Technology and Industry Development of Connected and Automated Vehicles

Yu Rundong

Technology and Standards Research Institute, CAICT

2018-9-14
Outline

1. The Concept of Connected and Automated Vehicles

2. The Key Technologies of Connected and Automated Vehicles

3. The Industry Development of Connected and Automated Vehicles

4. Development and Promotion of Connected and Automated Vehicles in CHINA
The Concept of Connected and Automated Vehicles

Connected and Automated Vehicles (CAVs) is a new Industry, which integrate the traditional industries of Automobile, ICT, Transportation and Traffic Management. Basing on the new generation of ICT technologies, which could realize the full V2X (Vehicle to Vehicle, Person, Infrastructure and Service Platform) connectivity and data interaction, so to construct a new Auto Society, and to improve traffic efficiency and users’ driving experience.

Related Items

**CITS** - Cooperative Intelligent Transportation System
Automatous Driving
Internet of Vehicles
**ICV** - Intelligent Connected Vehicles
Intelligent Traffic Management
Connected Vehicles Industry Overview

Based on the information communication technology, the connected vehicles industry provides comprehensive information services through telematics, as well as V2V, V2I, V2P, and V2X connection and data interaction. This new form of industry is a deep integration of the automotive, electronic, information communication, and road transportation industries.

**Significance of developing the connected vehicles industry**: connected vehicles promotes smart transportation, enables automated driving, increases information consumption, saves energy, and reduces emission of automobiles. The connected vehicles industry is significant for China's implementation of innovative driving development, promotion of structural reform on the supply side, and construction of a manufacturing and network power.
Why we need the Connected and Automated Vehicles

Connected and Automated Vehicles becomes a highly integration and application of the IoT and smart vehicles, is an important field of the integration of informationization and industrialization.

To promote industrial transformation and upgrading

Manufacturing ➔ Service

Connected and Data

To solve the prominent social problems

Traffic safety

Transportation efficiency

Green development

To accelerate the integration of new technologies

Accelerate IoT technologies evolution into a new stage of “Cross integration, integrated innovation and large scale development”
Networking and intelligence of automobile becomes a global consensus

USA NHTSA: Intelligent Transportation System (ITS) Strategic Plan 2015-2019
EU: Roadmap on Highly Automated vehicles
CHINA: CAVs Technology roadmap, Industry Policies, National Projects
JAPAN: SIP (Innovation of Automated Driving for Universal Services)
5G from mobile internet to IoT, Connected Vehicles is the key scenario

ITU IMT-2020 Vision

- eMBB
  - Area traffic capacity: 10 Mbps/m²
  - Peak data rate: 10~20 Gbps
  - Network energy efficiency: 100 x
  - User experienced data rate: 0.1~1 Gbps
  - Spectrum efficiency: 3~5x

- mMTC
  - Connection density: 1M/km²
  - Mobility: 500km/h

- URLLC
  - Latency: 1 ms (AI)

Three scenarios

URLLC is the key technology for Vehicles, Industry and other related vertical industries
Mobile communication technology & Connected and Automated Vehicles

<table>
<thead>
<tr>
<th>Generation</th>
<th>Voice</th>
<th>2G</th>
<th>3G</th>
<th>4G</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data rate:</td>
<td>Data rate:</td>
<td>Data rate:</td>
<td>Data rate:</td>
<td>Data rate:</td>
</tr>
<tr>
<td></td>
<td>10~300kbps</td>
<td>300k~50Mbps</td>
<td>50M~1Gbps</td>
<td>1~10Gbps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay:</td>
<td>Delay: 1.5s</td>
<td>Delay: 50ms</td>
<td>Delay: 1ms</td>
<td></td>
</tr>
</tbody>
</table>

With the help of 5G technology, communications between CAVs would achieve more advanced characteristics such as higher density, very low latency, high reliability, high data rate.
Outline

1. The Concept of Connected and Automated Vehicles

2. The Key Technologies of Connected and Automated Vehicles

3. The Industry Development of Connected and Automated Vehicles

4. Development and Promotion of Connected and Automated Vehicles in CHINA
Technical Architecture for CAVs

Regulation and Management

Platform

Sensing
- Ladder, Lidar, Camera
- Map and Localization
- RSU
- LTE-V2X/5G
- Telematics
- SATCOM

Decision
- processing platform
- Performance, Power Consumption
- Algorithm
- Planning etc

Control
- Controller
- self-adaption and cooperative
- HiMi
  Interface between human and machine

OEM
- Architecture
- Platform

Security and Privacy

ICT Integration
The understanding and advantages of V2X technology.
V2X communication faces technical path selection: 3GPP, IEEE

3GPP: LTE-V2X

- LTE-V2X is a V2X wireless communication technology based on LTE network technology. Through direct communication and cellular communication, two technologies support V2X.

