5G Automotive Association, **pioneering digital transformation** in the **automotive industry**

Learn more at WWW.5GAA.ORG

Igniting the Connected and Automated Mobility Revolution:

A Webinar Tailored for US Road Infrastructure Owner-Operators

5GAA
Automotive Association

Invitation for a discussion between 5GAA & US Road Infrastructure Owner-Operators on:

- ✓ **What is C-V2X**
- ✓ **C-V2X is a superior technology**
- ✓ **C-V2X is available today**
- ✓ **C-V2X is increasingly being deployed**

Agenda

Introduction
Dean Brenner Senior Vice President - Qualcomm & US Policy Task Force Vice-Chair – 5GAA

C-V2X Primer and Applications
John Roman, Director - Intel & Vice-Chair of Regulatory Affairs WG – 5GAA

Performance & Availability of C-V2X Today and 5G V2X Future
Jim Misener, Senior Director – Qualcomm & Board Member – 5GAA

Spectrum and Deployment
John Kwant, Global Director Ford, US Policy Task Force Chair – 5GAA

Q&A

About 5GAA

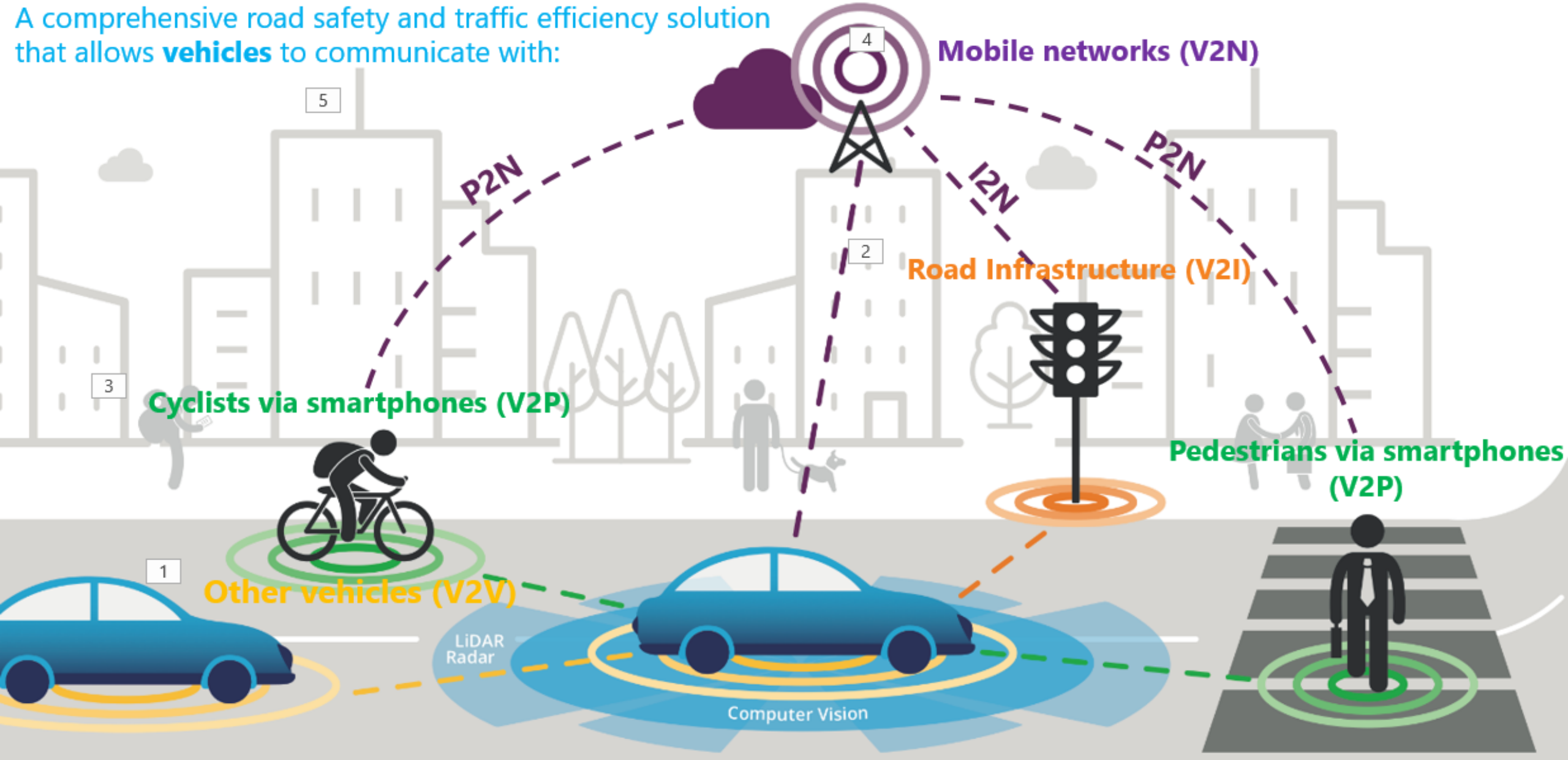
- The 5G Automotive Association (5GAA) is a global, cross-industry organization of companies from the automotive, technology, and telecommunications industries (ICT), working together to develop end-to-end solutions for future mobility and transportation services.
- 5GAA supports the idea that 5G will be the ultimate platform to enable C-ITS and the provision of V2X.
- Friends of 5GAA - 5GAA is a membership structure designed specifically for the road infrastructure operators, known as Infrastructure Owner Operator (IOO) in the US, and road authorities community.

