

# Intelligent Connected Vehicles in 5G Era

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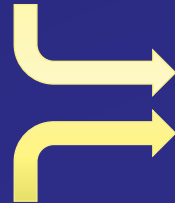


# Definition of Intelligent Connected Vehicles

Connected Vehicles

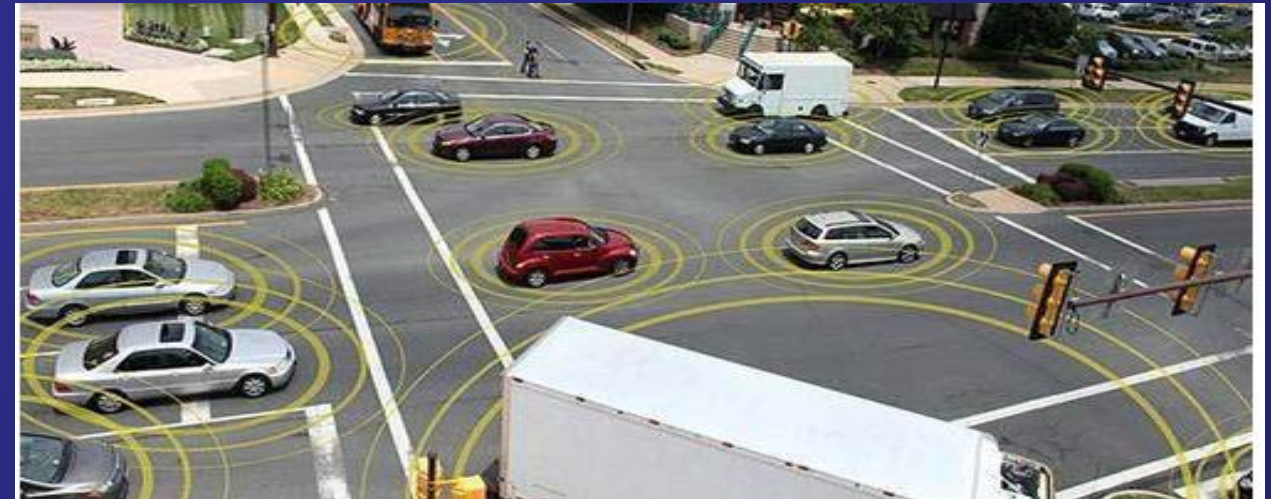


Intelligent Vehicles

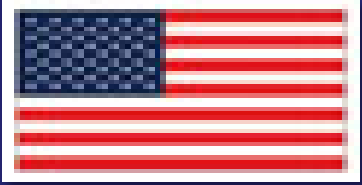


**Intelligent Connected Vehicles (ICV)**

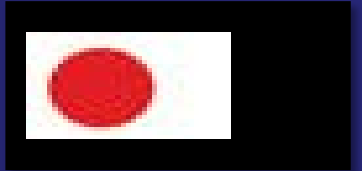
*From CAA (2015.10):* ICV are equipped with advanced automotive sensors, controllers, actuators and other devices. ICV are integrated by modern communications and network technology to achieve the car and X (people, cars, roads, background, etc.) intelligent information exchange sharing, with complex environment perception, intelligent decision making, collaborative control and execution functions. ICV can be safe, comfortable, energy efficient, efficient driving, and ultimately replace the people to operate a new generation of cars.



# ICV is Supported in Global



- ITS Strategic Plan ( 2015-2019 ) : “Connected Vehicle” and “ Advancing Automation” are two main aims.
- V2V mandatory regulations are expected in 2020, and V2V system will be installed in 90% of vehicles in 2040.



- The Cabinet Office: commercial ICV in late 2020.
- High level intelligence traffic: good infrastructure, good government support.



- Close collaboration among EU member states, with a complete top-level design, leading research in intelligent network of energy-saving and environmental protection.
- Automatic cars are expected with massive production in 2025.



- Strategy and roadmap of ICV are being developed.
- For national auto companies, the total progress of ICV is in pace with international companies.

