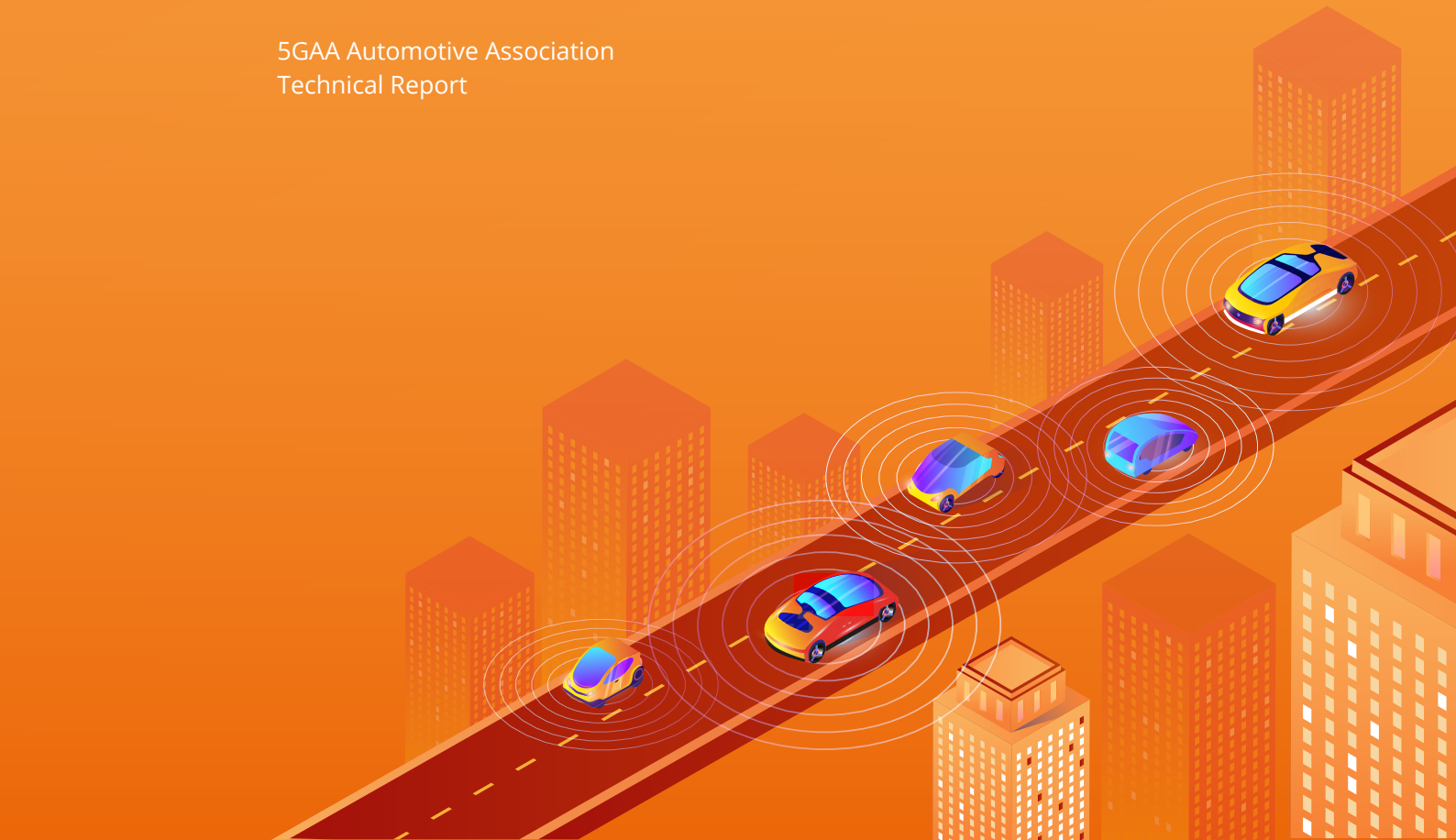
5GAA Automotive Association

V2X State of Play in China II

5GAA Automotive Association
Technical Report



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Contents

1 Scope

This Technical Report (TR) covers Vehicle-to-Everything (V2X) developments in China from 2022 to 2024. The TR explores 'C-V2X policies and regulations in China', 'C-V2X standardisation in China', and 'C-V2X pilot and demonstration areas in China'. The results and conclusions of this report will effectively reinforce overall comprehension by 5GAA members of the state of play of V2X in China, and then provide more effective C-V2X solutions, which will affect the global development of the Internet of Vehicles.

2 References

[1]	5GAA Technical Report, 'C-V2X policies and regulations in China', available at: https://5gaa.org/new-technical-report-c-v2x-policies-and-regulations-in-china
[2]	5GAA Technical Report, 'C-V2X standardisation in China', available at: https://5gaa.org/new-technical-report-c-v2x-standardisation-in-china
[3]	5GAA Technical Report, 'C-V2X Pilot and Demonstration Areas in China', available at: https://5gaa.org/new-technical-report-c-v2x-pilot-and-demonstration-areas-in-china
[4]	5GAA Technical Report, 'Business Perspectives on Vehicle-to-Network-to-Everything (V2N2X) Deployments', available at: https://5gaa.org/business-perspectives-on-vehicle-to-network-to-everything-v2n2x-deployments

3 Abbreviations

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

AVP	Automated Valet Parking
BRT	Bus Rapid Transit
CAICV	China's Industry Innovation Alliance for the Intelligent and Connected Vehicles
CCRH	High Speed Car to Car Rear
CCSA	China's Communications Standards Association
CIM	City Information Modelling
C-ITS	China's ITS Industry Alliance
C-NCAP	China-New Car Assessment Program
C-SAE	China's Society of Automotive Engineers
C2C SCPO	Car-to-Car Straight Crossing Path with Obstruction
CV	Connected Vehicles
C-V2X	Cellular Vehicle-to-Everything
ICV	Intelligent Connected Vehicles
IoV	Internet of Vehicles
LTE-V2X	Long Term Evolution – Vehicle-to-Everything
MEC	Multi-access Edge Computing
MIIT	Ministry of Industry and Information Technology
MNR	Ministry of Natural Resources
MOHURD	Ministry of Housing and Urban-Rural Development
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
MPS	Ministry of Public Security
NDRC	National Development and Reform Commission
NTCAS	National Technical Committee of Auto Standardisation
NTCTM	National Technical Committee on Traffic Management of Standardisation Administration of China
OBU	On-Board Unit
OEM	Original Equipment Manufacturer
RSU	Road-Side Unit
SAE	Society of Automotive Engineers
SDO	Standards Development Organisation
TSR	Traffic Signal Recognition
V2I	Vehicle-to-Infrastructure
V2X	Vehicle-to-Everything

4 Overview

4.1 C-V2X policies and regulations in China

The policies and regulations on C-V2X in China are progressively being refined, with government departments having issued a series of plans and guidelines to promote the development of connected vehicles and smart transportation. The Ministry of Transport (MOT) and the Ministry of Science and Technology (MOST) have jointly released the 'Medium- and Long-term Development Plan Outline for Science and Technology Innovation in Transportation Field (2021-2035)', which comprehensively and systematically deploys the tasks of technological innovation in transportation for the next 5-15 years. Departments such as the Ministry of Industry and Information Technology (MIIT) have successively released documents like the 'National V2X Industry Standard System Construction Guide', 'V2X Industry Development Action Plan', 'Medium- and Long-term Development Plan of the Automobile Industry', and the 'Notice on Carrying Out Pilot Applications of Intelligent and Connected Vehicles for Vehicle-Road-Cloud Integration' – all of which have promoted the development and application of C-V2X technology in China.

