Building the path towards 5G for Automotive Industry

Maxime Flament, CTO

5G Forum Workshop, 14 Nov 2018

C-V2X Gaining Momentum Worldwide

C-V2X Gaining Momentum Worldwide

- **"Continental successfully conducts Cellular V2X: Field Trials in Shanghai, China:** initial C-V2X trials in Shanghai with Huawei have successfully reached an average latency of 11 ms for direct communication between vehicles" (Continental Press Release, 18 December 2017)

- **"Ford and Qualcomm Collaborate on C-V2X Global Initiative** to improve vehicle safety, traffic efficiency and support for autonomous driving - [...] technology is planned for further field validations beginning in 1H 2018" (Ford Press Release, 09 January 2018)

- **Qualcomm** and Leading Automotive Companies Across the Globe Drive the Commercialization of C-V2X including Tier 1 suppliers **LGE**, **Continental**, **Ficosa-Panasonic**, **Lear** and **Valeo**, cellular module manufacturers **Gemalto**, **LG Innotek**, **Quectel**, **Sierra Wireless**, **Telit**, **WNC** and **ZTE**, V2X software application providers **Cohda Wireless**, **Commsignia** and **Savari**, system integrators **Sasken** and **Thundersoft** (Qualcomm Press Release, 22 February 2018)

- **"BMW Group is working on the implementation of the LTE-based, wireless C-V2X** technology offering unrivalled benefits for the development of the 5G ecosystem. The BMW Group already leads the way in implementing traffic safety messages based on backend-supported mobile technology (LTE) [...]. These will be **complemented within the next few months by the rollout of C-V2X direct communication technology** in the allotted frequency range, enabling time-sensitive traffic messages." (BMW Press Release @MWC, 26 February 2018)

- "**Rohde & Schwarz demonstrates test capability of 3GPP C-V2X technology** in preparation for GCF certification in preparation of commercialization" (Rohde & Schwarz Press Release @MWC, 27 February 2018)

C-V2X Gaining Momentum Worldwide

- **"Groupe PSA and Qualcomm Technologies** testing vehicle-to-vehicle communication featuring C-V2X technology: France's first C-V2X demonstration at In&Out Digital Mobility event in Rennes" (PSA Press Release & Demonstration video, 14 March 2018)
- **"5GAA, Audi, Ford and Qualcomm Showcase C-V2X Direct Communications Interoperability to Improve Road Safety"** C-V2X Communications' Superior Performance, Synergies with Telematics Units and Evolutionary Path Towards 5G Offers Greater Potential to Save Lives; World's First Showcase Across Vehicle Manufacturers Shows Readiness for Industry Deployment as Early as 2020 (Qualcomm Press Release, 26th of April 2018)
- **"Panasonic, Qualcomm and Ford Join Forces on First U.S. Deployment for C-V2X Vehicle Communications in Colorado"** (Qualcomm Press Release, 1st of June 2018)
- **"Savari Adds C-V2X to Roadside Units for the U.S.** V2X technology leader plans development of its first RSU equipped with both DSRC and Cellular-V2X radio technologies to future-proof smart city infrastructure deployments (Savari Press Release, 4th of June 2018)
- "**Commsignia Announces New C-V2X Roadside and Onboard Unit Product Line, Paving the Way for 5G-enabled Self-Driving Cars"** (Commisgnia Press Release, 5th of June 2018)
- **"ConVeX Consortium Hosts Europe's First Live C-V2X Direct Communication Interoperability Demonstration Between Motorcycles, Vehicles, and Infrastructure"** Audi, Ducati, Ericsson, Qualcomm, SWARCO, and Technical University of Kaiserslautern Collaborate to Demonstrate Advanced Connected Car Capabilities for Road Safety and Traffic Efficiency (Qualcomm Press Release, 4th of July)

C-V2X Gaining Momentum Worldwide

- "**Huawei Debuts its C-V2X Strategy and First RSU Commercial Solution at Mobile World Congress Shanghai**" During Mobile World Congress (MWC) Shanghai 2018, Xu Wenwei, Huawei's Executive Director and President of Strategic Marketing, presented Huawei's strategy for cellular vehicle-to-everything (C-V2X). Additionally, Huawei also launched the world's first Road Side Unit (RSU) supporting concurrency of Uu and PC5 (Huawei Press Release, 6th of July 2018)

- **"5GAA, BMW Group, Ford and Groupe PSA Exhibit First European Demonstration of C-V2X Direct Communication Interoperability Between Multiple Automakers"** Companies team up with Qualcomm and Savari to showcase C-V2X's advanced performance for safety, traffic efficiency, and autonomy. Exhibition includes communication between vehicles, motorcycles, and infrastructure, showing commercial readiness for industry deployments as early as 2020 (5GAA, 11th of July 2018)

- **"24 Members of 5GAA Send CEO Letter to the European Commission on Connected Car Legislation"** (5GAA, 7th of August 2018)

- "**Qualcomm and Datang Demonstrate World's First Multi-Chipset Vendor C-V2X Direct Communication Interoperability**" Successful C-V2X radio chipset interoperability represents accelerating commercial readiness for automaker and infrastructure deployments beginning in 2019 (Qualcomm Press Release, 22nd of August 2018)

- "**Groupe PSA showcases the leading-edge V2X communication technology for connected cars in China**" (Groupe PSA Press Release, 14th of September 2018)

- **"Ford Motor Company has successfully conducted tests of Cellular Vehicle-To-Everything (C-V2X) technologies for the first time on public roads in China, as part of an ongoing pilot project in Wuxi, Jiangsu"** (Ford Press Release, 17th of September)

5GAA CEO Letter

signed by 24 CEOs and Presidents

A1 Telekom Austria Group – Alejandro Plater, CEO
AT&T - Chris Penrose, President of Internet of Things Solutions
BMW Group – Harald Krüger, CEO
Daimler AG – Dr. Dieter Zetsche, CEO
Deutsche Telekom AG – Timotheus Höttges, CEO
Ericsson – Börje Ekholm, CEO
Ford Motor Company – James Hackett, CEO
Gemalto – Philippe Vallée, CEO
Huawei Technologies Co Ltd – Eric Xu, CEO (rotating)
Infineon Technologies AG – Dr. Reinhard Ploss, CEO
Intel Corporation – Greg Pearson, Global Policy Officer - Senior Vice President
Laird CVS (Connected Vehicle Solutions) – Steve Brown, CEO
LG Electronics – I. P. Park, President and CTO
Nokia – Rajeev Suri, CEO
noris network AG – Ingo Kraupa, CEO
Groupe PSA – Carlos Tavares, Chairman of the Managing Board
Qualcomm – Steven Mollenkopf, CEO
SAIC Motor – Chen Zhixin, CEO
Samsung – Young Sohn, President and CSO
Savari Inc. – Ravi Puvvala, CEO
Telefónica S.A – Enrique Blanco, Systems and Network Global Director
TerraNet AB - Ola Samuelsson, CEO
Vodafone Group Plc - Vittorio Colao, CEO
Wistron Neweb Corporation (WNC) – Jeffrey Gau, President & CEO
5G Automotive Association e.V.

5GAA

Brussels, July 06th 2018 (updated July 27th)

Connected car legislation taking the wrong turn: Europe risks falling behind in 5G

Dear President Juncker,
Dear Vice-Presidents Timmermans, Ansip, Katainen and Šefčovič,
Dear Commissioners Bulc, Gabriel, Bieńkowska, Moedas, Vestager and Oettinger,

Cc. Secretary General of the European Commission

As senior executives of global automotive, technology, and telecommunications companies, we fully share the European Commission's objective to "make Europe a world leader in the deployment of connected and automated mobility"[1], thereby significantly reducing the number of road fatalities and serious injuries, improving air quality and relieving traffic congestion.

To that extent, the Delegated Act being drafted under the Intelligent Transport Systems Directive[2] is of paramount importance, as it will set out the framework conditioning the uptake of Cooperative Connected and Automated Mobility in Europe.

Despite the European Commission's stated commitment to technology neutrality, **we are very concerned about the progressing Delegated Act. At the current time, it rules out the most recent technology, Cellular V2X (C-V2X)**, favouring a specific and single purpose WI FI based technology path (known as ITS-G5), thus precluding the evolution to 5G for connected cars.

Limiting C-ITS deployment for vehicle-to-vehicle and vehicle-to-infrastructure communications to ITS-G5 would imperil the EU automotive industry's ability to compete in today's global and constantly evolving technological marketplace. Carmakers would be locked into a technology, which, despite its name, has no relationship to 5G technology and certainly no evolutionary path towards compatibility with 5G. This places Europe at an economic disadvantage compared with other regions of the world including China and the United States, where C-V2X is emerging as a strong technology candidate for C-ITS.

Such a decision would stunt the overall emergence of 5G connectivity infrastructure in Europe, and run counter to the objectives of the Commission's own 5G action plan[3], which aims to promote early deployment of 5G along major transport paths. A de-facto ITS-G5 mandate will mean that the transportation and telecommunication industries have much less incentive to invest in 5G for automotive and to provide 5G coverage alongside road corridors.

[1] "On the road to automated mobility: An EU strategy for mobility of the future" COM(2018) 283
[2] Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport
[3] "5G for Europe: An Action Plan" COM(2016) 588

5GAA – 5G Automotive Association e.V.
Neumarkter Straße 21
81673 Munich, Germany
EU transparency register ID number: 802312827842-26

Contact
5gaa-liaison@5gaa.org
T +32 2 588 24 18
www.5gaa.org

Executive Committee
Markus Dillinger
Mark Hartje
Dino Flore

5GAA

C-V2X technology offers a direct evolution path to 5G. It provides the best of both worlds, combining both direct short-range communication in the 5.9 GHz ITS spectrum band (not requiring network coverage or subscription) and long-range communication in licensed spectrum allocated for 4G and 5G, into a single, cost-effective platform.

C-V2X builds upon the technical efforts and investments made thus far to standardise and implement C-ITS, such as today's deployment by some carmakers of Day 1 and 1.5 services via existing cellular networks, already benefiting customers.

C-V2X enables synergies with both the transport and telecom infrastructure: substantial economic benefits can be gained by leveraging existing mobile network infrastructure for C-ITS.[4] As 5G builds up, multiple synergies will be made possible with other vertical sectors e.g. smart cities or industry 4.0. In contrast, a single-purpose ITS-G5 network would have to be deployed and maintained in the next decades, at the sole cost of road operators.

In addition, C-V2X is the only technology offering the future capability to interlink the legacy fleet, or vulnerable road users, with the new C-ITS enabled vehicles via smartphone connectivity. This will lead to rapid positive safety impacts and thereby reduce fatalities and serious injuries on the EU's roads.[5]

It is important to understand that significant investment towards 5G by European companies is already taking place across Europe and around the world, with C-V2X technology trials in Germany, France, Spain, the United Kingdom, China, Japan, South Korea and the United States, and in-vehicle commercial launch foreseen at the latest by 2020 globally.

As highlighted by the European Commission's Communication "On the road to automated mobility"[6], Europe needs a regulatory framework that supports and encourages innovation, enables increased investment and, more importantly, assures that as a community we create a thoroughly safe environment for the benefit of each European citizen.

We therefore call on the European Commission to craft a forward-looking, technology neutral framework, and to urgently address the shortcomings of the current EC Delegated Act, by including C-V2X on the list of potential technologies that European stakeholders may pursue. Moreover, the Delegated Act adoption should not be rushed but conducted in transparent consultation with all stakeholders.

The alternative is that Europe forfeits one of the most consequential technology transformations in our lifetime to global competitors and discourages a technology that would provide Europeans with the most potential safety benefits.

