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

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

1. **Other vehicles (V2V)**
2. **Road Infrastructure (V2I)**
3. **Cyclists via smartphones (V2P)**
4. **Mobile networks (V2N)**
5. **Pedestrians via smartphones (V2P)**

**Notes:**
- LIDAR Radar
- Computer Vision
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

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

**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


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

2X the range @ 90% reception threshold
CV2X outperforms 802.11p in shadowing scenarios.
## Technology benchmark summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion</td>
<td><strong>Lab</strong> Cabled Congestion Control</td>
<td>Pass</td>
</tr>
<tr>
<td>Reliability</td>
<td><strong>Lab and Field</strong> Cabled Tx and Rx Tests, Line-of-Sight and non-Line-of-Sight Range Tests</td>
<td>CV2X better</td>
</tr>
<tr>
<td>Interference</td>
<td><strong>Lab</strong> Cabled Test with Simulated Co-channel Interference</td>
<td>CV2X better</td>
</tr>
<tr>
<td></td>
<td><strong>Lab</strong> Cabled Near-Far Test</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td><strong>Field</strong> Co-existence with Wi-Fi 80 MHz Bandwidth in UNII-3</td>
<td>CV2X better</td>
</tr>
<tr>
<td></td>
<td><strong>Field</strong> Co-existing of V2X with Adjacent DSRC Carrier</td>
<td>Pass</td>
</tr>
</tbody>
</table>

**CAMP Cellular V2X Device-to-Device Communication Project:**

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)

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Information</td>
<td>AI-500-065-02 C-V2X Aftermarket OBU</td>
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<tr>
<td></td>
<td>AI-500-095 C-V2X Roadside Unit (RSU)</td>
</tr>
<tr>
<td>Cohda Wireless</td>
<td>C-V2X Kit</td>
</tr>
<tr>
<td>Commsignia</td>
<td>C-V2X Roadside Unit (RSU)</td>
</tr>
<tr>
<td></td>
<td>C-V2X On Board Unit (OBU)</td>
</tr>
<tr>
<td>Danlaw</td>
<td>C-V2X Aftermarket OBU</td>
</tr>
<tr>
<td>Ficosa</td>
<td>Carcom – FITAX OBU</td>
</tr>
<tr>
<td>iSmartways Technology</td>
<td>MOCAR V-MASTER OBU</td>
</tr>
<tr>
<td></td>
<td>MOCAR I-MASTER RSU</td>
</tr>
<tr>
<td>Kapsch</td>
<td>RIS 9260: C-V2X Roadside Unit (OBU)</td>
</tr>
<tr>
<td>Savari</td>
<td>StreetWAVE 2000 RSU</td>
</tr>
</tbody>
</table>

### Commercially Available Wireless Modules (component-level solutions)

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG Innotek</td>
<td>LAM-V500 : C-V2X Module</td>
</tr>
<tr>
<td>Quectel</td>
<td>AG15 : C-V2X Module</td>
</tr>
<tr>
<td>SIMCOM</td>
<td>SIM8100 : C-V2X Module</td>
</tr>
<tr>
<td>Telit</td>
<td>VE915C1 C-V2X Module</td>
</tr>
<tr>
<td>WNC</td>
<td>CV2X Module &amp; PCIe MiniCard</td>
</tr>
<tr>
<td></td>
<td>EVK – RR3 C-V2X Platform</td>
</tr>
<tr>
<td>ZTE</td>
<td>ZM8350 : C-V2X Module</td>
</tr>
</tbody>
</table>
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

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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 sidelink

5G V2X
Rel 16+ sidelink
Multicast messages
The Journey Towards 5G

- **Release 8**: 2008 – 2013
  - LTE connectivity enabled cloud and streaming services

- **Release 13**: 2014
  - Vehicle-to-Everything (LTE-V2X)

- **Release 14**: 2015
  - 5G New Radio (eMBB), LTE-V2X PC5 Improvement

- **Release 15**: 2016
  - Ultra reliable low-latency communications (URLLC), NR-V2X

- **Release 16**: 2017 – 2020

**Source**: 3GPP
Uniform coverage by adding distance as a dimension

Should be notified, but does not get signal

Does not need to be notified, but gets signal

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.
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.

5.9 GHz spectrum regulations allow only DSRC.

FCC NPRM that include C-V2X in 5.9 GHz spectrum.

Adopted allocation (5905-5925 MHz) for C-V2X.

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
  o Threatens America’s Leadership in Connected and Autonomous Vehicles
• Inadequate Interference Protections for Basic C-V2X
  o 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

Traffic efficiency (safety related)
- 3GPP Release 14: Traffic Info (since 2016*)
- 3GPP Release 15: Day 1 UCs, e.g. Emergency Brake Light, Left Turn Assist, Cooperative Adaptive Cruise Control
- 3GPP Release 16: Hazard collection for AVs
- 3GPP Release 17: HD maps sharing for AVs
- 3GPP Release 18: MEC see through

(Road) Safety + Traffic efficiency
- 2020: VRU
  - Collective awareness
  - Dynamic Cooperative Traffic Flow
  - Dynamic Intersection management
  - HD Sensor Sharing for AVs

Advanced Safety + Convenience + Automated Driving (Step I)
- 2020: Group Start (basic)
  - Cooperative 4-Way-Stop
  - Sensor Sharing for AVs

Advanced Safety + Convenience + Automated Driving (Step II)
- 2020: VRU +
  - Complex interactions
  - Group Start (advanced)
  - Sensor Sharing for AVs

Note: Use cases listed are only examples
* E.g. start in some markets