KEYSIGHT WORLD 2019

Vehicle to Everything (V2X) Communications

Solution Marketing / Keysight Technologies

Seungtaek Chang

Road Traffic Accident Statistics

Autonomous Driving Systems

ENABLING TECHNOLOGIES

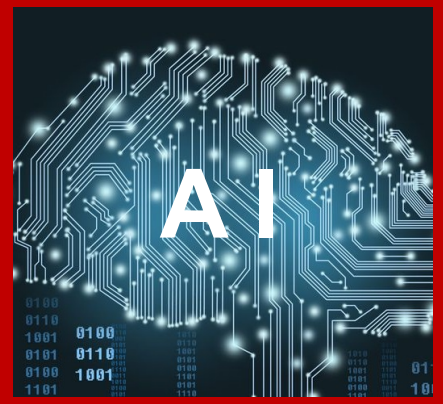
Communications

+

ADAS Sensors

+

Artificial Intelligence



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Telematics

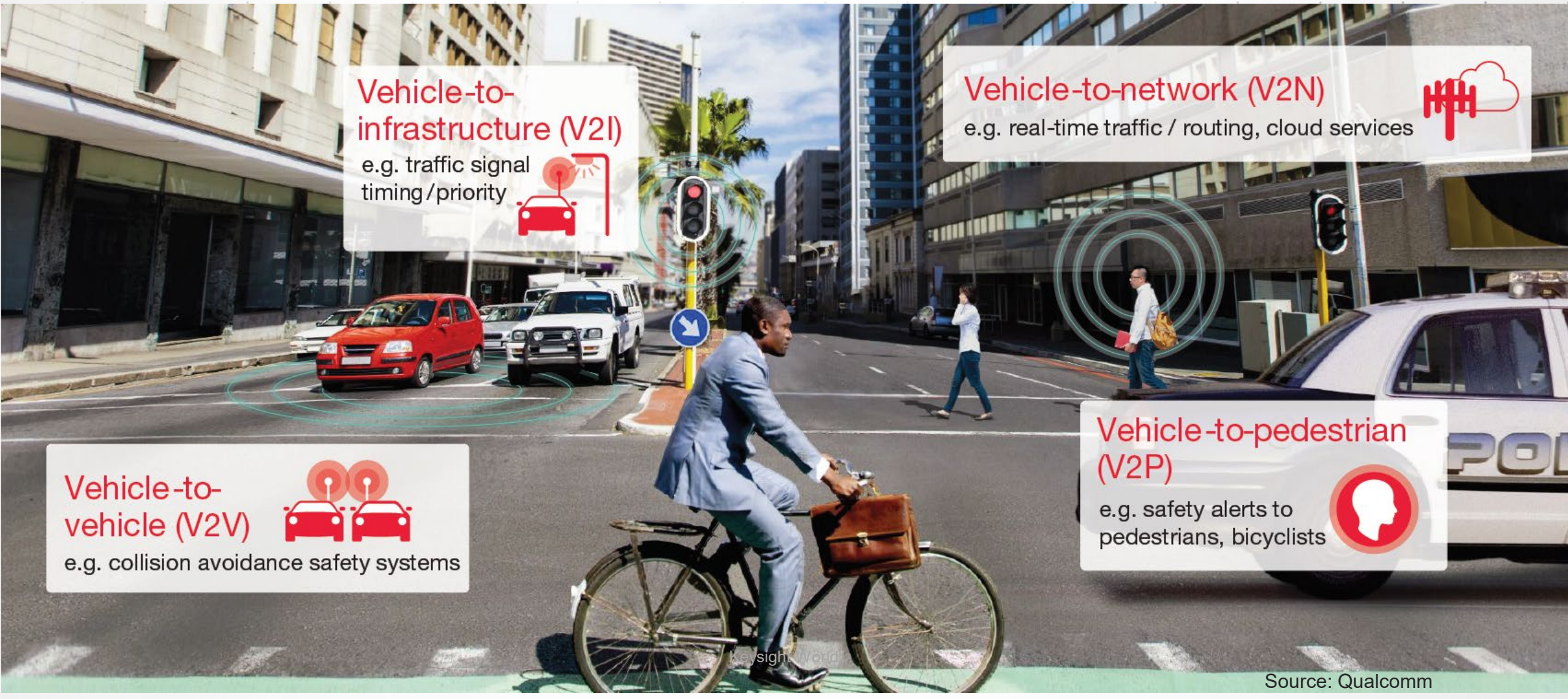
›SAFETY › NEW TECHNOLOGY › COST ›

Role Of V2X Communications For Autonomous Driving

What Vehicle to Everything (V2X) Communications Is Not

Vehicle to Everything (V2X) Communications

ENHANCED SAFETY, ENABLING HIGHER LEVELS OF AUTOMATION

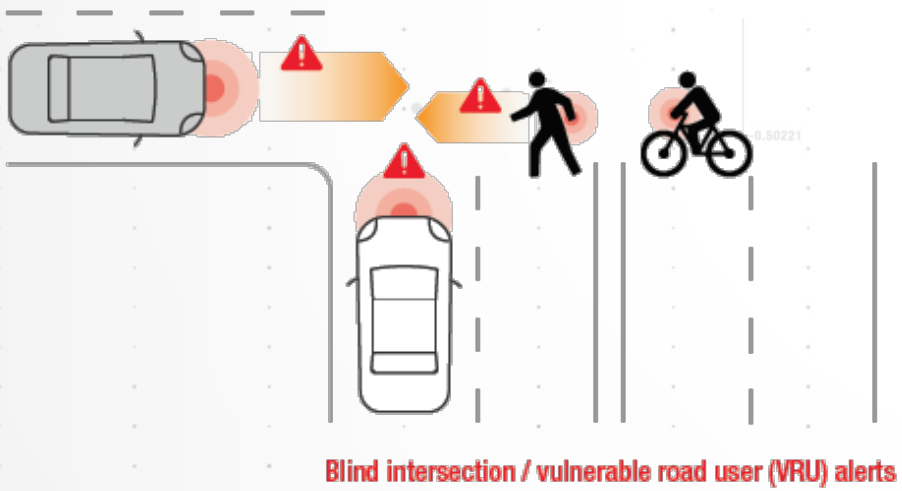


Source: Qualcomm

Critical Capabilities Enabled By V2X

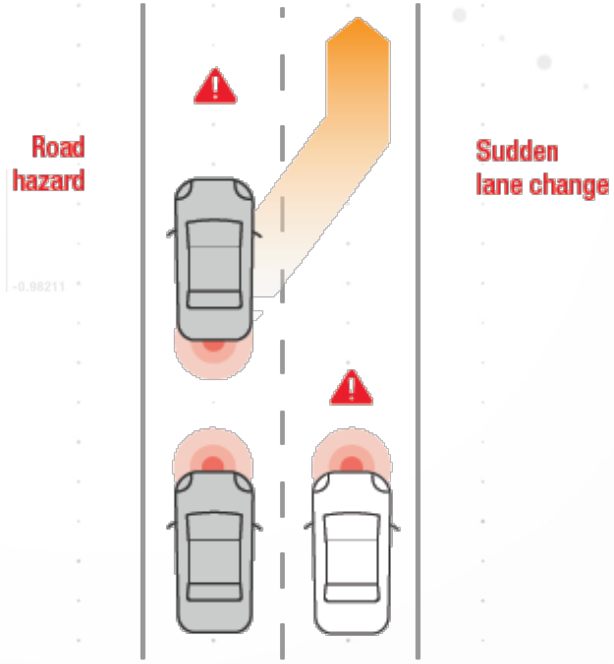
Non Line-of-sight Sensing

Provides 360 NLOS awareness, works at night and in bad weather conditions



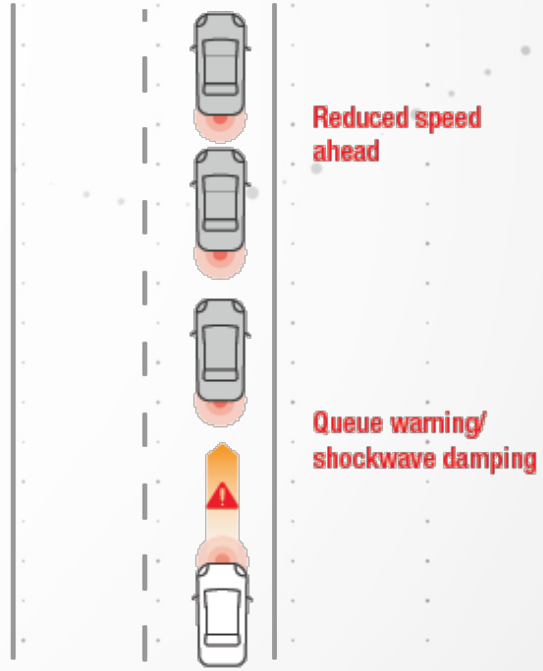
Conveying Intent

Shares intent, sensor data, and path planning info for higher level of predictability



Situational Awareness

Offers increased electronic Horizon to support soft safety Alerts and graduated warning



Battle Of The V2X Standards
DSRC vs. Cellular

