ITS Standards and Technology, C-V2X Integration

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The Visible Automotive Trends

Electrification (Electric)
- The electric car
- HEV → EV, all electric
- Wireless charging

Telemetry (Connectivity)
- The connected car
- Like a smartphone, multiple connectivity
- C-V2X (4G/LTE → 5G)

ADAS (Autonomy)
- The autonomous car
- Challenges: security, trust, and... connectivity

IVI (AR/VR)
- The UX car
- Digital cockpits, HUDs, supplemented with AR/VR
- Connectivity is key

Connectivity is key, both wireless & wired

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Other Trends, CE to Automotive

Consumer/Mobile Demands

- **Reduced device size:**
  - Smaller nodes/chips, packages, passives, IO
- **Reduced power:**
  - Silicon/system-level solutions
- **Evolving user I/O:**
  - More touch
  - Less-touch: 60 GHz radar sub-mm, voice interface, facial recognition
- **Wireless charging**
- **Seamless UI/UX experience**
- **Integration to Android**

Additive Automotive Demands

- **Safety**: more reliability
- **Harsher environment:**
  - *Greater*: distance, power, voltages, thermal, vibration
  - More radios: coexistence challenges
  - Environment/lifetime-aware tooling: silicon IP, EDA/Verification
- **Longer lifespan** (10’s not 1’s of years)
  - A phasing out technology doesn’t help
- **Fragmentation**: More car brands than mobile platforms, Diverse interfaces
- **Security**
  - Drive recorders
  - Parking sensors
Some Automotive Standards – Wireless, Software

3GPP
(ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC)

SAE International
C-V2X (Cellular V2X)

C2C-CC (EU)
(Car 2 Car - Comm. Consortium)
Auto-focused V2X profiles in Europe

ETSI ITS
C-ITS/V2X application standards

ISO 26262
ASIL Functional Safety

Vehicle Connectivity (wireless)

Telematics & Infotainment

Auto/Transport Industry Association

5GAA (5G Automotive Association)
Cross-industry consortia defining C-V2X and 5G in automotive

Software Standards/Platforms:
AGL (Automotive Grade Linux)
Linux Foundation
GENIVI Alliance
IVI Software platform
AUTOSAR (Open System Arch)
Software architecture
ITS Software Stack Providers
Numerous

CCC
(Car Connectivity Consortium)
Smartphone-centric car connectivity solutions, e.g. MirrorLink, Digital Key

ITS: Intelligent Transport Systems
SAE: Society of Automotive Engineers

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Qualcomm
Some Automotive Standards – Wired

**Legacy/Incumbent:**
CAN, LIN, LVDS, Ethernet, etc.

**IEEE:** Ethernet TSN-AVB

**USB-IF:** USB...

**PCI-SIG:** PCIe...

**CCIX:** Cross-chip cache coherency

**MIPI (Modem):** RFFE, SPMI, DigRF

**JEDEC**
LPDDR, DDR, UFS, e.MMC, NVDIMM, etc.

**MIPI (Storage)**
M-PHY, UniPro (for UFS)

**ISO 26262**
ASIL Functional Safety

**Vehicle Connectivity (wired)**

**Multimedia**

**Memory/Storage**

**SD Association (SDA):** SD

**NVM Express:** NVMe

**VESA**
DP, eDP (Display Port)
DSC, VDC-M
Automotive Group (use cases, reqmts)

**HDMI, HDCP**

**MIPI (Multimedia)**
CSI (camera), DSI (display), 13C (touch), SoundWire (audio)
Automotive Work Group (New A-PHY)

**TSN:** Time sensitive network
**AVB:** Audio video bridging
**DSC:** (VESA) Display stream compression
**VDC-M:** VESA Display Compression - Mobile

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Intelligently connecting the car to surroundings and cloud

V2V
Vehicle-to-vehicle
e.g., collision avoidance safety systems

V2I
Vehicle-to-infrastructure
e.g., traffic signal timing/priority

V2P
Vehicle-to-pedestrian
e.g., safety alerts to pedestrians, bicyclists

V2N
Vehicle-to-network
e.g., real-time traffic/routing, cloud services

Enhanced range and reliability for direct communication without network assistance

C-V2X
Establishes the foundation for safety use cases and a continued 5G NR C-V2X evolution for future autonomous vehicles

- Release 14 C-V2X completed in 2017
- Broad industry support—5GAA
- Global trials started in 2017
- Our 1st announced C-V2X product in September, 2017

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C-V2X enables network independent communication

Direct safety communication independent of cellular network
Low latency Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and Vehicle to Pedestrian (V2P) operating in ITS bands (e.g. 5.9 GHz)

- Direct PC5 interface
  e.g. location, speed, local hazards

Network communications for complementary services
Vehicle to Network (V2N) operates in a mobile operator's licensed spectrum

- Network Uu interface
  e.g. accident 2 kilometer ahead

Diagram:
- V2I (PC5) to RSU
- V2V (PC5) to vehicle
- V2P (PC5) to pedestrian
- V2N (Uu) to eNodeB

