Cellular-V2X overall development in China and Wu-xi C-V2X Project

Kodo SHU, Huawei Technologies

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C-V2X, technology selected for intelligent connected vehicles in China

NDRC (National Development and Reform Commission of China):
Defined a Clear Target of LTE-V2X Network Coverage reaching 90% in 2020

Strategic Vision

到 2020 年，中国标准智能汽车的技术创新、产业生态、路网设施、法规标准、产品监管和信息安全体系框架基本形成。智能汽车新车占比达到 50%，中高级别智能汽车实现市场化应用，重点区域示范运行取得成效。智能道路交通系统建设取得积极进展，大城市、高速公路的车用无线通信网络（LTE-V2X）覆盖率达到 90%，北斗高精度时空服务实现全覆盖。

2020
- The proportion of Intelligent connected vehicles out of new vehicles reaches 50%
- LTE-V2X coverage rate to reach 90% in big cities and highway

2025
All new vehicles will be the Intelligent Connected Vehicle as default on configuration

2035
Achieve a "safe, efficient, green and civilized" intelligent vehicles society

Source: Intelligent Vehicle Innovation & Development Strategy

Strategic Mission

2. 建设覆盖全国的车用无线通信网络。依托现有移动通信网络，开展车用无线通信专用频谱使用许可研究，快速推进车用无线通信网络（LTE-V2X）等部署。在重点地区、重点路段建立

➤Deploy nationwide wireless network for vehicles communication.
➤Relying on existing mobile network
➤carry out research of dedicated spectrum license for vehicle communications
➤quickly promote the deployment of vehicles using wireless communication network (LTE-V2X)

Official Website Link:
http://www.ndrc.gov.cn/zwfwzx/tztg/201801/
t20180105_873123.html

HUAWEI

Government support towards C-V2X in China

MIIT issued the spectrum planning for LTE-V2X PC5 in Oct 25, 2018

1. 5905-5925MHz for LTE-2X only
2. Deployment and operation of LTE-V2X should apply license from MIIT
3. Encourage different cities to deploy demo and trial IoV network

http://www.gov.cn/xinwen/2018-11/13/content_5339936.htm

MIIT issued the"V2X Industry Promotion Action Plan" in Dec 25, 2018

Target (till 2020):
1. Deploy LTE-V2X in partial Highway and major City Road
2. V2X User penetration larger than 30%

http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c6564118/content.html

C-V2X standardization progressed well in China
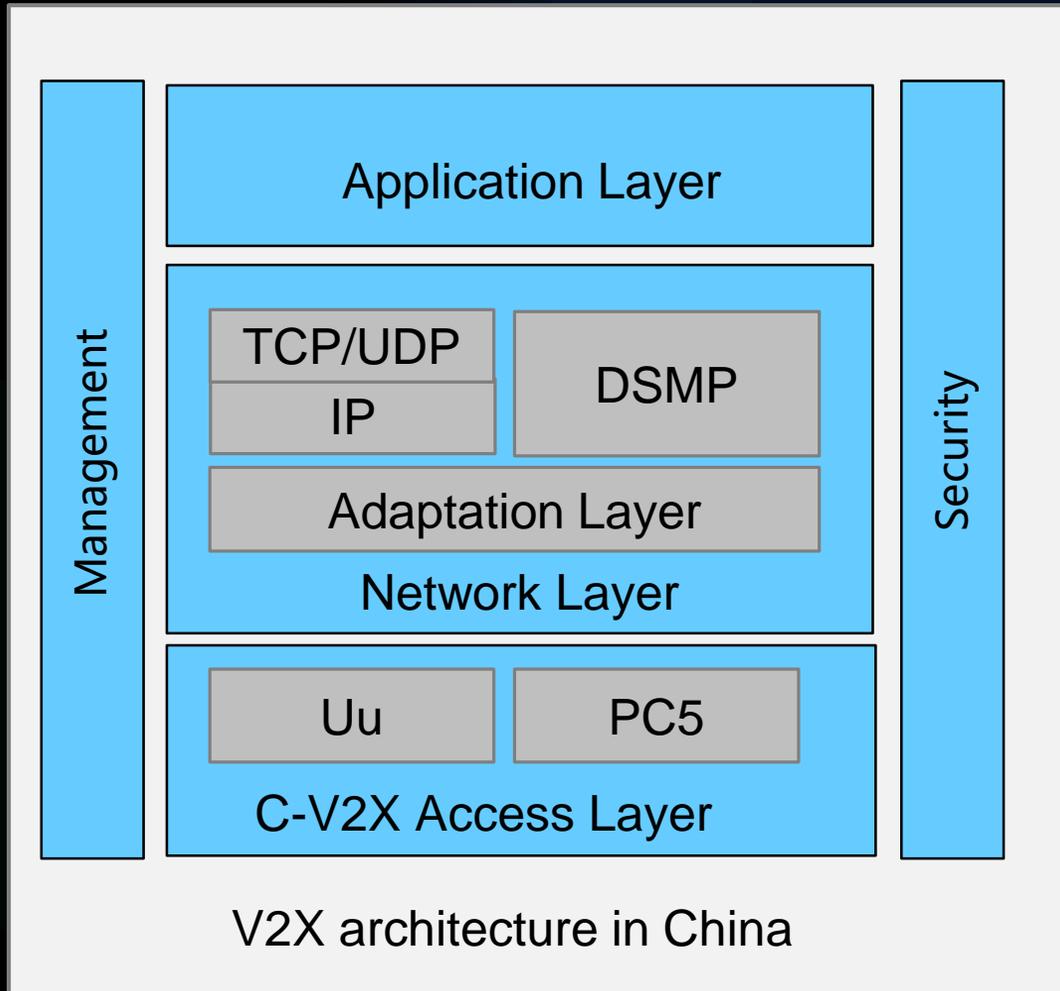
V2X architecture in China

