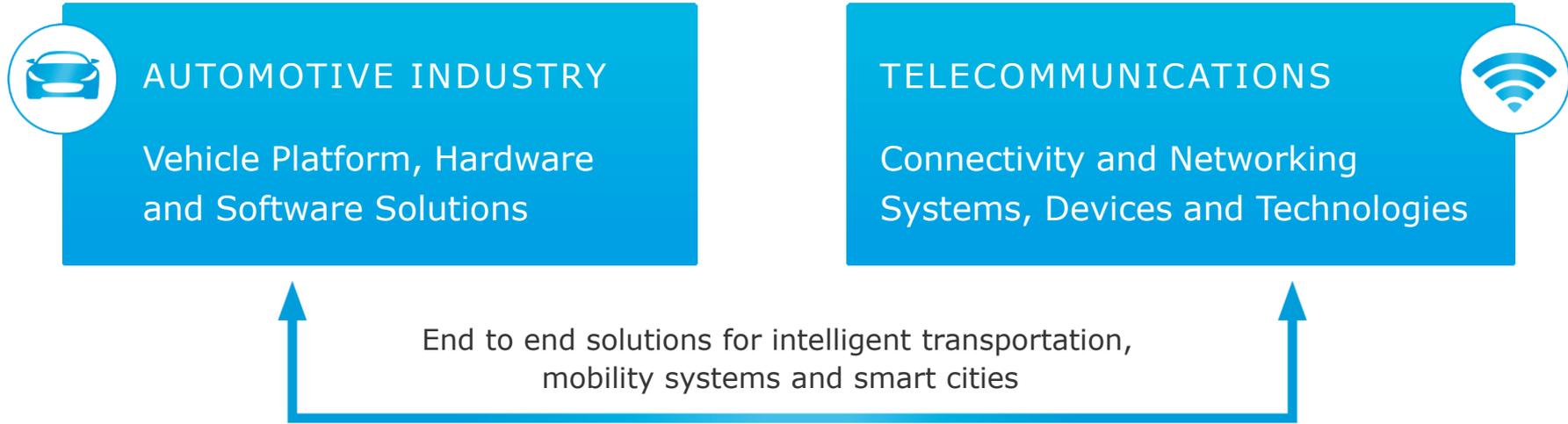


# THE ROLE OF CELLULAR-V2X (C-V2X) IN COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS

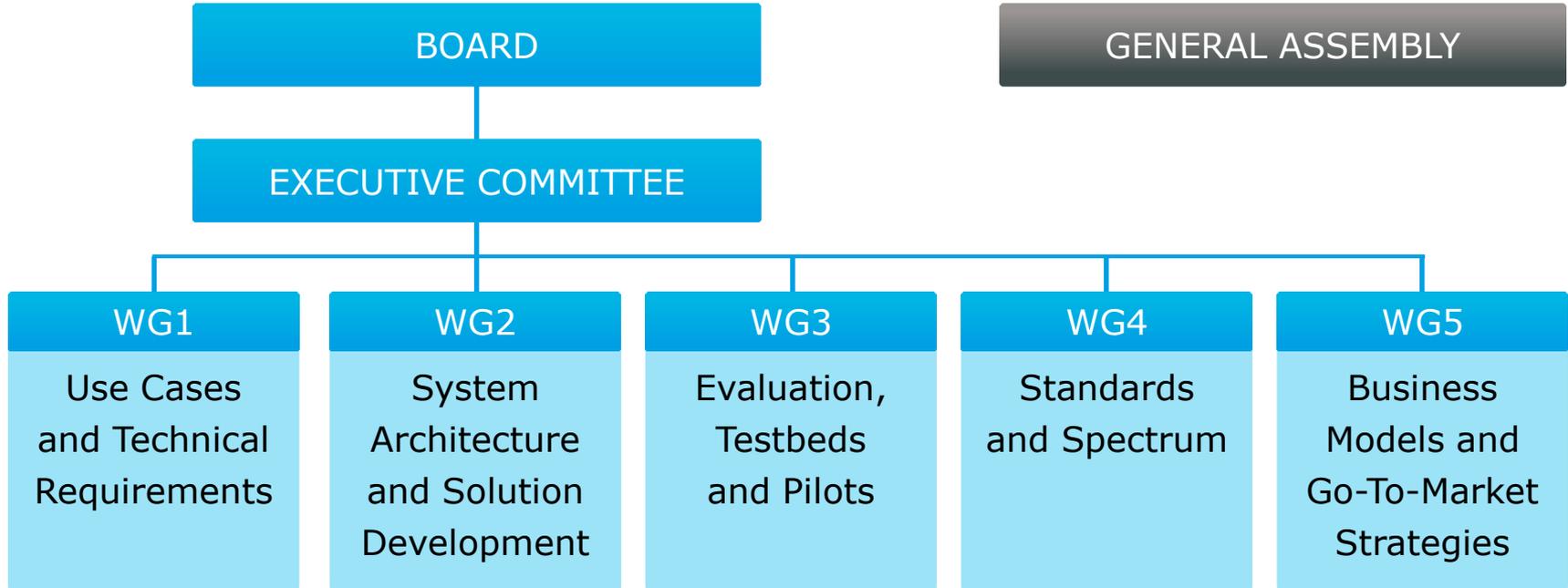
Bob Banks

5GAA Working Group 3 Chair

5GAA was created to connect telecom industry and vehicle manufacturers and work closely together to develop end-to-end solutions for future mobility and transportation services. It is – by its charter – a proponent of C-V2X and its current realisation, LTE-V2X, for vehicle-to-vehicle, vehicle-to-pedestrian, vehicle-to-infrastructure, and vehicle-to-network communications, and as a platform for evolution towards 5G technologies.







Vehicle-to-infrastructure (V2I)

e.g. traffic signal timing / priority



Vehicle-to-network (V2N)

e.g. real-time traffic / routing, cloud services



Vehicle-to-vehicle (V2V)

e.g. collision avoidance safety systems



Vehicle-to-pedestrian (V2P)

e.g. safety alerts to pedestrians, bicyclists



Picture courtesy of Qualcomm

<b>Left Turn Assist</b>	Alerts are given to the driver as they attempt an unprotected left turn across traffic, to help them avoid crashes with opposite direction traffic
<b>Intersection Movement Assist</b>	Informs driver when it is not safe to enter an intersection—for example, when something is blocking the driver’s view of opposing or crossing traffic.
<b>Emergency Electronic Brake Lights</b>	Driver is alerted to hard braking in the traffic stream ahead. This provides the driver with additional time to look for, and assess situations developing ahead
<b>Queue Warning</b>	Intended to engage well in advance of any potential crash situation, providing messages and information to the driver in order to minimize the likelihood of his needing to take crash avoidance or mitigation actions later. The infrastructure will broadcast queue warnings to vehicles in order to minimize or prevent rear-end or other secondary collisions.