1. RSU stands for roadside unit
C-V2X reuses upper layers defined by automotive industry

Reuse of DSRC/C-ITS established service and app layers
- Already defined by automotive and standards communities, e.g. ETSI, SAE
- Developing abstraction layer to interface with 3GPP lower layers (in conjunction with 5GAA)

Reuse of existing security and transport layers
- Defined by ISO, ETSI, and IEEE 1609 family

Continuous enhancements to the radio/lower layers
- Supports the ever-evolving V2X use cases
C-V2X complements other ADAS\(^1\) sensor technologies

Provides 360° NLOS\(^2\) sensing for higher levels of predictability and autonomy

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**Brain of the car to help automate the driving process by using:**

Sensor fusion | Machine learning

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1 Advanced Driver Assistance Systems; 2 Non-line of Sight

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C-V2X offers key advantages in multiple dimensions

Enhanced range and reliability for direct communication without network assistance

- Enhanced range and reliability
- Up to 500km/h relative speed support
- More cost efficient than other technologies
- Forward compatible evolution path to 5G

Self managed for reduced cost and complexity
Synergistic with cellular modem
Leverage of cellular ecosystem
Reuse of SAE/ETSI upper layers

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Qualcomm®
9150 C-V2X Chipset

The Qualcomm 9150 C-V2X chipset with integrated GNSS will be featured as a part of the Qualcomm® C-V2X Reference Design to deliver a complete solution for trials and commercial development.

Driving C-V2X towards commercialization

Qualcomm Technologies, Inc.’s (QTI) first-announced C-V2X solution supports C-V2X Direct Communications (V2V, V2I and V2P) based on 3GPP Release-14.
C-V2X gaining support from automotive and telecom leaders
5GAA is a cross-industry consortia to help define C-V2X and its evolution to 5G

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


Source: [http://5gaa.org/](http://5gaa.org/); accurate as of January, 2018
Summary and Forward Note

- Connectivity forms the center piece of ITS, and developed countries have a mandate on ITS involving connectivity aspects
  - The race towards automated driving is heating up across the industry
- Our focus remains in bringing the best technologies and products to commercialization, supported by a long-term roadmap, and in a manner that helps ensure mass adoption, and promotes innovation
- Furthermore, we are committed to an automotive vision, which enables continually safer and more automated driving experiences, to which sensors including V2X are integral
- India, being in the cusp of societal transformation, has an opportunity to leapfrog into & doing the right things
Backup
C-V2X is gaining momentum
Trials started in 2017 using the Qualcomm 9150 C-V2X solution

Global trials

ConVeX trial in Germany
Qualcomm, Audi, Ericsson, SWARCO, U. of Kaiserslautern

Towards 5G trial in France
Qualcomm, PSA Group, Orange, Ericsson

Ford trials in US
Qualcomm, AT&T, Ford, Nokia and McCain with SANDAG, Caltrans and the City of Chula Vista

Nissan trials in Japan
Qualcomm, Continental, Ericsson, Nissan, NTT DOCOMO, INC., OKI

C-V2X specifications completed in 2017

More trials to follow in 2018
C-V2X has strong evolution path towards 5G NR
While maintaining backward compatibility

Evolution to 5G NR, while being backward compatible
C-V2X R14/R15 is necessary and operates with R16

Basic and enhanced safety
C-V2X R14/R15 with enhanced range and reliability

Autonomous driving use cases
5G NR based C-V2X R16
- Backward compatible with R14/R15 enabled vehicles
- Higher throughput
- Higher reliability
- Wideband ranging/positioning
- Lower latency
R16 5G C-V2X complements R14 with new capabilities

Targeting new use cases for autonomous diving

**R14 C-V2X**
Automotive Safety

- Do not pass warning (DNPW)
- Intersection movement assist (IMA) at a blind intersection
- Blind curve/Local hazard warning

**R16 5G C-V2X**
Autonomous Driving

- Local high definition maps / “Bird’s eye view”
- Intention/Trajectory sharing
- High throughput sensor sharing
- Wideband ranging and positioning
V2X Definitions

- Mobile networks and technologies are at the heart of many of these advances through Cellular Vehicle-to-Everything (C-V2X) connectivity, which supports four basic use cases
  - Vehicle-to-Network (V2N): Connects vehicles to the mobile network to support services like streaming media for entertainment and connectivity for dynamic route management, etc.
  - Vehicle-to-Vehicle (V2V): Directly connects vehicles for early warnings (e.g. an upcoming emergency) including beyond line of sight so augments shorter-range on-board sensors
  - Vehicle-to-Infrastructure (V2I): Directly connects vehicles to roadside infrastructure like traffic lights which in turn can be connected to the wider mobile network
  - Vehicle-to-Person (V2P): Directly connects vehicles to pedestrians equipped with compatible mobile devices to issue alerts about potential dangers nearby