# China Government's Policies in ICV

## MIIT

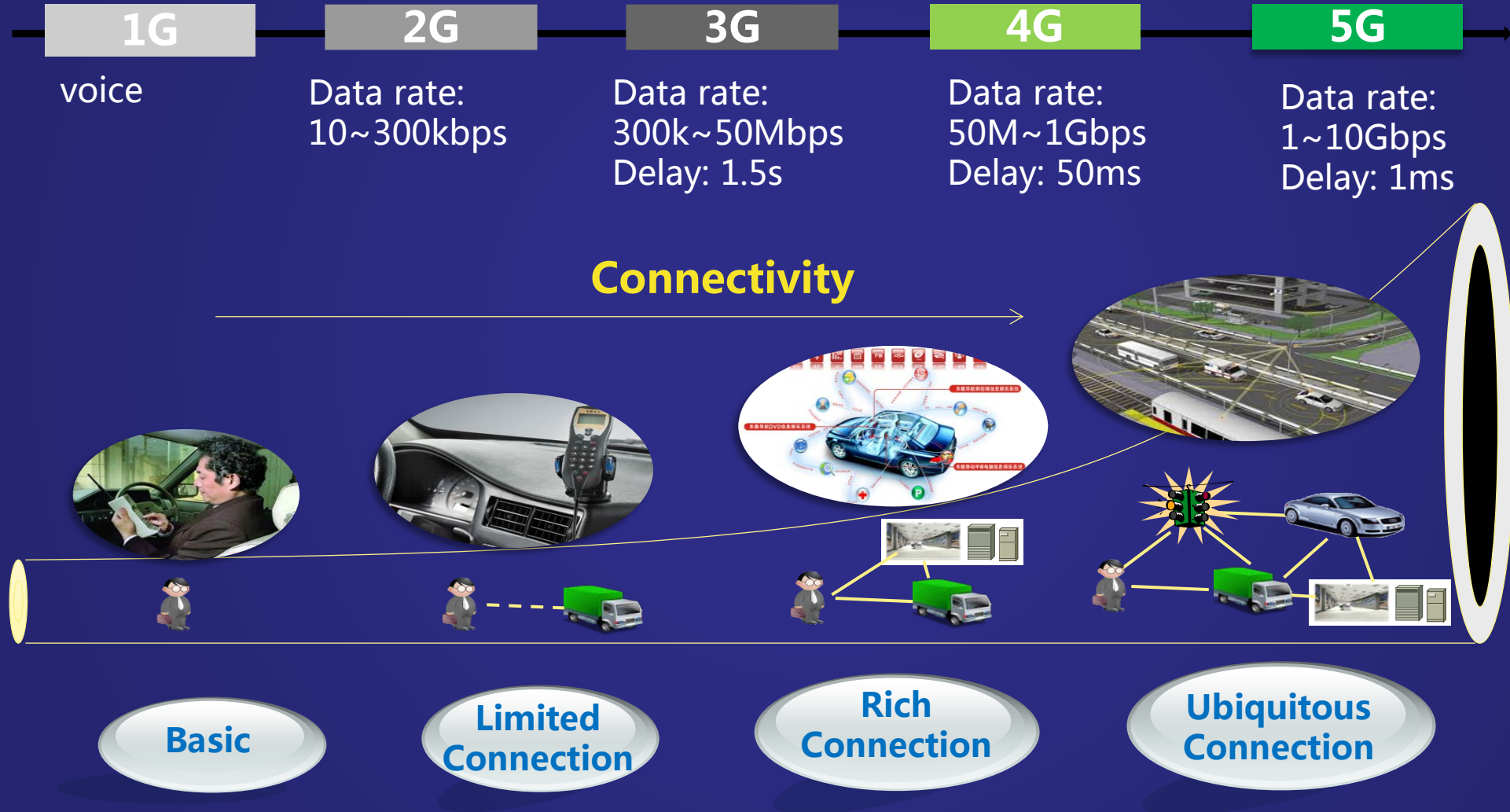
- ICV is one of ten key sectors within “Made in China 2025” strategy
- Technology roadmap of ICV
- Automobile Industry Developing Policy in Mid/long Term
- ICV related Pilot projects, e.g. Intelligent Manufacturing, Enhancing Industry Foundation

## MOT

- Implementation scheme on promoting internet plus convenient transportation& improving ITS development for “Internet Plus” strategy
- Preparing roadmap of Commercial Autonomous Driving Vehicle



# ICV Develops with Mobile Communication



# ICV Requirements in 5G




5G system will support hybrid access technologies, promoting ICV application with multi-mode.

