



Connectivity and V2X for Highly Automated Vehicles

5GAA Automotive Association
Position Paper

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VERSION:	1.0
DATE OF PUBLICATION:	12 October 2026
DOCUMENT TYPE:	Position Paper
EXTERNAL PUBLICATION:	Yes
DATE OF APPROVAL BY 5GAA BOARD:	23 September 2026

Connectivity and V2X for Highly Automated Vehicles

The presence of Automated Vehicles (AVs) on public roads is rapidly spreading, as this nascent industry has been transitioning from pilots to commercial deployments. Highly automated passenger and goods transport operating at SAE Level 4¹ (L4) within defined Operational Design Domains (ODDs) are now running at scale in complex environments in the United States and China, with growing operational maturity and documented safety performance. These deployments demonstrate that automated driving is no longer a purely experimental activity, but an emerging mobility service with real implications for road safety, traffic management and digital infrastructure.

Today's AVs are designed to operate safely using onboard sensing technologies for core operational functions. This paper advocates that connectivity creates opportunities for AV fleet operations beyond vehicle sensor information. As automated mobility expands, addressing the topic of connectivity will help ensure that the services associated with it remain efficient, reliable and scalable.

For the past ten years, the 5G Automotive Association (5GAA) has been actively engaged in the connected and automated mobility ecosystem, advocating for the safety benefits it can deliver – whether the vehicle is driven by a human or not. 5GAA considers it timely and necessary to underline the role that connectivity – and both network and direct Vehicle-to-Everything (V2X) in particular – will play as a foundational deployment layer for AVs, complementing onboard intelligence and supporting interoperability and trust across AV operations.

This paper targets industry stakeholders deploying highly automated road transport solutions for goods and passengers. In turn, it also targets global and regional policymakers and road transport authorities responsible for the related regulatory frameworks. We observe that, while peculiarities exist, connectivity requirements may be similar for lower levels of automation.

Connectivity as a Baseline for AVs

In general, the approach seen in L4 robotaxi operation can be summarised as **“autonomy-first, connectivity-enhanced”**. Connectivity in today's robotaxi deployments is largely confined to operational functions, such as fleet supervision, remote assistance, Over-the-Air (OTA) software updates and customer interaction, rather than being leveraged as a strategic capability for vehicle automation. However, robotaxi connectivity plays an important role in enhancing the efficiency and scalability of the road traffic system. Today, communication primarily serves to exchange non-critical operational information with the fleet management/operational centre.

Robotaxi connectivity is also central to fleet learning and system improvement. Robotaxis act as closed-loop mobile sensing platforms for telemetry, diagnostics and collecting data about unusual driving scenarios, traffic patterns and environmental

¹ https://www.sae.org/standards/j3016_202104-taxonomy-definitions-terms-related-driving-automation-systems-road-motor-vehicles

conditions. Selected and processed data can be consumed by backend systems to refine algorithms and improve performance across the entire fleet. In addition, software updates, including new AI models and system improvements, are delivered via OTA updates using the vehicle's network connection.² In certain situations, such as incidents and anomalies gleaned from selected sensor recordings, larger volumes of data may be uploaded for analysis.

In contrast, numerous automated machinery operations have been relying actively on proper connectivity to coordinate goods movement in specific areas. The solutions often rely on fully monitored and coordinated fleet management within a given geographic area, such as factories, logistics hubs, mines, parking lots, campuses, etc., and in some cases, expanding to designated public roads and controlled areas between hubs.

Future Connectivity Requirements

The transition to safe, large-scale L4 automated driving means moving beyond best-effort network connectivity. Poor connections may interrupt vehicle services, limit remote operations or cause vehicles to stop operating.

From a technical perspective, connectivity must support operational functions in a consistent, reliable and predictable manner. A key first critical feature of connectivity concerns **service availability and continuity**. Where connectivity is relied upon for functions such as fleet supervision, remote assistance or customer support, it must remain available throughout the vehicle's operation. Interruptions or degraded performance may directly affect the vehicle's decision-making and actions. This is critical in dense urban environments or cross-border operations, where network conditions may vary.

A closely related requirement is the need for **consistent performance across networks and operators**. Automated vehicles operate across different geographic areas and mobile networks. Therefore, they require a **comparable and compatible level of service quality**, regardless of the provider. This implies a degree of harmonisation, standardisation and interoperability in how connectivity is delivered, including consistent service behaviour and predictable handovers or selection between networks. In practice, this calls for differentiated Quality-of-Service (QoS) profiles because not all data flows can be considered equally critical: safety-related signals, remote-intervention commands, and cooperative-awareness messages require high reliability and low latency, whereas other data streams can tolerate delays.

The telecommunications industry is aware of these connectivity and interoperability challenges and has therefore launched several initiatives to address them. For example, CAMARA³ is an open-source project that develops harmonised mobile network Application Programming Interfaces (API) to address corresponding cross-operator API invocation and connectivity operations. Meanwhile, GSMA Open Gateway⁴ facilitates

² <https://www.rsinc.com/what-isp-service-to-use-inside-of-waymo-cars.php>

³ CAMARA open-source project: <https://camaraproject.org> develops APIs for cellular network capability exposure and activation

⁴ GSMA Open Gateway: <https://www.gsma.com/solutions-and-impact/technologies/networks/operator-platform-hp>

interoperability and harmonisation across the mobile industry, and Aduna⁵ simplifies global access to mobile network capabilities through a common platform. A similar coordinated approach is now needed to address the specific connectivity requirements of automated vehicles.

