



Making connected cars a reality with 5G (and LTE)

Maxime Flament, CTO, 5GAA



Driving Connected Mobility Forward

5GAA brings together automotive, technology and telecommunications companies to work closely together to develop end-to-end connectivity 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 118 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

5GAA: A Global Cross Industry Association

September 2016

- “Audi, BMW Group, Daimler AG are teaming with Ericsson, Huawei, Intel, Nokia, and Qualcomm to create the 5G Automotive Association (5GAA), which will help develop, test, and promote 5G standards”
- “Scope of the alliance is focused on bringing connectivity solutions to market addressing technical, business, and regulatory challenges”



Q2 2019

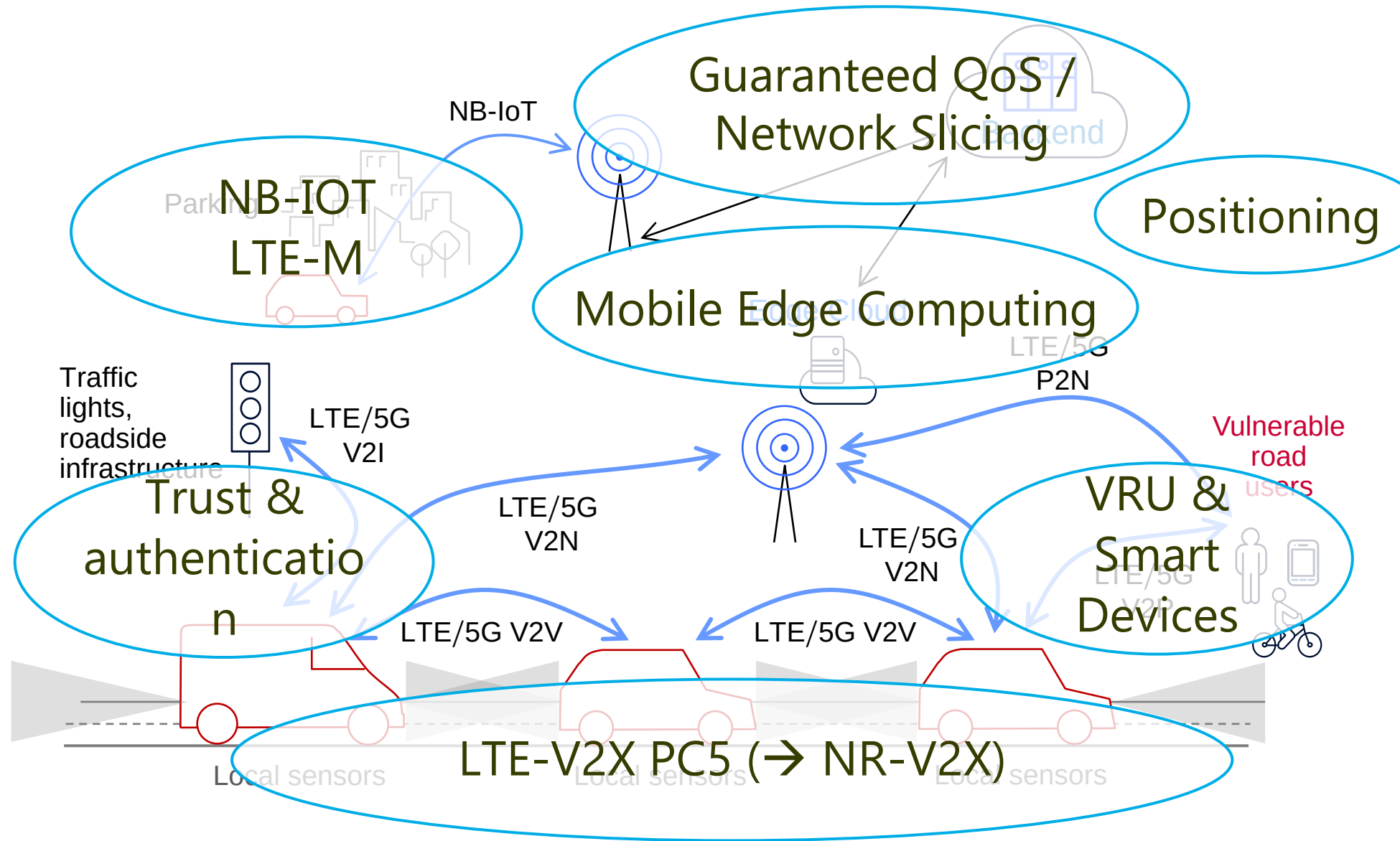
- › 5GAA unites 118 members working together to:
 - Deliver innovation for road safety, connectivity and sustainability
 - Accelerate cooperative, connected, automated mobility
 - Develop 360° solutions for SMART mobility services
 - Pave the way towards 5G mobility



Automotive Connectivity Landscape

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)

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)

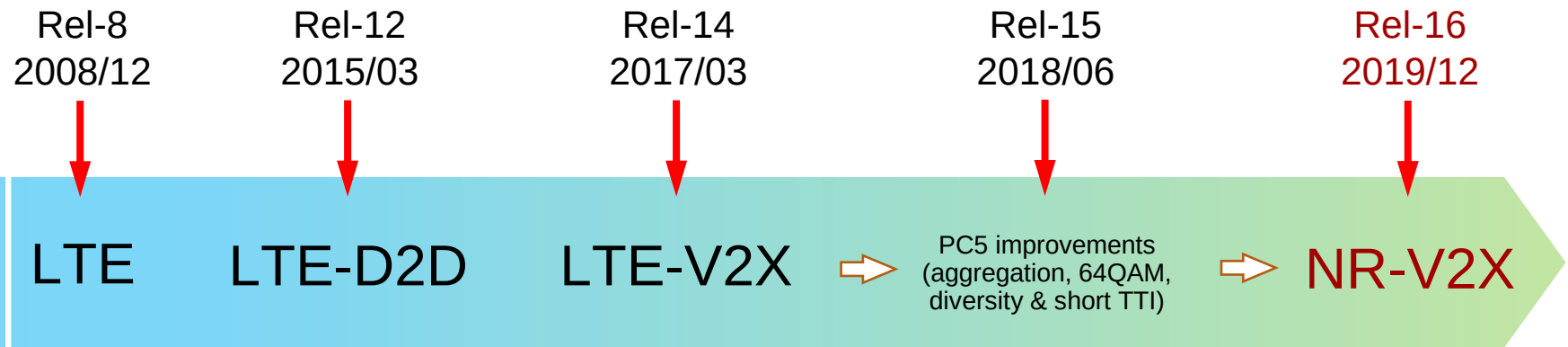
Short range (<1 kilometer), location, speed
Implemented over 3GPP's "PC5 interface"

Long range (>1 kilometers). e.g. accident ahead
Implemented over 3GPP's "Uu interface"

