Communications Technology Enabling Automated Driving
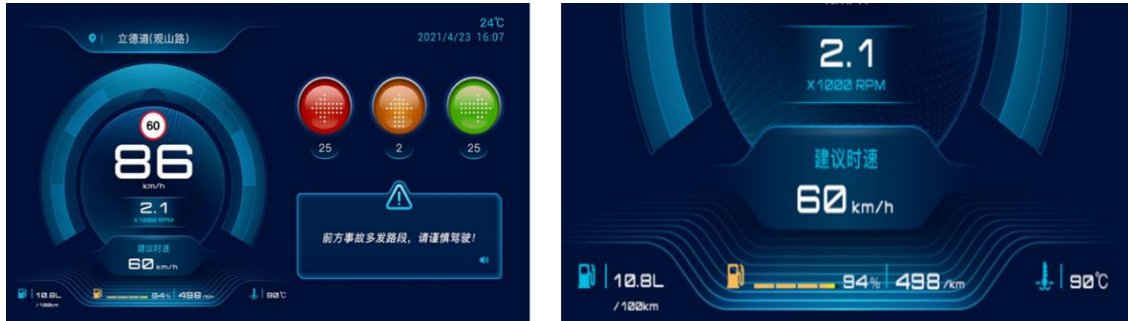
China Academy of Information and Communications Technology (CAICT)
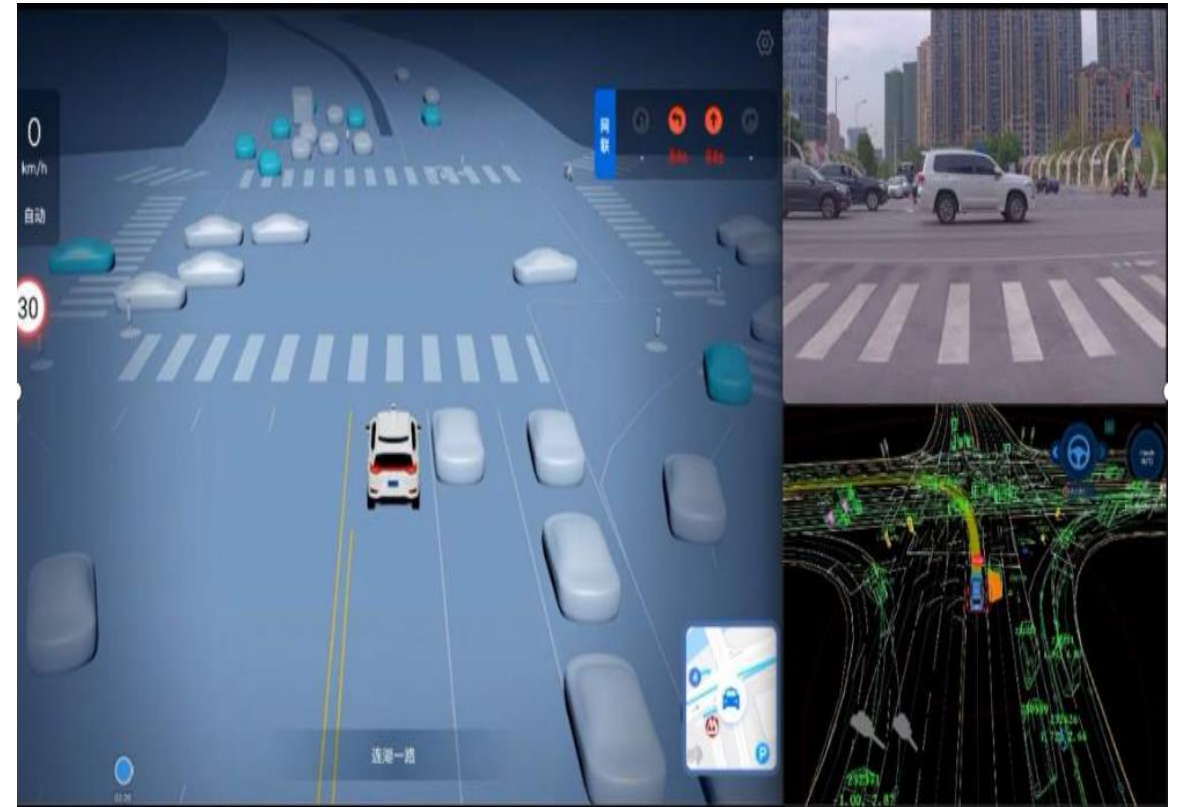
Yuming GE

2024.03

Vehicular communication improve the ability of assisted driving and autonated driving

Supporting the evolution of assisted driving from information services to safety and efficiency services.

Support automated driving to achieve typical applications in specific areas.

Phase I/ II and High Level Automated Driving application scenarios related standards

Application Scenarios

#	Scenario
1	FCW: Forward Collision Warning
2	ICW: Intersection Collision Warning
3	LTA: Left Turn Assist
4	BSW/LCW: Blind Spot Warning/Lane Change Warning
5	DNPW: Do Not Pass Warning
6	EBW: Emergency Brake Warning
7	AVW: Abnormal Vehicle Warning
8	CLW: Control Loss Warning
9	HLW: Hazardous Location Warning
10	SLW: Speed Limit Warning
11	RLVW: Red Light Violation Warning
12	VRUCW: Vulnerable Road User Collision Warning
13	GLOSA: Green Light Optimal Speed Advisory
14	IVS: In-Vehicle Signage
15	TJW: Traffic Jam Warning
16	EVW: Emergency Vehicle Warning
17	VNFP: Vehicle Near-Field Payment

BSM BasicSafetyMessage
RSM RoadsideSafetyMessage
MAP MapMessage
SPAT Signal Phase And Timing
RSI RoadSideInformation

Standard
- Cooperative intelligent transportation system—Vehicular communication application layer specification and data exchange standard （Phase I）
- Technical Requirements of Message Layer of LTE-based Vehicular Communication

Application Scenarios

#	Scenario
1	Vehicle Merge
2	Identification of Vulnerable Road User
3	Cooperative Intersection Passing
4	Guidance Service of Vehicle
5	Intersection Dynamic Lane Management
6	Dynamic Optimization of Traffic Signal Timing Based on Real Time Connected Data
7	Intelligent parking guidance
8	Platooning
9	Cooperative Fleet Management
10	Flexible management of highway dedicated lanes
11	Active and passive toll collection based on vehicle road collaboration
12	Dynamic Path Planning for Electric Vehicles
13	OTA based on vehicle road collaboration
14	In the loop simulation of autonomous driving vehicle based on vehicle road collaboration

Application Scenarios

#	Scenario
1	SDS: Sensor Data Sharing
2	CVM: Cooperative Vehicle Merge
3	CVM: Cooperative Vehicle Merge
4	CIP: Cooperative Intersection Passing
5	DDS: Differential Data Service
6	DLM: Dynamic Lane Management
7	CHPVP: Cooperative High Priority Vehicle Passing
8	GSPA: Guidance Service in Parking Area
9	PDC: Probe Data Collection
10	VRUSP: Vulnerable Road User Safe Passing
11	CPM: Cooperative Platooning Management
12	RTS: Road Tolling Service

TEST
RTCM
RSC
SSM
VIR
PAM
PSM
CLPMM
VPM

Standard
- The Requirements Standard for Enhanced V2X Application Layer Data Interaction
- Cooperative intelligent transportation system—Vehicular communication application layer specification and data exchange standard （Phase II）

Application Scenarios

#	Scenario
1	Cooperative Sensing
2	Unsigned Intersection Passing Based on Roadside Collaboration
3	Self Driving Vehicles Extrication Based on Roadside Collaboration
4	High Precision Map Version Alignment and Dynamic Updates
5	Autonomous Parking
6	Recognition of Zombie Vehicles Based on Roadside Sensing
7	Traffic Condition Recognition Based on Roadside Sensing
8	Recognition of Abnormal Driving Behavior Based on Cooperative Sensing

TEST
RTCM
RSC
SSM
VIR
PAM
PSM
CLPMM
VPM
CIM
RAM
RSCV

Standard
- Data exchange standard for high level automated driving vehicle based on cooperative intelligent transportation system

C-V2X communication core standards support upper layer applications

Completed the formulation of **LTE-V2X full protocol stack technical standards** including various aspects, such as the requirements,access layer,network layer,message layer,application functions, and so on.

Type	Standard Name
general	General Technical Requirements of LTE-based Vehicular Communication
access layer	The Air Interface Technical Requirements of Vehicular Communication based on LTE
network layer	Technical Requirements of Network Layer of LTE based Vehicular Communication
network layer	Test Method of Network Layer of LTE-based Vehicular Communication
message layer	Technical Requirements of Message Layer of LTE-based Vehicular Communication
message layer	Test Method of Message Layer of LTE-based Vehicular Communication
management	Application Identity Assignment and Mapping of LTE-based Vehicle Wireless Communication Technology
security	Technical Requirement of Security Certificate Management System for LTE-based Vehicular Communication

The LTE-V2X full communication protocol stack standards
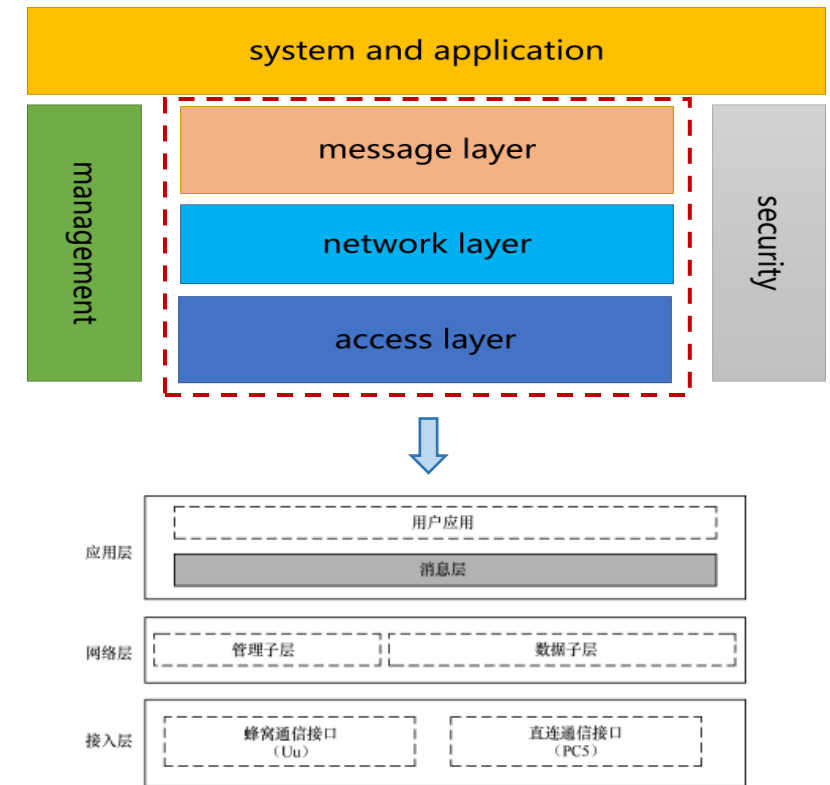
LTE-V2X communication protocol stack

5G based remote control driving standards are being developed across industries

The **technical requirements standards of 5G** enabled remote driving have been basically finished for approval, including various types of vehicles and different scenarios.

Standard Name
5G Enables Remote Driving: Technical Requirements for 5G Communication System
Technical requirements of information exchange system for 5G enabled remote driving
Technical requirements of 5G enabled remote driving information exchange system Mining remote operations
Technical requirements of 5G enabled remote driving information exchange system Remote Parking
Technical requirements of 5G enabled remote driving information exchange system Highway Platooning
Technical requirements of 5G enabled remote driving information exchange system Robotaxi remote control
Technical requirements of information exchang system for 5G enabled remote driving Emergency takeover of urban public traffic vehicles
Technical requirements of information exchang system for 5G enabled remote driving Remote driving of logistics-related vehicles
Technical requirements of 5G enabled remote driving information exchange system Remote operation in port
Test Evaluation Methods of information exchange system for 5G enabled remote driving
Technical Requirements of Information Exchange System for 5G enabled Remote Driving in Audio Video Transmission

The standard progress of IoV based on 5G

Mining operations

Port operation


Logistics in the park

Urban Taxi

Some ITU and ETSI standards on V2X supported scenarios

ITU SG16_Requirements for vulnerable road users service using vehicle gateway

It specifies the requirements for **Vulnerable Road Users (VRU)** service using vehicle gateway, including service requirements and function requirements for vehicle system, Vulnerable Road Users device, communication network, road infrastructure as well as cloud server.

Four types of Vulnerable Road Users service:
- Case 1: When VRU has the device with the communication capability, VRU device communicates with vehicle to trigger VRU protection.
- Case 2: When VRU hasn't the device with the communication capability, road infrastructure communicates with vehicle to trigger VRU protection.
- Case 3: When VRU hasn't the device with the communication capability, other vehicle communicates with vehicle to trigger VRU protection.
- Case 4: When VRU hasn't the device with the communication capability, cloud server communicates with vehicle to trigger VRU protection.
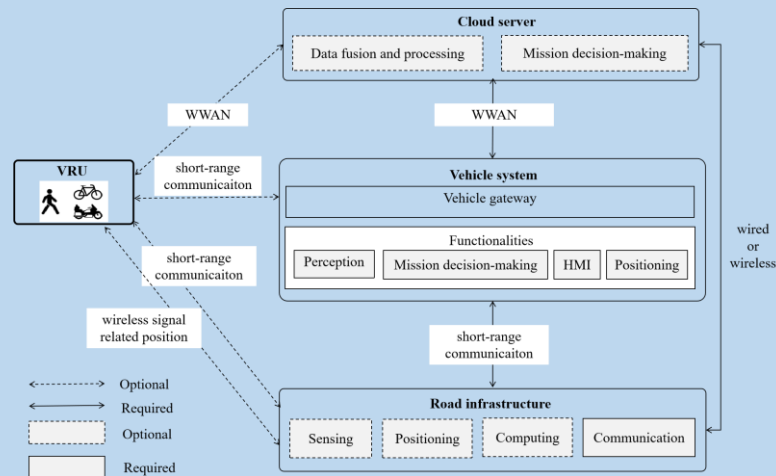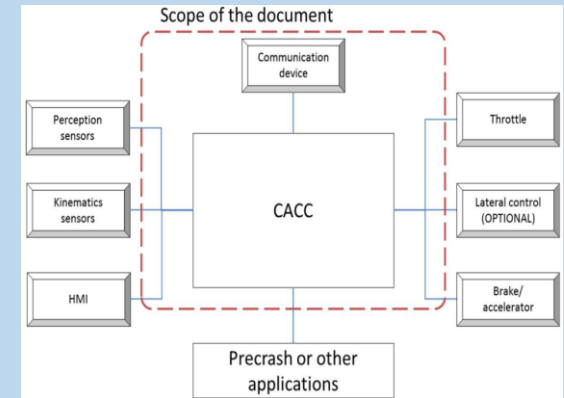

Architecture of Vulnerable Road Users service using vehicle gateway

## ETSI TC ITS_Cooperative Adaptive Cruise Control (CACC)

It is a pre-standardization study of the Cooperative Adaptive Cruise Control (CACC) application.

- Definition of the CACC use cases
- Definition of CACC architecture
- Requirement analysis of the application and the communication systems
- Recommendations on the standardization needs for the communication layers in support of the CACC application
- Recommendation on the CACC application standardization.

ETSI TC ITS_Vulnerable Road Users (VRU) awareness

- Part 1: Use Cases definition
- Part 2: Functional Architecture and Requirements definition
- Part 3: Specification of VRU awareness basic service
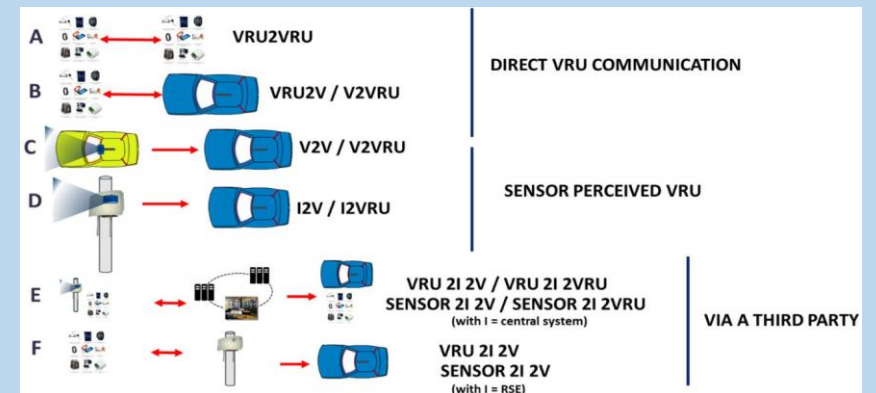

