C-V2X - CAT Coalition

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C-V2X
Established the foundation of C-V2X for safety in Rel-14/15 with continued evolution in Rel-16 5G NR for advanced use cases

- Release 14/15 C-V2X standards completed
- Broad industry support with 5GAA
- Global trials started in 2017
- Qualcomm® 9150 C-V2X chipset announced in September, 2017
- Integration of C-V2X into the Qualcomm® Snapdragon™ Automotive 4G and 5G Platforms announced in February, 2019

V2V
Vehicle-to-vehicle
e.g., collision avoidance safety systems

V2I
Vehicle-to-infrastructure
e.g., traffic signal timing/priority

V2P
Vehicle-to-pedestrian
e.g., safety alerts to pedestrians, bicyclists

V2N
Vehicle-to-network
e.g., real-time traffic/routing, cloud services
**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
Cellular-V2X (C-V2X)

C-V2X is a unified technology platform which integrates:

- **Short-range**, network-less, direct communications (LTE-V2X PC5 today)
- **Long-range** cellular network communications (LTE-V2X Uu today)

Source: 5G Automotive Association
Helping bring a comprehensive ecosystem together

Working across industries to forge sustainable relationships, unlocking new value

<table>
<thead>
<tr>
<th>Automotive</th>
<th>Transportation</th>
<th>Telecom</th>
<th>Internet/cloud</th>
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<tbody>
<tr>
<td>Vehicle OEMs</td>
<td>Road operators</td>
<td>Mobile operators</td>
<td>Cloud service providers</td>
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<tr>
<td>Tier 1 suppliers</td>
<td>Traffic industry suppliers</td>
<td>Telecom suppliers</td>
<td>Map providers</td>
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</tbody>
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Standards development organizations

Telecom and auto industry organizations

ITS organizations

Software companies

Test equipment vendors
C-V2X Resources

Target: Posting by Labor Day

• C-V2X Tutorials
• C-V2X FAQ
• So, you want to acquire RSU?
  Product Availability
  ◦ Dual Mode, Dual Active RSUs

Is it possible to co-locate C-V2X and DSRC RSUs?

What is the needed isolation?

How can the needed isolation be achieved?
## Robust Global C-V2X Ecosystem is Ready

<table>
<thead>
<tr>
<th>9150 Modules</th>
<th>RSU vendors</th>
<th>Tier1s/OBU vendors</th>
<th>System Integrators</th>
</tr>
</thead>
<tbody>
<tr>
<td>• WNC</td>
<td>• <strong>US</strong>: Commsignia, Savari, Kapsch, Danlaw</td>
<td>• Ficosa</td>
<td>• <strong>Sasken</strong></td>
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<td>• Quectel</td>
<td>• <strong>EU</strong>: Swarco, Lacroix, Aximum, Marben</td>
<td>• Cohda</td>
<td>◦ Integration &amp; support</td>
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<td>• ZTE</td>
<td>• <strong>China</strong>: Nebulalink, Genevict, Neusoft</td>
<td>• Valeo</td>
<td>• <strong>Thurdersoft</strong></td>
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<tr>
<td>• LG</td>
<td>• <strong>RoW</strong>: Cohda, Cybercom, Oki</td>
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<td>• Commsignia</td>
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<tr>
<td>Commercial ready module in 2018</td>
<td>12+ RSU products in the pipeline. Commercial</td>
<td>10+ OBU suppliers the pipeline. Commercial</td>
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<td>readym in Q1 2019</td>
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<td>Global foot print to support system Integration</td>
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**C-V2X is ready for deployment now!**
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 and enhanced safety
C-V2X Rel-14/Rel-15 with enhanced range and reliability

Basic safety
IEEE 802.11p

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
5G NR C-V2X is backward compatible at upper layers

By enabling coexistence of Rel16 with previous releases

Rel-16 C-V2X vehicles will be designed to support Rel-14/Rel-15 for safety
Cellular V2X (C-V2X)

- C-V2X has 2 components
  - Network C-V2N
  - Direct C-V2X (C-V2I and C-V2V)
Message Flow – Impact of C-V2N

C-V2N

Cloud-based App

Applied Information
Over 20 C-V2N CV Applications Currently Available

- SPaT/MAP display of signal timing – V2I
- Red-light running at traffic signals – V2I
- Bus/transit priority – V2I
- Intelligent school beacons – V2I
- Emergency vehicle getting through the signal – V2I
- Emergency vehicle proximity alert? – 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 to make signals work better – V2I
Current C-V2N Connected Vehicle Applications

- School Bus Active ahead warning – V2V
- Railroad active ahead warning – V2I
- Dynamic Message Sign (DMS) Annunciation – V2I
- Unprotected Left Turn Collision Avoidance
- Multi-lane Highway Crossing Collision Avoidance
- Wrong way vehicle warning – V2I
- Active Pedestrian in Crosswalk ahead – V2I
- Weather Warning - V2I
- Freight Priority
- Event Management Parking Information – V2I

C-V2N is not only here now, it is a link to the future.
US DOT Policy Development

• (June 2019) USDOT CV Policy re-defined as 3 points:
  • **Protect the 5.9GHz band** for transportation only use
  • **Remove the exclusivity of DSRC** to allow other technologies to co-exist
  • Make no choice of technology solution – let industry decide and **challenge industry** to give agencies confidence in buying infrastructure equipment
Accepting the Challenge: NEMA TS 10

• Newly formed committee to develop a standard to be used for procuring infrastructure-based equipment to support connected vehicle applications
• As well as traditional signal companies, this has attracted the support of communications companies: chip manufacturers, equipment suppliers
• A “multi-radio solution” is proposed as the basis
• Available end-2019
Projected Future-proof Solution

A multi-radio solution – just like the smartphone

Focus on what you want the solution to do, not how it should do it!

C-V2N

Cloud-based App

Direct C-V2X

RSU

DSRC