



# LITEPOINT

A Teradyne Company

## V2X

Vehicle to Everything

August 2019



# Communication is no more just limited to life forms

## 5G unified connectivity

Intelligently connecting the car to cloud and surroundings



# Agenda

- ❑ What is V2X ?
- ❑ Wireless Technologies in V2X – DSRC, C-V2X
- ❑ Autonomous vehicle ecosystem and Key players
- ❑ Market adoption
- ❑ 3GPP Evolution to C-V2X
- ❑ Testing challenges
- ❑ LitePoint solution offerings

What is V2X ?

## Vehicle to Everything Communication

Facilitates road safety, traffic flow optimization, & autonomous driving, by enabling vehicles to directly communicate with each other and with the infrastructure around

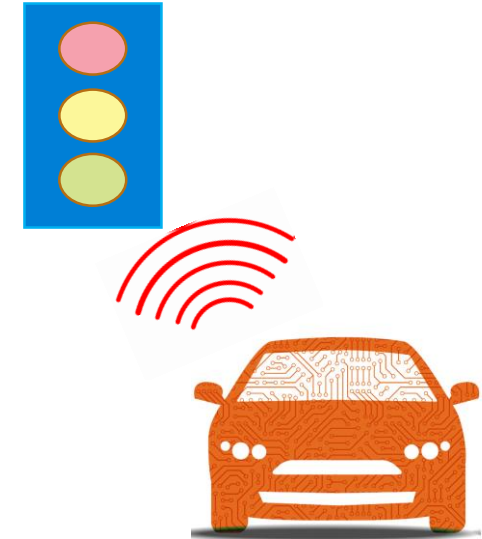
# Three Different Profiles of V2X Direct Communication



Vehicle to Vehicle  
(V2V)



Vehicle to Pedestrian  
(V2P)



Vehicle to Infrastructure  
(V2I)

# Wireless Technologies in V2X

# Two Competing Standards

## ❑ **DSRC** (Dedicated Short Range Communication)

- ❑ Defined by IEEE
- ❑ Supports direct communication (**V2V, V2I, V2P**)
- ❑ Operates in **5.9 GHz ITS band**, uses **802.11p** at PHY layer
- ❑ Key features - speed detection, collision avoidance, real-time road condition, toll payments, autonomous driving vehicle



## ❑ **C-V2X** (Cellular V2X)

- ❑ Defined by 3GPP
- ❑ Builds on the capabilities of DSRC. Additionally capable of using **optimized cellular technology**
- ❑ Supports direct communication (**V2V, V2I, V2P**) + enables **network assisted communication (V2N)**
- ❑ Dedicated radio in the **5.9 GHz band\***, additional cellular radio (**LTE, 5G NR sub 6Ghz and mmWave**)
- ❑ Support for advanced features – autonomous/ coordinated driving, situational awareness, precise positioning and path planning

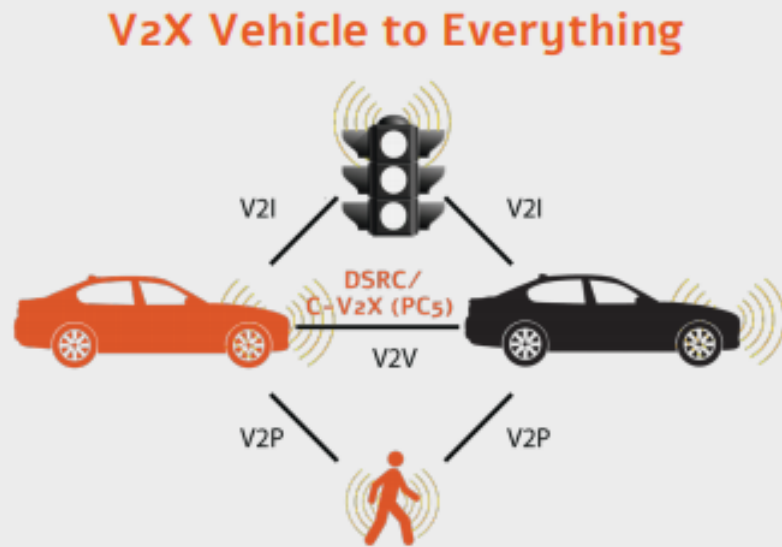


*\*E-UTRA Bands of operation: **46D** (5150 – 5925 MHz); **47** (5855 - 5925 MHz)*