Category	Title	Organization	State
Overview	General Technical Requirements for LTE-based Vehicle Communication	C-ITS CCSA	Published
Application (Day-1)	Technical requirements of Message layer of LTE-based vehicular communication	C-SAE C-ITS CCSA	Published
	Specifications for the information release interface of traffic signal controller	SAC TC576	In progress
	Performance requirements and test procedures for advanced emergency braking system of commercial vehicle	SAC TC268	Published
Network & Management	Technical requirements of network layer of LTE-based vehicular communication	CCSA/C-ITS	Approved
Access & Management	Air Interface Technical Requirements for LTE-based Vehicle communication	C-ITS CCSA	Published
Security	Technical Security Requirement for IoV communication based on the public LTE network	CCSA	Approved
	Technical requirements of Security Certificate management for Vehicular Communication based on LTE	CCSA	In progress
Profile	System Technical Requirements for LTE-based Vehicle Communication	SAC TC114	In progress

Progress of inter-operability test of C-V2X in China

Success of inter-operability test in Nov, 2018 marked the maturity of China's C-V2X industry eco-system:

-Realized the world's first cross-module (chip), cross-terminal, cross-vehicle inter-operability test
-based on Chinese application layer standards, C-V2X Mode-4 direct communication

Success of inter-operability test in Oct, 2019 further demonstrated the maturity of C-V2X security:

-Realized the cross-security-platform test on top of cross-module (chip), cross-terminal, cross-vehicle inter-operability test


CA: certificate authority

LTE-V2X has been considered in planning of national smart highways and transport control network construction

Highways for trial	Province	Length(KM)
Huiwu HighwayG12	Jilin	889
New Airport Highway	Beijing	35
Jingjingtang Highway	Beijing	142
Yanchong Highway	Beijing-Hebei	123
Beijing-Hongkong-Macao HighwayG4(Beijing-Shijiazhuang part)	Beijing-Hebei	480
Rongwu Highway G18(Baoding-Tianjing part)	Hebei	105
Airport West Highway	Henan	106
G107(Xinxiang-Zhengzhou part)、G207(Jiyuan-Zhengzhou part),G310(Kaifeng-luoyan part)	Henan	
Changjiu Highway G70	Jiangxi	138
Guangfo Highway S15	Guangdong	15.7
Hangzhou-Shaoxing-Ningbo HighwayG92N	Zhejiang	161
Huantaihu Highway	Jiangsu	19.3

Beijing Tongzhou Testfield

Jilin
Beijing
Hebei
Henan
Jiangxi
Jiangsu
Zhejiang
Fujian
Guangdong

➢ MOT (Ministry of Transportation) initiates **planning of 12 smart highways and transport control network across 9 provinces** and Beijing City