4.2 C-V2X standardisation in China

With the development of C-V2X, which is based on the LTE-V2X direct communication and 5G Uu communication technologies, the standardisation-related work – studied in IMT-2020(5G) PG C-V2X WG, CCSA, C-ITS, NTCAS, CSAE/CAICV, NTCTM and CNCAP – continuously focuses on the C-V2X ecosystem and its key issues and evolution of technologies. The main research objectives of standardisation appears to have changed from focusing on the collaboration between vehicle and road to the collaboration between vehicles, roads, and pedestrians with the edge and service cloud platform.

4.3 C-V2X pilot and demonstration areas in China

In the field of C-V2X and ICV, China has launched projects such as pilot areas, testing demonstration areas, CV pilots, and smart city infrastructure and ICV pilot cities. Until now, seven national CV pilot areas, 17 national-level ICV demonstration areas, and 16 smart city infrastructure and ICV pilot cities have been established nationwide.

On this basis, the scope of 'Vehicle-Road-Cloud Integration' applications will be further expanded, and through unified system architecture design, it will promote the deployment of city-level construction from 'single point' to 'contiguous' infrastructure construction, achieving a wide range of large-scale applications and practices. In the period covered by this TR, 20 cities were approved to be pilot cities to carry out

Vehicle-Road-Cloud Integration for ICV. The pilots will also highlight the empowerment of connectivity, covering different levels of connected functional applications in diverse scenarios such as collaborative warning, collaborative driving assistance, and collaborative automated driving.

5 Key information on policies and regulations

5.1 Medium- and Long-term Development Plan Outline for Science and Technology Innovation in Transportation Field (2021-2035)

In January 2022, the MOT and MOST jointly issued the 'Medium- and Long-term Development Plan Outline for Science and Technology Innovation in Transportation Field (2021-2035)'. According to the plan, the purpose is as follows: "Accelerate the application of new-generation information technology in the fields of transportation public services, transportation monitoring and early warning, comprehensive emergency command and supervision, proactive response to transportation-related public opinion, and driving training. Promote the research and development of road autonomous driving technology and its applications, breakthrough technologies such as integrated perception, vehicle-infrastructure information exchange, high-precision space-time services, intelligent computing platforms, and online evolution of perception-decision-control functions, and promote the application of autonomous and assisted driving in road freight, urban distribution, and urban public transport."

5.2 14th Five-Year National Road Traffic Safety Plan

In July 2022, the Office of the State Council Work Safety Committee issued the '14th Five-Year National Road Traffic Safety Plan' in order to "deepen the application of networked and controlled technologies in road traffic, advance refined organisation of urban traffic, accelerate the deployment of C-V2X, promote the internet-connected transformation of traffic facilities, enhance the networked control of traffic signals, and strengthen traffic travel guidance services".

5.3 14th Five-Year National Urban Infrastructure Construction Plan

In July 2022, the Ministry of Housing and Urban-Rural Development (MOHURD) and the National Development and Reform Commission (NDRC) jointly issued the '14th Five-Year National Urban Infrastructure Construction Plan'. This document's purpose is explained as follows: "Conduct comprehensive scenario demonstration applications

for vehicle-city collaboration. Promote the construction of intelligent sensing facilities for transportation aimed at vehicle-city collaboration, develop 5G-based vehicle-city collaborative application scenarios and industrial ecosystems. Conduct testing and demonstration applications in designated areas focusing on 'vehicle-city collaboration' for scenarios such as autonomous commuting, smart logistics distribution, and smart sanitation. Verify the accuracy of environment interaction perception between vehicles and cities. Develop new service industries based on unmanned vehicles such as unmanned logistics, mobile retail, and mobile offices to meet diverse intelligent transportation needs. Encourage eligible regions to carry out large-scale, comprehensive pilot applications of intelligent and connected vehicles at the city level, explore 'Holistic Road System' [sic] in key areas, and continuously improve the intelligent management of urban traffic and the experience of travel services for residents. Establish and improve the technical standards system for smart city infrastructure and intelligent connected vehicles."

5.4 Notice on Carrying Out Pilot Work for Intelligent and Connected Vehicle Access and Road Travel

In November 2023, the MIIT, MPS, MHURD, and MOT jointly issued the 'Notice on Carrying Out Pilot Work for Intelligent and Connected Vehicle Access and Road Travel'. Building upon the work of intelligent and connected vehicle road testing and demonstration applications, these organisations will select intelligent and connected vehicle products equipped with autonomous driving functions ready for mass production to conduct access pilots. For intelligent and connected vehicle products that have obtained access, pilot road tests will be conducted within designated areas. Vehicles intended for transport operations must comply with the operational qualifications and management requirements stipulated by the competent transportation authorities. The autonomous driving functions installed in the intelligent and connected vehicles mentioned in this notice refer to Level 3 (Conditional Driving Automation) and Level 4 (High Driving Automation), as defined in the national standard 'Classification and Requirements for Driving Automation of Motor Vehicles' (GB/T 40429-2021).

5.5 Notice on Carrying Out Pilot Applications of Intelligent and Connected Vehicles for Vehicle-Road-Cloud Integration

In January 2024, the MIIT, MPS, MNR, MHURD, and MOT jointly issued the 'Notice on Carrying Out Pilot Applications of Intelligent and Connected Vehicles for Vehicle-

Road-Cloud Integration'. In order to implement the 'New Energy Vehicle Industry Development Plan (2021-2035)', promote the construction of internet-connected/ cloud-controlled infrastructure, explore multi-scenario applications for autonomous driving technology based on efficient collaboration among vehicles, roads, networks, clouds, and maps, and to further accelerate technological breakthroughs and industrial development in intelligent and connected vehicles, these five organisations jointly initiated pilot applications for intelligent and connected vehicles to achieve vehicle-road-cloud integration, with a pilot period from 2024 to 2026.

6 Key SDOs or industry alliances

6.1 IMT2020 (5G) PG C-V2X WG

With the development of C-V2X based on the LTE-V2X and 5G Uu communication technologies, the IMT-2020(5G) PG C-V2X WG (www.imt2020.org.cn) is continuing to deepen and expand C-V2X ecosystem studies from vehicle-to-road collaboration towards the interplay of vehicles, roads, pedestrians and edge and service cloud platforms.

The following table lists the completed study items in the C-V2X Working Group from 2023 to 2024.

Table 1: Completed study items in C-V2X Working Group

Timeline	Topics	Output
2021-2023	Technical Requirements and Test Method of C-V2X Network Performance	Research report and standard
2021-2023	C-V2X Security Certificate Management System	Research report
2021-2023	C-V2X Identification System	Research report
2021-2023	Cloud Data Transmission for the Open-air Mining Vehicles	Research report
2022-2023	VRU Protection Use Scenarios and Key Technologies	Research report
2021-2023	C-V2X and Vehicle Intelligence Integration	Research report and white paper
2022-2024	Data Quality and Test Method for C-V2X Roadside Application	Research report
2022-2024	OBU Technology Trends	Research report
2022-2024	Research on the Interworking between 5G and C-V2X	Research report

6.2 CCSA

During the period 2022 to 2024, China's Communication Standardisation Association (www.ccsa.org.cn) is continuously studying and developing related C-V2X standards based on the deployment condition and key issues identified. Some of the output of IMT-2020(5G) PG C-V2X WG also form the basis for the standardisation work in CCSA.