IEEE: 802.11P

- The V2X wireless communication technology based on IEEE 802.11p provides the technology of short-range wireless transmission, and the vehicle and car road communication is the main application mode.

- China and Europe jointly lead the 3GPP LTE-V2X standards, and China's Huawei, Datang are the main reporters, and have a speaking right in standardization, IP rights and other aspects. The 802.11p standard and IP are mainly control by USA.
Technical performance: LTE - V2X coverage, reliability and other advantages

- **Far Cover distance**
  - Twice the cover distance compared to 802.11p, and the vehicle can be notified earlier

- **High Transmission reliability**
  - The single link is about 60% higher than 802.11p

- **Large System capacity**
  - It is about 40% larger capacity than 802.11p and supports more dense vehicle scenarios

- **Low delay**
  - Delay of 802.11p increases significantly in intensive scenarios
The understanding of C-V2X technology

- C-V2X is a kind of Cellular communication technology including direct communication working mode and cellular communication working mode.
- Better wireless communication performance, Advantage of deployment and promotion, evolution towards 5G
The evolution of C-V2X technology

V2X
3GPP R14

V2V, V2P, V2I, V2N
Safety-critical Use
Multimedia Service

Advanced V2X
3GPP R15, R16

Longer Range
Higher Density
Very low latency
High Reliability
High data rate

Emergency Brake

Road Speed limit Warning

Traffic light advisory

Platooning

Extended Sensors

Remote Driving

Advanced Driving
With the continuous evolution of wireless communications technologies, smart automobiles are developing towards advanced levels and more complex applications.

- **Information service**: Infotainment services, such as online navigation, congestion notification, and multimedia download, based on the 2G/3G/4G public mobile network; and innovative services, such as shared travel, personalized vehicle experience, vehicle full-service life-cycle management, and IoV insurance, that are derived thereafter.

- **Security and efficiency service**: Low-latency, high-reliable security advisory (SA); traffic efficiency improvement; and partial-automated driving services, driven by LTE-V2X.

- **Collaboration service**: Highly collaborative interconnection environment of "human-vehicle-road-cloud," driven by 5G and eV2X; advanced driving services, such as vehicle-road collaborative control, vehicle-vehicle collaborative formation, and remote operations, providing support for ultimate full-automated driving services.

Made in China 2025 (technical roadmap for key fields): C-V2X coverage rate:

<table>
<thead>
<tr>
<th>Year</th>
<th>Coverage Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>2025</td>
<td>&gt; 80%</td>
</tr>
</tbody>
</table>
The application and enhancement of LTE-V2X technology

**LTE-V2X Applications:**

**Safety:**
- FCW: Forward Collision Warning
- DNPW: Do Not Pass Warning
- ICW: Intersection Collision Warning

**Efficiency:**
- SLW: Speed Limit Warning
- TLOSA: Traffic light optimal speed advisory

**3GPP SA1 eV2X User Cases:**

<table>
<thead>
<tr>
<th>Use case</th>
<th>Illustration</th>
<th>Description</th>
<th>Payloads (Bytes)</th>
<th>Latency (ms)</th>
<th>Data rate (Mbps)</th>
<th>Range (meters)</th>
<th>Reliability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles platooning</td>
<td></td>
<td>Vehicles dynamically form a platoon travelling together. Vehicles in the platoon obtain information from the leading vehicle to manage this platoon.</td>
<td>50 - 6000</td>
<td>10 - 25</td>
<td>0.002 - 0.05</td>
<td>80 - 350</td>
<td>90 - 99.99</td>
</tr>
<tr>
<td>Advanced driving</td>
<td></td>
<td>Vehicle/RSU shares its own perception data obtained from its local sensors with vehicles in proximity and that allows vehicles to coordinate their trajectories.</td>
<td>300 - 12000</td>
<td>3 - 100</td>
<td>10 - 50 (including UL: 50 DL: 0.5)</td>
<td>300 - 7000</td>
<td>90 - 99.99</td>
</tr>
<tr>
<td>Extended sensors</td>
<td></td>
<td>Exchange of data gathered through local sensors or live video images among vehicles, RSUs, Pedestrian and V2X server.</td>
<td>[1803]</td>
<td>3 - 100</td>
<td>10 - 1000</td>
<td>50 - 1000</td>
<td>90 - 99.99</td>
</tr>
<tr>
<td>Remote driving</td>
<td></td>
<td>Enables a remote driver or a V2X application to operate a remote vehicle.</td>
<td>-</td>
<td>5</td>
<td>UL: 25 DL: 1</td>
<td>-</td>
<td>[99.999]</td>
</tr>
</tbody>
</table>