➢ **Yanchong smart Highway will be on service in 2019,** preparing for Beijing Winter Olympic game, 200 LTE-V2X RSUs along 33KM(Beijing part) in planning
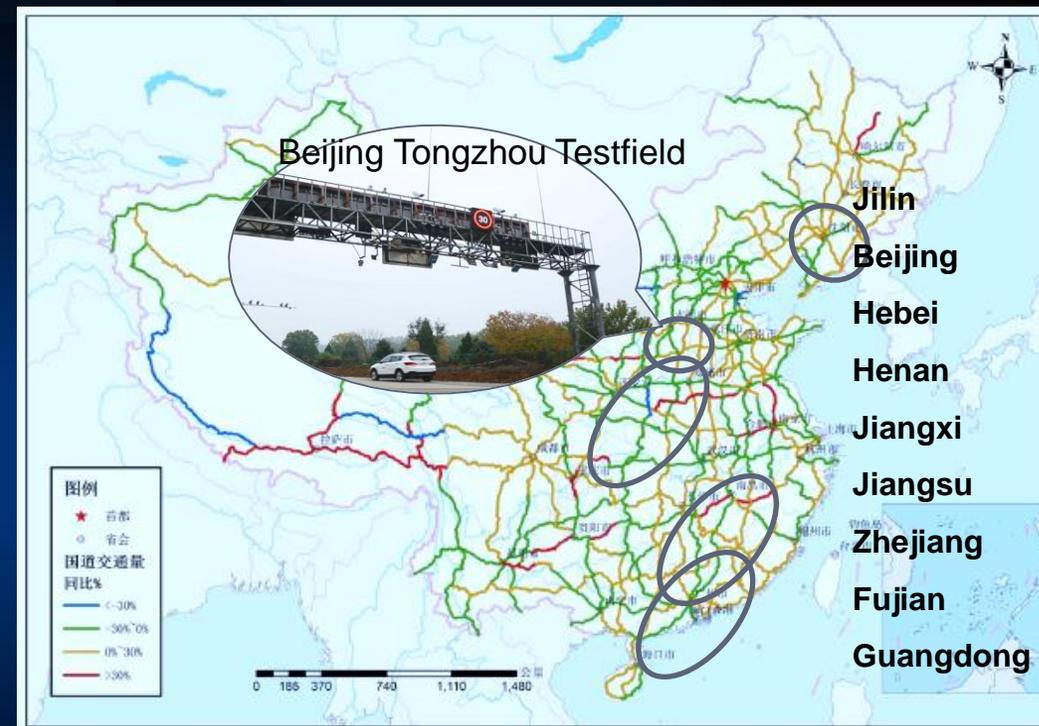
- LTE-V is preferred ITS technology for all the trials.
- V2X value, business model, operation owner, etc. such key issues will be explored.

Cities in China planning to deploy LTE-V2X

City	Car OEM	Investor/Operator
Wu Xi	No.	City Government/China Mobile
HaiNan province	For car test in China south area	Road Operator/ China Tower
Shanghai	SAIC, VW, GM	City district government
Shenzhen	BYD	City district government
Liuzhou	WuLing	City Government
Beijing	BAIC, Mecedez	Road Operator/City Government
Changchun	FAW, Audi, VW	City district government
Chongqing	ChangAn, Ford	City Government
Hangzhou	JiLi	City Government
Changsha	No.	City Government
ZhengZhou	YuTong (Bus)	City Government
GuangZhou	GAC, Toyota, Honda	TBD
ShenYang	BMW	TBD
Wuhan	DongFeng, PSA	City Government

The main motivation for city government to deploy C-V2X network includes:

- Optimize the traffic efficiency and improve the traffic safety, realize smart-city

- Serve the local car OEM and build the local industry eco-system

Mass-production plan of C-V2X Cars from 2H/2020 in China

Ford China announced in April, 2019 to mass-produce the first model equipped with C-V2X in China in 2021 to accelerate its intelligent connected-car strategy

13 car OEM in Shanghai Motor Show (April, 2019) jointly announced the launch of mass production of C-V2X car from 2H/2020

Source: http://www.sohu.com/a/309278895_296821

Geely announced in MWC Barcelona 2019 to officially release C-V2X-equipped cars in 2021.

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Huawei's IoV Vision: Improve traffic efficiency and road safety，accelerate the process of autonomous driving

"We are Committed to building ICT infrastructure for "Cooperative ITS", making active bi-directional interaction between vehicles and Infrastructures a standard, improving traffic efficiency and road safety, and evolving toward "Cooperative Autonomous Driving" in order to accelerate the process of autonomous driving."

Long range radar
Medium and short range radar
LIDAR
Camera
Ultrasonic Radar

Advantages of C-V2X:
- Traffic signal recognition
- Bad weather Condition
- NLOS
- Long range communication