- AIR Delay: 1 ms
- E2E Delay: 5 ms
- Reliability: nearly 100%
- Experience data rate : xGbps



## LTE V2X Awareness, Sensing

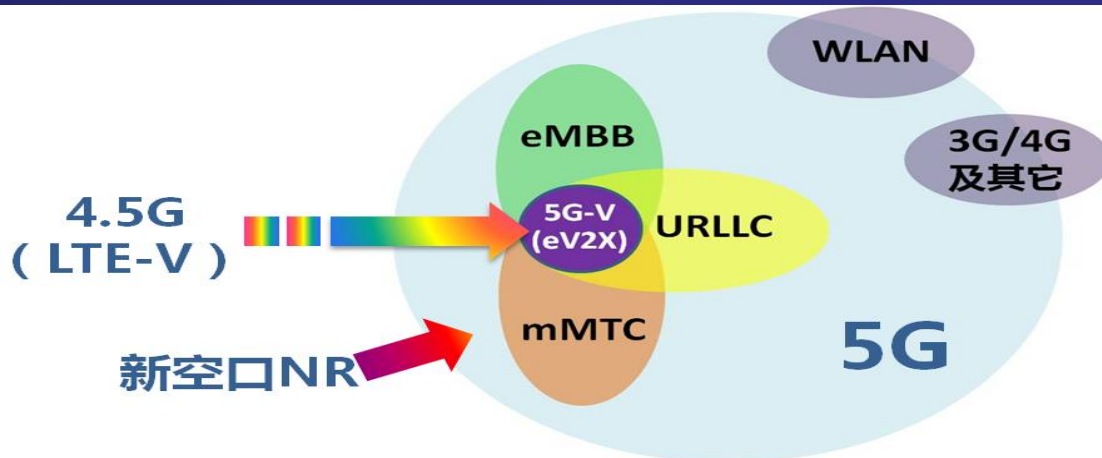
**Enhanced Mobile Broadband**



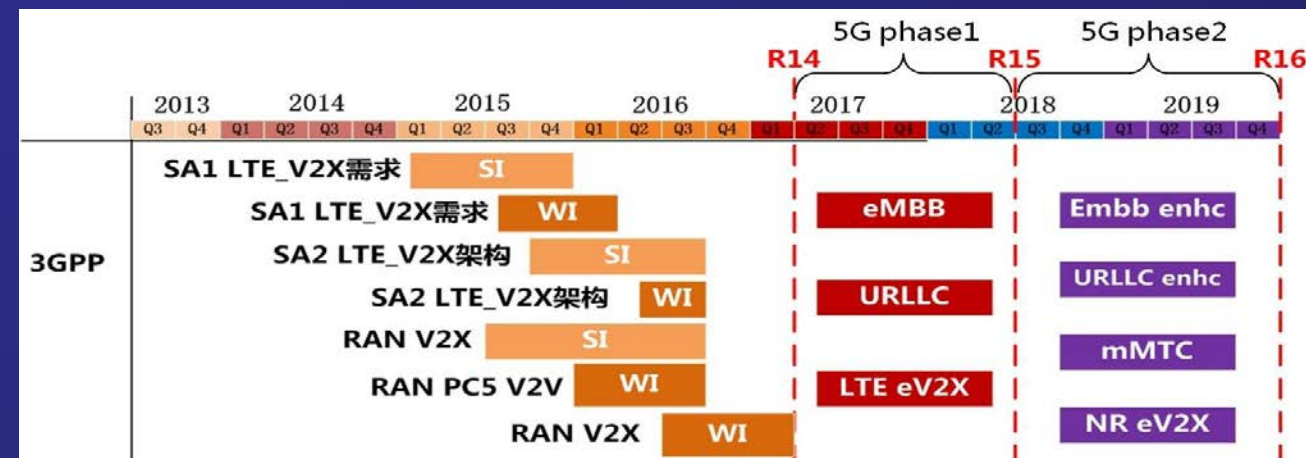
**Ultra-reliable and Low Latency**

## 5G V2X Cooperative, Control

# 5G: NR plus LTE-A Pro



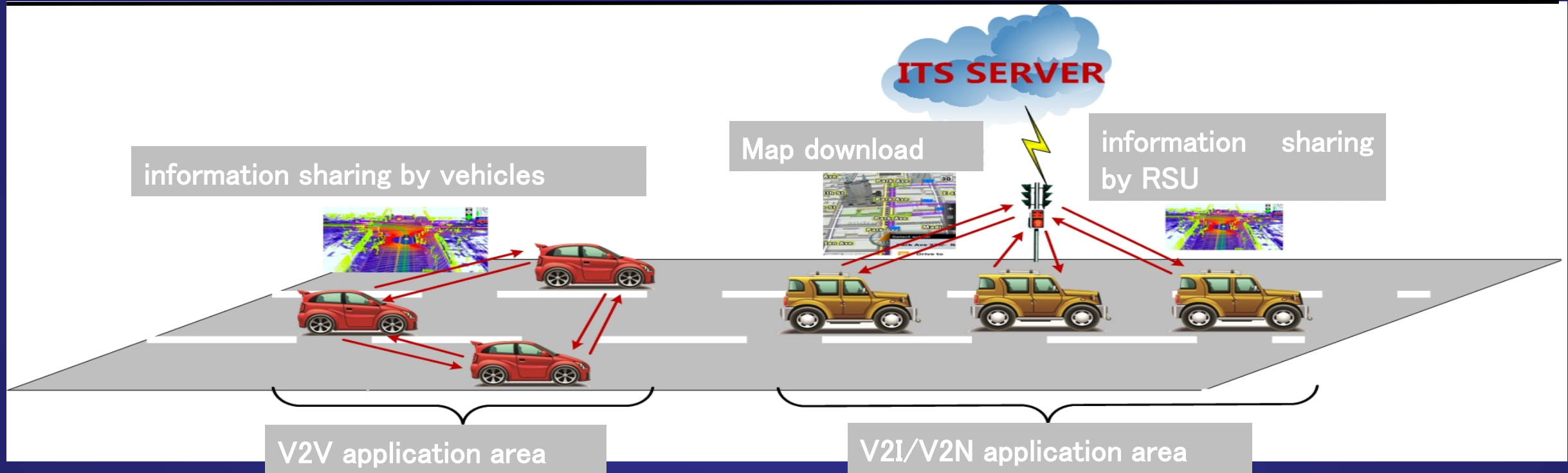
## Standard Timetable for 3GPP V2X



# Quantitative Analysis of ICV Requirements

Application Scenarios	Function	System	Coverage	Traffic	Delay	Data rate	Reliability
Sensor data sharing	Auto-driving	V2V , V2I	Small ( 100m level )	High ( 100Mbps )	Low ( ms )	High	High ( ~100% )
Road test equipment real - time traffic information broadcast	Auto-driving	V2I	Small ( 100m level)	High ( 100Mbps )	Low ( ms )	High	High ( ~100% )
3D map download	Auto-driving	V2I , V2N	Large ( km level )	High ( 100Mbps~1Gbps)	High ( s )		Best Effort
Sensor data cloud upload	Auto-driving	V2N	Large ( km level )		High ( s )	Medium	Best Effort
Multimedia information download	Media entertainment	V2N	Large ( km level )	High ( 100Mbps~1Gbps)	High ( s )		Best Effort
Video stream application	Media entertainment	V2N	Large ( km level )	High ( 100Mbps~1Gbps)	Low ( 100ms )		Best Effort
Mobile information relay	Media entertainment	V2N	Large ( km level )	High ( 100Mbps~1Gbps)			Best Effort

