CAR Management Briefing Seminars
Connected and Automated Vehicles Technology Session

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V2X: A Road to 5G

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Rel-14 C-V2X

Gaining momentum for automotive safety

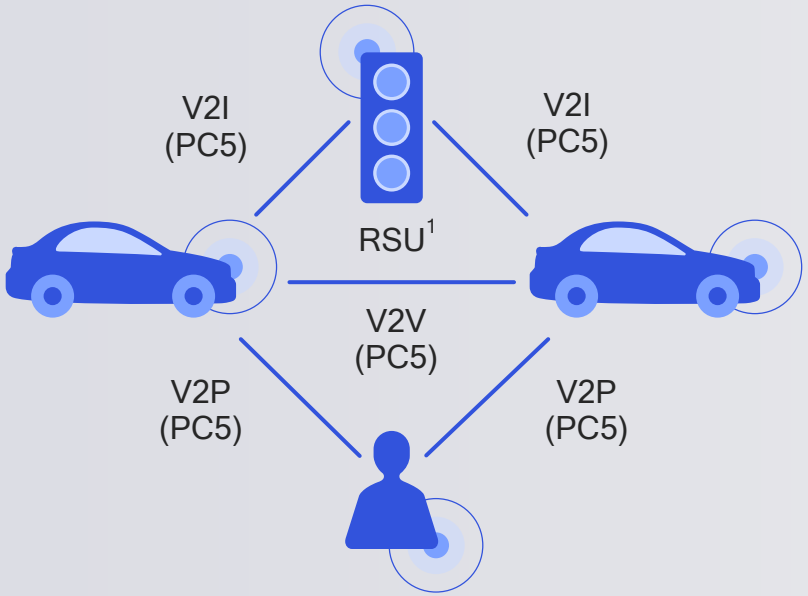
C-V2X enables network independent communication

Direct safety communication independent of cellular network

Low latency Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and Vehicle to Person (V2P) operating in ITS bands (e.g. 5.9 GHz)

