and scale aren't outcomes of a good launch. They're products of good engineering, made early, when it still matters most.



For teams evaluating transportation technologies and platform design decisions, Avnet provides technical resources and support across the path to deployment.





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