Competing Technologies: WiFi DSRC vs. Cellular C-V2X

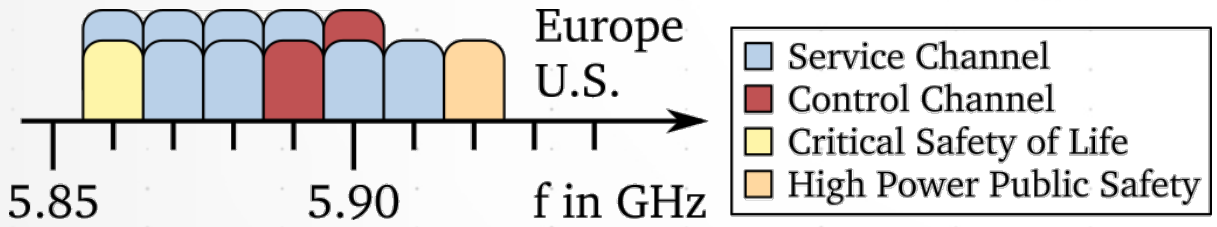
Radio Design	DSRC 802.11p	C-V2X Release 14/15
Synchronization	• Asynchronous	• Synchronous
Channel size	• 10/20 MHz	• Rel. 14: 10/20 MHz • Rel. 15: 10/20 MHz/Nx20 MHz)
Resource multiplexing across vehicles	• Time division multiplexing (TDM) only	• TDM & frequency-division multiple (FDM) access
Data channel coding	• Convolutional	• Turbo
Hybrid automatic repeat request (HARQ) Retransmission	• No	• Rel. 14/15: Yes • Rel. 15: Ultra-reliable communication possible
Waveform	• Orthogonal frequency-division multiplexing (OFDM)	• Single-carrier FDM (SC-FDM)
Resource selection	• Carrier-sense multiple access with collision avoidance (CSMA-CA)	• Semi-persistent transmission with frequency domain
MIMO support	• No support standardized	• Rx diversity for 2 antennas mandatory • Tx diversity for 2 antennas supported
Deployment	• Since 2017. OEM rollout in 2019	• 2020/2021
Roadmap	• 802.11NGV: Targets interoperability with 802.11p	• C-V2X Rel. 16 based on 5G New Radio • Rel. 16 will operate in different channel from • Rel. 14/15

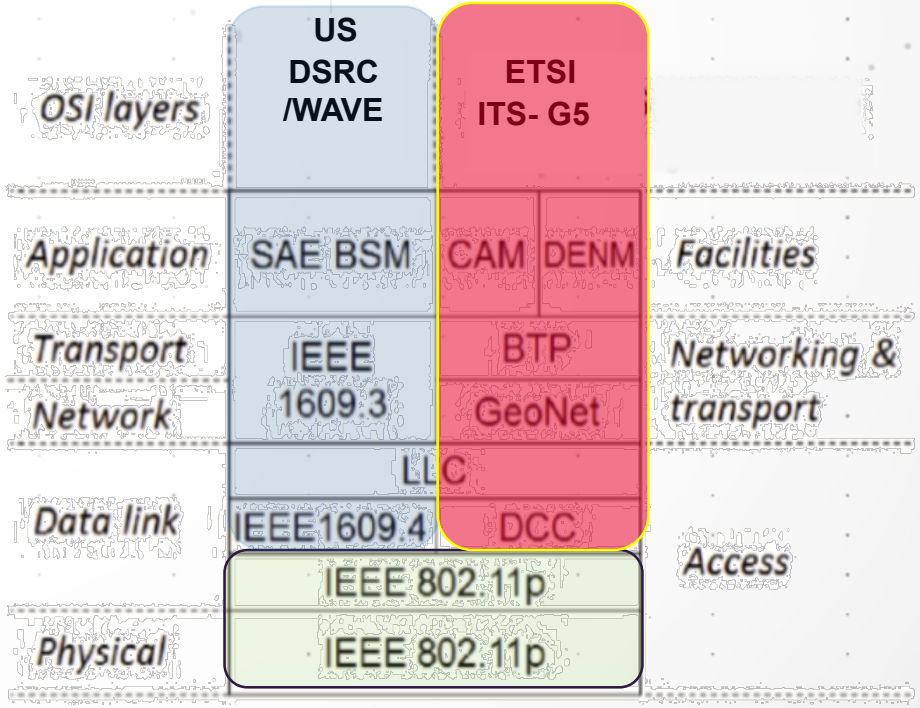
Source: Autotalk/5GAA/Qualcomm

What Is Dedicated Short Range Communication (DSRC)