- 3GPP start R15 LTE-V2X enhancement research, plan to finish 2018.06. Maintain the compatibility with R14 LTE-V2X, to improve PC5 performance, including reliability, data rate and delay
5G-V2X, high level and more complexity applications

5G Stage, vehicle networking evolution to cooperative, final to support Full Automatous

Platooning

Intention Sharing

Remote Driving

Extended sensor
International C-V2X Standardization Plan and Progress

Three phases of 3GPP C-V2X standardization

- 3GPP release 14 that supports LTE-V2X has been officially released in 2017.
- 3GPP release 15 that supports LTE-V2X enhancement (LTE-eV2X) has been officially released in June, 2018.
- 3GPP release 16+ that supports 5G-V2X has been announced in June, 2018, and will complement LTE-V2X/LTE-eV2X.
LTE-V2X standardization in China has been preliminarily systematized, covering LTE-V2X overview, air interfaces, network and application layers, and security. The overall architecture supports LTE-V2X R&D and application at different layers.

### Application layer
- **Overview**: Overall technical requirements for LTE-based IoV communications (Industry standards, CCSA, Submitted for review)
- **Application layer**: Cooperative intelligent transportation system – Dedicated short range communications – Part 3: Technical requirements for the network layer and application layer (China national standards, TC/ITS and CCSA, Submitted for review)
  - Cooperative intelligent transportation system – Application layer and application data interaction standards for vehicle communications (Alliance standards, SAE-C and C-ITS, Released)
- **Network layer**: Cooperative intelligent transportation system – Dedicated short range communications – Part 3: Technical requirements for the network layer and application layer (China national standards, TC/ITS and CCSA, Submitted for review)
- **Air interface**: Technical air interface requirements for LTE-based IoV communications (Industry standards, CCSA, Submitted for review)
- **Security**: Technical security requirements for IoV communications based on the public LTE network (Industry standards, CCSA, Soliciting opinions)

C-V2X standard protocol architecture in China
Outline

1. The Concept of Connected and Automated Vehicles
2. The Key Technologies of Connected and Automated Vehicles
3. The Industry Development of Connected and Automated Vehicles
4. Development and Promotion of Connected and Automated Vehicles in CHINA
The developing pattern of CAVs is basically stable

The research on CAVs by various organizations and enterprises is deepening, and the government support is increasing.

01 Government policies
- Us advances demonstration testing, as of January 2018, 49 road-testing licenses have been issued in California
- EU launches "adaptive" program to promote research and development of intelligent driving technology, technical standards and road traffic regulations to match automated cars
- Japan has developed a road map for the popularization of autonomous driving and revised relevant regulations

02 Research institutions and universities
- The University of Michigan's M-City project has become the world's largest test site for automated cars, with autonomous commuter cars being developed for use on campus
- Nagoya University develops Open Source Framework for Autopilot “AutoWare”, Integrated Open Source Software for Urban Autonomous driving
- The Pegasus project in Germany brings together 17 business institutions to develop a standard process for testing and ensuring autopilot

03 OEM and technology companies
- Google is currently leading the world in autopilot technology and has been targeting the L4 since its inception
- Electric and autopilot are two key directions of Tesla's technology research and development. Autopilot has close cooperation with chip suppliers
- OEM has the advantage of vehicle technology integration, and has the communication protocol of vehicle core

04 Component suppliers
- Traditional suppliers already have a head start at the ADAS product level, and the high level autopilot business is growing more frequently
- Chip manufacturer provides technical support for Tier1, Tier1 provides application practice platform for map, data, communication and other technical vendors
Vehicle sales for new mobility services are expected to exceed 10% of new car sales by 2025 in the US and the EU.