# ICV Application in 5G (1): Automotive Driving



- **Information sharing among vehicles, expanding sensing area to achieve oversight perception**
  - Safe, efficient, supporting automatic driving
  - Improve road traffic supervision
- **High precision map downloading from the roadside/cloud in strange areas**
  - No need to store the map locally in advance
  - Map upgrading is quick and easy



# ICV Application in 5G (2): Information & Entertainment



Office



Video



VR/AR

## ■ Large bandwidth Internet access support for car infotainment

- Enhance the traveler's journey experience
- Provide fruitful multimedia applications
- High speed hot spot access, such as BYOD



# ICV Application in 5G (3): Vehicle Formation

## Queue - Passenger vehicles



- **Intensive formation fleet, reduce the distance between vehicles**
  - Improve road utilization
  - Reduce overall wind resistance and energy consumption
- **Communication mode**
  - Formation Discovery/Join/Adjust/Leave
  - Frequent news

## Queue - Commercial vehicles



- **Connect all vehicles using D2D technology**
  - Full team synchronization control in sudden situation
  - Avoid accumulative transfer of sensor delay
- **Application mode**
  - Mode 1: head car man-driven, following cars unmanned
  - Mode 2: head car unmanned, following cars unmanned

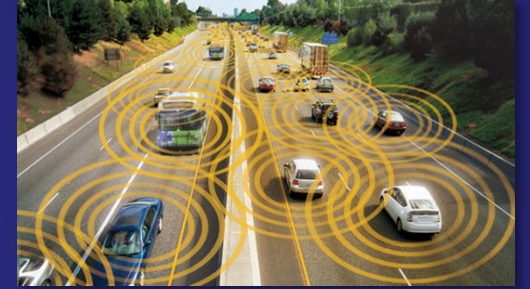
# ICV Application in 5G (4): Remote Driving



