In the framework of SESEI

In association with CII Confederation of Indian Industry

3rd Indo-European Conference on Standards and Emerging Technology

26th April, 2018 – New Delhi

ITS Standards and Technology, C-V2X Integration

Presented by Dr. Vinosh Babu James

Qualcomm

The Visible Automotive Trends

Electrification (Electric)

- The electric car
- HEV → EV, all electric
- Wireless charging

Telemetry (Connectivity)

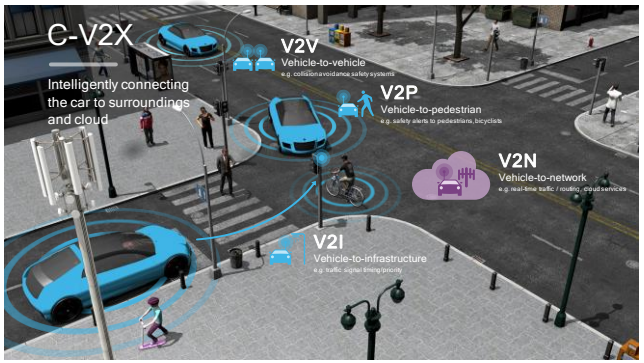
- The connected car
- Like a smartphone, multiple connectivity
- C-V2X (4G/LTE → 5G)

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

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

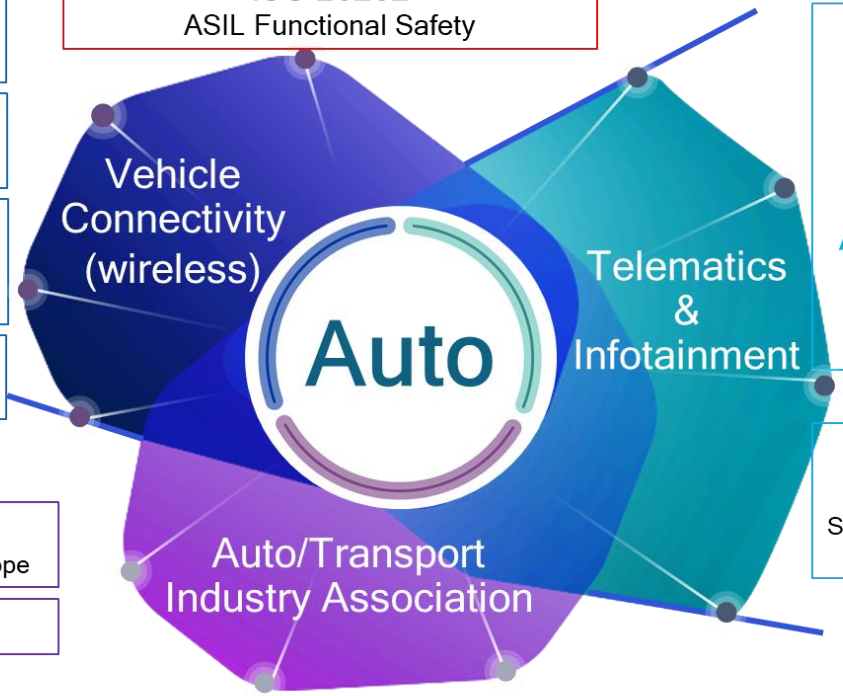
3GPP
(ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC)

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



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 Europe (ERTICO)
C-ITS and eCall community in Europe