**Share of vehicle sales for New Mobility** $[^1] [% passenger car sales]

- **United States**: 2%, 8%, 10% in 2015, 2020, 2025 respectively.
- **EU-28**: 2%, 9%, 15% in 2015, 2020, 2025 respectively.
- **China**: 3%, 9%, 35% in 2015, 2020, 2025 respectively.

- New mobility sales are expected to grow through 2025 due to:
  - Changes in car ownership patterns
  - Growing urbanization
  - Enhancements in technology & mobility business models
- The disruption potential in China is higher due to its relatively lower base of ownership levels today (1 car for 7 people vs. 1 for 2 in EU and 1 for 1.25 in US)
- Post 2025, the introduction of RoboCabs could drive a significantly larger share of sales to new mobility

---

1) Includes forecast for car sharing, ride hailing, ride sharing, and Robocabs. Does not include sales for conventional taxis or rental car fleets.

Source: Roland Berger
Automated driving is set to arrive at fast pace – With new entrants and real-life pilots already under way

Commercialization timeline of automated driving functionality by SAE\(^1\) levels

1) Society of Automotive Engineers; 2) Blind spot detection; 3) Automated emergency braking; 4) Advanced cruise control
Future penetration of highly automated vehicles will depend on overcoming current hurdles and convergence on shared mobility.

Autonomous driving – Penetration rate of highly automated cars (SAE Levels 4/5)*

Disruptive/High scenario

- Sharing proliferates with high acceptance of car ride sharing services
- High penetration of autonomous vehicles in shared fleets and privately owned premium and volume vehicle segments
- Autonomous, shared vehicles, called RoboCabs provide on-demand mobility services to consumers and businesses
- High use of autonomous vehicles by ride sharing services drives down costs significantly

Low scenario

- Shared mobility confined to early adopters in dense urban areas
- Automated driving penetration primarily in flagship premium models
- Continued use of human drivers renders ride sharing services' business models mostly unsustainable

*In % passenger car sales; includes RoboCabs and private autonomous cars

In addition, according to the forecast of Boston Consulting Group, the CAV will have 20 years' high speed development from 2018, and will occupy about 25% of the new car market in the world by 2035.
Trend1: Tradition automobile company using AI and ICT technologies actively

Daimler AG in CES2017 publish “CASE-Connected, Automated, Sharing, Electronic” strategy

Basing on AI and other related new generation ICT technologies, also with the development of ADAS evolution, the Automated Driving technology is develop from Level 2 to Level 3, and toward to the development of Level 4 automatous driving

Toyota using new AI technology develop a car emotion engine
Trend2: ICT companies expand the layout of automobile field actively

Connectivity

- Google, Android Auto, the ecosystem
- Apple, Carplay more than 3000 users
- Baidu, Carlife the HMI connection
- DATANG LTE-V2X car terminal

Automated Driving

- UBER Automated driving cars research and test
- Lyft and NuTonomy, automated driving car sharing

Innovative Car company

- Tesla
- NEXTEV, high performance electromobile
- UISEE
Trend3: Cross Industry cooperation

The cross industry cooperation between traditional automobile company and ICT company is more becoming more and more obvious, like BMW, Intel and Mobileye, Lyft and GM, BOSCH and NVIDIA

The same situation in China, **ICT company joint with automobile company to promote the development of CAVs**, like Baidu and Chery, Alibaba and SAIC, like Changan and Huawei
The integration of Industry Chain

**Operation**
- After Service
- User
- Automobile

**Application**
- System integrator
- Software platform

**Hardware**
- Module provider
- Hardware provider
- Sensors provider

**Communication**
- Data and Content
  - Map
  - Data
  - Content...

**Service**
- Public
- Industry

**Device**
- Automobile
- Electronic system
- Component
- Software
  - OS
  - APPs

**Operation**
- TSP
- Network Operator

**Application**
- System integrator
- Software platform

**Hardware**
- Module provider
- Hardware provider
- Sensors provider
“Sharing, Automated, Connected, Electric”, to construct a new ecosystem

An interconnected network for information exchange among people, vehicles, roads, and cloud

Not only

A data platform with information and things integrated

But also

A new ecological system of services and business models

- Active safety warning application
- Traffic guidance and traffic control management
- Entertainment and transportation integrated information service
- Production and manufacturing such as personalized customization
- Self-driving applications such as vehicle queuing
- Smart traveling applications such as vehicle sharing
- Smart transportation system
However, improved internal & external connectivity will make modern vehicles vulnerable to an increasing number of cyber threats.