<b>Speed Harmonization</b>	Determines speed recommendations based on traffic conditions and weather information. It detects the developing roadway or congestion conditions that might necessitate speed adjustments for upstream traffic and broadcasts such recommendations to vehicles long before they reach the affected area.
<b>Real Time Situational Awareness</b>	Provides mechanisms for vehicles to receive real time information about city/roadway projects, lane closures, traffic, and other conditions that may necessitate adjustments to driving patterns.

<b>Software updates</b>	Provides mechanisms for vehicles to receive the latest software updates and security credentials required to ensure their safe operation.
<b>Remote Vehicle Health Monitoring</b>	Provides mechanisms to diagnose vehicle issues remotely. As driving becomes more autonomous this becomes the key mechanism for remote supervision of vehicle functions and its health.
<b>Real-Time High Definition Maps</b>	Provides situational awareness for Autonomous vehicles at critical road segments in cases of changing road conditions (e.g. new traffic cone detected by another vehicle some time ago)
<b>High definition sensor sharing</b>	Provides mechanism for vehicles to share high definition sensor data (Lidar, cameras, etc) to enable better driving coordination for platooning and intersection management
<b>See-Through</b>	Provides ability for vehicles such as trucks, minivans, cars in platoons to share camera images of road conditions ahead of them to vehicles behind them
<b>Vulnerable Road User Discovery</b>	Provides ability to identify potential safety conditions due to the presence of vulnerable road users such as pedestrians or cyclist

- For the access part, 3GPP finalized an initial version of C-V2X, namely LTE-V2X, in Release 14 by end of March 2017. Discussion is already underway to define next version of C-V2X capabilities
- For the upper layers, C-V2X will leverage ETSI-ITS, ISO, SAE and IEEE standards and tests refined by the automotive industry and others in the ITS community for over a decade
- Multiple trial activities are ongoing (see next slide)

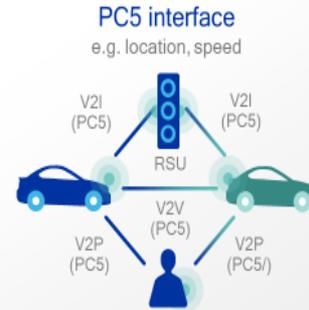
Name, Place	Companies
RACC track, MWC 2017	Audi, Vodafone, Huawei @ MWC
ConVeX (A9), Germany	Audi, Ericsson, Qualcomm, Swarco, Kaiserslautern Univ.
Towards 5G, France	Ericsson, Orange, Qualcomm, PSA Group
Mobilifunk (A9), Germany	Vodafone, Bosch and Huawei
UK CITE, UK	Jaguar Land Rover, Vodafone, et al
DT (A9), Germany	Audi, Deutsche Telekom, Huawei, Toyota
Car2X at A9, Germany	Continental, DT/T-Systems, Nokia, Fraunhofer
Car2X in Wuzhen, China	CMCC, Continental, Nokia, Fraunhofer
ICV pilot projects, China	CMCC, Huawei, SAIC, et al
MEC pilot project, Germany	Bosch, DT/T-Systems, Nokia

- V2X (C-V2V/P/I – namely PC5) use cases to operate in ITS 5.9 GHz spectrum on a technology neutral basis (noting the 5GAA's response to the recent RSPG consultation on 'Spectrum Aspects of Intelligent Transport Systems' and the deployment of C-V2X and IEE-802.11p in 5.9 GHz, see next slide)
- Additional and complementary automotive use cases and applications to operate via V2N (Uu) in licensed spectrum bands

## C-V2X defines two complementary transmission modes

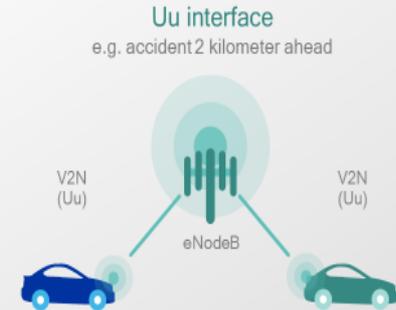
### Direct communications

V2V, V2I, and V2P on "PC5" Interface, operating in ITS bands (i.e. ITS 5.9 GHz) independent of cellular network



### Network communications

V2N on "Uu" interface operates in traditional mobile broadband licensed spectrum



- 5GAA has recently responded to the RSPG consultation on "Spectrum Aspects of Intelligent Transport Systems". 5GAA stated that in order to enable ITS growth in a smooth manner within Europe, it is proposed for the following steps to be taken:
  - Until a certain date, IEEE-802.11p and C-V2X would be restricted to operate on mutually different specific channels within the ITS 5.9 GHz band. The RSPG should consider publishing guidance to support the adoption of this proposal by the relevant industries, stakeholders, and Member States.
  - RSPG to consider additional spectrum authorisation arrangements for ITS (V2V, V2P, V2I) applications in spectrum harmonised for ITS to ensure future support of ITS services uptake and service scalability.
  - RSPG, in conjunction with industry, other stakeholders, and Member States, develop a plan that would enable all available ITS technologies, including future C-V2X enhancements e.g. 5G, to co-exist in applicable bands.
- Coexistence is a critical issue for the ITS industry, and that it is beneficial for all stakeholders to arrive at a proportionate, fair, and pragmatic solution to resolve this matter, and allow the market to proceed with the deployment of ITS equipment. 5GAA is currently studying this aspect.

# Q&A