# Modes of Communication

## Direct Communication/ (PC5/Sidelink)



**Direct Communications**  
DSRC/C-V2X (PC5) for V2X  
Operates in the ITS Band (5.9 GHz)

## Network Communication (Uu Interface)



**Network Communications**  
LTE/5G for V2N Operates in  
Licensed Cellular Spectrum

Source: AutoTalks

# Technology Comparison & Similarities

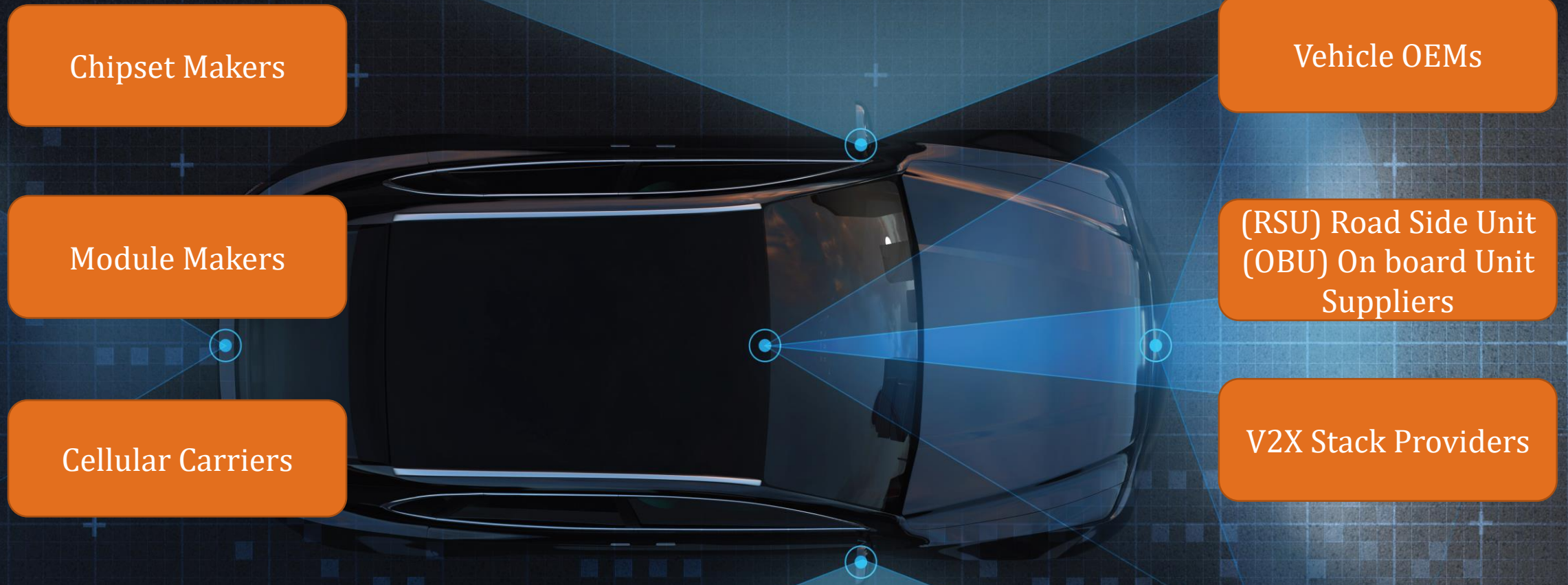
| Radio Design                  | DSRC  | C-V2X (Cellular + Sidelink)   |
|-------------------------------|---|---|
| Standard                      | IEEE  | 3GPP  |
| Radio Technology              | 802.11p   | Optimized Cellular technology (Rel-14/15/16)                                      |
| Frequency Band                | Dedicated radio in 5.9GHz                           | Dedicated radio 5.9GHz.<br>With optional support for cellular radio               |
| Channel Size                  | 10/20MHz  | Rel 14/15 - 10/20MHz<br>Rel 16 - 10/20/40/60/80/100/...MHz                        |
| Waveform<br>Transmission Mode | OFDM<br>TDM   | SC-FDM<br>TDM & FDM (Longer transmission time provides better quality of service) |
| Resource Selection            | Carrier Sense Multiple Access – Collision Avoidance | Semi-persistent scheduling based on relative energy; eNB based scheduling         |
| Latency                       | <10 msec  | <10 msec  |
| Modulation Support            | Up to 64QAM   | Up to 64QAM direct comm<br>Up to 256QAM with cellular support                     |
| Transmission Range            | Up to ~250m   | ~250m using direct communication<br>Large via cellular network infrastructure     |