ITS America

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

ITS: Intelligent Transport Systems
SAE: Society of Automotive Engineers

Some Automotive Standards – Wired

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

+

IEEE: Ethernet TSN-AVB

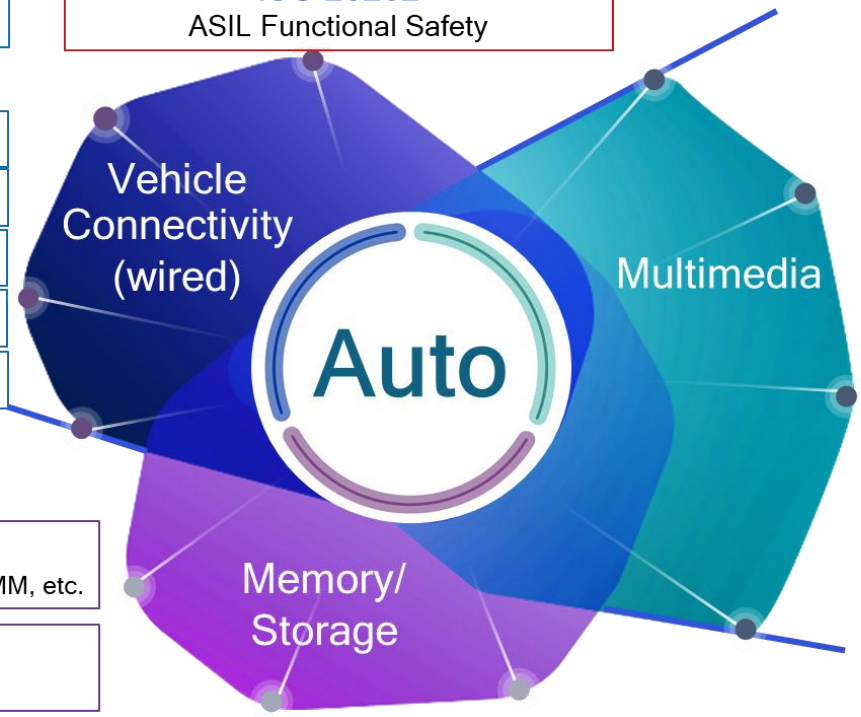
USB-IF: USB…

PCI-SIG: PCIe…

CCIX: Cross-chip cache coherency

MIPI (Modem): RFFE, SPMI, DigRF

ISO 26262
ASIL Functional Safety



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

HDMI, HDCP

MIPI (Multimedia)
CSI (camera), **DSI** (display), **I3C** (touch),
SoundWire (audio)
Automotive Work Group (New A-PHY)

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

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

SD Association (SDA): SD

NVM Express: NVMe

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

Intelligently connecting the car to surroundings and cloud

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

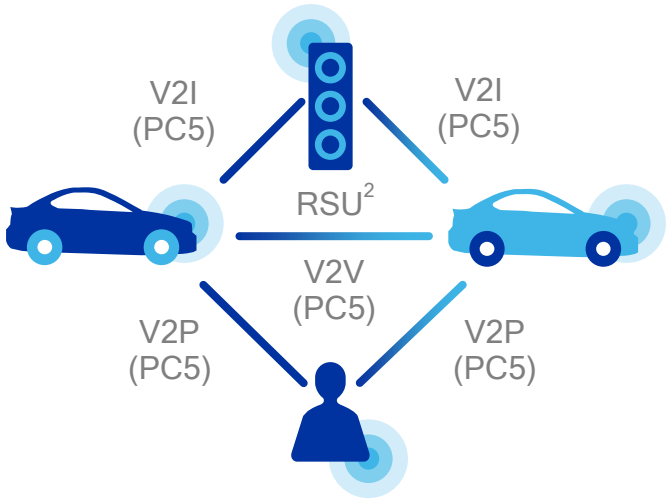
C-V2X enables network independent communication