The V2X sub-working group was elevated to Working Group 5 of CCSA TC10 in August 2022, which will help to promote C-V2X standards work in CCSA.

The following table summarises the list of V2X standards completed in CCSA from 2022 to 2024.

Table 2: List of C-V2X standards completed in CCSA TC10 WG5 (V2X) from 2022 to 2024

No.	Standard	Status	Standard Category
2021-0138T-YD	Technical Requirements of V2I Basic Information Unicast of LTE-based Vehicular Communication	Specification ready for approval	Industry standard
2021-0187T-YD	Technical Requirements of Vehicle Misbehaviour Management for C-V2X	Specification ready for approval	Industry standard
2021-CCSA-30	5G-Enabled Remote Driving: Technical Requirements for 5G Communication System	Published	Consortium standard
2019-0007T-YD	LTE-based V2X Communication – Test Methods of MEC Platform	Specification ready for approval	Industry standard
2021-1033T-YD	Measurement Methods of Roadside-LiDAR in Vehicle-Infrastructure Cooperation System	Specification ready for approval	Industry standard
2022-1347T-YD	Technical Requirements and Test Methods of Roadside Sensing System for Vehicle-Road Collaboration	Specification ready for publishing	Industry standard
2022-1348T-YD	Use Case and Technical Requirements of V2X Based on Mobile Internet	Specification ready for approval	Industry standard
2022-CCSA-09	Technical Specification of Roadside Computing Device in Vehicle Infrastructure Cooperation System	Published	Consortium standard
2022-CCSA-11	Technical Requirements for Roadside Computing Equipment Operation and Maintenance Management Platform	Specification ready for approval	Consortium standard
2022-CCSA-12	Test Method of Operation and Maintenance Management Platform for Vehicle Road Collaborative Roadside	Specification ready for approval	Consortium standard
2022-CCSA-13	Test Method of Operation and Maintenance Management Platform for Vehicle Road Collaborative Roadside	Specification ready for approval	Consortium standard
2019-0008T-YD	Requirements and Architecture of MEC for LTE-V2X Service	Published	Industry standard
2019-0006T-YD	MEC for C-V2X Service Capability and Interface Technical Requirements	Published	Industry standard
2023-0694T-YD	IoV – Technical Requirements for Cryptographic Applications of Vehicle Road Collaboration Communication	Specification ready for approval	Industry standard
	Basic Requirements for Cryptography Applications of Vehicle Cloud Communication	Specification ready for approval	Industry standard
2022-CCSA-06	Performance Requirements and Test Methods of C-V2X Network Coverage	Published	Consortium standard
2023-CCSA-033	Test Methods of Wired Bearer Network for Freeway Vehicle-Road Collaboration Service	Specification ready for approval	Consortium standard

6.3 NTCAS: SC34

Subcommittee (SC) 34 is working on ICV and belongs to the National Technical Committee (TC) 114, which is working on administrative aspects for Road Vehicle Standardisation in China, and it is funded and guided by the MIIT. By September 2024, NTCAS SC34 had submitted and published 70 standards and 38 studies, and conducted more than 40 standard validation tests.

Below is a list of connected vehicle-related national standards. There are also industrial standards, studies and pilot projects related to C-V2X.

Table 3: C-V2X-related national standards in NTCAS SC34

Standard	Status	Remarks
Intelligent and connected vehicle - Methods and requirements of road test for automated driving functions	Published	GB/T 44719-2024
Intelligent and connected vehicle - General technical requirements for automated driving system	Published	GB/T 44721-2024
Intelligent and connected vehicle - Technical requirements and testing methods for combined driver assistance system – Part 2: Multi-lane manoeuvre	Published	GB/T 44461.2-2024
Intelligent and connected vehicle - Technical requirements and testing methods for combined driver assistance system – Part 1: Single-lane manoeuvre	Published	GB/T 44461.1-2024
Technical requirements for vehicle cybersecurity	Published	GB/T 44464-2024
Technical requirements for vehicle cybersecurity	Published	GB 44495-2024
General technical requirements for software update of vehicles	Published	GB 44496-2024
Intelligent and connected vehicle - Data storage system for automated driving	Published	GB 44497-2024
Intelligent and connected vehicles - Symbols for controls, indicators and tell-tales	Published	GB/T 44298-2024
Intelligent and connected vehicle - Terms and definitions	Published	GB/T 44373-2024
Intelligent and connected vehicles - Track testing methods and requirements for automated driving functions	Published	GB/T 41798-2022
Road vehicles - Extended vehicle (ExVe) methodology - Part 1: General information	Published	GB/T 41901.1-2022
Road vehicles- Extended vehicle(ExVe) methodology - Part 2: Methodology for designing the extended vehicle	Published	GB/T 41901.2-2022
Performance requirements and test methods for intelligent parking assist system	Published	GB/T 41630-2022

The national standard 'Technical requirements and test methods of vehicular communication system based on LTE-V2X direct communication' (or LTE-V2X OBU profile) completed its standard validation test and public consultation process in 2023. Now the standard was published. It is the first national standard in China concerning LTE-V2X direct communication technology in which BSM message transmission and OBU component requirements and test methods are raised.

On top of the LTE-V2X OBU profile, the 'Intelligent and connected vehicles – Technical and test specification for safety warning system based on direct connection technology' national standard was kick offs . Its purpose is to set up C-V2X application-level requirements and test methods. In the latest draft, three categories of C-V2X applications are defined and regulated: Intersection Collision Warning, Abnormal Vehicle Reminder, and Red Light Violation Warning.

6.4 CSAE/CAICV

The 'Roadmap for the Intelligent and Connected Convergence Development Based on C-V2X (Draft for Comments)' was initiated and compiled by 14 cross-industry societies, alliances, and research institutions – including CSAE, CAICV, the IMT-2020 (5G) Promotion Group C-V2X Working Group, while supported by more than 40 enterprises, universities, and research institutions in various fields (including automotive, communications, transportation, and safety).

The roadmap will greatly accelerate the deep integration of ICV with intelligent transportation and smart cities, support the strategic planning and formulation of government departments, promote cross-industry collaborative technological innovation, facilitate the integrated development and application of V2X technology and intelligent driving technology, and guide the next step in conducting large-scale demonstrations and promotions,