V2N
V2P
V2I
V2V
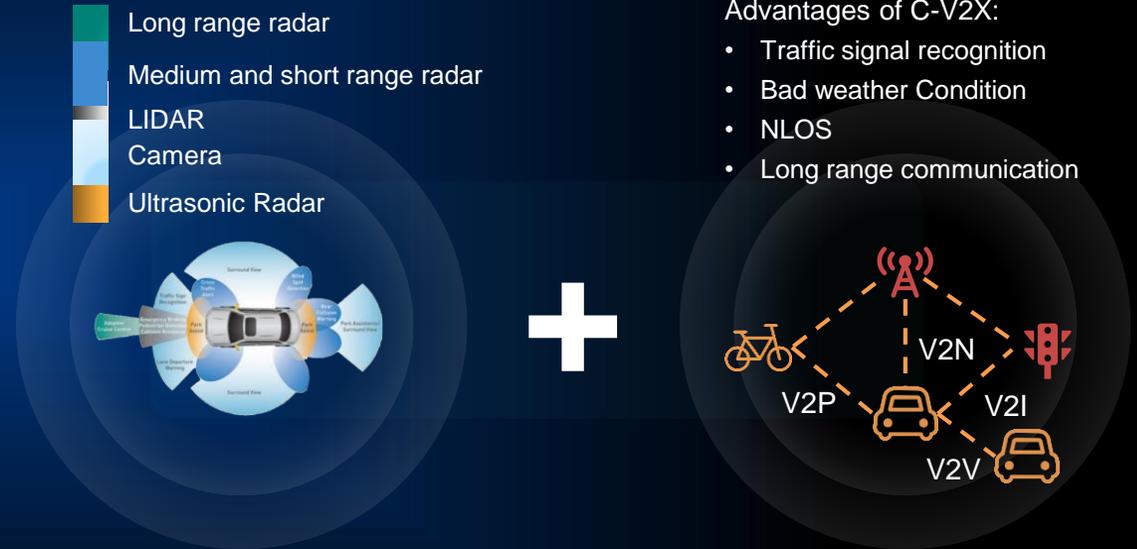
Huawei IoV solution strategy: Leverage ICT to enable Mobility transformation, smart Vehicles, and smart Roads

Ecosystem

| ITS | TSP | CP/SP | More… |

Cloud platform

Traffic brain
V2X server   TrafficGo
HUAWEI CLOUD

Network   🌐   4G/5G/C-V2X/ETH/PON…

Road   ▦ RSU   ▤ RSS   📷 Camera

Vehicle   ▦ T-Box/Module   ▭ MDC
(Mobile Data Center)