Cybersecurity threat vectors

- Threat vectors span all connected vehicle components and systems
- Suppliers must design E/E architectures to prevent component-level attacks and understand the design implications for integration into vehicle sub-systems
- Organization structures and design processes must adapt accordingly
- Evolving legal and regulatory requirements for data security & protection and product safety must be addressed as well

Action items for holistic security concept

<table>
<thead>
<tr>
<th>Secure processing (secure boot, run-time integrity, OTA updates)</th>
<th>Secure network (message authentication, CAN ID killer, distributed intrusion detection)</th>
<th>Secure gateway (domain isolation, firewalls/filters, centralized intrusion detection)</th>
<th>Secure interfaces (secure M2M authentication, secure key storage)</th>
</tr>
</thead>
</table>

Source: Roland Berger
Security is still an important issue for CAVs

➢ Uber fatal crash: Self-driving SUV saw pedestrian, didn't brake

➢ 49-year-old Elaine Herzberg was killed in March in Tempe, Arizona, when she was struck by the self-driving Uber. Herzberg was crossing the street with a bicycle when she was hit. The car was in autonomous mode, but an operator was inside the vehicle at the time.

The method of judging accident responsibility is urgently needed in CAV Road Tests
Outline

1. The Concept of Connected and Automated Vehicles

2. The Key Technologies of Connected and Automated Vehicles

3. The Industry Development of Connected and Automated Vehicles

4. Development and Promotion of Connected and Automated Vehicles in CHINA
The collaborative development of intelligent and internet of automobile has become a global consensus. As new-generation information communications technologies, such as 5G, are increasingly integrated into Internet of Things (IoT), cellular vehicle-to-everything (C-V2X) has become an important application scenario.
Ma Kai, the deputy prime minister, has officially approved to establish **CAV industry development inter-ministry coordination mechanism** under the **great country of manufacturing leadership team**, with the joint effects from 20 departments under the Ministry of Public Security, the Ministry of Transport, and the National Development and Reform Commission, in order to tackle the major challenges of CAV development.

- In May 2015, the state council officially launched **Made in China 2025**.
- To promote R&D and industrialization of **intelligent transportation tools**
- The technology roadmap for key fields has been worked out, and the following systems will be established: **smart vehicle self-development innovative system**, and **smart vehicle industry chain** and **smart transportation system**.

- In July 2015, the State Council officially issued **Guidance on Internet+ Action Promotion**.
- **Transportation based on Internet+** helps promote intellectual technology applications, such as Internet of Vehicles (CAV).
- **Artificial Intelligence based on Internet+** helps quickly accelerate the development and application of intelligent-assisted driving, complex environment awareness, and vehicle-mounted smart devices.

- In June 2016, the China Ministry of Industry and Information Technology strengthened top-level design, assigned overall planning and key tasks for CAV, and launched **Promotion Plan on CAV Innovation and Development**.
- The CAV development has been promoted from the following six key tasks (involving 20 sub-tasks): **key technology research and development**, research on standard systems, establishment of platforms and experimental sites, infrastructure development, application and promotion, as well as network and information security protection.

- In June 2016, the China Ministry of Industry and Information Technology strengthened top-level design, assigned overall planning and key tasks for CAV, and launched **Promotion Plan on CAV Innovation and Development**.
- The CAV development has been promoted from the following six key tasks (involving 20 sub-tasks): **key technology research and development**, research on standard systems, establishment of platforms and experimental sites, infrastructure development, application and promotion, as well as network and information security protection.

- In April 2017, the China Ministry of Industry and Information Technology, together with NDRC and Ministry of Science and Technology (MOST), issued **Medium-and Long-term Automobile Industry Development Plan**.
- Green and smart automobiles are taken as breakthrough points to lead the industry transformation and upgrade. **The smart automobile promotion project** has been proposed, with specified goals at the DA, PA, and CA phases.