- **High reliability: Accurate reception of control signals**
  - Identity authentication mechanism
  - Data reliability authentication mechanism
- **Low delay: control signal is received in time**
  - Meet the human body limit reaction speed (ms)
  - New network architecture reduces latency
- **High bandwidth: remote video stream backhaul**
  - Support UHD video streaming



# Mapping of ICV Application with 5G Scenarios



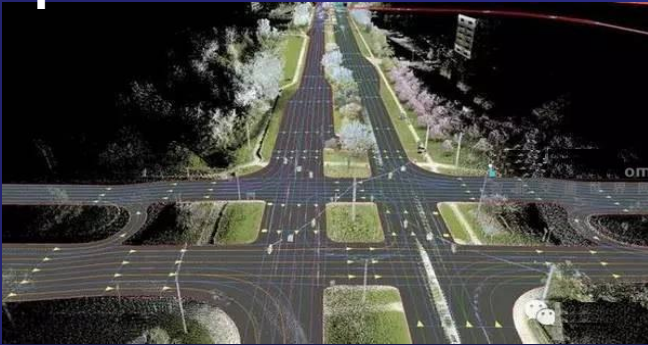
ICV Application Scenarios	eMBB	URLLC	mMTC
High-precision map upload and download	✓		
Information distribution (sensor/video/intention)	✓	✓	
Vehicle formation		✓	
Remote driving	✓	✓	
Crew broadband access	✓		
Roadside facilities interconnection			✓



# eMBB Solution for ICV

## ■ Typical Application Scenarios

High-precision map upload and download



Car audio and video entertainment applications



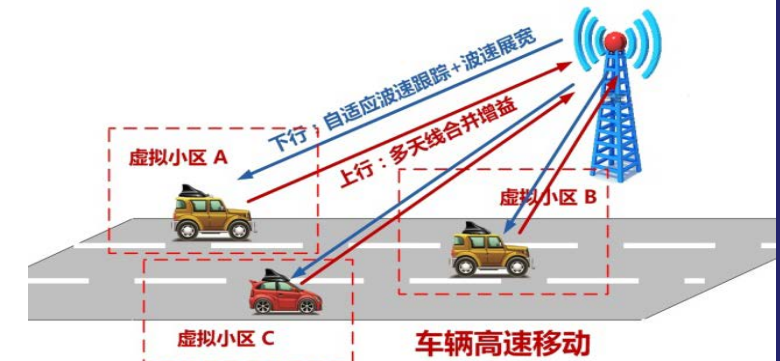
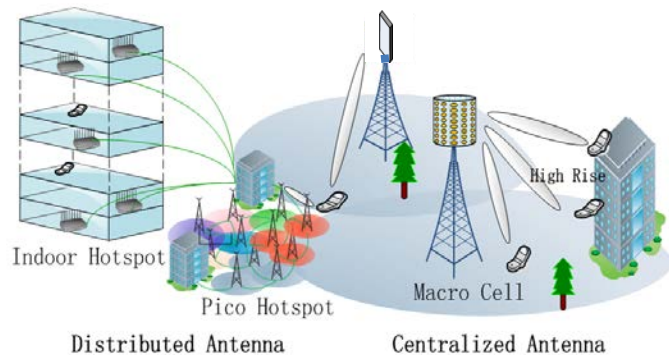
In-car video conference



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■ Requirements: large wideband , high traffic ; not strict with delay and reliability

■ Key Technologies : massive MIMO, UDN, High mobility enhancement...



