5G for Cooperative Connected and Automated Mobility

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European Commission
DG CONNECT E1- Future Connectivity Systems
5G in the Digital Single Market (DSM)

The 5G Public Private Partnership (5G PPP)
- 700 M€ initiative under R&I H2020 programme
- Technologies, systems, applications,
- spectrum, standards;
- International cooperation
- Supply Side

The 5G Action plan
- Commission Communication: to support European industrial leadership;
- Part of the September 2016 "Connectivity Package"
- Preparing Framework Conditions at EU level for 5G deployment
- Demand Side
"5G Action Plan" approach to EU 5G Introduction:

- **2018**: Early 5G launch in selected areas. Commercial launch of 5G services in at least one major city in all MS.

- **2020**: 5G in all urban areas and along main transport paths. Consistent/quasi-simultaneous launch throughout single market.

- **2025**: Roll-out with geographical and sectorial focus. Verticals "centre stage".
CCAM Holistic Picture (exemple)

OEM and 3rd party - Backend(s)
(variety of services, e.g. fleet mgmt., remote services, secure autocloud, etc.)

OEM-Backend
(virtual vehicle)

Infotainment Communications

Road side infrastructure
(e.g. traffic lights, digital street signs)

100

NB-IoT/ LTE-M

C-V2x

G5/C-V2V

G5/C-V2V

LOCAL SENSOR COVERAGE

Source: EUCNC Conference 2017, CAD Panel
From Partly Automated to Fully Automated Driving

Source: Continental
Multiplicity of Issues

- Safety center stage, C-ITS objectives
- Environment
- Industry, competitiveness
- Innovation/technologies
- Spectrum and standards
- User data, security & Privacy
- Global positioning of Europe
Collaborative, Connected and Automated Mobility

- GEAR 2030
  - Roundtable;
  - 5G action plan;
  - IoT;
  - Data Communication

- C-ITS Platform

- R & I: STRIA / Horizon 2020

- Industry
- Digital
- Transport
- Research
CCAM Impact: around € 1 Trillion /year

- Fewer driving fatalities/injuries
- More predictable, productive travel
- Less greenhouse gas emissions

> 1,2 M
People die each year on the roads worldwide

>10 B
Litres of fuel wasted due to traffic congestion in large countries

14%
Of global warming emissions from transportation
<table>
<thead>
<tr>
<th>Country/Region</th>
<th>ITS spectrum (GHz)</th>
<th>Technology</th>
<th>Standardization Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63-64</td>
<td>Technology neutral [ECC Dec [09]01]</td>
<td>Harmonized Standard EN 302 686 3GPP-Rel14 Study on evaluation methodology for new V2X use case</td>
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<tr>
<td>Japan</td>
<td>0.7555 – 0.7645</td>
<td>IEEE 802.11 based [ARIB STD-T109]</td>
<td>V2V and V2I ITS-safety</td>
</tr>
</tbody>
</table>

**V2X Spectrum Background**

⇒ **5G Pioneer Bands**

For specific Safety/Non-Safety ITS use cases see:
3GPP TR 22.885 Study on LTE support for Vehicle to Everything (V2X) services
Regulatory framework (spectrum)


- 30 MHz for safety-related ITS applications
- No specific technology is mandated (technology neutral)
- Must be safety-related

EN 302 571 v.2.1.1 of 8 June 2017

- Any technology fulfilling the requirements of this harmonised standard has access to 5.9 GHz band
CEPT Mandate (ongoing)

**T1:** Study the possibility to **extend** the 5 875-5 905 MHz frequency band to the range 5 875-5 925 MHz for use by **safety-related road and rail ITS systems** under harmonised technical conditions including sharing conditions. ...study measures which allow **coexistence of LTE-V2X and Urban Rail ITS** (such as technologies for CBTC already in operation in the 5 905-5 925 MHz frequency band) **with existing ETSI ITS-G5** w/i the 5 875-5 925 MHz frequency band.

**T2:** ...assess the suitability of the existing harmonised technical conditions applicable to the 5 875-5 905 MHz frequency band for **use by Urban Rail ITS** (such as technologies for CBTC); amend these conditions, if necessary, so as to **develop consistent technical, including sharing, conditions for the whole 5 875-5 925 MHz frequency band.** This should not result in segmentation and segregation of the band. The principle of **equal access to shared spectrum shall be applied** taking into account the need to avoid harmful interference and the need for reliable safety-related operation in the whole band.
Guiding principles

1) Uncompromised safety services for all users in case of multiple technologies implementation;
2) Technology neutrality of spectrum use
3) Efficient spectrum use;
4) Introduction in the longer-term of 5G for the further development of CCAM.
V2X Radio Technology development

LTE/LTE ev (4G/5G)
- First 4G deployment (2008)
- LTE-Advanced specified (2011)
- LTE-V standardization start (2015)
- LTE-V specifications complete (2017)
- LTE-V backwards compatible enhancements (2018)