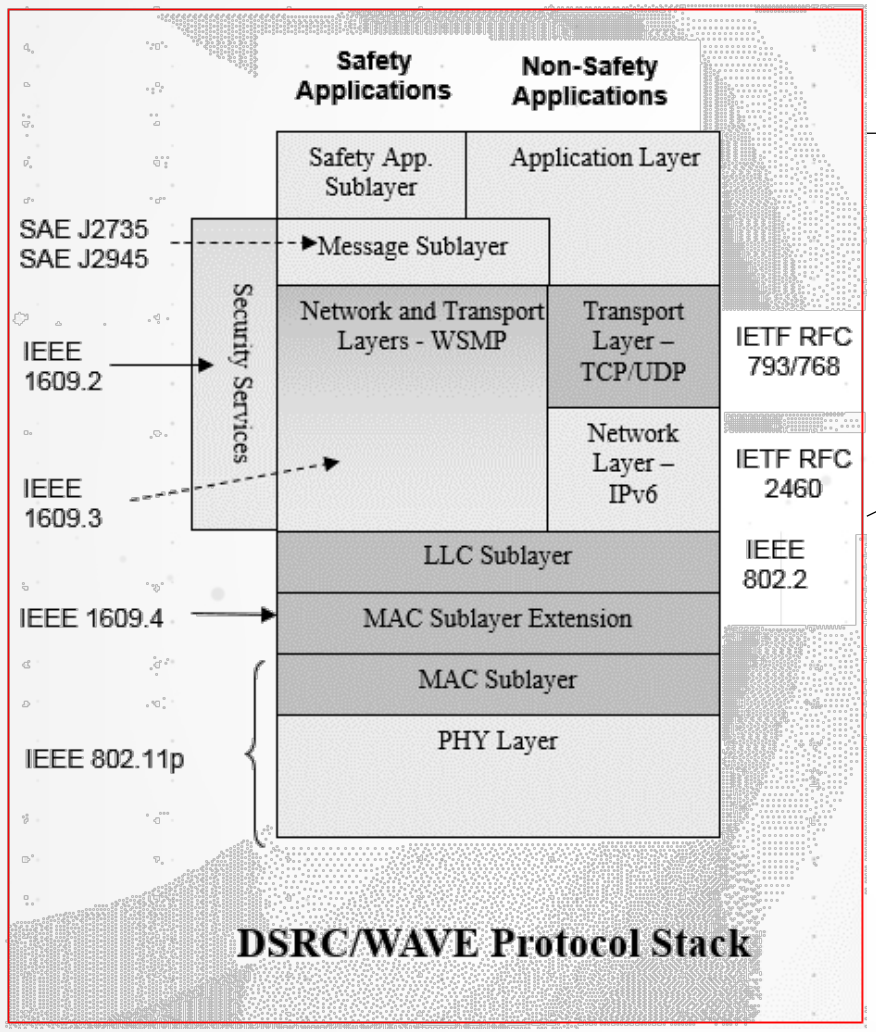
IEEE 802.11P

- DSRC is an approved amendment to 802.11 for wireless access in vehicular environments (WAVE)
- ITS-G5 is the term used in Europe
- V2X communications such as vehicles and infrastructure (V2I) or vehicle to vehicle (V2V)
  - Vehicle safety services
  - Commerce transactions via cars
  - Toll collection
  - Traffic management

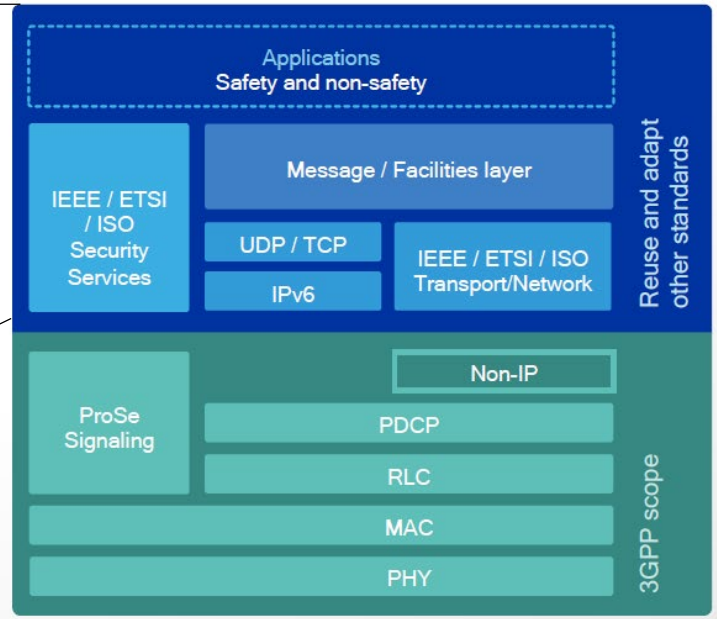




Shared ITS Stack Upper Layers For DSRC And C-V2X



C-V2X reuses upper layers defined by automotive industry



Reuse established service and app layers

- Already defined by automotive and standards communities, e.g. ETSI, SAE
- Developing abstraction layer to interface with 3GPP lower layers (in conjunction with 5GAA)