Security

C-ITS
- T-Box
- RSU, RSS, and camera
- Network
- V2X server

Smart vehicle
- MDC

Smart road
- Smart camera
- EI TrafficGo
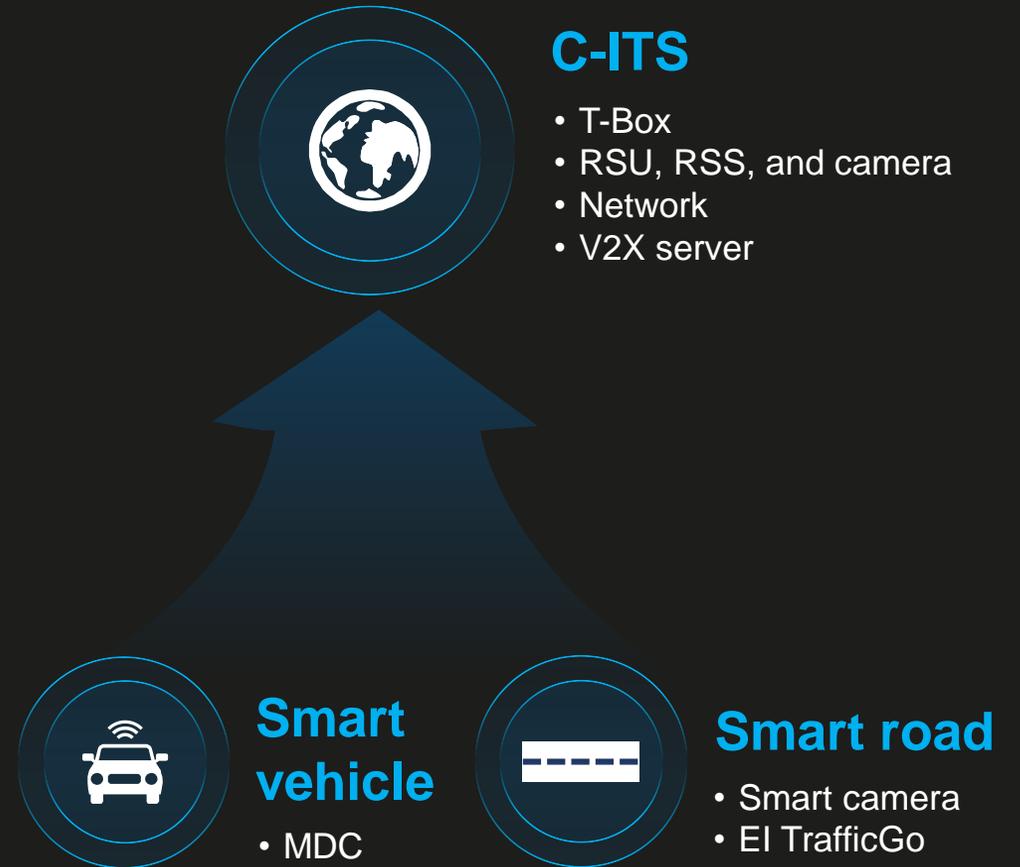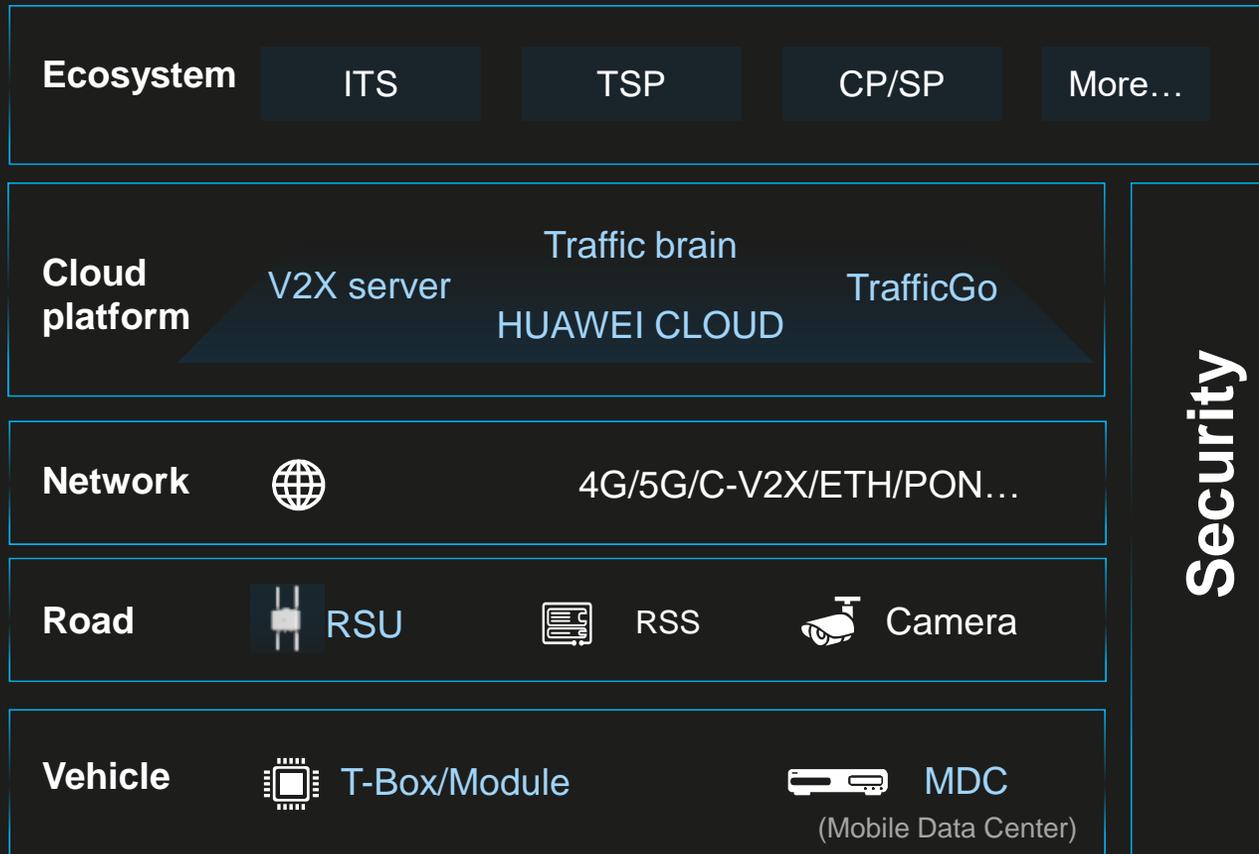
MDC: Mobile Data Center;   RSS: Road Side Server;   EI: Enterprise Intelligence;

Huawei C-V2X devices support OEM and aftermarket Solutions

Consolidated tech / Open architecture / Smooth evolution / Excellent performance

C-V2X chipset
(Balong 765)

OBU
(T-Box)

V2X antenna

RSU
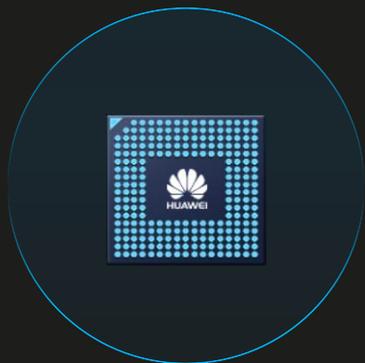
**All-in-one
Uu + PC5 + AP**

- 3GPP Rel. 14
- Downlink peak rate: 1.6 Gbit/s
- 4CC CA + 4x4 MIMO
- 2CC CA + 8x8 MIMO
- DL 256 QAM
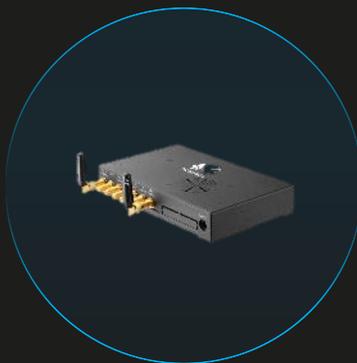
**V2X APIs for
secondary development**

- Develop V2X applications on the T-Box using Huawei APIs for differentiated design.
- Huawei provides GNSS, V2X stack, Vehicle, and Sensor APIs.

