Conformity Assessment Strategy Evaluation (CASE)

5GAA Automotive Association
Technical Report

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VERSION:	Version 5.0
DATE OF PUBLICATION:	22 June, 2022
DOCUMENT TYPE:	Technical Report
EXTERNAL PUBLICATION:	Yes
DATE OF APPROVAL BY 5GAA BOARD:	23 May, 2022

Contents

Foreword

This Technical Report has been produced by 5GAA.

The contents of the present document are subject to continuing work within the Working Groups (WG) and may change following formal WG approval. Should the WG modify the contents of the present document, it will be re-released by the WG with an identifying change of the consistent numbering that all WG meeting documents and files should follow (according to 5GAA Rules of Procedure).

Introduction

The automotive industry is moving from a world where vehicles were entirely independent entities under the full control of the manufacturer for the life of the vehicle to a world where every vehicle is connected to every other vehicle as well as road infrastructure and no longer under the total control of the manufacturer. This is because certain aspects of the vehicle's performance (especially safety aspects) will be dependent on other entities, e.g. similarly enabled vehicles, road infrastructure and network coverage. One of the key technologies enabling this transformation is C-V2X.

Over and above connecting vehicles, C-V2X has the potential to improve traffic safety and efficiency, thereby saving lives, preventing injuries, improving traffic flow, and reducing emissions. To allow the industry to fully realise the benefits of this technology, it is critical for C-V2X-enabled devices (chipsets, modules, OBU's, RSU's) to:

- Comply with the relevant standards (global and regional performance criteria)
- Seamlessly interoperate with devices from other brands
- Successfully demonstrate the technology works as designed in the various trials
- Reach a critical mass of C-V2X enabled vehicles as quickly as possible
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To achieve these goals steps need to be taken to ensure devices interoperate and meet relevant communication standards.

An extremely high degree of interoperability and performance has been achieved by the cellular industry. Most people now take for granted that our mobile phones work in any country, all the time. This was not always the case so lessons from the cellular industry can be learned and leveraged.

1 Scope

Based on the outcome of WG3 WI3.3 ‘General Aspects and Strategy to Assess System Performance, Interoperability, and Conformance’ (TR P-180065), where an overview and general structure of a conformance assessment scheme has been proposed, the CASE Work Item evaluated a practical 5GAA strategy along with guidelines for Conformance Assessment (CA). Since it is expected that the communication CA over the Uu interface will be driven by MNOs, along with relevant certification organisations (e.g. GCF), and thus included in the already existing CA schemes of the telecommunication industry, this WI place special focus on the PC5 interface.

The goal of this WI is to develop a proposal for a cost-effective, voluntary process for C-V2X Conformity Assessment which could be applied globally.

The WI comprised of five discrete tasks:

- Stimulate auto industry awareness in CA among members and collect a list of supporting OEMs
- Document regional CA status
- Review CA for Dedicated Short Range Communications (DSRC) to learn lessons for C-V2X
- Develop a Cost-Benefit Analysis of CA adoption
- Propose a framework for a harmonised CA

2 References

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] Global Certification Forum (GCF) http://www.globalcertificationforum.org/

[2] WG3 WI3.3 ‘General Aspects and Strategy to Assess System Performance, Interoperability, and Conformance’ (TR P-180065)

[3] Utah DOT Deployments - Partnership with Panasonic to Build “Smart Roadways” Data Network Announced | UDOT (utah.gov)

[4] Colorado DOT Deployments - https://www.codot.gov/news/2018/july/cdot-and-panasonic-take-first-steps-to-turn-i-70-into-connected-roadway

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[7] Hawaii DOT Honolulu Deployments - https://appinfoinc.com/applied-information-cv2x-hawaii/

[8] Texas DOT Arlington Deployments - Texas DOT Arlington Deployments

[9] Virginia DOT Deployments - https://www.qualcomm.com/news/releases/2020/09/29/c-v2x-communication-technology-now-deployed-virginia-roadways

[10] Release 14 PC5 trial report (2019/5/31) NTT DoCoMo, Continental, Ericsson, Nissan, Oki, Qualcomm
https://www.nttdocomo.co.jp/binary/pdf/corporate/technology/rd/topics/2018/topics_181213_01.pdf

[11] 5G and C-V2X trial Softbank and Subaru (2020/11/24)
https://www.softbank.jp/en/corp/news/press/sbkk/2020/20201124_01/

[12] The complete CBA Final Report is available via 5GAA:

https://files.5gaa.org/remote.php/webdav/Work%20Items%20(WI%20%26%20XWI)/2.%20Closed%20Work%20Items/WG3_WI%20CASE%20(closed)/2.%20Deliverables/2.%20Task%204%20CBA/5GAAPC5CONFORMANCE-Final-Report-V2-CLEAN.docx

[13] Recommended Practices for DSRC Licensing and Spectrum Management - DSRC Licensing | National Operations Center of Excellence (transportationops.org)

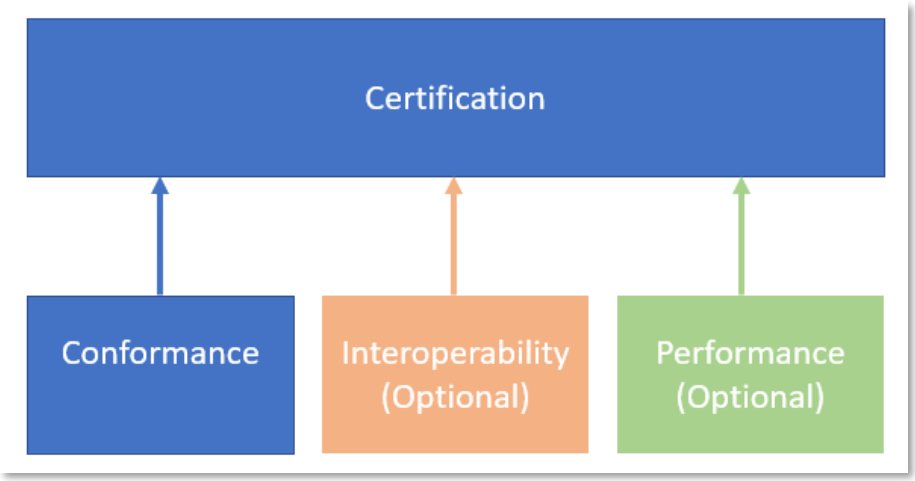
3 Definitions and Abbreviations

3.1 Definitions

For the purposes of the present document, the following definitions apply:

Certification	Results in the issuance of a Certificate. A Certificate can be awarded based on passing Conformance Assessment only but may also include some elements of Interoperability and Performance.
Conformance*	Conformance Assessment or compliance means checking that devices and services are implemented according to relevant reference specifications and standards. This is the focus of this WI.
Interoperability	Testing devices against other brands to ensure they work with each other. This is excluded in this WI and may be the subject of further work.
Performance	In the communications industry this is bi-lateral agreement on certain aspects of performance tests eg OTA. This is excluded in this WI.
Regulatory	Tests mandated by a regulator. This is excluded in this WI.

* Conformance, Conformity Assessment and Compliance are used interchangeably in this report.



3.2 Abbreviations

For the purposes of the present document, the following acronyms apply:

API	Application Interface
BS	Basic Software
C-V2X	Cellular Vehicle-to-Everything
CA	Conformance Assessment
CBA	Cost-Benefit Analysis
CVWS	Connected Vehicle Work Stream
DSRC	Dedicated Short Range Communications
ETSI	European Telecommunications Standards Institute
EVK	Evaluation Kit
FuSa	Functional Safety
GCF	Global Certification Programme
GNSS	Global Navigation Satellite System
HL	Higher Layer
HLT	Higher Layer Testing
HW	Hardware
I/O	Input/Output
IT	Integration Test
LL	Lower Layer
LLT	Lower Layer Testing
MNO	Mobile Network Operator
NS	Number of Services
OBU	On-Board Unit
OEM	Original Equipment Manufacturers
PCB	Printed Circuit Board
PTCRB	PCS Type Certification Review Board
RFQ	Request For Quotation
RO	Road Operator
ROI	Return on Investment
RSU	Road-Side Unit
SAR	Specific Absorption Rate
SDK	Software Development Kit

SOTIF	Safety of the Intended Functionality
SW	Software
TCU	Telematics Control Unit
TLC	TL Certification Centre
Uu	LTE Mobile Network Interface
VC	Value Chain
V2I	Vehicle-to-Infrastructure
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything

4 Conformity Assessment

Conformance Assessment, often also referred to as Compliance Testing, ensures the compliance of the developed product or feature with binding regulatory guidelines, quality standards and technical specifications. Testing will usually be done against a predefined set of reference test cases.

Conformance Testing concentrates on specific components or units in a system, according to a certain standard or set of related standards. It is conducted under controlled conditions using a dedicated test system which is normally developed by trusted test and measurement equipment vendors. Generally, Conformance Testing is thorough and accurate but limited in scope. It gives a high level of confidence that key components of a system are working as specified and designed. But a conformant component will not necessarily always interoperate with other components in a larger system.

In the mobile telecommunication industry, conformity assessment is handled by the Global Certification Forum (GCF), which was established mainly by Mobile Network Operators (MNO) in order to ensure that mobile devices have proven compliance with the GCF requirements. Even though the GCF process is a voluntary certification scheme, it is mandated by MNOs in order to prove that the tested device is not doing any harm to MNO infrastructure. Hence, the GCF certificate is typically required by MNOs who also sell mobile devices together with their customer contracts. Since the commonly used term 'Certification' in the communication industry often created confusion in discussions with automotive and security experts[1], the terms 'Compliance Assessment' or 'Conformance Assessment' are typically used instead in the EU.

4.1 The Case for a Conformity Assessment Scheme

A high level of interoperability between different brands and models of connected vehicles and infrastructure elements will be essential for the successful rollout of C-V2X. Nothing will damage go-to-market strategies more than C-V2X-enabled devices (OBUs and RSUs) failing to communicate with each other, negating the value proposition of the technology and increasing costs.

It is therefore essential to have a testing framework in place to assess how well devices comply with global and regional standards from the outset. Delaying the establishment of such a framework will increase the risk of poor end customer experience resulting in a lack of trust in the underlying technology, commercial deployment delays, and in the worst case, compromised safety.

4.2 The Position of the Automotive Industry

The willingness of the automotive industry to adopt Conformity Assessment is highly recommended and their position related to this topic is covered in **Section 5**.

4.3 Regional Status of Conformity Assessment

The current status of Conformity Assessment schemes around the world varies and detailed assessments for the regions listed below are covered in **Section 6**.

- China
- Europe
- North America
- South Korea
- Japan

4.4 Learning from Past DSRC Experiences

An investigation, led by SGS Taiwan, aimed to leverage best practices and avoid repeating mistakes that were made in the development of a CA scheme for DSRC. The study focused on North America and explored in particular the steps adopted by OmniAir who have a DSRC Certification Program in place. This is covered in **Section 7**.

4.5 Cost-Benefit Analysis

A Cost-Benefit Analysis was undertaken for the following reasons:

[1] 'Certification' in the automotive sector often refers to type approval. Type approval is a roadworthiness regulatory framework defined by a set of standards agreed at UNECE WP.29 level. We therefore avoid mentioning the term 'Certification' in this report.

- To address concerns that a Conformity Assessment scheme would be expensive for OEMs/Road Operators
- To determine the most optimal test scenario that should be adopted to keep costs to a minimum

After a selection process following a Request for Proposals, WG3 proposed to the 5GAA Board to have an external agency carry out the CBA. The successful proposal came from VVA (Valdani Vicari & Associati) who collaborated with Alter Technology. A summary of the report is presented in **Section 8.**

4.6 Harmonised CA Framework

The final task of the CASE WI was the development of a Harmonised CA Framework based on workflows from organisations such as GCF and OmniAir, which are currently in use today. The proposal is summarised in **Section 9.**

5 Position of the Automotive Industry

5.1 Design Cycle

The automotive industry is heavily regulated, which means it is not a simple exercise to change or modify components on vehicles. If a redesign or change of a component is required, another homologation[2] procedure would need to be carried out, which can be expensive and time consuming. Therefore, OEMs strive to design vehicles that do not need upgrades or modifications during the life of the vehicle. Of course, sometimes things happen or regulations change that necessitate some level of redesign, which then requires homologation and bears associated costs (kept to a minimum wherever possible).

One of the biggest issues that OEMs need to deal with related to vehicle connectivity is the comparison between the development time of the automotive and communications industries. The development life-cycle of a new vehicle model can be anywhere between three to six years and, by contrast, the cellular industry design cycles are in the range of only a few months. It is therefore clear that aligning these two 'cycles' for the Connected Vehicle is extremely challenging for OEMs.

5.2 Factors Related to RF Communications

Having a target specification for a TCU – e.g. a C-V2X OBU that could be sent to the supply chain or used in a RFQ and which outlines the RF and protocol performance – allows OEMs to focus on design aspects related to the vehicle.