Reuse existing security and transport layers

- Defined by ISO, ETSI, and IEEE 1609 family

Continuous enhancements to the radio/lower layers

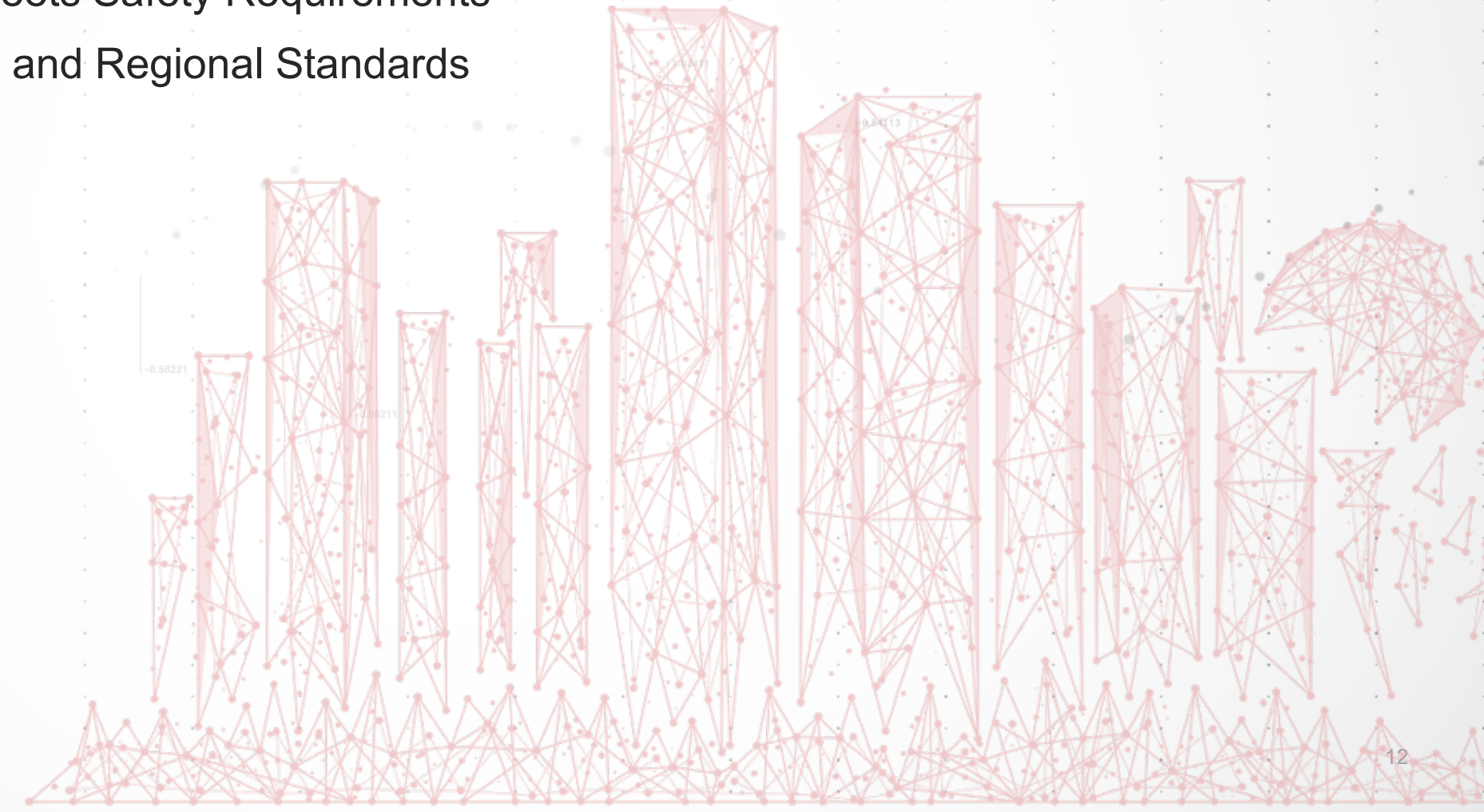
- Supports the ever-evolving V2X use cases

USIM-less operation

C-V2X direct communications doesn't require USIM

DSRC 802.11p Challenges To Overcome

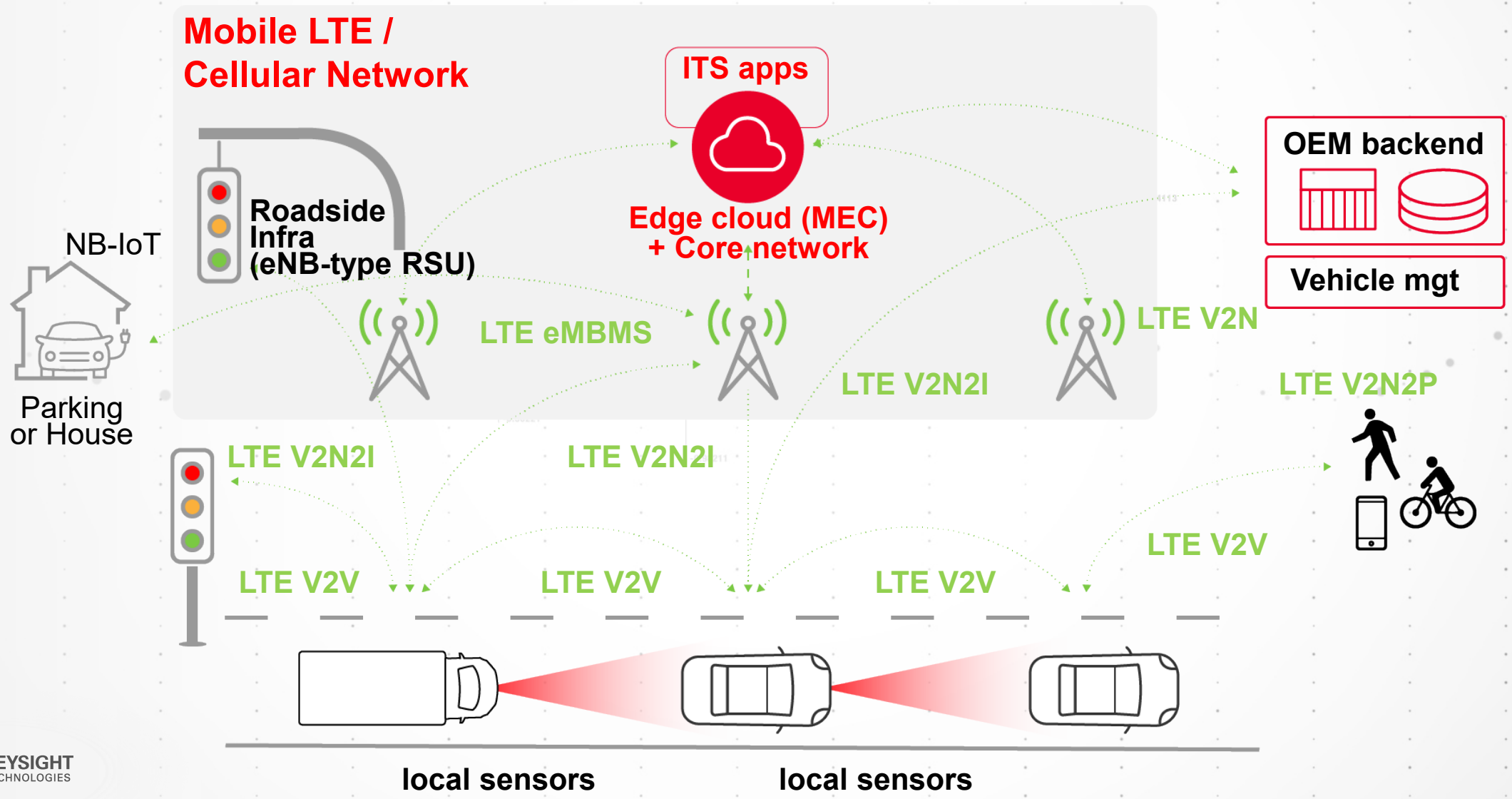
- Ensure Performance Meets Safety Requirements
- Conformance to Global and Regional Standards
- Interference Mitigation
- Interoperability
- Security