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

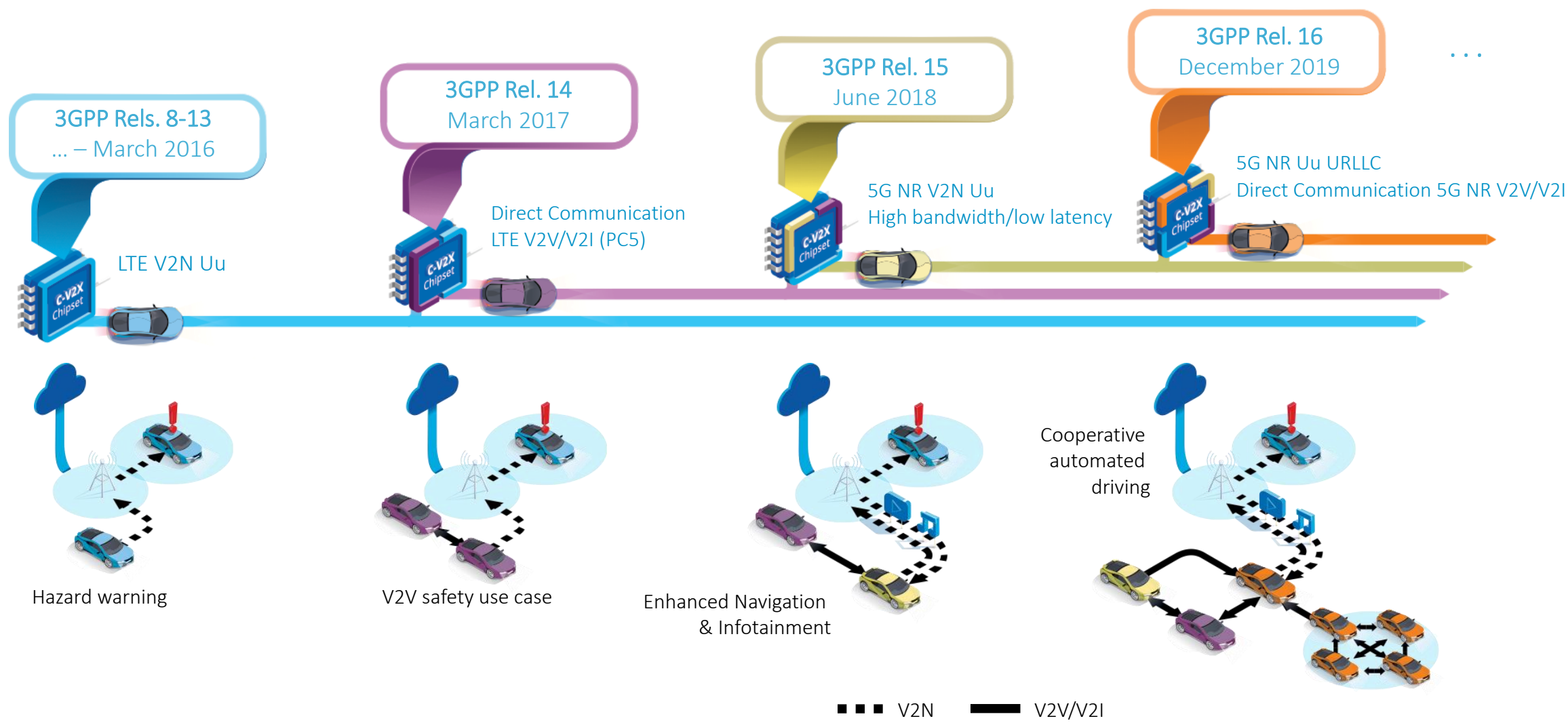


- ❑ Current version of C-V2X is called **LTE-V2X** as part of 3GPP Rel-14 & 15.
- ❑ **NR-V2X** as part of Rel-16 comes as an improvement to support automated driving.
- ❑ NR-V2X will **complement, co-exist** and **support interworking** with LTE-V2X i.e. operation of NR-V2X alone is not considered.



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

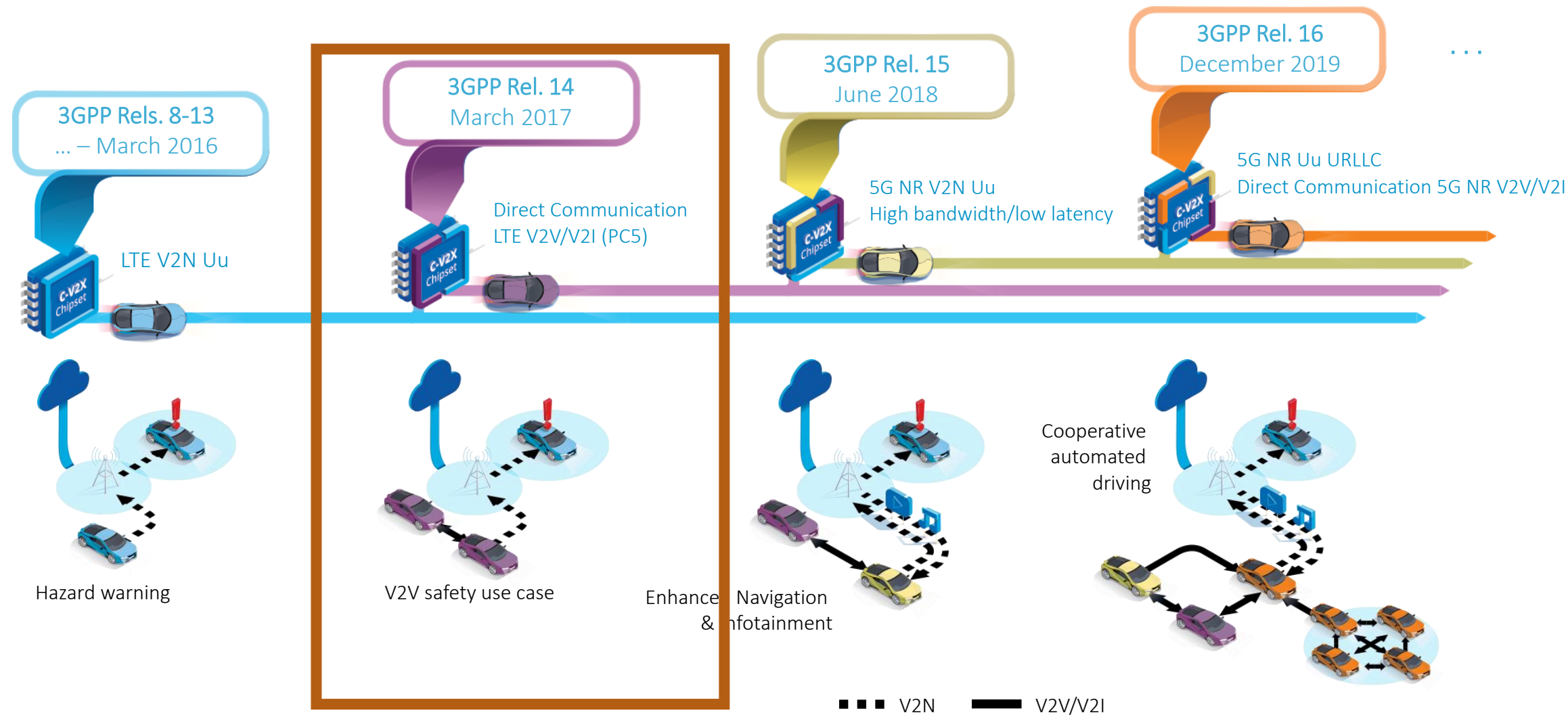
C-V2X: Evolution to 5G maintains backward compatibility





C-V2X Rel-14
Ready for deployment
today
around the world

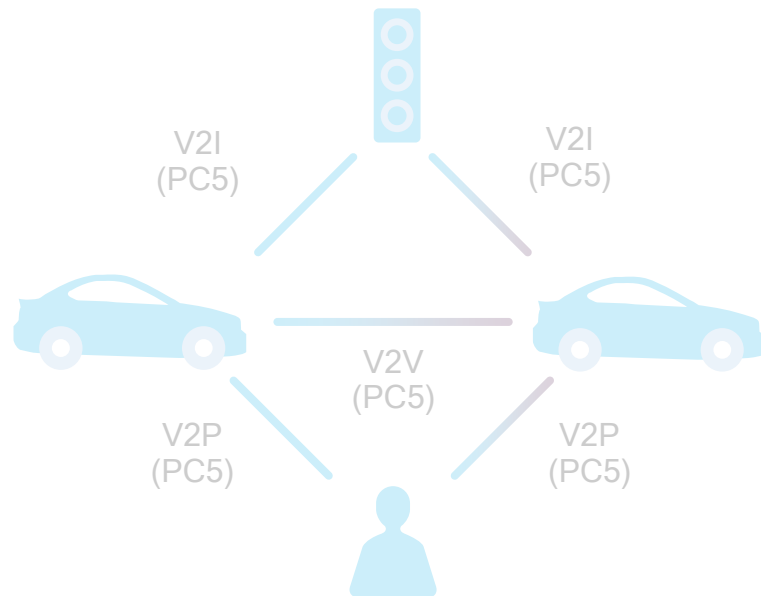
C-V2X: Evolution to 5G maintains backward compatibility



C-V2X has two complementary communication modes

Direct (= Sidelink)