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

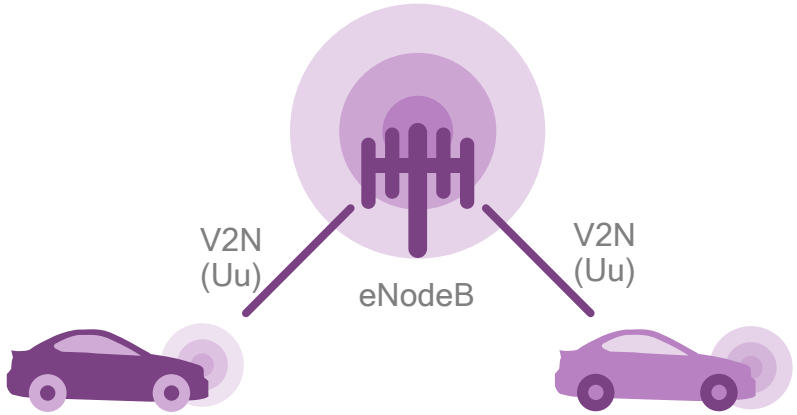


Network communications for complementary services

Vehicle to Network (V2N) operates in a mobile operator's licensed spectrum

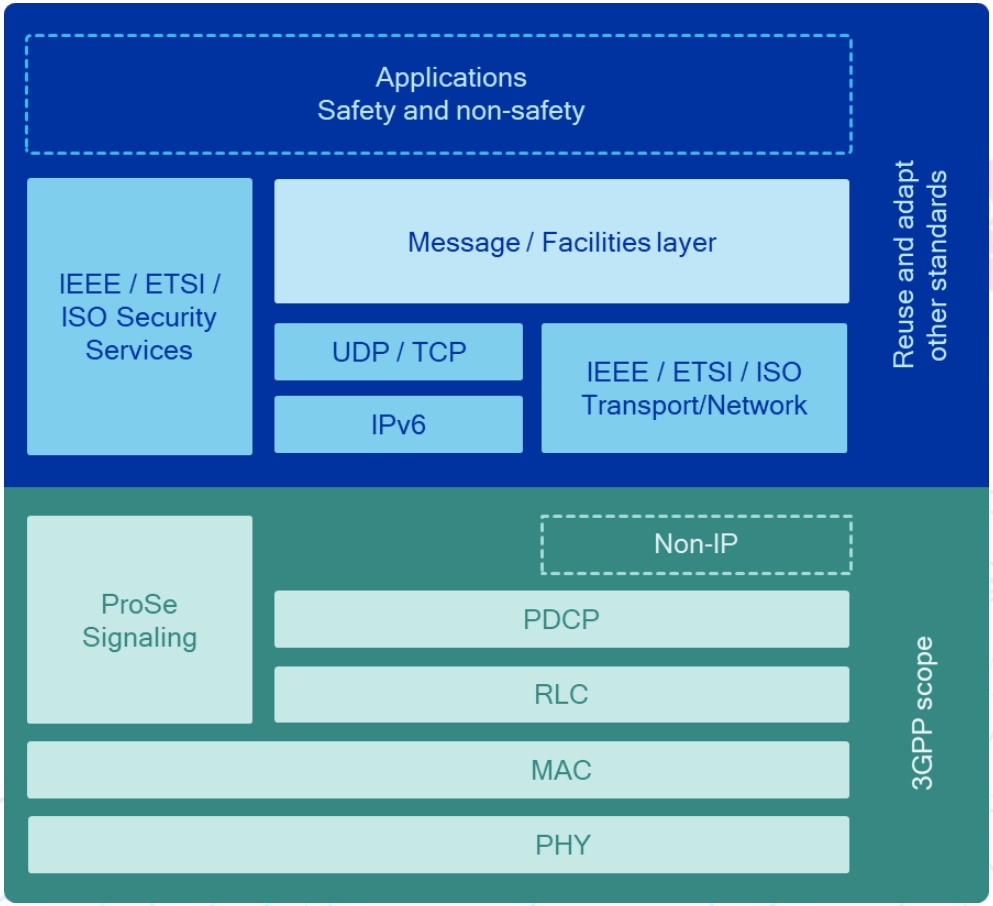
Network Uu interface

e.g. accident 2 kilometer ahead



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

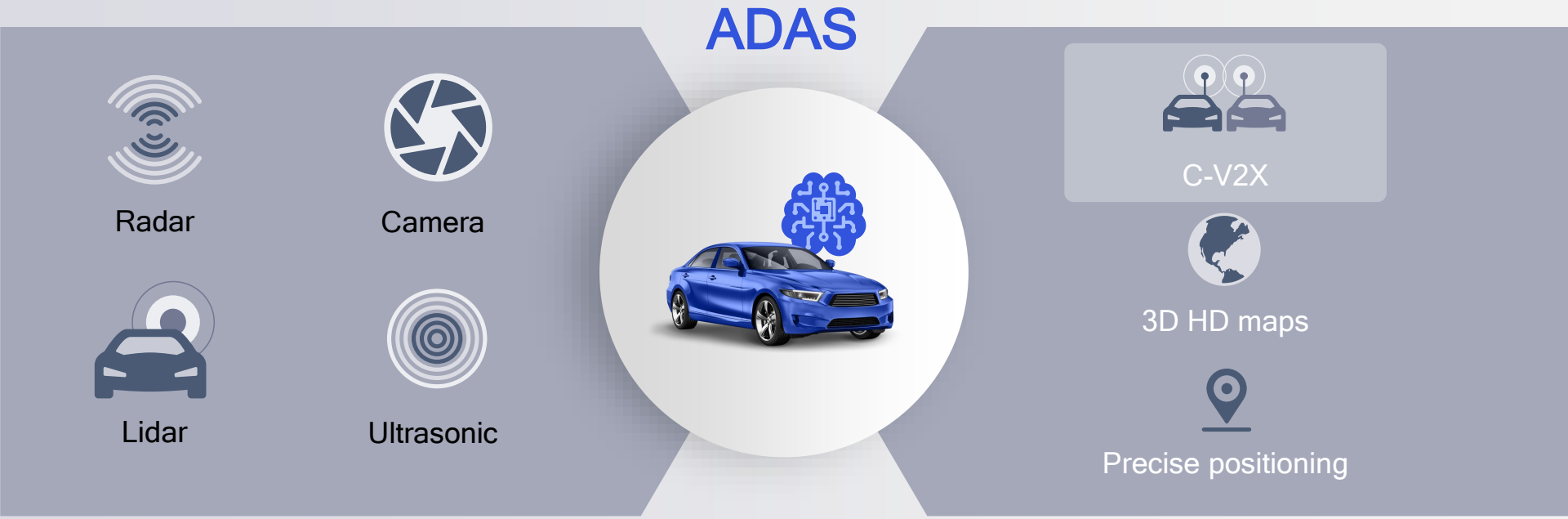
- Defined by ISO, ETSI, and IEEE 1609 family

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



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

Sensor fusion | Machine learning

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

C-V2X offers key advantages in multiple dimensions

Enhanced range and reliability

More cost efficient than other technologies

Up to 500km/h relative speed support

5G NR

Forward compatible evolution path to 5G

Enhanced range and reliability for direct communication without network assistance

Self managed for reduced cost and complexity

Synergistic with cellular modem

Leverage of cellular ecosystem

Reuse of SAE / ETSI upper layers

Qualcomm

9150
C-V2X

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

5GAA Automotive Association

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