Cellular V2X (C-V2X)

What Is Cellular Vehicle-To-Everything (C-V2X)

V2X USING CELLULAR TECHNOLOGIES WITH OR WITHOUT NETWORK SERVICE



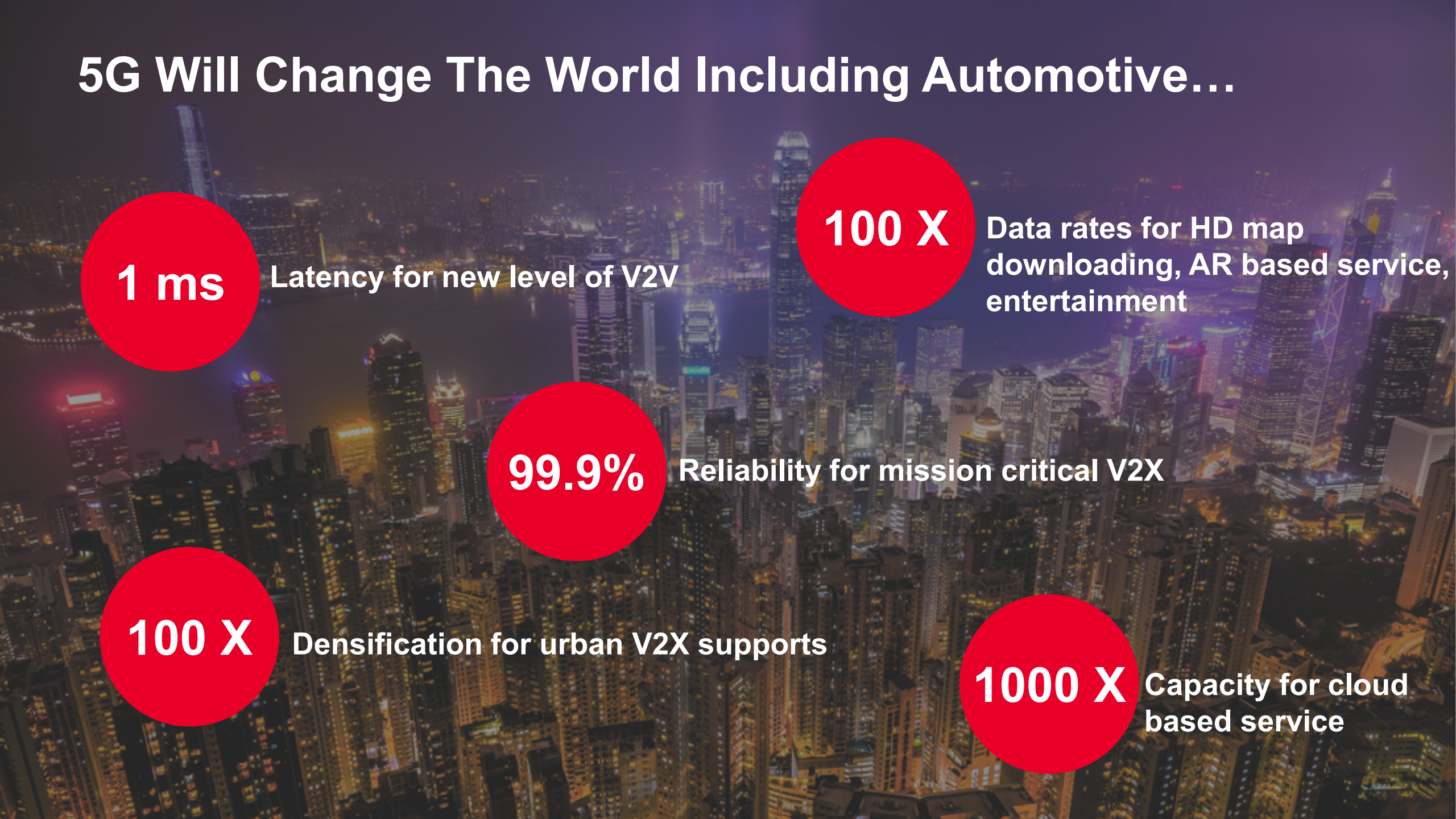
Advantages Of Cellular V2X Over WiFi-Based DSRC

LEVERAGING AN UBIQUITOUS STANDARD

- Evolution to 5G
- Better Security
- Improved Range
- Enhanced Reliability
- Vulnerable Road User (VRU) Use Cases
- Ecosystem of 100+ companies in the 5GAA

C-V2X Evolution To 5G

5G Will Change The World Including Automotive…



Are Car Makers Really Doing 5G?

YES INDEED!

- "**Ford** Will Equip All New U.S. Vehicles With 5G Technology Starting in 2022" – Fortune, Jan 2019 "…. all its new U.S. models starting in 2022 with cellular vehicle-to-everything technology…."
- "5G for car manufacturing: **Audi** and Ericsson announce partnership" – ZDNet, Aug 2018
  - "Ericsson will fit out Audi's production lab in Germany with 5G networking technology to test how it can be used in manufacturing vehicles."
- "What's Better Than 4G? 5G! And **Kia**'s Got It, at CES" – Car and Driver, Jan 2018
- "**Toyota** Unveils Autonomous Car Prototype "…at CES – The Street, Jan 2019
  - "Efforts to integrate new radio technologies such as 5G and cellular vehicle-to-everything (C-V2X) within cars will also get talked up."
- "CES 2019 preview: What to expect from the world's biggest technology show" – gearbrain, Jan 2019 "…5G networks helps make this a more seamless experience. **Harman** says its Digital Cockpit concept will "set the stage for an entire new chapter in automotive technology.""

5G Scenarios And Use Cases

NEW SERVICES AND CONNECTIVITY PARADIGMS

Courtesy of METIS: 2014

Amazingly Fast	Great Service In a Crowd	Best Experience Follows You	Real-Time & Reliable Communications	Ubiquitous Things Communicating

Mobile Broadband Access

- All data, all the time
- 2 billion people on social media

Massive Machine Communication

- 30 billion “things” connected
- Low cost, low energy

Mission-Critical Machine Communication

- Ultra high reliability
- Ultra-low latency

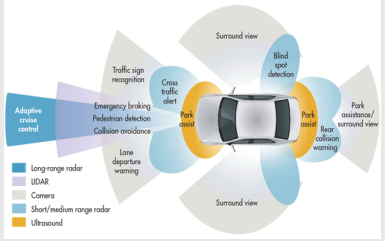
5G NR C-V2X And Use Cases

HIGH/FULL AUTOMATION(L4/L5) WILL NEED 5G NR C-V2X

Vehicle Platooning

- Cooperative driving for vehicle platooning
- Information sharing for platooning
- Reporting Needed for platooning

Extended Sensors



- Cooperative collision avoidance
- Information sharing for automated driving
- Emergency trajectory alignment
- Intersection safety information
- Video sharing

Advanced Driving

- Sensor information sharing
- Video sharing

Remote Driving

- Information exchange between UE V2X application and V2X application server

5G NR-V2X Release 16 (Advanced Safety)

- Leveraging vehicles as moving sensor platforms (Bandwidth)
- With 5G comes Enhanced Security
- How to test?
- 3GPP delayed to mid-2020
  - Adding b/w to SL
- Ready to support NR

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.