**Performance
optimization**

- V2X PC5 5.9 GHz RF performance optimized to deliver omnidirectional coverage, with at least 300 meters of direct coverage and at most 1200-meter LOS
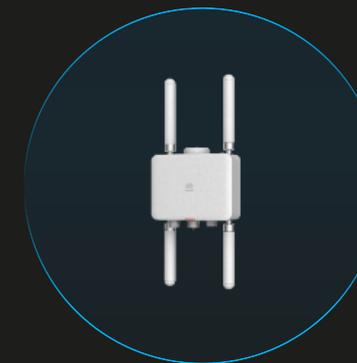
**World's first Uu + PC5
concurrency**

- 4 kg | 3.5 L | 26 W | 23 dBm
- Uu + PC5 communication encryption
- BDS and GPS dual positioning systems
- Wired and wireless deployment modes

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1 C-V2X status and plan of China

2 Connected-car solutions of Huawei

3 Development of C-V2X project in Wu-xi

Overview of WuXi C-V2X-based urban C-ITS project

Big-scale use-case verification

V2X coverage： 240 intersections, 170 Sq km
Trialed use-cases: V2I/V2V/V2P/V2N， ~40 in total
Installation type： pre-install, after-market, APP

2017

2018

2019

Technology verification

V2X coverage： 6 intersections, 3.7 km open road
Trialed use-cases: V2I (9), V2V(3)

Commercial environment set-up

Use-case for commercialization： ~20
V2X users: order of 100,000
Explore business model of V2X network

WuXi urban C-ITS project: infrastructure scale up phases

WuXi C-V2X Urban C-ITS Project, Infrastructure scale up phases

	Phase I	Phase II	Phase III
Phases	Trial commercial	Large-scale construction	Citywide full coverage
Time Period	05.2018 – 12.2019	01.2020 – 06.2021	07.2021 – 12.2022
Intersections (Traffic light & RSU)	400	1000	2000
Coverage area (KM^2)	260	500	1200
Construction Objective	• From technical / functional verification to value service use case	• Build completed & trusted urban Intelligent Transportation system	• Inter-city interconnection • Verify business model

Wuxi has completed 100% C-V2X deployment of its pilot area by the end of Sept. 2019

Project Participants (2018)

6 core participants

China Mobile	中国移动 China Mobile
Traffic Management Research Institute of the Ministry of Public Security	TMRI 公安部交科所
Huawei Technologies Co.,Ltd.	HUAWEI
Traffic Police Division of Wuxi Municipal Public Security Bureau	无锡交警支队
China Academy of Information and Communications Technology	CAICT 中国信通院
Jiangsu TIANAN Smart Science&Technology Co.,Ltd.	天安车联网 TIAN·NET

China FAW Group Co.,Ltd.	红旗
Audi (China) Enterprise Management Co. Ltd.	Audi
SAIC Motor Corporation Limited	上汽集团
Chongqing Changan Automobile Co.,Ltd.	长安汽车 CHANGAN
Dongfeng Motor Corporation	东风汽车
Ford Motor Company	Ford
Groupe PSA	PSA
Volvo Car Corporation	VOLVO
Volkswagen China	Volkswagen
ZOTYE Automobile Co.,Ltd	众泰汽车
China Commnications Television Broadcasting Network	中国交通频道
AutoNavi Software Co., Ltd.	omap.com
Jiangsu Aerospace Daway Technologies Co.,Ltd.	
Shanghai SEARI Intelligient System Co.,Ltd.	SEISYS
LatticeData Science and Technology Co.,Ltd.	BrightMap
United Automotive Electronic Systems Co., Ltd.	UAES
Intel China Ltd.	intel
NavInfo Co.,Ltd.	NAVINFO
NEUSOFT	Neusoft 东软
Nanjing Sky Traffic Safety Technology Stock Co.,Ltd.	赛康交安 SKY TRAFFIC SAFETY
DeepMotion Co., Ltd.	DeepMotion
QuectelWirelessSolutionsCo.,Ltd.	QUECTEL
Hong Kong Applied Science and Technology Research Institute Company Limited	ASTRI