# Technology Comparison & Similarities

| General               | DSRC  | C-V2X (Cellular + Sidelink)   |
|-----------------------|---|---|
| Communication         | Supports only direct communication (V2V, V2P, V2I)  | Includes both direct and network communication (V2V, V2P, V2I and V2N)  |
| Target Use Case       | Mainly for safety   | Safety, precise positioning, autonomous driving   |
| Performance           | Packet loss at high density   | Promise for almost no packet loss at higher densities   |
| High Mobility Support | Up to relative speeds of 500km/hr   | For relative speeds much > 500km/hr   |
| Advantages            | Mature technology<br>Reliable, road-tested  | Leverages LTE infrastructure<br>3GPP viewed as high reliability   |
| Limitations           | Short range comm.<br>Limited scalability<br>Vehicular speed limitations<br>No cloud/local area update | Long range communication<br>Scalable (better spectral efficiency)<br>For speeds >500Km/hr<br>Capable of real time updates |

# V2X Ecosystem and Market Adoption

# Ecosystem



# Key Players

## Chipset Makers

### C-V2X

- ❑ Qualcomm - 9150
- ❑ Huawei - Balong5000

### DSRC

- ❑ NXP - RoadLINK® SAF5400
- ❑ Marvell - 88W8987xA

### Hybrid

- ❑ Auto Talks - AEC-Q100 grade 2



## Module Makers

### C-V2X

- ❑ Quectel
- ❑ WNC
- ❑ ZTE
- ❑ SIMCOM

### DSRC

- ❑ LG Innotek

### IOT

- ❑ Telit



## Road Side Unit and On Board Unit Providers

### C-V2X

- ❑ Commsignia (OB4, RS4)
- ❑ Kapsch (RIS 9260 road side unit)
- ❑ Genevict (OBU)
- ❑ Neusoft (OBU, RSU)

### DSRC

- ❑ Fiasco FITAX (DSRC based OBU)

### Hybrid

- ❑ Savari (MobiWAVE2000 OBU)  
(StreetWAVE2000 RSU)



# Market Adoption

Market Adoption for C-V2X and DSRC is a fine mesh.

- ❑ **France** : Orange with Ford and PSA group conducted C-V2X trials
- ❑ **Germany** : Ericsson, Qualcomm with Audi and Ducati conducted C-V2X trials
- ❑ **China** : Huawei has conducted trials with China Mobile, Audi, Toyota
- ❑ **Japan** : Continental, Ericsson, Nissan, NTT DOCOMO, OKI, Qualcomm conducted C-V2X trials
- ❑ **USA** :
  - ❑ **Ford and Geely partnering with Qualcomm and Huawei, to integrate C-V2X in their vehicles by 2021 and 2022**
  - ❑ BMW, Daimler, Groupe PSA, SAIC, Audi, and JLR (Jaguar Land Rover) favoring C-V2X
  - ❑ Toyota and General Motors leaning towards DSRC in North America