Source: 5GAA

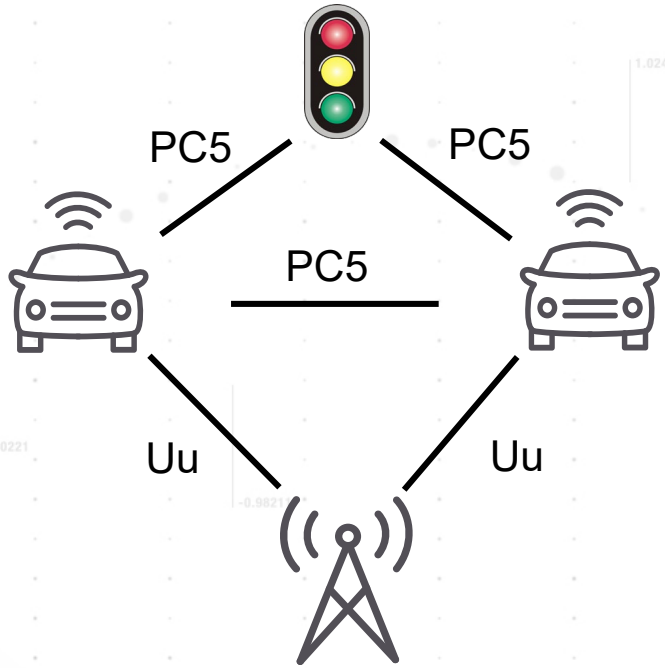
C-V2X Challenges To Overcome

Ensure Performance Meets Safety Requirement

Ensure products meet performance specs (ETSI, 3GPP, SAE)

Interference Mitigation

Interference will be a critical factor to overcome as the spectrum between 2-6 GHz is extremely crowded and since V2X is a safety oriented system this is even more important to be tested.



Conformance to Global and Regional Standards

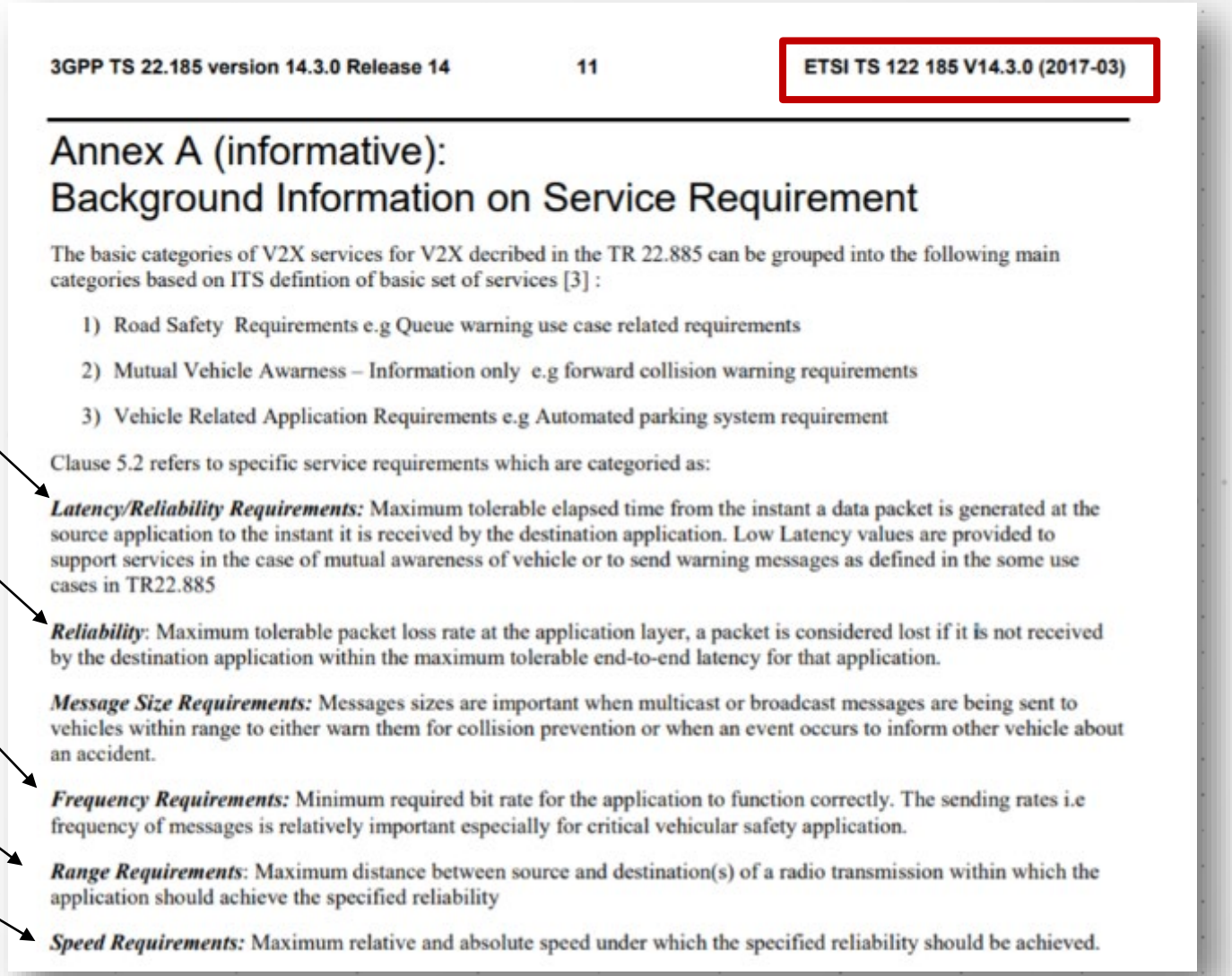
EU, North America, China and Japan all have different standards to adhere to. Conformance to these specs will be compulsory and therefore there is a need for test eqt and Test Labs to offer this service.

Interoperability

Multiple vendors developing V2X modules (C-V2X or DSRC) need to interoperate with each other and is a critical test that needs to be carried out.

