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Industry Draft

Vehicular Communication Overview for the Task Force on Vehicular Communication (TF on VC)

This document provides an overview of vehicular communication. Only a few of the uses of vehicular communication in this document will be subjects for consideration by WP.29 bodies in the future.

I. Vehicular Communication Definition

Vehicular communication, in the context of road transport, is the exchange of information and data between vehicles, as well as between vehicles and their surroundings directly or over a managed network. Vehicular communication involves the use of various wired and wireless communication technologies for information and data sharing by vehicles with other vehicles, other road users, roadside units, traffic management systems and equipment, other infrastructure components, cloud-based data storage, etc. In the context of road transport, the other inland transport means like rail trains and water vessels are considered as part of the road vehicle surroundings.

II. Vehicular Communication Value

Vehicular communication, if available, can improve road safety, transport efficiency and the overall transport experience, as well as simultaneously improving their environmental footprint.

III. Vehicular Communication Use-Cases

Note: Some of the technologies required for the use cases mentioned here are still immature and under development.

Vehicular communication can be used for many applications, including but not limited to:

(a) *Safety and traffic-related information sharing:* Vehicular communication allows in-vehicle systems to issue warnings to drivers based on information transmitted by other vehicles, electronic signs and other infrastructure, and from weather services, cloud services and information-sharing services, etc. This can include detection of wrong-way driving, traffic backups, hazards on roadways, etc.

(b) *Traffic management:* Vehicular communication can assist in optimising traffic flow, reducing congestion and improving overall transport efficiency through exchange of information between vehicles and road infrastructure. Emergency and other prioritised vehicles can send their location, speed and trajectory to inform road infrastructure (traffic signal controller) and vehicles about their anticipated routes and behaviours. Vehicular communication can broadcast information about reduced speed, lane reconfiguration, etc. in work zones.

(c) *Collision warning and avoidance:* Vehicular communication can help vehicles and drivers detect and avoid potential collisions with other road users by sharing information with other vehicles and road infrastructure. Vehicular communication can report information that can be used to identify many different types of possible risks. Vehicular communication can be seen as an additional sensor of the vehicle to especially detect vehicles, objects and traffic participants whose visual recognition is compromised.

(d) *Protecting vulnerable road users (VRU):* Vehicular communication can alert vehicles about presence of VRU in two ways. 1) Vehicles and Road infrastructure can exchange messages about detected VRUs and their behaviour in their vicinity and 2) by messages from devices carried by pedestrians, bicyclists and motorcyclists. In the future, such messages might be used as an

additional sensor for assisted and automated driving functions to better protect vulnerable road users.

(e) *Automated driving support:* Vehicular communication can support, to enhance safety of and possibly accelerate the deployment of automated driving systems (ADS). The use of vehicular communication can improve the performance and safety of ADS within their operational design domain (ODD).

Information received by ADS via vehicular communication can be used as that of an auxiliary sensor, going beyond the detection capabilities of traditional vehicle on-board sensors. Moreover, via vehicular communication, ADS can receive explicit information about their surroundings. As a consequence, the calculation of the appropriate reaction to the surrounding can take place earlier hence in a safer, more comfortable and more sustainable way.

Roadside infrastructure can provide information to vehicles with engaged ADS about detected hazardous objects or obstructed traffic participants, changed road conditions such as special events and activities, roadworks and accident sites, as well as information about challenging topological situations such as tunnel entries, highway entries and exits, complex junctions and intersections.

Vehicles with engaged ADS might announce reaching their ODD limit, eventually allowing them being driven remotely.

Vehicles with ADS might also use vehicular communication to implement valet parking services.

(f) *Emergency services:* Vehicular communication can enable faster response times for emergency services by providing real-time information about crashes, road hazards and other incidents. E.g. the ECall-function can support better responses. Vehicular communication could allow emergency services to become able to remotely control vehicles with ADS that do not have a fallback user.

(g) *Cooperative automated driving:* Vehicular communication can improve vehicles collaboration to enhance safety and efficiency, such as platooning, cooperative driving and manoeuvring. Vehicular communication can support ADS challenging manoeuvres like lane changing and merging. ADS can be informed about Emergency and other prioritised vehicles earlier (see Traffic management).