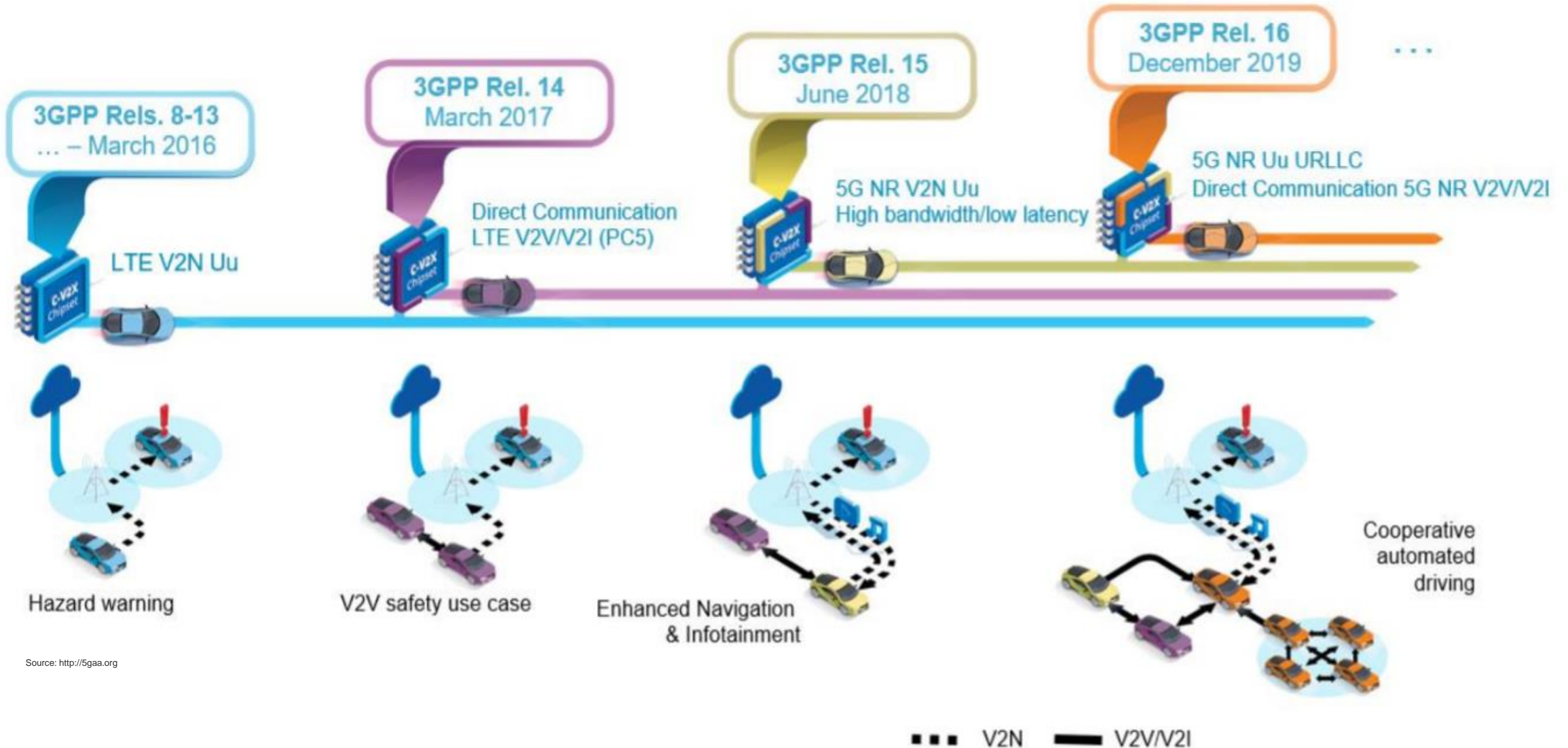
Some automakers are trying to adopt a flexible approach and deploying technologies based on the region.

- ❑ e.g.: GM has its Cadillac equipped with DSRC in N.America and plans to deploy C-V2X in its vehicles across China.