Airgain Alpine Electronics Analog Devices Anritsu EMEA Ltd AT&T Audi BAIC Beijing University Bell Mobility BMW Bosch CATT Cetecom China Transinfo China Unicom CMCC Continental Daimler Danlaw DEKRA Denso Deutsche Telekom Ericsson FEV Ficosa Ford Fraunhofer Gemalto Hirschman Car Hitachi Automotive US Honda Huawei Infineon Intel Interdigital Jaguar Land Rover Juniper KDDI Keysight KT Laird Tech LG Murata Nissan Nokia NTT DoCoMo OKI Orange P3 Group Panasonic Proximus PSA Qualcomm Rohde & Schwarz Rohm SAIC Samsung Savari SIAC SK Telecom Skyworks Softbank Sumitomo Telefonica Telekom Austria Telstra TÜV Valeo Veniam Verizon Viavi Vodafone Volkswagen (VW) ZF ZTE

Source: 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

C-V2X specifications completed in 2017

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

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

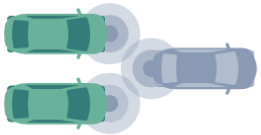
Basic safety
IEEE 802.11p

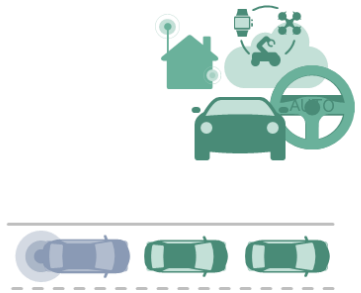
Basic and enhanced safety
C-V2X R14/R15 with enhanced range and reliability

Autonomous driving use cases
5G NR based C-V2X R16

Backward compatible with R14/R15 enabled vehicles

- Higher throughput
- Wideband ranging/positioning
- Higher reliability
- Lower latency





R16 5G C-V2X complements R14 with new capabilities

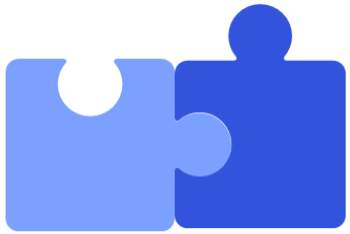
Targeting new use cases for autonomous diving

Do not pass warning (DNPW)

Intersection movement assist (IMA) at a blind intersection

Blind curve/ Local hazard warning

R14 C-V2X
Automotive Safety



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