NR (5G)
- Start of study of “New Radio” (NR) (2016)
- NR-V specifications ready (2019)
- 5G ITS trials in DE (5G-CM E/// project)

DSRC/ITS-G5
- IEEE Std 802.11-2012 complete (PHY/MAC for DSRC/ITS-G5)
- Cooperative ITS Corridor trial (EU)
- Launch of CCAM 5G Pilot in pan EU corridors
- Today
Interpretation and Plausibility Check

Cooperative maneuver and trajectory planning

Prediction of situation and of intention

Cooperative recognition

- Car Internal
- V2X

V2X Radio Range up to 1 km
Reliability: 99.9999%
Availability: 99.9999%

Data and Infobasis for Subsequent Traffic

Roadusers: Pedestrians, Bicyclists, New & Old Cars

-Few Mbps, 100 msec E2E
-Up to 20 Mbps, 10 msec E2E
-Up to 2 Mbps, 3 msec E2E
-Up to 1 Mbps, 3 msec E2E
-Up to 20 Mbps, 10 msec E2E

5GPPP White Paper: Connectivity for Future Cars

- Up to 20 Mbps, 10 msec E2E
- Up to 1 Mbps, 3 msec E2E
- Up to 20 Mbps, 10 msec E2E
- Few Mbps, 100 msec E2E

Sensors of other roadusers

Information to other roadusers

Car

Own sensors

Exchange with other roadusers

Negotiation and exchange of information with other roadusers

Driver

- e.g. Longitudinal & Lateral Accelerations, car distances, video (HD or preprocessed), Sensors for local road conditions, etc.
Use cases categories of eV2X use cases as per TR 22886
Data rates beyond 25 Mb/s, scenario dependent
EU Strategic Support to 5G CCAM

- Preparation of CCAM trials through cross border 5G corridors
  - EC, European Ministers and Industry agreed to work together on digital cross-border corridors and started mapping them
  - Further test sections soon to be added in the to the set of test sections agreed among MS (e.g. Munich-Brenner-Bologna)
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5G CAD corridors need public support

• Test licenses for vehicles

• Authorisation/facilitation of cross-border roads for trials

• Test frequency spectrum licences for 5G: in the relevant frequencies considered for 5G: possibly 3.x GHz, 700MHz, 26GHz.

• Agreed understanding on data access and sharing: relevant rules would normally also include liability provisions (in case of an accident/malfunction) as well as appropriate data-access and sharing rules to ensure safety.
Helping Cross Industries pan European Partnerships:

**5G PPP Phase 3, > € 200 millions for trials**

User needs, partnerships with vertical industries

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Phase 3 a) Verification Demo/Trial Platform - Integration radio+ network

- Integration radio+ network

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Phase 3 b) Integrated Verification Trial - radio+ network + applications

Early 5G introduction Lower frequency bands

Later 5G introduction Higher frequency bands

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Phase 2 - Demos PoC*- Core Techs Components

Phase 3 a) Verification Demo/Trial Platform - Integration radio+ network

5G Connected Cars in EU cross-border corridors

5G R&I for "Long Term Evolution"

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*Proof of Concept
5G CCAM Business Issues

- Key technologies for 5G V2X are in sight. Need to clarify:
  - Stakeholders and their relationships
  - Investment and business models
  - Required investment to provide advanced ITS services
  - Required investment cost
  - Expected profit and estimated payback time of investment

👉 Study by 5G PPP to progress the issue.
Four scenarios are considered to investigate the role of
- CAPEX/OPEX, e.g. when sharing of ITS and other services as infotainment
- Service fee (paid by the user)
- HD maps and connectivity fee (paid by the road infrastructure operator)
- Traffic density and yearly user penetration over a 10 years time

<table>
<thead>
<tr>
<th>Parameter \ Scenarios</th>
<th>1 (Baseline)</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX – 100 km (kEuro)</td>
<td>17,500</td>
<td>17,500</td>
<td>17,500</td>
<td>8,750</td>
</tr>
<tr>
<td>OPEX – 100 km (kEuro / 10 years)</td>
<td>17,500</td>
<td>17,500</td>
<td>17,500</td>
<td>8,750</td>
</tr>
<tr>
<td>CAD service fee (Euro per 100 km)</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Income (% of the CAD service fee)</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Traffic density (vehicles/100 km/day)</td>
<td>100,000</td>
<td>200,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Accumulated profit

- Profit grows exponentially due to assumption of 10% user penetration per year
- Growth depends on traffic density and service fee
- Infrastructure sharing, i.e. lower CAPEX/OPEX shifts curves
- Payback period depends on the scenario and can vary between 3 and 8 years (extreme case)

=> User penetration and traffic density will be key parameters.
By Way of Conclusion

- 5G strategic position on the overall CCAM connectivity roadmap
- Target: create complete ecosystems around cars
- Co-existence/complementarity sought
- Principle of technology neutrality important
- Europe moving forward to make it happen