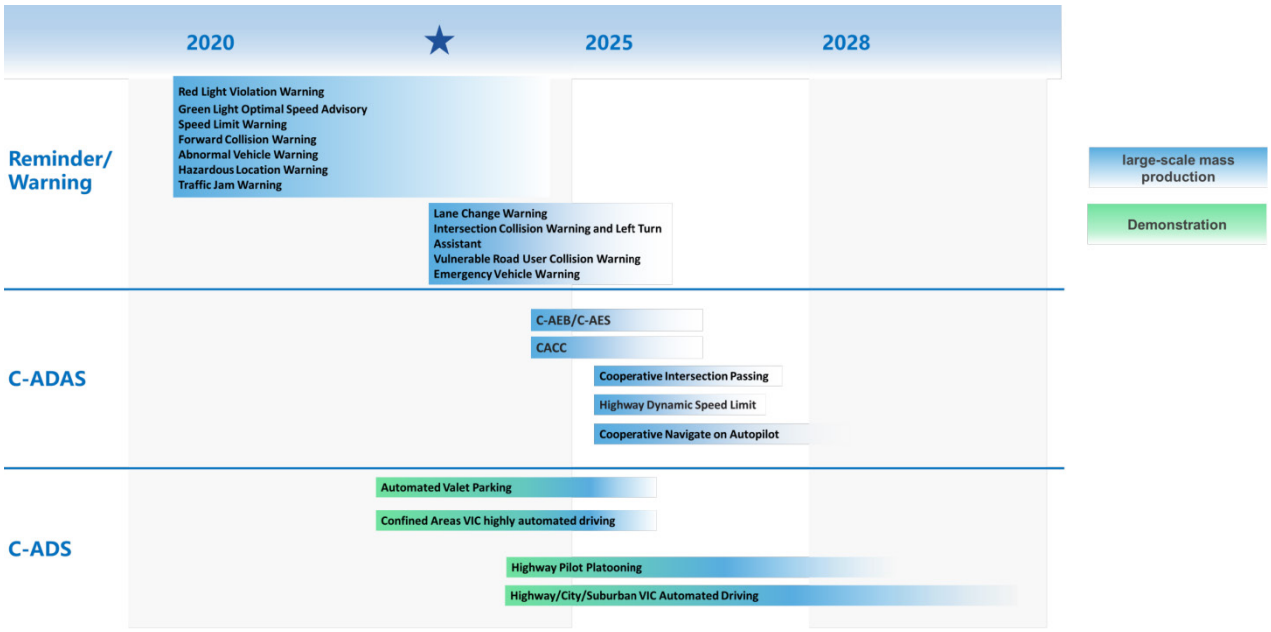

Figure 1: Roadmap for integrated vehicular-infrastructure cloud scenarios

The following table lists the V2X standards in CSAE from 2022 to 2024.

Table 4: List of the V2X consortium standards in CSAE

Standard	Field	Status
T/CSAE 246-2022 – Test and evaluation methods for V2X system warning application function of intelligent and connected vehicles	ICV	Published
T/CSAE 295.1-2023 – Vehicle-road-cloud integrated system – Part 1: System composition and basic platform architecture	ICV	Published

T/CSAE 295.2-2023 – Vehicle-Road-Cloud Integrated System – Part 2: Vehicle-cloud data exchange specification	ICV	Published
T/CSAE 295.5-2023 – Vehicle-road-cloud integrated system – Part 5: Platform service scene specification	ICV	Published
T/CSAE 297-2023 – Technical requirement of scenario database and specification of simulation testing for V2X warning application	ICV	Published
T/CSAE 315.1-2023 – Collaborative intelligent transportation systems – Application layer interaction technical requirements – Part 1: Intention and cooperation	ICV	Published
T/CSAE 159-2024 LTE-based vehicular communication – Direct communication system roadside unit technical requirements	ICV	Published

6.5 C-ITS

The standards related to C-ITS are listed in the following table.

Table 5: List of C-V2X standards in C-ITS (from 2022)

Standard	**Status**
Specification for electromechanical interface of roadside terminals on smart pole(T/ITS 0192-2021)	Published
Technical requirements for traffic management and control multi-edge computing device in mixed traffic environment (T/TIS 0193-2022)	Published
Intelligent mining vehicle automated driving cooperative operation system – Part 1: General technical requirements (T/ITS 0198.1-2022)	Published
Intelligent mining vehicle automated driving cooperative operation system – Part 2: Vehicle technical requirements (T/ITS 0198.2-2022)	Published
Intelligent mining vehicle automated driving cooperative operation system – Part 3: Cloud control platform technical requirements (T/ITS 0198.3-2022)	Published
Intelligent mining vehicle automated driving cooperative operation system – Part 4: Information interaction requirements (T/ITS 0198.4-2022)	Published
Intelligent mining vehicle automated driving cooperative operation system – Part 5: Test methods and requirements for vehicle and control platform (T/ITS 0198.5-2022)	Published
Specification for information interaction interface between road traffic signal controller and RSU equipment (T/ITS 0210-2022)	Published
Cooperative intelligent transportation system-data interface specification between RSU and central sub-system (T /ITS 0117-2022)	Published
Distribution mechanism for intelligent driving electronic map (T /ITS 0167-2022)	Published
Cloud control basic platform for vehicle-infrastructure cooperative system – Technical requirements for cybersecurity (T/ITS 0183-2022)	Published
Road safety classification for autonomous driving	Published
Cooperative intelligent bus system – Part 1: General architecture and application (T/ITS 0191.1-2022)	Published
Cooperative intelligent bus system – Part 2: General architecture and application (T/ITS 0191.2-2022)	Published
Cloud control basic platform for vehicle-infrastructure cooperative systems – General requirements (T/ITS 0199.1-2022)	Published
Cloud control basic platform for vehicle-infrastructure cooperative systems – Function test requirements (T/ITS 0199.2-2022)	Published

Monitoring system for intelligent and connected vehicles testing – Part 1: Technical requirements for monitoring platform (T/ITS 0201.1-2022)	Published
Monitoring system for intelligent and connected vehicles testing – Part 2: Technical requirements for on-board terminal (T/ITS 0201.2-2022)	Published
Monitoring system for intelligent and connected vehicles testing – Part 3: Technical requirements for monitoring platform and vehicle terminal interface (T/ITS 0201.3-2022)	Published
Smart expressway-cloud control platform – General technical requirements (T/ITS 0181-2022)	Published
Technical specification for green light optimal speed advisory system of cooperative vehicle infrastructure (T/ITS 0211-2023)	Published
Technical specification for communication on traffic information edge acquisition terminal at road intersection (T/ITS 0218-2023)	Published
Traffic operation status evaluation diagnosis and governance system for intelligent and connected intersections – Part 1: General requirements (T/ITS 0223.1-2023)	Published
Traffic operation status evaluation diagnosis and governance system for intelligent and connected intersections – Part 2: Evaluation indicators and methods (T/ITS 0223.2-2023)	Published
Traffic operation status evaluation diagnosis and governance system for intelligent and connected intersections – Part 3: Monitor and diagnosis governance (T/ITS 0223.3-2023)	Published

6.6 NTCTM

The following national standards and traffic management industry standards were scheduled to be or ultimatelypublished in 2024.

Table 6: List of C-V2X standards in NTCTM (scheduled or published in 2024)

Standard No.	Title	Status
National standard 20205083-T-312	Technical requirements for working safety test of intelligent connected vehicles	ready for approval
National standard 20205084-T-312	Environment technical requirements for working safety test of intelligent connected vehicles – Part 1: Open road	ready for approval
National standard 20213512-T-312	Environment technical requirements for working safety test of intelligent connected vehicles – Part 2: Half open road	review
Industry standard	Elements and requirements for setting up testing scenarios for the safe operation of intelligent connected vehicles in enclosed areas	ready for approval
Industry standard	Elements and requirements for setting up semi open road testing scenarios for the safe operation of intelligent connected vehicles	ready for approval
Industry standard	Elements and requirements for setting up public road testing scenarios for the safe operation of intelligent connected vehicles	ready for approval
Industry standard	Specification for data exchange of safety testing and evaluation for intelligent connected vehicles	ready for approval

6.7 C-NCAP

The China New Car Assessment Program (C-NCAP) refers to the vehicle safety performance evaluation activities led by China Automotive Technology & Research Center Co. Ltd. (CATARC), which has been updated to the 2024 version. In the C-NCAP 2024 version, there are three application scenarios, two of which are mandatory – Automatic Emergency Braking System (AEB) test and Emergency Lane Keeping (ELK)

test – and one the Driver Monitoring System (DMS) test is optional. Several active safety test cases are targeted for C-V2X implementation, including the Car-to-Car Straight Crossing Path with Obstruction (C2C SCPO) case, Traffic Signal Recognition (TSR), High Speed Car to Car Rear (CCRH), and others.

