5G and Automotive
The Perfect Storm?

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### EVOLUTION

<table>
<thead>
<tr>
<th>Advanced MIMO</th>
<th>CA</th>
<th>D2D</th>
<th>Dual connectivity</th>
<th>eBroadcast</th>
<th>IoT</th>
<th>C-V2X</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTE-Advanced</td>
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<td></td>
<td>5G</td>
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<td>(Rel 10-11-12)</td>
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<td></td>
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<td>(Rel 15 &amp; beyond)</td>
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<tr>
<td>LTE-Advanced Pro</td>
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<td>(Rel 13-14)</td>
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<table>
<thead>
<tr>
<th>2014</th>
<th>2016</th>
<th>2017</th>
<th>2020+</th>
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</thead>
<tbody>
<tr>
<td>3GPP TR 36.nnn Rel. 14 – LTE V2X</td>
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<tr>
<td>3GPP TS 22.261 V15.1.0 (2017-06) Rel. 15 - Service requirements for the 5G system (eV2X)</td>
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**eV2X Services (Rel. 15)**

- **Platooning:** vehicles dynamically forming a group travelling together

- **Advanced Driving:** sharing driving intentions, sensor data and videos with RSUs, other vehicles, pedestrians and V2X servers for safety, traffic efficiency, semi- or fully-automated driving

- **Remote Driving:** a remote driver or a V2X application operate a vehicle (disabled passengers, vehicles in dangerous environments, public transportation)

<table>
<thead>
<tr>
<th>Use case</th>
<th>Data rate</th>
<th>Latency</th>
<th>Area traffic capacity</th>
<th>Availability/Reliability/Resilience</th>
<th>Connection density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>0.5/10 Mbps</td>
<td>1 ms-</td>
<td>0-500 km/h</td>
<td>99.9999%</td>
<td>4000 veh/km²</td>
</tr>
<tr>
<td></td>
<td>25/50 Mbps</td>
<td>10 ms</td>
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KEY 5G INNOVATIONS FOR THE AUTOMOTIVE DOMAIN

- Network slicing
- Multi-access Edge Computing (MEC)

- eV2X communications
- mmWave communications
• Network slice: partitioning of virtual resources and functions to satisfy verticals’ requirements

• Enabling technologies: SDN & NFV
Navigation service

- best route algorithm
- packet inspection & data extr.
- decryption

computational resources
storage resources
MEC – MULTIACCESS EDGE COMPUTING
(aka Mobile Edge Computing)

MEC: Distributed server deployment at network edge
EXTREME MEC

Pros:
1. Ultra-low latency
2. Lower bandwidth consumption
3. Lower energy consumption
4. Better privacy
5. Higher resilience

Cons:
1. Lower availability
2. Consistency issues
3. Service migration
4. Higher complexity
CELLULAR V2X (C-V2X) [Rel. 14]
• V2V, V2I, V2P communications through side link (PC5)
• PC5 uses LTE radio interface but in the 10 MHz unlicensed band at 5.9 GHz
• Resource pool allocated by BS if under coverage, or a-priori allocated if out of coverage
• Random access (not fully specified yet)
C-V2X vs. DSRC/ITS-G5

Pros:
- High PHY layer performance (in 5G: new radio waveforms)
  C-V2X: 500 m vs. DSRC: 225 m
- More efficient channel access: reduced packet losses due to random selection
- No need for multihop
- In 5G: cooperative sharing of operators’ frequencies for safety
- Interaction with any user equipment (e.g., pedestrians)

Cons:
- Cost
- Broadcasting
- Synchronization
- Unclear out-of-coverage performance

Possible scenario:

Different radio technologies will be integrated, addressing a variety of use cases and requirements

No registration required ➔ Security threats
mmWAVE FOR CARS

• WHY
  o Connected cars will need Gbps data rate due to the expanding number of sensors
  o Cannot achieve Gpbs in 10 MHz channels @ 5.9 GHz
  o mmWave possible in low cost consumer devices

• HOW
  o Use carriers at 28-30 GHz or 76-78 GHz
  o Directional beamforming to compensate high path loss
  o Narrow beams reduce interference
  o mmWave already used for radars
THANK YOU