5GAA Members*

*as of March 2020

What is C-V2X (Cellular-Vehicle to Everything)?

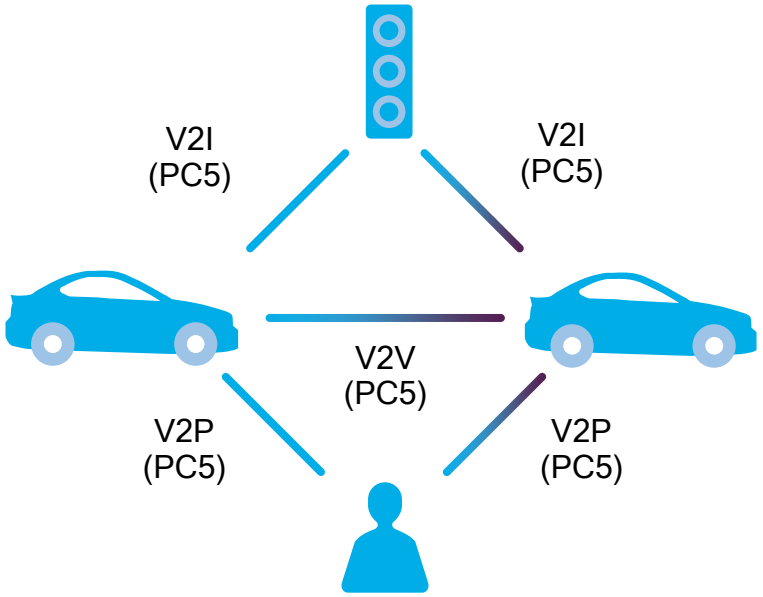
A comprehensive road safety and traffic efficiency solution that allows **vehicles** to communicate with:



C-V2X has two complementary communication modes

Direct (= Sidelink)

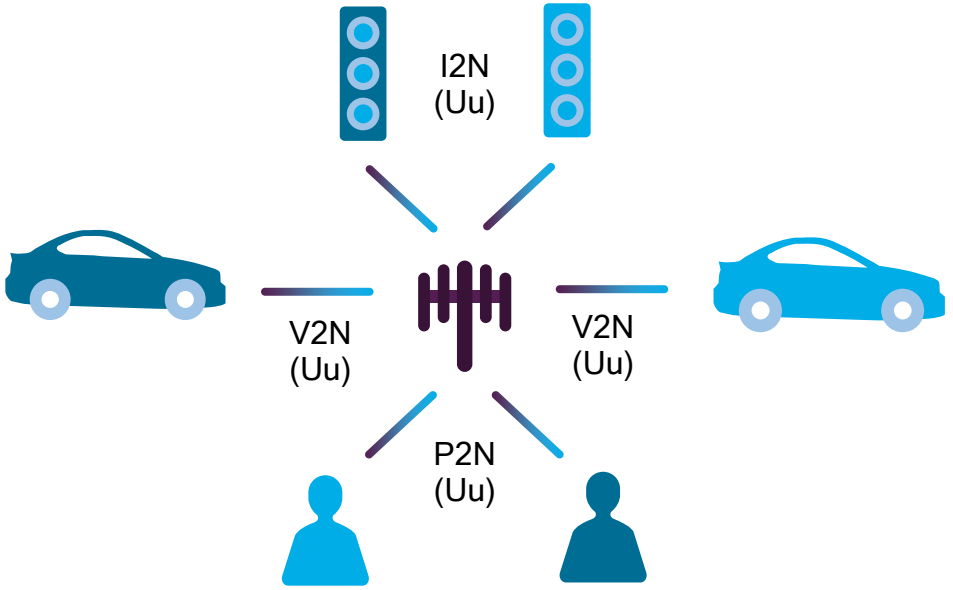
V2V, **V2I**, and **V2P** operating in ITS bands (e.g. ITS 5.9 GHz) independent of cellular network



Short range (<1/2 mile), location, speed
Implemented over 3GPP's "PC5 interface"

Network (= Up/Downlink)

V2N operates in traditional mobile broadband licensed spectrum



Long range (>1/2 mile), e.g. accident ahead
Implemented over "Uu interface"