5.3 Costs

Costs are a major factor in all decisions taken by OEMs. There is constant pressure to minimise costs and consequently testing is always scrutinised to see if there are any ways to reduce or keep them to an absolute minimum. Often OEM communications departments need to justify any additional expense required for testing modules and this can require detailed explanation and justification to upper management who are typically not knowledgeable on these technical subjects and don't understand what is required.

Testing of modules is often delegated to suppliers such as Tier 1 manufacturers but end-to-end testing is always handled by the OEMs. When it comes to testing for C-V2X, the wireless communications teams within OEMs often need to educate colleagues of the PC5 interface's benefits and what standards need to be adhered to. It is the case that some OEMs prefer to carry out testing themselves, rather than the supplier, as they must bear the cost themselves regardless of who performs the testing.

Whether tested in-house or externalised, the OEM would take these tested modules, install them in vehicles and then carry out end-to-end performance tests against their back-end servers. As most OEMs typically only test at the vehicle level, test and certification of C-V2X OBUs would normally be carried out by the OEM suppliers.

Typically, OEMs produce a quote and the Tier 1 manufacturers then respond. This process involves several rounds of negotiation to ensure all aspects are covered until a final offer/quote is submitted. Since everything in a vehicle must have a specification associated with it (from buttons on the dashboard to RF modules), the fact that a PC5 specification and/or

[2] Homologation is the term for the whole vehicle approval process. An approval is a government-issued certificate that allows a product to enter a market.

Conformance Assessment is not widely available does pose a problem for the OEM as to what to specify in the RFQ. At least for some OEMs, a harmonised CA for PC5 and a Certification scheme to prove a module had achieved its designed performance and Interoperability goals would be helpful.

It is likely that Road Operators (ROs) would have a similar position as they also produce RFQs for their infrastructure requirements and suppliers respond in the same way as for OEMs. A harmonised specification and Conformance Assessment for PC5 would allow ROs to accurately specify this to their suppliers. However, as mentioned previously, there will be costs associated with this additional requirement that would ultimately be borne by the OEMs or ROs as specifiers – and these costs need to be justified.

6 Regional Status of Conformity Assessment

6.1 China

While it is acknowledged that China is first to commercially deploy C-V2X services, the overall structure of Regulation and Standards Development is complex – an overview of the stakeholders in China can be seen in the **Figure 1**.

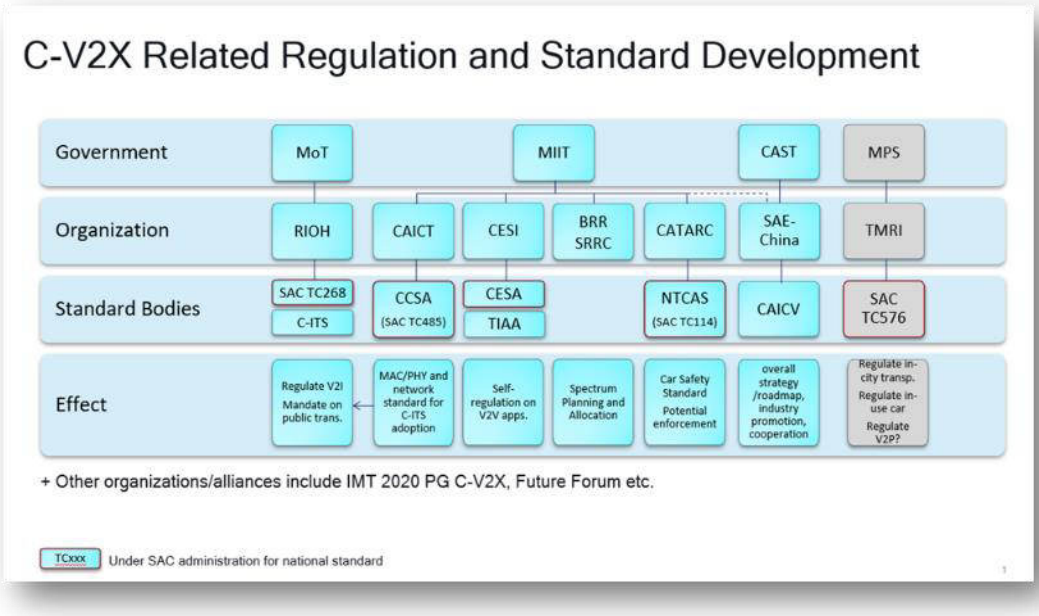


Fig 1: Chinese C-V2X Regulation and Standards Development Structure

6.1.1 Chinese Regional CA Strategy

Communications Industry:

CA focused on C-V2X terminals, e.g. OBU and RSU and will include RF and conformance checks such as access layer, network layer, message layer tests.

Automotive Industry:

CA focused on the vehicle level, e.g. application functional Conformity Assessment (i.e. verify that C-V2X application layer functions comply to standards).

Transportation Industry:

CA focused on Roadside Infrastructure and commercial vehicles, e.g. transportation equipment Conformity Assessment (i.e. RSU application requirements and related interface conformance, such as the interface between RSU and traffic lights, etc).

6.1.2 Chinese CA Objectives

Chinese Conformity Assessment will include the following product categories:

- V2X Chipset/Module
- V2X OBU
- V2X RSU
- V2X Server
- Passenger vehicle equipped with V2X OBU
- Commercial vehicle equipped with V2X OBU
- Road-Side Infrastructure equipped with V2X RSU

6.1.3 Conformity Assessment Processes

There is currently no clear mandatory Certification for C-V2X, however there is a Certificate for Protocol Conformance Test (PCT) available via TL Certification Centre Ltd.

6.1.4 CA Roles and Responsibilities

6.1.4.1 CATARC

China Automotive Technology and Research Centre (CATARC) is a science research institute established in 1985 to meet China's automotive industry management needs. CATARC is the centralised technical organisation of the auto industry and the technical supporting body to the relevant national government departments.

6.4.1.2 IMT2020(5G) PG C-V2X WG

IMT-2020 Promotion Group was jointly established in 2013 by three ministries of China [including the Ministry of Industry and Information Technology (MIIT), National Development and Reform Commission (NDRC) and Ministry of Science and Technology (MOST) (5G)] based on the original IMT-Advanced Promotion Group. IMT-2020 (5G) Group C-V2X Working Group is committed to promoting and integrating innovation among ICT, automobile, transportation, and other sectors. C-V2X Working Group has attracted over 168 members, and a number of partners with 5GAA in common. C-V2X Working Group is the major platform to promote LTE-V2X and 5G-V2X technology research, verification, and industry development in China.

6.4.1.3 Chinese Communication Standardisation Association

The Chinese Communication Standardisation Association (CCSA) was established on 18 December 2002 to establish a national and unified communications standardisation organisation that can adapt to market demand and align with international standards and national conditions. Its remit was forged on the basis of the former Research Group of Communication standards, with the approval of the former Ministry of Industry and Information Technology, the Standardisation Administration of the People's Republic of China, and the Ministry of Civil Affairs.

6.4.1.4 NTCAS: SC34 (Automobile)

Formally, the MIIT is responsible for standardisation within the automotive industry. The National Technical Committee of Auto Standardisation (NTCAS), which is also the name of the standardisation body SAC/TC114, works under the leadership of the MIIT. Its task is to establish and further develop standards applicable to NEVs, including FCEVs, as well as for relevant parts and components. NTCAS was established in 1988 and has 30 technical subcommittees. As the national road vehicle standardisation organisation, NTCAS represents China in the corresponding international bodies ISO/TC22, IEC/TC69 and UNECE WP29. Its secretariat is part of CATARC.

6.4.1.5 CSAE/CAICV V2X WG (Automobile)

The Chinese Society of Automotive Engineers (C-SAE) was founded in 1963 to promote the healthy and sustainable development of China's automotive industry. At present, C-SAE has several tens of thousands of individual members and many thousands of corporate members. The Chinese Industry Innovation Alliance for the Intelligent and Connected Vehicles (CAICV) was established on 12 June 2017. It is the industry alliance under C-SAE and the Chinese Association of Automobile Manufacturers (CAAM) that focuses on Intelligent Connected Vehicle-related technology development and industry promotion. It is supported and administered by MIIT. CAICV now counts more than 500 members: automotive manufacturers (Tier 1 and Tier 2), ICT companies, ITS players, universities as well as research institutes.

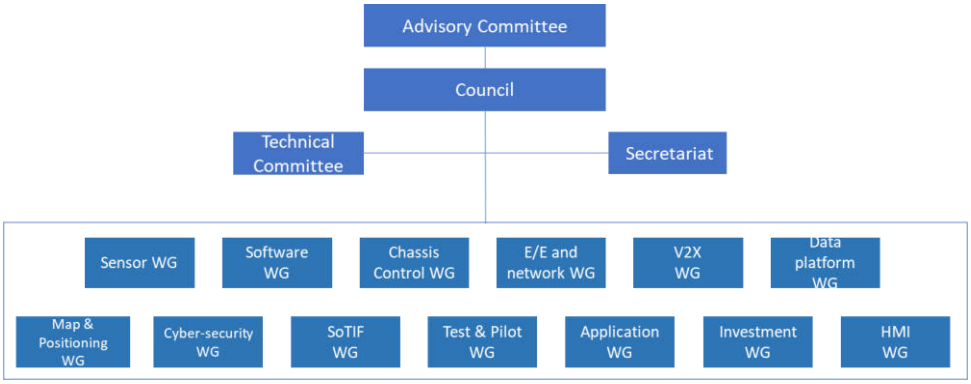


Fig 2: WGs under CAICV

CAICV works on ICV-related standards, including autonomous/perception/vehicle control, HD mapping and positioning, V2X/cooperative vehicle and infrastructure systems, FuSa/SoTIF, vehicle E/E and in-vehicle networks, etc. The figure below gives an overall picture of the standards that CAICV works on.

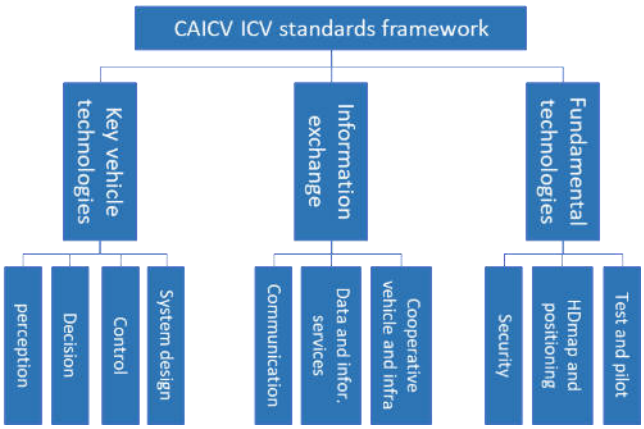


Fig 3: CAICV Standards Framework

CAICV has been working on V2X-related standards since 2017, shortly after it was established. The focus has been on the V2X-related message set and application standards as well as related profile standards. The table gives a full list of the V2X standards that CAICV published as well as those it is currently working on.

6.1.5 Certification Authorities and Test Labs

CAICT

The China Academy of Information and Communications Technology (CAICT) is subordinate to the MIIT and is an increasingly important player in all aspects of China's telecommunications and now digital economy sectors. Formerly known as the China Academy of Telecommunications Research (CATR), it is still sometimes referred to by this name in industry circles. CAICT is a major player in China's 5G mobile communications network trials. Chinese government ministries are already conducting 5G trials to certify equipment compliance with performance and other technical

standards, with the third phase completed in mid-2018. MIIT is overseeing these, with CAICT in particular playing the role of a key technical certifier in the IMT-2020 Promotion Group, a 5G development agency constituted by MIIT, the National Development and Reform Commission (NDRC), and the Ministry of Science and Technology (MOST).

CATARC

China Automotive Technology and Research Centre is a science research institute established in 1985 to meet China's automotive industry management needs. CATARC is the centralised technical organisation of the auto industry and the technical supporting body to the relevant national government departments.

TL Certification Centre Ltd.

Under the instruction of IMT-2020 C-V2X WG, TL Certification Centre Ltd. established the Certificate for LTE-V2X protocol conformance certification. The Centre is responsible for Certification application, materials review and related certificate issuing work.

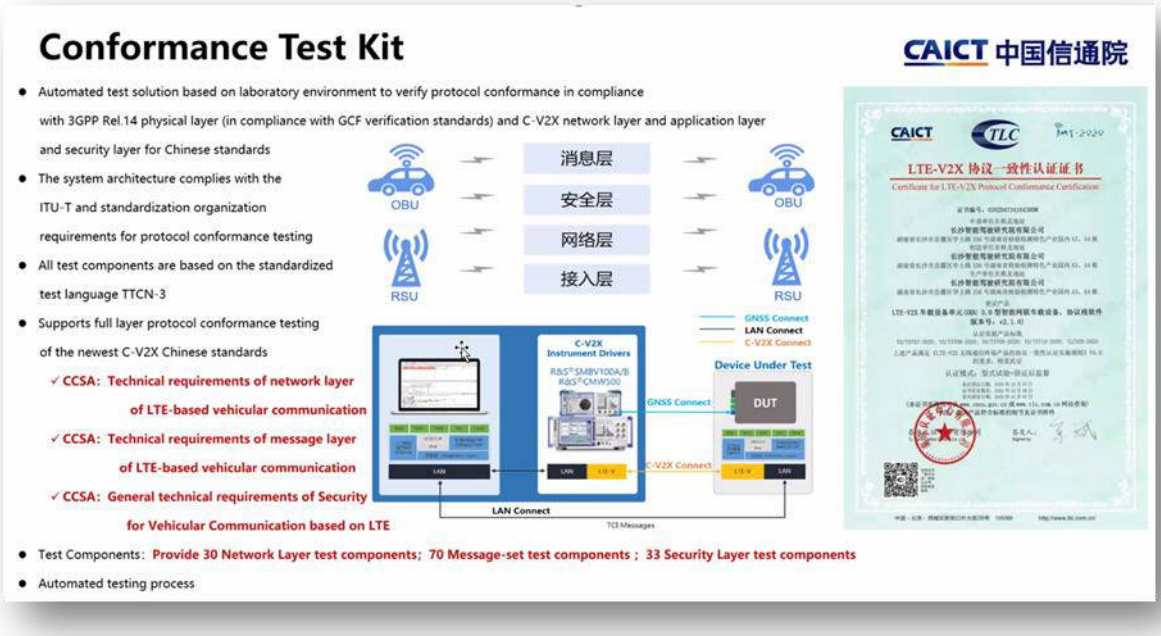


Fig 4: C-TLC Protocol Conformance Test

6.1.6 Applicable Standards

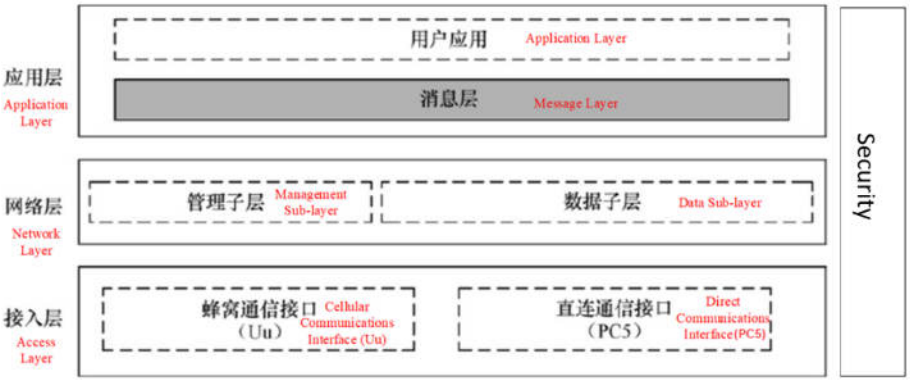


Fig 5: Chinese Standards

CSAE 246-2022 ‘Test and Evaluation Methods for V2X System Warning Application Function of Intelligent and Connected Vehicles’. Chinese standards are documented in **Annex A**.

6.1.7 Relevant/Significant Dates

China has an ongoing series of trials.

6.1.8 Regional Activities (Plugfests, Trials, etc.)

Four Layers Interoperability V2X Application Demonstration

From 22-24 October 2019, IMT-2020(5G) Promotion Group C-V2X Work Group, China Industry Innovation Alliance for the Intelligent and Connected Vehicles, SAE-China and Shanghai International Motor City (group) Co. Ltd. jointly held a ‘Four Layers’ Interoperability V2X Application Demonstration in Shanghai. This project realised the first C-V2X application demonstration in China spanning the isolation of chip modules, terminals, vehicles, and security platforms. The activity fully demonstrated the whole chain of C-V2X technical standard capability, and further promoted the implementation of C-V2X industrialisation in China.

2020 C-V2X New Four Layers and Large-scale Pilot Plugfest ITS

This C-V2X demonstration was made up of two parts: the ‘New Four Layers’ component and the ‘Large-scale Pilot Plugfest’. The first part is based on the 2019 ‘Four Layers’ demo, adding high-precision map and positioning, adopting a new digital certificate format, and exploring technical solutions to the map and positioning regulatory issues faced by C-V2X. The Pilot Plugfest part focuses on verifying the scaled operational capability of C-V2X and the cross-regional mutual recognition of C-V2X security authentication systems. The key point is to provide 200 vehicles equipped with C-V2X terminals to implement all standard protocols including the physical layer, network layer, message layer and security layer, and to provide a full range of security protocols. Communication performance and functional tests are carried out for the whole industrial chain.

6.1.9 Observations

Recent C-V2X-enabled vehicle announcements can be seen in Fig 6.

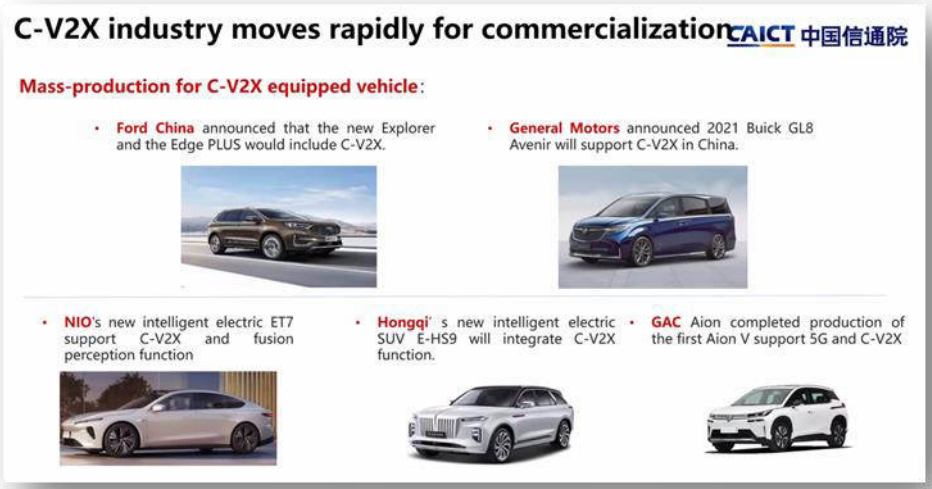


Fig 6: Chinese OEM Announcements

6.1.10 China Summary

While there may still be some uncertainty as to when the relevant Chinese standards will move from ‘draft’ to ‘completed’ and formally approved, it is clear that China is moving ahead with C-V2X faster than any other region. The main stakeholders include companies from the telecom industry as well as automotive industry.

6.2 Europe

6.2.1 Regional CA Strategy

At present there is no specific Conformity Assessment for C-V2X (nor ITS-G5) for Europe. Neither is there an identified organisation responsible to undertake the testing requirements.

Three key problems in Europe are:

- Lack of interoperability and continuity of applications, systems and services
- Lack of effective cooperation among stakeholders
- Unresolved issues related to the availability and sharing of data supporting ITS services

6.2.2 Regional CA Objectives

European objectives for CA are regarded to be:

- Increase interoperability and cross-border continuity of ITS applications, systems and services
- Establish effective coordination and monitoring mechanisms between all ITS stakeholders
- Solve issues related to the availability and sharing of data which support ITS services

6.2.3 Conformity Assessment Processes

Currently there is no C-V2X Conformity Assessment in place in Europe.

6.2.4 CA Organisations and Organisation Structures

From a voluntary and complementary conformity assessment perspective, no dedicated CA organisation in Europe is defined for C-V2X products, but 3GPP device manufacturers and network operators use the generic cellular (3GPP)-driven Global Certification Forum for basic modem conformance testing (layer 1-3). This also includes devices with 3GPP C-V2X functionalities.

ETSI CTI has hosted C-V2X Interoperability Plugtests which enable OBU/RSU vendors to perform tests to appropriate standards via ETSI CTI Test Cases as well as outdoor sessions testing against each other.

6.2.5 Roles and Responsibilities

In the complementary Conformity Assessment world, GCF provides Certifications on the basis of the compliance to 3GPP standards. It acts as the related certification body as driven by its members.

GCF uses recognised ISO 17205 Test Labs (RTL) and Assessment Capable Entities (ACE) to ensure ISO 17025 compliant test results as the basis for every Certification.

6.2.6 Applicable Standards

EU standards are documented in **Annex B**.

6.2.7 Relevant/Significant Dates

There are no specific dates or milestones to be mentioned since the current schemes are in place and they are frequently updated and complemented by additional standards. In addition, from a vehicle homologation perspective, additional delegated regulations are likely to apply by the end of 2022.

6.2.8 Regional Activities (Plugfests, Trials, etc.)

From the various technology perspectives, Europe arranges many trials and pilots using either ITS-G5 and/or C-V2X communication technologies. Nearly all of these activities have been sponsored by the European Union, e.g. under the framework of the Horizon 2020 research programme and others.

ETSI CTI have held three C-V2X plugtests in partnership with 5GAA:

- Hosted by Dekra in Malaga in December 2019
- Help remotely due to the Pandemic from 20-31 July 2020
- Hosted by Dekra, Klettwitz from 28 March to 1 April 2022
-

6.2.9 Observations

Europe is well regulated when it comes to the use of technologies and related products. However, the regulations address mainly requirements to protect the users and spectrum used. It does not provide assistance to ensure quality of service and interoperability of products. As mentioned previously, there is currently no identified organisation which is well placed to enable C-V2X Conformity Assessment.

6.2.10 Europe Summary

The status in Europe is as follows:

- No C-V2X Conformity Assessment in place
- Competing technologies available (e.g. ITS-G5)
- ITS deployment strategies not clear or harmonised across Europe

6.3 North America

6.3.1 Regional CA Strategy

In 2015, the US DOT issued the following document - [11] wherein it highlights that FCC requires all transponders, transmitters, and transceivers associated with either RSUs or OBUs and used in the 5.9 GHz band to be certified. Entities seeking to deploy RSUs must work with RSU vendors to ensure that devices are certified. The United States Department of Transportation (USDOT) DSRC RSU Specification version 4.1 requires compliance with FCC CFR Title 47 Parts 0, 1, 2, 15, 90, and 95 in order for the RSU to be certified.

Funding was made available to develop the criteria by which certification would be granted and a consortia emerged from interested companies including Danlaw, 7 Layers and OmniAir Certification Services (OCS), which included SWRi. An initial set of test cases were developed to test for RSU compliance with IEEE 802.11p PHY and SAE Standards. After the funding was exhausted, OCS (which has since changed name to OmniAir Consortium) took these test cases and assumed the role of DSRC Certifier for which they charged a fee. When C-V2X began to exert its influence on the North America Connected Vehicle market, OmniAir's Technical Working Group was formed to develop similar test cases for 3GPP-based direct communication based on 3GG R14 LTE, and now offer C-V2X Certification for both RSUs and OBUs.

6.3.2 Regional CA Objectives

A number of Road Operators and Regional DOTs require OmniAir Certification before RSUs can be deployed. It is possible that OmniAir Certification will become a requirement for infrastructure installations across North America. It is yet to be seen how OEMs plan to adopt OBU Certification.

6.3.3 Conformity Assessment Processes

The OmniAir Consortium has put in place a Certification Programme for C-V2X:

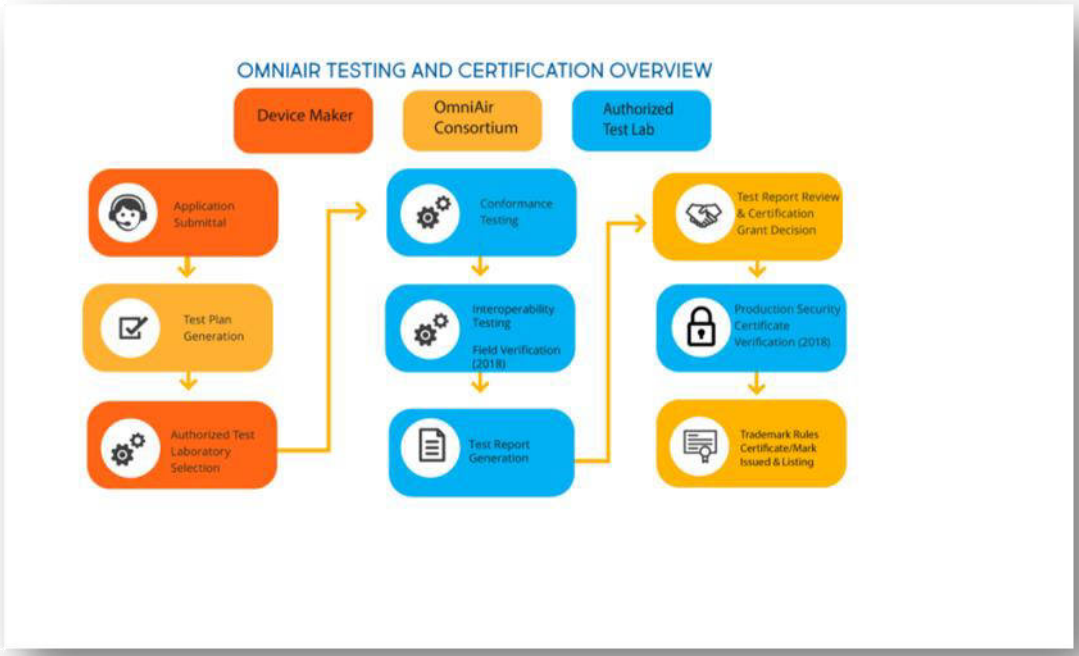


Fig 7: OmniAir Certification Programme for C-V2X

6.3.4 CA Organisations and Organisation Structures

US DOT

The US Department of Transportation occupies a unique leadership role in global transportation. Since its first official day of operation nearly 50 years ago, transportation programmes have evolved to meet the demands of a changing nation. Today, DOT is composed of the Office of the Secretary, the Surface Transportation Board, the Office of the Inspector General, and ten Operating Administrations.

OmniAir

Founded in 2004, OmniAir Consortium is the leading industry association promoting interoperability and certification for connected vehicles, ITS, and transportation payment systems. OmniAir's membership includes public agencies, private companies, research institutions, and independent test labs.

6.3.5 Roles and Responsibilities

The DOT's Intelligent Transportation Systems Joint Program Office (ITS JPO), within the Office of the Assistant Secretary for Research and Technology (OST-R), is charged with executing the 'Intelligent Transportation System Research of Public Law 109-59 Safe Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users', enacted 10 August 2005.

OmniAir's membership includes public agencies, private companies, research institutions, and independent test labs. Only those test labs, equipment and tool providers, devices and systems that pass rigorous test programmes can carry the OmniAir Certification Mark. OmniAir is participating US Department of Transportation's (USDOT) 'Next Generation Certification Program for Connected Vehicles'. OmniAir and member companies are developing technical specifications for testing of V2V/V2I – for both C-V2X and DSRC.

- Conformance and Interoperability for Transportation Technologies
- Diverse Membership – Device Suppliers, Laboratories, Test Equipment/Software Providers, Engineering Firms, Agencies, Research Institutions and ITS Deployment Services
- Industry Conformance/Certification Development and Communications Media Independent
- Certification Services through Testing and Programme Scope
- Initiated V2X-Based Tolling and Road Usage Charging Work Item

6.3.6 Certification Authorities and Test Labs

Refer to OmniAir website for a list of OmniAir approved test labs and approved testing equipment: www.omniair.org

6.3.7 Applicable Standards

For North America C-V2X Standards – See **Annex C**.

6.3.8 Relevant/Significant Dates

In 1997, ITS America petitioned the Federal Communications Commission (FCC) to allocate 75MHz of spectrum in the 5.9 GHz band for ITS, in particular for DSRC. The following year, Congress passed and the President signed into law the Transportation Equity Act for the 21st Century (TEA-21), which directed the Commission, in consultation with the DOT, to consider the spectrum needs "for the operation of intelligent transportation systems, including spectrum for the dedicated short-range vehicle-to-wayside wireless standard". TEA-21 also directed DOT to promote, through the national architecture, interoperability among ITS technologies implemented across the United States. In October 1999, the Commission allocated the 5.9 GHz band for DSRC-based ITS applications and adopted basic technical rules for DSRC operations.

In 2003, the Commission adopted a Report and Order (see clipping below) establishing licensing and service rules for the DSRC for ITS Radio Service in the 5.850-5.925 GHz band (5.9 GHz band).

In 2006, the Commission adopted a memorandum opinion and order which, among other decisions, designated Channel 172 exclusively for vehicle-to-vehicle safety communications for accident avoidance and mitigation, and safety of life and property applications; and designated Channel 184 exclusively for high-power, longer distance communications to be used for public safety applications involving safety of life and property, including road intersection collision mitigation.

NPRM Report & Order Nov 2020.WASHINGTON, November 18, 2020 – The Federal Communications Commission today adopted new rules for the 5.9 GHz band (5.850-5.925 GHz) to make new spectrum available for unlicensed uses, such as Wi-Fi, and improve automotive safety.

FCC's new rules will make 45 MHz of the 5.9 GHz band available for unlicensed use. The Report and Order adopts technical rules to enable full-power indoor unlicensed operations in the lower 45 MHz portion of the band immediately, as well as opportunities for outdoor unlicensed use on a coordinated basis under certain circumstances.

Under the new rules, ITS services will be required to vacate the lower 45 MHz of the band within one year.

The new rules also will improve automotive safety by reserving the upper 30 MHz of the band for Intelligent Transportation System (ITS) services and designating C-V2X as the technology standard for safety-related transportation and vehicular communications.

The action therefore begins the transition away from DSRC services—which are incompatible with C-V2X—to hasten the actual deployment of ITS services that will improve automotive safety.

In addition to the new rules, the Commission adopted a Further Notice of Proposed Rulemaking which proposes:

- Technical rules for outdoor unlicensed operations across the United States (except for limited number of areas) in the lower part of the band once ITS operations have vacated that spectrum eg OOBE.
- How to transition ITS operations to C-V2X-based technology, including the appropriate implementation timeline and technical and operational parameters for C-V2X service.
- Whether the Commission should allocate additional spectrum for ITS applications in the future.
- Finally, the Commission also adopted an Order of Proposed Modification which proposes to modify all 5.9 GHz band ITS licenses in accordance with today's changes.

It is expected that a Report and Order on the proposal put forward in the NPRM is likely to be signed off by middle of 2022.

6.3.9 Regional Activities (Plugfests, Trials, etc.)

OmniAir has hosted four plugfests – both hybrid and F2F – and C-V2X plugfest events are organised on a regular basis with an evolving emphasis, e.g. early plugfests focused on the PHY layer with more recent events focusing on upper layers.

Known C-V2X pre-deployments:

[3] Utah DOT Deployments

[4] Colorado DOT Deployments

[5] Georgia DOT Highway Deployments

[6] Georgia Alpharetta Deployments

[7] Hawaii DOT Honolulu Deployments

[8] Texas DOT Arlington Deployments

[9] Virginia DOT Deployments

6.3.10 Observations

OmniAir has moved quickly to establish a set of test cases for C-V2X. This was done by setting up sub-working groups under the auspices of the Technical Working Group and driving to closure before end of 2020. OmniAir has had DSRC Certification in place for some time and now have a C-V2X program in place. The FCC NPRM decision mentioned above has significantly moved momentum to C-V2X in the US and, as previously noted, it is expected that a Report and Order is likely to be signed off in 2022.

6.3.11 Summary

OmniAir was established in 2004 and has a history in tolling and payment technologies. The US DOT initially sponsored OmniAir to develop test cases and a Certification Programme for ITS (DSRC at that time).

OmniAir has successfully developed a set of C-V2X test cases that cover all layers of the ITS stack up to the application layer. It should be noted that, while there are no test cases approved for the application layer, there is an applications sub-working group focused on this task.

6.4 Japan

6.4.1 Regional CA Strategy

Vehicle Information and Communication System (VICS) , Electronic Toll Collection (ETC), Driving Safety Support Systems (DSSS), etc. have been put in place by utilising ITS technology, which connects people and vehicles with information. ITS Connect is a system that provides assistance to drivers by providing information obtained via wireless communication by infrastructure-based equipment installed on the roadside, in front of intersections, etc. with poor visibility. To our knowledge, due to the relatively small ecosystem of vendors, no CA has been required for ITS Connect OBUs or RSUs.

The Ministry of Internal Affairs and Communications (MIC) in Japan is currently investigating the use of the 5.9 GHz band for V2X technologies. The choice of short-range technology has not been confirmed and there are no current plans in place for Conformance Assessment of C-V2X.

6.4.2 Regional CA Objectives

Japan's MIC is responsible for framing and administering a wide range of fundamental socio-economic activities at local, regional and national level, from administrative systems and local autonomy programmes, to emergency services, to ICT strategies aimed at promoting growth.

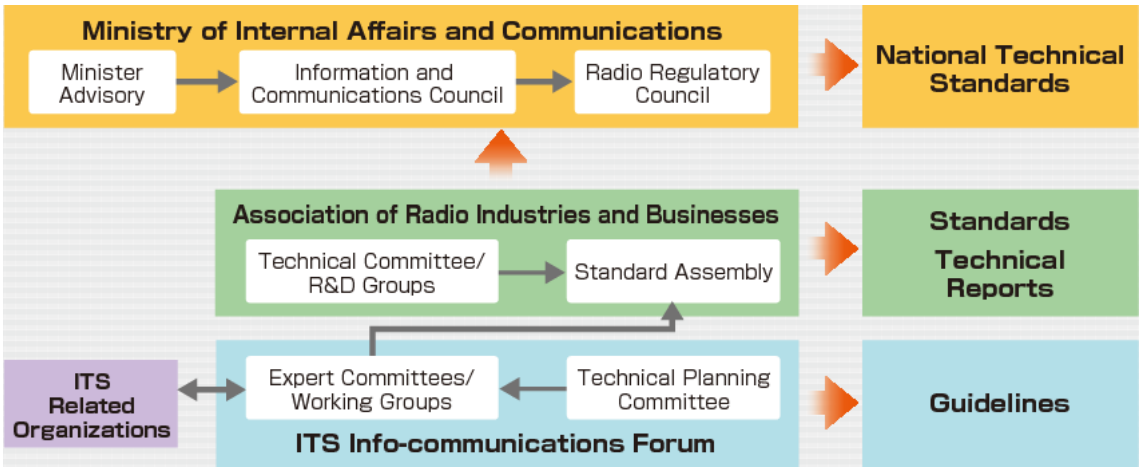


Fig 8: Ministry of Internal Affairs and Communications

6.4.3 Conformity Assessment Processes

No current plans in place for Conformity Assessment of C-V2X.

6.4.4 CA Organisations and Organisation Structures

ITS Connect (ITS Connect Promotion Consortium)

Established 28 October 2014 with the aim of achieving road safety, anti-congestion measures, environmental measures, etc.

ITS-TEA

ITS Technology Enhancement Association is the DSRC Certification Organisation.

Electronic Toll Collection (ETC) systems can mitigate traffic congestion at tollgates, increase convenience with drivers by offering cashless payment at tollbooths, and reduce road management costs. ETC plays a key role in ITS by utilising

wireless communication between an ETC OBU installed on a vehicle and a roadside station because the vehicle is allowed to pass through tollbooths without stopping.

6.4.5 Roles and Responsibilities

ITS Connect Promotion Consortium

ITS Connect was established to accelerate ITS efforts and facilitate practical applications. Its goal is to achieve safe, smooth and stress-free transportation by studying and improving fundamental technology for driver support systems utilising an ITS-dedicated frequency band, and carrying out operational support. For example, it helps drivers during poor visibility by providing information obtained via wireless communication from roadside infrastructure and surrounding vehicles.

Objectives:

- Planning, promotion, liaison and coordination of the 'ITS Connect System'

- Main activities:
- Discussion and management of the communication protocols, technical specifications, and standards of the ITS Connect System, and solving technical problems
- Marketing and distribution promotion of the ITS Connect System
- Other activities necessary for achieving the Consortium's goals

ITS Connect is only looking at the 700 MHz DSRC communication and does not include the 5 GHz ETC communication. It is not mandatory (not regulation- or ministry-led) and is thus driven by car OEMs who put this into their supplier requirements.

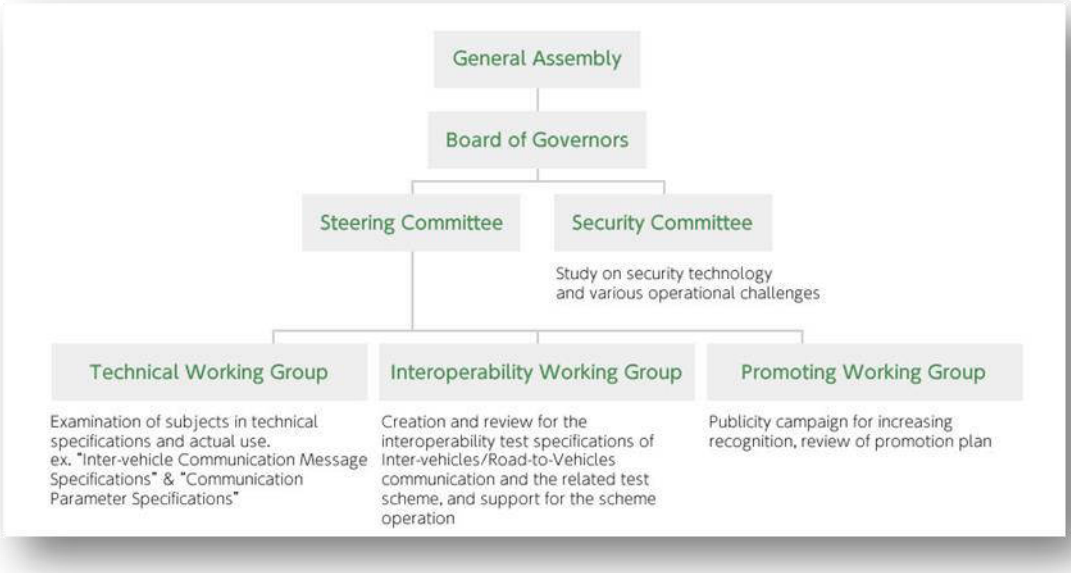


Fig 9: ITS Connect Promotion Consortium

ARIB ITS Info-Communication Forum

Objectives:

- To promote R&D and ICT standardisation needed for the successful introduction of ITS
- To provide a forum that encourages and promotes the exchange of R&D and standardisation information regarding ITS among related organisations
- To promote the smooth development of all aspects of ITS

Main activities:

- Conduct investigations and studies regarding R&D and standardisation of communications systems for ITS
- Liaise and coordinate with organisations related to and/or involved in the development of communications systems for ITS
- Increase understanding of ITS among the general public

Membership:

- Industrial: Automobile manufacturers, telecommunications equipment manufacturers, telecommunications carriers, broadcasting companies, etc.
- Government agencies: Ministry of Internal Affairs and Communications; National Police Agency; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism

ITS-TEA

Objectives:

- Provide information security standards related to the ETC system

Main activities:

- Issue encrypted data to set up the ETC system
- Provide a platform regarding information security in DSRC, and its management
- Standardisation of technologies in ETC and DSRC systems
- Promotional activities for ETC and DSRC systems
- R&D to enhance technologies related to ETC and DSRC systems
- Gathering and providing information on technologies related to ETC and DSRC systems, and technological exchange with other organisations
- Utilise technologies based around ETC and DSRC systems
- Execution of entrusted tasks regarding the above activities
- Other tasks to fulfil the purposes of ITS-TEA

6.4.7 Certification Authorities and Test Labs

No information available.

6.4.8 Applicable Standards

No definitive discussions on C-V2X.

Japan's DSRC standards can be seen in **Annex D.**

6.4.9 Relevant/Significant Dates

No specific dates for C-V2X-related activities.

6.4.10 Regional Activities (Plugfests, Trials, etc.)

'Initiatives for a Self-Driving Society – Commercial Broadcasting Radio Stations and Fixed-Satellite Services' [5.9 GHz band].

Based on the progress and importance of automatic driving systems (including safe driving support), a study is being carried out into the essential technical conditions for frequency sharing using existing wireless systems. For example, when introducing V2X communications, and considering existing wireless systems on frequency bands being studied internationally (5.9 GHz band), in addition to the existing ITS frequency bands (760 MHz band, etc.). Moreover, based

on the results of these studies, a conclusion will be reached within FY 2022 regarding frequency allocation policy, such as frequency sharing and migration/reorganisation when introducing V2X communications in the same frequency band, etc. [10] [11].

6.4.11 Observations

There is research and experimental work being undertaken on NR-V2X and 5G connectivity.

No firm plans for C-V2X (R14).

6.4.12 Summary

The Japanese MIC is responsible for setting national technical standards and is advised by various organisations, as depicted above. For radio-related activities, input comes from the Association of Radio Industries and Business which is responsible for developing technical standards. When it comes to ITS-related activities there are at least two leading organisations providing input and developing guidelines – the ITS Forum and ITS Connect.

Japan has an existing ITS system based on WiFi/802.11p currently operating in the 700 MHz range, but encouraged by 5GAA spectrum work, the country is investigating the prospects of using 5.9 GHz. A decision is expected in 2022 or 2023.

Some interesting research is also going on with 5G and early NR-V2X for Platooning and Tele-operated Driving.

6.5 South Korea

6.5.1 Regional CA Strategy

The Korean government and Road Operator have invested in DSRC technology; multiple pilot projects have already been carried out on the subject. With respect to ITS, mainly basic services are considered while advanced services are not in focus at present. Key players in these developments are the Ministry of Science and ICT (MSIT) and Ministry of Land, Infrastructure and Transport (MOLIT).

6.5.2 Regional CA Objectives

National requirements:

- National requirements are defined by the National Radio Research Agency (RRA)
- A broadcasting and communication equipment conformity assessment system has been implemented and is divided into the certification of conformity, registration of compatibility, and interim conformity
- Wireless communication devices usually require certification of conformity for any device intended to be imported, manufactured or sold in South Korea

Industry requirements:

- ITS Korea has launched a trial programme for LTE-V2X starting in 2022 and lasting until 2024
- Requirements are based on OmniAir standards.
- A decision will be made to adopt a single technology in 2024 and all highways in South Korea will have RSU deployed

6.5.3 Conformity Assessment Processes

C-V2X: Conformity Assessment in South Korea can be seen in Figure 10

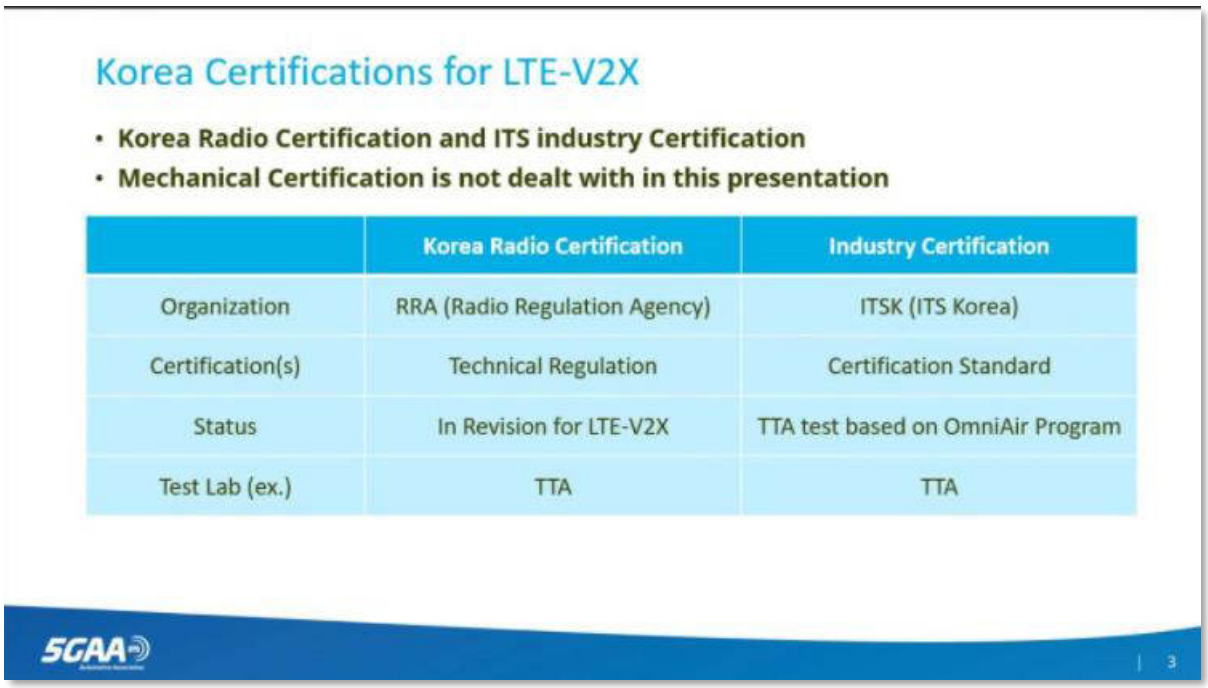


Fig 10: South Korea C-V2X Conformity Assessment

6.5.4 CA Organisations and Organisation Structures

- Ministry of Land, Infrastructure and Transport (MOLIT)
- Intelligent Transport Society of Korea (ITS-Korea)
- National Radio Research Agency (RRA)
- Cooperative Automated Driving Industry Development Council (CADIC)

6.5.5 Roles and Responsibilities

MOLIT

The Ministry of Land, Infrastructure and Transport is a cabinet-level division of the government of South Korea. Its headquarters is in the Sejong Government Office in Sejong City. The ministry was originally the Ministry of Construction and Transportation.

ITS Korea

ITS Korea's role is to promote mutual cooperation among the public and private sectors for efficient implementation of ITS, and to contribute to the development of ITS through research, policy consultation, technology promotion, and business activities related to ITS. Responsibilities include:

- ITS Standardisation
- Standards Observance Verification and Certification, and Performance Evaluation
- ITS Overseas Business Assistance and Consulting
- ITS R&D (incl. the latest ITS Technology Trends)
- ITS-related National/Local Government Consignment Business
- ITS Education
- International Cooperation (incl. hosting ITS World Congress)
- Revision and Management for Standards of Estimate in ITS
- Collection, Verification, Dissemination of ITS Traffic Information
- Other ITS-related Business

National Radio Research Agency

- Research on Radio Resource matters
- Certification Body for broadcast and communication equipment

CADIC

CADIC was appointed by ITS Korea as the National Certification Body for ITS Systems in September 2020 with the following responsibilities:

- ITS standardisation
- Committee Origination and Operation
- Governance of Certification Programme
- Test Laboratory Authorisation

6.5.6 Certification Authorities

The Certification process is led by:

- Cooperative Autonomous Driving Industry Council
- Launched in March 2018

Certification Organisation:

- ITS-Korea

Certification Test Lab:

- TTA and BV Korea
- As of April 2022, only TTA can run LTE-V2X RSU/OBU Certification Test
- TTA has been qualified by OmniAir and has test equipment

Current Status (April 2022):

- Two devices passed TTA test (NOT full OmniAir test BUT include all indoor cases)

6.5.7 Applicable Standards

Fig 11: South Korea C-V2X Radio Certification

From the above, since 40 MHz is being considered, the Korea Government is researching NR-V2X in the same timeframe.

6.5.8 Relevant/Significant Dates

New revision of Technical Regulation is expected to be released in CY2022.

Fig 12: South Korea C-V2X Roadmap

6.5.9 Regional Activities (Plugfests, Trials, etc.)

LTE Trail being carried out from 2022-2023.

Fig 13: Commercial Spectrum Allocation

6.5.10 Observations

OEMs (Hyundai, Kia Motors) and Tier 1s (LGE, LG Innotek) are interested in C-V2X.

The Korean Government decision on which technology to adopt nationally is expected in 2024.

6.5.11 Summary

- National Requirements and Conformity Assessment are in place for ITS products
- Industry Conformity Assessment for DSRC ITS products launched in December 2020
- New government Establishing Trial of C-V2X – final decision on technology in 2024

7 Lessons from Other CA Schemes

7.1 Scope

To develop an efficient, cost-effective Conformity Assessment it was appropriate to review other schemes.

7.2 Comparing Certification Schemes A and B

The following table summarises key aspects of a comparison of two CA schemes currently up and running:

	Certification A	Certification B
Test scope	Access, transport, network, security and facilities	Access layer
Lab qualification	Qualified by certifier in addition to 17025	Qualified by 17025 and self-declaration
TE vendor qualification	Qualified by certifier	Qualified by industry members
Certifier audit costs	Yes	No
Certification inheritance	Not currently established	Established
Regression for HW/SW changes	Rerun full test unless exception obtained from certifier	Retest only needed for changes
Prerequisites	Regulatory declarations where applicable	None
Test condition	Extreme voltages and temperatures in addition to nom; condition for RF (under review)	Extreme voltages and temperatures in addition to nom; condition for RF (under review)
Certification validity	Regional	Global

Table 1: Comparison of Scheme A and B

7.3 Observations on Certification Schemes A and B

- Certification for both schemes can take several iterations.
- Device certification for Scheme A must secure regulatory declarations where applicable before granting certification.

- For Scheme A, test labs and test equipment validation is carried out by the certifier rather than industry members, as in Scheme B.
- Additional audit costs are incurred in Scheme A.
- For Scheme B, test case validation is carried out by industry vendors whereas for Scheme A, test case validation is carried out by the certifier.
- Scheme A is only valid regionally, whereas Scheme B is valid globally.
- Both schemes have some pros and cons – the pros have been included in the **Harmonised Framework** section.

8 Cost-Benefit Analysis

A Cost-Benefit Analysis [12] for an industry-led Conformance Assessment and Certification Scheme of C-V2X PC5 devices for the automotive and road operator industries was undertaken by VVA and Alter Technology after a selection process took place.

8.1 Objective and Methodology

The study sought to assess the costs and benefits of an industry-led Conformance Assessment and Certification Scheme of C-V2X PC5 ('C-V2X PC5 CA' for short) devices for the automotive and road operator industries across the globe.

C-V2X PC5 devices are a key component of the C-V2X ecosystem. They support effective communication and connectivity between vehicles, and with the road infrastructure. The concept of interoperability is key here because vehicles from different OEMs and RSUs from different manufacturers will have to communicate with one another. The concept of CAs and Certification Schemes is to ensure the effective interoperability between PC5 devices from different manufacturers.

Based on discussions with 5GAA members, the C-V2X PC5 CA has been divided into two phases. Phase 1 focuses on the Lower Layer (LL) and Higher Layer (HL) and the Phase 2 covers the stages from the Application Layer up to the end vehicle, assuming this gets the go ahead. The LL (radio layer) can be tested at the chipset level. The HL (message, transport, security layers) includes both hardware and software components and can be tested at the level of the module as well as sometimes to the OBU/RSU level. The Application Layer has been identified as part of the C-V2X PC5 CA Phase 2. Indeed, the approach in this phase will not be vertical, as in Phase 1 (i.e. chipset, module, OBU/RSU), but rather horizontal because each OEM might have a different approach to PC5 interoperability testing.

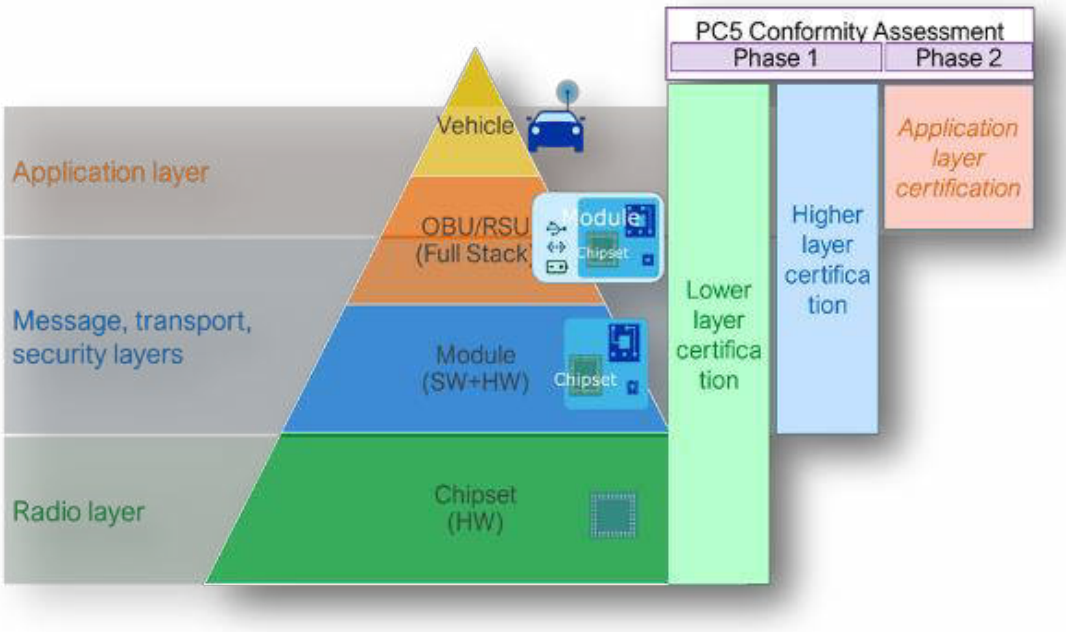


Fig 14: C-V2X Stack and PC5 CA Phase 1 and Phase 2

The consortium defined three scenarios of CA schemes**.** The different schemes have been compared to recommend the most beneficial one and compare them to a baseline (no CA) scenario. Both the LL and HL certification scenarios include an integration test, which takes place at the OBU/RSU level to ensure the combination of hardware and software in the devices has not affected the level of interoperability The following three scenarios were developed:

Scenario 1: Multi-step CA. Each stakeholder will perform testing at their level of core competencies. The Chipset manufacturer will perform the LL testing on the Chipset, then the Module manufacturer will perform the HL testing on the Module, and finally the OBU/RSU manufacturer will perform an Integration test on the OBU/RSU.

Scenario 2: Module level CA**.** The Conformance Assessment will start at the level of the Module manufacturer who will perform both the LL and HL testings on the Module, then the OBU/RSU manufacturer will perform an Integration test on the OBU/RSU. The Chipset manufacturer will not be involved in the PC5 CA Phase 1.

Scenario 3: OBU/RSU level CA. The Conformance Assessment will be performed at the level of the OBU/RSU manufacturer who will perform the LL and HL testings and the Integration test. Chipset and Module manufacturers will not be involved in the PC5 CA Phase 1.

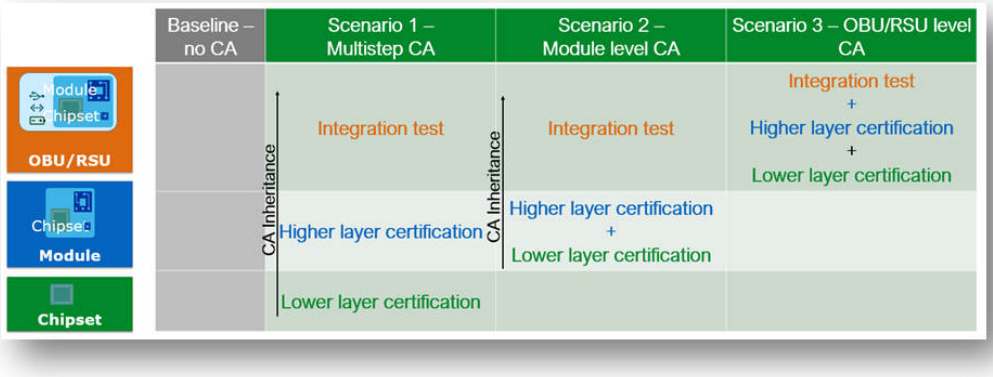


Fig 15: CBA Scenario Overview

Under Scenario 1 and Scenario 2, the study duly considers a CA ‘inheritance concept’, which means that testing will not have to be repeated along the value chain. For example, a single chipset model will have performed the LL testing once, then for each different module model the HL testing will be performed in similar way to OBU models.

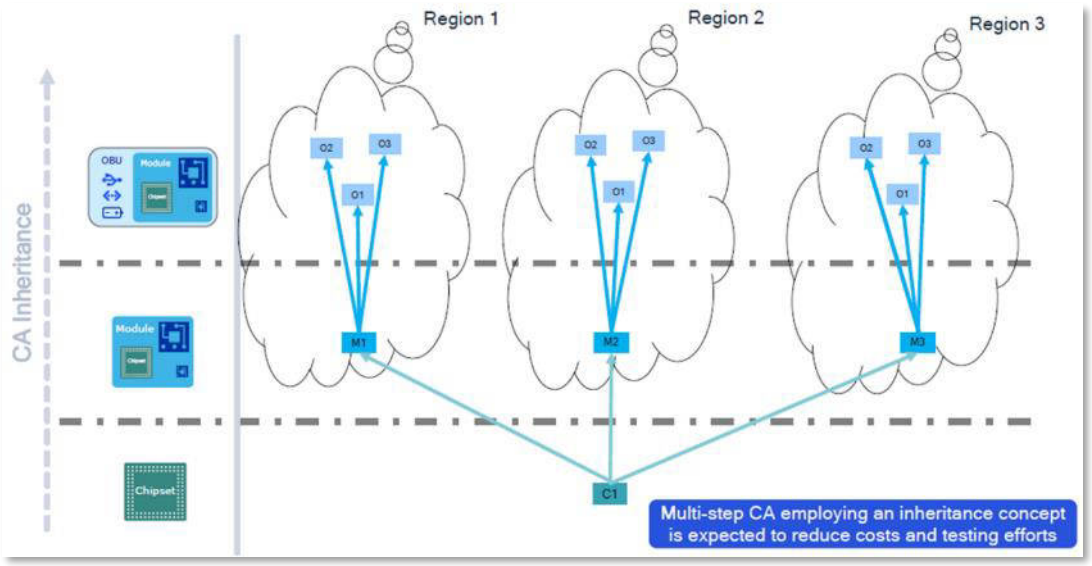


Fig 16: CA Inheritance Concept Applied to a Chipset Model

The study has assessed costs and benefits related to the three scenarios for the whole value chain impacted by the C-V2X PC5 CA Phase 1 (i.e. from chipset manufacturers to OEMs). Regarding costs, the study has validated that both for the LL and HL certification a set of instruments will be required (i.e. software and hardware) on top of resources to effectively perform the test. The Integration test will require dedicated software, and here the cost might be impacted by the level of complexity of OBU/RSU (i.e. the number of services implemented in the model).

It is expected that each family of product models will have to pass the Conformance Assessment, meaning that a manufacturer will have to perform the CA only if two product models are significantly different. For example, a chipset manufacturer deploying a second version of a C-V2X PC5 certified chipset with minor updates, not impacting the interoperability aspect, will not have to perform the C-V2X PC5 Phase 1 again. In addition, in the absence of global harmonisation for C-V2X PC5 testing, it is expected that devices will face additional tests for the HL testing in different regions.

Regarding the willingness of stakeholders to implement the C-V2X PC5 CA Phase 1, the approach undertaken by this study has been welcomed by industry across the entire value chain. Stakeholders strongly support the Scenario 1 – Multi-step CA because they need to perform extensive testing on their devices, even if the PC5 CA is not implemented. Effectively including a C-V2X PC5 CA at their level of expertise will thus include a negligeable level of disruption to established processes.

The CBA modelling has also highlighted that the Scenario 1 – Multi-step CA is the most relevant option, from an economic point of view. Indeed, this scenario introduces a lower amount of additional costs compared to other scenarios – less testing is needed because the number of chipset models is lower than the number of modules and OBU/RSU models. The inheritance concept thus plays a key role, allowing significant cost savings.

Overall, it is important to highlight that the cost of the C-V2X PC5 CA Phase 1 is rather marginal in terms of the whole automotive industry. Depending on the assumptions included in the model, the unit cost per vehicle stabilises at around EUR 0.05 once a significant number of C-V2X vehicles are on the market.

The study has also stressed that the costs and benefits of C-V2X PC5 CA Phase 1 are relatively limited, simply because it is a necessary step to implement Phase 2 (i.e. Application Layer onward). Phase 2 is expected to be slightly more complex but will ensure that PC5 devices are fully interoperable, unleashing a wide range of benefits coming from C-V2X applications.

8.2 Modelling, Cost and Benefit Elements

The CBA aims to provide a quantification of costs and benefits incurred by stakeholders involved in the C-V2X PC5 value chain. The objective of this activity is to assess and compare different scenarios against each other and versus the baseline scenario (i.e. no CA).

In comparison with the baseline situation, the three CA scenarios foresee testing overheads, to prevent the cost of recalls (as well as to enable the PC5 C-V2X use cases, which is in not within the scope of this study).

The impacts are measured by quantifying the additional costs related to the introduction of a C-V2X PC5 CA Phase 1 (i.e. conforming to cellular standards and the delta costs connected to liability and operational issues which might be prevented).

The last stage of the analysis plans a future global harmonisation of the CA across different regions. As this is not foreseeable in the short term, its impacts are considered only qualitatively.

While the costs for the implementation of C-V2X PC5 Phase 1 are supported by stakeholders in the upper value chain (i.e. chipset, module, OBU and RSU manufacturers) at first, it is assumed that these costs will be then transferred to so-called 'end-users' (i.e. OEMs for OBUs implemented on C-V2X vehicles and road operators for RSUs implemented on roads).

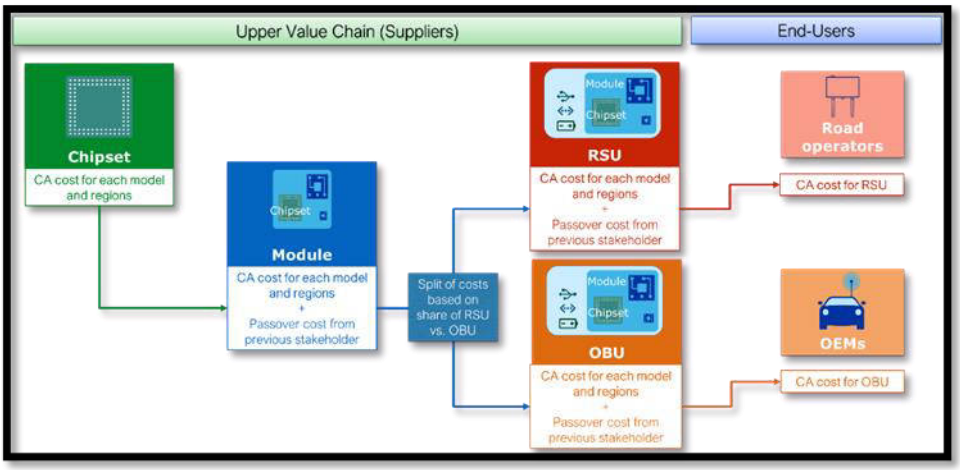


Fig 17: Costs Relationship between Stakeholders for Scenario 1 – Multi-step

9 Harmonised CA Framework

Theoretically, a globally harmonised CA scheme could reduce complexity across the industry, from OEMs to suppliers, chipset vendors, test equipment vendors, and test labs. A globally agreed set of standards from PHY to Applications Layer would make it easier to develop test requirements, specifications and cases to lower the costs of testing solutions and reduce the time at CA test labs.

Building blocks of a CA Framework would include:

- Chipsets, modules, devices to be assessed
- Specifications and standards
- CA organisations responsible for assessments
- CA scheme or process
- Test labs and rest solutions to perform CA

An example of a voluntary, industry-controlled CA Framework is represented in the diagram below which, as can be seen, leverages the GCF model with a developed certification scheme for C-V2X PHY in place by using the proposed building blocks.

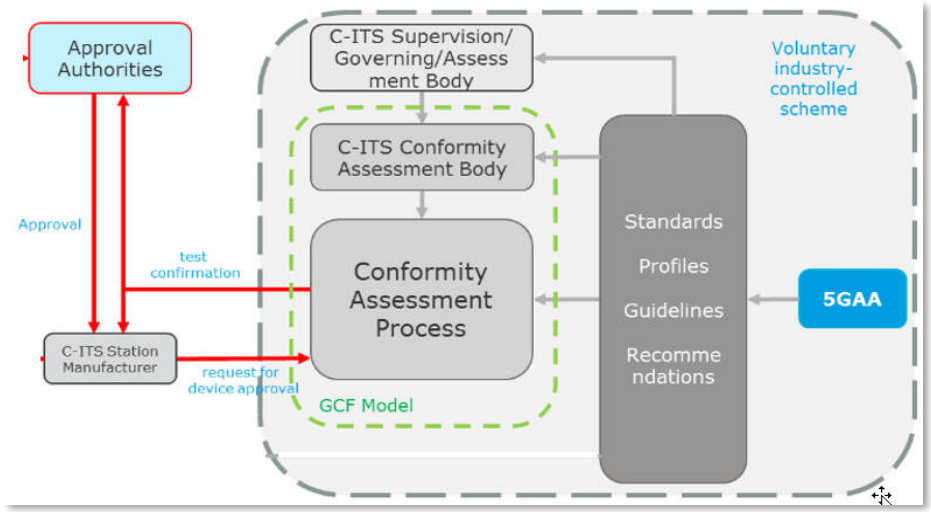


Fig 18: Example of a Voluntary Industry-Controlled Conformity Assessment Framework

Using the Framework depicted above, a workflow can be created outlining the steps that could be taken for Conformance Assessment as shown in Fig 18.

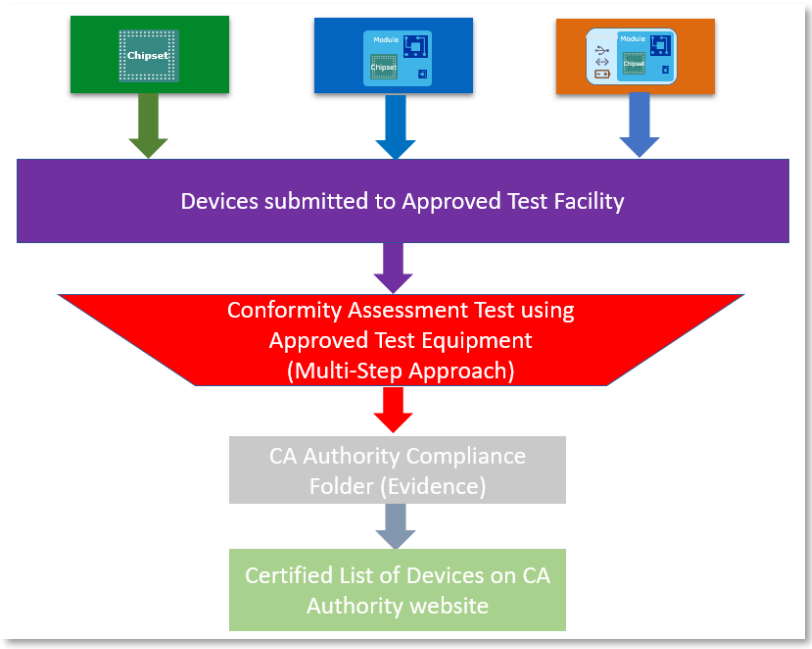


Fig 19: Simplified Workflow Based on CA Framework

As covered in the CBA, the most cost-effective scenario is the Multi-step Approach where a CA is performed on the separate CA building blocks, such as chipsets, modules and devices with the corresponding CA 'inherited' and passed on to the next phase of assessment.

These building blocks would be submitted to an Approved Test Facility (e.g. a test lab or 'test house') who would use Approved Test Equipment to perform the appropriate CA (e.g. PHY Layer Test on chipset and Upper Layer on devices (OBU/RSU).

Assuming the product under assessment passes the CA, evidence of this result is documented in some form of evidence folder held by the CA Authority, and this is listed on their website.

10 Conclusions

To reduce costs and improve efficiency, implementation and acceptance of a Conformity Assessment inheritance scheme across multiple certification schemes should be encouraged.

Regional certifiers of Conformity Assessment should be encouraged to allow the inheritance of global certification and adopt relevant global standards where possible.

The three different scenarios identified in the Cost-Benefit Analysis (i.e. Scenario 1: Multi-step CA, Scenario 2: Module level CA, and Scenario 3: OBU/RSU level CA) for C-V2X PC5 Phase 1 covers most cases currently faced by the industry. It was agreed that the CA should be performed for each product model family, meaning that if a manufacturer is deploying a slightly modified version of a product model it could benefit from the CA of the original version.

The CBA revealed that **Scenario 1: Multi-step CA** is the preferred option because it has the lowest costs, although it should be left to the discretion of stakeholders; which of the investigated scenarios fits their deployment strategies (if no such deployment has already taken place) and provides the greatest benefit.

There is an impression that OEMs and ROs have a low willingness to pay extra, however the total cost might be small compared to quantitative and qualitative benefits arising from a PC5 CA, such as product recalls, damage to the brand image, etc.

Finally, it is important to stress that synergies should be explored with existing CA organisations (e.g. GCF, OmniAir, CAICTB, CATARC) when developing the C-V2X PC5 CA. Stakeholders are eagerly looking for guidance on this topic and they will welcome a global push to disseminate strategic information on the state-of-the-art on C-V2X PC5 CA, but also regional initiatives collectively acting as a global hub on this topic.

Annex A:

Chinese C-V2X-Related Standards

Classification		Title	SDO	Status
Technical	General	General Technical Requirements for LTE-based Vehicle Communication	CCSA	YD/T 3400-2018
	Application	Technical requirements of Message layer of LTE-based vehicular communication	CCSA	YD/T 3709-2020
		Specifications for the information release interface of traffic signal controller	SAC/TC 576	GAT 1743-2020
	Network	Technical requirements of network layer of LTE-based vehicular communication	CCSA	YD/T 3707-2020
	Access	Air Interface Technical Requirements for LTE-based Vehicle communication	CCSA	YD/T 3340-2018
	Security	Technical Security Requirement for IoV communication based on the public LTE network	CCSA	YD/T 3594-2019
		Technical Requirement of Security Certificate for LTE-based Vehicular Communication		Approved
Device	OBU	Technical Requirement of vehicle terminal for LTE based vehicular communications	CCSA	YD/T 3756-2020
	RSU	Technical Requirement of sidelink enabled road side unit for LTE based vehicular based communications	CCSA	YD/T 3755-2020
	Base Station	The eNB Equipment Technical Requirements for vehicular communications based on LTE	CCSA	YD/T 3592-2019
System Profile	Vehicle/OBU	Direct Communication System Technical Requirements for LTE-based vehicle comms	SAC/TC 114	
System Profile	RSU	Information Interaction between roadside facilities and road vehicles	TC 268	

Vehicle	Infrastructure	Traffic Light
GB/T "System Technical Requirements for LTE-based Vehicle Communication"	JTG "General technical specifications for highway auxiliary facilities adapted to automated driving"	GA/T 1743-2020 "Specifications for the information release interface of traffic signal controller"

Standard	Status	Note
CSAE 246-2022 Test and Evaluation Methods For V2X System Warning Application Function of Intelligent And Connected Vehicles	Published	
T/CSAE 53-2020 Cooperative intelligent transportation system: vehicular communication application layer specification and data exchange standard phase I	Published	Phase I message set
T/CSAE 157-2020 Cooperative intelligent transportation system: vehicular communication application layer specification and data exchange standard phase II	Published	Phase II message set

T/CSAE 158-2020 Data exchange standard for high level automated driving vehicle based on cooperative intelligent transportation system	Published	Message set for L4/5 autonomous driving
T/CSAE 159-2020 LTE-based vehicular communication – direct communication system roadside unit technical requirements	Published	RSU message transmission profile
Code of practice about test and evaluation for V2X system warning application function of intelligent and connected vehicles	Under drafting	V2X application test
Profiles for C-V2X certificates in security credential management system	Under drafting	C-V2X security profile

Additional specifications for OBU/RSU requirements and test methods:

YD/T 3755 -2020 Technical requirement of sidelink-enabled roadside unit for LTE-based Vehicular communication

YD/T 3847 -2021 Test method of sidelink-enabled roadside unit for LTE-based Vehicular communication

YD/T 3756 -2020 Technical requirement of terminal for LTE-based Vehicular communication

YD/T 3848 -2021 Test method of terminal for LTE-based Vehicular communication

Technical requirements of vehicular communication system based on LTE-V2X direct communication:

No fixed reference numbers have been published so far.

This document specifies the general requirements, access layer configuration requirements, network layer configuration requirements, system functional requirements, communication performance requirements, positioning and timing requirements and test methods, etc. for the Long Term Evolution Vehicle-to-Everything (LTE-V2X) in supporting the vehicular communication system based on direct communication.

This document is applicable to the vehicular communication system based on LTE-V2X direct communication (hereinafter referred to as the 'system') used by Type-M and Type-N vehicles and can be implemented by reference for other vehicle types. It is a Chinese National Recommended Standard which is still under development. The NTCAS OBU profile standard is largely based on SAE J3161/1

The standard is intended to be the basis of vehicle level C-V2X testing (focusing on testing vehicles with C-V2X functionality). The test methods are China-specific according to CATARC's vehicle test experience. While there are certainly overlaps with OmniAir test specs, they are different. The methods are targeted at vehicular communication systems based on LTE-V2X direct communication, and primarily for OBU. They provide an end-to end approach, in terms of technical requirement as well as testing for the vehicular communication system based on LTE-V2X direct communication. It is recommended that this be taken into account for the CASE WI, despite being in an early phase of development.

CCSA specification published – 25 April 2021: LTE-based car networking wireless communication technology, test method for vehicle-mounted terminal equipment supporting direct communication.

Test method (terminal) for LTE-based vehicular communication – normative references:

YD/T 1763.1, TD-SCDMA/WCDMA Digital Cellular Mobile Communication Network Test Method for Cu Interface Between Universal Integrated Circuit Card (UICC) and Terminal Part 1: Physical, Electrical and Logical Characteristics

YD/T 2582.1, LTE Digital Cellular Mobile Communication Network Universal Integrated Circuit Card (UICC) and Terminal Cu Interface Test Method Part 1: Universal User Identity Module (USIM) Application Features Supporting LTE

YD/T XXXX-XXXX, LTE-based car networking wireless communication technology Technical requirements for vehicle-mounted terminal equipment supporting direct communication

3GPP TS 36.521-1, Conformance specification: Radio transmission and reception Part 1: Conformance specification; Radio transmission and reception; Part 1: Conformance testing

3GPP TS 36.521-3, User Equipment Conformance Specification: Radio Frequency Transmission and Reception Part 3: Radio Resource Management Test (User Equipment (UE) conformance specification; Radio transmission and reception; Part 3: Radio Resource Management (RRM) conformance testing)

3GPP TS 36.523-1, Evolved Universal Terrestrial Radio Access System and Evolved Packet Core Network: User Equipment Conformance Specification Part 1 Protocol Conformance Specification (Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); User Equipment (UE) conformance specification; Part 1: Protocol conformance specification)

Annex B:
European C-V2X-Related Standards

C-V2X Standards with regulatory validity (e.g. Radio Equipment Directive):

Directive 2014/53/EU of the European parliament and of the council of 16 April 2014

Directive 2010/40/EU of the European Parliament and of the Council

ECC Decision (08)01: 'ECC Decision of 14 March 2008 on the harmonised use of the 5875-5925 frequency band for Intelligent Transport Systems (ITS)', approved 14 March 2008 and latest amended on 6 March 2020

EN 62368-1:2014/AC:2015: Audio/video, information and communication technology equipment – Part 1: Safety requirements

EN 62311:2008: Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz-300 GHz)

EN 303 413 V1.1.1: Satellite Earth Stations and Systems (SES); Global Navigation Satellite System (GNSS) receivers; Radio equipment operating in the 1 164 MHz to 1 300 MHz and 1 559 MHz to 1 610 MHz frequency bands; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU

ETSI EN 302 571 (draft) / ETSI EN 302 571 V2.1.1 (2017-02): Intelligent Transport Systems (ITS); Radio Communications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU

EN 301 489-1 V2.2.0: Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard covering the essential requirements of Article 3.1(b) of Directive 2014/53/EU and the essential requirements of Article 6 of Directive 2014/30/EU

EN 301 489-19 V2.1.0 (draft): Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 19: Specific conditions for Receive Only Mobile Earth Stations (ROMES) operating in the 1,5 GHz band providing data communications and GNSS receivers operating in the RNSS band (ROGNSS) providing positioning, navigation, and timing data; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU

EN 301 489-52 V1.1. (draft): Electromagnetic Compatibility (EMC)standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU

Other standards helping complementary conformance assessment (e.g. ETSI):

ISO/TS 19321: Intelligent transport systems – Cooperative ITS – Dictionary of in-vehicle information (IVI) data structures

ISO 3166-1:2013: Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes

ISO 14816:2005 and Amendment 1: Road transport and traffic telematics; Automatic vehicle and equipment identification; Numbering and data structure

ISO/TS 14823:2017: Intelligent transport systems – Graphic data dictionary (under review)

ETSI TS 103 613 V1.1.1 (2018-11): Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems using LTE Vehicle to everything communication in the 5.9 GHz frequency band: includes LTE-V2X access layer specifications with references to 3GPP LTE specifications

ETSI TS 103 574 V1.1.1 (2018-11): Intelligent Transport Systems (ITS); Congestion Control Mechanisms for the C-V2X PC5 interface; Access layer part

ETSI TS 102 636-4-1: Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media independent functionalities. Test Specifications

ETSI TS 102 636-7-1 V1.1.1 (2019-01): Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 7: Amendments for LTE-V2X; Sub-part 1: Amendments to ETSI EN 302 636-4-1 (Media-Independent Functionality): includes the GeoNetworking packet structure for LTE-V2X access layer technology.

ETSI TS 102 636-7-2 V1.1.1 (2019-01): Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 7: Amendments for LTE-V2X; Sub-part 2: Amendments to ETSI EN 302 636-5-1 (Basic Transport Protocol): includes the BTP packet structure for LTE-V2X access layer technology (with MAC, RLC, PDCP and non-IP headers). To be included in ETSI EN 302 636-5-1 V2.2.0 (2019-02) (Under approval).

ETSI EN 302 636-5-1: Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol

ETSI TS 103 301: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services

ETSI EN 302 637-2: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service,

ETSI EN 302 637-3: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralised Environmental Notification Basic Service

ETSI TS 103 097 (V1.3.1): ITS Security; Security header and certificate formats

ETSI TS 102 941 (V1.3.1): ITS Security; Trust and Privacy Management

ETSI TS 102 940 (V1.3.1): ITS Security; ITS communications security architecture and security management

IEEE 1609.2a-2017: IEEE Standard for Wireless Access in Vehicular Environments – Security Services for Applications and Management Messages

EU CP v1.1: EU Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS) ETSI TS 103 600 (V1.1.1): 'Intelligent Transport Systems (ITS); Interoperability test specifications; Test descriptions for security'

ETSI TS 103 096 (V1.4.1): ITS Security; Conformance test specifications for ITS Security

ETSI TS 103 525 (V1.1.1): ITS Security; Conformance test specifications for ITS PKI management

Other standards helping complementary conformance assessment (e.g. ETSI):

ISO 8855: Road vehicles – Vehicle dynamics and road-holding ability – Vocabulary

ISO/TS 19321: Intelligent transport systems – Cooperative ITS – Dictionary of in-vehicle information (IVI) data structures

ISO 3166-1:2013: Codes for the representation of names of countries and their subdivisions – Part 1: Country codes

ISO 14816:2005 and Amendment 1: Road transport and traffic telematics; Automatic vehicle and equipment identification; Numbering and data structure

ISO/TS 14823:2017: Intelligent transport systems – Graphic data dictionary

ISO/TS 19091: Intelligent transport systems – Cooperative ITS – Using V2I and I2V communications for applications related to signalised intersections

ETSI EN 302 665: Intelligent Transport Systems (ITS); Communications Architecture

ETSI ES 202 663: Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band

ETSI EN 302 663: Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band

ETSI TS 102 687: Intelligent Transport Systems (ITS); Decentralised Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part

ETSI TS 102 792: Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range

ETSI TS 102 724: Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band

ETSI EN 302 931: Vehicular Communications; Geographical Area Definition

ETSI TS 103 175: Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium

ETSI EN 302 636-4-1: Intelligent Transport Systems (ITS); Vehicular Communication; Geonetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-independent functionality
ETSI TS 102 636-4-2: Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 2: Media-dependent functionalities for ITS-G5, V1.1.)

ETSI EN 302 636-5-1: Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol

ETSI TS 103 301: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services

ETSI EN 302 637-2: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service

ETSI EN 302 637-3: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralised Environmental Notification Basic Service

ETSI TS 102 894-2: Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary

ETSI TS 103 248: Intelligent Transport Systems (ITS); GeoNetworking; Port Numbers for the Basic Transport Protocol (BTP)

SAE J2945/1: On-board System Requirements for V2V Safety Communications

ETSI TS 103 097: Intelligent Transport Systems (ITS); Security; Security Header and Certificate Formats

ETSI TS 102 941 (V1.3.1): ITS Security; Trust and Privacy Management

ETSI TS 102 940 (V1.3.1): ITS Security; ITS communications security architecture and security management

IEEE 1609.2a-2017: IEEE Standard for Wireless Access in Vehicular Environments – Security Services for Applications and Management Messages

EU CP v1.1: EU Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS)

ETSI TS 103 600 (V1.1.1): ‘Intelligent Transport Systems (ITS); Interoperability test specifications; Test descriptions for security’

ETSI TR 103 099: Intelligent Transport Systems (ITS): Architecture of conformance validation framework

ETSI EG 202 798 (V1.1.1): ‘Intelligent Transport Systems (ITS); Testing; Framework for conformance and interoperability testing’

ETSI TS 102 859: Conformance test specifications for Transmission of IP packets over GeoNetworking (GN6)

ETSI TS 102 868: Conformance test specification for Co-operative Awareness Messages (CAM)

ETSI TS 102 869: Conformance test specification for Decentralized Environmental Notification Messages (DENM)

ETSI TS 102 870: Conformance test specifications for GeoNetworking Basic Transport Protocol (BTP)

ETSI TS 102 871: Conformance test specifications for GeoNetworking ITS-G5 (GN)

ETSI TS 103 191: Conformance test specifications for Signal Phase And Timing (SPAT) and Map (MAP)

ETSI TS 103 096: Conformance test specification for TS 102 867 and TS 102 941 Security Testing

ETSI TS 103 096 (V1.4.1): ITS Security; Conformance test specifications for ITS Security.

ETSI TS 103 525 (V1.1.1): ITS Security; Conformance test specifications for ITS PKI management.

ETSI TR 103 099 (V1.4.3, draft): Intelligent Transport Systems (ITS); Architecture of conformance validation framework (draft for PKI conformance tests).

ETSI TS 103 600 (V1.1.1): ‘Intelligent Transport Systems (ITS); Interoperability test specifications; Test descriptions for security’

Car-2-Car CC Basic System Profiles: https://www.car-2-car.org/documents/basic-system-profile/

Annex C:

North America C-V2X-Related Standards

C-V2X Standards:

GPP 36-521 & 36-523 Radio Transmissions and Receptions

SAE J3161_202204: LTE Vehicle-to-Everything (LTE-V2X) Deployment Profiles and Radio Parameters for Single Radio Channel Multi-Service Coexistence

SAE J3161/1:2020 : OBU LTE-V2X Communications

IEEE 1609.2:2017, 2a & 2b:2019: Security Services

IEEE 1609.2.1(CAMP): 2020 SCMS and Certificates

IEEE 1609.3:2020: Network Services

IEEE 1609.4:2016: Multi-Channel Operations

SAE J2735: Message Decoding

SAE J2945/1:2020: V2V Minimum Performance

SAE J2945/1 & /1A:2020: BSM Checklist Driving Test

SAE J2945/1A:2020: BSM Min. Performance & Location Accuracy Field Testing

SAE J2735: SPAT per 783-OA-TSS&TP-SPAT

SAE J2735: MAP per 782-OA-TSS&TP-MAP

Standards / Specifications	OAC Test Procedure	Standards Applied to Certification Testing Description	Standard Status	Current Scope Release
IEEE 802-11(p)	760	Physical Layer (PHY) & MAC	2012	DSRC R1 & R2
3GPP 36-521	761	Radio Transmission & Reception	R14	LTE-V2X RY
IEEE 1609.2, 2A&.2B	763	Security Services	2017/2019	All
IEEE 1609.2.1	764*	SCMS Interface	2022	--
IEEE 1609.3:2020	765	Network Services & WSA	2020	All
IEEE 1609.4	766	Multi-Channel Operations	2016	DSRC R1 & R2
IEEE 1609.12	--	Identifiers (PSID)	2019	All
SAE J2735	--	V2X Message Dictionary (BSM, MAP, SPAT)	2020	2020
SAE J3161& 3GPPr14	759*	CV2X Module	MVC-1Q2022	LTE-V2X RY
SAE J3161/0&1 & 1A	762 & 769*	OBU LTE-V2X V2V Requirements (Min Performance) & Test Procedure	MVC--1Q2022	LTE-V2X RY
SAE J2945/0&1 & 1A	768 & 769	OBU V2V Requirements (Minimum Performance) & Test Procedure (Vehicle)	2020	DSRC & LTE-V2X
SAE J3217	788*	OBU V2V Min. Performance Test Procedure (Vehicle-Level)	2022	TBD
SAE J2945/xx (V2I)	TBD	/3 Weather(Pub), /4, RSM, /A MAP, /B SPAT, /C Traffic Probe & J3238 App Testing	2022+	TBD
SAE J2945/xx (V2V)	TBD	/6 CACC & Platooning, /8 Cooperative Perception, /9 PSM & /D Courteous R2R	2022+	TBD
FHWA-JPO-17-589	770	RSU 4.1	2017	All
NEMA TS10	771*	Connected Vehicle Infrastructure – Roadside Equipment	2020	Applicable
NTCIP 1202v3	784*	Object Definitions for Actuated Signal Controllers with SPAT	2019	No
NTCIP 1218v01	785*	Object Definitions for Roadside Units (RSUs)	2020	No
ITE CTI 4001v1.0RSU	772*	Next Generation Roadside Unit	2021	No
ITE CTI 4501v1.0 CI	773*	Connected Intersections (RLWV, SPAT, MAP, RTCM, RSU &TSC)	2021	No

Annex D:

Japanese V2X-Related Standards

DSRC Standards

RC-	ITS Forum Title of GUIDELINE	Version number	Date of publication	Classification
014	ITS APPLICATION SUB-LAYER SPECIFICATION GUIDELINE	1.0	May 25, 2017	Establishment
013	700MHz BAND INTELLIGENT TRANSPORT SYSTEMS - Experimental Guideline for Vehicle-to-Vehicle Communication Messages	1.1	Sep 30, 2017	Update
012	700MHz BAND INTELLIGENT TRANSPORT SYSTEMS - Experimental Guideline for Infrastructure-to-Infrastructure Communications	1.1	Sep 30, 2017	Update
011	700MHzBAND INTELLIGENT TRANSPORT SYSTEMS - Test Items and Conditions for Mobile Station Interroperability Verification Guideline	1.2	Sep 30, 2017	Update
010	700MHz BAND INTELLIGENT TRANSPORT SYSTEMS - Extended Functions Guideline	1.1	Sep 30, 2017	Update
009	Security Guideline for Driver Assistance Communications System	1.2	Nov 25, 2013	Update

Annex E:

South Korean C-V2X-Related Standards

ITS Korea DSRC Standards:

Doc. number: ITSK-00114-2
Title: C-ITS 노변기지국 규격 - 제 1 부 : 요구사항
Title in ENG : C-ITS RSU Specification - Part 1. Requirements
Latest update : 2020-12-14

Doc. number: ITSK-00114-2
Title: C-ITS 노변기지국 규격 - 제 2 부 : 기능시험방법
Title in ENG: C-ITS RSU Specification - Part 2. Function test method
Latest update: 2020-12-14

Annex F:

Date	Meeting	Doc	Subject/Comment
2022-04			First draft of Final Report
2022-05	Atlanta F2F		V3.0 Final draft
2022-05-20			Rev 4.0 5GAA CTO comments
2022-05-25			Rev 5.0 Keysight update based on CTO comments
2022-06-09			Rev 5.0 Comments from proof-reader
2022-06-14			Rev 5.0 Keysight update based on proof-reader comments