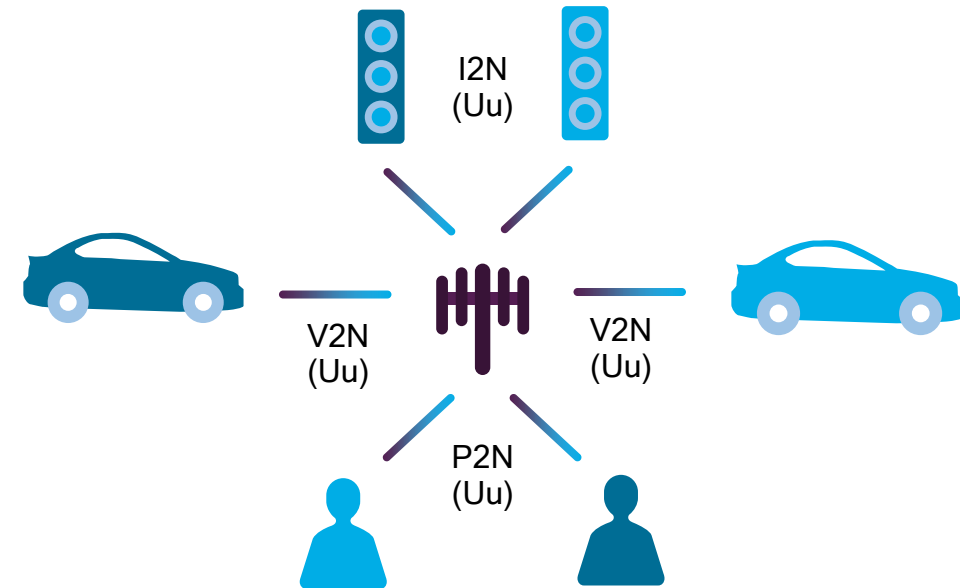
V2V, V2I, and V2P operating in ITS bands (e.g. ITS 5.9 GHz) independent of cellular network



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

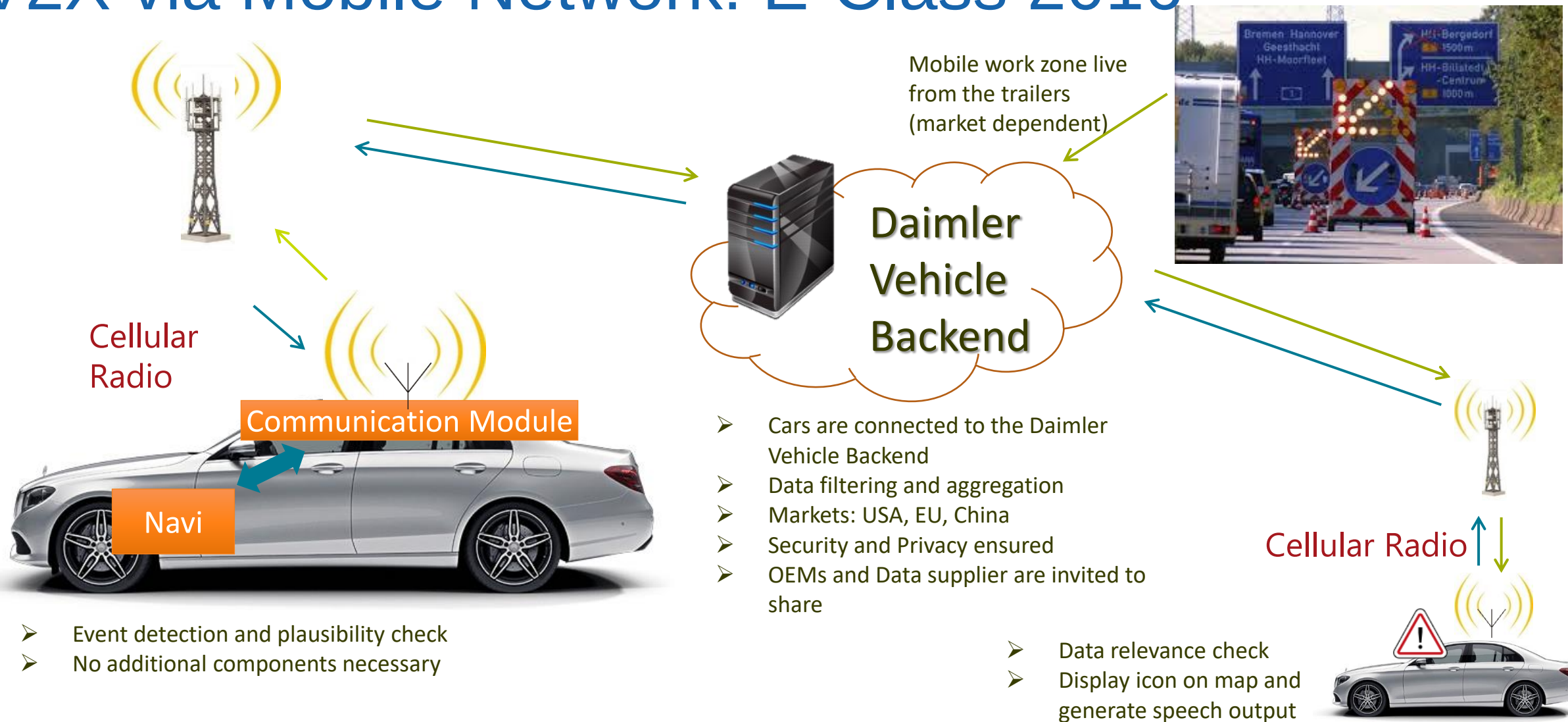
Network (= Up/Downlink)

V2N operates in traditional mobile broadband licensed spectrum



Long range (>1 kilometers). e.g. accident ahead
Implemented over 3GPP's "Uu interface"

V2X via Mobile Network: E-Class 2016*



V2X via Mobile Network: E-Class 2016*

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

HAZARD LIGHT ALERT

Part of Connected Safety



Green Light information (based on SPAT)

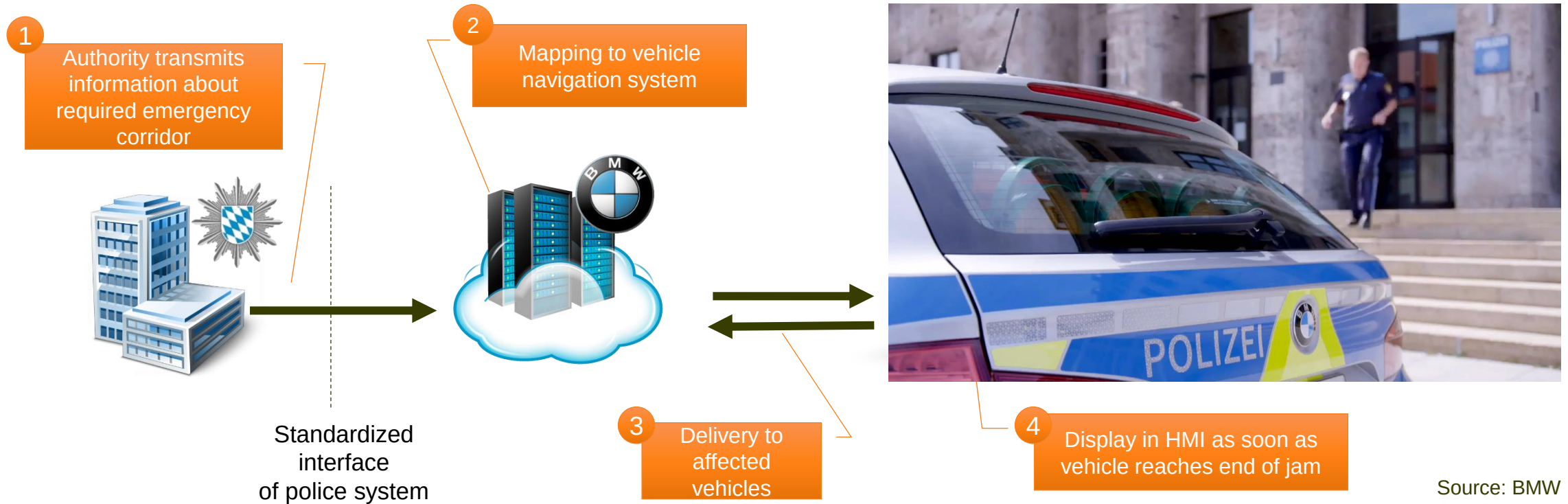
AUDI: Real-time “time-to-green” information via 4G LTE data connection from the traffic management system

Deployed in 20+ cities in US & EU



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.