National **CAV industry integration and innovation guidance** and **Guidelines for construction of CAV industry standard system** will be issued.
The IMT-2020 (5G) promotion group has conducted LTE-V2X direct communications tests on the 5.905-5.925 GHz band (20 MHz bandwidth in total).

According to the progress of LTE-V2X R&D and industrialization, LTE-V2X tests are conducted in different phases.

Tests in phase 1 and phase 2 have been completed (a few of vehicles covered in the lab and in the field).

Phase 3: It is planned to carry out performance tests and E2E application verification on many vehicles to promote industrialization.
Phase 1: LTE-V2X Lab Tests and Verification

- Simulate different traffic scenarios and various vehicle-vehicle wireless communications environments to test LTE-V2X (V2V) performance counters, such as the E2E delay and packet sending success rate.
- Organize interoperability tests of direct communications on LTE-V2X terminals in the lab and in the field to implement multi vendor (MV) interoperation in compliance with the international standard 3GPP release 14.
Phase 2: Field V2X Performance Tests and Typical V2X Application Verification (Chongqing Demonstration Area)

- Test site: test fields of China Automotive Engineering Research Institute and Chang'an Automobile
- Test scenario: Simulate a LOS scenario in urban areas, an NLOS scenario in urban crossroads, and a LOS scenario in express ways.

**Diagram:**
- V2X test vehicle
- LTE-V2X sample device A
- LTE-V2X sample device B

**Conclusion:** In the field, each V2X test vehicle is integrated with one LTE-V2X sample device of a vendor to verify typical V2V applications, such as forward collision warning and cross-intersection collision warning.

**Performance Test Scenario**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Coverage Distance</th>
<th>E2E Delay</th>
<th>Data Packet Transmission Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Express way (LOS)</td>
<td>340 m</td>
<td>≤ 100 ms</td>
<td>≥ 90%</td>
</tr>
<tr>
<td>Absolute vehicle speed: 60 km/h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossroad (NLOS)</td>
<td>120 m</td>
<td>≤ 100 ms</td>
<td>≥ 90%</td>
</tr>
<tr>
<td>Absolute vehicle speed: 20 km/h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Phase 2: Field V2X Performance Tests and Typical V2X Application Verification (Shanghai Demonstration Area)

- Test site: closed test field of National Intelligent Connected Vehicle (Shanghai) Pilot Zone
- Test scenario: a) Two test vehicles stay still. b) Two test vehicles drive towards each other (turning left or overtaking). c) Two test vehicles drive towards a crossroad from different directions, where there are obstacles (collision avoidance).

Conclusion: In the field, LTE-V2X functions and performance are preliminarily tested. LTE-V2X PC5 communications are available, and performance counters, such as the coverage distance, E2E delay, and data packet transmission reliability, meet the requirements of typical V2V services in different scenarios (delay ≤ 100 ms; reliability ≥ 90%).
In 2018, the IMT-2020 C-V2X work team is set up to plan and organize LTE-V2X large-scale tests, verification, and application in both Shanghai and Chongqing demonstration areas.

- Conduct communications function and performance tests on many vehicles, and verify MV, cross-layer interoperability in more test scenarios.
- Comprehensively evaluate the impact of C-V2X technology on vehicle operation security and traffic efficiency improvement, and collect user feedback to form a C-V2X industry shared database.

**Vehicle scale and auxiliaries:**
- More than 3000 vehicles, providing C-V2X communication applications
- Various vehicle types, including cars, buses, and trucks
- Mapping between standardized data collection and information services

**Vehicle source:**
- SIAC – EvCard
- SIAC – AppAdvice
- Buses and official vehicles in Jiading district
- Company buses and enterprise vehicles in SIAC
- Voluntary vehicles
- Test vehicles of OEMs and tier-1 vendors
Phase 3: Establishing an LTE-V2X Public Road Showcase

In Wuxi demonstration area, verification and application of typical V2I applications

**Scope of the demonstration area:**
Wuxi Taihu New City, a key district in the main urban area, is connected to the airport, high-speed railway station, and main roads of new and old urban areas. There are about **222 crossroads** in total.

**Number of target users:**
**Tens of thousands to hundreds of thousands** users, including rear-vision mirror users, app users, and enterprise cooperation users

**Project completion time:**
The network is expected to be constructed by the end of June, 2018, to be open to friendly users, and to be exhibited in **September** at WIoT.