Direct PC5 interface

e.g. location, speed, local hazards

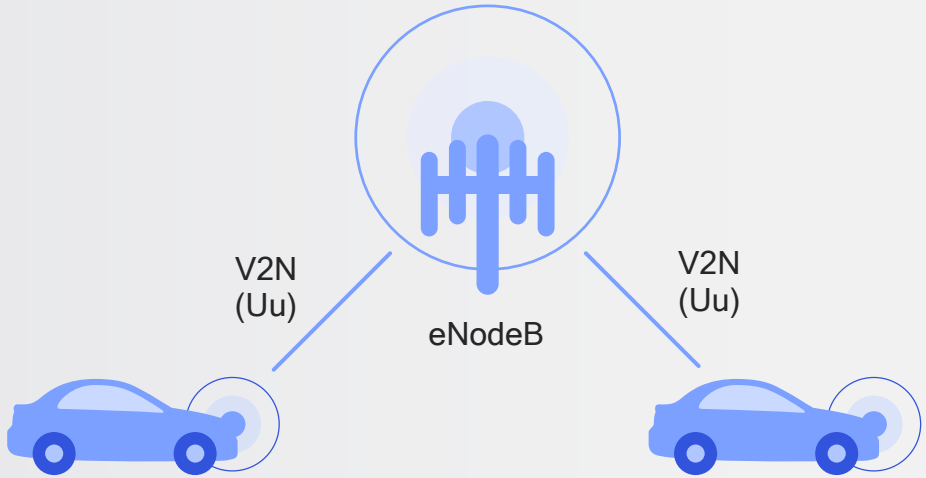


Network communications for complementary services

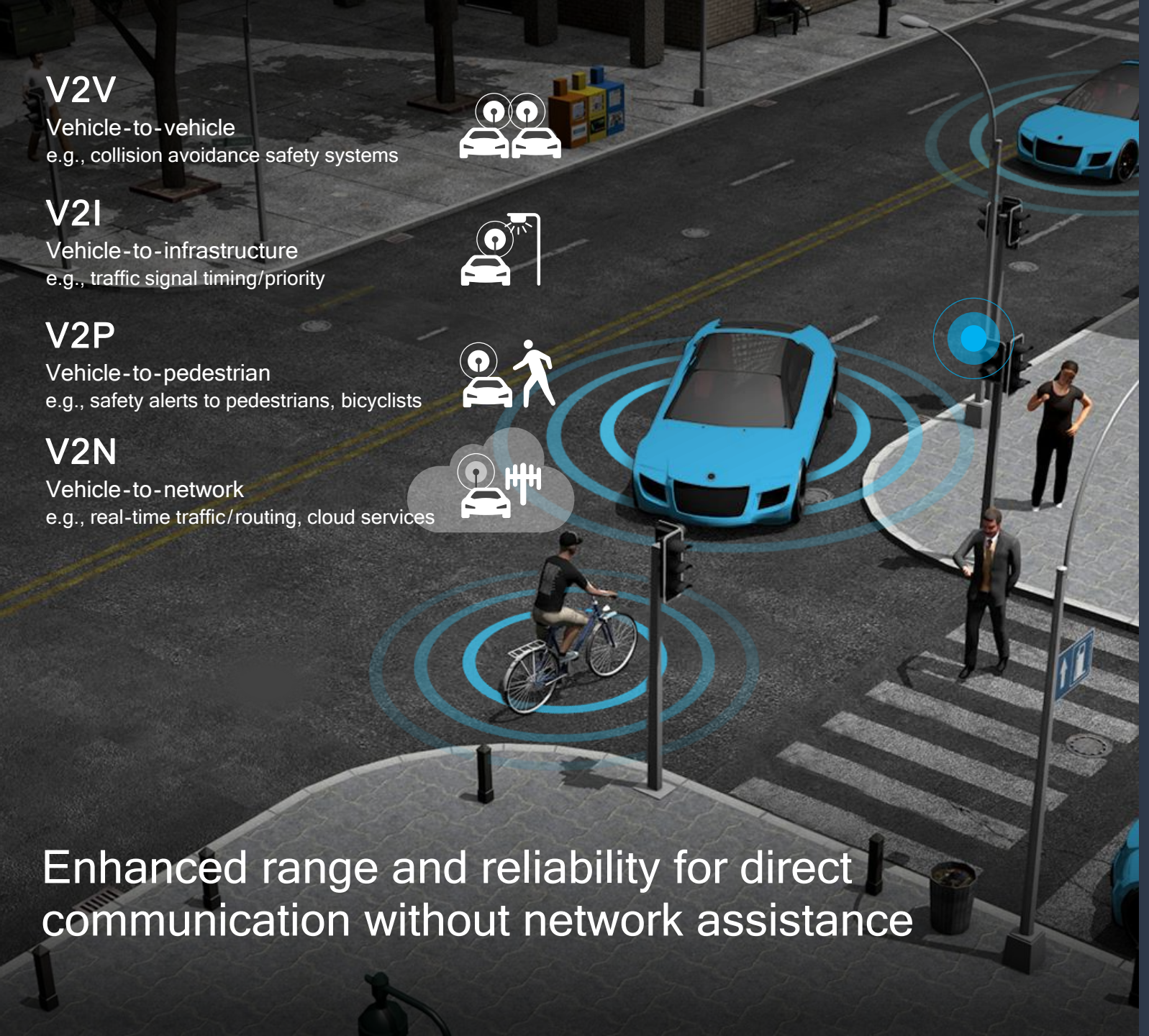
Vehicle to Network (V2N) operates in a mobile operator's licensed spectrum

Network Uu interface

e.g. accident 2 kilometer ahead



1. RSU stands for roadside unit



C-V2X

Establishes the foundation for safety use cases and a continued 5G NR C-V2X evolution for future autonomous vehicles

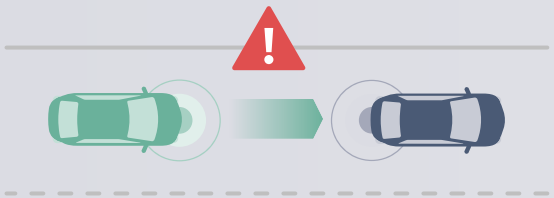
- Release 14 C-V2X completed in 2017
- Broad industry support – 5GAA
- Global trials started in 2017
- Our 1st announced C-V2X product in September, 2017

Evolving C-V2X Direct Communications towards 5G NR

While maintaining backward capabilities

Evolution to 5G NR, while being backward compatible
C-V2X Rel-14 is necessary and operates with Rel-16

Basic safety
IEEE 802.11p

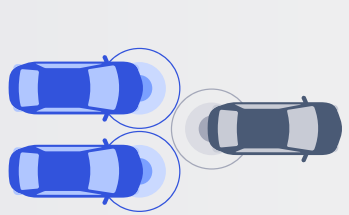


Basic and enhanced safety
C-V2X Rel-14/Rel-15 with enhanced range and reliability