Cross border connection interruption
(change of Mobile Network Operator)



Ericsson and Daimler have shown down to
100 ms handover time with IP address continuity
using standard cellular functionality*



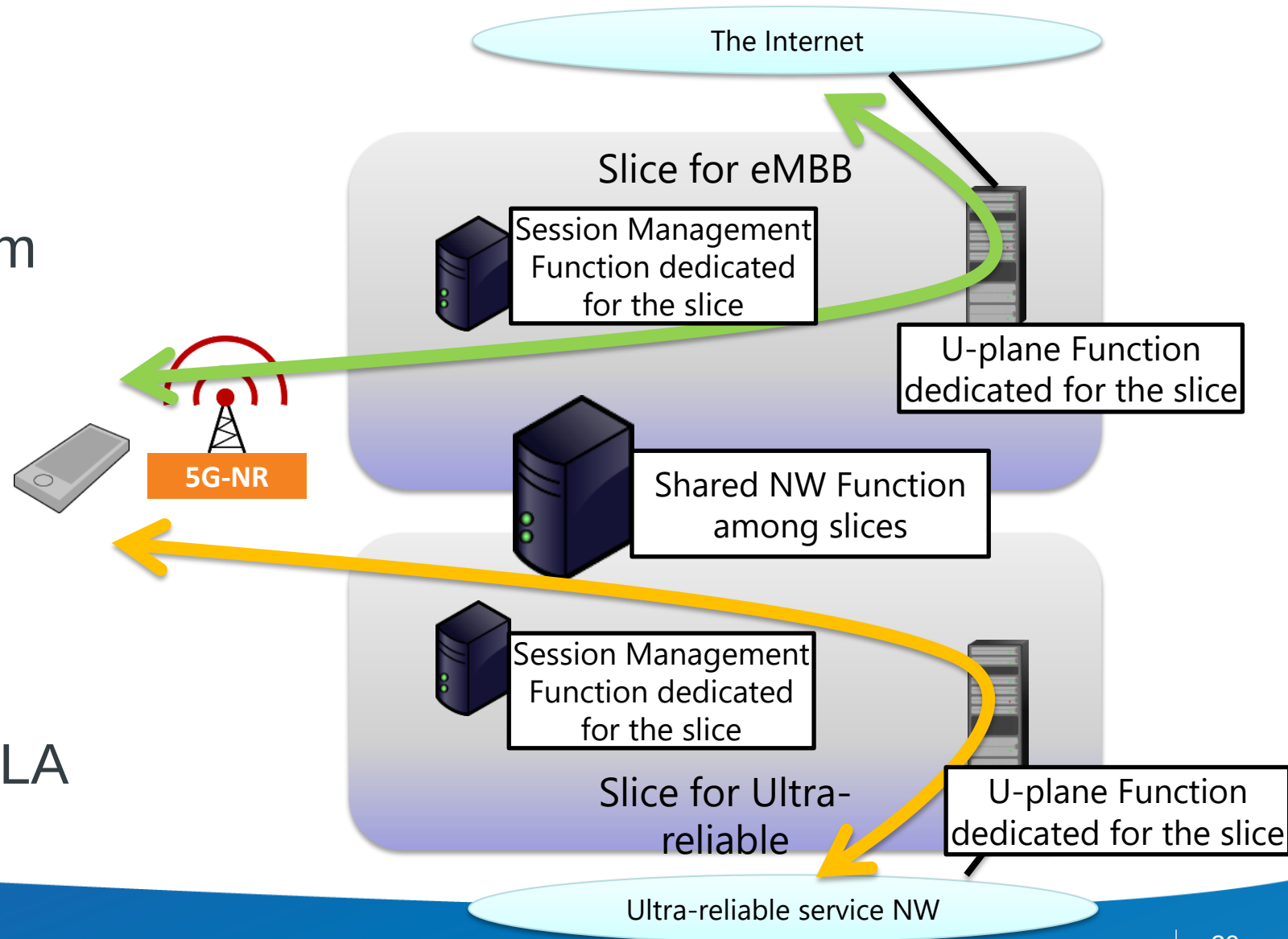
**Further V2N features
enabled
by 5G core and New
Radio**

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

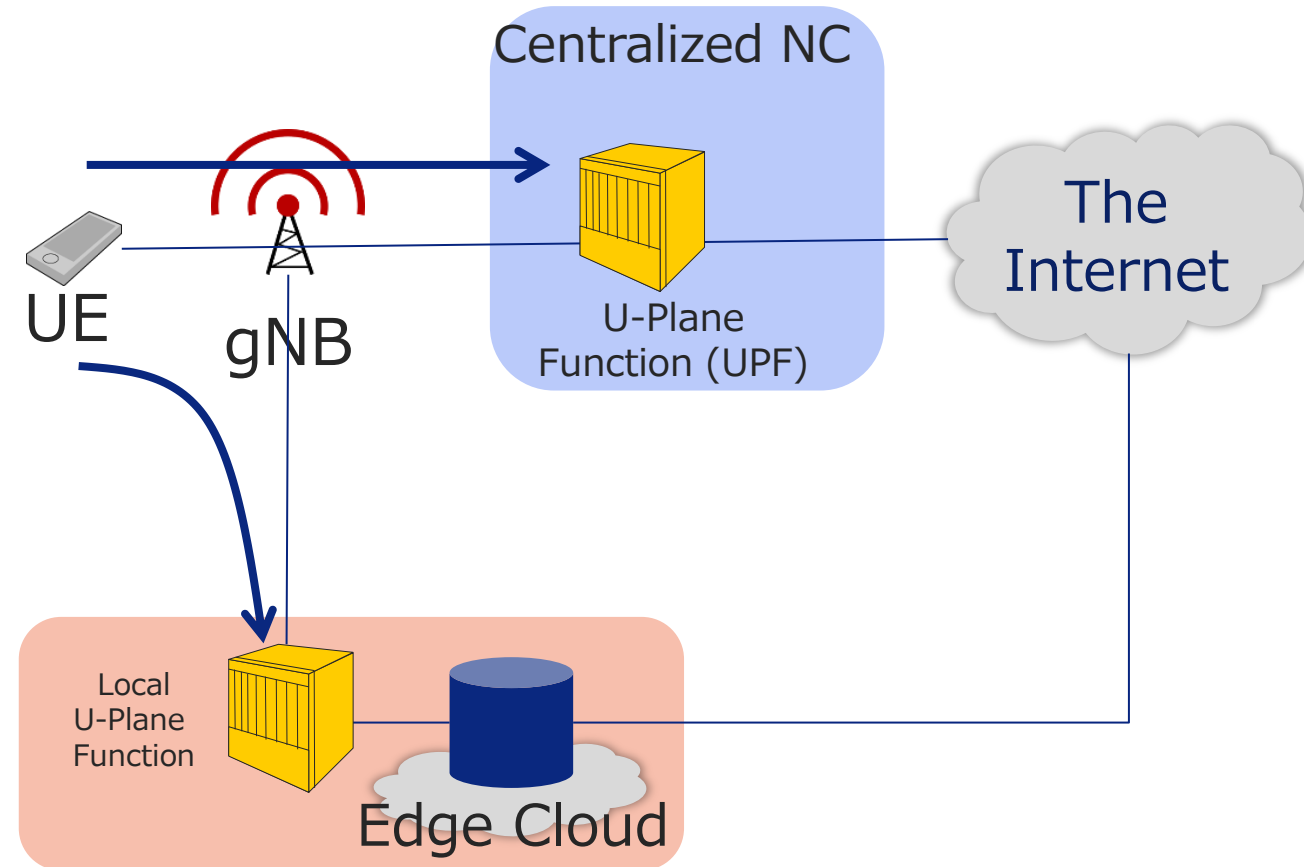


Ultra-reliable and Low Latency Communications

Edge Computing

Applications can be hosted at
“Edge-side”

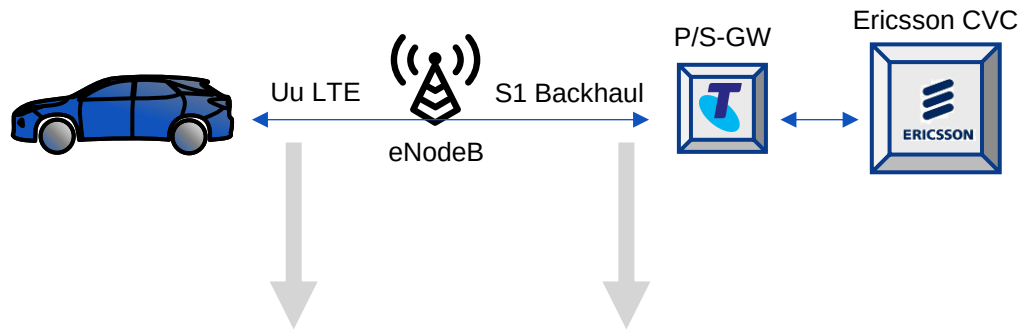
→ Low Latency compared with
centralized manner