Connected Vehicle Applications

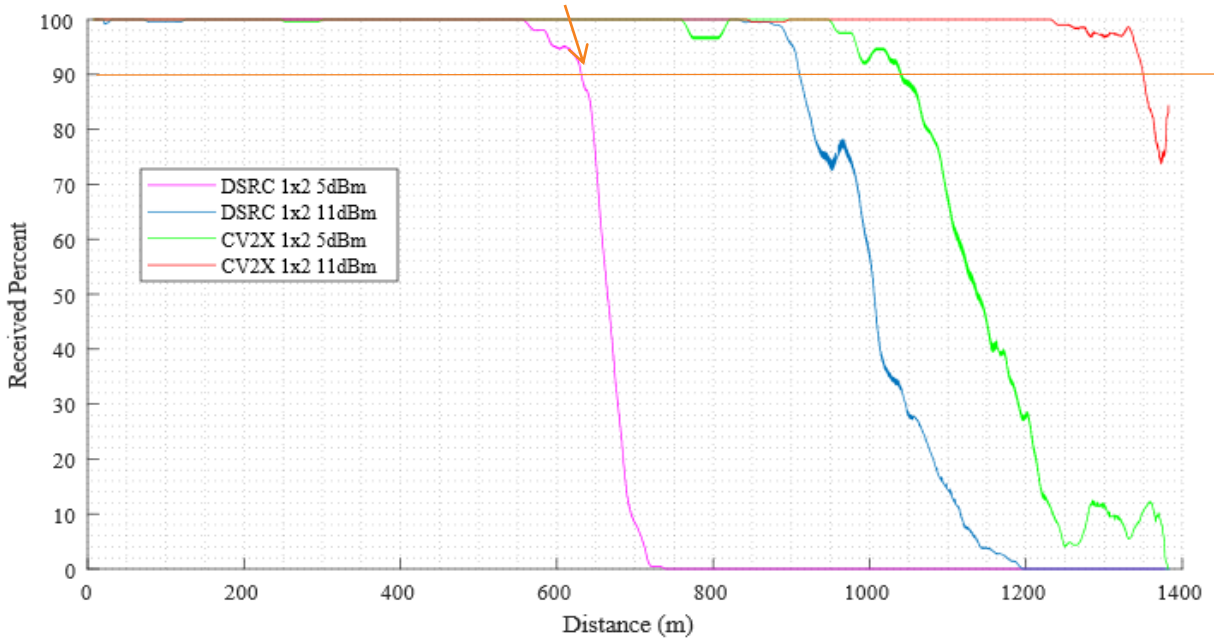
- SPaT/MAP display of signal timing – V2I
- Red-light running at traffic signals – V2I
- Bus/transit priority – V2I
- Intelligent school beacons – V2I
- Emergency vehicle preemption– V2I
- Where is the emergency vehicle coming from? – V2V
- Motorist – Cyclist communication - V2V
- Motorist – Pedestrian communication – V2V
- Work zone warnings – V2I
- Curve warning/reduce speed – V2I
- Rear end collision warning – V2V
- Virtual/advance traffic detectors – V2I
- School Bus Active ahead warning – V2V
- Railroad active ahead warning – V2I
- Dynamic Message Sign (DMS) Annunciation – V2I
- Wrong way vehicle warning – V2I
- Active Pedestrian in Crosswalk – V2I
- Congestion Ahead Warning– V2I
- Weather Warning - V2I
- Event Management Parking Information – V2I

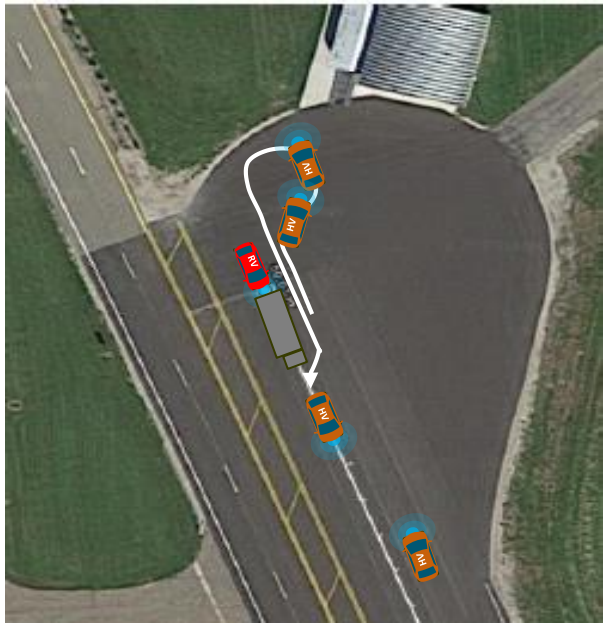
5GAA field test measurements comparing LTE V2X and DSRC

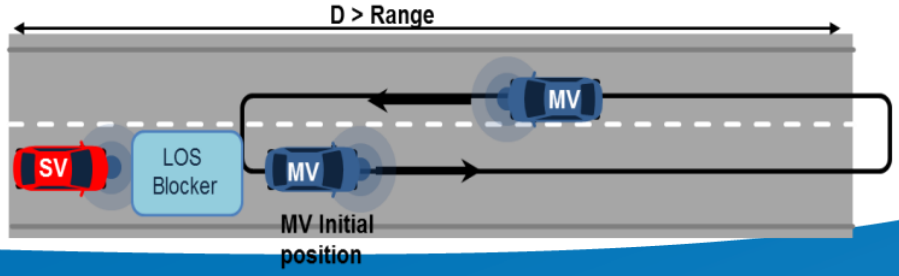
From: https://5gaa.org/wp-content/uploads/2018/11/5GAA_P-190033_V2X-Functional-and-Performance-Test-Report_final-1.pdf

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

2X the range @ 90% reception threshold



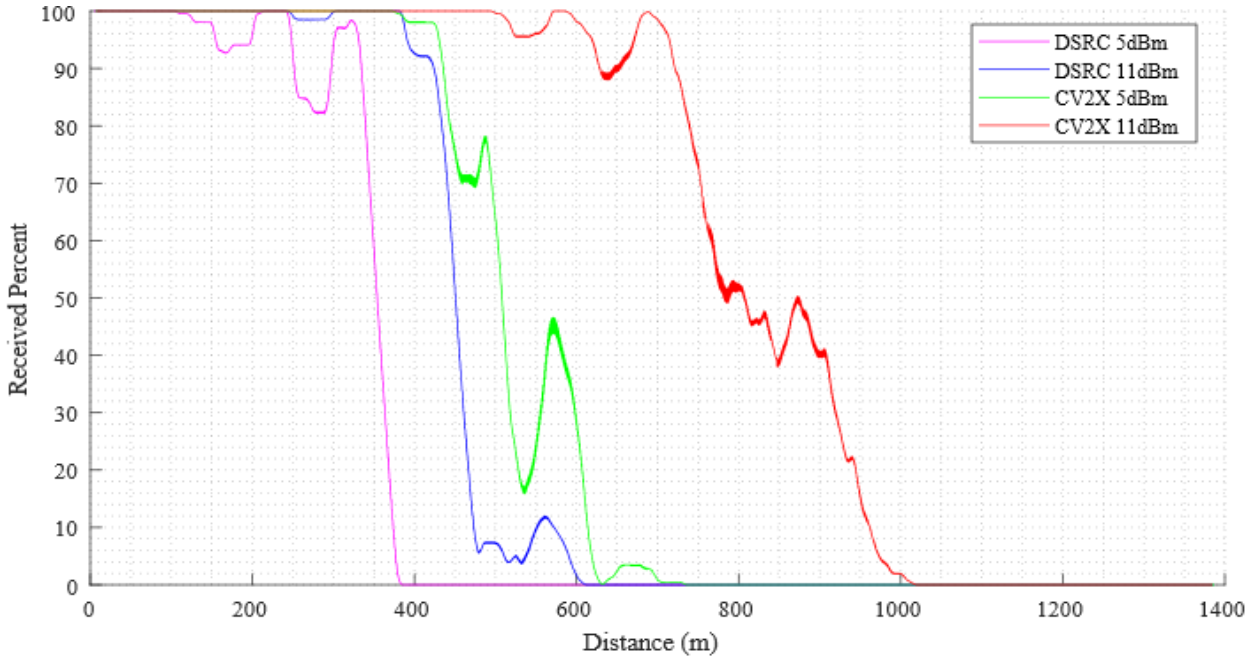


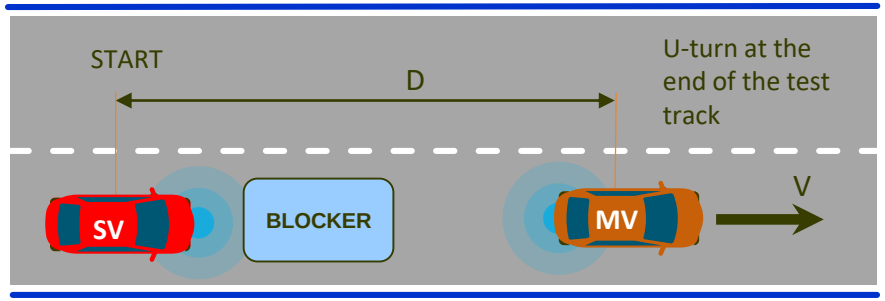


Shadowing Test RESULTS

From: https://5gaa.org/wp-content/uploads/2018/11/5GAA_P-190033_V2X-Functional-and-Performance-Test-Report_final-1.pdf

5GAA shadowing test, Approach





- CV2X outperforms 802.11p in shadowing scenarios.

Technology benchmark summary

Congestion	**Lab** Cabled Congestion Control	Pass
Reliability	**Lab** and **Field** Cabled Tx and Rx Tests, Line-of-Sight and non-Line-of-Sight Range Tests	CV2X better
Interference	**Lab** Cabled Test with Simulated Co-channel Interference	CV2X better
	Lab Cabled Near-Far Test	Pass
	Field Co-existence with Wi-Fi 80 MHz Bandwidth in UNII-3	CV2X better
	Field Co-existing of V2X with Adjacent DSRC Carrier	Pass

CAMP Cellular V2X Device-to-Device Communication Project:
https://pronto-core-cdn.prontomarketing.com/2/wp-content/uploads/sites/2896/2020/02/CAMP-CV2X_SAE_01152020_v2.pdf

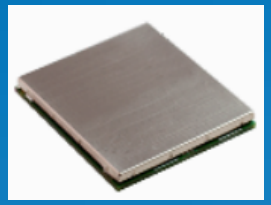
Addressed Lab Characterization, On-Road Performance and Scalability (260 equivalent cars)

C-V2X radio technology consistently outperforms DSRC.

	Commercially Available Products: Roadside Units (RSU) and OnBoard Units (OBU)
Applied Information	AI-500-065-02 C-V2X Aftermarket OBU AI-500-095 C-V2X Roadside Unit (RSU)
Cohda Wireless	C-V2X Kit
Commsignia	C-V2X Roadside Unit (RSU) C-V2X On Board Unit (OBU)
Danlaw	C-V2X Aftermarket OBU
Ficosa	Carcom – FITAX OBU
iSmartways Technology	MOCAR V-MASTER OBU MOCAR I-MASTER RSU
Kapsch	RIS 9260: C-V2X Roadside Unit (OBU)
Savari	StreetWAVE 2000 RSU

	Commercially Available Wireless Modules (component-level solutions)
LG Innotek	LAM-V500 : C-V2X Module
Quectel	AG15 : C-V2X Module
SIMCOM	SIM8100 : C-V2X Module
Telit	VE915C1 C-V2X Module
WNC	CV2X Module & PCIe MiniCard EVK – RR3 C-V2X Platform
ZTE	ZM8350 : C-V2X Module



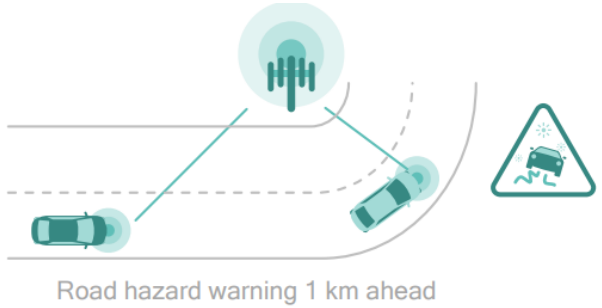


C-V2X evolution roadmap towards 5G

Since 2016

Traffic Efficiency
4G/LTE (network-only)

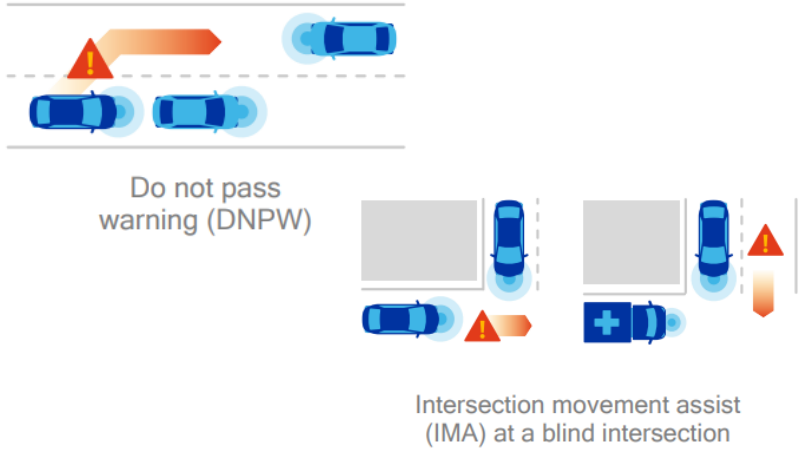
- Only using mobile networks (V2N)
- +20 million EU connected cars*
  - Local Hazard Warning
  - Traffic Info (in some markets)



As of 2020/2021

Basic & Enhanced Safety
LTE-V2X (+ direct short-range)

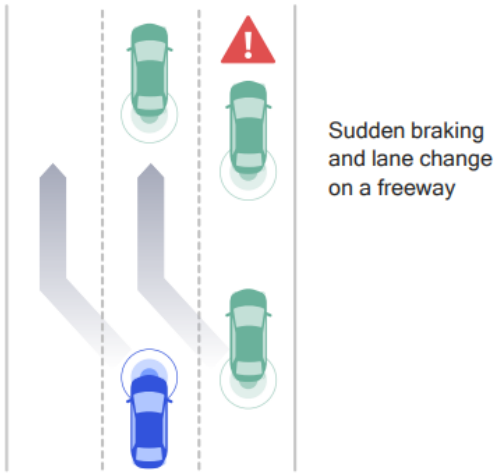
- Short-range communications (V2V/V2I)
- China first-mover: 13 OEMs (2020/2021)
- US deployment announced 2022 (Ford)
- Audi US initial deployment Q3/2020



As of 2024/2025

Autonomous Driving
5G-V2X enhancing ADAS

- Direct short-range + network communications
- Backward compatible with LTE-V2X
- Ultra-reliable at low latency (<1 millisecond)
- Almost unlimited data exchange



** Services provided depend on the OEM*

NR C-V2X builds on LTE C-V2X

with advanced use cases

Safety use cases

Advanced safety use cases

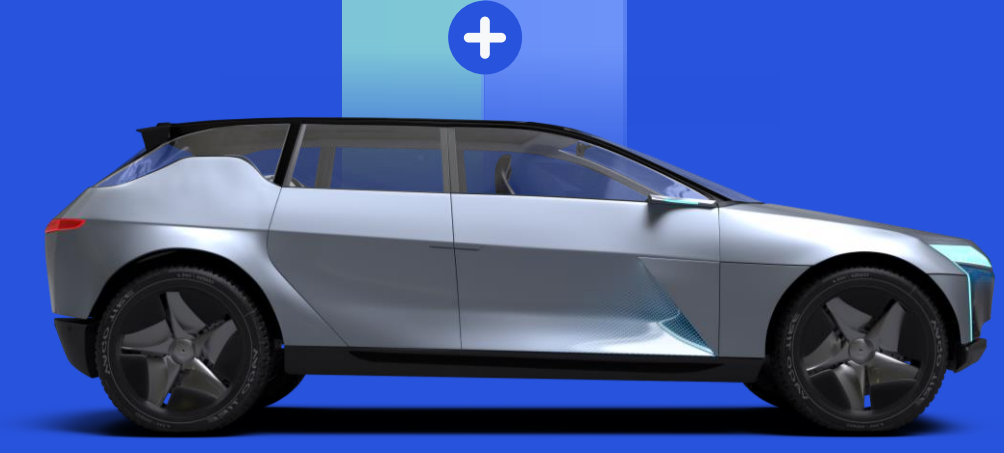
Upper layers

Mapping use cases to transport profile

C-V2X

Rel 14/15 sidelink

Broadcast messages



5G V2X

Rel 16+ sidelink

Multicast messages

5G V2X sidelink

The Journey Towards 5G

Release 8

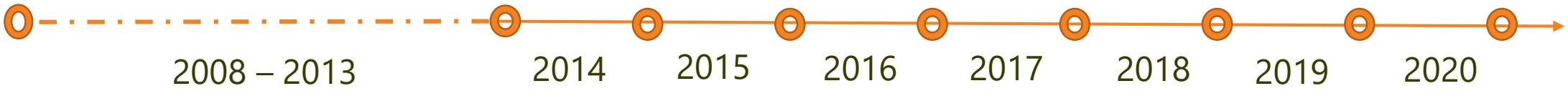
LTE connectivity enabled cloud and streaming services

Release 13

Vehicle-to-Everything (LTE-V2X) Release 14

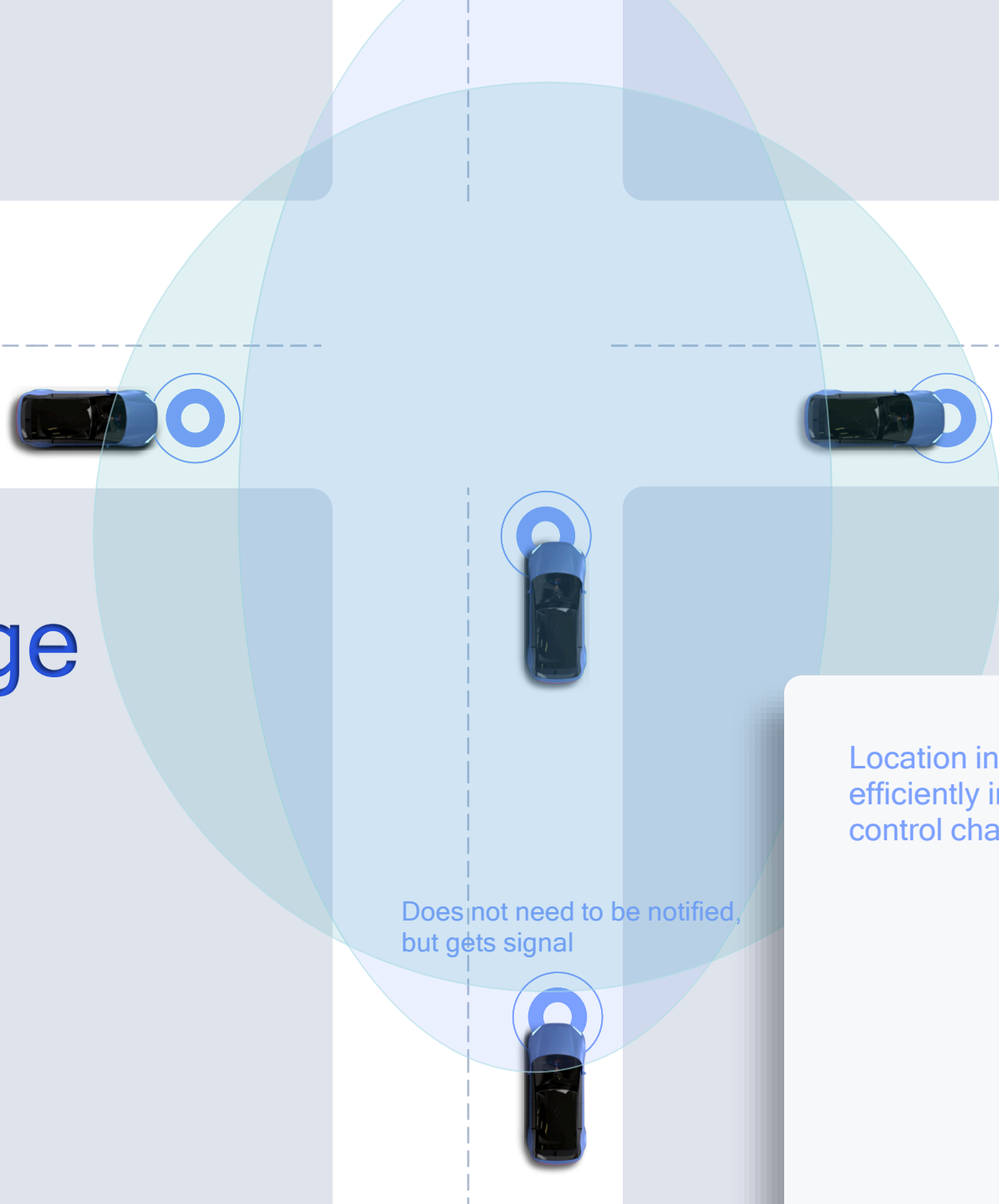
5G New Radio (eMBB), LTE-V2X PC5 Improvement Release 15

Ultra reliable low-latency communications (URLLC), NR-V2X Release 16



Source: 3GPP

Uniform coverage by adding distance as a dimension

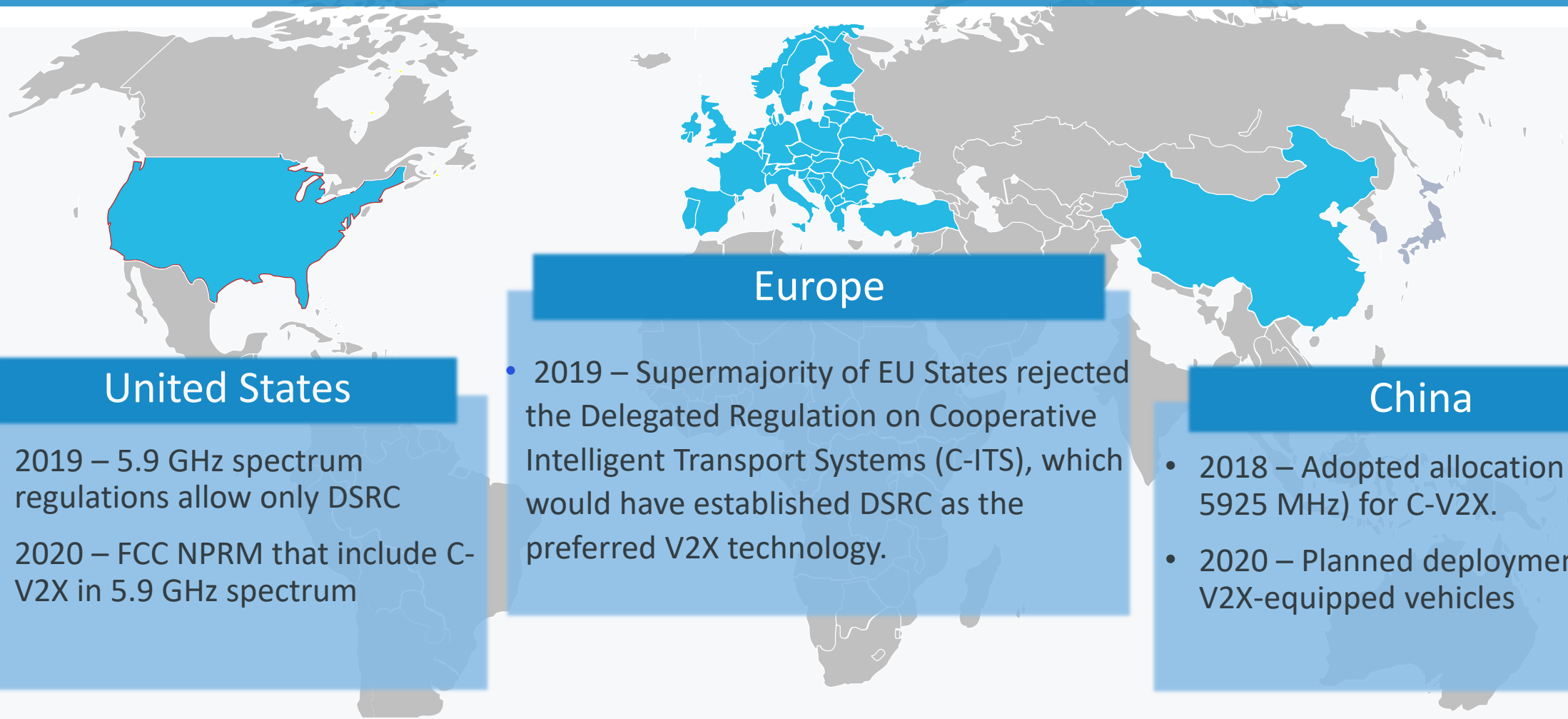


Location information shared efficiently in the physical layer control channel

Groups can reliably connect based on distance

Vehicles within a certain distance and interested in same services form an ‘on-the-fly’ group

