Note by the secretariat

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

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

I. Vehicular Communications Definition

Vehicular communications is the exchange of information and data between vehicles, as well as between vehicles and their surroundings. Vehicular communications involves the use of various wired and wireless communications 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.

II. Vehicular Communications Value

Vehicular communications can improve road safety, transport efficiency and the overall transport experience, while reducing the negative environmental impacts of road transport.

By facilitating the interchange of information among vehicles, other road users and the infrastructure, vehicular communications enables the exchange of data such as vehicle speed, vehicle location, vehicle acceleration, vehicle braking, vehicle signalling, road conditions and traffic flow, as well as the receipt by vehicles and vehicle occupants of information from the infrastructure and the cloud.

Vehicular communications can reduce the cost of transport for people, businesses, government authorities and the environment.

III. Vehicular Communications Uses

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

(a) *Safety and traffic-related information sharing:* Vehicular communications 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 communications can assist in optimising traffic flow, reducing congestion and improving overall transport efficiency. Vehicles can provide authorities and road operators with information about their current position and dynamics, detected objects, intended manoeuvres at specific locations, etc. Vehicles can provide locally detected hazards such as road surface issues, locations with excessive braking and electronic stability control activation, etc. for traffic management and infrastructure improvement.

(c) *Collision warning and avoidance:* Vehicular communications can help vehicles and drivers detect and avoid potential collisions by sharing information about their locations, velocities and trajectories. Vehicular communications can report information that can be used to identify many different types of possible risks.

(d) *Protecting vulnerable road users:* Vehicular communications can alert vehicles, by messages from devices in the possession of pedestrians, bicyclists and motorcyclists, about their presence. In the future, such messages might be used as an additional sensor for AEBS and other safety functions. Additionally, vehicles and road infrastructure equipment that is able to detect

such vulnerable road users (VRU) can send the information to neighbouring vehicles for implementation of VRU protection use cases

(e) *Automated driving support:* Vehicular communications can support, and possibly accelerate, the deployment of automated driving systems (ADS). The use of vehicular communications can improve the performance of ADS products within their operations design domain (ODD) or even allow extension of their ODD across automation levels.

Information received by ADS products via vehicular communications can be used as an additional sensor, going beyond the detection capabilities of traditional vehicle sensors. Moreover, via vehicular communications, ADS products can receive explicit information about their surrounding environment which can be an addition to the ADS products' interpretation of the surrounding environment from processing their sensor information. As a consequence, automated reactions can take place earlier and in a more comfortable way.

Roadside infrastructure can provide information to vehicles with ADS active about changed road conditions such as special events and activities, roadworks and accident sites, as well as information about challenging topological situations such tunnel entries, highway entries and exits, complex junctions and intersections.

Since lane changing and merging are difficult activities for ADS, vehicular communications can support such manoeuvres. Emergency and prioritised vehicles can send their location, speed and trajectory to inform vehicles with ADS active that might not otherwise be aware of the emergency vehicles' intentions.

Vehicles with ADS active might announce reaching their ODD limit, eventually allowing them being driven remotely by human operators or automatically with instructions from the road infrastructure.

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

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

(g) *Cooperative automated driving:* Vehicular communications can support vehicles collaboration to enhance safety and efficiency, such as platooning and vehicles with ADS active determining the order to enter an intersection.

(h) *Charging support:* Vehicular communications can provide information from the grid to control the timing of charging. Information can be provided to charging points about payment. Vehicular communications 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:* Vehicular communications can send messages from emergency vehicles, and possibly public transport vehicles, to traffic signal controllers to change the signal to green. Traffic signal controllers can send their signal phase and timing (SPaT) as well as their topological description of the intersection with allowed crossing connections to vehicles so that they can adjust their speed to reduce energy use. Traffic signal controllers can receive information on the number of vehicles at and approaching an intersection to optimise traffic signal timing. Vehicular communications might eventually eliminate the use of inductive-loop traffic detectors. Vehicles with ADS active 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 SPaT.

(j) *Infotainment and convenience:* Vehicular communications can deliver multimedia content, internet access and personalised services to enhance the in-vehicle experience. Vehicular communications can provide information about the location of rest areas along the route for passenger vehicles, availability of overnight parking spaces for 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.

(k) *Police authorities*: Vehicular communications can allow police persons to retrieve information from vehicles, including if ADS is active.

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

In the future, lives might be saved when communications infrastructure is interrupted by using vehicle-to-vehicle communications 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 communications infrastructure. Similarly, vehicles that have connection to the communications network can use vehicle-to-vehicle communications by multi-hop across the road network to deliver warnings and disaster messages to vehicles located where the communications infrastructure is not working.

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

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

(o) *Vehicle maintenance*: Vehicular communications 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.

(p) *Work zones*: Vehicular communications can broadcast information about reduced speed, lane reconfiguration, etc. in work zones.

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

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

(s) *Remote management*: Vehicular communications can be used for remote vehicle actions such as locking and unlocking, starting heating and cooling, managing charging, opening the trunk for delivery and pick up of items, etc. Vehicular communications can be used for management of home or destination controls such as starting an oven, initiating heating and air conditioning, opening garage doors, etc. Vehicular communications can support service such as vehicle sharing and renting.

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

IV. Vehicular Communications Structure

Vehicular communications is information and data exchange between communications devices in vehicles and communications devices in something, including other vehicles. Vehicular communications includes information and data sent from vehicles and information and data sent to vehicles. Vehicular communications can be separated into wired and wireless communications.

Current wired communications in vehicles is information and data exchange through the OBD and the vehicle charging equipment. Both OBD and vehicle charging equipment might also use wireless approaches in the future.

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

a. Proximity, such as key fobs.
b. Close range, such as Bluetooth, UWB and Wi-Fi.
c. Sender-authenticated direct communications.
d. Cellular, providing voice, text messages, data, and mobile internet.
e. Radio, including digital audio broadcasting (DAB), FM, AM and short wave.
f. Satellite, including GNSS, satellite radio and satellite internet.
g. Vehicle-to-vehicle multi-hop that can be used when the mobile network is not available.