# URLLC Solution for ICV

## ■ Typical Application Scenarios

Road environment perception



Remote driving



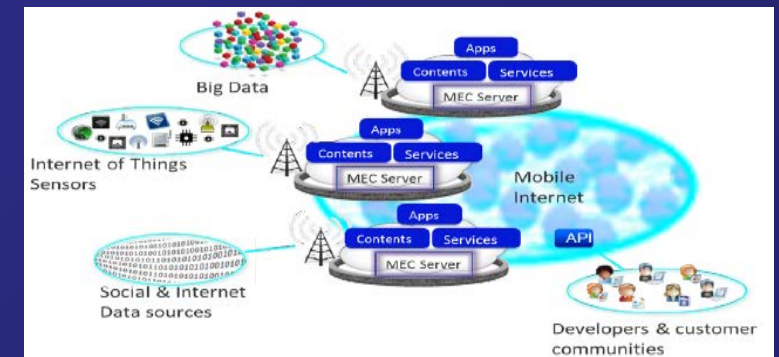
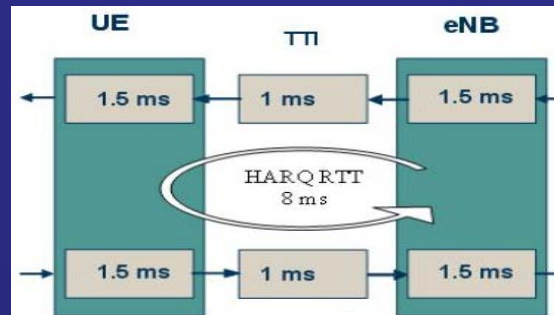
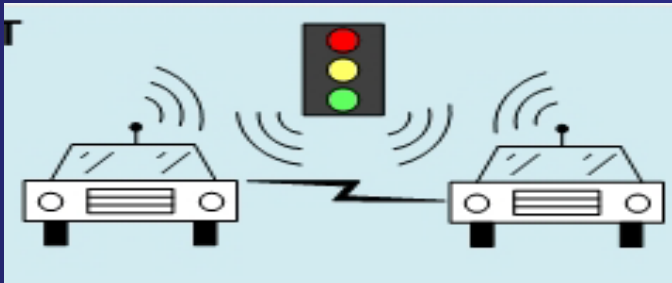
Fleet



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■ Requirements: low delay, high reliability, indoor/outdoor coverage

■ Key Technologies : D2D, short TTI, MEC...