Uu Optimized for V2X

V2N2V Latency ~50 ms (Round trip)

I2N2V Latency ~30 ms (One-way)



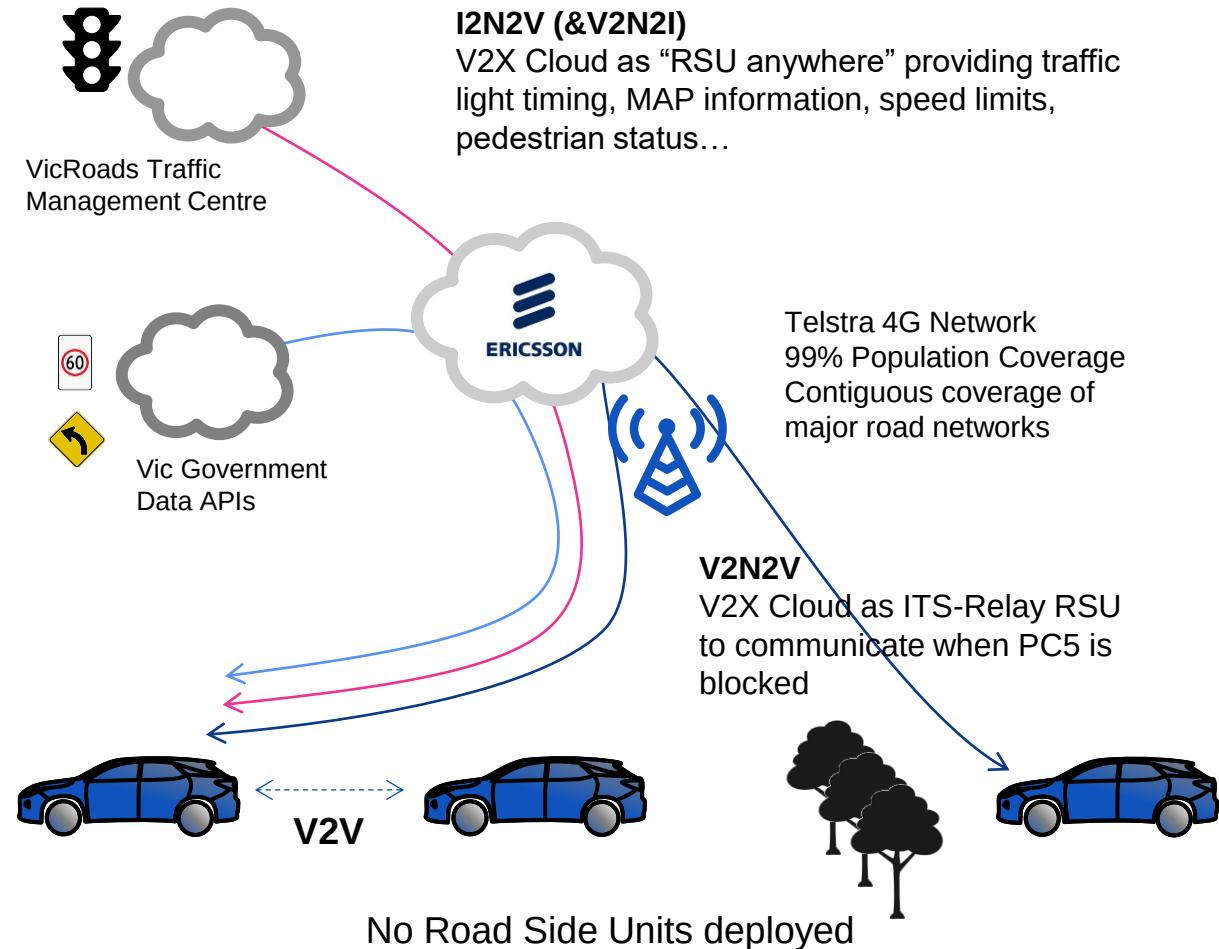
V2X latency on Uu

- **Deterministic scheduling** for V2X users
- **Idle-Mode** and **DRX** modifications
- **Minimum rate** for V2X users to sustain CAMs/DENMs
- **Partial priority** over general internet users, (lower than emergency services etc).

E2E QoS across entire Telstra Network

- **3GPP QCI 79** (Non GBR V2X)
- **Same Quality of Service (QoS)** system that exists for Voice over LTE (VoLTE)

“Virtual RSU” Architecture





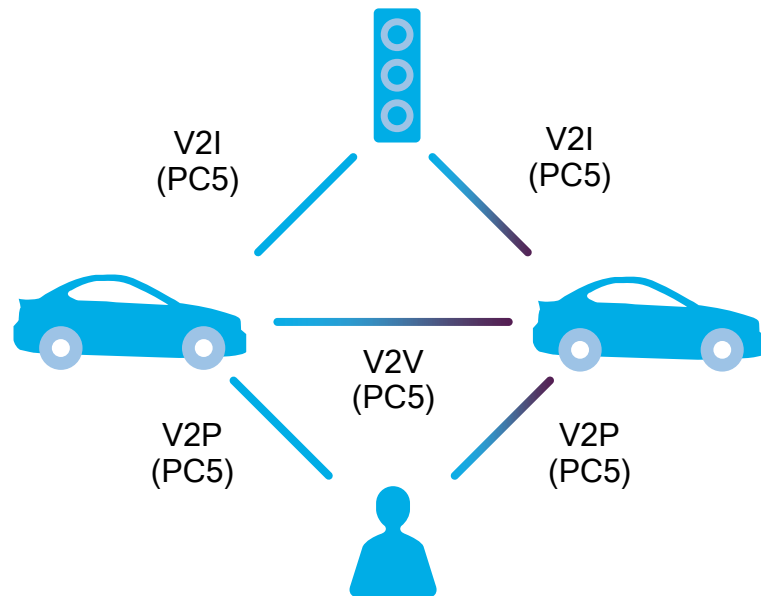
What about V2V / V2I?
3GPP Rel-14 LTE-V2X PC5
operating at 5.9 GHz*

* License exempt band for ITS applications

C-V2X has two complementary communication modes

Direct (= Sidelink)

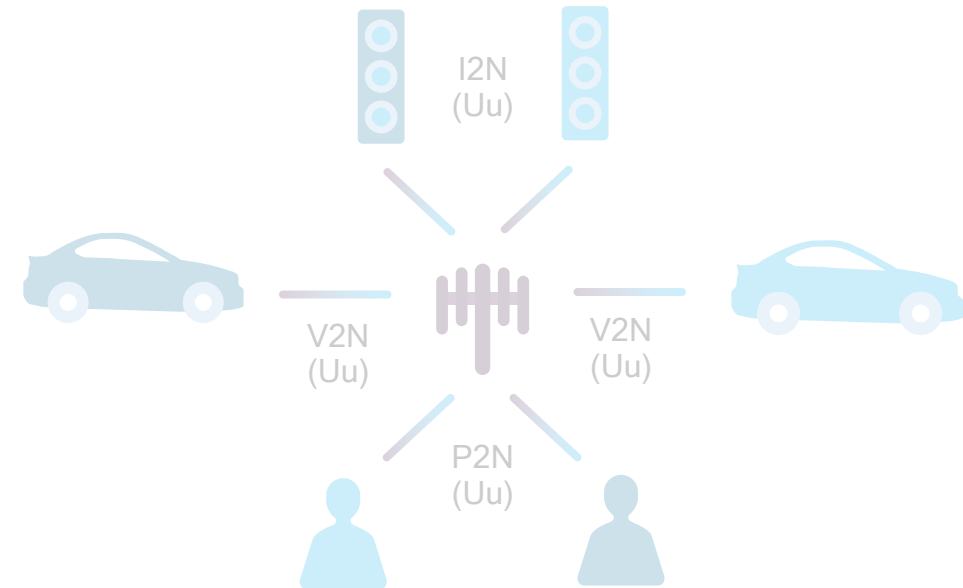
V2V, V2I, and V2P operating in ITS bands (e.g. ITS 5.9 GHz) independent of cellular network