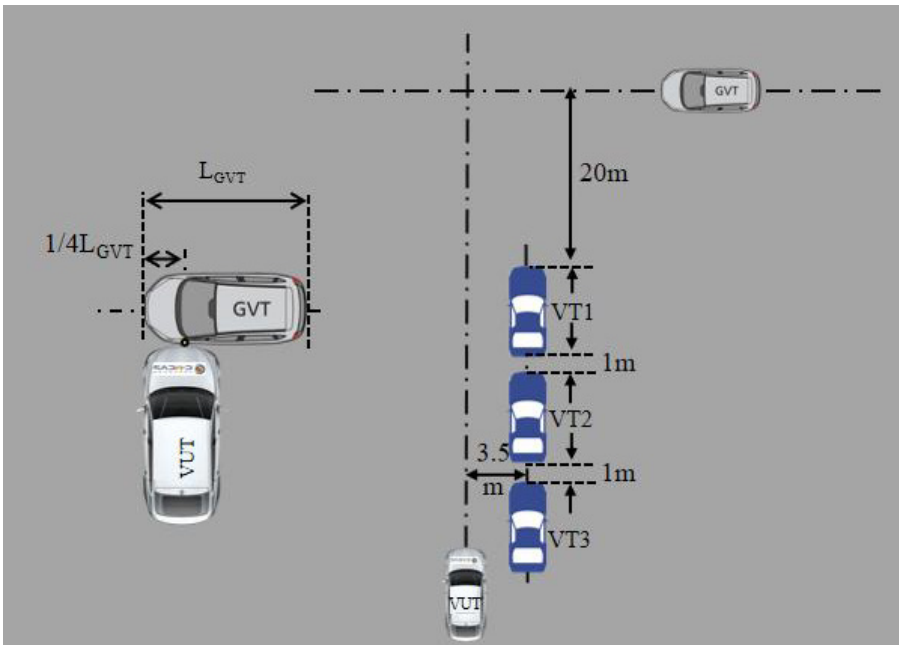

Figure 2: Car-to-Car Straight Crossing Path with Obstruction test case

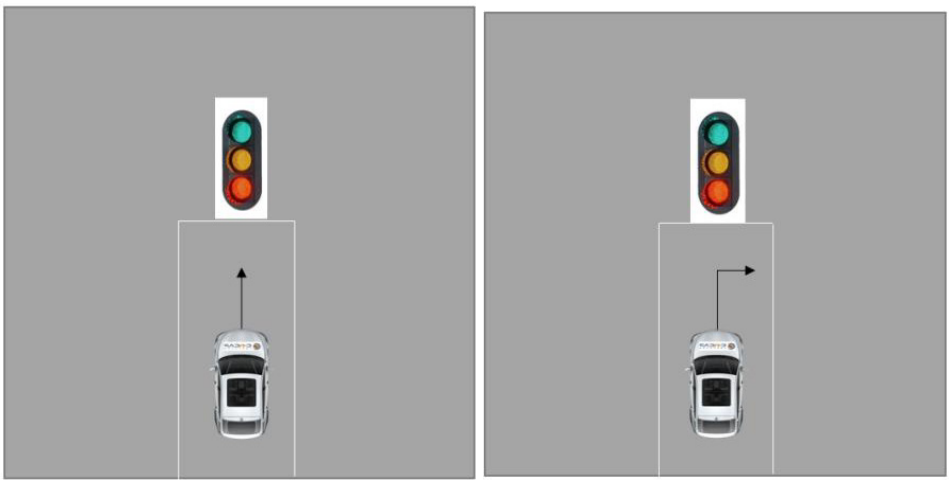

Figure 3: Traffic Signal Recognition test case

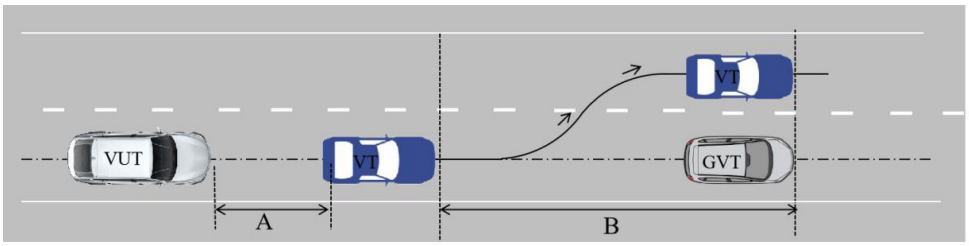

Figure 4: High Speed Car to Car Rear test case

7 Main pilot and demonstration areas

7.1 National pilot areas for CV

During the construction of CV national pilot area in China, a strong ecosystem was created with new infrastructure and applications for collaboration between ITS and ICV, and the support of the local industrial chain.

Wuxi is a comprehensive national ITS test base built jointly by the MIIT, MPS and Jiangsu Province, and from it the world's first urban LTE-V2X application project was conducted. Tianjin has established the ICV quality supervision and inspection centre, which offers a common platform for research and development, standards formulation, testing and verification services for key technologies. Changsha has issued several plans to vigorously promote the transformation of ICV on urban roads and for public and specialised vehicles. Chongqing focuses on full-scenario tests and the large-scale commercial use of complex road traffic characteristics and special road conditions. Xiangyang plans to build deep applicationof connected vehicles. Deqing is concentrating support on geographic information and county-wide regional openness. Liuzhou is promoting development of CVs as part of automotive industry transformations.

7.1.1 Jiangsu Province (Wuxi City)

Wuxi is today recognised as the world's first urban LTE-V2X application project. As of writing (end 2024) connected vehicle deployment in Wuxi has reached several hundred kilometres. Based on traffic management data, Wuxi has developed and realised information warning applications such as 'Abnormal Vehicle Warning', real-time information notification applications such as 'Green Wave Traffic', and other applications such as 'High Priority Vehicle Passing'. The Wuxi government is focusing on promoting large-scale transportation services. More than 200 intersections have integrated online navigation of signal lights into Baidu Maps, providing road information services ('Traffic Light Information Display', 'Green Wave Traffic', 'Vulnerable Road User Collision Warning', etc.) to four models including Audi A7 and Ford EDGE.

Wuxi has pioneered the 'one centre, three platforms' architecture for the CV system, focusing on technical breakthroughs from three levels: cloud, management, and terminal. It has built the Connected Vehicles Big Data Centre, Traffic Management Data Interaction Platform, V2X Data Application Service Platform, and Traffic Condition Diagnosis and Information Release Platform. Wuxi has fully opened up data exchange in areas such as traffic management, vehicles, and travel services.

7.1.2 Tianjin Municipality (Xiqing District)

Tianjin Municipality (Xiqing District) Connected Vehicles Forerunner Pilot Zone was approved by MIIT in December 2019. The main tasks and objectives are as follows:

- Explore new models of cross-industry standardisation, strengthen the construction of testing and evaluation system, and promote the improvement of related policies and regulations.