For AV system providers, connectivity can now provide access to trusted contextual information that may not be directly observable through vehicle sensors. Examples include emergency vehicle notifications, incident and road closure information, temporary traffic management measures, dynamic access restrictions and geofencing, traffic signal information, curbside and road authority information, infrastructure status and network conditions. Recent connectivity requirements for L4 AVs resulted from challenging interactions with police officers and other first responders. All such ecosystem interaction scenarios require more efficient human-machine or machine-machine interactions, based on reliable network connectivity.

An important aspect concerns the recognition of **connectivity as part of the connected vehicle safety and operational framework**. The usual approach is to separate safety-critical vehicle functions, delivered by onboard systems, from safety-enhancing cooperative services enabled through connectivity and V2X. However, where connectivity enables functions – such as remote supervision, tele-assistance and cooperative services – it may need to be treated as an integral component of the Automated Driving System (ADS). This includes clarifying how connectivity is assessed in type-approval, certification and operational authorisation processes; an area where current approaches remain limited or inconsistent.

Regulatory frameworks also increasingly include **implicit connectivity-related requirements**, particularly through obligations on supervision, monitoring and intervention. This does not necessarily mandate a single technology, but rather ensures that deployment requirements assess cooperation needs and connectivity dimensions, including direct and network V2X, where they are safety- and operations relevant. This would help ensure that the connectivity layer is considered an integral part of a safe and efficient deployment from the outset, rather than being introduced later as a corrective measure.

5GAA works on guiding how regulatory frameworks should evolve to reflect demonstrated operational needs and industry best practices. For instance, several national approaches (e.g. US⁶ and German⁷ frameworks) require technical supervisors to be able to monitor vehicle operation and intervene, when necessary, even if not physically present in the vehicle. This implies the need for continuous communication with and within the vehicle's ODD – including availability, latency and reliability – to support remote interactions with the vehicle and/or its passengers. In all these examples, connectivity is recognised indirectly through functional requirements rather than explicitly addressed as a fundamental component. This creates uncertainty, as similar regulatory intentions may lead to different interpretations of the underlying technical requirements, particularly in the context of ODD certification and approval processes.

⁵ Aduna network platform: <https://adunaglobal.com/work-with-us/availability>

⁶ <https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/california-autonomous-vehicle-regulations>

⁷ <https://www.gesetze-im-internet.de/stvfernlv/BJNR0B00A0025.html>

Call for Action

Therefore, 5GAA calls on the AV ecosystem to work together towards achieving the following:

1. Develop a catalogue of (technology-agnostic) connected vehicle use cases which would directly add value to the operation of highly automated vehicle fleets.
2. Define harmonised connectivity requirements and best-practice recommendations, including an aligned network exposure API framework, and QoS/SLA levels for emerging AV mobility services and use cases.
3. Design AV frameworks to enable cooperative capabilities, especially for urban and mixed-traffic scenarios using trusted, reliable and accountable sources supported by a clear allocation of liability, roles and operational responsibilities.
4. Align deployment approaches to avoid divergent connectivity requirements as AVs scale globally; propose network APIs and supporting capabilities for the ecosystem, including network, modem/applications and their interactions.
5. Establish and maintain consistent connectivity and QoS across operators for AV scenarios (and potentially in roaming scenarios).
6. Understand how to address the operational responsibilities of different actors providing trustworthy information for AV operation, including liabilities.
7. Work with policymakers and regulators to recognise connectivity as a foundational AV deployment layer (road traffic safety, road traffic efficiency, reliable AV operation, emergency response, V2X service-level interoperability).

Safer, more consistent and reliable connectivity is vital to the widespread introduction of highly automated vehicles. A world where automated mobility is delivered in an end-to-end ecosystem benefiting from harmonised technical frameworks and close collaboration across the automotive and telecommunications industries, and helping successful pilots transition to large-scale commercial L4 deployments. In this scenario, onboard ADS remains responsible for core driving functions, with network and direct V2X connectivity providing the essential cooperative, operational and contextual support.

Indeed, as deployments move from controlled pilots to commercial operations across different geographies, 5GAA members will continue working together to define and establish added-value propositions, common requirements and performance targets in an effort to develop interoperable solutions and replicable operations across different mobile networks, vehicles and geographic regions.

The 5G Automotive Association (5GAA) is a global, cross-industry organisation of over 100 members, including leading global automakers, Tier-1 suppliers, mobile operators, semiconductor companies, and test equipment vendors. 5GAA members work together to develop end-to-end solutions for future mobility and transport services. 5GAA is committed to helping define and develop the next generation of connected mobility, automated vehicles, and intelligent transport solutions based on C-V2X. For more information, please visit <https://5gaa.org>

