
Safe Automated Driving Needs Smarter Roads — Not Just Smarter Cars

Eight priorities for building infrastructure that support making automated road traffic truly safe

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The narrative around (highly) automated driving still leans heavily toward the vehicle: better sensors, more powerful processors, increasingly sophisticated algorithms. Yet this perspective is incomplete. Safety in automated mobility will not be delivered by vehicles alone. It will emerge — or fail — as a property of the entire system in which those vehicles operate. And at the heart of that system lies infrastructure.

What follows are eight key priorities for shaping infrastructure that enables safe automated driving — not in a distant future, but throughout the complex transition already underway.

If the ambition is truly Vision Zero, then roads must evolve from passive surfaces into active, intelligent partners. The future of safe automation depends less on isolated technological excellence and more on systemic coherence: vehicles, infrastructure, and governance working as a tightly coupled safety ecosystem.

1. Manage the risks of the transition phase

The coexistence of automated and human-driven vehicles will define road safety for years to come. This mixed-traffic phase introduces a new layer of complexity: humans and machines interpret the road environment differently.

Infrastructure must actively reduce ambiguity. Temporary roadworks, inconsistent markings, or unclear layouts can create disproportionate risks for automated systems while also confusing human drivers. Transition-aware infrastructure design — including clear temporary guidance and real-time (traffic) data — is therefore essential to stabilise this mixed traffic system in terms of road safety.

2. Make readability a core safety function

Infrastructure must now be legible to both humans and machines. This dual readability raises the standard for design, consistency, and maintenance.

Lane markings, signage, and intersection layouts need to be standardised, high-quality, and sensor-compatible. Variability that humans can easily compensate for may undermine automated perception. Maintenance thus becomes a safety-critical task: degraded markings or obscured signs are no longer minor defects, but system-level risks.

3. Build a robust digital safety layer

Physical infrastructure alone cannot guarantee reliable perception under all conditions. A complementary digital layer is required to extend situational awareness.

Roadside Units (RSUs), Vehicle-to-Infrastructure (V2I) communication, and continuously updated high-definition maps can provide critical information beyond line of sight — particularly at intersections, tunnels, or other high-risk locations.

However, this digital layer must be highly reliable. Redundancy, low latency, and strong cybersecurity are prerequisites. Infrastructure must be designed so that partial failures do not translate into safety-critical blind spots.

4. Balance safety and traffic flow

A central challenge lies in the tension between safety and efficiency. Traditional traffic systems are optimised for flow, while automated systems tend to behave more cautiously — especially under uncertainty.

Infrastructure must mediate this conflict. Measures that improve safety may reduce capacity, while flow-optimised environments can introduce complexity and risk. Adaptive traffic management is therefore key: dynamically prioritising safety or efficiency depending on context.

During the transition phase, trade-offs are unavoidable. These must be managed deliberately and transparently — with safety as the guiding principle.

5. Protect vulnerable road users proactively

Urban environments, with their density and unpredictability, remain the greatest challenge for automated driving — and the place where safety improvements are most urgently needed.

Infrastructure can actively support the protection of vulnerable road users (VRUs). Sensor-equipped intersections, clearly defined and machine-readable crossing areas, and contextual data (e.g., signal timing or temporary hazards) can help anticipate and mitigate conflicts before they occur. This shifts infrastructure from a passive backdrop to an active contributor to safety.

6. Establish clear governance and interoperability

Smart infrastructure depends on clear institutional frameworks. Questions of data responsibility, system maintenance, cybersecurity, and privacy must be addressed explicitly.

Authorities need to define who ensures data quality, how temporary changes are communicated, and how systems remain secure and interoperable. In Europe's interconnected road network, harmonisation across borders is essential to ensure predictable system behaviour.

Without governance, technical solutions cannot deliver consistent safety outcomes.

7. Reinforce and maintain the physical foundation

Despite digital advances, the physical road network remains the backbone of safety. Its condition directly affects both human drivers and automated systems.

Durable, high-contrast markings, consistent layouts, and sensor-compatible materials are fundamental. Infrastructure should also provide safe fallback options for automated vehicles in case of system limitations.

Investments in digital infrastructure must not come at the expense of maintaining and improving the physical layer.

8. Design, deploy and operate infrastructure as a resilient system

Infrastructure for automated mobility must be conceived as a high-reliability system. This includes redundancy across physical and digital layers, phased deployment in suitable environments, and continuous monitoring and protection.

Early deployment should focus on controlled settings such as motorways or dedicated corridors, allowing systems to mature before entering more complex urban environments. At the same time, infrastructure operators must adopt new capabilities — integrating engineering, data management, and cybersecurity.

Resilience is achieved not through perfection, but through the ability to manage complexity, adapt to change, and maintain safety under real-world conditions.

Conclusion: One system, one responsibility

The safety of automated mobility will not be determined by any single innovation. It will depend on how effectively vehicles, infrastructure, and institutions function together as one coherent system.

Roads that are readable, reliable, and intelligently connected do more than enable automation — they improve safety for everyone. Investing in such infrastructure today is therefore a strategic decision.

And it is one that requires clarity: when safety and efficiency come into tension, it is safety that must set the direction.

The considerations outlined above are not speculative. They are largely grounded in ongoing and completed European research and innovation activities on connected, cooperative and automated mobility. Across Horizon 2020 and Horizon Europe, a substantial body of work has emerged that consistently points to the same conclusion: safe automated driving is not primarily a vehicle challenge, but a system challenge — with infrastructure as a central pillar.

Key European research projects on automated driving and infrastructure

The following projects are among the most relevant and widely recognised in supporting the arguments made above:

- TransAID (Horizon 2020)
Focus: Mixed traffic, transition areas, and interaction between automated and conventional vehicles. Addresses safety risks during the transition phase
- ICT4CART (Horizon 2020)
Focus: Hybrid connectivity, V2X communication, cybersecurity, and infrastructure architectures. Demonstrates how digital infrastructure enables safe automated driving.
- PoDIUM (Horizon Europe)
Focus: Integration of physical and digital infrastructure for CCAM deployment. Highlights the need for combined infrastructure layers.
- ARCADE (Horizon 2020 Coordination Action)
Focus: Harmonisation, knowledge exchange, and common frameworks for CAD deployment. Supports standardisation and interoperability across Europe.
- 5G-CARMEN (Horizon 2020)
Focus: 5G-enabled cross-border connectivity for automated driving corridors. Shows how advanced communication improves safety and cooperation.
- C-Roads Platform (CEF / EU Member States)
Focus: Deployment and harmonisation of Cooperative ITS services across Europe. Ensures interoperability of infrastructure-based communication.
- AUGMENTED CCAM (Horizon Europe)
Focus: Enhancing physical and digital infrastructure for automated mobility deployment. Directly targets infrastructure readiness for automation.
- SHOW (Horizon 2020)
Focus: Large-scale demonstrations of shared automated mobility in urban environments. Provides real-world validation of system-level impacts.

This column is written in a personal capacity and reflects only the views of the author.