(h) *Charging support:* Vehicular communication can install a dialogue between the vehicle and the grid to control among others the timing of charging. Information can also be provided to charging points about e.g. payment. Vehicular communication might facility two-way energy flows, e.g. to allow electric-vehicle batteries to provide power to the grid or a vehicle owner's home.

(i) *Traffic signal interface:* Emergency vehicles, special vehicles and public transport vehicles can send messages to traffic signal controllers, which can give them the right of way. Traffic signal controllers can send their signal phase and timing messages as well as their topological description messages of e.g. the intersection with allowed crossing connections to vehicles so that they can adjust their respective speed and path to increase safety and streamline the energy use. Same messages can be used by any road vehicle for safe and efficient crossing of signalised intersections or complex road structures (roadworks, roundabouts). Traffic signal controllers can receive information on the number of vehicles approaching or queuing at an intersection to optimise traffic signal timing. Vehicles with ADS engaged might communicate their intended route at the junction to further optimise their signal timing and automatically adjust their speed to match the green light timing based on the received messages.

(j) *Infotainment and convenience:* Vehicular communication can deliver multimedia content, internet access and personalised services to enhance the in-vehicle experience, for example for coach passengers. Vehicular communication can provide information about the location of rest areas along the route for passenger vehicles, availability of overnight parking spaces for long haulage lorries, status of facilities for campers, etc. Location, availability and pricing of charge points and petrol stations can be provided. Availability of parking spaces can be provided.

Reservations can be made for parking, charging, eating, sleeping, etc. with consequently some benefits on traffic fluidity.

(k) *Police authorities*: Vehicular communication can allow police personal to retrieve information from vehicles, including if ADS is engaged.

(l) *Emergency alerts*: Vehicular communication can deliver alerts about tsunamis, typhoons, fire, etc. Vehicular communication can support evacuations, including by vehicles with ADS that do not have a fallback user.

In the future, lives might be saved, when e.g. terrestrial communication infrastructure is interrupted, by using vehicle-to-vehicle communication to relay information by multi-hop across the road network until a vehicle can transmit the information or data where there is no outage of the communication infrastructure. Similarly, vehicles that have connection to the communication network can use vehicle-to-vehicle communication by multi-hop across the road network to deliver relevant warnings and messages to vehicles located where the communication infrastructure is not working.

(m) *Public transport*: Vehicular communication can provide information about public transport vehicle arrival time and service variations to waiting passengers. Vehicular communication can assist public service fleet operations and management.

(n) *Fleet management*: Vehicular communication can be used by fleet operators to collect information from their managed vehicles and control their managed-vehicle operation.

(o) *Vehicle maintenance*: Vehicular communication can update vehicle software, firmware, map data, etc. The status of vehicle components can be retrieved. Maintenance issues detected by vehicle systems can be transmitted to vehicle owners and vehicle manufacturers.

(q) *Event management*: Vehicular communication can provide information about road closures, rerouting etc. for special situations like sporting events, parades, protests, VIP travel, etc.

(r) *Freight movement*: Vehicular communication can track freight movement and improve freight transport efficiency. Lorries can send weights and electronic manifests to infrastructure controllers.

(s) *Remote management*: Vehicular communication can be used to give remote assistance for automobile operation.

(t) *Payment services*: Vehicular communication can be used for purchase of, or payment for, in-vehicle services and functions. Vehicular communication can be used to pay for external items such as tolls, road prices, parking, fuelling, charging and drive through activities.

IV. Vehicular Communication Structure

In the context of road transport, Vehicular communication is information and data exchange between communication devices in vehicles and communication devices in "something", including other vehicles. Vehicular communication includes information and data sent from vehicles and information and data sent to vehicles. Vehicular communication can be separated into wired and wireless communication.

Current wired communication in vehicles is information and data exchange through the OBD and the vehicle charging equipment or other wired interfaces. The wired interfaces might also use wireless approaches in the future.

Wireless communication technologies in vehicles include, but are not limited to:

a. Proximity, such as access control technology (e.g. key fobs).

b. Short range communication, such as Bluetooth, Ultra-Wide-Band (UWB) and Wi-Fi.

c. Trusted, direct Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication.

d. Communication based on cellular networks, providing voice, text messages, data, and mobile internet.

e. Radio broadcasting, including digital audio broadcasting (DAB).

f. Satellite communication, including GNSS, satellite radio and satellite internet.

g. Vehicle-to-Vehicle multi-hop-routing communication, that may be used when the mobile network is not available.
