How V2X Sensors can Augment ADAS for Connected & Automated Driving

Ravi Puvvala
CEO, Savari

IWPC Workshop
June 2018
V2X

Vehicle

Infrastructure

360°
situational awareness

Pedestrian

Network
Cellular V2X

**Active Safety (PC5 - 5.9 GHz)**
Safety messages from Vehicles, Pedestrians, Infrastructure messages from RSU

**Informational Safety (Uu - LTE Bands)**
Real-Time Situational Awareness about lane closures, traffic, hazards, speed advisories, queue warnings
Combine Global Navigation Satellite Systems (GNSS) with Dead Reckoning, Real Time Kinetics Technology (RTK). RTK Correction Messages broadcasted via Infrastructure support
Infrastructure Support - Security Support

Distribute Certs, Renewals, Revocation Lists and do Misbehavior Detection
Accuracy Levels

Lane (< 1.5 m)

- Sudden lane change

Road (< 3m)

- Road hazard
- Blind intersection/vulnerable road user (VRU) alerts

Seamless connectivity for Positioning & Security makes cellular a must have option
V2X Modem to be added to every Telematics Platform

CV2X becomes a perfect sensor on auto platforms
## Connected Use Cases

<table>
<thead>
<tr>
<th>Active Safety</th>
<th>Informational</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forward Collison Warning</strong></td>
<td>Evade colliding vehicle in front</td>
</tr>
<tr>
<td><strong>Left Turn Assist</strong></td>
<td>Dilemma resolution on the timing to make assisted left turns</td>
</tr>
<tr>
<td><strong>Blind Spot Warning</strong></td>
<td>Identify targets in the driver’s blind spot</td>
</tr>
<tr>
<td><strong>EEBL</strong></td>
<td>Emergency electronic brake light warning</td>
</tr>
<tr>
<td><strong>Intersection Movement Assist</strong></td>
<td>Collision avoidance at intersections</td>
</tr>
</tbody>
</table>

6/21/18
V2X Software

**HMI API**

**V2X Applications (Safety, Mobility)**
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Forward Collision Warning (FCW)
- Traffic Signal Priority (TSP)

**Advanced Connected Vehicle Algorithms**
- Path History
- Path Prediction
- Target Filtering and Classification
- Vehicle Data Filters
- Improved POTI
- Maps
- Positioning
- Road-Side-Unit (RSU) Selection

**Messages**
- BSM
- TIM
- PVD
- SPaT/MAP
- MAP
- CAM
- IVI
- DENM
- Local Certificate Manager (LCM)

**Security**
- Verify on Demand/ Verify All

**Network Services**
- GeoNet/BTP

**Low Level API**
- Wireless API
- Positioning API
- Vehicle API
- Security API
- QNX
- Linux
- OS
- AutoSAR
- Other OS

**Hardware**
- C-V2X
- GPS
- CAN
- HSM

**C-V2X Chipset providers**
- US only
- EU only
- Automotive Tier-1

**On-Board-Unit**

6/21/18 // 10
V2X Software Characteristics

Data Fusion
- Path History/Path Prediction
- Target Filtering & Classification
- Infrastructure Data Selection

Performance
- Reduction of false positives
- Time-To-Warn – 1ms … 100 ms … 3 seconds
- Connected … Automated (ASIL- B/C/D)
## Automated Use Cases

<table>
<thead>
<tr>
<th>L3 Use Cases (Release 14)</th>
<th>L4 Use Cases (Release 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Offload</strong></td>
<td><strong>Sensor Data Sharing</strong></td>
</tr>
<tr>
<td>Dependent on available RF links</td>
<td>Distribute data</td>
</tr>
<tr>
<td><strong>Dynamic Maps</strong></td>
<td><strong>Platooning</strong></td>
</tr>
<tr>
<td>Broadcast updated lane-level maps with real time context</td>
<td>Auto driving fleet of vehicles</td>
</tr>
<tr>
<td><strong>Real-Time Road Awareness</strong></td>
<td><strong>See Through</strong></td>
</tr>
<tr>
<td>Dynamic queue warning, traffic light recognition</td>
<td>Video data exchange between vehicles</td>
</tr>
<tr>
<td><strong>Vulnerable Road Users</strong></td>
<td><strong>Remote Driving</strong></td>
</tr>
<tr>
<td>Enable pedestrian detection with low latency</td>
<td>Remote control of autonomously driving vehicles</td>
</tr>
<tr>
<td><strong>Algorithm Tuning</strong></td>
<td><strong>Distributed AI</strong></td>
</tr>
<tr>
<td>Dynamic updates to ease man to machine transition</td>
<td>Distributed self-learning algorithms and artificial intelligence</td>
</tr>
</tbody>
</table>
## V2X Sensor for Automated Cars: Needed for L3 – L5

<table>
<thead>
<tr>
<th>Automated Car</th>
<th>Autonomy levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>LIDAR</strong></td>
<td>✓</td>
</tr>
<tr>
<td>Light detection and ranging</td>
<td></td>
</tr>
<tr>
<td><strong>Camera</strong></td>
<td>✗</td>
</tr>
<tr>
<td><strong>V2X</strong></td>
<td>✗</td>
</tr>
<tr>
<td><strong>RADAR</strong></td>
<td>✗</td>
</tr>
</tbody>
</table>

Sources: NHTSA; U.S. Department of Transportation

*Commercial cars today*
Automated V2X Software

Sensing
- Remote Sensing (RADAR, Vision, LiDaR)
- Collaborative Sensing (C-V2X)
- Global Positioning & MAP
- Vehicle Dynamic Sensing (Yaw Rate)

Perception
- Target Detection & Classification
- Road Attribute Detection & Classification

Applications
- Sensor Fusion
- Threat Assessment
- Path Planning

Actuation
- Dynamic Control
- HMI Control

Automated V2X
3rd Party Integration
Sensor Fusion of V2X and Other Sensors

Cooperative Automated Driving

Connected

Automated

Local Sensors

Perception

Mapping

Localization

Path Planning

Actuator

CV2X Data

Cooperative Perception

Cooperative Mapping

Cooperative Localization

Cooperative Path Planning

Actuator

Fusion

Local Sensors

SAVARI
Cooperative Perception, Mapping & Localization

Perception
- Enables the driver to know the traffic situation even beyond line-of-sight or beyond field-of-view

Mapping
- Enable live maps to be fused with V2X data

Localization
- Extract map data such as road geometry, traffic signs and landmarks from V2X data
Shaping the future of V2X

- Radio Agnostic
- Connected, Automated
- Infrastructure Services
OEMs, Infrastructure, Mobile Operators

- Ford, Nokia, AT&T - US
- Audi, Vodafone - Germany
- SAIC, China Mobile - China
5GAA

Semiconductor

HUAWEI

intel

QUALCOMM

SAMSUNG

5G Automotive Association
Thank you