- Deploy V2X infrastructures and upgrade the transportation facilities and systems in key areas, promote deployment of V2X terminals, establish cloud service platforms for V2X security management, authentication system, and information openness and interconnection.
- Explore and enrich the application scenarios of V2X, build an open and innovative industrial ecology, and explore feasible operation mode for V2X pilot zone.

The Tianjin (Xiqing) Connected Vehicles Forerunner Pilot Zone has completed the first of two phases. Intersections with full-range perception and V2X communication have been upgraded; more than 200 road infrastructures, including MECs, RSUs, LIDARs, radars and cameras, covering 48 kilometres of road open area. Phase two of the project is under preparation (end 2024) and will continue to expand in scope to cover the Xiqing district's core area and main roads, open road intersections, and more than 100 scenarios – the platform could also provide V2X services for connected vehicles.

The pilot zone has built a vehicle-road collaborative platform consisting of a V2X application service system, data analysis system, operating system, and service provision in different scenarios for governments, enterprises, and individuals. More than 100 use cases have been carried out for traffic safety, traffic efficiency and information services, including typical Day-1 use cases, vehicle/VRU warnings based on infrastructure perception, and others. Various kinds of user terminals are supported via both PC5 and 4G/5G Uu to increase the penetration rate of uses, such as OEM front-loading OBUs, aftermarket OBUs, and smart phone apps/WeChat mini apps.

The test and verification system has been established in Tianjin for ICV, including virtual test fields, closed test fields, and open roads. Verifying V2X security capabilities and applications are key tasks for the Tianjin pilot zone. A series of C-V2X security verification activities were conducted in April 2022; 20 security-related scenarios were set along 7.6 kilometres of open road for enterprises to verify C-V2X security mechanisms, such as secure communication protocols, security certificate applications, and security certificate management.

7.1.3 Hunan Province (Changsha City)

To achieve the coverage of connectivity, the first batch of robot taxis from Baidu are being tested on public roads in Changsha. Network infrastructure and other intelligent devices are being deployed in Changsha step by step. In the first phase, LTE-V2X RSU and 5G base stations were first deployed in some sections to support the basic ITS applications, such as smart bus and the intelligent traffic management; in the second phase, communication device combining with MEC platform and sensing devices, such as cameras and LIDARs will be deployed. Some other ITS applications, such as VRU and HD map distribution will be achieved with these devices.

7.1.4 Chongqing Municipality (Liangjiang New Area)

Chongqing (Liangjiang New Area) National Pilot Area was approved by the MIIT in January 2021 to promote simultaneously the construction of 'three zones, one line and two points' combining road infrastructure an various scenarios and platforms. Meanwhile, the three types of application scenarios are promoted for industrial

upgrades and digital transformation purposes. The three zones, namely Lijia, Yuelai and Longsheng, are constructed for CIVS test scenarios. The one line is Liyue Road, which connects Yuelai and Lijia zones, to provide CIVS demonstration scenarios integrated with ITS, smart city, and life and leisure aspects. The two points including Comprehensive Airport Functional Area and Orchard Port are supported by a collaborative application scenario of intelligent logistics, vehicles, and roads.

The pilot area was completed in two stages, the first in August 2021 and the second finalised in December 2022. At the time of writing (end 2024), the Chongqing pilot area had built nearly 100 kilometres of urban demonstration roads (including intelligent network test roads), i-VISTA intelligent vehicle integration test area, intelligent logistics 5G automated driving, and Phase I of the Airport Industrial Park. The pilot zones, such as Lijia Smart Park and Liangjiang Collaborative Innovation Zone, are a large-scale demonstration of CV applications.

7.1.5 Hubei Province (Xiangyang City)

On 30 August 2023, the MIIT approved the establishment of the National Pilot Area in Hubei Province (Xiangyang City) as one of the seven national CV pilots in China.

With the goal of building a pioneer CV city in China, Xiangyang is now working to build a city-level CV application environment. Featuring 'one network, multiple zones' in the central urban area will be realized for the demonstration of ICV. The wider pilot comprises two industrial parks and four cities in an effort to establish a 'unified' CV infrastructure and application service platform, and to create multi-level areas for ICV admission testing, demonstration applications, and commercial operations. The plan is to build (intelligent) CV industrial parks in the High-Tech Zone and Dongjin New Area, and to promote the implementation of commercial scenarios in Xiangcheng, Fancheng, Xiangzhou, Yuliangzhou Development Zone, and other places.

7.1.6 Zhejiang Province (Deqing City)

On 14 May 2023, the MIIT approved the establishment of the National ICV Pilot Zone in Zhejiang Province (Deqing), as one of its seven such pilots in China. The Deqing Intelligent Connected Vehicle Closed Test Zone has since been built and put into use. It promotes the combination of closed and open road test zones, forming a three-layer – 'closed test zone-open test road-virtual test field' – testing and verification capability.

Deqing focuses on four fields: geographic information, autonomous driving, smart city, and smart transportation, achieving more than 20 applications such as 'Green Wave Traffic' at intersections and 'Traffic Accident Warning Remind', as well as six characteristic applications deeply integrated with urban governance, including county-level integrated digital distribution and red-light violation warning for non-motorised vehicles.

7.1.7 Guangxi Province (Liuzhou City)

In April 2023, the MIIT approved the establishment of the National ICV Pilot Zone in Guangxi Province (Liuzhou City), again as one of the seven national CV pilots. The main task and goal of this pilot area is to deploy the C-V2X network on urban roads with the coordinated development of 5G and smart cities, complete the transformation of

CV functions and enhance core system capabilities in key areas, and create an open and interconnected cloud service platform. Based on automotive industry foundations, the plan remains to build typical commercial application scenarios, effectively develop in-vehicle use cases, promote the installation and use of shared mobility/vehicles, strengthen the user/service experience and value analysis, and create a new ecosystem for the connected car industry. The pilot ultimately seeks to deepen policy and institutional innovation, establish a healthy and sustainable construction/operation model, improve safety management and systems, and establish experiences and practices that can be replicated and promoted.

7.2 Demonstration areas for CV and pilot cities for the coordinated smart city and ICV development

7.2.1 Demonstration areas for CV

The various ministries have actively promoted and cooperated with local governments to further support the construction of 17 CV Demonstration Areas in Shanghai, Beijing, etc.

Different climatic conditions and geomorphic characteristics enable testing and verification to be carried out under diverse conditions. Another selection criteria are how well developed the automobile industry is in the ICV Demonstration Area being considered. Typical scenarios, such as urban versus rural roads and other features, are covered in the Demonstration Areas with installed C-V2X devices, transportation facilities, cellular networks and other infrastructure. The related constructions and the supported use cases and scenarios are gradually promoted. National Demonstration Areas in Shanghai, Beijing and Hebei, Chongqing, Changchun are ongoing, while earlier test sites in Changsha, Jiangsu Taixing, Shanghai Lingang have already been put into operation. Other test Pilot and Demonstration Areas are in active planning or construction phase. Cross-regional architecture has been established to further promote data-sharing and business collaboration.