Proposed categories of use cases

Significantly improving vehicle driving safety and traffic efficiency

Mass-produced applications

The AION V mass-produced model of GAC Group integrates **LTE-V2X** information with cameras and radars for perception, which not only enhances traditional ADAS functions, but also supports **scenarios such as intersection collision warning** that cannot be supported without communication.
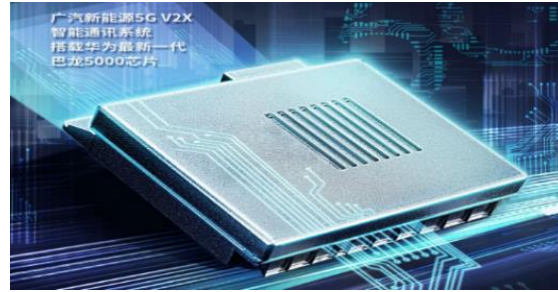
The 315 smart bus based on LTE-V2X in Changsha, Hunan can achieve functions such as bus signal priority and traffic light information sharing. The average travel time optimization rate is **12.6%**, and the average travel speed increase rate of the route is **14%**.
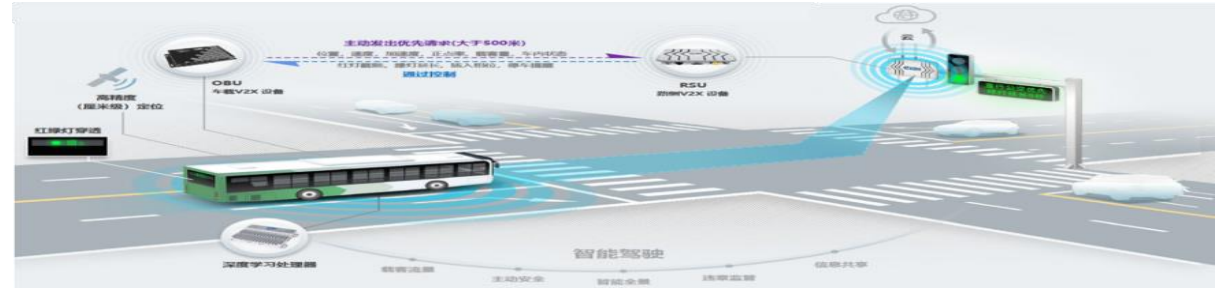
Prospective applications

Substantial progress has been made in the validation of **ADAS+C-V2X collaborative adaptive cruise control** applications.

Prototype verification of **L4 level autonomous driving** application scenarios with pure road end perception

Remote control driving applications have attracted widespread attention

Mining operations

Huaneng Yimin open-pit mine: achieving remote control operation of 20 electric shovels

Port operation

Tianjin Port: Implementing remote control of port machinery equipment and unmanned container trucks

Logistics operations

Liuzhou Industrial Park: Implementing remote control driving of autonomous electric logistics vehicles

Robotaxi operation

Baidu: The Apollo RT6 released in 2022 is equipped with remote control function

Penetration rate of vehicle network connection significantly increases

SAIC Feifan Marvel R

Audi A7L

NIO ET7

HongQi E-HS9

GAC AION V

SAIC Feifan R7

Audi A6L

ARCFOX

GWM Tank

Hiphi X

SAIC GM Buick GL8

In 2023, the penetration rate of vehicle network connection for new passenger cars in China was **78.31%**
- **1,737,300** vehicles (466,400 last year) equipped with **5G modules**
- **311,300** vehicles (170,000 last year) have been equipped with **LTE-V2X PC5 modules**

ITU C-ITS Expert Group on Communications Technology for Automated Driving

- V2X is very important, not only for the future automated driving system (ADS), but also V2X + ADAS, like a sensor.

- EG-ComAD is a joint platform for cross industries and cross domain cooperation, the bridge of "requirements" and "solutions" and the link between "regulations" and "standards".

- Opening, Contributing, Understanding

Thank you

Ge Yuming Email: geyuming@caict.ac.cn