LTE-V2X / NR-V2X
C-V2X and intelligent transport systems

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CEPT workshop: New spectrum solutions for industry sectors
2-3 May 2019
Introduction
C-V2X is a unified technology platform which integrates:

- **Short-range**, network-less, direct communications (LTE-V2X PC5) (5G NR-V2X PC5)

- **Long-range** cellular network communications (LTE-V2X Uu) (5G NR-V2X Uu)
Current version of C-V2X is called LTE-V2X as part of 3GPP Rel-14.

NR-V2X as part of Rel-16 comes as an improvement to support automated driving.

NR-V2X will complement, co-exist and support interworking with LTE-V2X.

NR-V2X study item started in June 2018 and is now complete.

Subsequent NR-V2X work item started in March 2019.
C-V2X availability and deployment

- C-V2X products are available today from a number of vendors, including:
  - Chipsets
  - Modules
  - On board units
  - Roadside units

- We expect LTE-V2X (PC5) to be deployed in vehicles at 5.9 GHz by 2020 globally, with widespread availability of equipment in the market from 2019.

  Cellular connectivity offers fastest way to large-scale penetration of C-ITS; all new cars are expected to be connected to the internet by 2022. Many OEMs have already deployed some Day 1 C-ITS services using existing 2G/3G/4G networks and LTE-V2X (Uu).

5GAA timeline for deployment of C-V2X (V2V/V2I)

- **5.9 GHz** is key for C-V2X.
LTE-V2X PC5
LTE-V2X

- LTE-V2X was specified at 3GPP in Q1-2017 and is today’s realisation of C-V2X.

- LTE-V2X is designed to support basic safety applications via
  - a) direct short-range communications at 5.9 GHz on a standalone basis, and
  - b) cellular network connections for long-range communications in MFCN bands.

- LTE-V2X complies with ETSI EN 302 571 harmonised standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.

- In Q4-2017, the EC issued a mandate to CEPT to address coexistence of Road ITS (LTE-V2X, ITS-G5) and Rail ITS at 5.9 GHz.
Work items on spectrum sharing between LTE-V2X and ITS-G5 are on-going at ETSI.

5GAA is committed to this activity, and advocates market led preferred channels combined with detect-and-vacate where needed.

NOTE 1: No harmful interference shall be caused to the application having priority. NOTE 2: Road ITS and Rail ITS shall remain confined to their respective prioritised frequency range until appropriate co-channel sharing solutions are defined by ETSI (but see 3). NOTE 3: In absence of co-channel sharing solutions for protection of Rail ITS, national regulators can allow Road ITS limited to V2I in 5915-5925 MHz if coordinated with Rail ITS. V2V can only be permitted in 5915-5925 MHz when solutions for protection of Rail ITS become available at ETSI.
NR-V2X PC5
Uses cases for autonomous driving applications (SA1 TS22.186)

- Vehicle Platooning
- Cooperative Operation, Sensor Sharing
- Remote Driving
- Advanced Driving

NR-V2X requirements for autonomous driving (SA1 TS22.186)

<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>

<table>
<thead>
<tr>
<th></th>
<th>Lateral (m)</th>
<th>Longitudinal (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioning Accuracy</td>
<td>0.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Flexible selection between LTE-V2X and NR-V2X

### Basic safety application by LTE-V2X (PC5) @ 5.9 GHz

New vehicles deploy both LTE-V2X and NR-V2X to enable the inter-operability with old vehicles:

1) LTE-V2X (PC5): Basic safety
2) NR-V2X (PC5): Advanced autonomous

### Flexible selection between LTE-V2X and NR-V2X

Provide policies/criteria to UE to assist radio technology selection, according to V2X application type, QoS requirements, etc.

#### V2X Application

- CAM
- DENM
- Platooning
- Auto Driving

#### V2X Adaptation Layer

- LTE-V2X
- NR-V2X
Spectrum needs for advanced ITS

- NR-V2X will support a broad range of advanced safety use cases for autonomous driving including sensor information sharing, trajectory information sharing, and others.

- Initial 5GAA studies have indicated that 20–30 MHz is required for basic safety applications at 5.9 GHz, with advanced ITS and autonomous driving use cases requiring at least an additional 40 MHz.

- Given the available 50 MHz harmonised for ITS in Europe at 5.9 GHz, which is to be shared between road-ITS and rail-ITS, early indications are that additional spectrum might be needed for advanced ITS use cases.

- ITU-R is working on global harmonization of 5850-5925 MHz, or parts thereof, for current and future ITS applications and this is supported by many regions (EU, US, Korea, China).
Spectrum harmonisation/authorisation in Europe

- **Spectrum**
  - **Harmonised for MFCN**
    - Licensed*
      - 700 MHz, 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 1900 MHz, 2100 MHz, 2300 MHz, 2600 MHz, 3600 MHz, 26 GHz, 40 GHz.
  - **Harmonised for ITS**
    - Licence exempt
      - 5.9 GHz, 64 GHz**

* Predominantly intended for long-range communications via Uu, however NR-V2X PC5 can operate along with Uu (V2N) links in spectrum harmonised for MFCN.
** Implications of radio propagation in this band for V2V are being investigated.
<table>
<thead>
<tr>
<th>Implications of different approaches</th>
<th>Harmonised for MFCN (licensed*)</th>
<th>Harmonised for ITS (licence exempt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting all vehicles</td>
<td>Requires some form of multi-MNO collaboration.</td>
<td>Shared spectrum (public commons) to connect all vehicles.</td>
</tr>
<tr>
<td>Inter-technology interference</td>
<td>None. Technology is decided by licensee.</td>
<td>Measures required to manage co-channel interference.</td>
</tr>
<tr>
<td>Fees for spectrum usage rights</td>
<td>Licence fees paid (primarily for eMBB).</td>
<td>No fees.</td>
</tr>
<tr>
<td>Bandwidth availability</td>
<td>Limited availability below 6 GHz.</td>
<td></td>
</tr>
<tr>
<td>Timelines for availability</td>
<td>Available today or soon.</td>
<td>5.9 GHz and 64 GHz** available today.</td>
</tr>
</tbody>
</table>

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Summary
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- Important that European ITS regulations ensure uncompromised road safety, while abiding by the key principle of technology neutrality.

- LTE-V2X is today’s realisation of C-V2X, and will support basic road safety use cases at 5.9 GHz. Deployments are expected in 2020. Work is in progress at ETSI on spectrum sharing between LTE-V2X and ITS-G5. 5GAA advocates market led preferred channels combined with detect-and-vacate where needed.

- NR-V2X will complement LTE-V2X to address advanced ITS and autonomous driving use cases. A 3GPP work item on NR-V2X began in March 2019, with specifications expected to be completed by March 2020.

- Early indications are that bandwidth requirements for advanced ITS and autonomous driving use cases may exceed 40 MHz. As such, it is expected that such advanced ITS use cases may require additional spectrum.
Thank you!

For more information please contact:
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ANNEX
5GAA connects the telecom industry and vehicle manufacturers to work closely together for developing end-to-end solutions for future mobility and transportation services.

**AUTOMOTIVE INDUSTRY**
Vehicle Platform, Hardware and Software Solutions

**TELECOMMUNICATIONS**
Connectivity and Networking Systems, Devices and Technologies

End to end solutions for intelligent transportation, mobility systems and smart cities
September 2016

- “Audi, BMW Group, Daimler AG are teaming with Ericsson, Huawei, Intel, Nokia, and Qualcomm to create the 5G Automotive Association (5GAA), which will help develop, test, and promote 5G standards”

- “Scope of the alliance is focused on bringing connectivity solutions to market addressing technical, business, and regulatory challenges”

Q1 2019

5GAA unites +110 members working together to:

- Deliver innovation for road safety, connectivity and sustainability
- Accelerate cooperative, connected, automated mobility
- Develop 360° solutions for SMART mobility services
- Pave the way towards 5G mobility
C-V2X: Evolution to 5G maintains backward compatibility

3GPP Rel. 8-13
March 2016

3GPP Rel. 14
March 2017

3GPP Rel. 15
June 2018

3GPP Rel. 16
March 2020

Hazard warning
V2V safety use case
Enhanced Navigation & Infotainment
Cooperative automated driving

LTE V2N Uu
LTE V2V/V2I (PC5)
5G NR V2N Uu
High bandwidth/low latency
5G NR Uu URLLC
Direct Communication 5G NR V2V/V2I

V2N
V2V/V2I

V2X: Evolution to 5G maintains backward compatibility