Ensure Performance Meets Safety Requirements

- Latency
- Reliability
- Data Rate
- Range
- Speed



3GPP TS 22.185 version 14.3.0 Release 14 11 ETSI TS 122 185 V14.3.0 (2017-03)

Annex A (informative): Background Information on Service Requirement

The basic categories of V2X services for V2X decribed in the TR 22.885 can be grouped into the following main categories based on ITS defintion of basic set of services [3] :

1) Road Safety Requirements e.g Queue warning use case related requirements
2) Mutual Vehicle Awarness – Information only e.g forward collision warning requirements
3) Vehicle Related Application Requirements e.g Automated parking system requirement

Clause 5.2 refers to specific service requirements which are categoried as:

Latency/Reliability Requirements: Maximum tolerable elapsed time from the instant a data packet is generated at the source application to the instant it is received by the destination application. Low Latency values are provided to support services in the case of mutual awareness of vehicle or to send warning messages as defined in the some use cases in TR22.885

Reliability: Maximum tolerable packet loss rate at the application layer, a packet is considered lost if it is not received by the destination application within the maximum tolerable end-to-end latency for that application.

Message Size Requirements: Messages sizes are important when multicast or broadcast messages are being sent to vehicles within range to either warn them for collision prevention or when an event occurs to inform other vehicle about an accident.

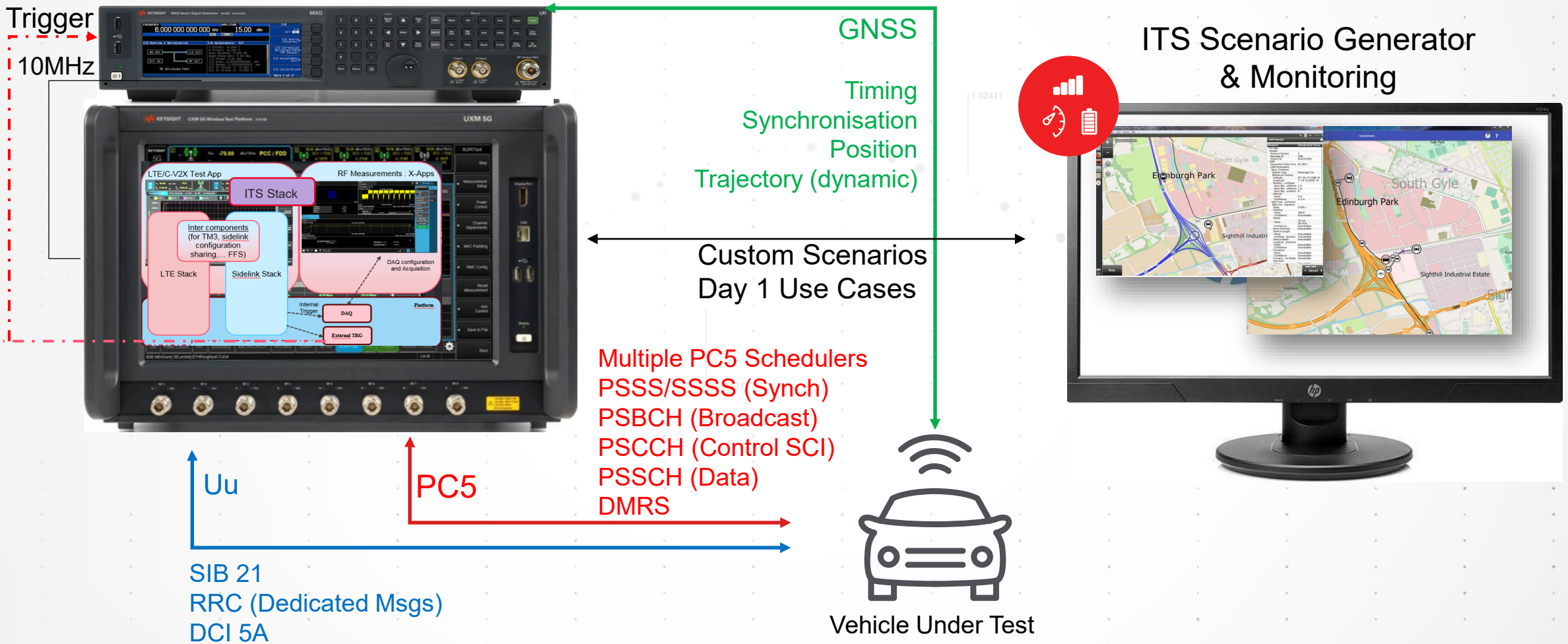
Frequency Requirements: Minimum required bit rate for the application to function correctly. The sending rates i.e frequency of messages is relatively important especially for critical vehicular safety application.

Range Requirements: Maximum distance between source and destination(s) of a radio transmission within which the application should achieve the specified reliability

Speed Requirements: Maximum relative and absolute speed under which the specified reliability should be achieved.

C-V2X Performance And Safety Requirements

C-V2X PROTOCOL, FUNCTIONAL, RF TEST AND ITS STACK



C-V2X Certification Process

TEST CASES BEING DEFINED AND CERTIFIED NOW

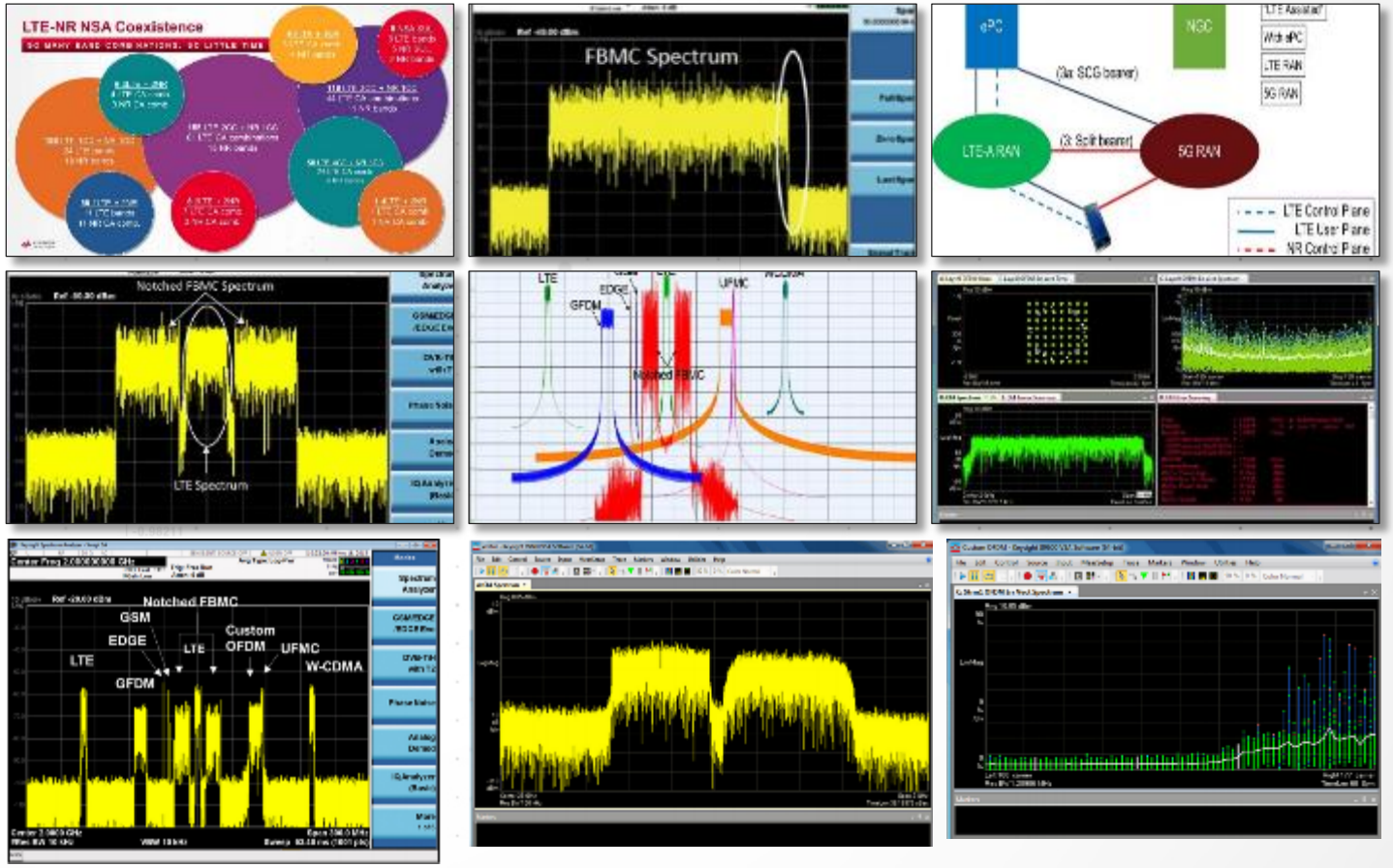
- **Industry Certification**
  - Global Certification Forum(GCF)
    - Global Modem 3GPP Certification
    - 3 main areas : RF(Tx/Rx), Protocol, RRM(Demod, Performance)
  - OmniAir
    - US-based certification for upper layer stack
    - Running DSRC device certification in US

- **Regulatory**
  - Europe : Radio Equipment Directive (RED)
    - Based on ETSI
    - Address Radio/EMC/Safety/Environmental
  - US: FCC
    - CFR47 Radio Requirement
    - CFR Part15B unintentional emissions
  - China: SRTC(Radio), NAL(Network Requirement), CCC(EMC/Safety)

Interference Mitigation – 5.9GHz Coexistence

CHALLENGES OF COEXISTENCE

- DSRC/ITS-G5 Co-Existence
- U-NII-3 Unlicensed WiFi Bands
- 5G NR coexistence with 2G, 3G, 4G spectrum
- Wider bandwidths of 5G
- Time alignment of LTE and NR



Images from: Keysight Technologies Exploring 5G Coexistence Scenarios Using a Flexible Hardware/Software Testbed White Paper, 5992-1917EN, 3GPP RP-161266 (Deutche Telekom AG)

5GAA C-V2X Plugfest April 2019

HOSTED BY DEKRA

5GAA Automotive Association

About 5GAA | Membership | 5GAA In Motion | The Technology | Calendar

15/04/2019

5GAA C-V2X testing event in Europe successfully demonstrates exceptional level of interoperability

Keysight & 5G Automotive Association (5GAA)

CONNECTING 5G INNOVATIONS WITH LATEST AUTOMOTIVE APPLICATIONS

Accelerating Deployments Of V2X Evolution

DEVELOP WITH CONFIDENCE AS V2X EVOLVES

CHALLENGE
Ensure Performance Meets Safety Requirement

Holistic approach to testing RF, protocol & application

Achieve quality, performance & safety goals

CHALLENGE
Multiple wireless application integrated in telematics module

R&D RF Physical layer measurement

Reduce the time you spend on multiple signal creation and analysis

CHALLENGE
Interoperability test become more complex

5GAA/OmniAir Contributing Member & Plugfest Participant

5GAA Automotive Association

OMNIAIR CONSORTIUM

Test with Confidence and Leverage Ecosystem for Standards

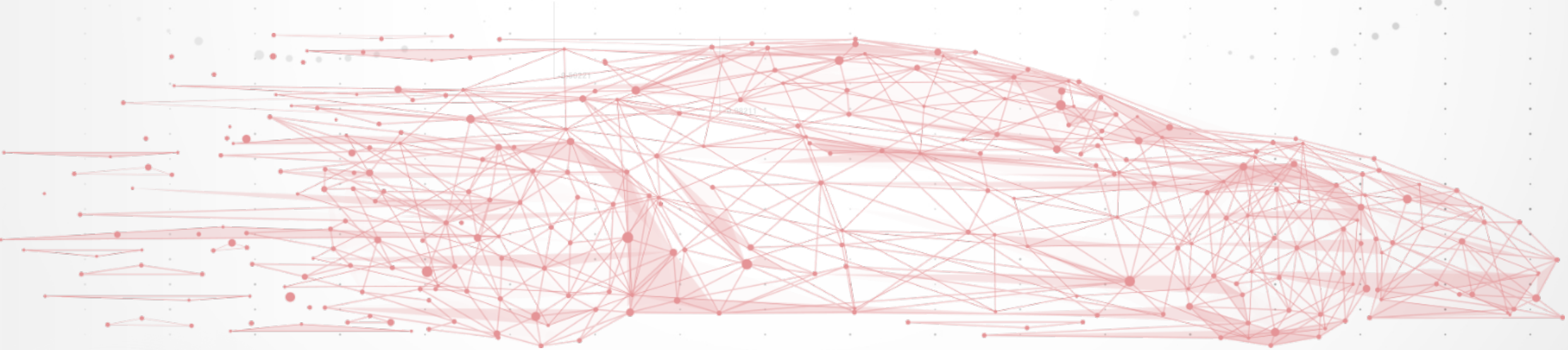
CHALLENGE
Conformance to Global and Regional Standards

OmniAir DSRC Certification

Single platform to be expanded for future V2X test needs

Vehicle to Everything (V2X) Communications Summary

- The next generation of cars will communicate with others and the road.
- Continuous V2X technology evolution leads to more complexity.
- Develop V2X with confidence as 5G evolves.



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