# 3GPP Evolution to C-V2X



# C-V2X Evolution with 3GPP Release



Source: <http://5gaa.org>

# Newer Capabilities with Sidelink

## NR Design

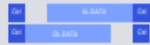
## 5G NR C-V2X capabilities for autonomous driving

Scalable OFDM-based air interface



5G C-V2X is expected to efficiently address diverse spectrum bands for different use cases. Leveraging wideband carrier support and OFDMA to deliver **higher data rates**

Self-contained slot structure



Smaller slot structure with immediate feedback to enable **ultra reliable low latency communications**

Advanced channel coding



State of the art LDPC/polar coding to deliver **higher reliability** with low complexity

Wideband carrier support



Wideband carrier based **higher data rates and system capacity**

Larger number of antenna



Efficiently utilize larger number of antennas than Rel-14 to deliver **higher data rate** and long range

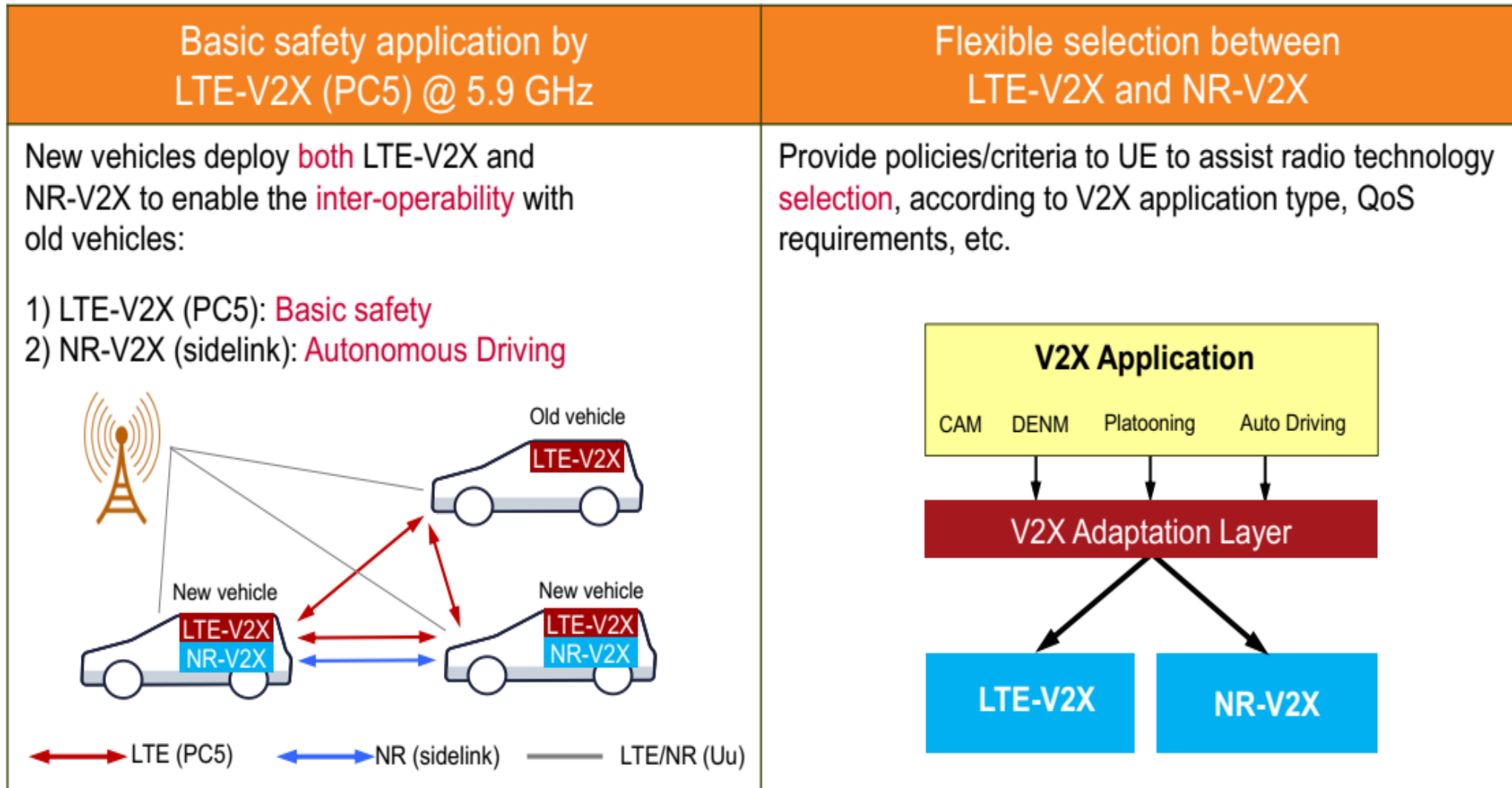
**Wideband  
Carrier Support**

**High  
Throughput**

**Low  
Latency**

**Ultra High  
Reliability**

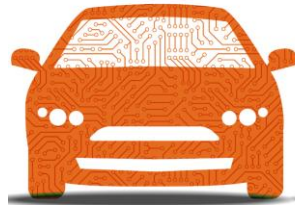
# LTE-V2X and NR-V2X



Source: 3gpp.org

# Cellular-V2X

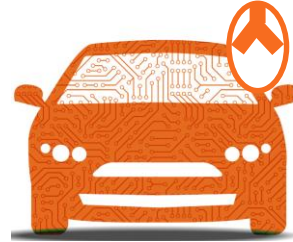
Manned Vehicle  
without C-V2X



Source: highwaysafety.utah

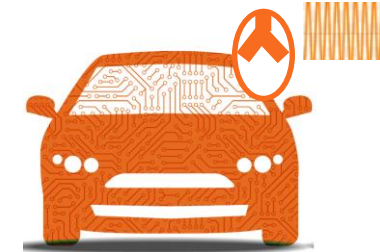
No blind Spot detection  
Chances of collision

Smart vehicle  
without C-V2X



Still less reliable  
higher latency & response time

Smart vehicle  
with 5G NR + C-V2X

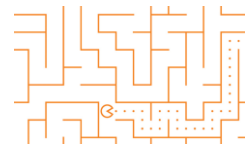


Highly reliable, safe & fast



Source: gopointu.com

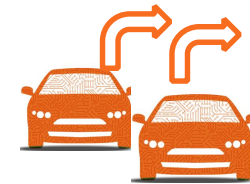
Sensor data sharing



Path Planning



Real time Updates



Coordinated Driving

**Wideband Carrier  
Support**

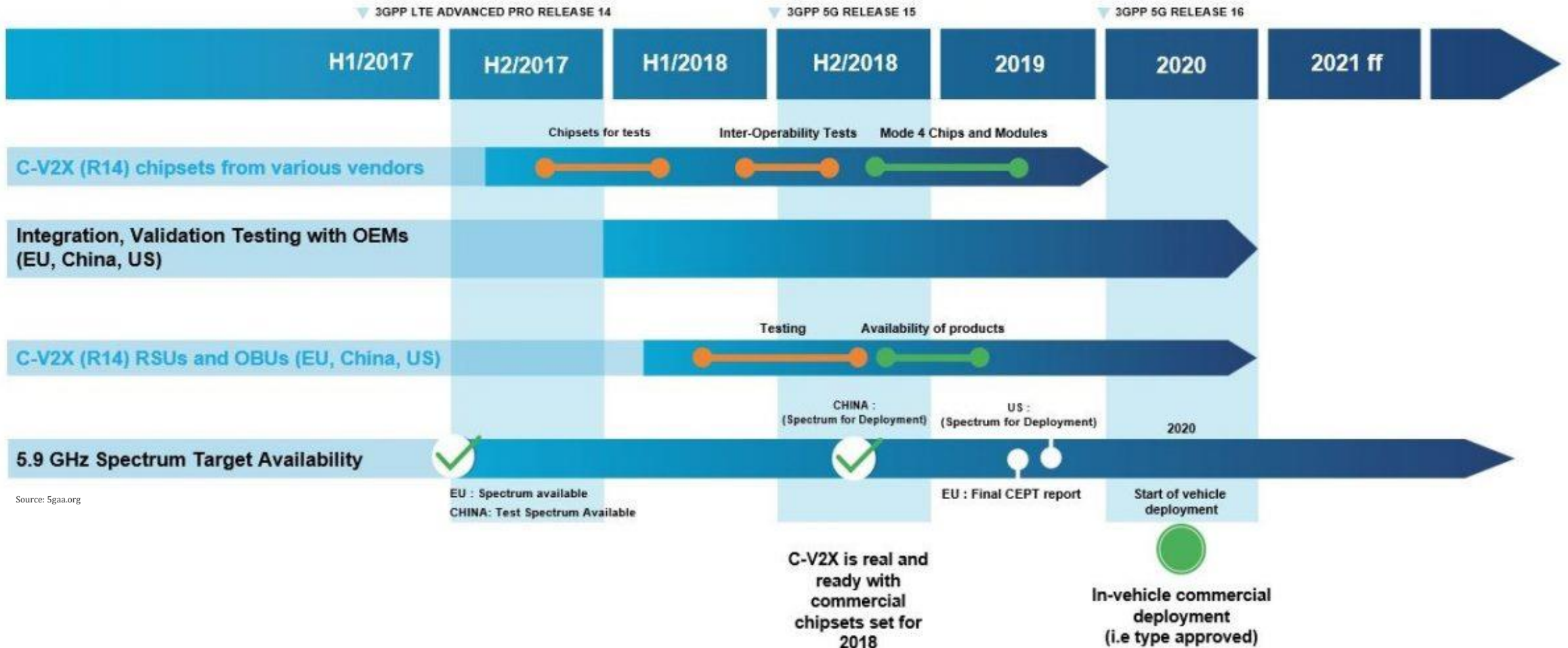
**High  
Throughput**

**Low  
Latency**

**Ultra High  
Reliability**

# Timeline for Deployment

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

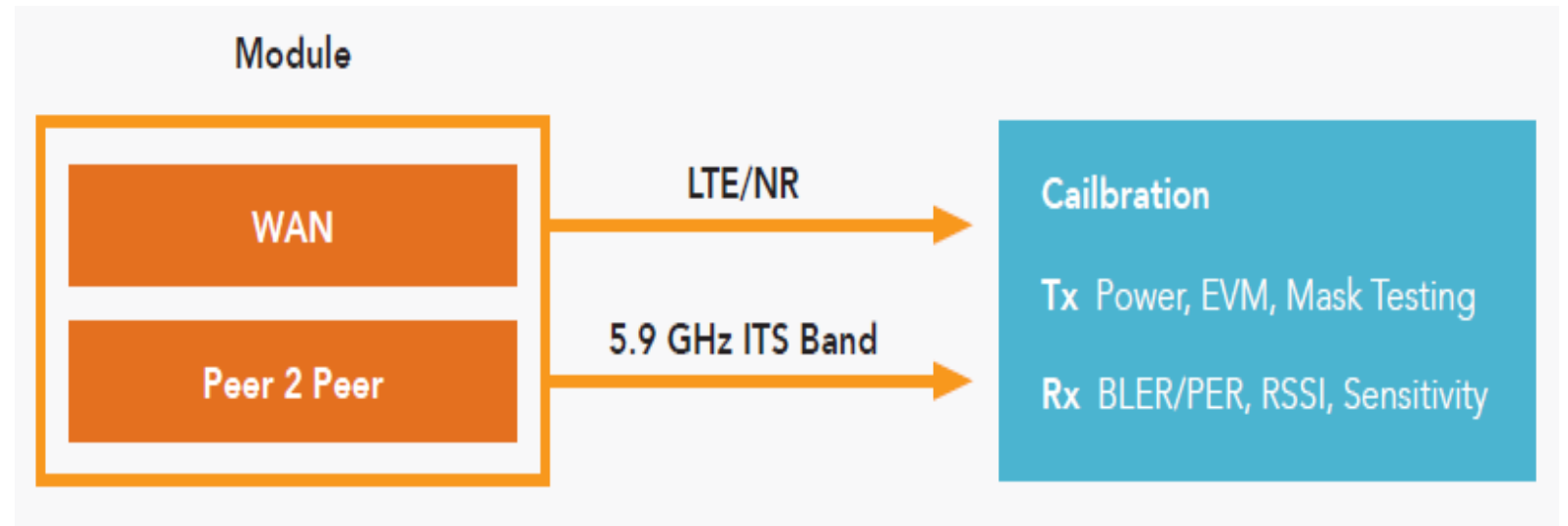


Source: 5gaa.org

Innovation Does Not Come Easy

# Physical Layer Test Challenges

- ❑ Scalability
- ❑ Rx Sensitivity (PER)
- ❑ Latency
- ❑ Calibration
- ❑ Small Error Tolerance
- ❑ Wide Area Network (range enhancement)