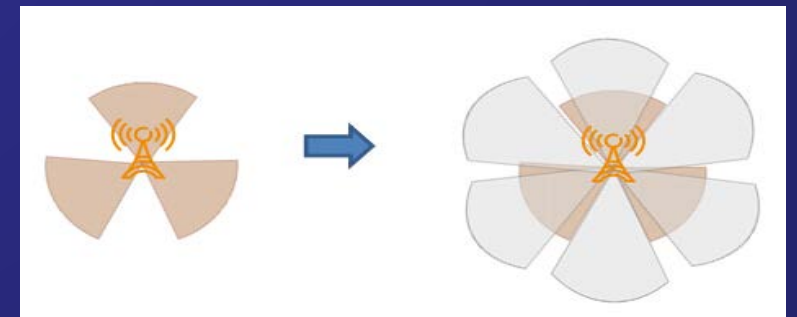
# mMTC Solution for ICV

## ■ Typical Application Scenarios



## ■ Requirements: low cost, high density, high path loss

## ■ Key Technologies : NOMA for massive connection, Massive MIMO, low power consumption, enhanced coverage...



# LTE-V: Solutions for CV/ITS

Based on  
LTE

Customized  
ITS solution

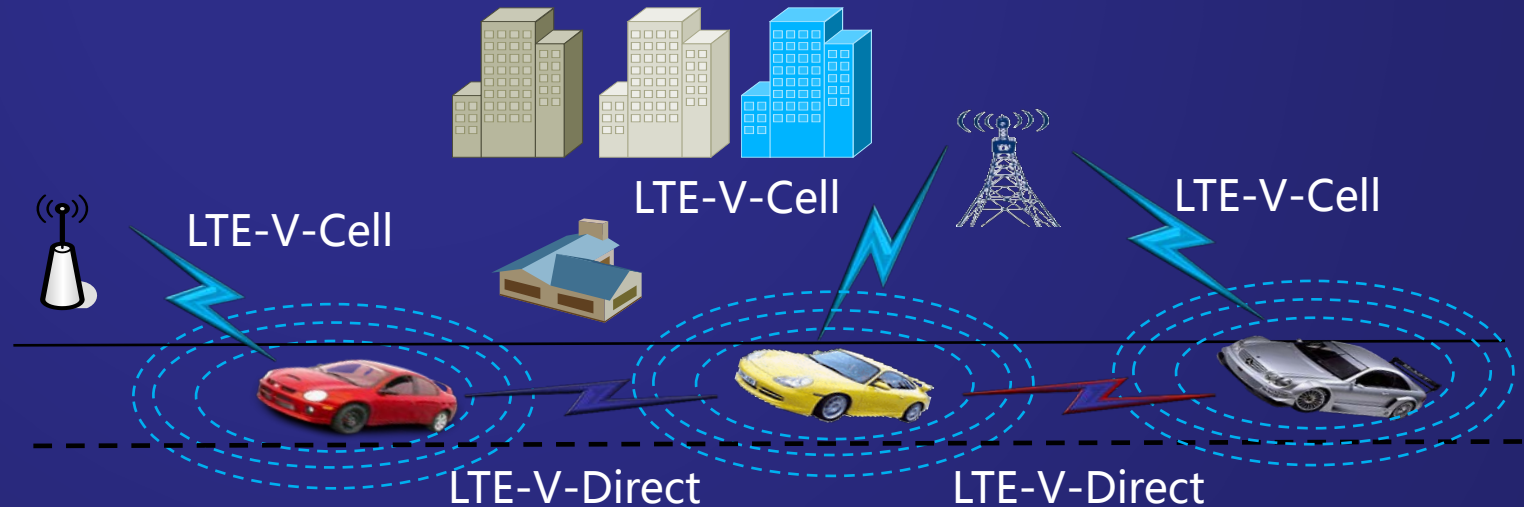
Road Safety  
support

**LTE-V: LTE based V2X system solution for  
connected vehicles/ITS**

**LTE-V-Cell: LTE centralized enhancements**



**LTE-V-Direct: LTE decentralized design**





# Contribution on C-V2X

- Proponent pioneer of LTE-V concept

2013



- Key technology research

- Promote LTE-V study in 3GPP
- Promote LTE-V study in China

2014



- First LTE-V Prototype

- Reporter of 3GPP RAN LTE-V SI/WI

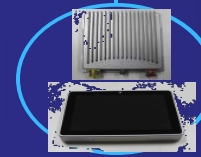
2015



- The 2nd generation LTE-V equipment
- Field Demonstration
  - ◆ Hannover, CEBIT
  - ◆ Nanjing, 14th Asia-Pacific ITS forum
  - ◆ Wuhan, 3rd ICTIS
  - ◆ Shanghai, SAE

- Complete V2V standardization in 3GPP

2016



- Release the chip-level LTE-V pre-commercial products: OBU and RSU
- Co-operation with companies in automotive and transportation industry, e.g. FAW, Chang'an, GAC, Chery, BAIC

- Complete V2X standard in 3GPP
- Start eV2X study in 3GPP

2017



- 3GPP R14 Commercial LTE-V products

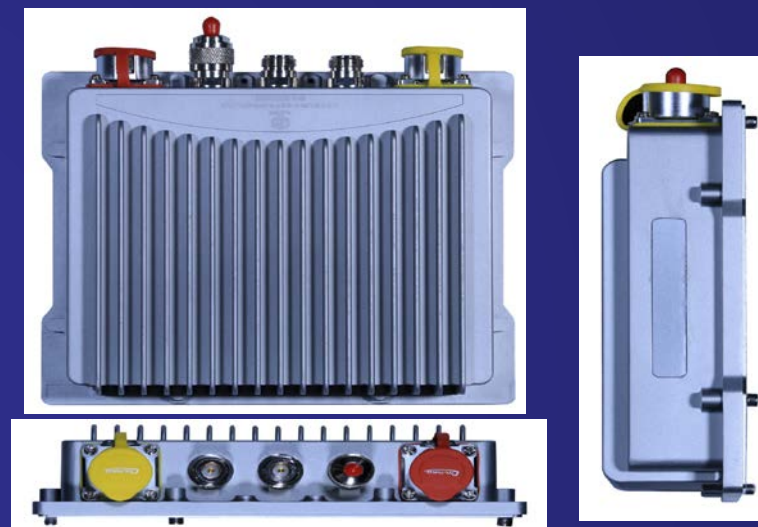
# C-V2X Product: OBU/RSU

## OBU



- Size: 185\*124\*23mm Weight:1kg
- Supporting LTE-V-Direct and LTE-V-Cell based on Datang-designed chipset
- Linux/Android OS
- Diverse interfaces of CAN, Serial Ports, RJ45, USB

## RSU



- Size: 212\*204\*53.5mm Weight: 2.5kg
- High reliability with Water-proof, dust prevention and anti-corrosion, protection grade IP65
- Integral-designed product with small size, plug and play
- High-gain antennas with the coverage of 1.5Km

# C-V2X Live Demo –SAECCE2015



## Live demo

- Partners : Tsinghua university, Chang An automobile, Datang
- Public road in AUTO-EXPO
- 2 OBUs, 5 RSUs
- Use cases
  - V2V safety warning, Speed advisory, Pedestrians detection, green wave tape