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

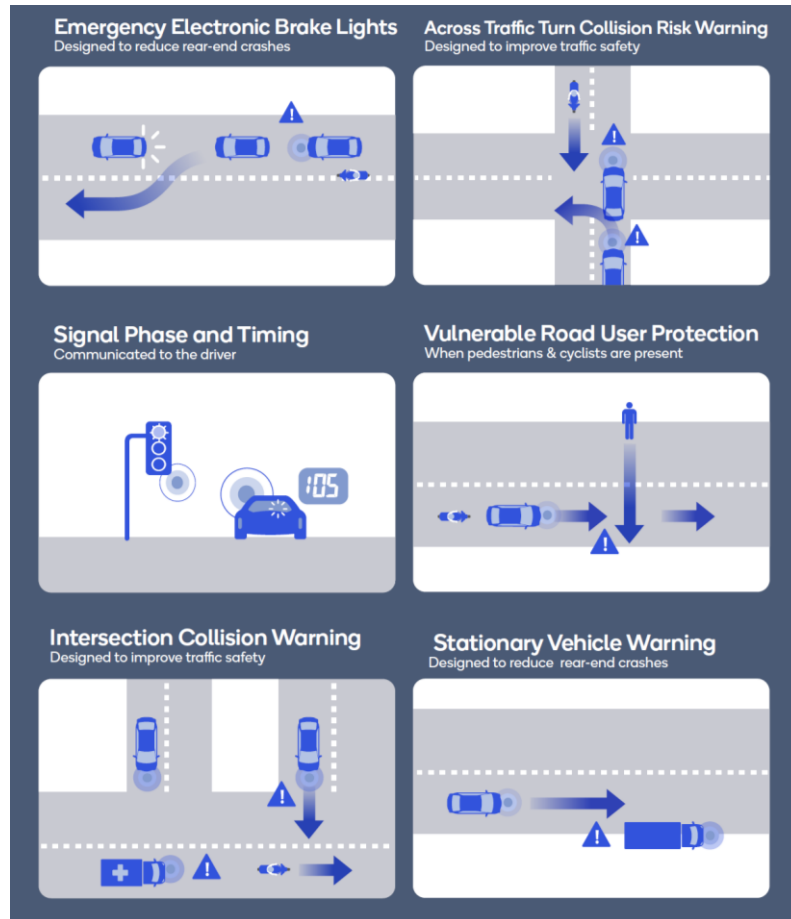
Network (= Up/Downlink)

V2N operates in traditional mobile broadband licensed spectrum



Long range (>1 kilometers). e.g. accident ahead
Implemented over 3GPP's "Uu interface"

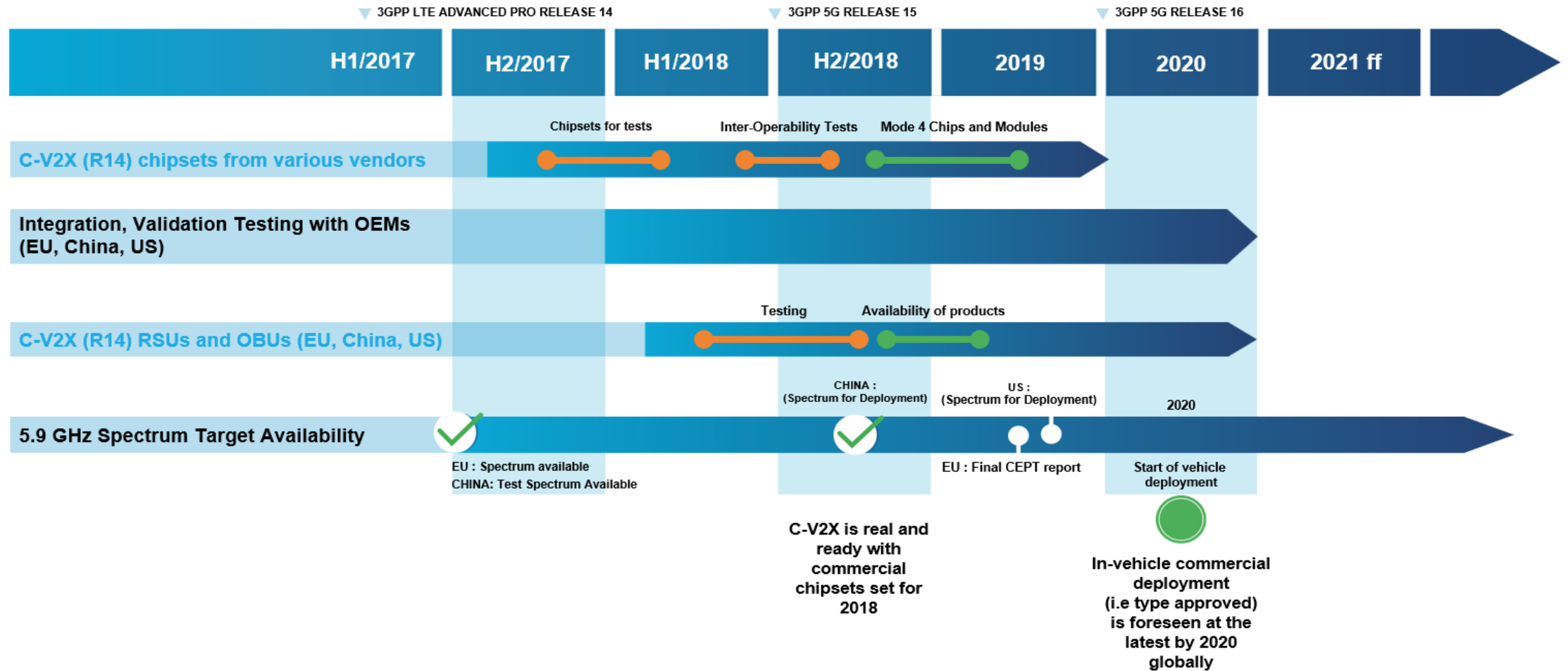
Rel-14 Basic Safety Use Cases: V2V Demonstrations in Shanghai, Washington, Paris and Berlin (2017-2018)*



C-V2X
Transforming road safety



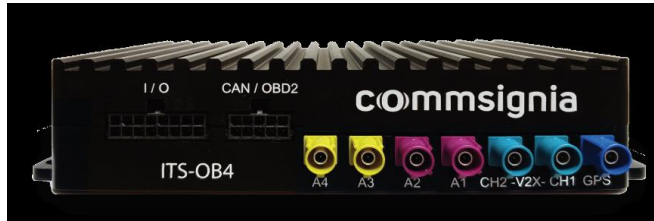
5GAA Timeline for deployment of LTE-V2X (V2V/V2I)



Commercial availability of LTE-V2X solutions

- LTE-V2X is ready for deployment with many hardware/software solutions now commercially available.
- On-board units (OBUs) or roadside units (RSUs) enable both C-V2X direct short-range and long-range:

commsignia OBU ITS-OB4



SAVARI™ OBU MW2000



FICOSA C-V2X On-Board Unit



HARMAN A SAMSUNG COMPANY S5G1
TELEMATICS CONTROL UNIT



commsignia RSU ITS-RS4



HUAWEI LTE-V RSU5201



SAVARI™ RSU SW2000

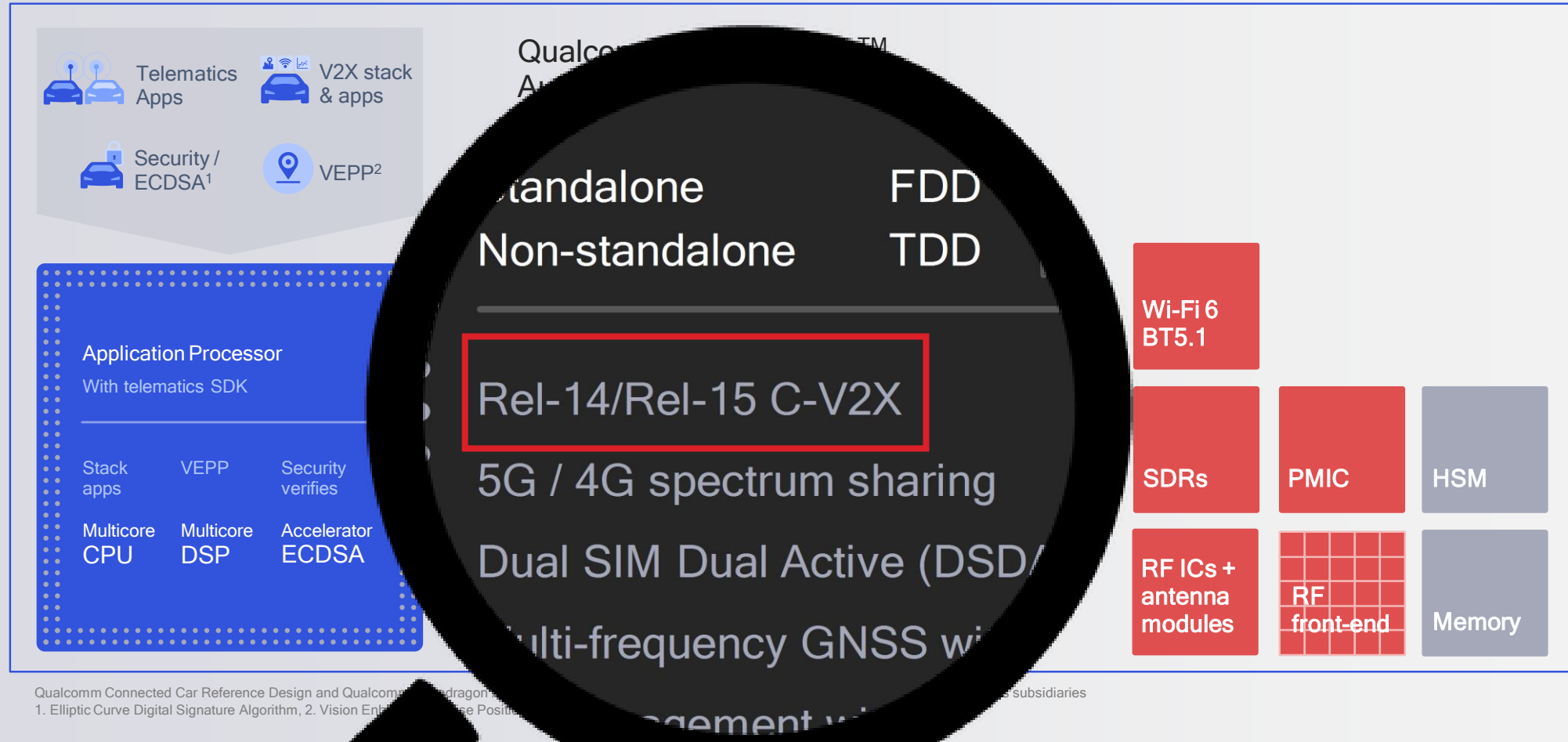


Enabling Deployment: lift barriers and accelerate time-to-market

- 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:



Qualcomm® Connected Car Reference Design, Gen 2



Source: Qualcomm,
Announced at the MWC2019, Barcelona

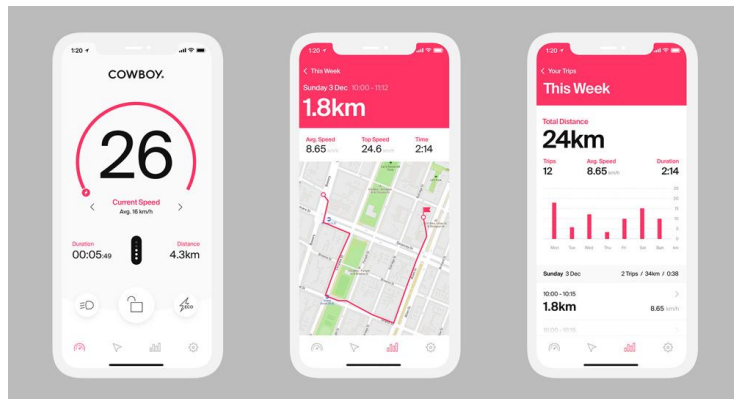
Include pedestrians and cyclists



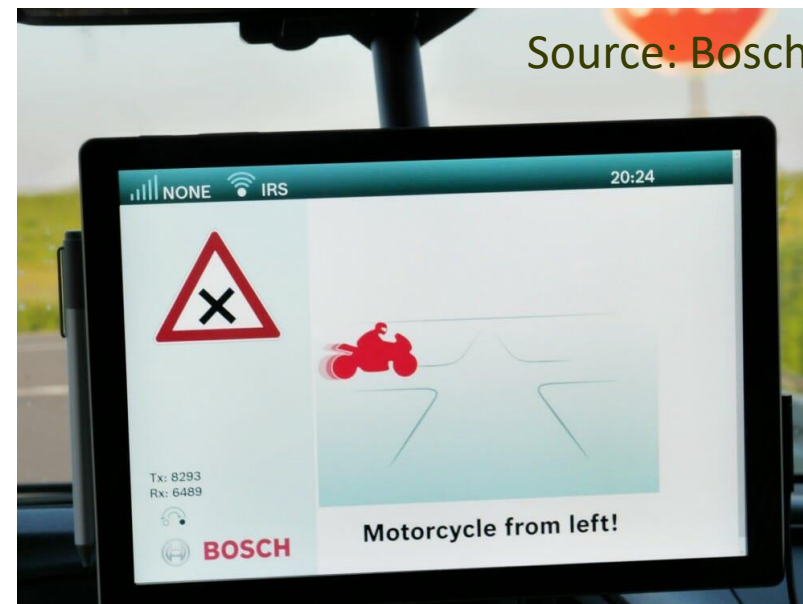
Source: Cobi



Source: BMW



Source: Cowboy



Source: Bosch

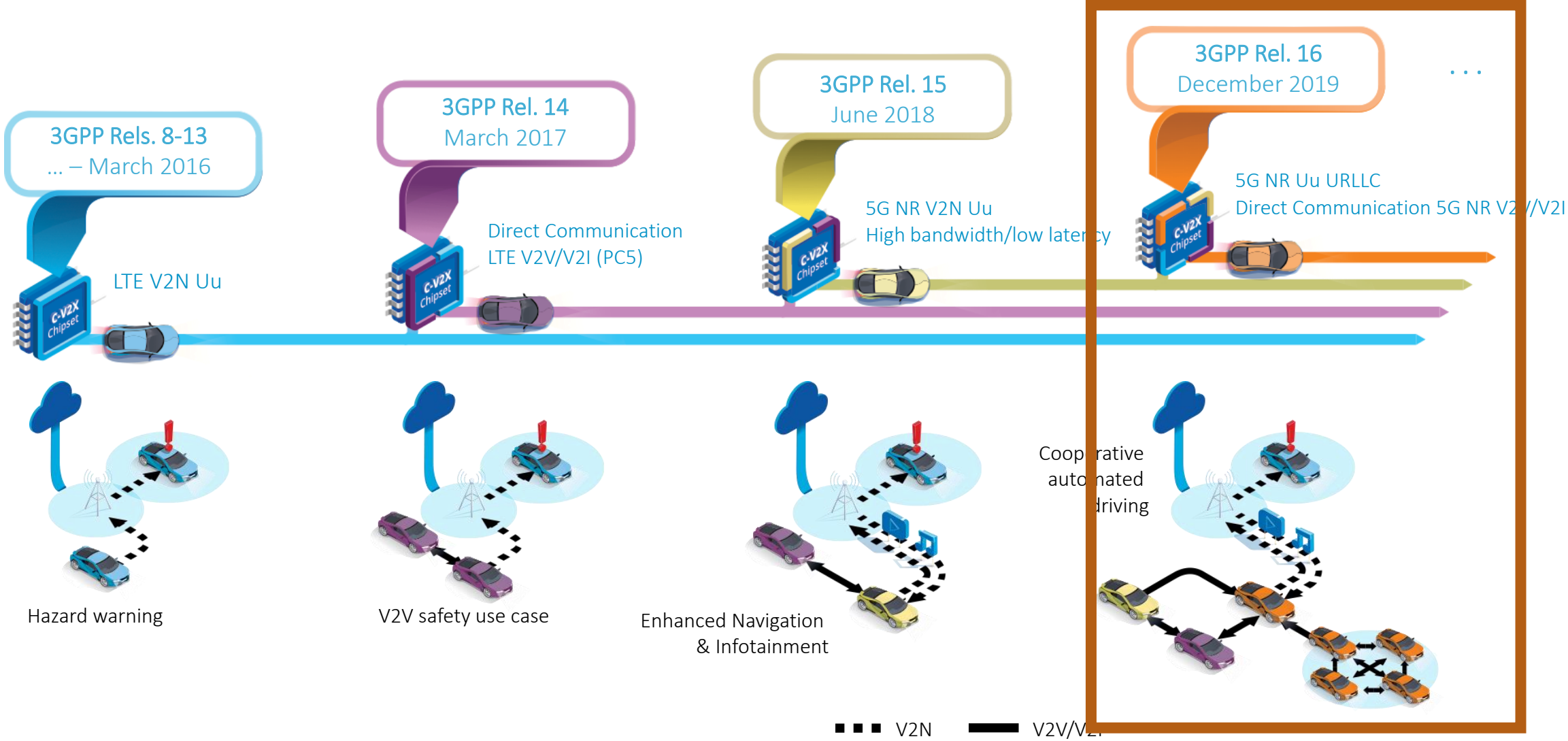


Source: Bosch



Path towards Rel-16 NR-V2X

C-V2X: Evolution to 5G maintains backward compatibility



5G NR C-V2X

Communication augments
autonomous driving



Perception

Sharing of high throughput sensor data and real world model



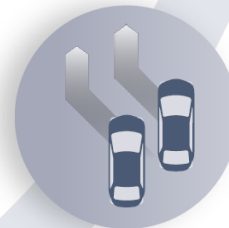
Path planning

Intention and trajectory sharing for faster, yet safe maneuvers



Real-time local updates

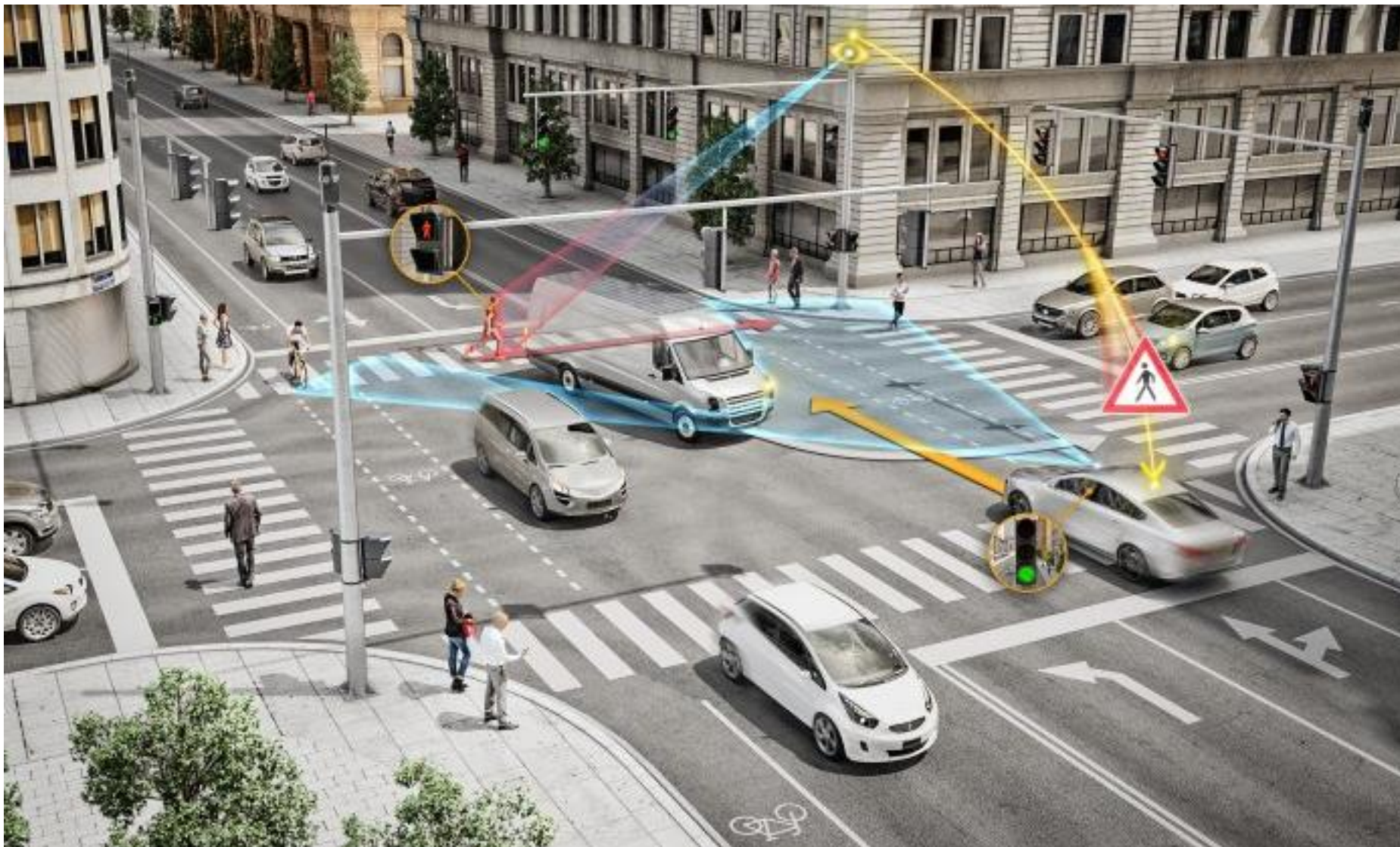
Real-time sharing of local data with infrastructure and other vehicles (e.g. 3D HD maps)



Coordinated driving

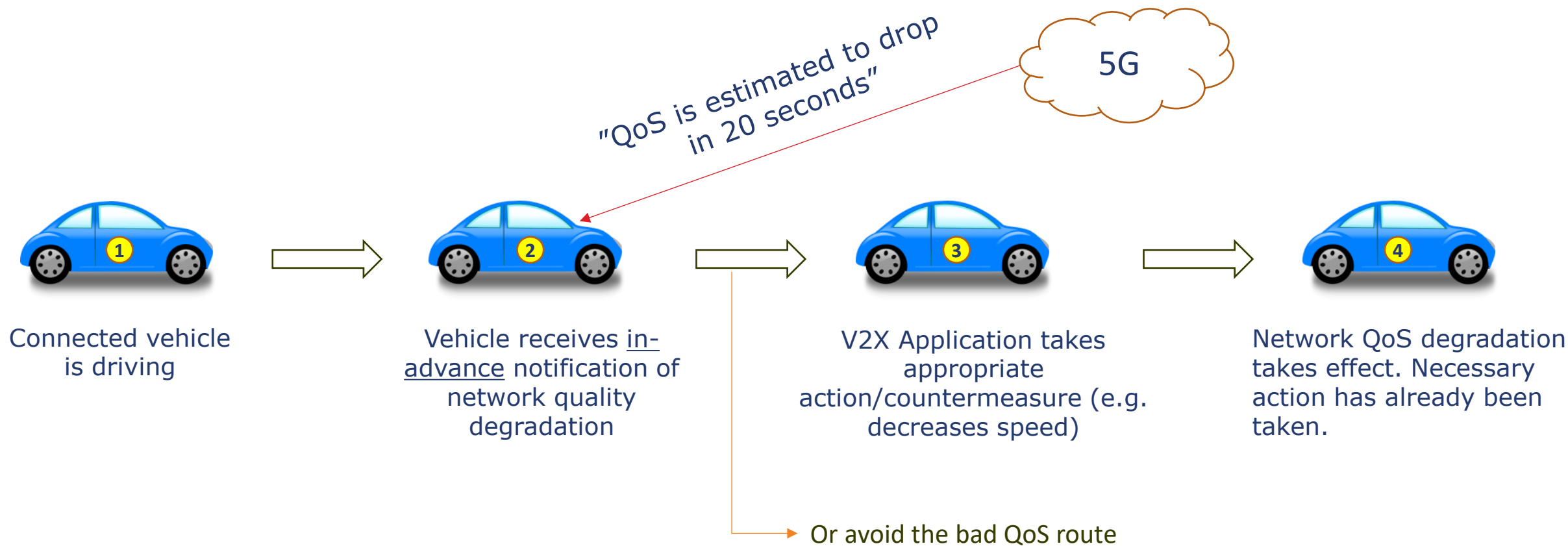
Exchanging intention and sensor data for more predictable, coordinated autonomous driving

Enable complex interaction Use Cases (perception, negotiation, multi-lateral agreements)



Source: Continental

C-V2X supported by Predictive QoS



Conclusions

- Many ITS day 1 services are readily delivered using 4G/LTE technology via service clouds (OEMs, Traffic management)
 - Current focus on adding interconnection between service clouds.
- C-V2X Rel-14 adds short range V2V communication (using PC5)
- C-V2X V2V around the world is driven by Chinese market.
- In Europe, non-tech neutral regulation may delay the market introduction of the V2V/V2I based on C-V2X (PC5) at 5.9GHz.
- C-V2X radio improvements are being standardized (NR-V2X) to accommodate automotive needs for higher levels of automation.



Thank you!