# LitePoints Solution

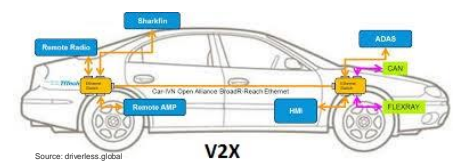
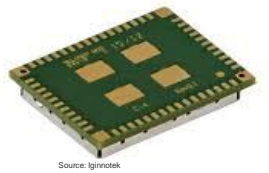
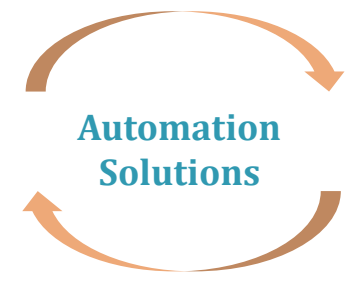
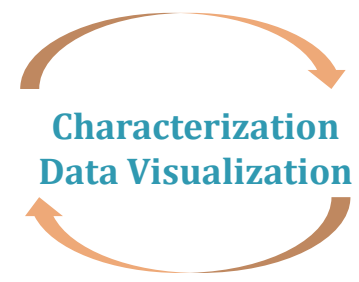
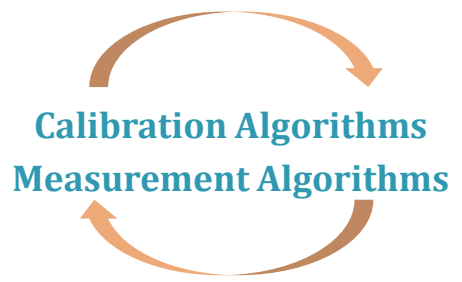
- ❑ Upgradable
- ❑ Cost Effective



Source: abroadship.org



# Our Portfolio Spans Over The Ecosystem



# C-V2X Waveform Analysis

Qxstream-M LED STATUS Technology Admin Tools File Session Active

LTE Advanced

VSA1 VSG1 CHAN1 Offset: 0 Count: 2 UL Frequency: 5890.000 MHz Reference Level: 30.0 dBm

Hardware Results Settings

List Tree View: Sync Remove

- CCDF
- ACLR
- Spectrum Flatness
- Spectrum Flatness Table
- Spectrum Flatness vs RB
- In-band Emissions
- Spectrum
- Spectrum Mask
- Tx Quality
- Constellation
- Power vs. time

Power vs. time

Power [dBm]

Time [us]

Scale: Auto Reset

Power Spectral Density

Power Spectral Density [dBm/RBW per 30 kHz]

Frequency [MHz]

OBW 6.0742 MHz

Scale: Auto Reset

Result 1 AVER MAX

LIMIT\_FAIL

Average Filtered Power CBW: 21.18 MBW: 21.17 dBm

| Name               | CC1      | CC2 | Unit |
|--------------------|----------|-----|------|
| Average Power      | 21.05    | --  | dBm  |
| IQ Offset          | -37.38   | --  | dB   |
| Frequency Error    | -1283.89 | --  | Hz   |
| Data EVM           | 3.70     | --  | %    |
| Peak Data EVM      | 19.44    | --  | %    |
| RS EVM             | 2.65     | --  | %    |
| Peak RS EVM        | 10.99    | --  | %    |
| IQ Imbalance Gain  | 0.00     | --  | dB   |
| IQ Imbalance Phase | 0.13     | --  | deg  |

EVM

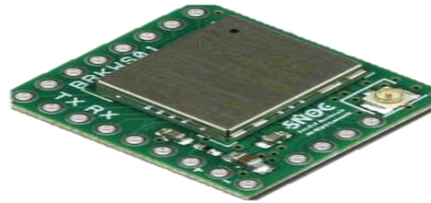
Tx Quality

Constellation

Modulation quality

Scale: Auto Reset

# Testing Made Much Simpler and Faster



Chipset or Module  
we test it all



Higher Throughput  
with multi DUT testing



Shorter time to market

LITEPOINT



Reduced Testing cost



Customer Support



# LITEPOINT

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