Autonomous driving use cases
5G NR C-V2X Rel-16

Backward compatible with Rel-14/Rel-15 enabled vehicles

- Higher throughput
- Higher reliability
- Wideband carrier support
- Lower latency

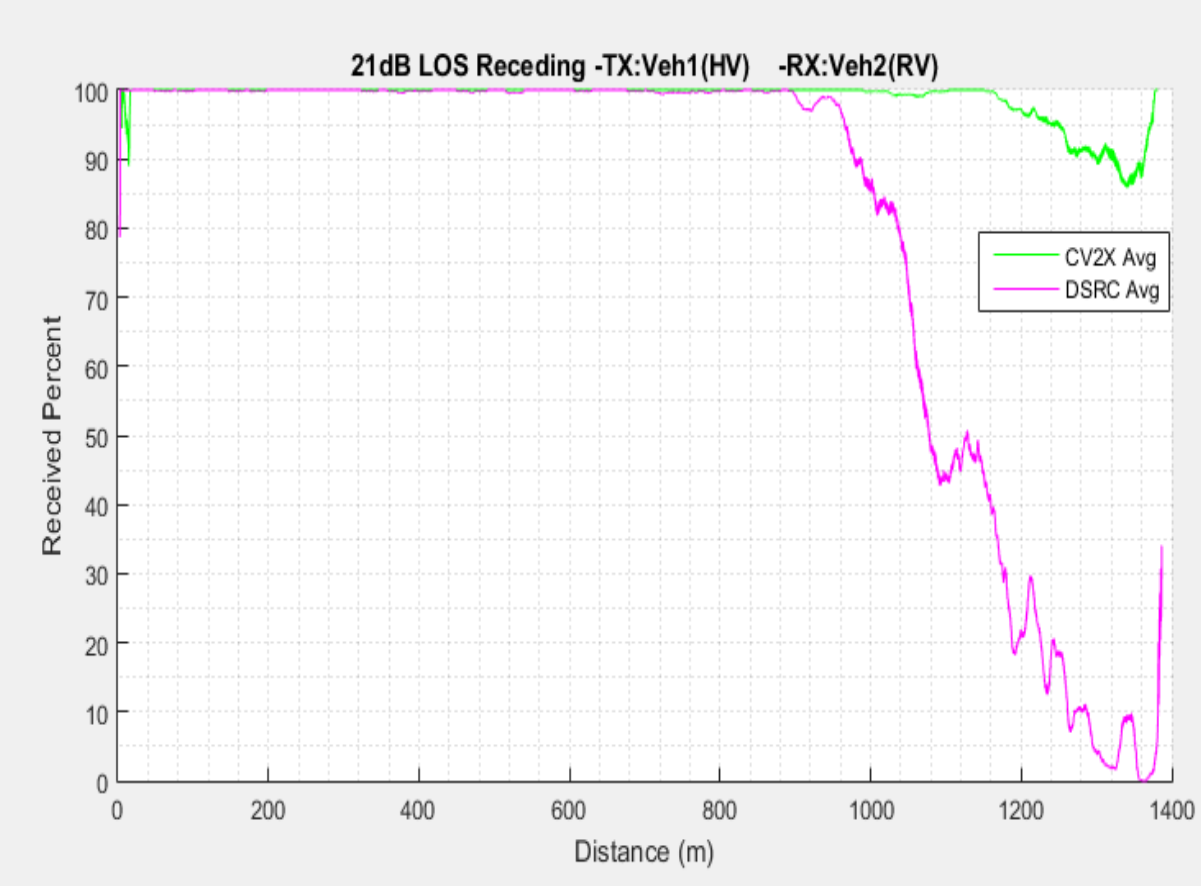


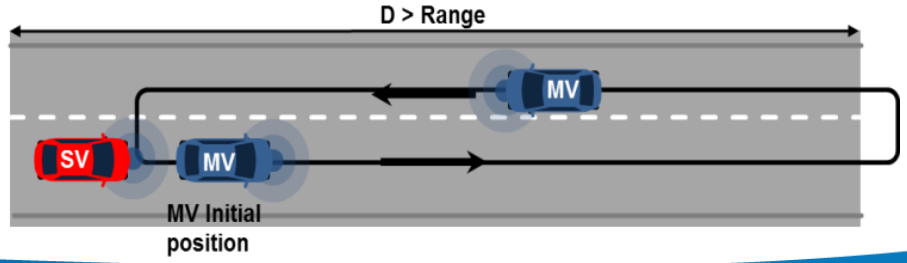
Ten attributes about C-V2X

1. Designed for low-latency direct communications without relying on network assistance
2. Designed to work on harmonized ITS 5.9 GHz spectrum for safety applications
3. Designed for high-speed vehicular use case
4. A safer technology with predictable performance due to 3GPP-defined rigorous minimum requirements
5. A modern technology with superior radio performance
6. Features robust synchronization even in the absence of satellite/GNSS
7. Designed to leverage investments in upper layers as defined for DSRC
8. Expected to be ready for commercial deployment in vehicles for 2020
9. More cost efficient than other V2X technologies
10. The only V2X technology with a clear and forward compatible evolution path to 5G

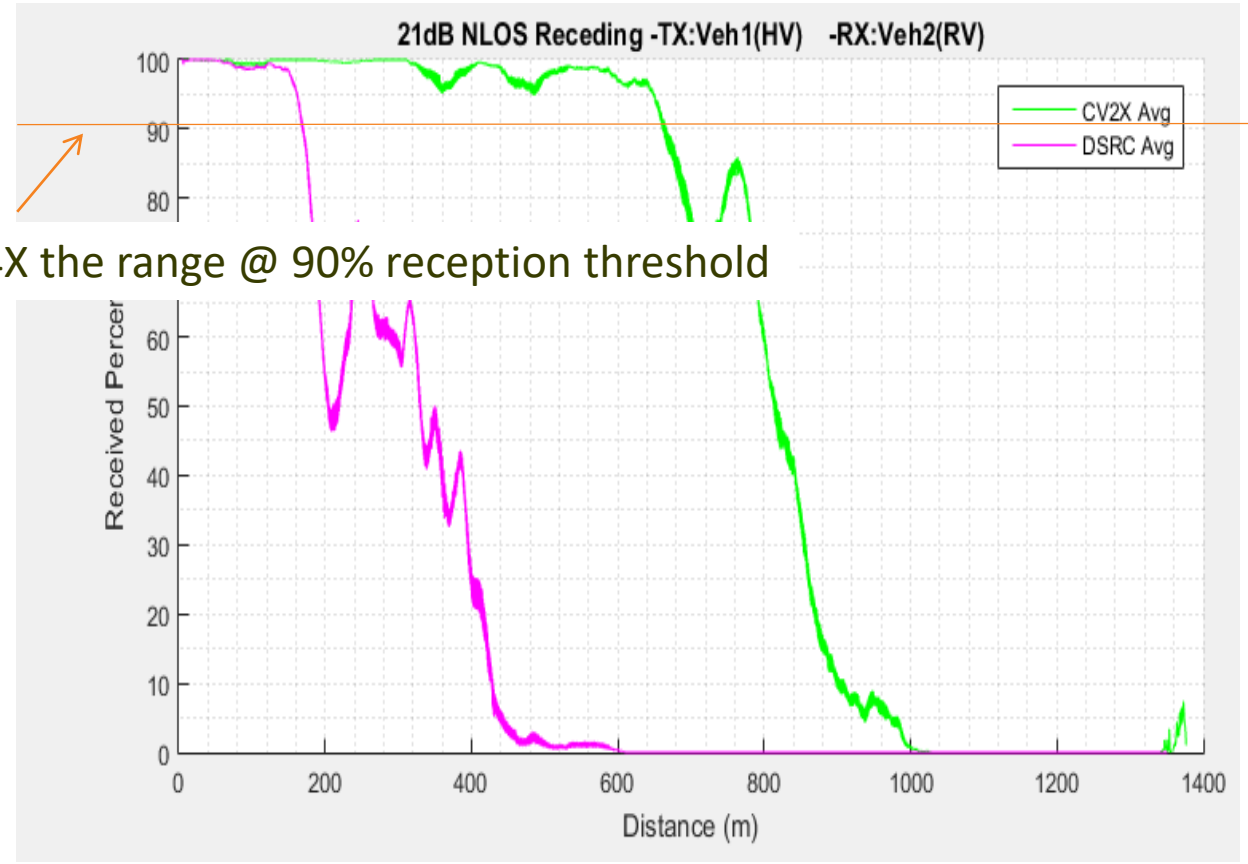
GNSS = Global Navigation Satellite System

Line-of-Sight (LOS) Range / Reliability Road Test in Fowlerville, Michigan

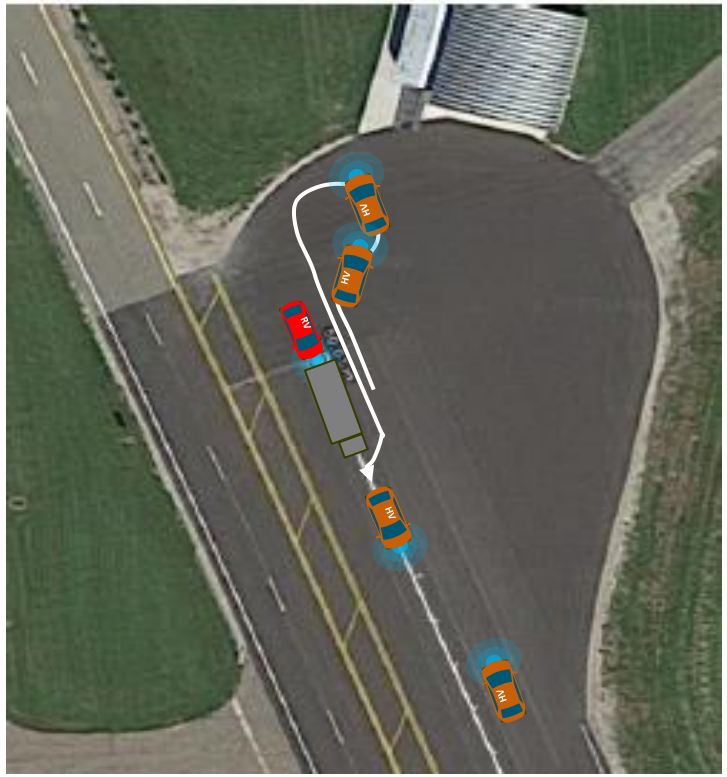


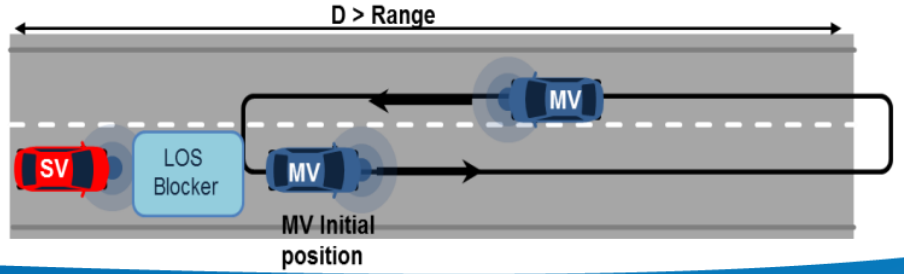


Obstructed Non-Line-of-Sight (NLOS) Range/Reliability Road Test in Fowlerville, Michigan



4X the range @ 90% reception threshold





C-V2X access control advantages over 802.11p

System keeps on scaling

Optimized resource scheduling

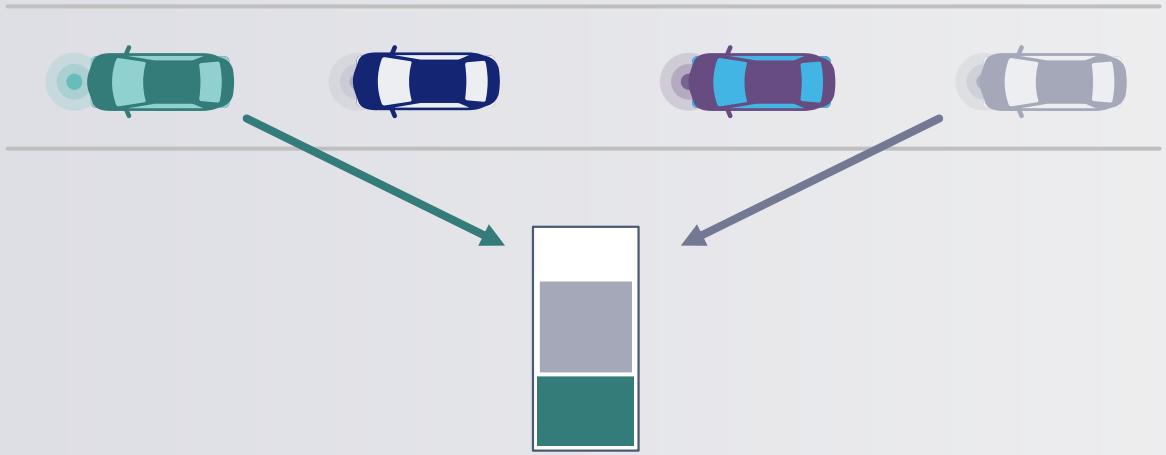
By choosing the lowest relative energy blocks

Never get denied access

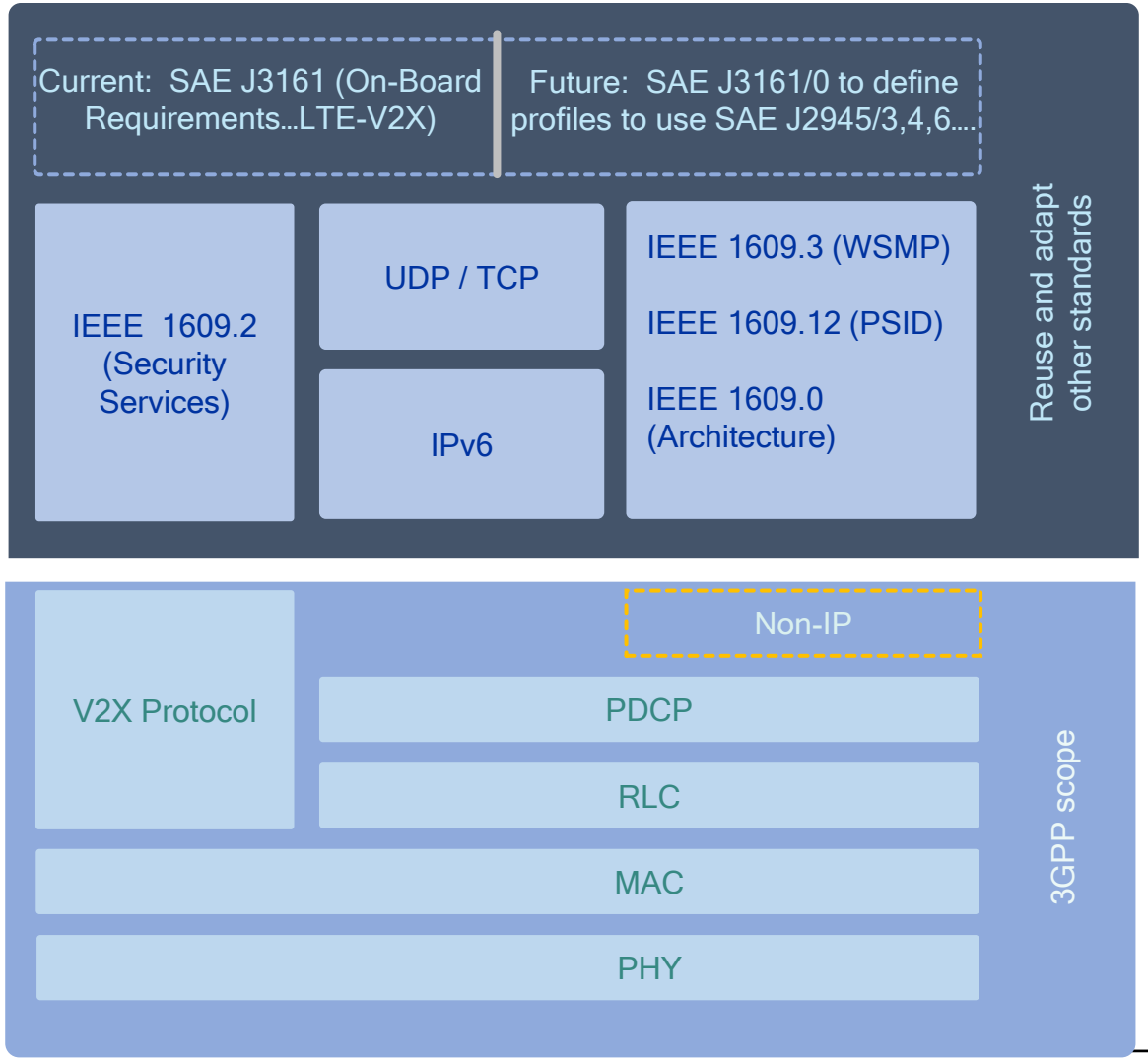
Two cars far apart from each other can use same resources

Designed to meet latency requirements

By scheduling and obtaining access to resources in timely manner

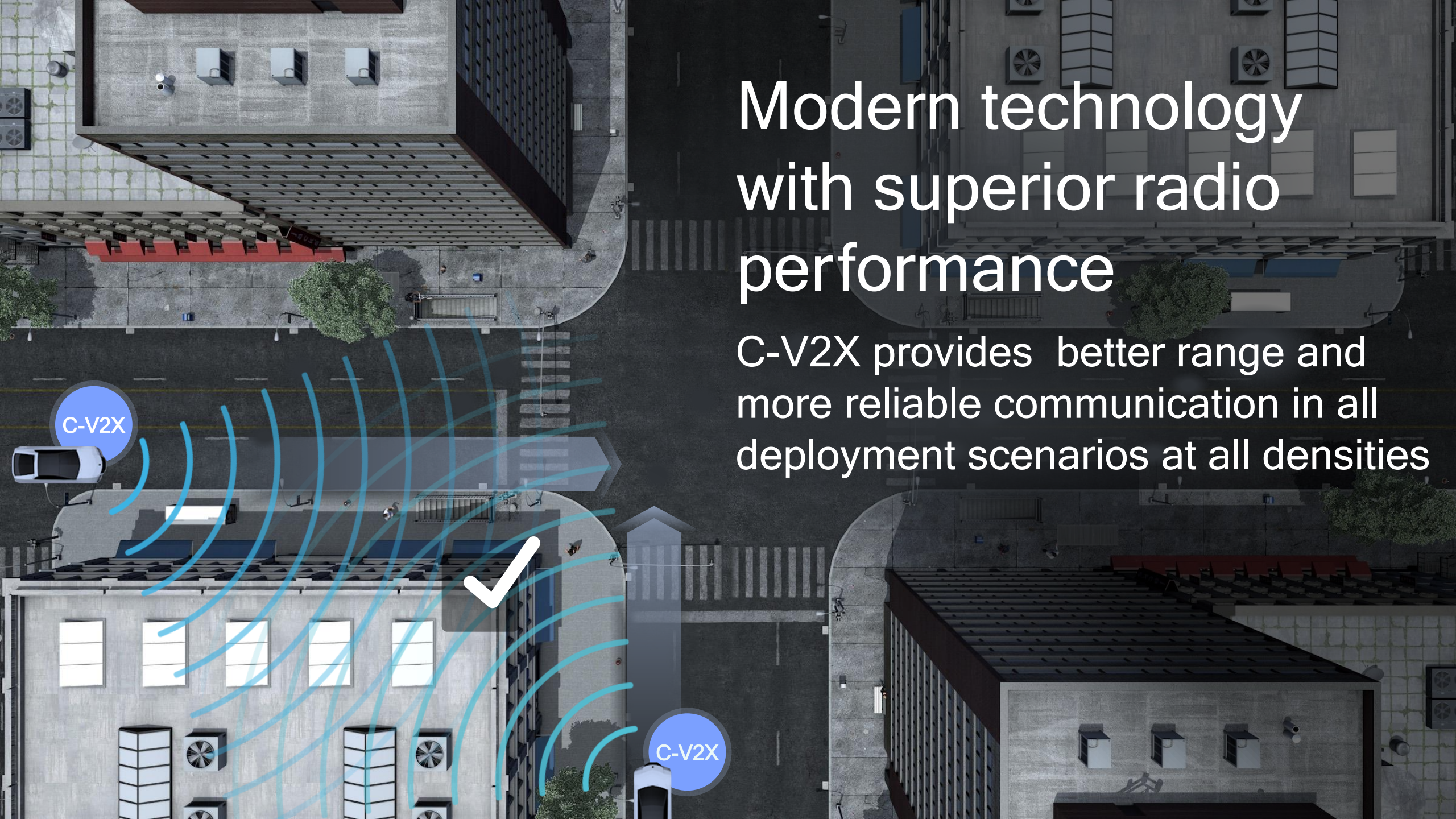


A Road Ahead: SAE C-V2X Standardization



- Media independence on next IEEE 1609 WG meeting agenda
  - Will be able to support a full featured 1609.3 over PC5
- For Vehicle Safety Channel, PC5 can transport BSM, SPAT, MAP, RSM (and other J2945/3, /4 and /6 enhancement) exactly like DSRC
  - Plan introduce a “/0”-type document to describe C-V2X specifics

V2V/V2I/V2P reuses existing DSRC upper layers



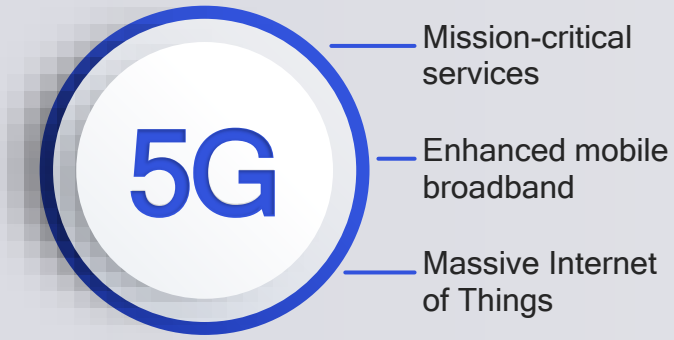
Modern technology with superior radio performance

C-V2X provides better range and more reliable communication in all deployment scenarios at all densities

5G NR C-V2X

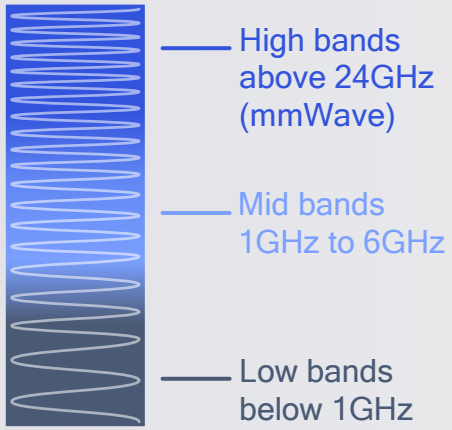
Brings new capabilities to
C-V2X for autonomous driving

5G NR Designing a unified, more capable 5G air interface



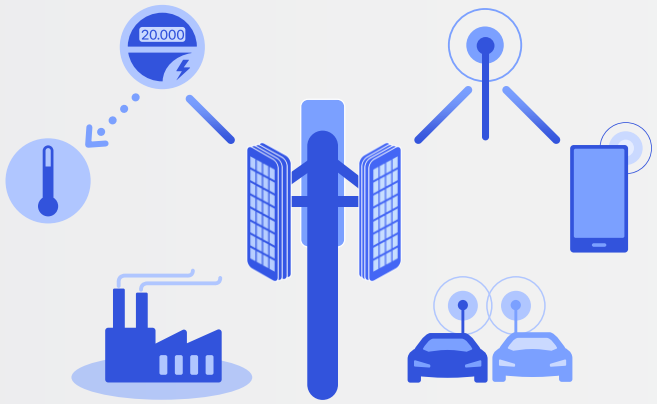
Diverse services

Scalability to address an extreme variation of requirements



Diverse spectrum

Getting the most out of a wide array of spectrum bands/types



Diverse deployments

From macro to indoor hotspots, with support for diverse topologies

A unifying connectivity fabric for future innovation

A platform for existing, emerging, and unforeseen connected services

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

Resulting in a 5G NR C-V2X design that addresses autonomous vehicle use case requirements

5G NR C-V2X

Higher throughput

High spectral efficiency to achieve higher data rate

High vehicle speeds

Support higher data rates at relative speeds up to 500km/h

Lower latency

Access latency below 1ms for time critical use cases

Harmonious coexistence

Can coexist with Rel-14 in the same channel/band

Higher reliability

Unicast multicast support using efficient feedback

Backward compatibility

Vehicles with Rel-16 will also support Rel-14 for safety

C-V2X gaining support from automotive and telecom leaders

5GAA is a cross-industry consortia to help define C-V2X and its evolution to 5G

5GAA Automotive Association

Automotive industry

Vehicle platform, hardware, and software solutions

Telecommunications

Connectivity and networking systems, devices, and technologies

End-to-end solutions for intelligent transportation mobility systems and smart cities

Airgain Alpine Electronics Analog Devices Anritsu EMEA Ltd AT&T Audi BAIC Beijing University Bell Mobility BMW Bosch CATT Cetecom China Transinfo China Unicom CMCC Continental Daimler Danlaw DEKRA Denso Deutsche Telekom Ericsson FEV Ficosa Ford Fraunhofer Gemalto Hirschman Car Hitachi Automotive US Honda Huawei Infineon Intel Interdigital Jaguar Land Rover Juniper KDDI Keysight KT Laird Tech LG Murata Nissan Nokia NTT DoCoMo OKI Orange P3 Group Panasonic Proximus PSA Qualcomm Rohde & Schwarz Rohm SAIC Samsung Savari SIAC SK Telecom Skyworks Softbank Sumitomo Telefonica Telekom Austria Telstra TÜV Valeo Veniam Verizon Viavi Vodafone Volkswagen (VW) ZF ZTE

Source: http://5gaa.org/; accurate as of January, 2018

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