5GAA brings together the automotive and telecommunications industries to accelerate the global deployment of Cellular Vehicle-To-Everything (C-V2X) as a first step towards a fully integrated intelligent transport system with 5G.

5GAA unites 100+ members* from around the world working together on all aspects of C-V2X including technology, standards, spectrum, policy, regulations, testing, business models and go-to-market.

*as of Oct 2018
5GAA Organisational Structure

BOARD

EXECUTIVE COMMITTEE

GENERAL ASSEMBLY

WG1
Use Cases and Technical Requirements

WG2
System Architecture and Solution Development

WG3
Evaluation, Testbeds and Pilots

WG4
Standards and Spectrum

WG5
Business Models and Go-To-Market Strategies
What is Cellular-Vehicle-to-Everything (C-V2X)
C-V2X is a comprehensive road safety and traffic efficiency solution that allows vehicles to communicate with:

- **Other vehicles (V2V),**
- **Pedestrians and Cyclists via smartphones (V2P),**
- **Road Infrastructure (V2I),**

supported by the

- **Mobile network (V2N, P2N, I2N)**

to guarantee **full coverage** and **continuity of services.**
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 kilometer), location, speed

Implemented over “PC5 interface”

**Long range** (>1 kilometers), e.g. accident ahead

Implemented over “Uu interface”

**Network (= Up/Downlink)**

V2N operates in traditional mobile broadband licensed spectrum

V2N operates in traditional mobile broadband licensed spectrum
Current version of C-V2X is called LTE-V2X as part of 3GPP Rel-14 & 15.
NR-V2X as part of Rel-16 comes as an improvement to support autonomous driving.
NR-V2X will complement and co-exist with LTE-V2X i.e. operation of NR-V2X alone is not considered.

NR-V2X study item started in June 2018.
Subsequent NR-V2X work item by December 2019.
Basic Safety Use Cases
as part of Rel-14 C-V2X
Evolution to 5G, while maintaining backward compatibility

Basic safety
802.11p or C-V2X R14
Established foundation for V2X

Enhanced safety
C-V2X R14/15
Enhanced range and reliability

Advanced safety
C-V2X R16 (building upon R14)

Higher throughput
Higher reliability
Wideband ranging and positioning
Lower latency

Source: Qualcomm

- Emergency Electronic Brake Lights
- Across Traffic Turn Collision Risk Warning
- Signal Phase and Timing
- Vulnerable Road User Protection
- Intersection Collision Warning
- Slow Vehicle Warning and Stationary Vehicle Warning

*(+ This week in Yokosuka)
V2N Application: Emergency corridor – A cooperation between BMW and the Bavarian emergency services

1. Authority transmits information about required emergency corridor
2. Mapping to vehicle navigation system
3. Delivery to affected vehicles
4. Display in HMI as soon as vehicle reaches end of jam

• Sovereign authorities are able to warn road users through back end systems at an early stage.
• Information is transmitted only to concerned cars; high level of reliability and low failure rate increase customer trust.
Worldwide Trials of Rel-14 C-V2X

- **C-V2X Connected Car Technology Trials**
  - San Diego, USA

- **V2V C-V2X radio performance tests**
  - Michigan, USA

- **CDOT traffic management trial**
  - Colorado, USA

- **RACC track MWC 2017**
  - Spain

- **Towards 5G**
  - France

- **InOut C-V2X Demo**
  - France

- **UK CITE**
  - UK

- **NordicWay**
  - Sweden

- **Mobilfunk (A9)**
  - Germany

- **DT (A9)**
  - Germany

- **Car2X (A9)**
  - Germany

- **5G-CM (A9)**
  - Germany

- **MEC pilot project**
  - Germany

- **ICV pilot projects**
  - China

- **C-V2X Performance Test @ SIAC**
  - China

- **Car2X Wuzhen**
  - China

- **C-V2X Trials**
  - Japan

- **5G and cellular communication showcase trials**
  - Korea

- **LTE-V2X Project**
  - China

- **San Diego, USA**

- **France**

- **Germany**

- **Korea**

- **China**

- **Sweden**

- **UK**

- **Spain**

- **Michigan, USA**

- **CDOT traffic management trial**

- **NordicWay**

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- **Car2X Wuzhen**

- **C-V2X Trials**

- **5G and cellular communication showcase trials**

- **LTE-V2X Project**
Timeline for deployment of Release 14 C-V2X (V2V/V2I) products

- **H1/2017**: 3GPP LTE Advanced Pro Release 14
- **H2/2017**: 3GPP 5G Release 15
- **H1/2018**: 3GPP 5G Release 16

**C-V2X (R14) chipsets from various vendors**
- Chipsets for tests
- Inter-operability tests
- Commercial availability of Mode 4 chips

**Integration, Validation and Testing with OEMs (EU, China, US)**

**Testing of traffic infrastructure (EU, China, US)**

**5.9 GHz Spectrum Target Availability**
- EU: Spectrum available
- China: Test spectrum available
- Start of vehicle deployment

**2020**
- EU: Final CEPT report
- C-V2X is real and ready with commercial chipsets set for 2018.
- In-vehicle commercial deployment (i.e., type-approved vehicles) is foreseen at the latest by 2020 globally.
Path towards Rel-16 NR-V2X
Evolution to 5G, while maintaining backward compatibility

**Basic safety**
802.11p or C-V2X R14
Established foundation for V2X

**Enhanced safety**
C-V2X R14/15
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**Advanced safety**
C-V2X R16 (building upon R14)
Higher throughput
Higher reliability
Wideband ranging and positioning
Lower latency

Source: Qualcomm
Requirements for autonomous driving

Uses cases for autonomous driving applications (SA1 TR22.886)

<table>
<thead>
<tr>
<th>Use Cases</th>
<th>E2E latency (ms)</th>
<th>Reliability (%)</th>
<th>Data rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Platooning</td>
<td>10</td>
<td>99.99</td>
<td>65</td>
</tr>
<tr>
<td>Advanced Driving</td>
<td>3</td>
<td>99.999</td>
<td>53</td>
</tr>
<tr>
<td>Extended Sensors</td>
<td>3</td>
<td>99.999</td>
<td>1000</td>
</tr>
<tr>
<td>Remote Driving</td>
<td>5</td>
<td>99.999</td>
<td>UL:25, DL:1</td>
</tr>
</tbody>
</table>

Positioning Accuracy

<table>
<thead>
<tr>
<th>Lateral (m)</th>
<th>Longitudinal (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: 5GAA may adjust the above requirements according to inputs from car OEMs.
Accelerating 5G NR, the global standard for 5G

- **3GPP 5G NR R14 Study Item**
- **R15 5G NR Study Items**
- **R16+ 5G NR study items continue to evolve/expand 5G NR**
- **R15 5G work items**
- **R16 5G work items**
- **R17+5G evolution**
  - 5G NR Standalone (SA) mode
  - Intermediate milestone for 5G NR Non-Standalone (NSA) mode
  - **5G NR R15 launches**
    - Enabling deployments as early as 2019
  - **5G NR R16 launches**

- **Gigabit LTE and LTE IoT deployments**
- **Continue to evolve LTE in parallel to become a critical part of the 5G Platform**

Source: Qualcomm
Flexible selection between LTE-V2X and NR-V2X

<table>
<thead>
<tr>
<th>Basic safety application by LTE-V2X (PC5) @ 5.9 GHz</th>
<th>Flexible selection between LTE-V2X and NR-V2X</th>
</tr>
</thead>
<tbody>
<tr>
<td>New vehicles deploy both LTE-V2X and NR-V2X to enable the inter-operability with old vehicles:</td>
<td>Provide policies/criteria to UE to assist radio technology selection, according to V2X application type, QoS requirements, etc.</td>
</tr>
<tr>
<td>1) LTE-V2X (PC5): Basic safety</td>
<td></td>
</tr>
<tr>
<td>2) NR-V2X (sidelink): Autonomous Driving</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram showing inter-operability of new and old vehicles using LTE-V2X and NR-V2X technologies.]

*V2X Application*
- CAM
- DENM
- Platooning
- Auto Driving

*V2X Adaptation Layer*
- LTE-V2X
- NR-V2X
Strategic views on 5G
C-V2X and its evolution to 5G V2X will foster synergies between the automotive industry and other verticals which are moving to 5G.
Expanding 5GAA’s strategy

**New Radio**
“Define the next step” - accelerate definition of 5G-V2X based on 5G

**Push V2N**
Intense functional rollout of V2N based applications in order to reach broad penetration fast

**Joint Ecosystem**
Create a joint eco system car – smartphone - home

**Vehicle to Smart Device**
V2X-based vehicle interface for smartphone controlled functions

**Mobile Edge Computing**
Mobile Edge Computing as one of the key elements of the connected future

**Interoperability**
Make sure that cross OEM cars and cross operator networks can „speak“ with each other
Thank you!