Global Stakeholders Are Increasingly Recognizing the Benefits of C-V2X



United States

- 2019 – 5.9 GHz spectrum regulations allow only DSRC
- 2020 – FCC NPRM that include C-V2X in 5.9 GHz spectrum

Europe

- 2019 – Supermajority of EU States rejected the Delegated Regulation on Cooperative Intelligent Transport Systems (C-ITS), which would have established DSRC as the preferred V2X technology.

China

- 2018 – Adopted allocation (5905-5925 MHz) for C-V2X.
- 2020 – Planned deployment of C-V2X-equipped vehicles

5GAA Positions on FCC NPRM

Support

- Rulemaking to Modernize the 5.9 GHz Band
- Designation of Upper 20 MHz for C-V2X

Oppose

- Insufficient Bandwidth for Advanced C-V2X
  - Threatens America's Leadership in Connected and Autonomous Vehicles
- Inadequate Interference Protections for Basic C-V2X
  - Would Render Basic C-V2X Ineffective

Q&A Session

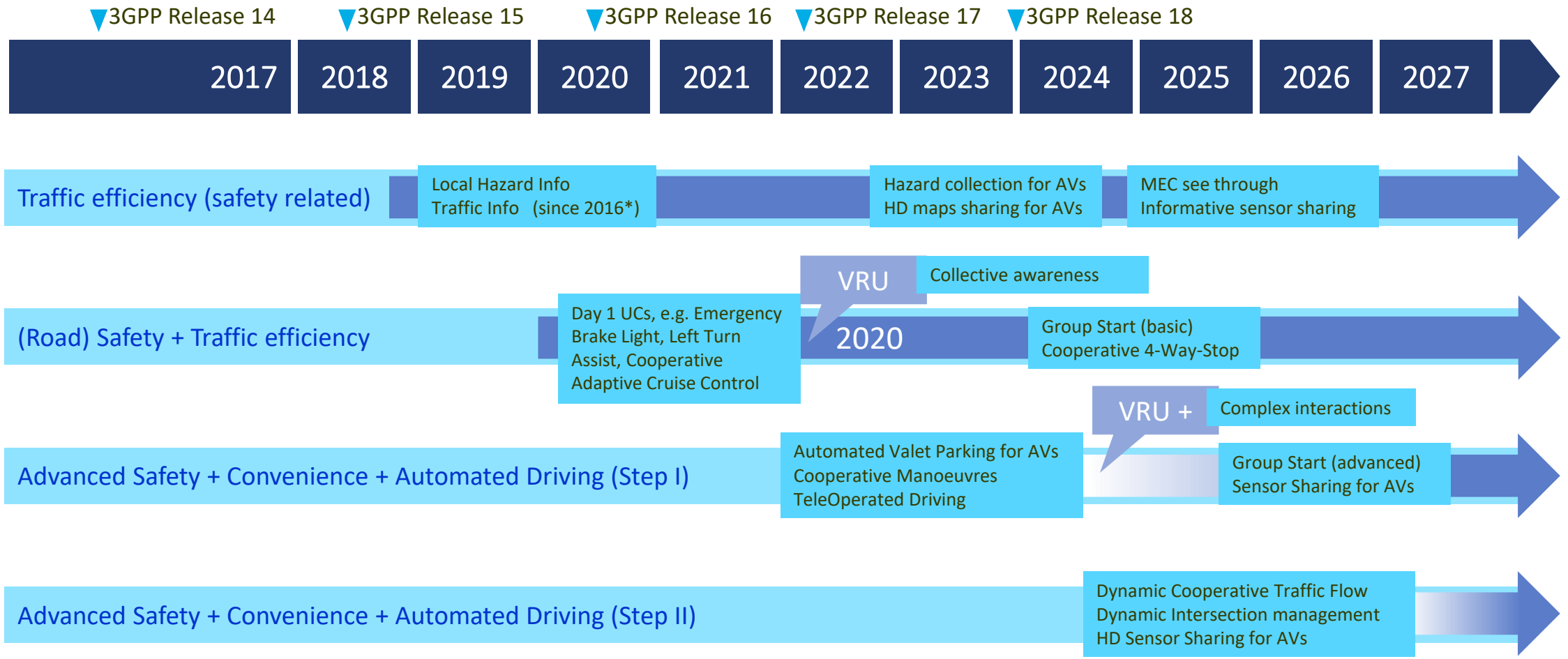
Thank you for joining!

For more information please contact:

liaison@5gaa.org

Back Up Slides

Timeline for deployment of V2X Use Cases



Note: Use cases listed are only examples

* E.g. start in some markets