7.2.2 Pilot cities for the coordinated development of smart city and ICV

The MOHURD and MIIT approved two sets or batches of 16 pilot cities for the coordinated development of smart city infrastructures and ICV. Cities include Beijing, Shanghai, Guangzhou, Wuhan, Changsha, Wuxi, Chongqing, Shenzhen, Xiamen, Nanjing, Jinan, Chengdu, Hefei, Cangzhou, Wuhu, and Zibo.

The task of the 16 pilot cities is not only to boost construction of smart city infrastructure and build demos and applications for different levels of intelligent connected vehicles in specific scenarios, but also to establish best practices and cases that can be repeated and showcased in other cities. This ICV and Smart Cities pilot project has achieved phased results. Firstly, in terms of urban digital infrastructure construction, 16 pilot cities have deployed 'perception' facilities, such as visual radar, and 'driving interaction'

facilities at more than 2000 key intersections.

In addition, pilot cities have strengthened the development and supervision of infrastructure, urban transportation, public services, and disaster prevention and emergency response facilities through the construction of the Vehicle-City-Network Platform, which collects massive dynamic and static data on vehicles, roads, and cities. Breakthroughs have also been made in regulatory standards, among which Shenzhen has released the regulation on the management of intelligent connected vehicles; Beijing has released documents such as the Management Measures for Policy Pilot Zones.

7.2.3 ICVs in Shanghai international automotive city (SIAC)

SIAC is situated in Jiading District which is Shanghai's gateway to the Yangtze River Delta and a key city along the Shanghai-Nanjing development axis. Jiading District is the home of China's largest and most comprehensive automobile industry base. As the core area of Jiading's automobile industry, SIAC has successfully established the National ICV (Shanghai) Pilot Demonstration Area and maintained an internationally recognised environment for innovative ICV developments.

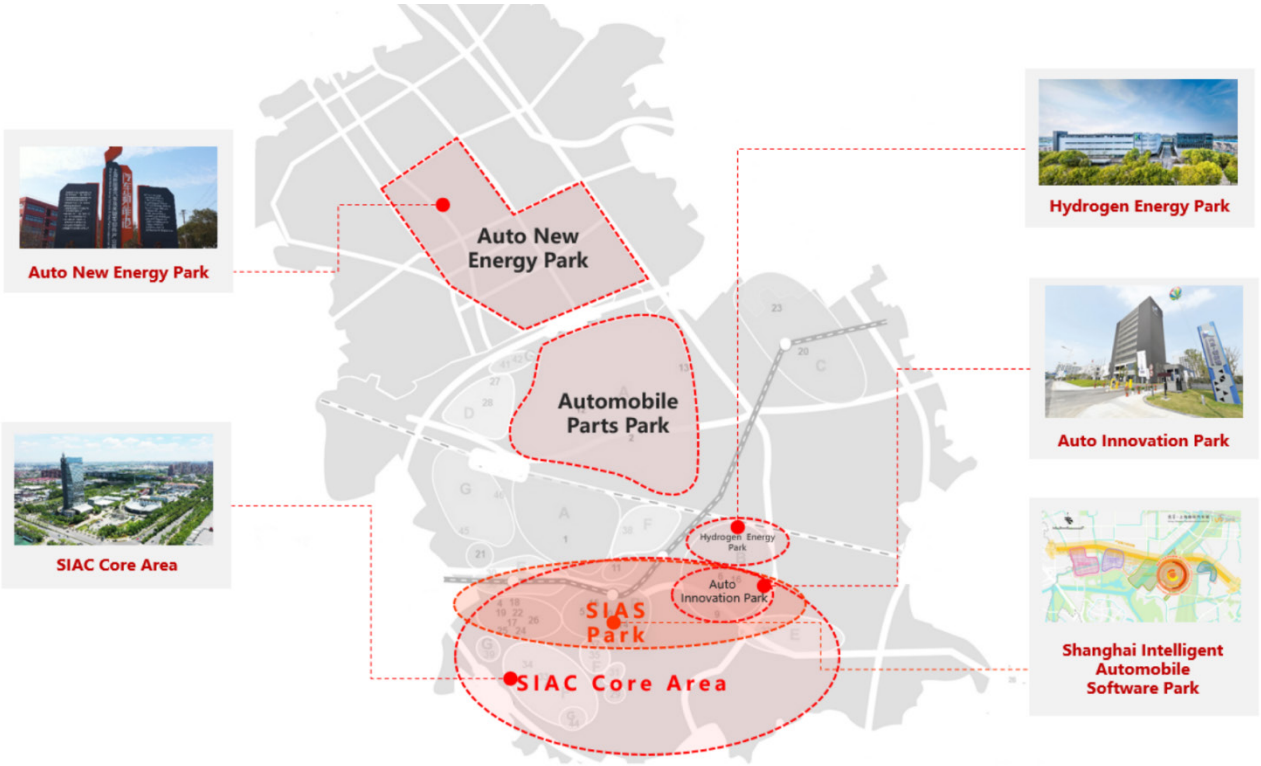

Figure 5: Overview of Shanghai International Automobile City

According to the ICV multi-pillar testing methodology, SIAC has established a digital twin virtual simulation laboratory, the closed testing zone, the public test roads, C-V2X heterogeneous communication network, data center, and Cloud-control-platform. These facilities support various technological innovations and test verifications including autonomous driving and IMT2020 (5G), thereby promoting the development of ICVs.

(1) Closed test zone

SIAC has established three complementary closed test zones (X-Zone, F-Zone, and C-Zone) for ICVs, offering the most diverse test scenarios in China. These zones have collectively provided testing services to both domestic and international companies.

(2) ICV data centre

All of datas such as L4 autonomous vehicles driving status, vehicle road collaboration, roadside perception, signal light status and traffic incident have been process automatically in ICV data centre, the data centre supports daily management and safety monitoring of public road tests for ICVs in Shanghai and offers data application, evaluation and analysis services.

(3) Public test roads

SIAC is committed to extending the operational domain for CVs from closed test zones to public roads.In March 2018, Jiading District opened a series of ICV test roads (the first public test road in China). In March 2018, Jiading District opened a series of ICV test roads. Until the end of 2024, the entire road network in Jiading District can be accessible to ICVs.

(4) Road test

SIAC has been actively advancing urban intelligent travel services and in March 2018 issued road test licences, followed by the pilot application and test licences for the Yangtze River Delta in 2019. Large-scale manned pilot applications for Robotaxis were then launched in June 2020, and Shanghai's pilot ICV Robotaxis started operating.

(5) C-V2X pilot projects

In 2021, SIAC successfully assisted Jiading District in gaining approval for the Smart City Infrastructure and Intelligent Connected Vehicles Pilot Project, organised by the MOHURD and MIIT, joining the other major national pilots. In December 2023, the project successfully passed national inspection and acceptance with the highest overall score, achieving several milestones in terms of construction, innovation, and implementation across multiple fields.

1) SIAC thus established China's lightweight, large-scale V2I environment, covering open test roads and intelligent intersections, including several holographic intersections enabling precise and dynamic 'perception' of traffic participants, incidents, and urban events.
2) SIAC built an end-to-end network supporting IPv6+ ICVs, intelligent transportation, and smart city services. Featuring low latency, high bandwidth, and high reliability, this network integrates 5G and C-V2X networks to provide V2I coordinated services for autonomous vehicles across various SAE autonomy levels.
3) SIAC developed China's safe and compliant cloud-based ICVSC digital twin platform (Shanghai Intelligent Connected Vehicle and Smart City Platform), enabling the fusion of vehicle, road and city data. This platform features a unified data foundation and an intelligent data platform, achieving integrated access to multi-dimensional vehicle, road and city data collected within the area. It also links multiple public data service platforms to empower ICV, intelligent transportation, and smart city applications.

4) SIAC established China's integrated virtual simulation and real-life vehicle testing environment, as well as a system that supports comprehensive simulation testing and capability evaluation for ICVs, providing strong support for vehicle twin simulations.

5) SIAC achieved China's city-level, full-scenario, large-scale demonstration of all types of automated vehicles. Over 800 intelligent vehicles, including Robotaxis, specialised automated vehicles (for unmanned delivery, unmanned cleaning, unmanned retail, etc.), and intelligent connected buses are being demonstrated in Jiading District, showcasing the power of diverse application scenarios and innovations.

Looking ahead, SIAC will actively respond to national and industry demands by conducting a thorough Vehicle-Road-Cloud Integration Pilot Project. It will also promote ICV market access and road operation pilots (L3 ICV Pilot) while collaborating with the IMT2020 (5G) PG C-V2X WG to host a series of Four-Layer Test Activities to advance the V2I coordination industry, explore C-V2X scenario applications, and develop closed-loop business models – ultimately achieving profound vehicle-road-city integration.

7.3 Vehicle-Road-Cloud integration pilot cities

In January 2024, the MIIT, MPS, MNR, MOHURD and MOT jointly announced plans to carry out pilot applications of vehicle-road-cloud integration for ICV in a range of cities between 2024 and 2026. The main requirements described in the work plan include funding, technical development and implementation measures to accelerate the formation of replicable and scalable experiences.

The final list of only 20 cities was released in July 2024 as shown in Table 7.

Table 7: Approved 20 Vehicle-Road-Cloud Integration Pilot Cities in China

Geographical area	Pilot areas (Municipality; Province, City)
North	Beijing (1)
	Inner Mongolia Autonomous Region, Ordos (2)
Northeast	Liaoning Province, Shenyang (3)
	Jilin Province, Changchun (4)
East	Shandong Province, Jinan (5)
Middle	Hubei Province, Wuhan (6)/Shiyan (7)
	Anhui Province, Hefei (8)
Southeast	Shanghai (9)
	Jiangsu Province, Nanjing (10)/Suzhou (11)/Wuxi (12)
	Zhejiang Province, Hangzhou-Tongxiang-Deqing collaboration (13)
	Fujian Province, Fuzhou (14)
Southwest	Sichuan Province, Chengdu (15)
	Chongqing (16)
South	Hunan Province, Changsha (17)
	Guangdong Province, Guangzhou (18)/Shenzhen (19)
	Hainan Province, Haikou-Sanya-Qionghai collaboration (20)

According to the announcement, the plans to construct intelligent roadside infrastructure in the pilot area include full 5G network coverage, and the deployment of

C-V2X infrastructure with LTE-V2X direct RSU. C-V2X terminals are proposed or planned for city buses, official vehicles, taxis and other public sector vehicles. New sales of mass-produced vehicles in the pilot cities with L2-level and above automated driving functions are encouraged to carry C-V2X terminals (i.e. interconnection of terminals with city-level platforms must be supported).

Construction of the city-level service management platform is set to include a two-level infrastructure platform for the edge and regional clouds, with the ability to provide vehicles with fusion sensing, collaborative decision-making planning and control, and be able to achieve secure data connectivity with vehicle-side equipment, road-side equipment, edge computing systems, traffic safety integrated service management platforms, traffic information management public service platforms, and CIM platforms.

The plan is also to carry out large-scale demonstration applications, encouraging pilot implementation of smart public transportation, smart passenger vehicles, automatic parking, urban logistics, automatic delivery, and other multi-scenario applications within the restricted area. Selected bus routes will also seek network-wide recognition of transportation facilities and automatic driving mode operation.

In order to better promote the relevant work in the pilot cities, several aspects were deemed especially important including the need to secure high-precision maps, continued improvement of standards and testing evaluation systems, development of a cross-domain mutual identity recognition system, enhanced road traffic safety capabilities, and simultaneous exploration of new business models and opportunities.

7.4 Series of cross-layer test and verifications

In order to further verify the C-V2X application of multiple venders in the real road environment, IMT-2020 (5G) PG C-V2X WG and CAICV organised three large-scale C-V2X interoperability test activities from 2018 to 2024. The cross-layer tests and verification activities in recent three years from 2022 to 2024 are summarised in Figure 6.

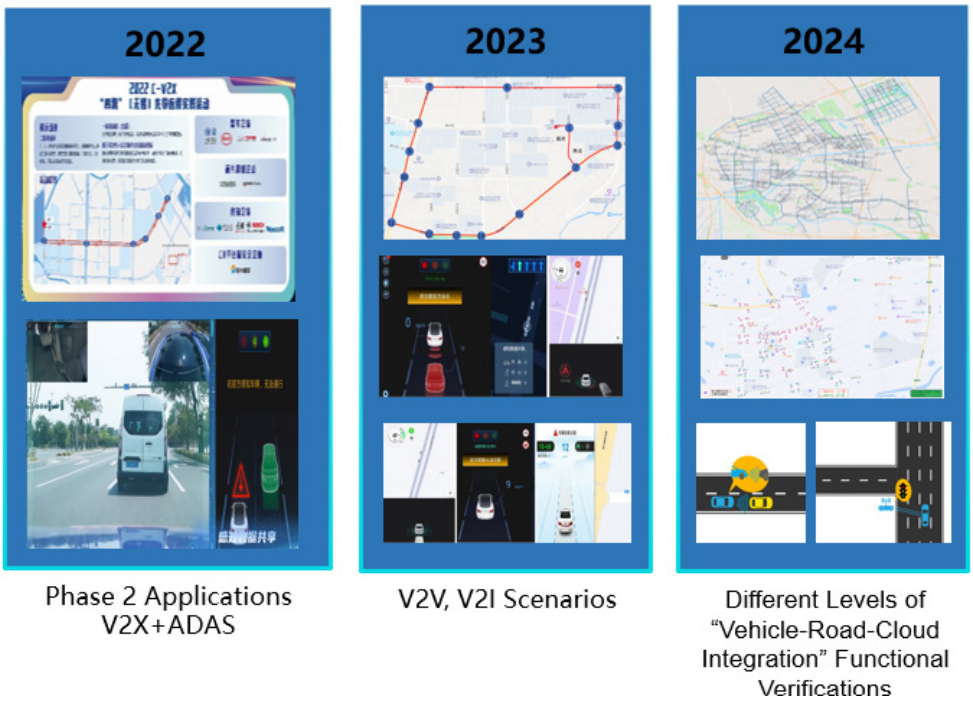

Figure 6: Recent three years of cross-layer test and verifications activities

8 Summary

This Technical Report provides a solid introduction and overview of China's latest C-V2X policies, regulations, standards, testing, and validation activities, including valuable insights and experiences on related research and development in this field.

At a pivotal stage of C-V2X developments, this TR calls for greater collaboration with all stakeholders working together to accelerate actions leading to the realisation of safer, greener, more efficient C-V2X solutions harnessing progress in ICV, ITS, and smart city applications.

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5GAA members work together to develop end-to-end solutions for future mobility and transport services.
5GAA is committed to helping define and develop the next generation of connected mobility, automated vehicles, and intelligent transport solutions based on C-V2X.
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