[4] Socio-economic benefits of Cellular V2X, Analysys Mason and SBD Automotive, December 2017
[5] An assessment of LTE-V2X (PC5) and 802.11p direct communications technologies for improved road safety in the EU, 5GAA, December 2017
[6] "On the road to automated mobility: An EU strategy for mobility of the future" COM(2018) 283

5GAA – 5G Automotive Association e.V.
Neumarkter Straße 21
81673 Munich, Germany
EU transparency register ID number: 802312827842-26

Contact
5gaa-liaison@5gaa.org
T +32 2 588 24 18
www.5gaa.org

Executive Committee
Markus Dillinger
Mark Hartje
Dino Flore

So what is 5GAA

5GAA brings together automotive, technology and telecommunications companies to work closely together to develop end-to-end solutions for future mobility and transportation services

AUTOMOTIVE INDUSTRY

Vehicle Platform, Hardware and Software Solutions

TELECOMMUNICATIONS

Connectivity and Networking Systems, Devices and Technologies

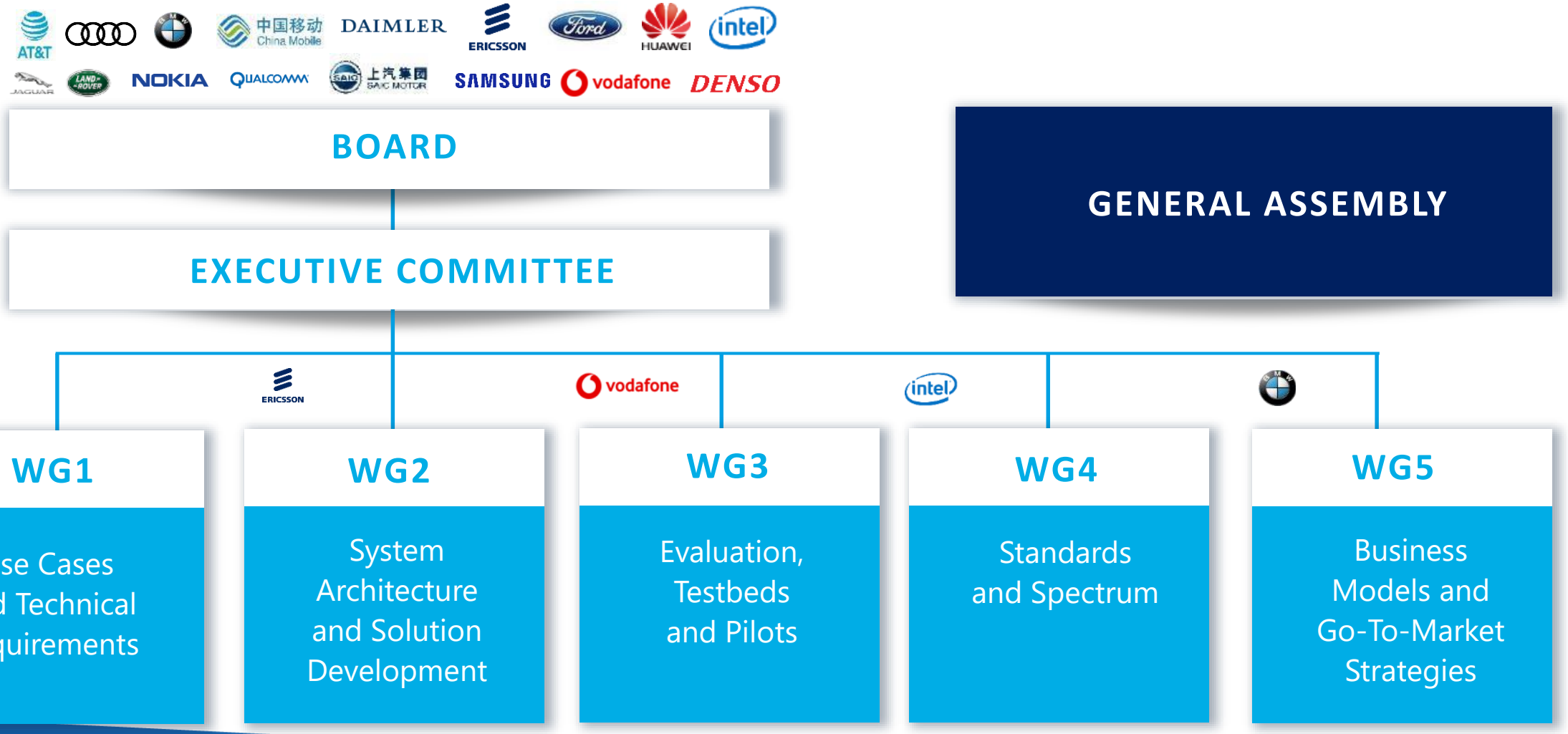
5GAA unites 100+ members* from around the world working together on all aspects of C-V2X including technology, standards, spectrum, policy/regulations, testing, certification, business models and go-to-market

*as of Oct 2018


Airgain
ALPINE
AMERICAN TOWER
ANALOG DEVICES
Anritsu
envision:ensure
AT&T
Audi
BAIC GROUP
Bell
BlackBerry
BMW GROUP
BOSCH
CETECOM
CHINA TRANSINFO
China Mobile
China unicom
Cohda Wireless
commsignia
Continental
The Future in Motion
DAIMLER
DANLAW
AUTOMOTIVE MADE SMART
DEKRA
DENSO
Dt&C
ERICSSON
Faraday Future
FAREASTONE
FEV
Ford
Fraunhofer
GEELY
gemalto
security to be free
GM
Gotell
Hirschmann Car Communication
HITACHI
Inspire the Next
HONDA
HUAWEI
HYUNDAI
MOTOR GROUP
iDIRECT
infineon
intel
INTERDIGITAL
JAGUAR
LAND ROVER
JUNIPER
NETWORKS
KDDI
KEYSIGHT
TECHNOLOGIES
kt
Laird
LEAR
CORPORATION
LG
MAGNETI MARELLI
MITSUBISHI ELECTRIC
Changes for the Better
muRata
NAVINFO
Neusoft
NIO
NISSAN
MOTOR CORPORATION
NOKIA
noris network
NTT docomo
OKI
orange
Panasonic
proximus
PSA
GROUPE
QUALCOMM
ROHDE&SCHWARZ
ROHM
SEMICONDUCTOR
SAIC MOTOR
SAMSUNG
SAVARI
SGS
Anting · Shanghai International Automobile City
SK telecom
SKYWORKS
SMART MOBILE LABS
SoftBank
SUMITOMO ELECTRIC
Telefonica
A1 Telekom Austria Group
TELUS
TERRANET
TÜVRheinland
Valeo
VENIAM
verizon
VIAVI
vodafone
Volkswagen
VOLVO
WNC
Wistron NeWeb Corp.
ZF
ZTE

7% of 5GAA members are Korean-based organizations

5GAA Organisational Structure



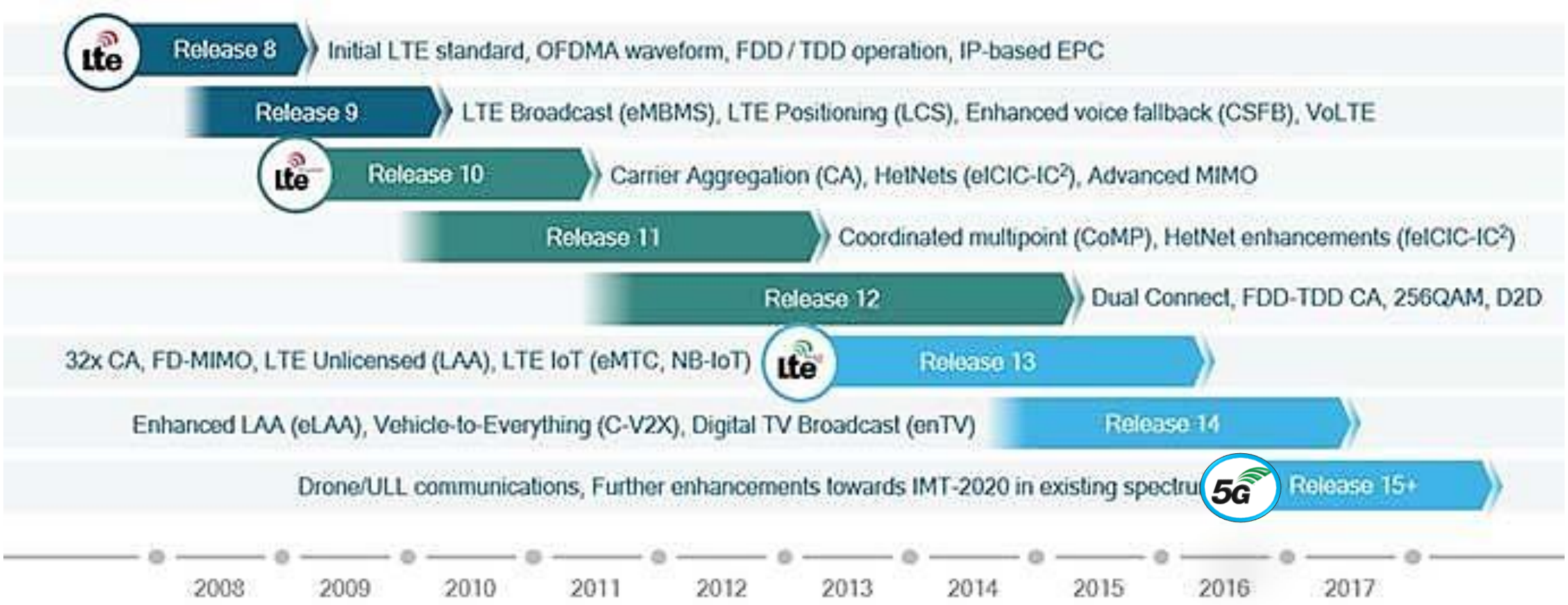

3GPP
A GLOBAL INITIATIVE
ETSI
EATA
GTI
Global TD-LTE Initiative
IMT-2020
CEPT ECC
Electronic Communications Committee
ngmn
the engine of broadband wireless innovation
5GAA
Automotive Association
ENSEMBLE
Ecosystem Cooperation
5G IA
INFRASTRUCTURE ASSOCIATION
Connected Motorcycle Consortium
VDT
Alliance
5GIMIF
The Fifth Generation Mobile Communications Promotion Forum
Tiaa

Why is 3GPP so important for the Automotive

3GPP: A Global Partnership Project

599 member organizations in 41 territories

- A journey towards 5G



3GPP is steadily building the blocks towards a family of air interfaces embedded in 5G

5G Vision: a swiss knife for all industries

Automotive

Public safety

Manufacturing

Multimedia & gaming

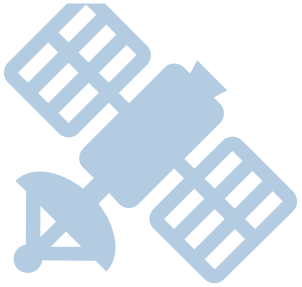
Energy

Health

Smart cities

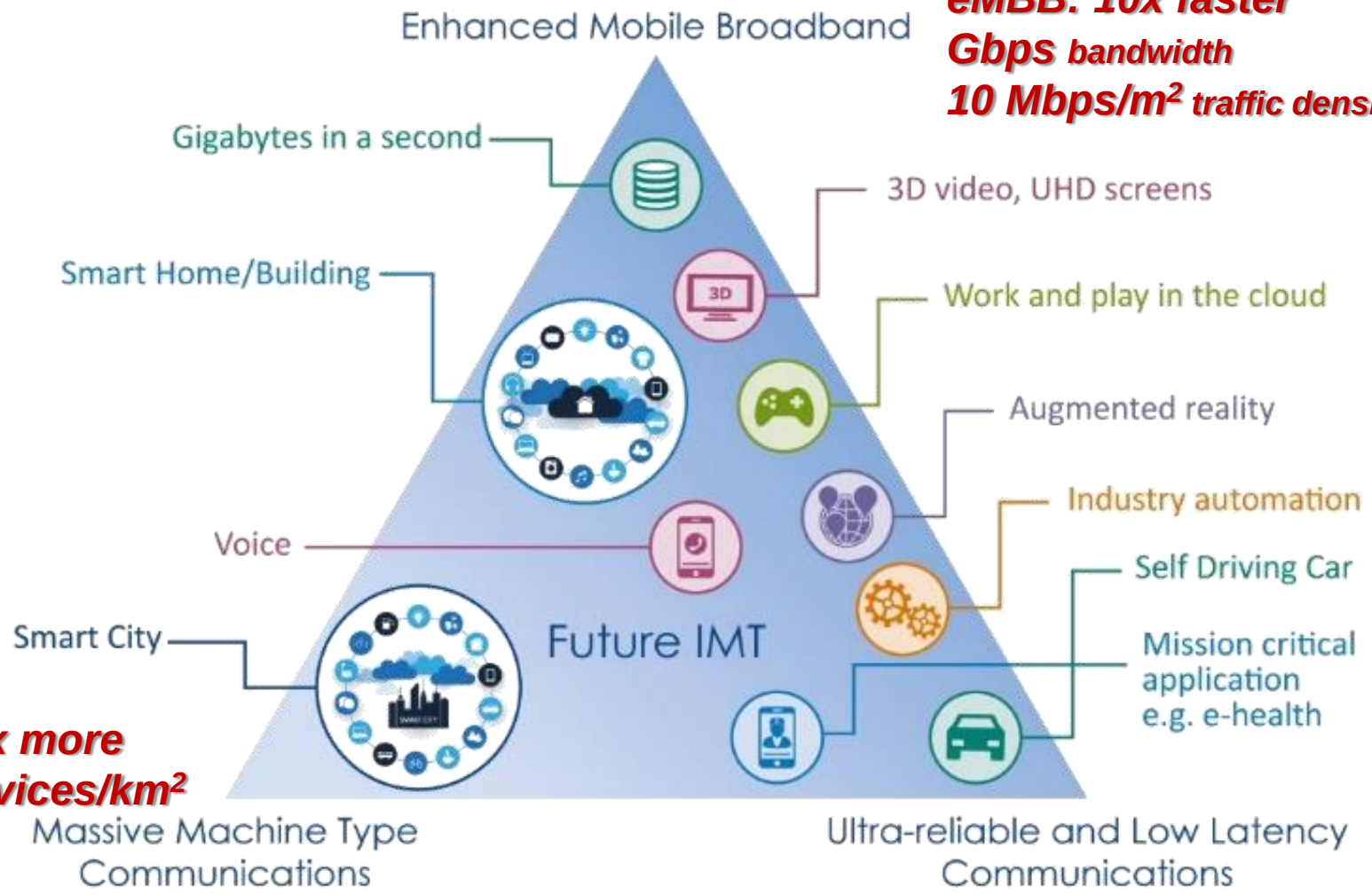
Public Transport

Farming & food



Aerospace

Setting the basis for 5G New Radio (NR) in Rel-15



eMBB: 10x faster
Gbps bandwidth
10 Mbps/m² traffic density

mMTC: 100x more
1 million devices/km²

URLLC: 10x better
True ms latency
99,999% reliability

ULTRA WIDE BANDWIDTH

ADAPTED NUMEROLOGIES
AT DIFFERENT FREQUENCIES

NATIVE **FORWARD COMPATIBILITY** MECHANISMS

LOW TO VERY HIGH FREQUENCY BANDS

LEVERAGING ON
CUTTING EDGE IMPROVEMENTS

NATIVE SUPPORT FOR
NETWORK SLICING

NEW CHANNEL CODING

NATIVE SUPPORT FOR **LOW LATENCY AND ULTRA RELIABILITY**

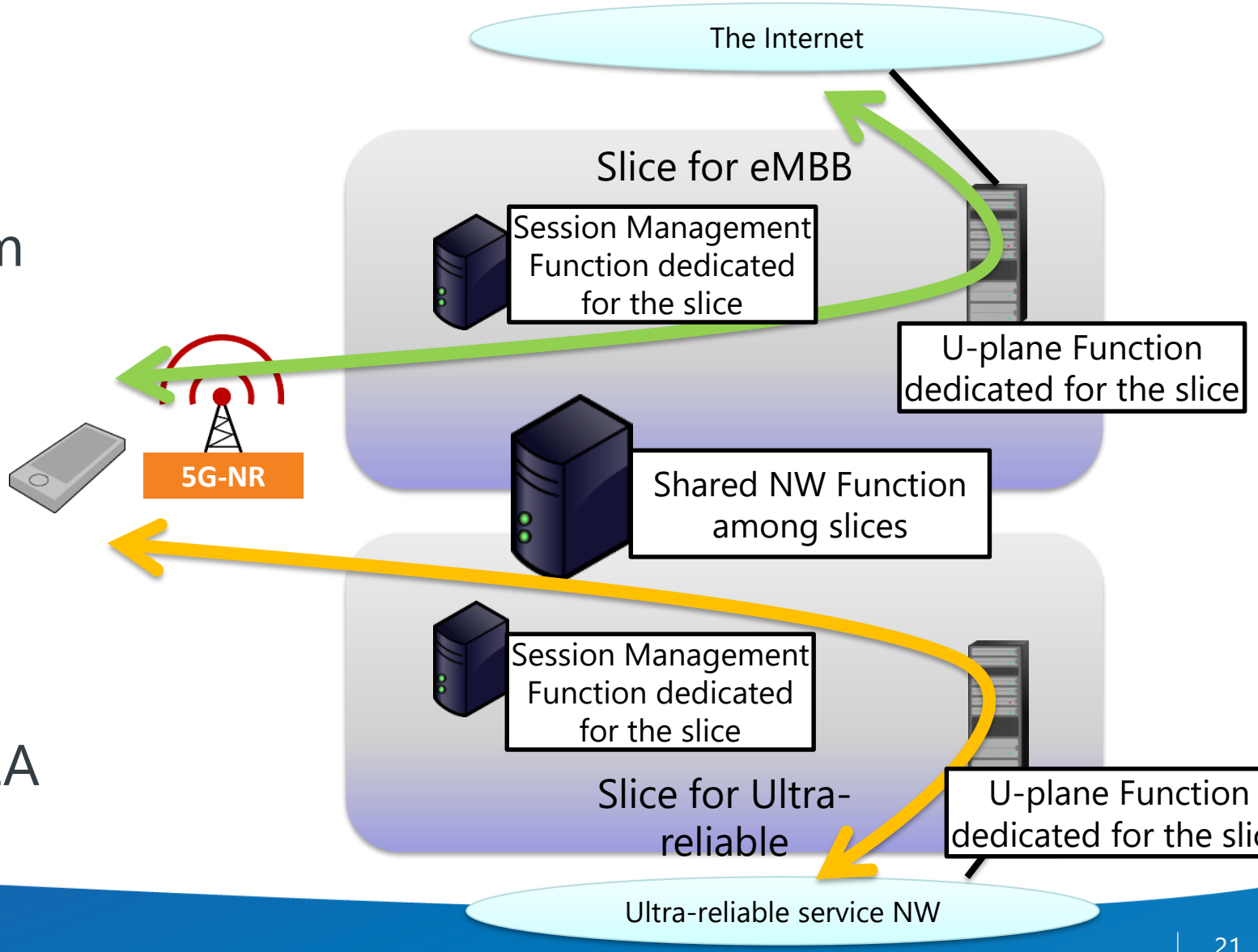
FLEXIBLE AND MODULAR
RAN ARCHITECTURE

Ultra-reliable and Low Latency Communications

Network slicing

Resource isolation from other service
→ No service impact caused by other slices failure

Customized NW functions and/or capacities to ensure SLA

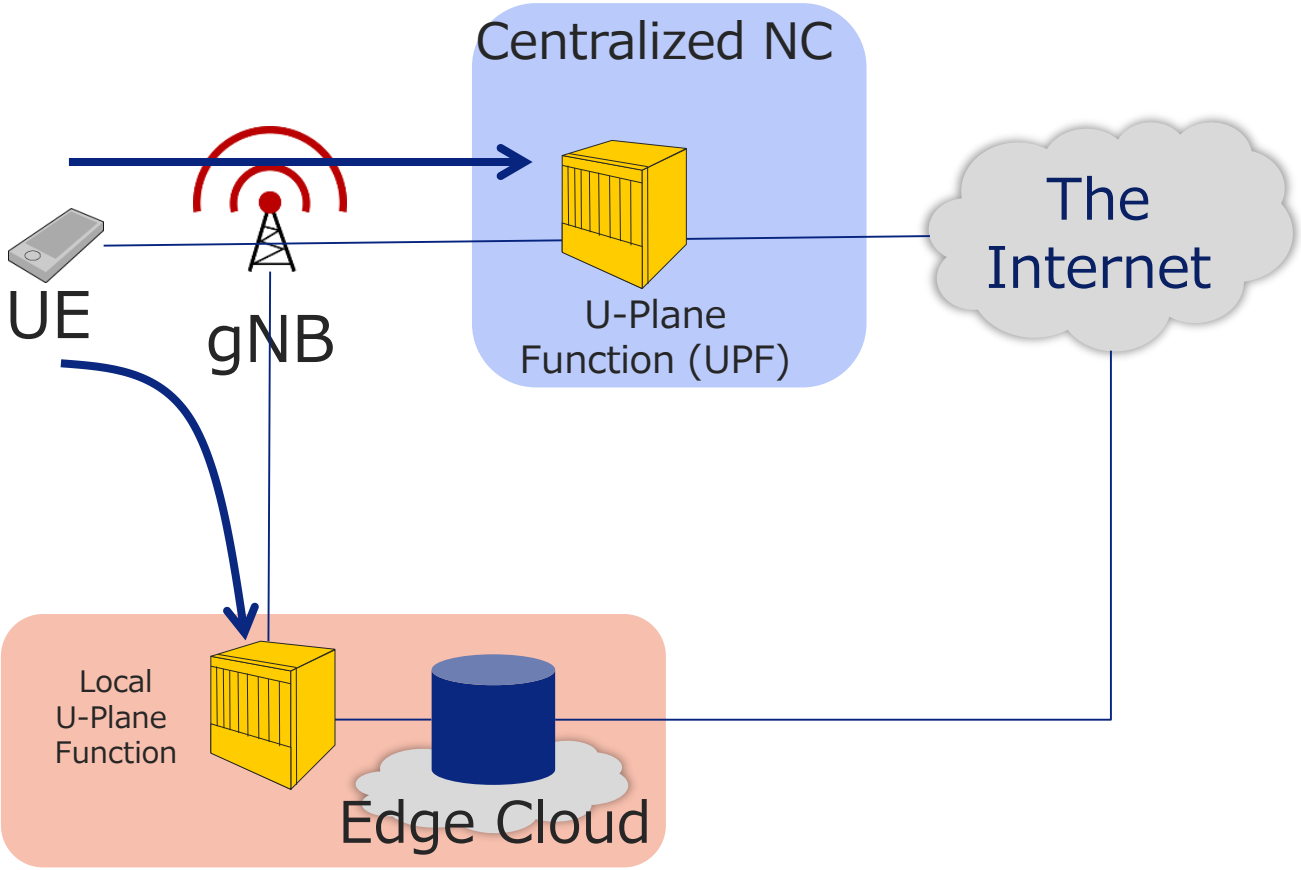


Ultra-reliable and Low Latency Communications

Edge Computing

Applications can be hosted at "Edge-side"

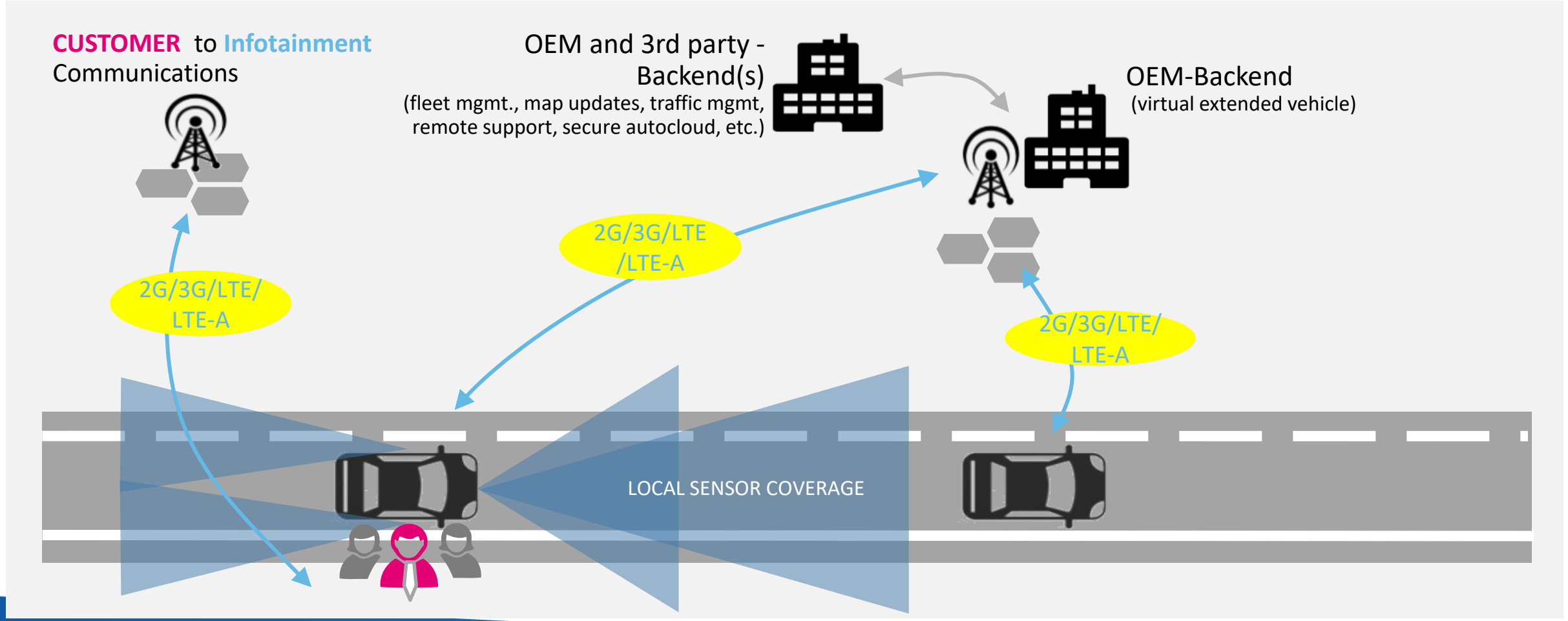
→ Low Latency compared with centralized manner



What can 3GPP do for Automotive

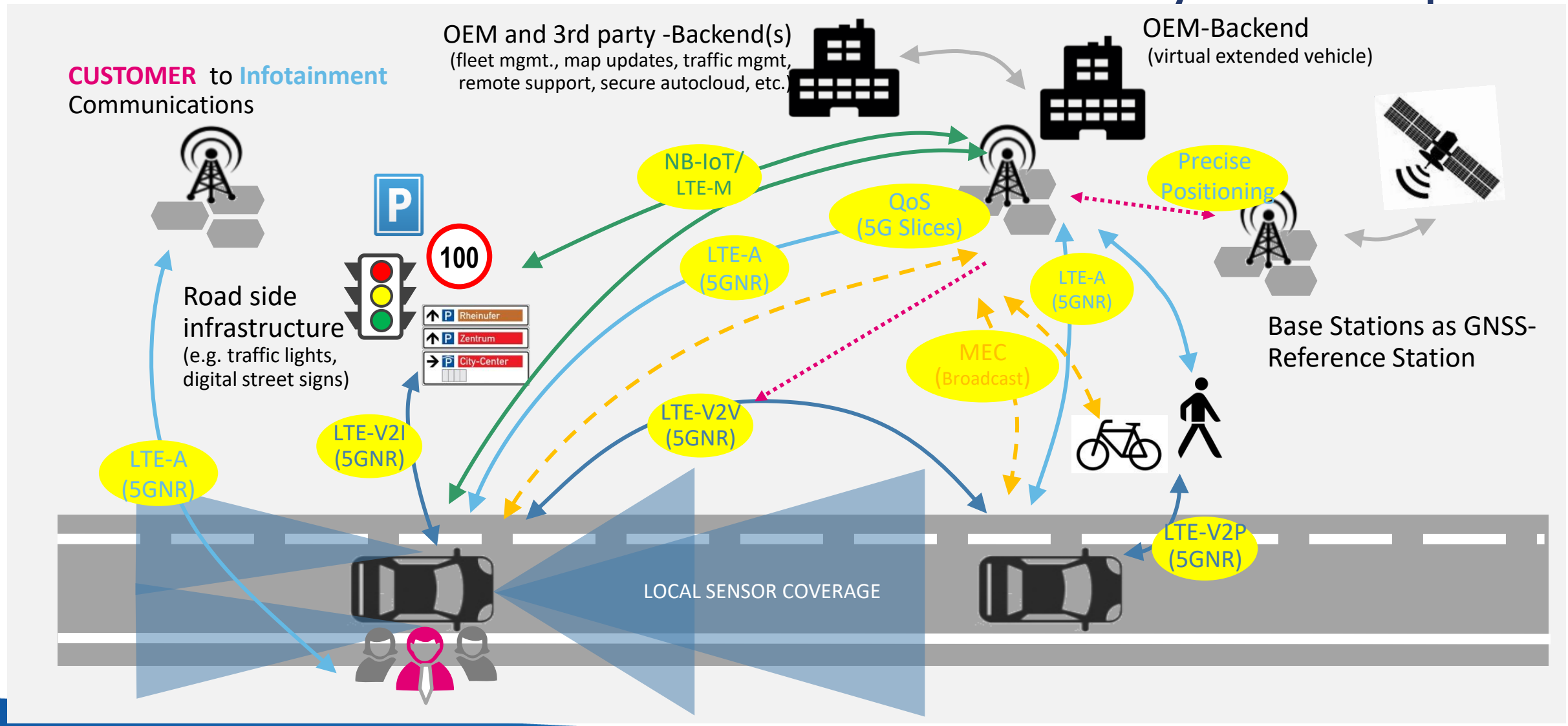
Source: Deutsche Telekom

Automotive picture today
cellular connectivity as a matter fact



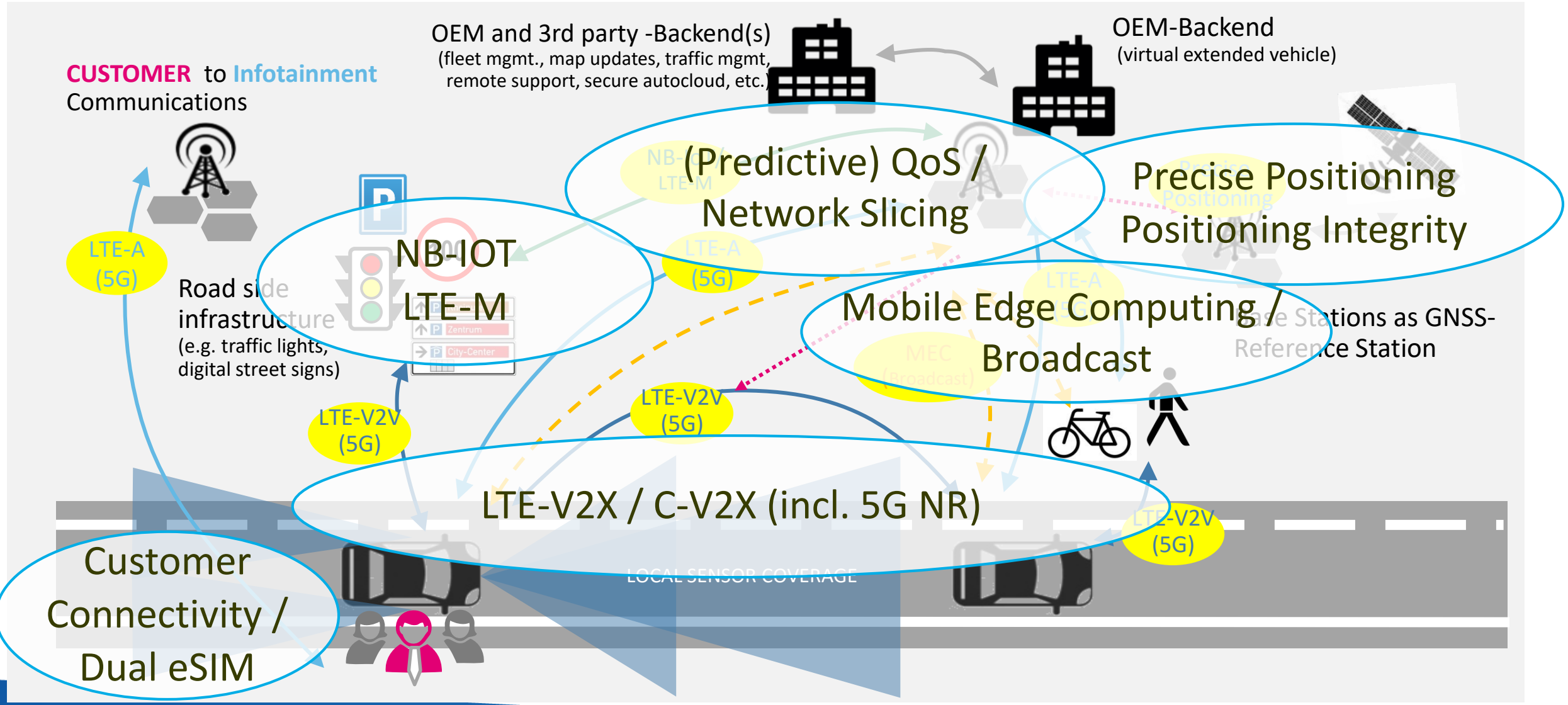
Source: Deutsche Telekom

Extended automotive cellular connectivity landscape



Source: Deutsche Telekom

Automotive cellular connectivity / topics



Let’s focus on C-V2X

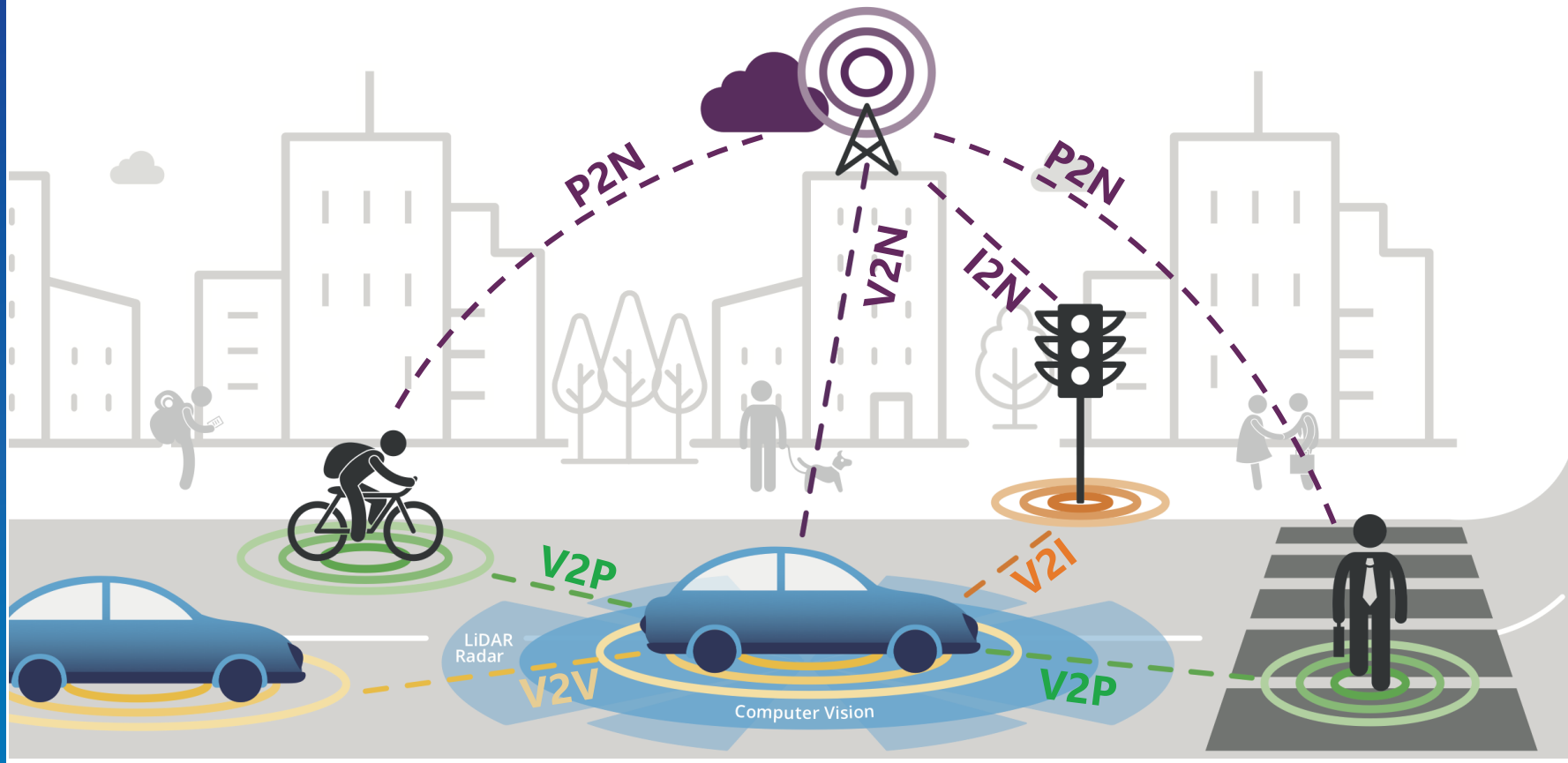
C-V2X is a comprehensive road safety and traffic efficiency solution that allows **vehicles** to communicate with

- **Other vehicles (V2V),**
- **Pedestrians and Cyclists via smartphones (V2P),**
- **Road Infrastructure (V2I),**

supported by the

- **Mobile network (V2N, P2N, I2N)**

to guarantee **full coverage** and **continuity of services**.

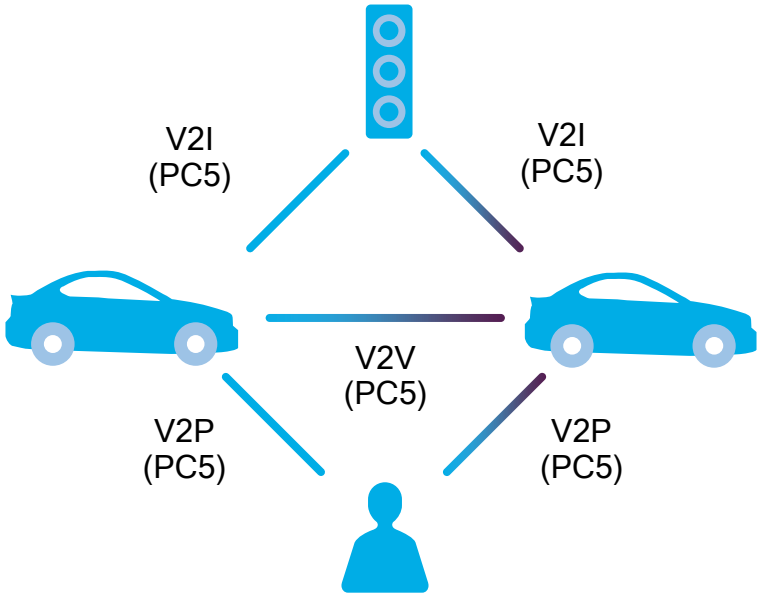


5GAA Automotive Association

C-V2X has two complementary communication modes

Direct (= Sidelink)

V2V, **V2I**, and **V2P** operating in ITS bands (e.g. ITS 5.9 GHz) independent of cellular network

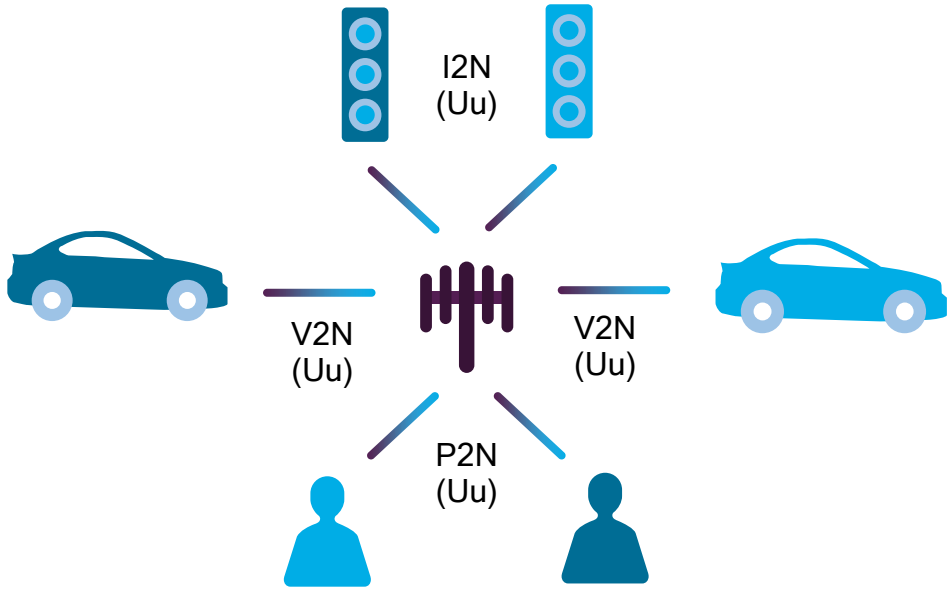


Short range (<1 kilometer), location, speed

Implemented over “PC5 interface”

Network (= Up/Downlink)

V2N operates in traditional mobile broadband licensed spectrum

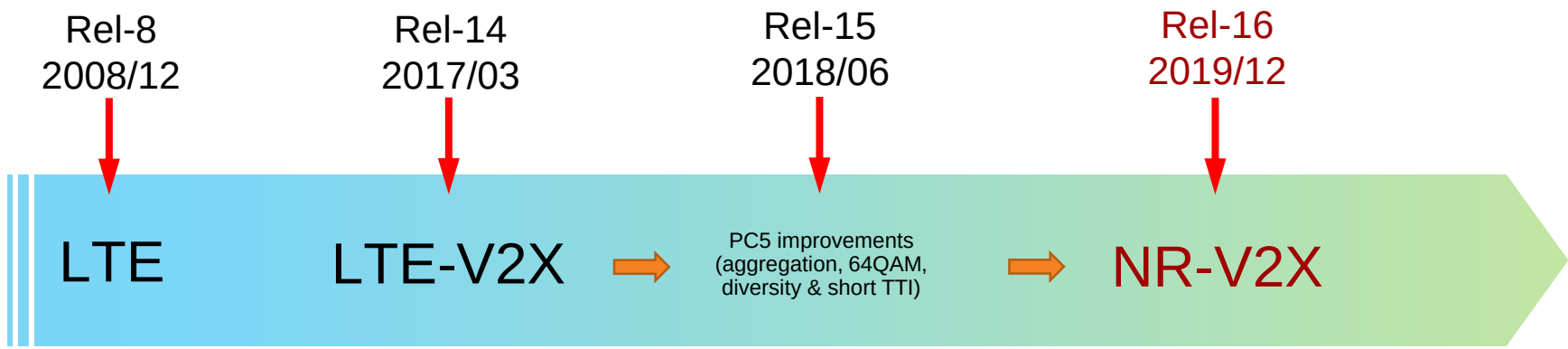


Long range (>1 kilometers). e.g. accident ahead

Implemented over “Uu interface”

3GPP time plan

- Current version of C-V2X is called LTE-V2X as part of 3GPP Rel-14 & 15
- NR-V2X as part of Rel-16 comes as an improvement to support autonomous driving
- NR-V2X will complement and co-exist with LTE-V2X i.e. operation of NR-V2X alone is not considered.

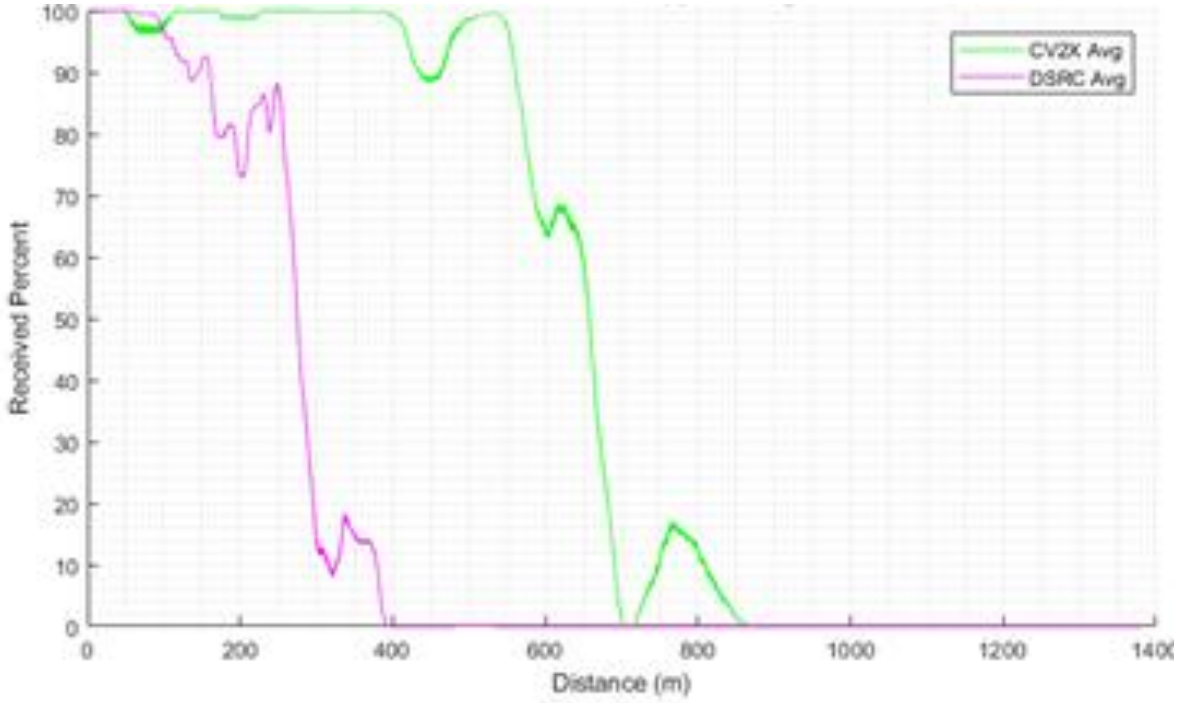


- NR-V2X study item started in June 2018.
- Subsequent NR-V2X work item by December 2019.

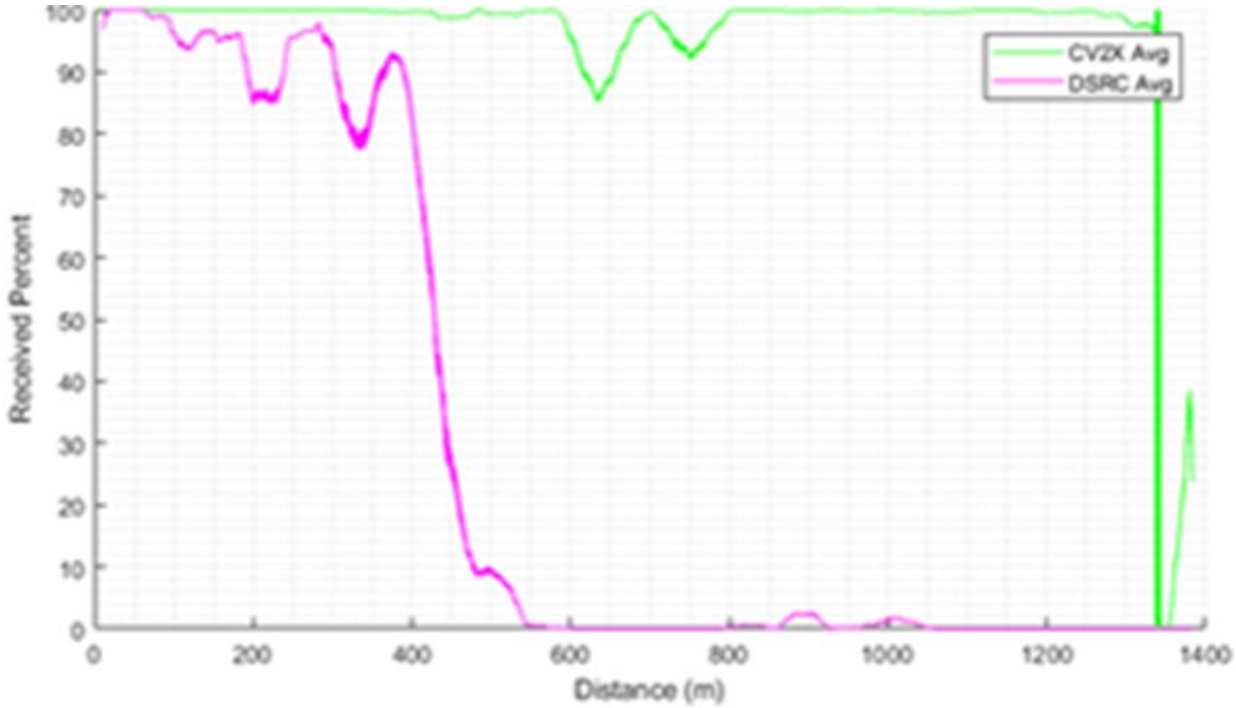
C-V2X compared to DSRC

Shadowing Test RESULTS

5GAA shadowing test, Approach



CAMP shadowing test, Approach



- 5GAA shadowing test is more demanding than CAMP test.
- CV2X outperforms 802.11p in shadowing scenarios.

testing results Summary

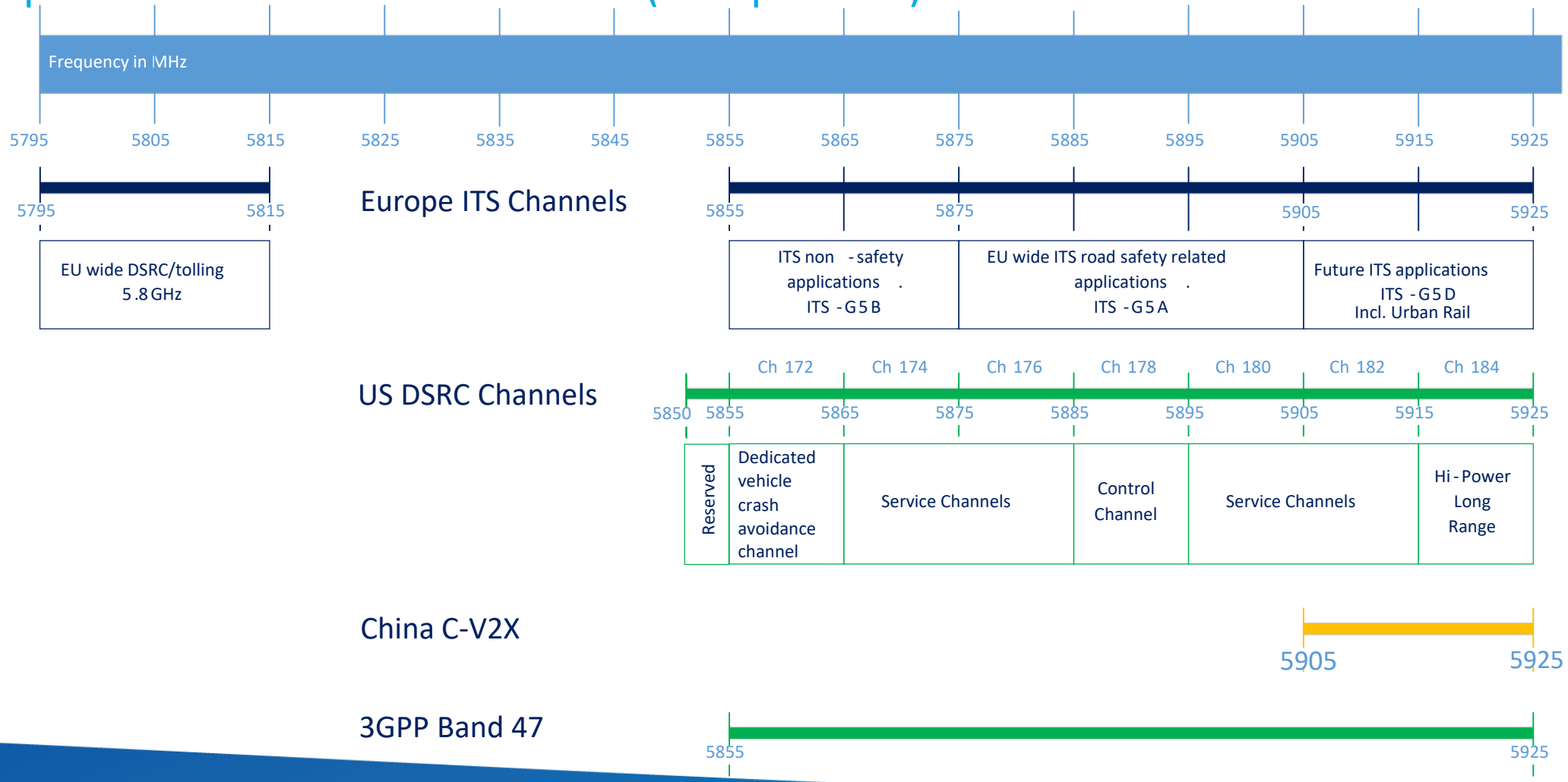
Reliability	**Lab** Cabled Tx and Rx Tests	CV2X better
	Field Line-of-Sight (LOS) Range Tests	CV2X better
	Field Non-Line-of-Sight (NLOS) Range Tests	CV2X better
Interference	**Lab** Cabled Test with Simulated Co-channel Interference	CV2X better
	Lab Cabled Near-Far Test	✓
	Field Co-existence with Wi-Fi 80 MHz Bandwidth in UNII-3	CV2X better
	Field Co-existing of V2X with Adjacent DSRC Carrier	✓
Congestion	**Lab** Cabled Congestion Control	✓

- Complete benchmark report will be published in October on 5GAA.org

ITS spectrum utilization status

Current ITS Spectrum Allocation Worldwide

- ITS Spectrum is allocated in 5.9 GHz (Europe & US)

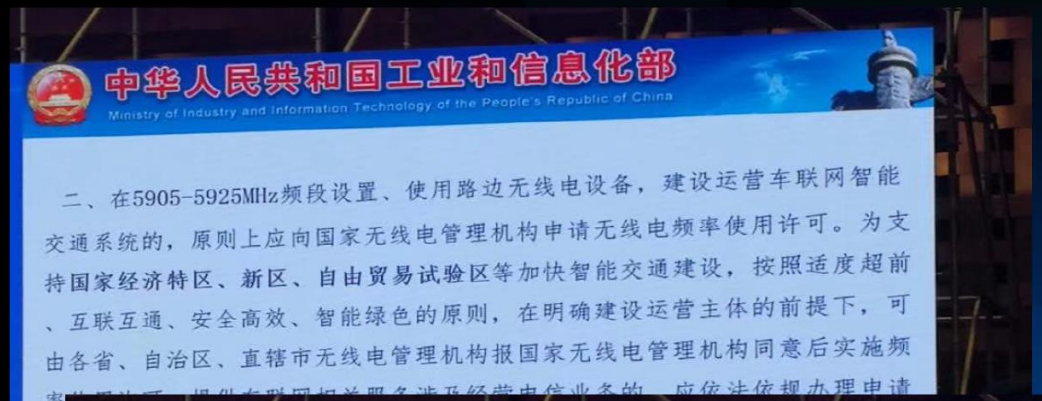


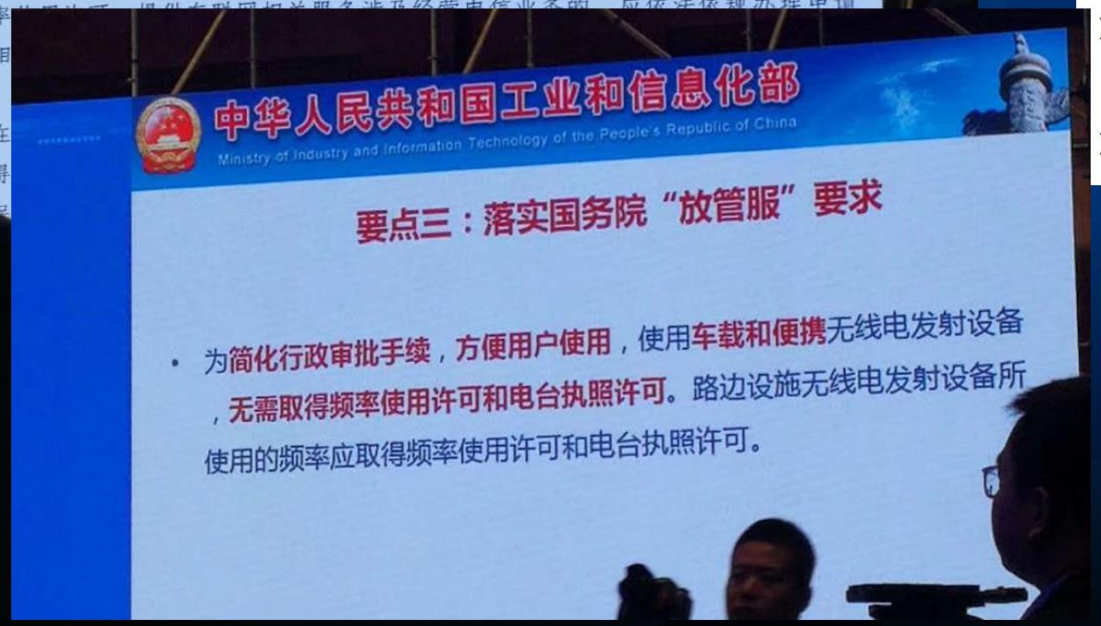
U.S. Regulatory Environment

- In 2016, the USDOT proposed a rule that would advance the deployment of connected vehicle technologies (DSRC)
  - The NPRM has not moved ahead since
  - USDOT is “not in the business of picking technologies for the industry” (per new NHTSA administrator Heidi King)
- In 2003, the Federal Communication Commission (FCC) adopted rules mandating the use of DSRC radios in the 5.9 GHz band.
  - Under these rules C-V2X operations are not permitted in the band
  - 5GAA is prosecuting a petition to change FCC service rules for 5.9 GHz band to allow C-V2X operations while preserving the band for ITS

5GAA is working towards creating a conducive regulatory environment in the US for deployment of C-V2X as soon as possible.

Formally Release the LTE-V2X Spectrum for IoV

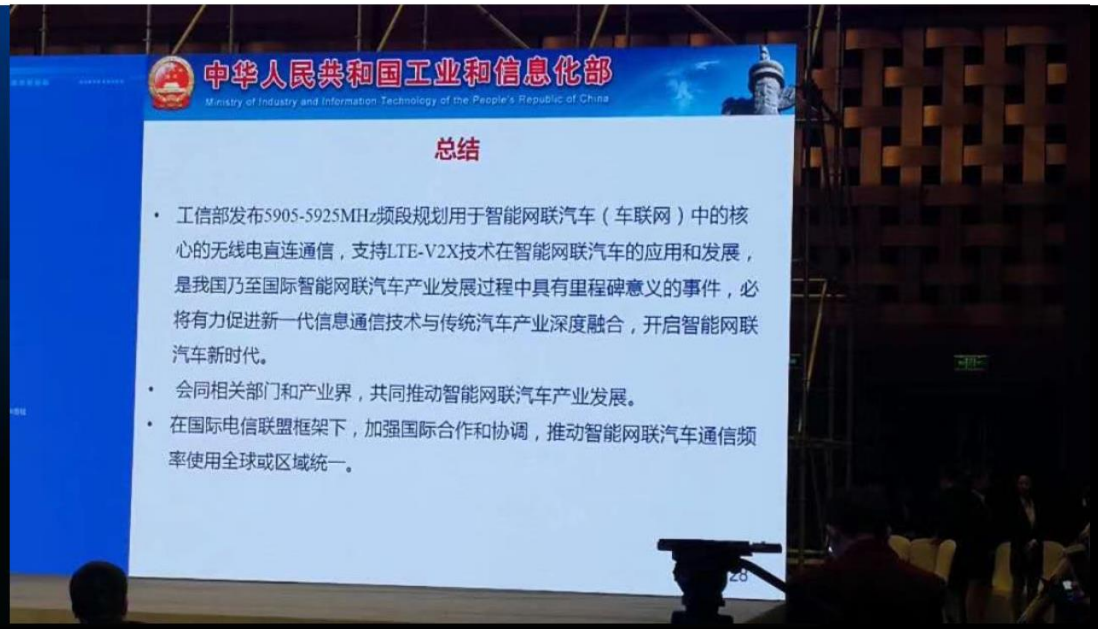




ver7E89.tmp.png

IoV (Internet of Vehicle) direct communication 5905 – 5925MHz Spectrum Usage Regulation

- Deployment and operation of IoV should apply license from MIIT to support the ITS system deployment, If the IoV operator is confirmed, the spectrum usage can be approved by provincial radio regulator.
- The usage of vehicle onboard and portable V2X device doesn't need spectrum permission and radio station license.
- Strengthen the worldwide cooperation to realize spectrum harmonization.

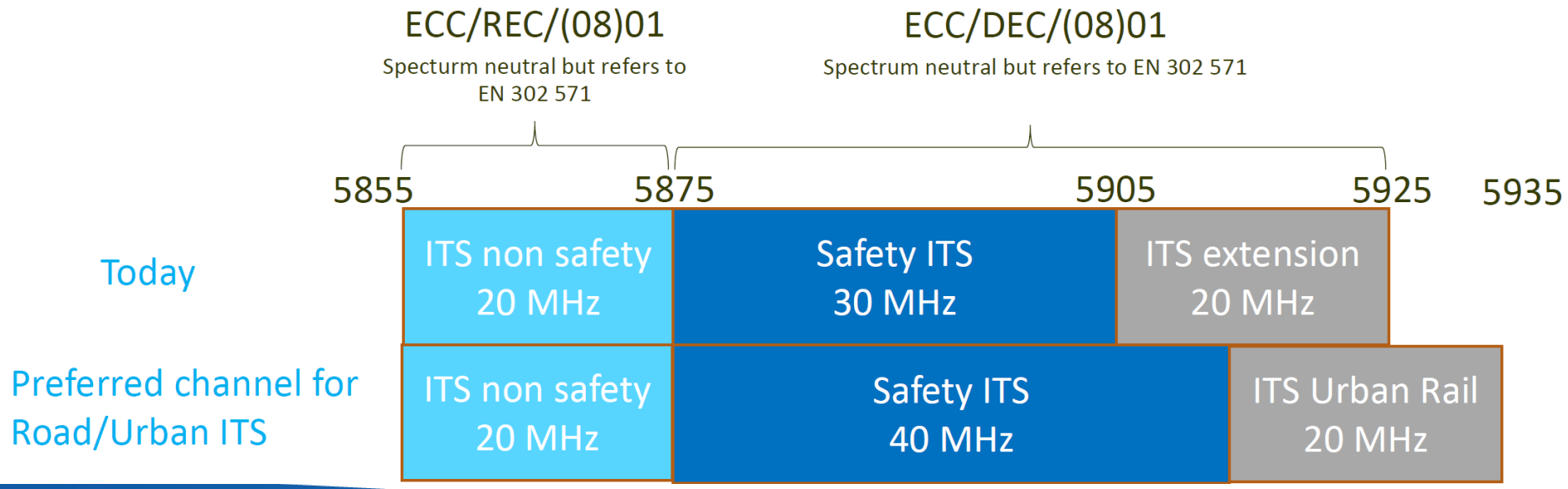


HUAWEI

5.9 Ghz Spectrum for ITS safety services in Europe

- 2018 EC Mandate to CEPT & ETSI (updated)
  1) study the definition of priority bands within the prioritised Road-ITS band for the two competing technologies
  2) extend the mandate to cover the band up to 5935 MHz for Urban Rail.

➢ To update EC Decision 2008/671/EC on 5.9 GHz

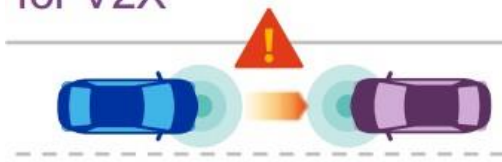


Basic Safety Use Cases as part of Rel-14 C-V2X

Evolution to 5G,
while maintaining backward compatibility

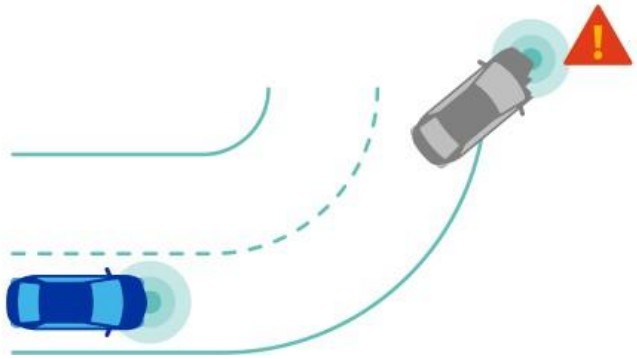
Basic safety
802.11p or C-V2X R14

Established foundation for V2X



Enhanced safety
C-V2X R14/15

Enhanced range and reliability



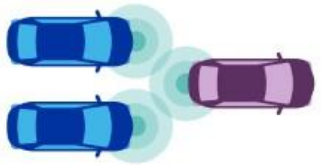
Advanced safety
C-V2X R16 (building upon R14)

Higher throughput

Higher reliability

Wideband ranging and positioning

Lower latency



Source:Qualcomm

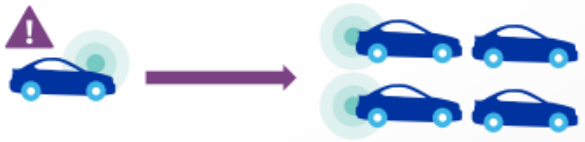
V2X enables a broad and growing set of use cases

Much more than collision avoidance

Forward collision warning

Do Not Pass Warning (DNPW)

Blind intersection



Queue warning

Curve speed warning

Cooperative adaptive cruise control & platooning

Vulnerable Road User (VRU) alerts

Discover parking and charging

Traffic signal priority and optimal speed advisory

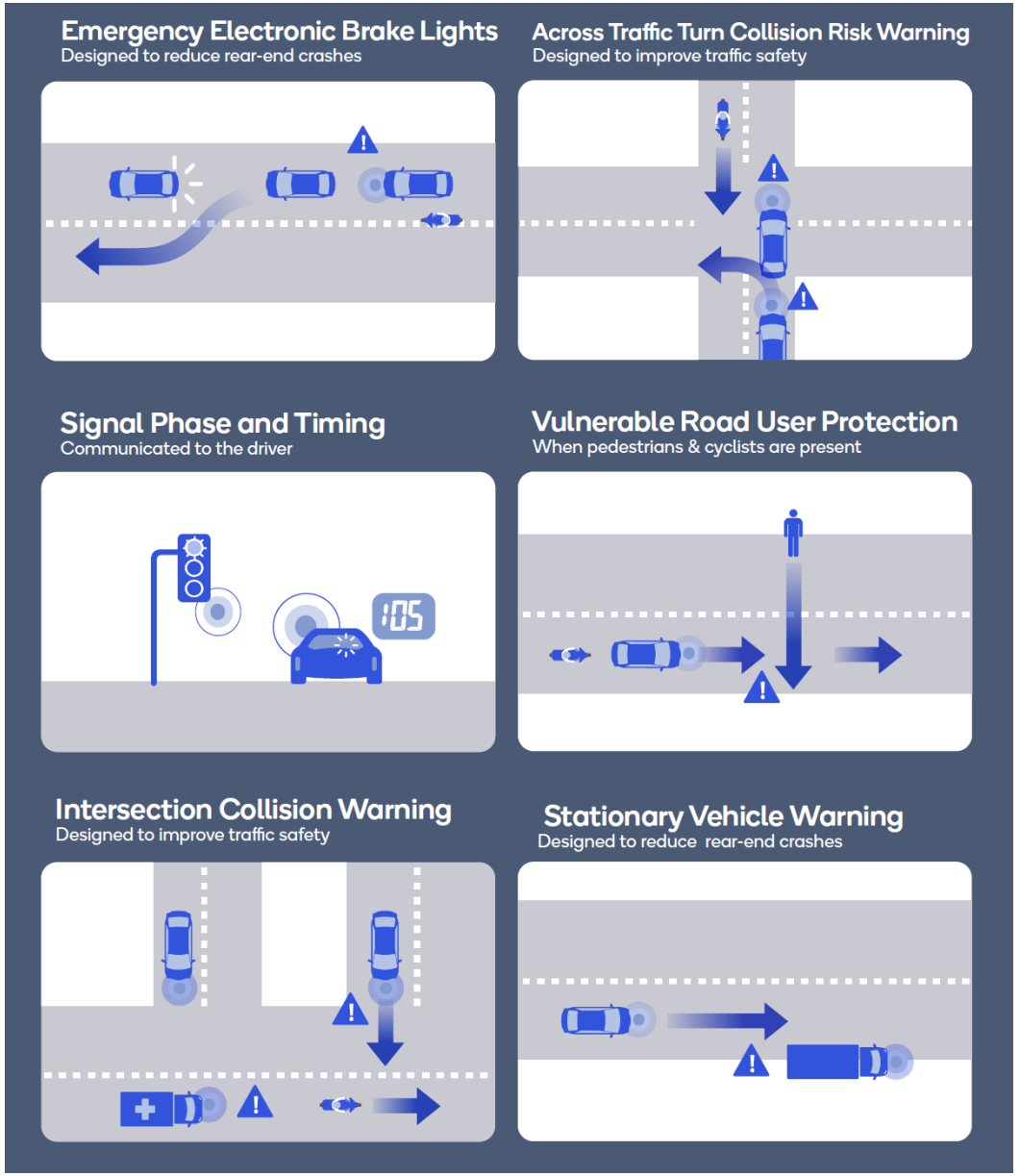
Emergency vehicle alert

Source: Qualcomm

Rel-14 Basic Safety Use Cases: V2V Demonstrations in Shanghai, Washington and Paris (2017-2018)*

- Emergency Electronic Brake Lights
- Across Traffic Turn Collision Risk Warning
- Signal Phase and Timing
- Vulnerable Road User Protection
- Intersection Collision Warning
- Slow Vehicle Warning and Stationary Vehicle Warning

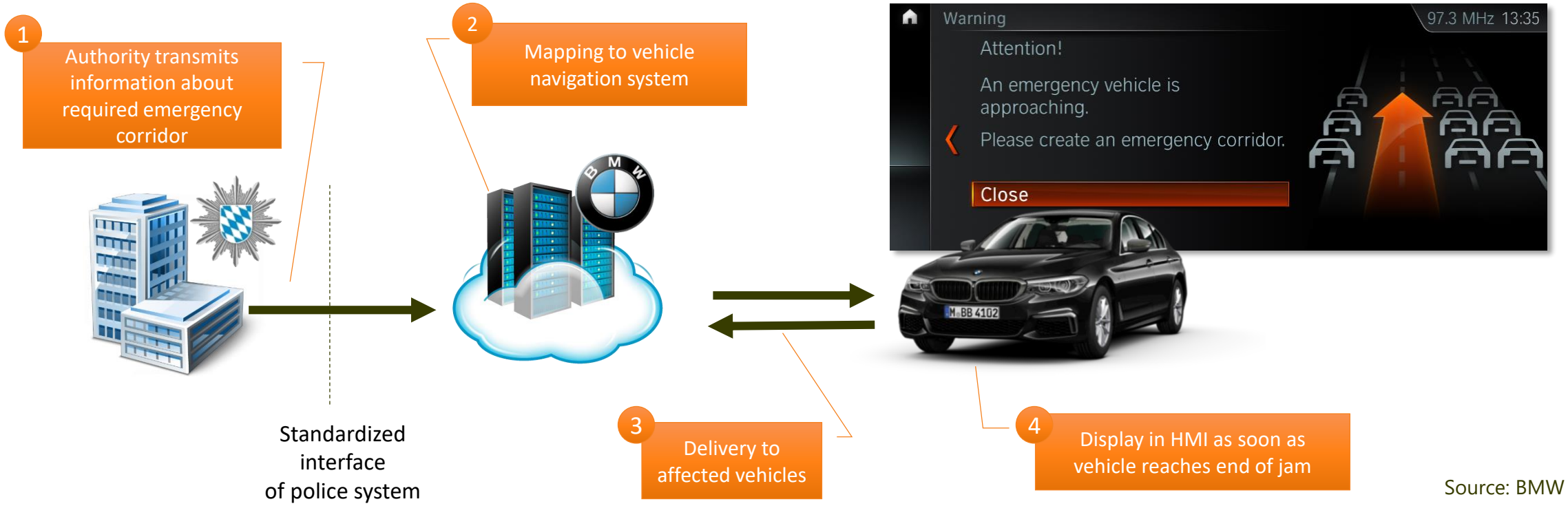
*(+ This week in Yokosuka)



C-V2X

Transforming road safety

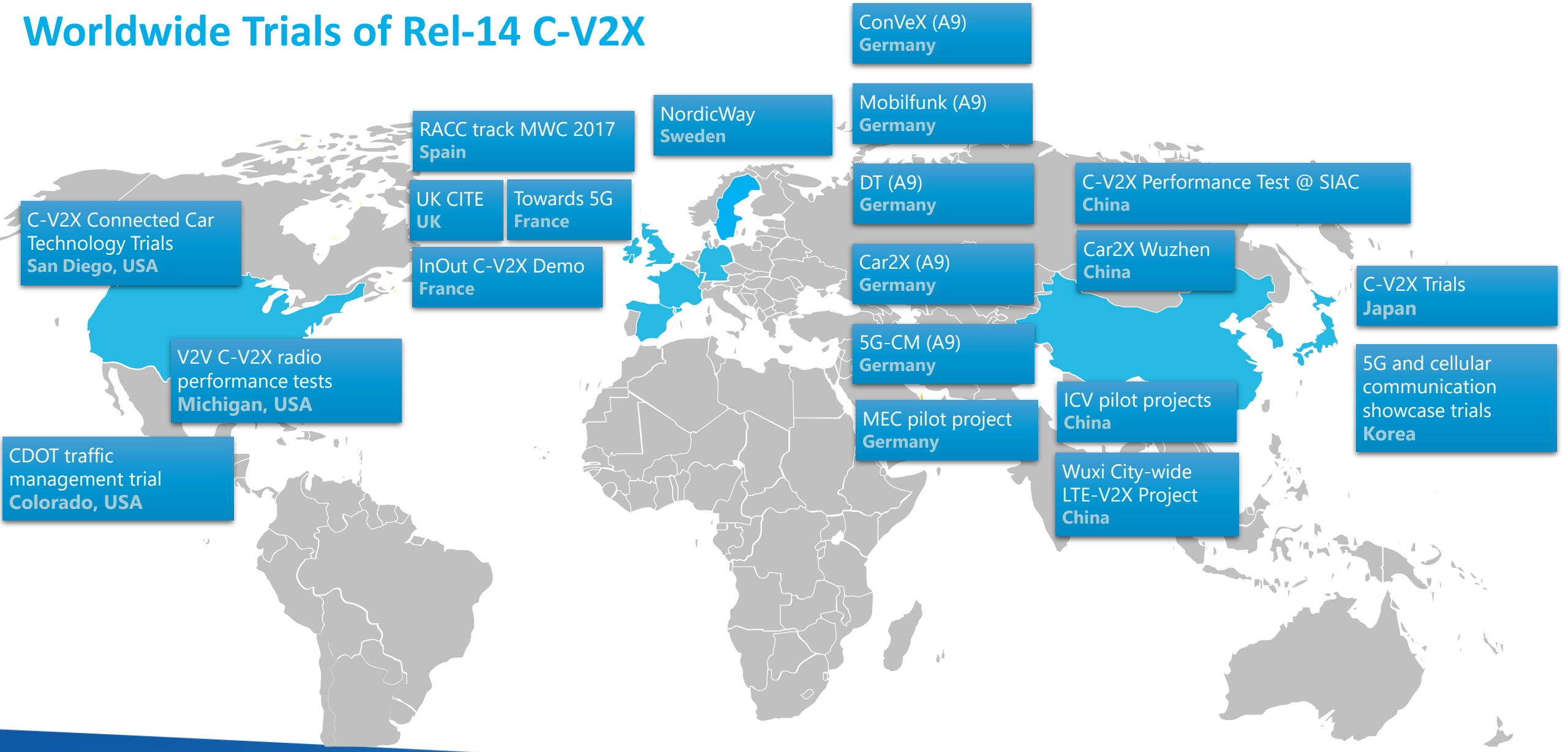
V2N Application: Emergency corridor – A cooperation between BMW and the Bavarian emergency services



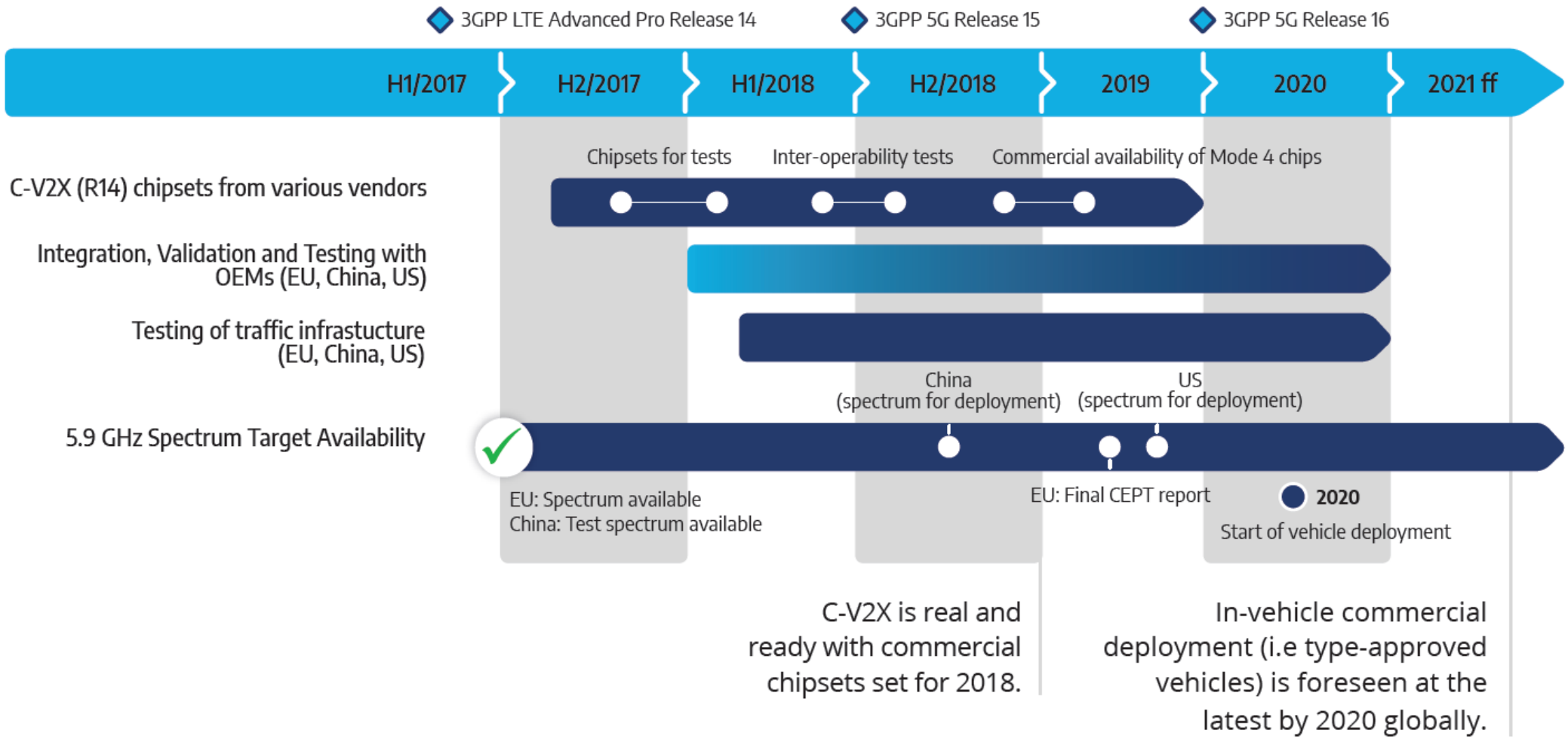
Source: BMW

- Sovereign authorities are able to warn road users through back end systems at an early stage.
- Information is transmitted only to concerned cars; high level of reliability and low failure rate increase customer trust.

Worldwide Trials of Rel-14 C-V2X



Timeline for deployment of Release 14 C-V2X (V2V/V2I) products

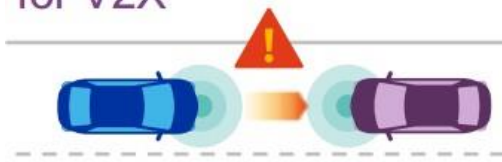


Path towards Rel-16 NR-V2X

Evolution to 5G,
while maintaining backward compatibility

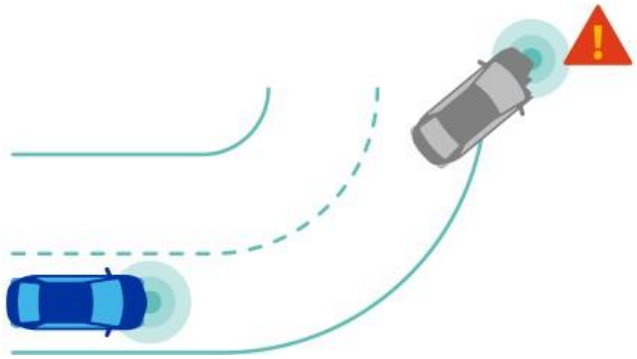
Basic safety
802.11p or C-V2X R14

Established foundation for V2X



Enhanced safety
C-V2X R14/15

Enhanced range and reliability



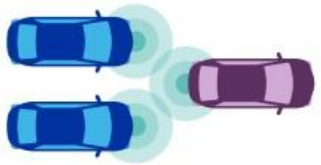
Advanced safety
C-V2X R16 (building upon R14)

Higher throughput

Higher reliability

Wideband ranging and positioning

Lower latency

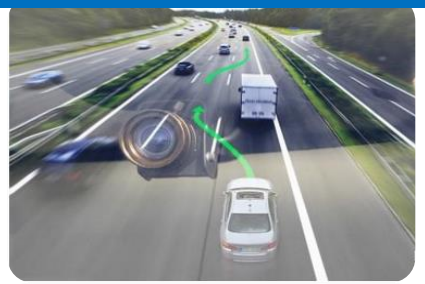


Source:Qualcomm

Requirements for autonomous driving

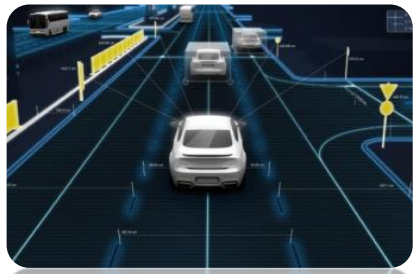
Uses cases for autonomous driving applications (SA1 TR22.886)

Vehicle Platooning



Cooperative Operation, Sensor sharing

Remote Driving



Advanced Driving

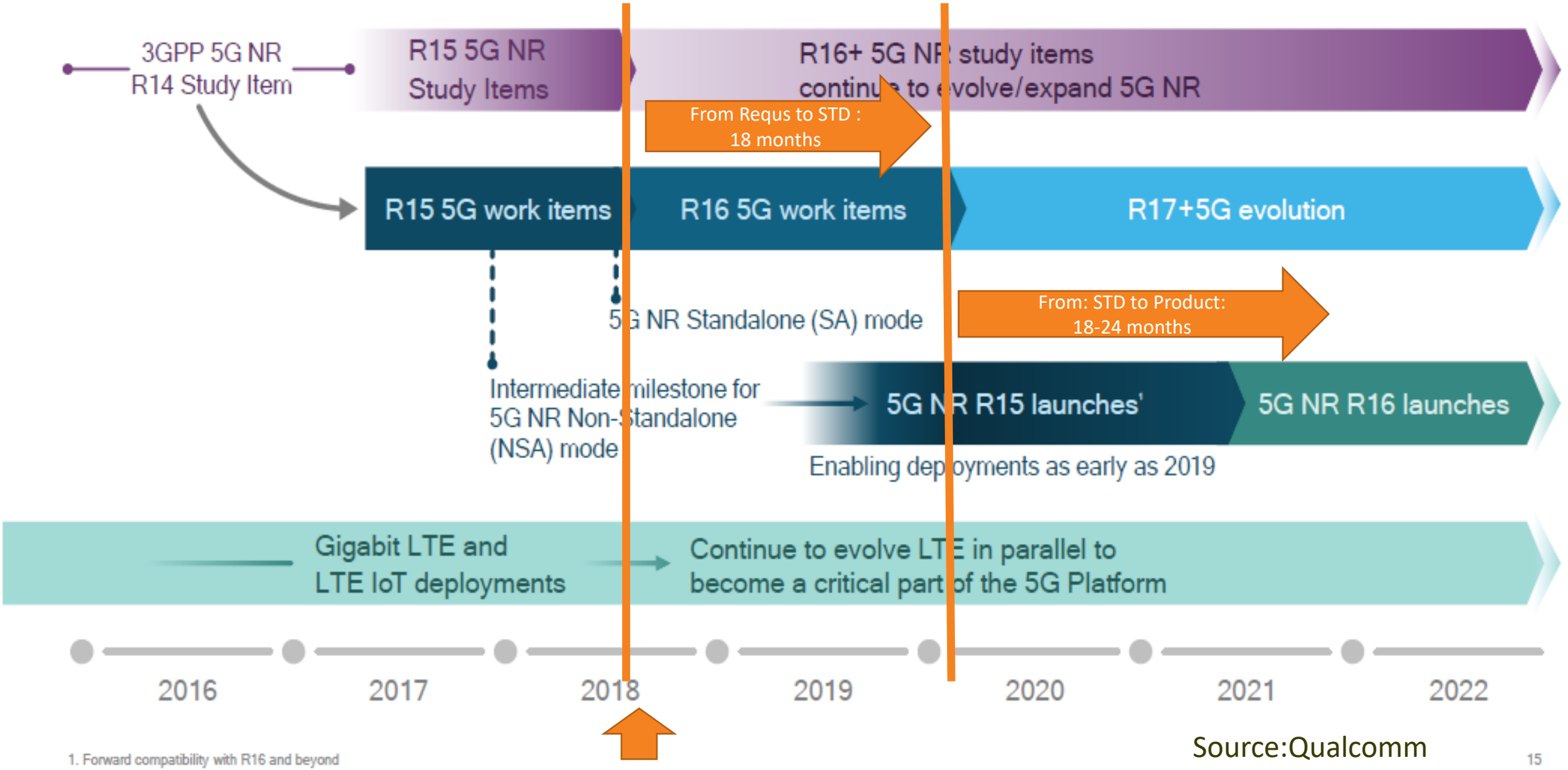
NR-V2X requirements for autonomous driving (SA1 TS22.186)

Use Cases	E2E latency (ms)	Reliability (%)	Data rate (Mbps)
Vehicle Platooning	10	99.99	65
Advanced Driving	3	99.999	53
Extended Sensors	3	99.999	1000
Remote Driving	5	99.999	UL:25, DL:1

	Lateral (m)	Longitudinal (m)
Positioning Accuracy	0.1	0.5

Note: 5GAA may adjust the above requirements according to inputs from car OEMs.

Accelerating 5G NR, the global standard for 5G

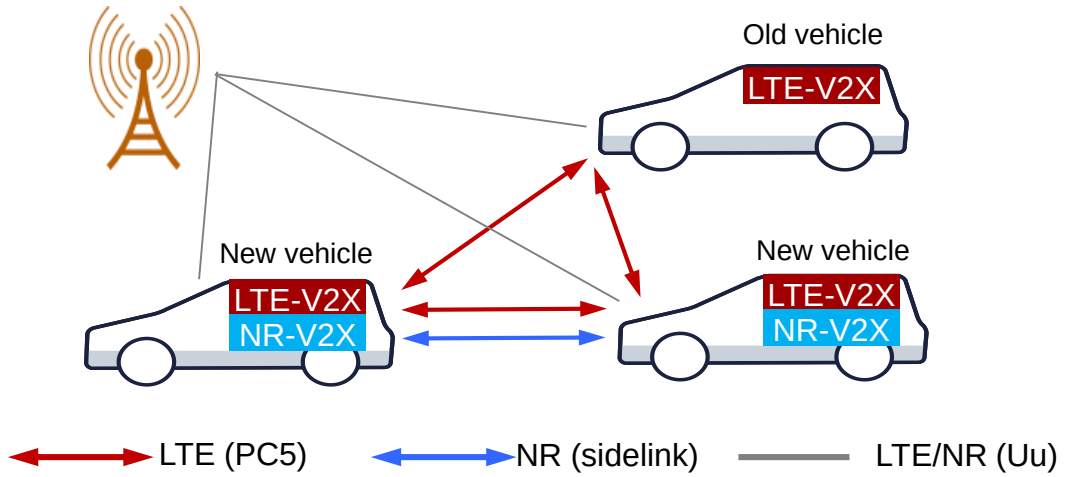


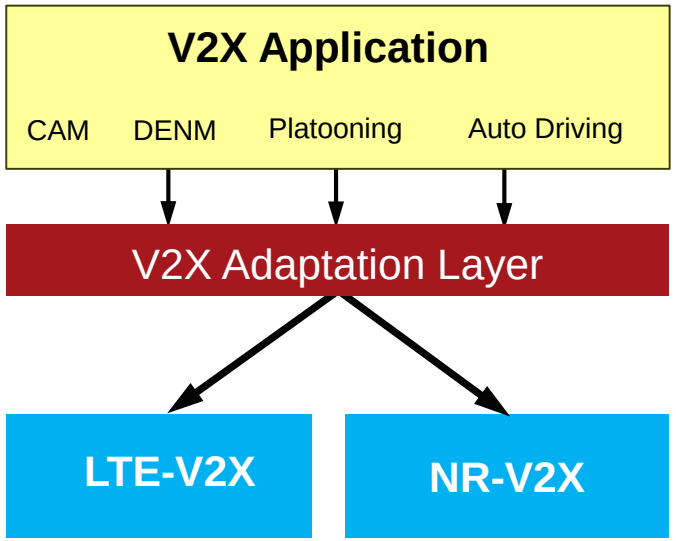
1. Forward compatibility with R16 and beyond

Source:Qualcomm

Flexible selection between LTE-V2X and NR-V2X

Basic safety application by LTE-V2X (PC5) @ 5.9 GHz	Flexible selection between LTE-V2X and NR-V2X
New vehicles deploy both LTE-V2X and NR-V2X to enable the inter-operability with old vehicles: 1) LTE-V2X (PC5): Basic safety 2) NR-V2X (sidelink): Autonomous Driving	Provide policies/criteria to UE to assist radio technology selection, according to V2X application type, QoS requirements, etc.





In Japan: Basic Safety is ensured at 760MHz. So how to guarantee that future NR-V2X will still work?

Conclusions

- 5GAA became a global reference association for cooperation between Automotive and Telecom sectors.
- 5GAA helps to meet the interests and needs of the Automotive industry when 5G is being deployed.
- 5GAA works closely with 3GPP as the global leader for standardization of 4G/5G mobile networks
- 5GAA works on 5G enablers for automated driving: Network Slicing and Edge Computing
- C-V2X includes Sidelink and Up/Downlink and will evolve from LTE-V2X (PC5-Uu) towards 5G-V2X
- 5G-V2X will work complementary to the LTE-V2X Sidelink

5GAA Automotive Association

Thank you!