Overall solution planning and design

Network infrastructure and basic infrastructure reconstruction

Basic setting and network device optimization

Support and assurance

Solution formulation and application development

Small-scale joint commissioning and tests

Application optimization and user promotion

Field, integrated, joint commissioning

User promotion and participation in tests and demonstration
Promote the construction of the C-V2X test, certification, and assessment system for cross-industry collaboration of automobiles and information communications, and promote the unified mutual certification with international industry organizations.

Research on current certification systems
- Automobile announcement, CCC certification
- Network access license, model approval, CCC certification
- Qualification requirements for tier-1 vendors
- Research on international C-V2X certification

Test items and specifications
- Communication modules, parts, and OEM vehicles
- Suggestions on test items and specifications planning

Collaborative certification system
- Collaboration of test items and specifications
- Research report output

International unified certification
- Connection with 5GAA, OmniAir, and GCF certification systems and test specifications
On September 1, 2017, Qualcomm released its first C-V2X commercial solution, Qualcomm® 9150 C-V2X chipsets, based on 3GPP release 14 specifications and oriented to PC5 direct communications. The chipsets are expected to be put into commercial use in the second half of 2018 to meet the mass requirements of automobile manufacturing enterprises to ensure road safety.

On November 16, 2017, Datang launched the LTE-V2X commercial communication module DMD31, RSU (DTVL3000-RSU), and OBU (DTVL3000-OBU), providing solutions for the upstream and downstream of the industry chain.

During the Mobile World Congress 2018, Huawei officially released Balong 765, a commercial chip based on LTE-V2X. This chip, in compliance with 3GPP release 14 specifications, has a peak rate of 1.6 Gbit/s, and supports the PC5 and Uu interfaces in Mode 3/Mode 4.
Gradual Layout of the C-V2X Industry

### C-V2X industry chain

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication chips</td>
<td>Communication modules</td>
</tr>
<tr>
<td>Communication modules</td>
<td>Terminals</td>
</tr>
<tr>
<td>Terminals</td>
<td>Vehicle manufacturing</td>
</tr>
<tr>
<td>Vehicle manufacturing</td>
<td>Tests and verification</td>
</tr>
<tr>
<td>Tests and verification</td>
<td>Operations and services</td>
</tr>
</tbody>
</table>

### Industry support

- Research institutes
- Standards and industry organizations
- Related technology industries
- Investment agencies

### C-V2X industry map

- Communication chips
- Communication modules
- Terminals
- Vehicle manufacturing
- Operations and services
- Tests and verification
- High-precision locating and map services
Problems facing the commercial deployment of the C-V2X industry

- Key products have not been commercialized.
- The C-V2X business model has not been clarified, and the network deployment solution is not determined.

Commercialization mode of the C-V2X industry

- Ensure that the industry strategy for C-V2X devices is supported.
- Construct smart highways, and conduct information upgrades for urban road facilities.
Building a Cross-Industry Innovation Platform to Conduct Tests and Verification, Accelerating Product Maturity and Industrialization

The IMT-2020 (5G) promotion group has set up the C-V2X work team to organize technical researches, tests, verification, and industry and application promotion of LTE-V2X and 5G-V2X. A total of 75 research institutes and enterprises have joined to form an alliance for"production, learning, research, and use" cooperation and "automobile, information communications, and transportation" collaboration.
Key Tasks of the IMT-2020 C-V2X Work Team

Organize technical researches, tests, verification, and industry and application promotion of LTE-V2X and 5G-V2X.

- **LTE-V2X tests and assessment**
- **LTE-V2X deployment and networking**
- **LTE-V2X business model**
- **C-V2X business requirement evolution**

### 2017

- LTE-V2X frequency requirements and planning
- C-V2X test, certification, assessment system
- LTE-V2X large-scale tests
- LTE-V2X security authentication mechanism
- Integration with MEC
- C-V2X application and business model
- High-precision locating enhancement application

### 2018

- LTE-V2X tests and assessment
- LTE-V2X deployment and networking
- LTE-V2X business model
- C-V2X business requirement evolution

**Technology maturing**

**Industrialization**
Trainer: Rundong Yu
Engineer of China Academy of Information and Communications Technology

E-mail: yurundong@caict.ac.cn

Department: RITT

Address: 3G building, No. 52 North Garden Road, Haidian District, Beijing, China

Photo: