



# Connectivity Standards in the Automotive Industry

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Learn more at

[WWW.5GAA.ORG](http://WWW.5GAA.ORG)

# Connected mobility for vehicles, people and transport infrastructure

**5GAA brings together the automotive and telecommunications industries to accelerate the global deployment of Cellular Vehicle-To-Everything (C-V2X) as a first step towards a fully integrated intelligent transport system with 5G**



## **AUTOMOTIVE INDUSTRY**

Vehicle Platform, Hardware  
and Software Solutions



## **TELECOMMUNICATIONS**

Connectivity and Networking  
Systems, Devices and Technologies

**5GAA unites 120+ members\* from around the world working together on all aspects of C-V2X including technology, standards, spectrum, policy, regulations, testing, business models and go-to-market**



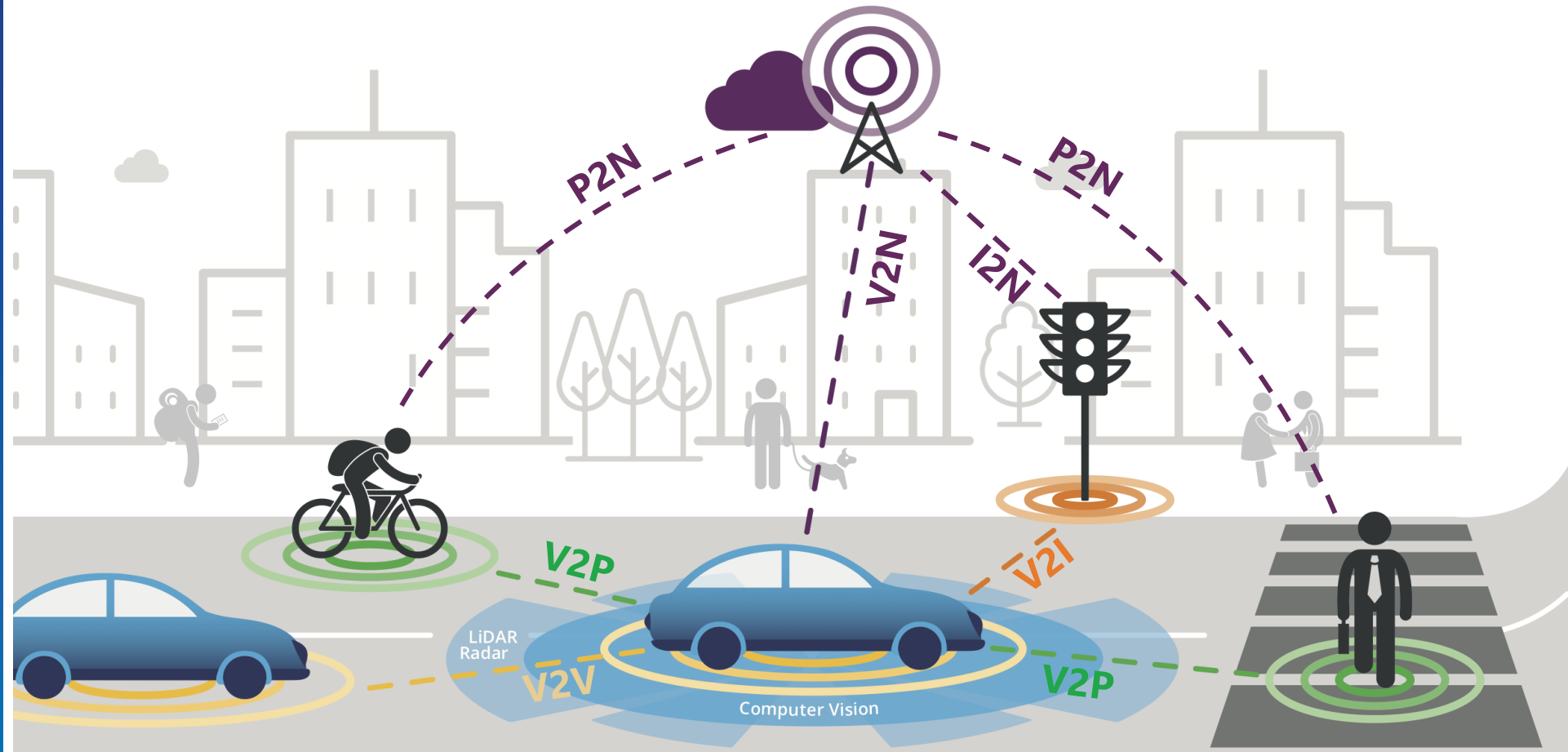
**C-V2X** is a comprehensive road safety and traffic efficiency solution that allows **vehicles** to communicate with

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

supported by the

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

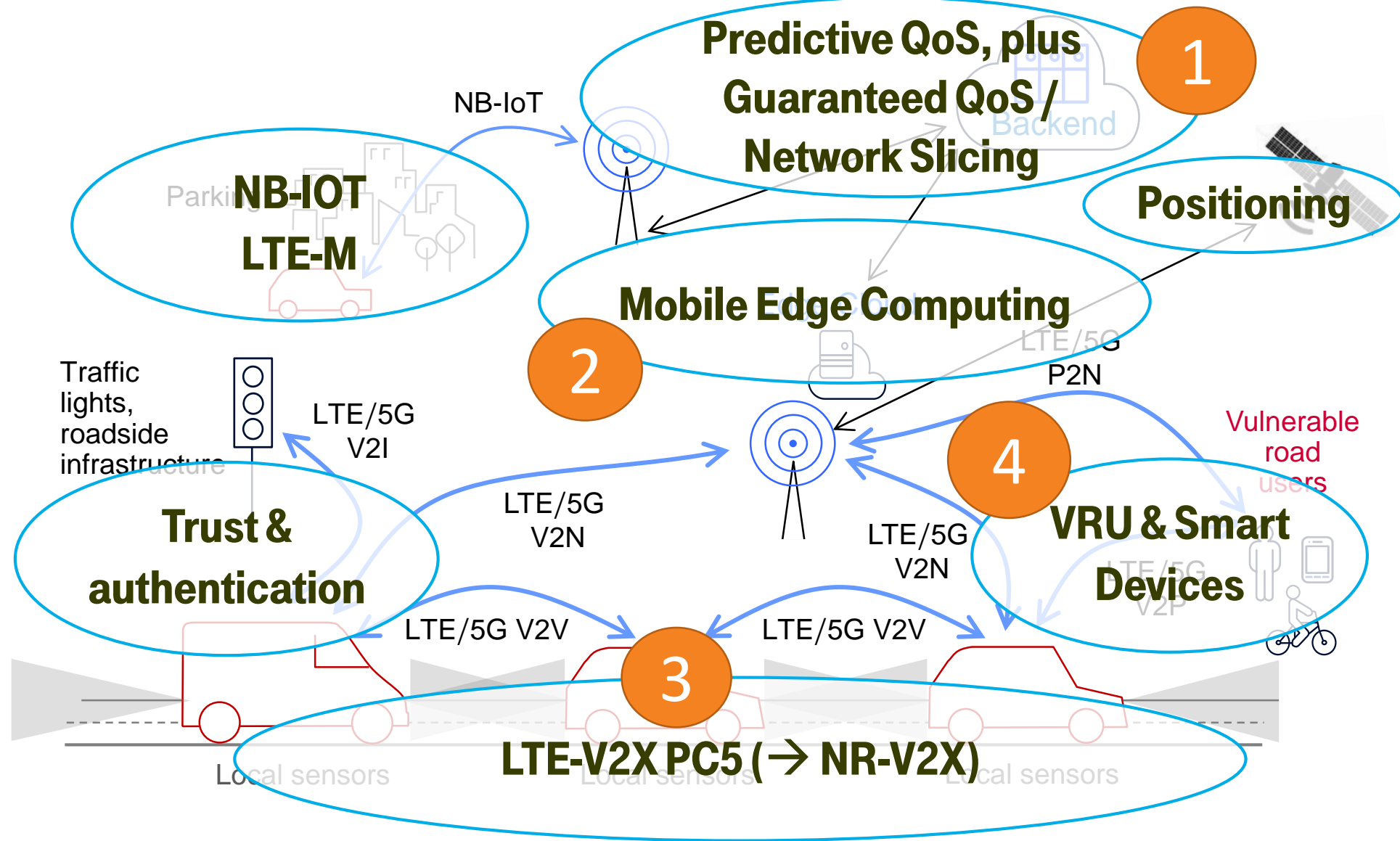
to guarantee **full coverage** and **continuity of services**.



# Automotive Connectivity Tool-Box

C-V2X is a unified technology platform which integrates:

- **Short-range**, network-less, direct communications (LTE-V2X **PC5** today)
- **Long-range** cellular network communications (LTE-V2X **Uu** today)



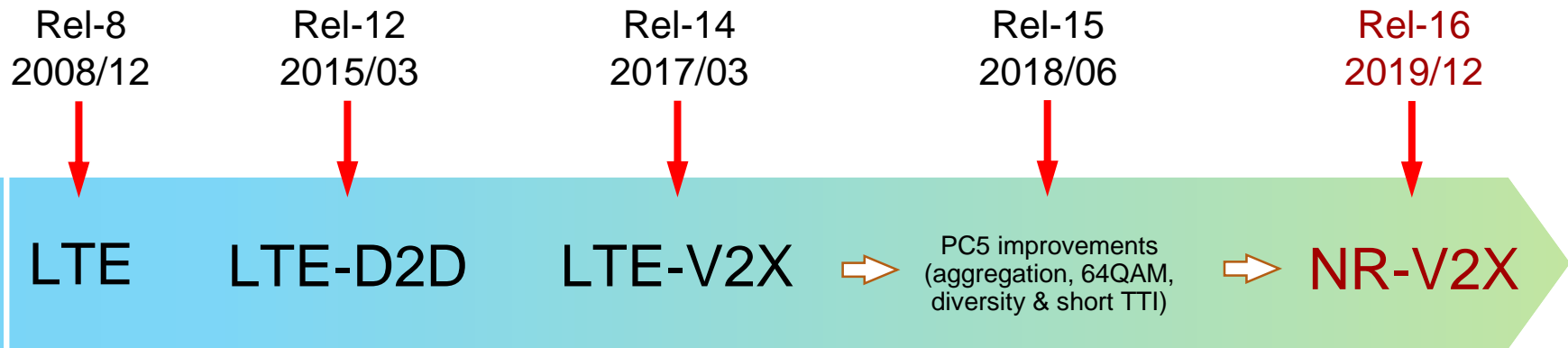


# 3GPP: Cellular-V2X (C-V2X)

# 3GPP time plan: from LTE-V2X to 5G NR-V2X



- ❑ 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 automated driving.
- ❑ NR-V2X will **complement, co-exist** and **support interworking** 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 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

## Network (= Up/Downlink)

V2N operates in traditional mobile broadband licensed spectrum

### It's ONE cellular technology

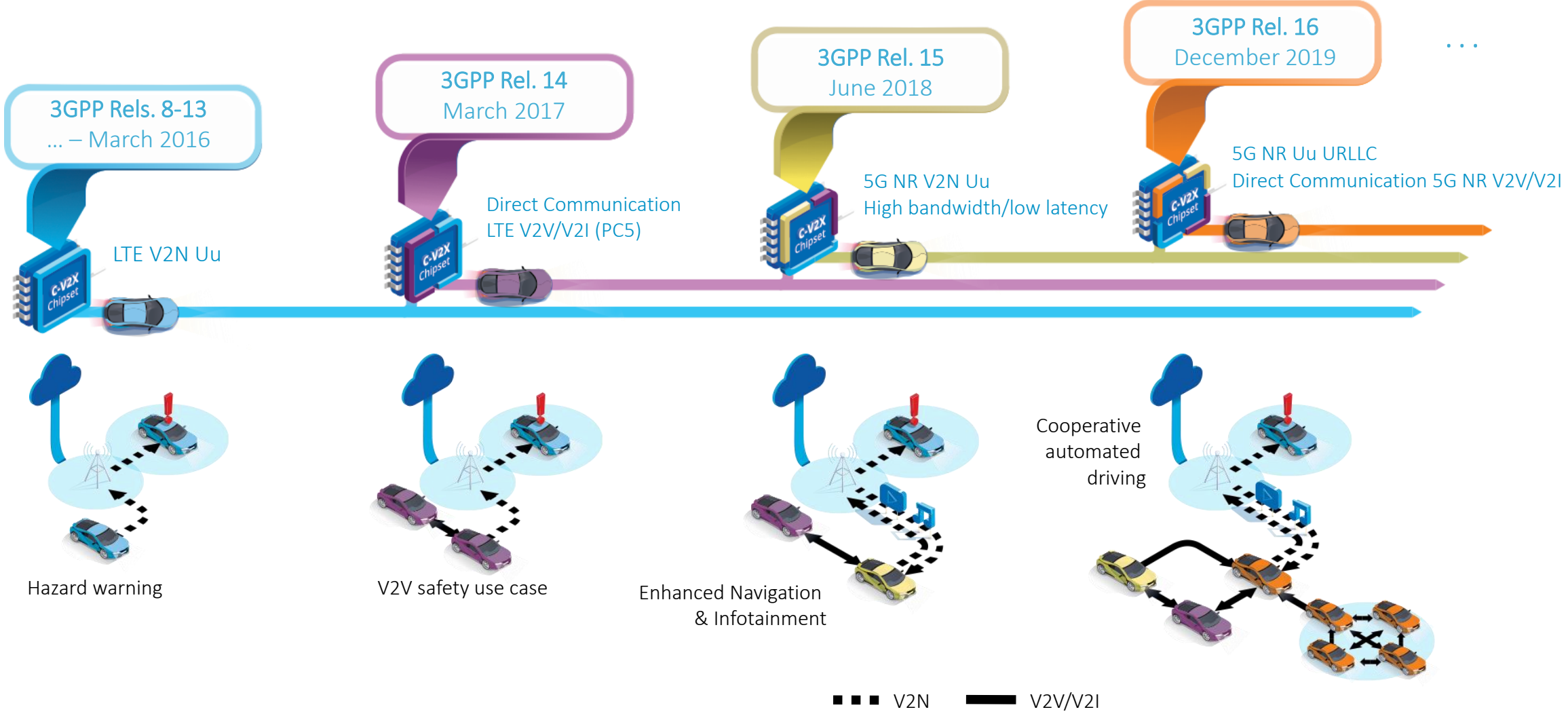
fully integrated chipset solution  
one antenna system  
reduced complexity and cost (on-board & infrastructure)

**Short range** (<1 kilometer), location, speed  
Implemented over 3GPP's "PC5 interface"

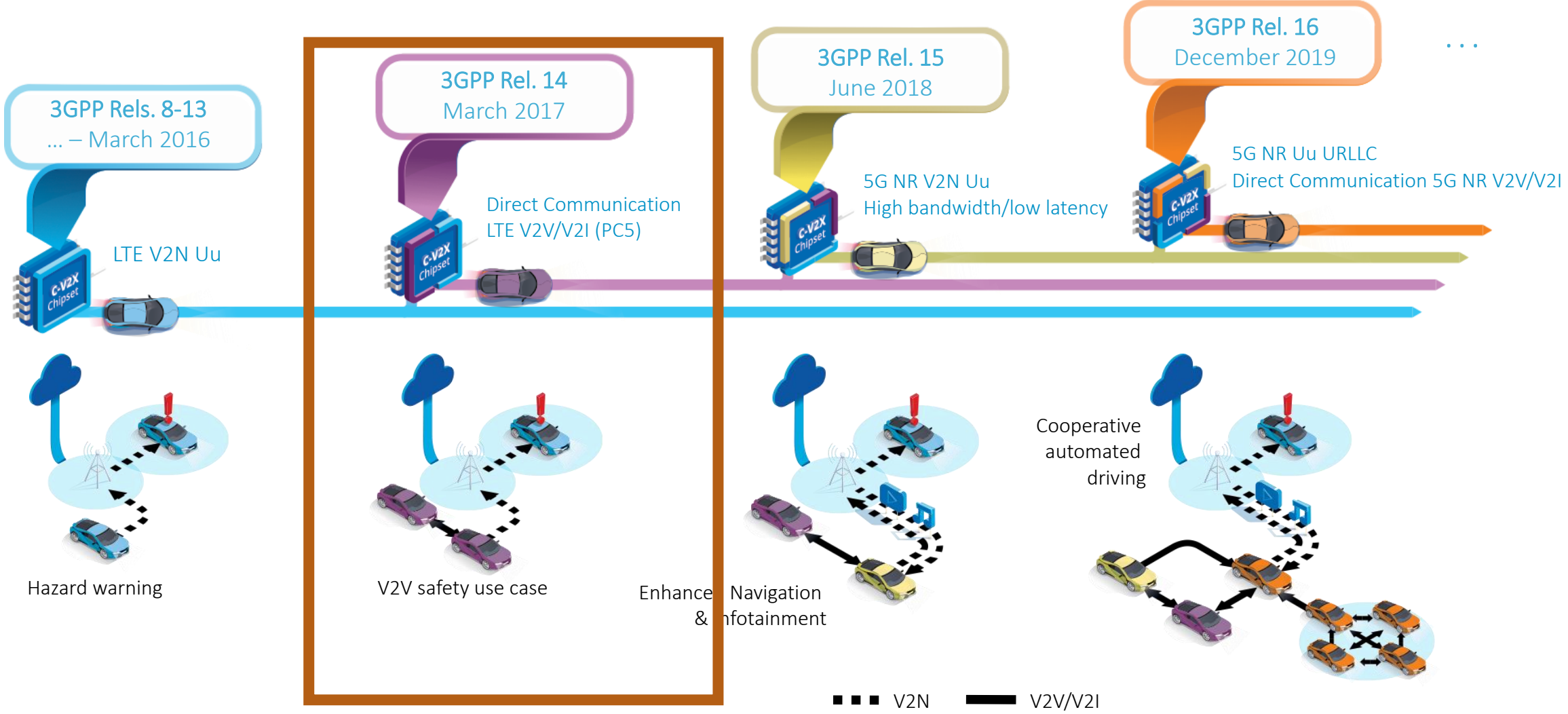
**Long range** (>1 kilometers). e.g. accident ahead  
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# C-V2X: Evolution to 5G maintains backward compatibility



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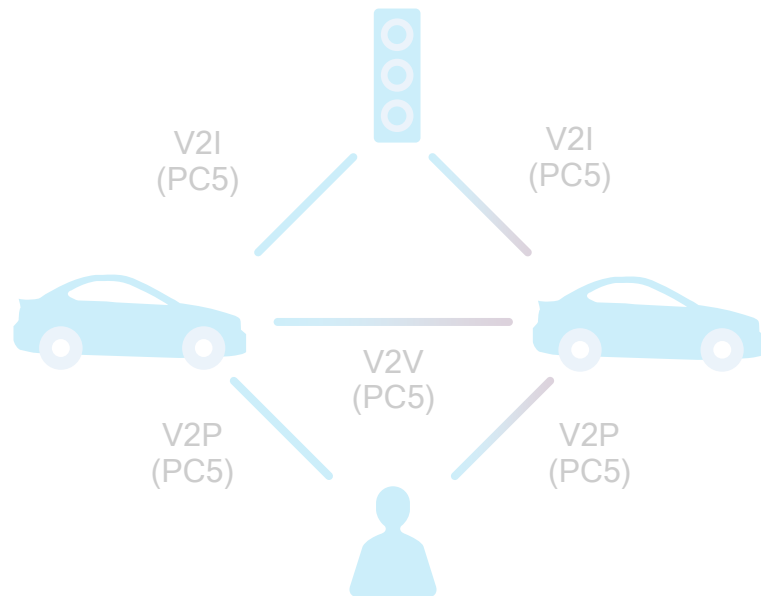


# C-V2X Rel-14 deployment around the world

# C-V2X has two complementary communication modes

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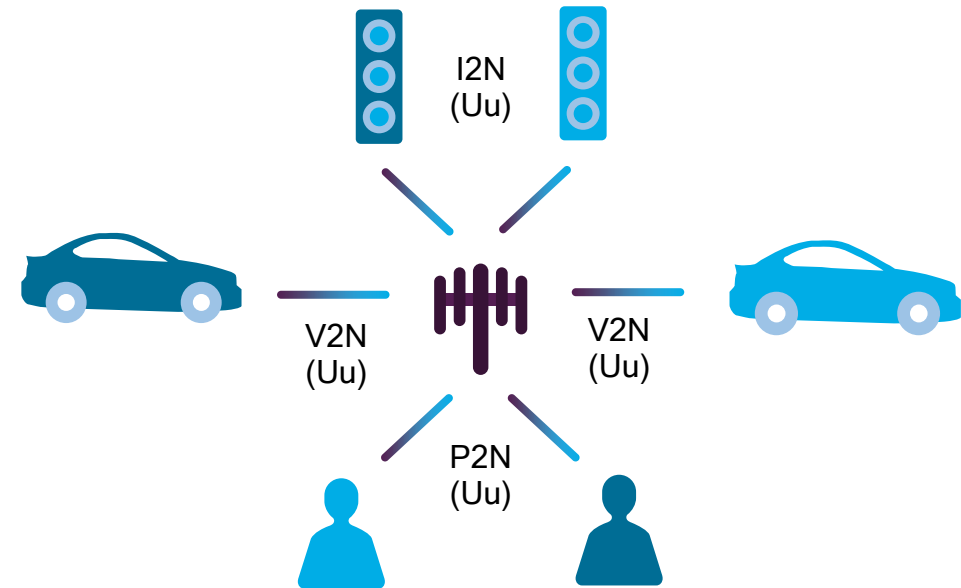
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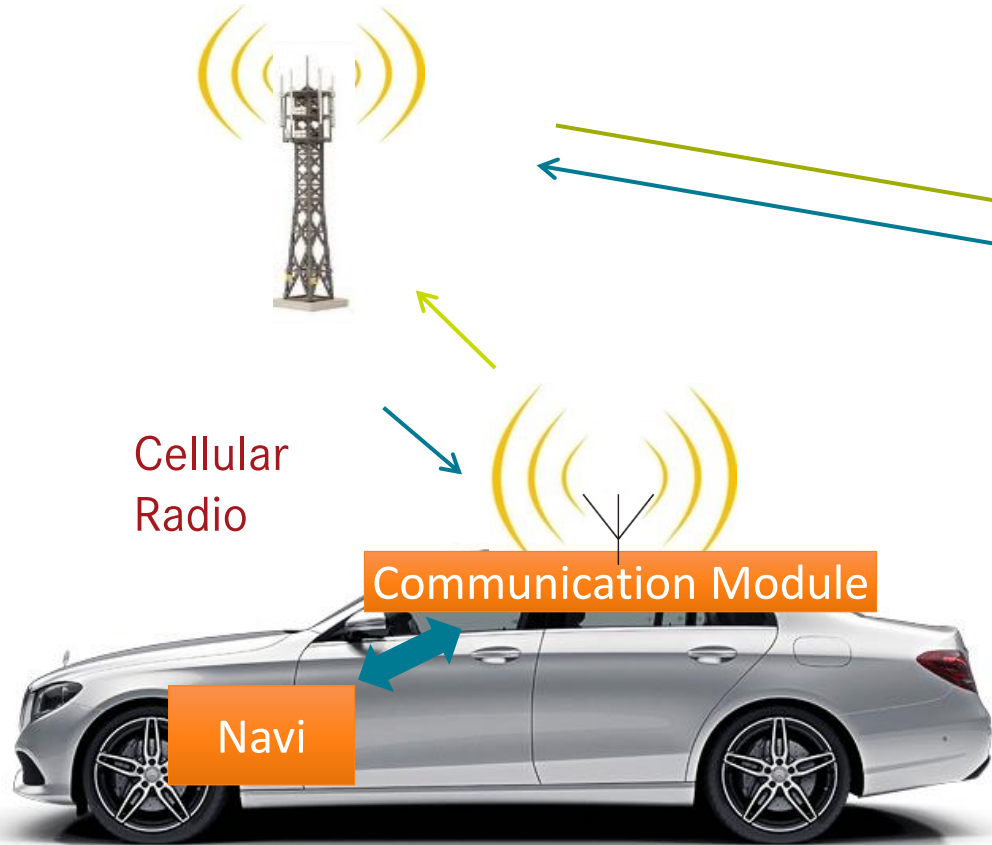
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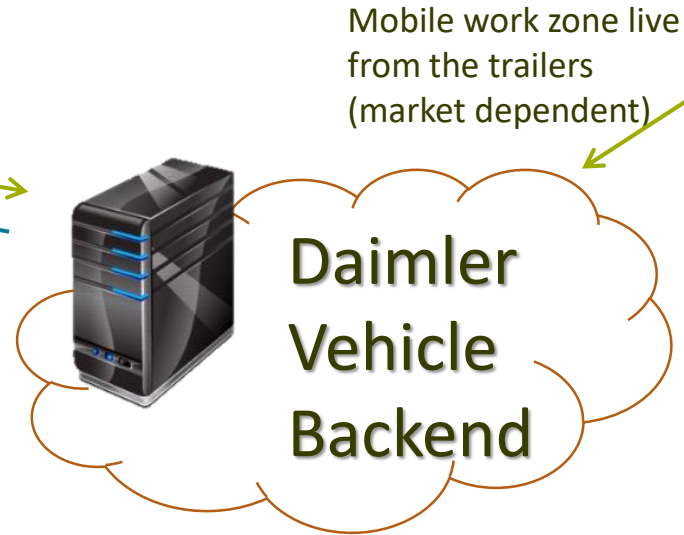


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# V2X via Mobile Network: E-Class 2016



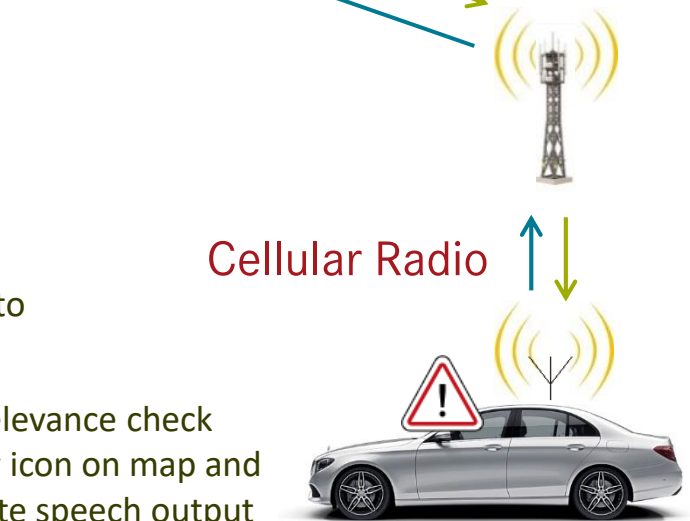
- Event detection and plausibility check
- No additional components necessary



Mobile work zone live from the trailers (market dependent)











- Cars are connected to the Daimler Vehicle Backend
- Data filtering and aggregation
- Markets: USA, EU, China
- Security and Privacy ensured
- OEMs and Data supplier are invited to share



- Data relevance check
- Display icon on map and generate speech output

Source: Daimler

# V2X via Mobile Network: E-Class 2016

Event	Triggering Conditions	Icon on Map	Speech output
<b>Broken down vehicle</b>	Vehicle system signals		Yes
<b>Vehicle accident</b>	Air bag inflation and others		Yes
<b>Hazard lights</b>	Hazard light on		Yes
<b>Heavy Rain</b>	Highest wiper level for 20 s		No
<b>Slippery road</b>	Antilock braking system intervention		No
<b>Fog</b>	Rear fog light on		No
<b>Mobile work zone</b>	External data from work zone trailers		Yes
<b>General Warning</b>	Driver manual input		Yes

# HAZARD LIGHT ALERT

Part of Connected Safety



## Green Light information (based on SPAT)

**AUDI:** Real-time “time-to-green” information via 4G LTE data connection from the traffic management system

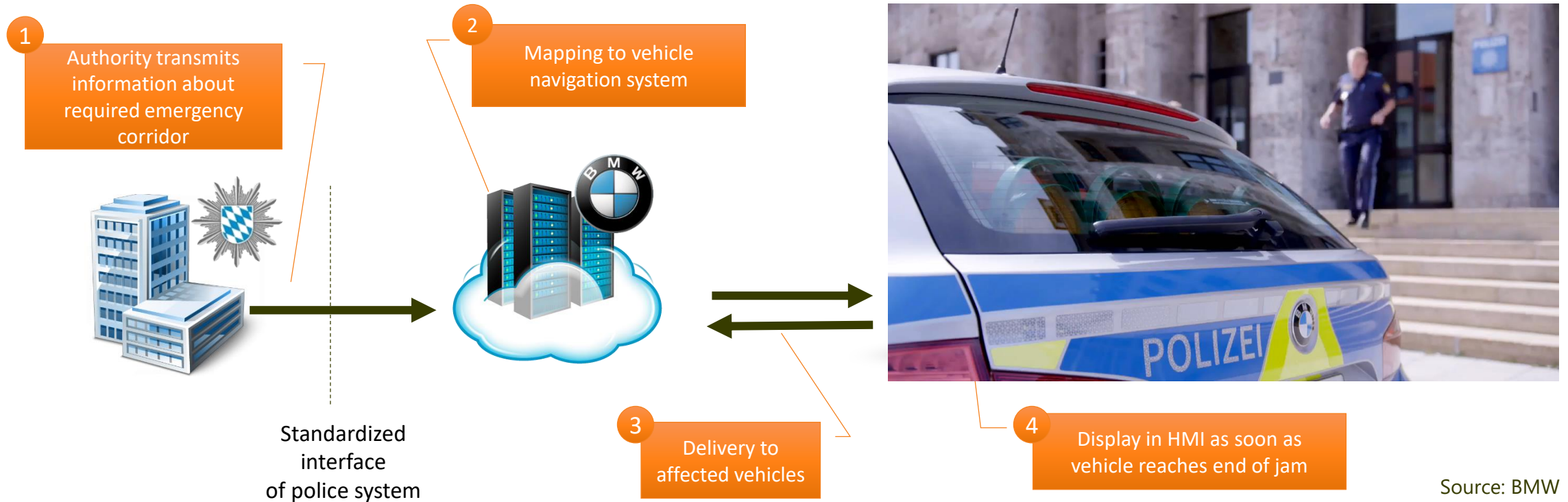
Deployed in 20+ cities in US & EU; Pre-deployment in [Wuxi, China](#)



Enables future integration within start/stop function, GLOSA, routing, and other predictive services

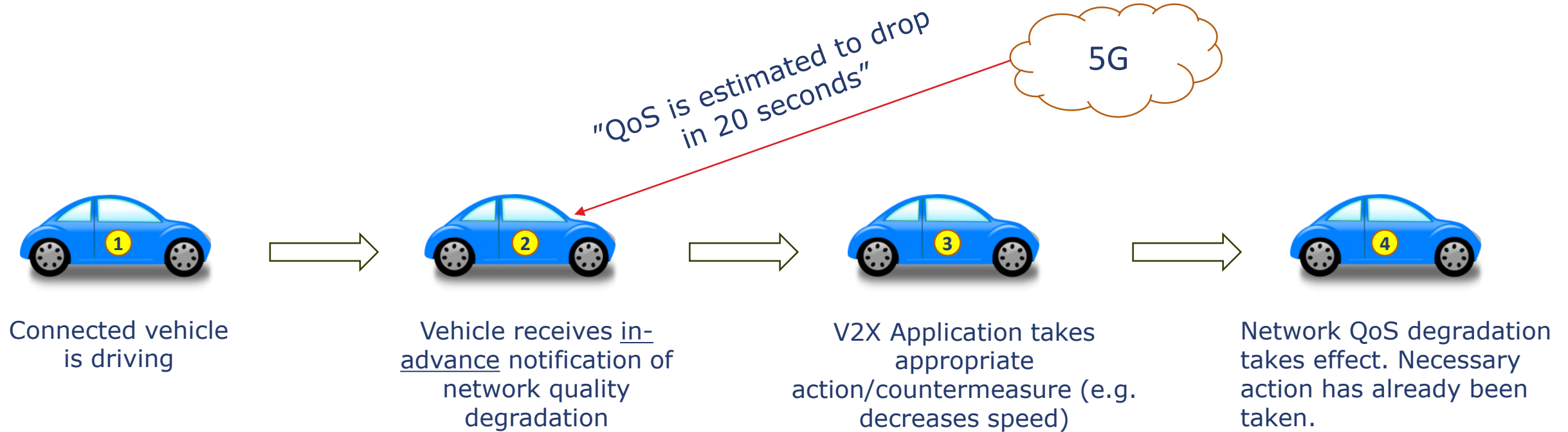


# V2N Application: Emergency corridor – A cooperation between BMW and the Bavarian emergency services



- 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.

## 1<sup>st</sup> Step: Predictability: C-V2X supported by **Predictive QoS**

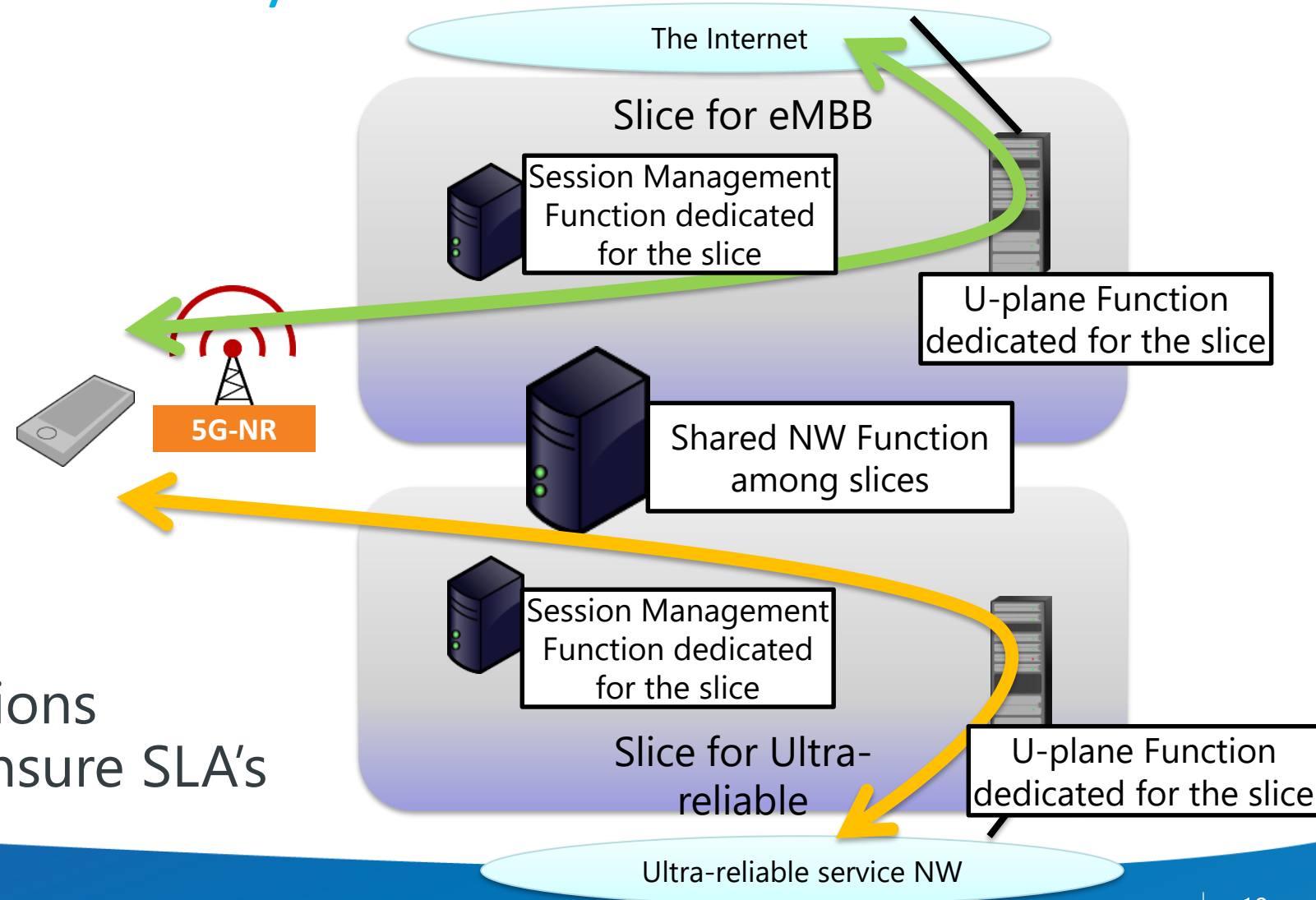


## 2<sup>nd</sup> Step: Network Management and Guarantees → Ultra-reliable and Low Latency Communications

### Quality of Service / Network slicing

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

Customized NW functions and/or capacities to ensure SLA's

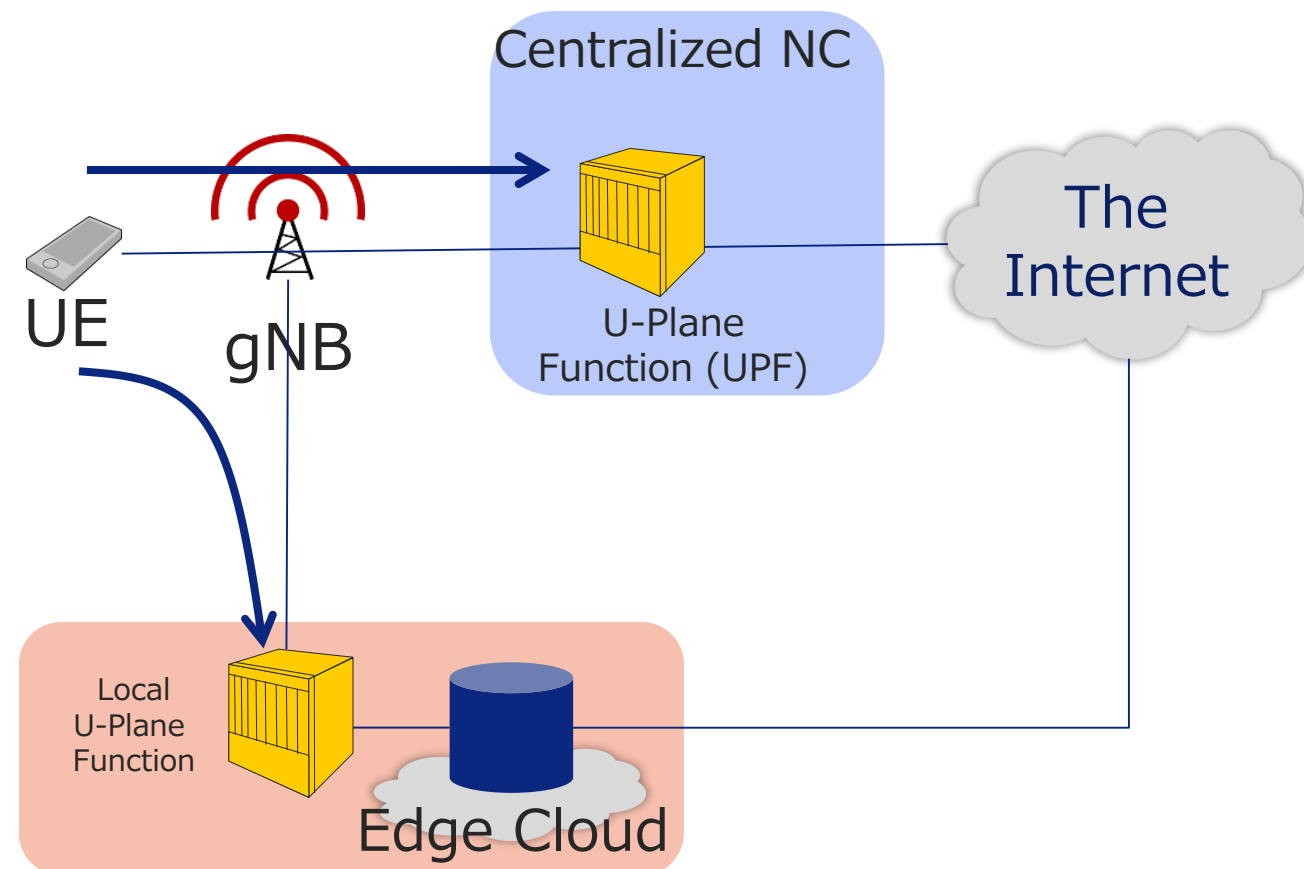


# Ultra-reliable and Low Latency Communications

## Edge Computing

Applications can be hosted at "Edge-side"

→ Low Latency compared with centralized manner







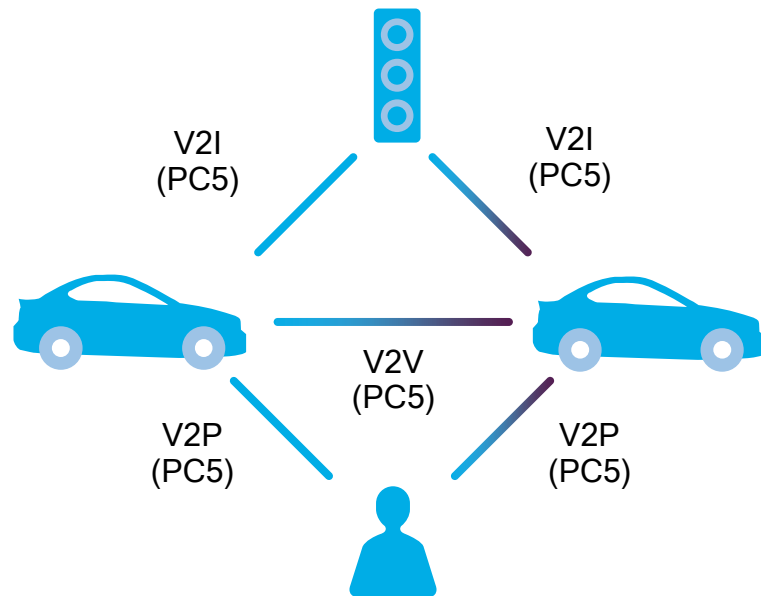
What about V2V / V2I / V2P?

### 3. Integrated Short Range Mode, works also out-coverage (V2V, V2I)

## C-V2X has two complementary communication modes

### Direct (= Sidelink)

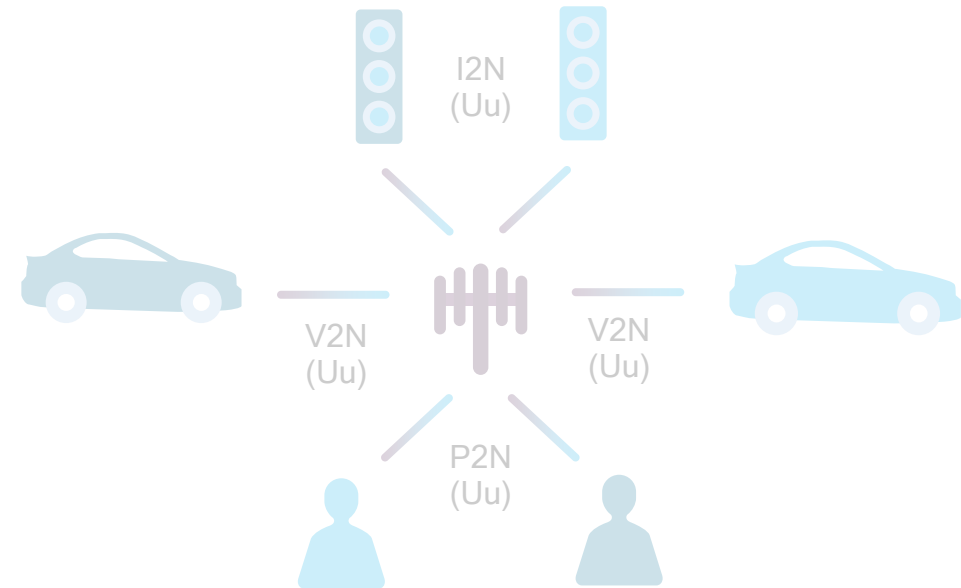
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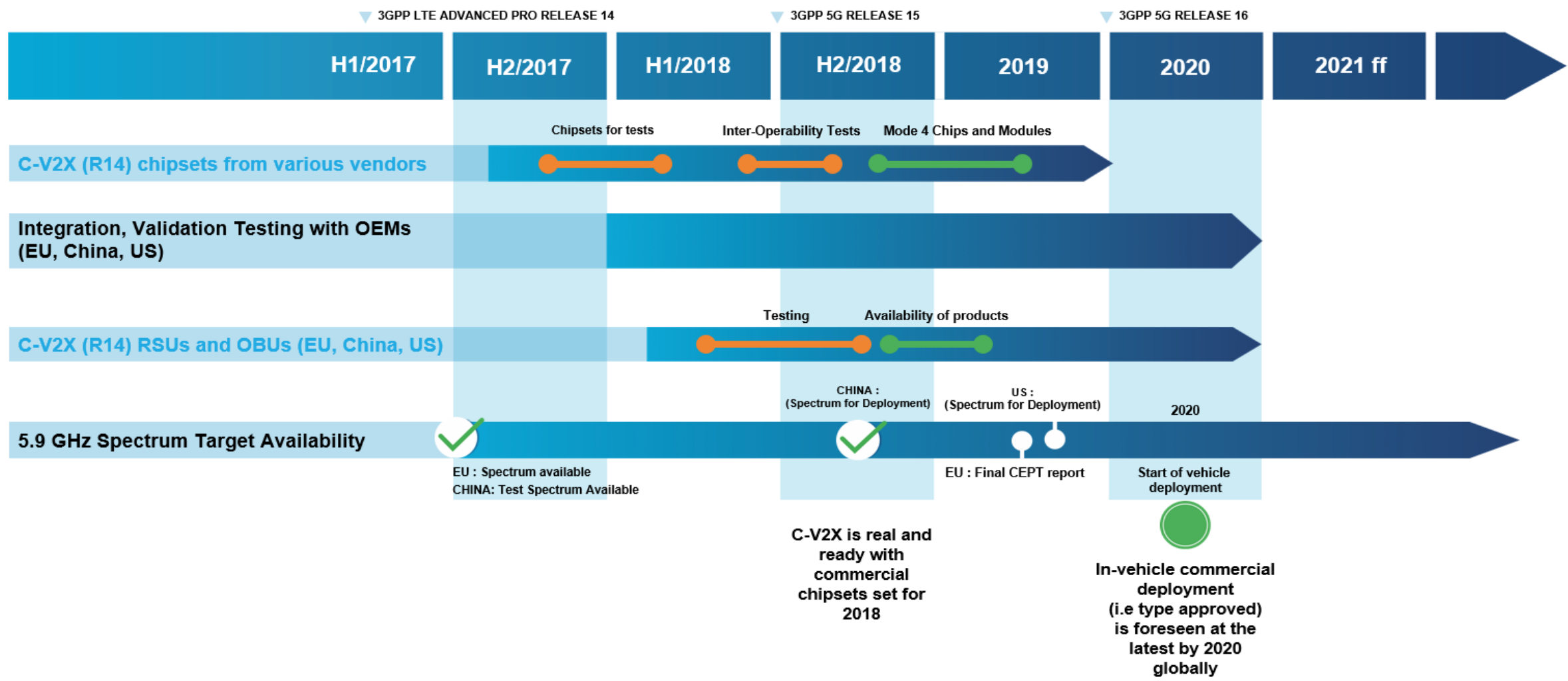
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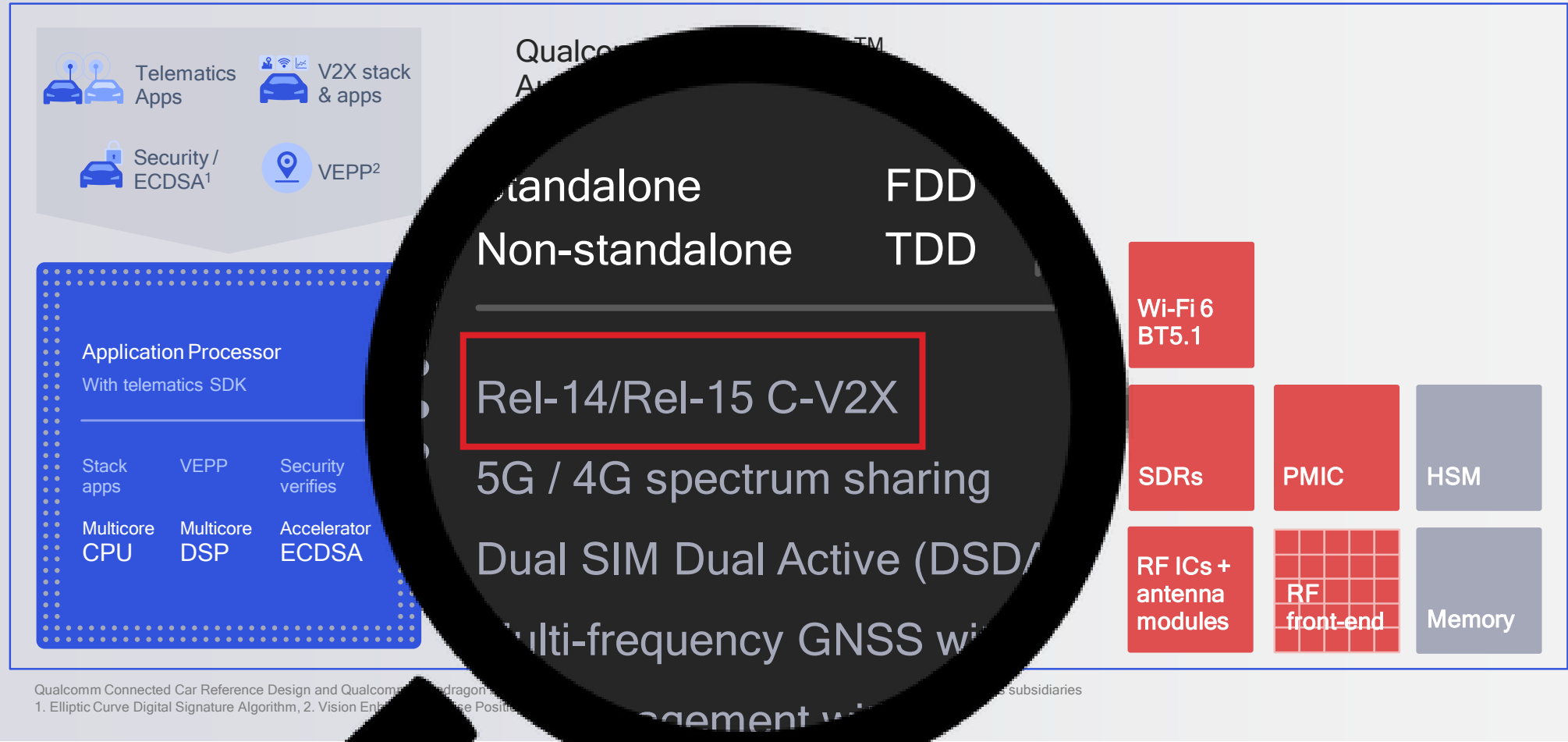
# 5GAA Timeline for deployment of C-V2X (V2V/V2I)





### 3. Make cutting-edge V2V/V2I technology available globally

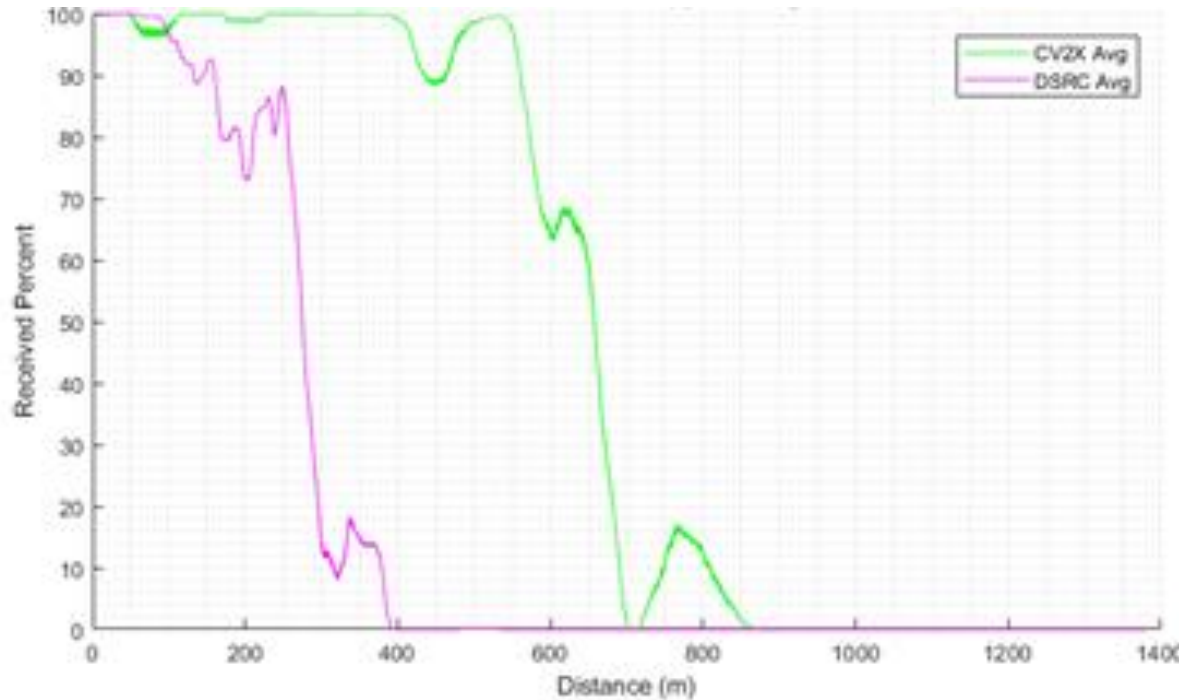
## Qualcomm® Connected Car Reference Design, Gen 2



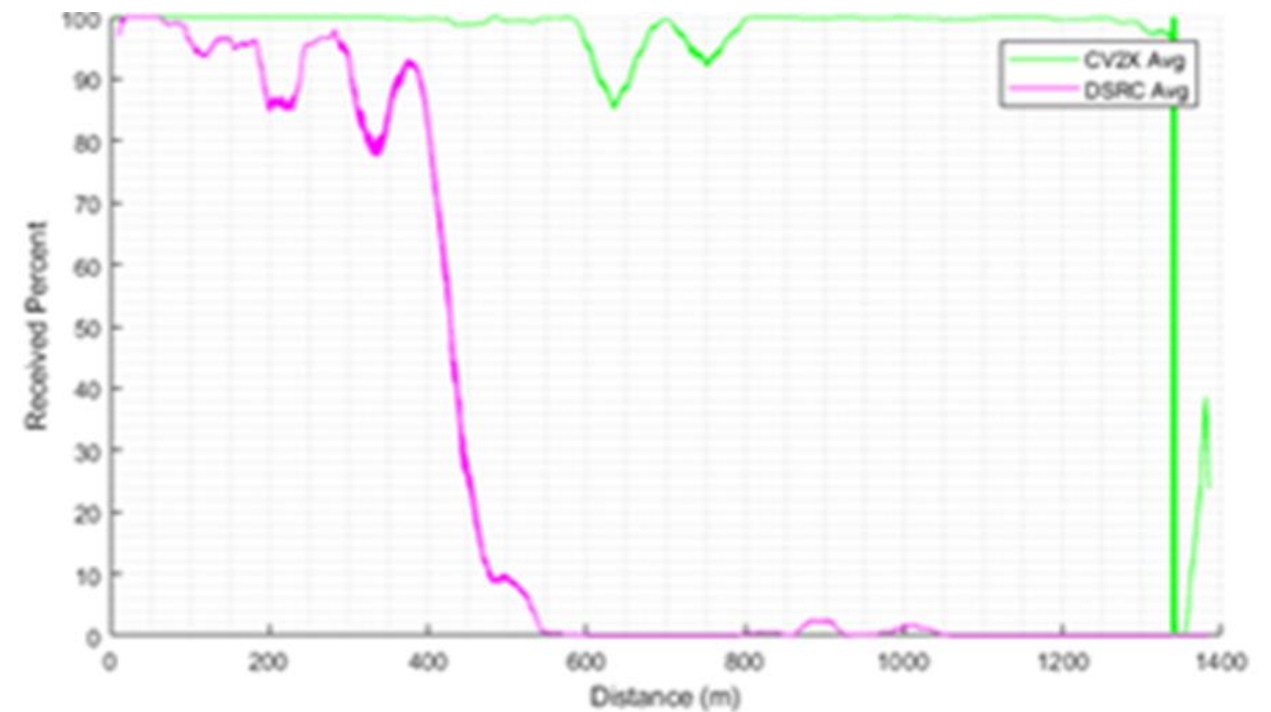
Source: Qualcomm, Announced at the MWC2019, Barcelona

# Shadowing Test RESULTS

5GAA shadowing test, Approach

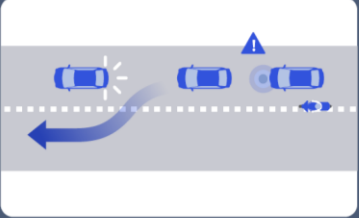
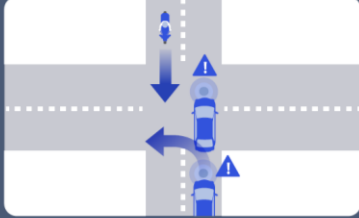

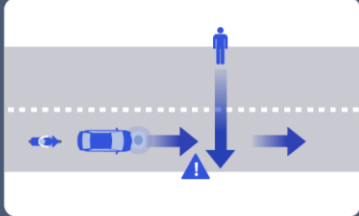
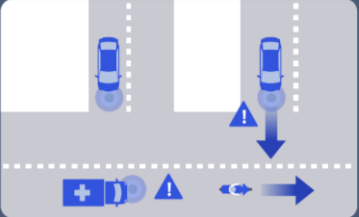
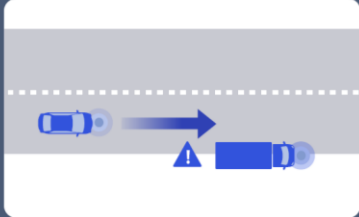


CAMP shadowing test, Approach



- 5GAA shadowing test is more demanding than CAMP test.
- C-V2X outperforms 802.11p in shadowing scenarios.

# Rel-14 Basic Safety Use Cases: V2V Demonstrations in Shanghai, Washington, Paris, and Las Vegas (2017-2019)\*

<b>Emergency Electronic Brake Lights</b> Designed to reduce rear-end crashes	<b>Across Traffic Turn Collision Risk Warning</b> Designed to improve traffic safety
	
<b>Signal Phase and Timing</b> Communicated to the driver	<b>Vulnerable Road User Protection</b> When pedestrians & cyclists are present
	
<b>Intersection Collision Warning</b> Designed to improve traffic safety	<b>Stationary Vehicle Warning</b> Designed to reduce rear-end crashes
	

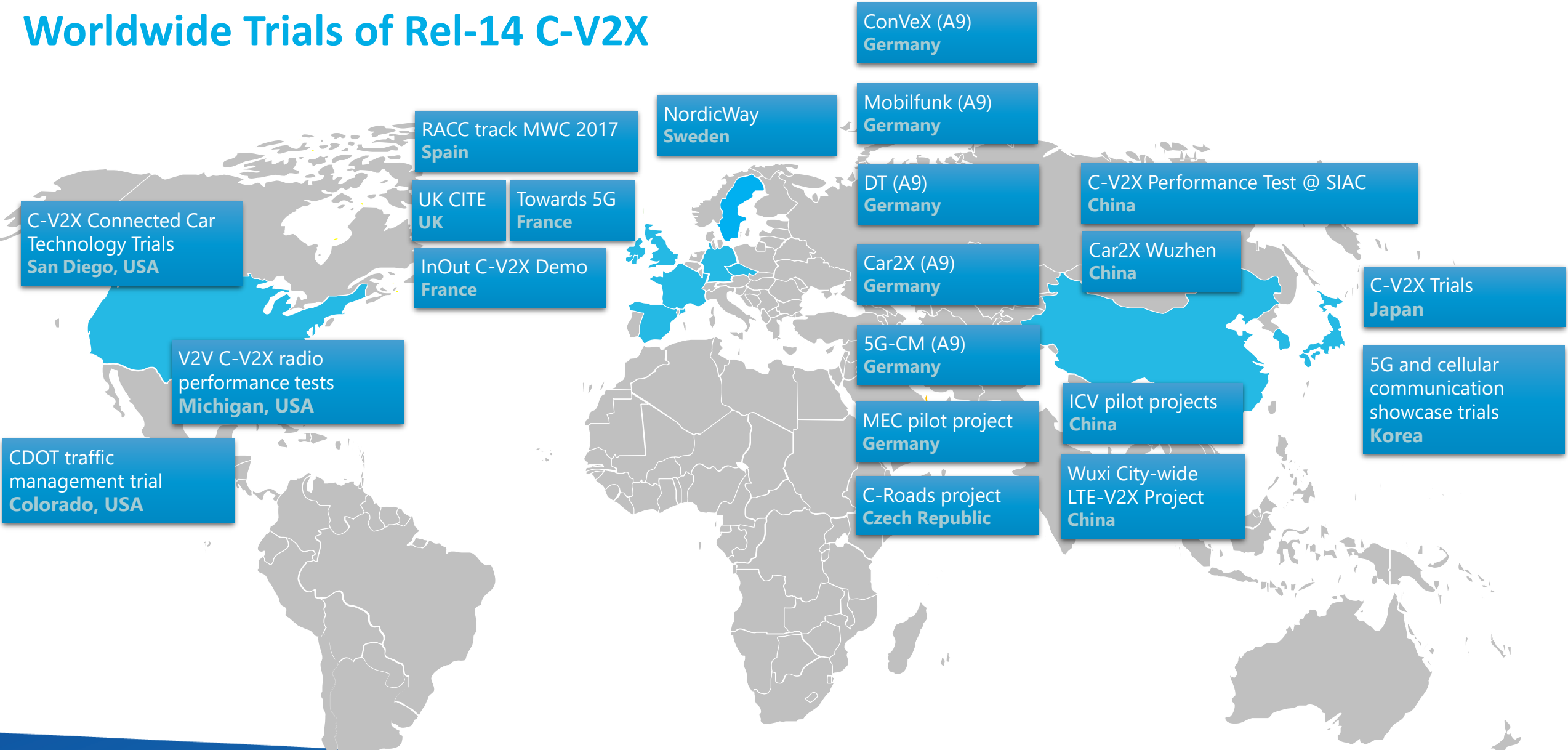
# C-V2X

*Transforming road safety*



(\* ) Video: Paris July, 2018

# Worldwide Trials of Rel-14 C-V2X



# LTE-V2X Rel-14 interoperability tests in Shanghai (Nov 2018)

- First Triple-level Interoperability testing of LTE-V2X applications
- Multi-vendor Interoperability at module/device/OEM level
- Access layer implementing 3GPP R14 LTE-V2X PC5 standard

## Triple-level Interoperability

- Communication Module (3)
  - CATT(Datang), Huawei Hisilicon, Qualcomm
- OBU Device (9)
  - Nebula Link, Genvict, Datang, Neusoft, Huawei, Huali-tec, China Transinfo Technology(CTFO), Savari, Wanji-Technology
- Vehicle OEM (12)
  - Changan, SAIC, BAIC, Ford, Geely Auto, Great Wall Motor, Dongfeng Motor, BJEV, General Motors, Audi, BMW, FAW

### Enabling Deployment: lift barriers and accelerate time-to-market

- 5GAA C-V2X testing event in Europe successfully demonstrated exceptional level of interoperability (April 2019, Germany)
- Memorandums of Understanding signed in 2019 with leading interoperability and certification organisations to accelerate deployment roadmap:



# LTE-V2X (PC5) Interoperability – Next Steps

 **OmniAir Consortium**  
@OmniAirCon

What a great start to the @OmniAirCon #EuropeanPlugfest! Thank you to our keynote and opening presenters @5GAA\_official, @DEKRA\_Test\_Cert, @DGTes, @maximeflament! #V2X #CV2X



12:14 PM · Sep 30, 2019 from Caterpillar Malaga Demonstration & learning Center · Twitter for Android

IMT-2020 Interoperability Plugtest, Shanghai, October 2019



 **ETSI**  
@ETSI\_STANDARDS

Save the date! The 1st Cellular-#V2X Plugtests event, organized by ETSI #TheStandardsPeople in partnership with #5GAA @5GAA\_official, will be held in Europe from 2 to 6 December 2019. More information available soon



1:25 PM · Sep 9, 2019 · Hootsuite Inc.

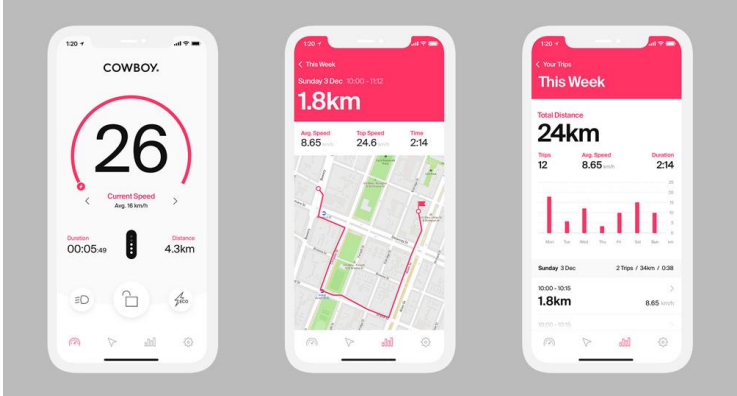
# 4. Include pedestrians and cyclists



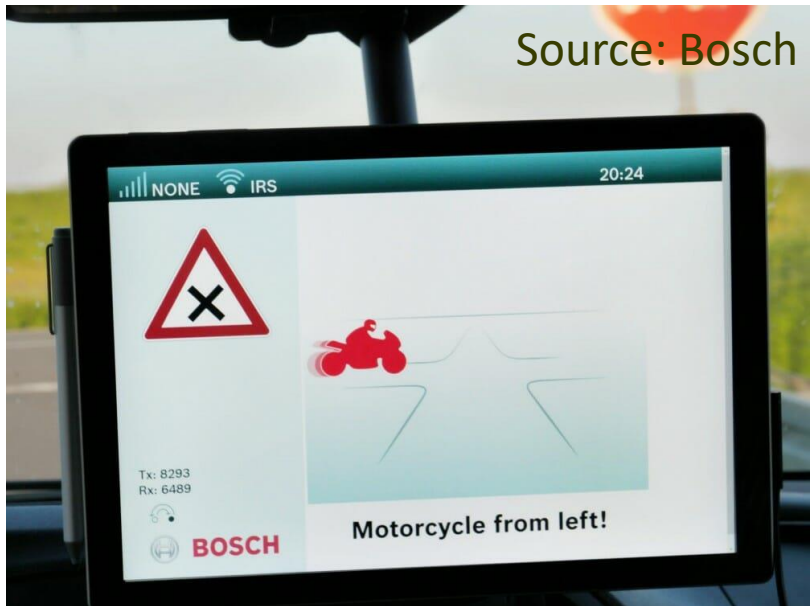
Source: Cobi



Source: BMW



Source: Cowboy



Source: Bosch



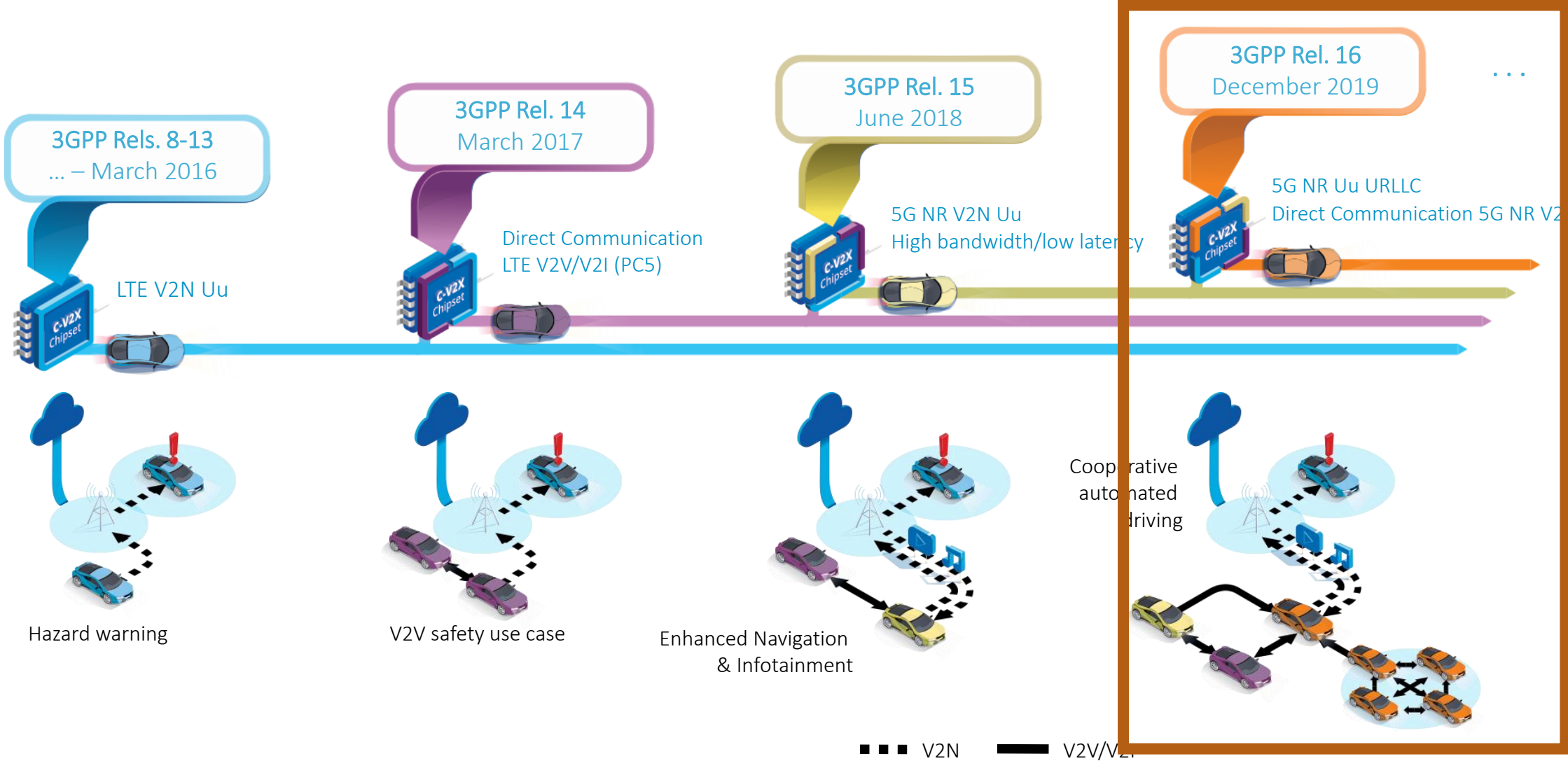
Source: Bosch



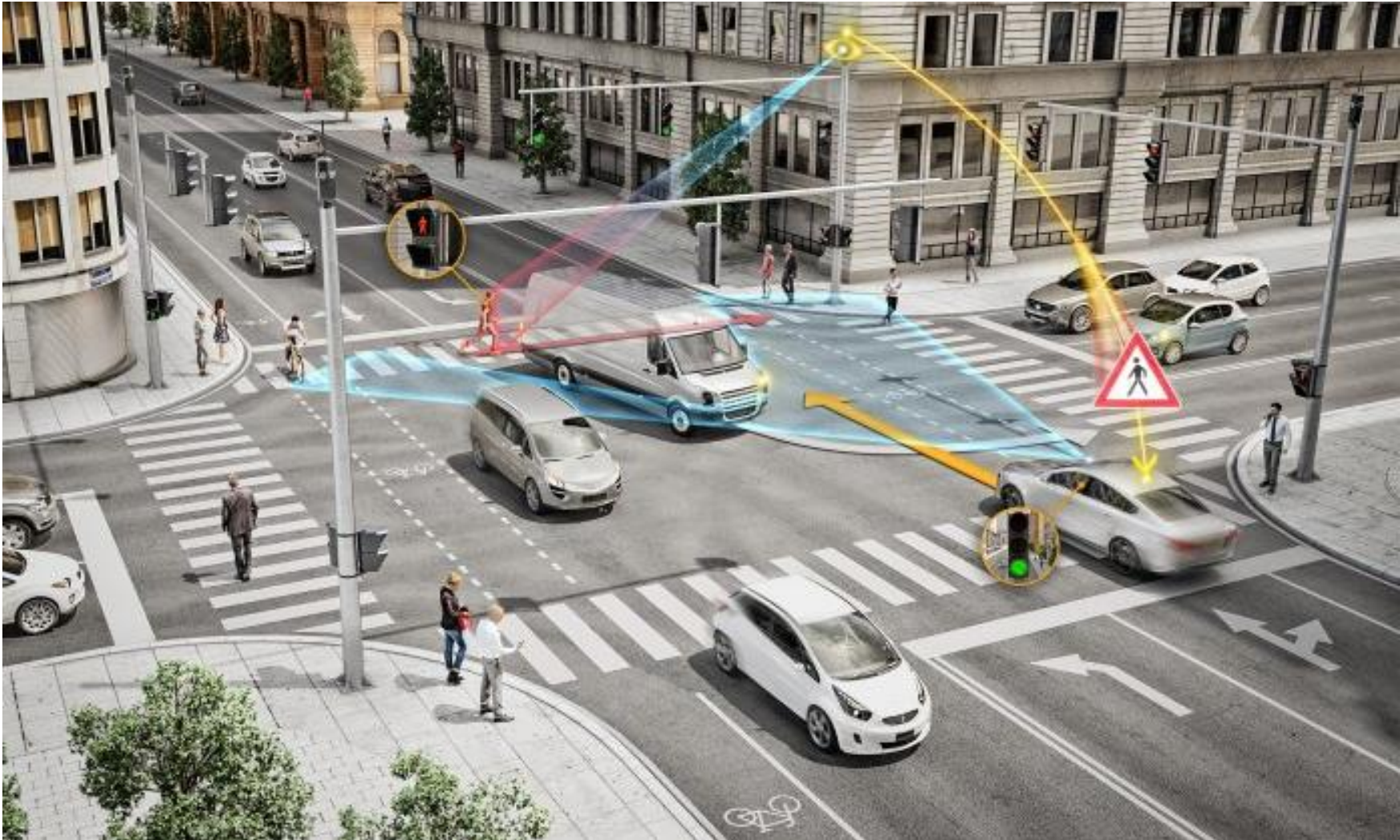


# Path towards Rel-16 NR-V2X

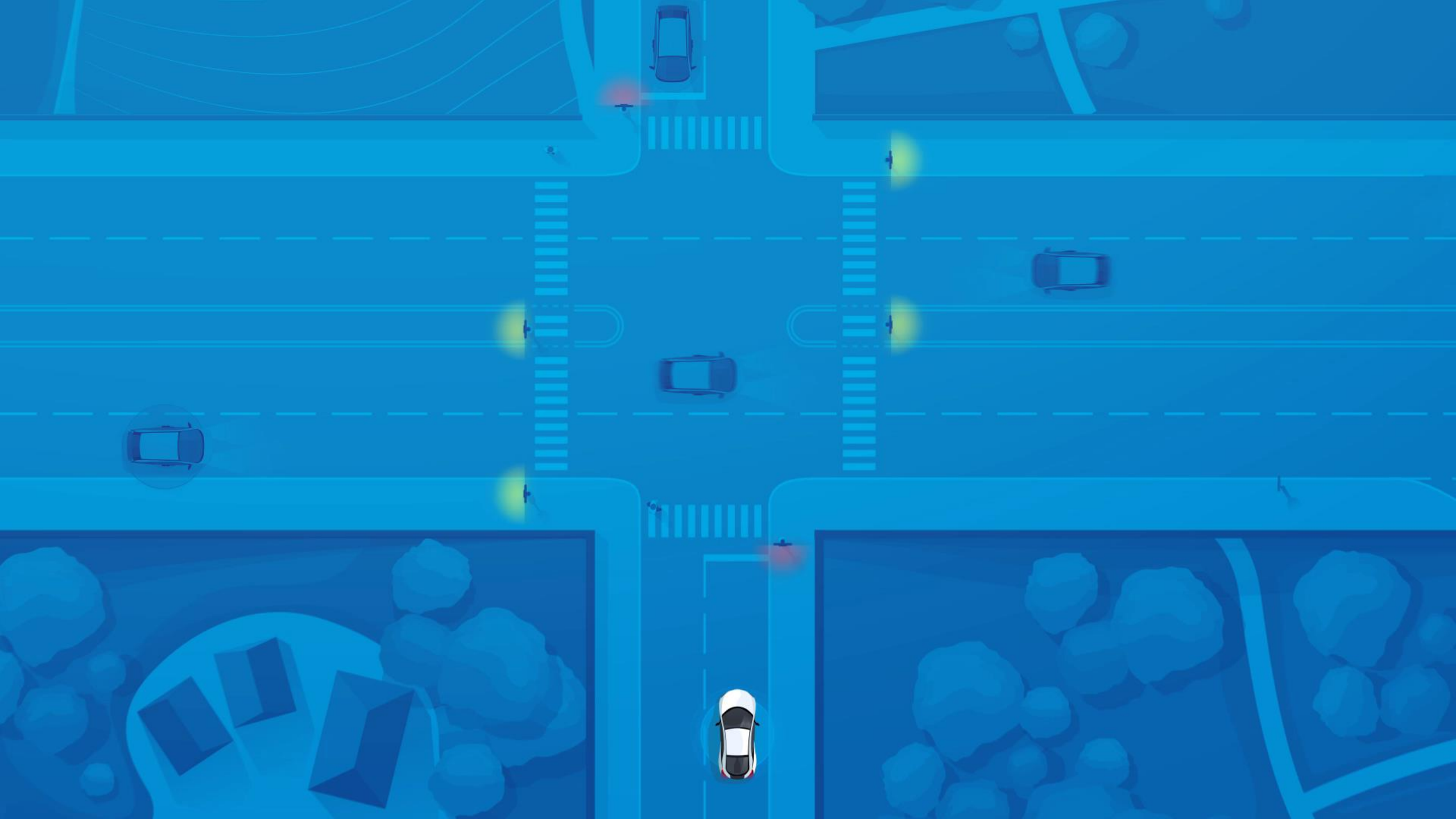
# C-V2X: Evolution to 5G maintains backward compatibility



# Enable complex interaction Use Cases



Source: Continental

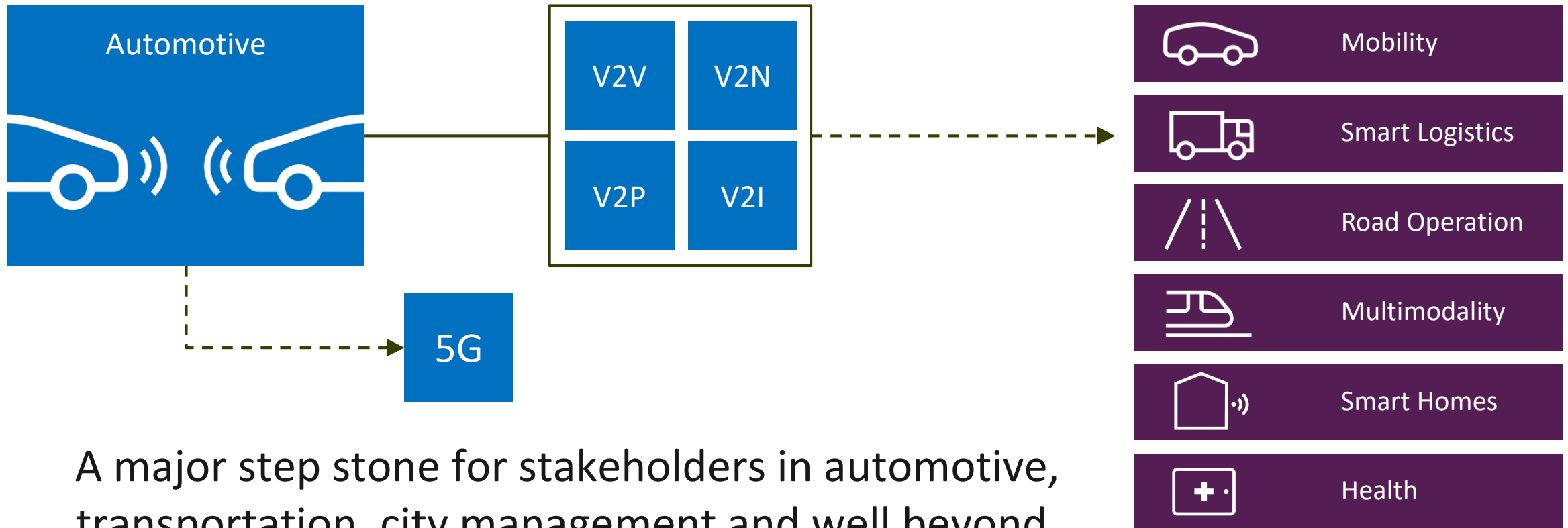




# Collaboration

# Beyond Automotive

## – Other 5G Automotive enabled applications



A major step stone for stakeholders in automotive, transportation, city management and well beyond

## Driving innovation: Leveraging solutions together

- On-going dialogue between 5GAA and leading technology partner organisations to advance innovation in all world regions
- 5GAA to continue strengthen technical cooperation and maximise benefits with existing organisations or projects by reinforcing engagement via common members
- Develop new partnerships with relevant organisations on specific aspects e.g. vulnerable road users or road authorities



# Conclusions

- 5GAA became a global reference association for cooperation between Automotive and Telecom sectors.
- 5GAA works closely with 3GPP as the global leader for standardization of 5G mobile networks
- 5GAA helps to meet the interests and needs of the Automotive industry when 5G is being deployed.
- C-V2X is evolving from LTE-V2X (Rel-14) towards 5G-V2X (Rel-16)
  - includes both Sidelink and Up/Downlink
  - supports both basic safety and advanced Use Cases





Thank you!