Various scenarios to promote V2X installation

Pre-install scenario

Target:
200 users

FAW
➢Developing e2e V2I application based on Hongqi H7

Others
➢Expressed its willingness to fully upgrade existing users through OTA and start PC5 functional test

After-market scenario

Smart Rear-view Mirror

Target:
20,000 users

CMCC
➢Developing smart rearview mirror integrated with LTE-V2X functionality
➢Planning to promote 20K-30K end users

Enterprise scenario

Target:
5,000 users

Commercial vehicles
➢Bus
➢Taxi
➢School bus
➢Business vehicles

OTT's user scenario

Target:
75,000 users

➢ Baidu Map
➢ amap
➢ Didi
➢ Other APPs of Smart phone's

WuXi Project（~2018.9）17 typical use-cases trialed

1	FCW: Forward Collision Warning	V2V
2	ICW：Intersection Collision Warning	V2V
3	LTA：Left Turn Assist	V2V
4	BSW/LCW：Blind Spot Warning/Lane Change Warning	V2V
5	DNPW：Do Not Pass Warning	V2V
6	EBW：Emergency Brake Warning	V2V
7	AVW：Abnormal Vehicle Warning	V2V
8	CLW：Control Loss Warning	V2V
9	HLN: Hazardous Location Warning	V2I
10	SLW：Speed Limit Warning	V2I
11	SVW: Signal Violation Warning	V2I
12	TLOSA: Traffic light optimal speed advisory	V2I
13	TSC: Traffic Sign In Car	V2I
14	TJW：Traffic Jam Warning	V2I
15	EVP: Emergency Vehicle Priority	V2V
16	VRUCW: Vulnerable Road User Collision Warning	V2I
17	Ramp vehicle approaching warning	V2I

E.g., Use-case 2,3,9,12,15,17 are similar to those discussed in Japan

WuXi Project （~2018.9)

V2X Server
(Road Vehicle Coordination Platform)

ITS Server

Police Platform

RSU

RSU

60

RSU

RSU

Traditional Camera

- Traffic Flow
- Pedestrian
- Bicycle

- Static /Dynamic Limitation

- Sediment Monitoring

- Traffic Light Message / Adjust

Vehicle to Camera
* Event Warning
* Traffic Jam Warning
* Pedestrian Warning

Vehicle to Sign
* Traffic Sign In Car
* Speed Limit Warning

Vehicle to Sediment Sensor
* Sediment Event

Vehicle to Traffic Light
* Signal Violation Warning
* Traffic Light Guiding

V2V
* Vehicle Approaching
* Collision Warning
* Emergency Vehicle Priority

☐ Different kind of info input leads to dynamic event discovery & route planning
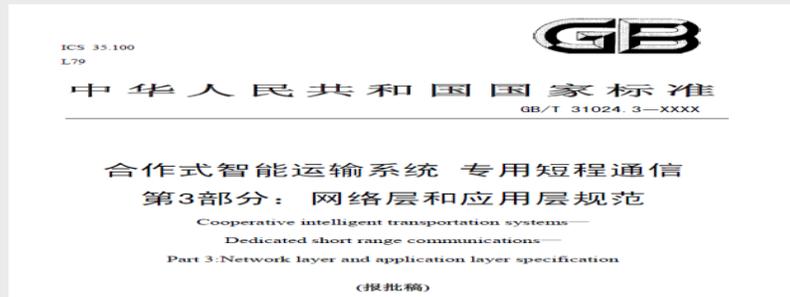
Collaboration among C-V2X trials and standardization activities

Referring to C-V2X trials incl Wuxi-trial, <u>application layer specification and data exchange standard of cooperative ITS</u> specified in China（Sept，2018）

National standard： GB/T 31024.3

Standards for road traffic signal control system and information release interface of traffic signal controller are nearly completed
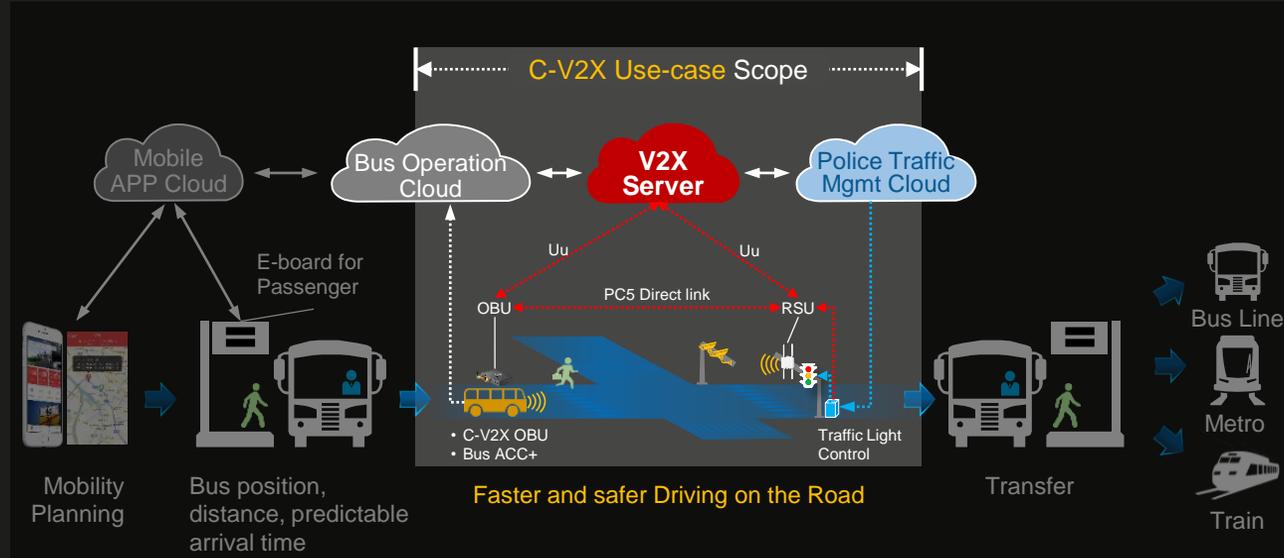

17 use-cases defined in the China standard are almost same as those of Wu-xi

scenario description, the basic signal flow, the performance requirement and the required information were defined.

Category	Communication type	Service
safety	V2V	Forward Collision Warning
	V2V/V2I	Intersection Collision Warning
	V2V/V2I	Left Turn Assistant
	V2V	Blind Spot Warning
	V2V	Do Not Pass Warning
	V2V-Event	Emergency Brake Warning
	V2V-Event	Abnormal Vehicle Warning
	V2V-Event	Control Loss Warning
	V2I	Hazardous Location Warning
	V2I	Speed Limit Warning
	V2I	Red Light Violation Warning
	V2P/V2I	Vulnerable Road User Collision Warning
efficiency	V2I	Green Light Optimal Speed Advisory
	V2I	In-Vehicle Signage
	V2I	Traffic Jam Warning
	V2I/V2V	Emergency Vehicle Warning
information	V2I	Vehicle Near-Field Payment

Highlight of Wuxi C-V2X project 2019 : City Smart Bus use-case, for improving bus punctuality and aiming for foot-free (L2) autonomous driving with V2X assistance

Business Service UseCase End-to-End Scope / Perspective

C-V2X Use-case Scope

Mobile APP Cloud

Bus Operation Cloud

V2X Server

Police Traffic Mgmt Cloud

E-board for Passenger

Uu   Uu

PC5 Direct link

OBU   RSU

Traffic Light Control

- C-V2X OBU
- Bus ACC+

Faster and safer Driving on the Road

Mobility Planning

Bus position, distance, predictable arrival time

Transfer

Bus Line

Metro

Train

Role	Top Benefits (2019)
Passenger	• Get punctual and comfortable public bus experience
Bus Company	• Decrease bus delay caused by road congestion • Increase Passenger Satisfaction • Save resources to develop customized bus route services
Government	• Get available verification of C-V2X application for urban transportation policy, ROI and ecosystem development

OBU

Roadside Perception RSU

Roadside Perception RSU

Roadside Perception RSU

Bus Only Lane

Bus Only Lane

Bus Only Lane

UC1: BUS ACC+   (V2X-assited)
- Throttle-by-wire, Brake-by-wire
- Upload Speed | Distance | Location

UC2: Roadside Perception
- Intersection traffic situation to BUS
- Vehicle type | route | license identify

UC3: BUS Green Wave - Traffic signal priority
- Coordination priority | Active priority
- Green light optimal speed advisory (GLOSA)

Highlight of Wuxi C-V2X project 2019: Audi verifying cooperative ITS and also its plan of L4 autonomous driving testing

Since Sept. 2018, Audi has obtained the L4 automatic driving test license for public roads and highways in Wuxi

In September 2019, Audi demonstrated 16 use-cases in 2019 World IoT Expo held in Wuxi, based on C-V2X technology

Use-case: Intersection Passing Boost

路口协同起步
Intersection Passing Boost (IPB)

Use-case: Traffic light cruise control

Use-case: Traffic light cruise control

交通灯巡航控制
Traffic Light Information + pACC

Source: http://www.sohu.com/a/339439270_121861

Use-cases and related demo-video of WuXi C-V2X trial for your reference:
https://www.huawei.com/en/industry-insights/outlook/mobile-broadband/lte/use-cases/wuxi-internet-of-vehiclec-project-use-cases

Thank You