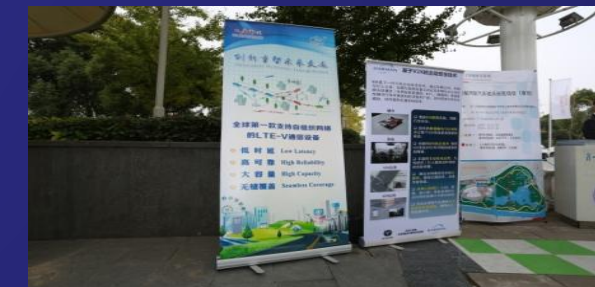
RSU



OBU



Live demo on public road





# Real Road Test: Chong Qing Pilot Area



## Deployment Solution

- 8 RSU , 4 OBU , 2 eNB
- 8 use cases, 1.5KM road

## Show Cases

Intersection movement assist

Emergency brake warning

Pedestrian warning

Over speed warning

Curve warning

Speed advisory

Road construction warning

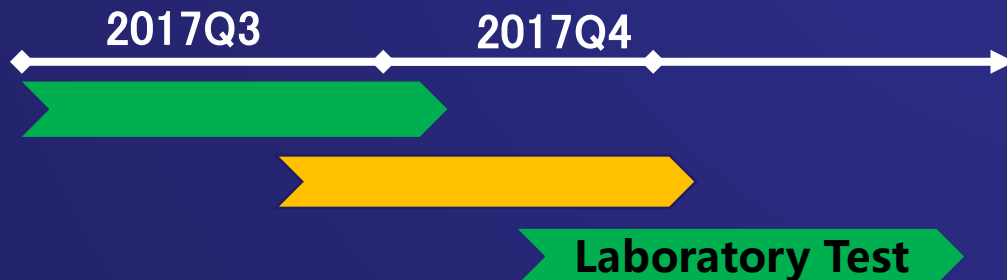
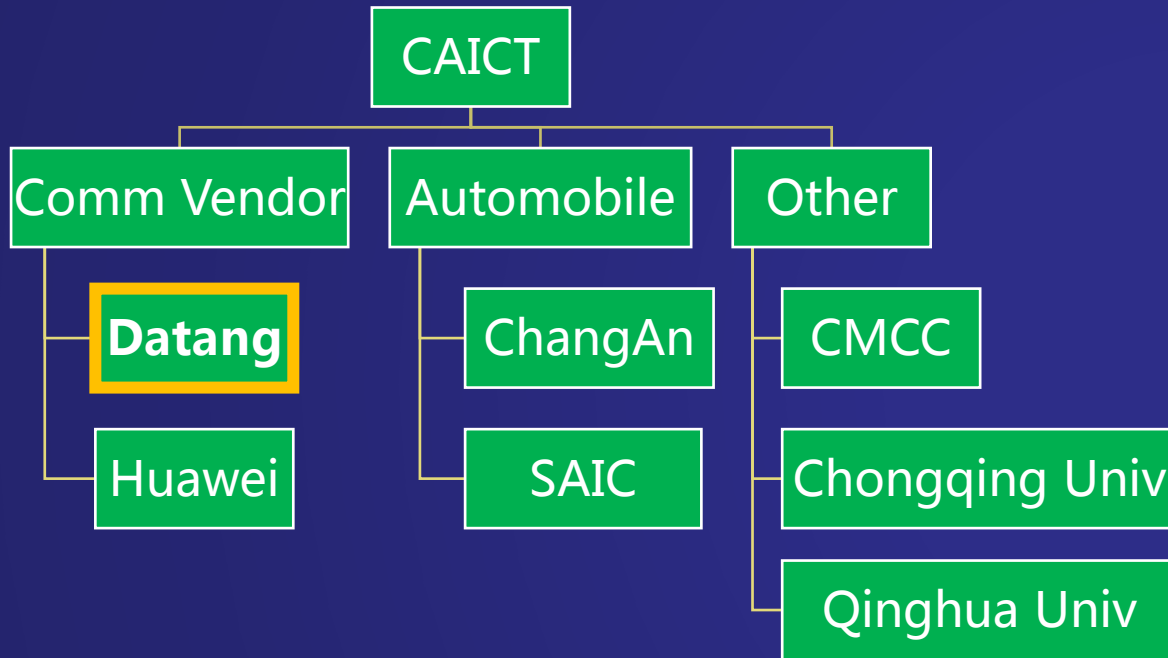
Malfunction alert



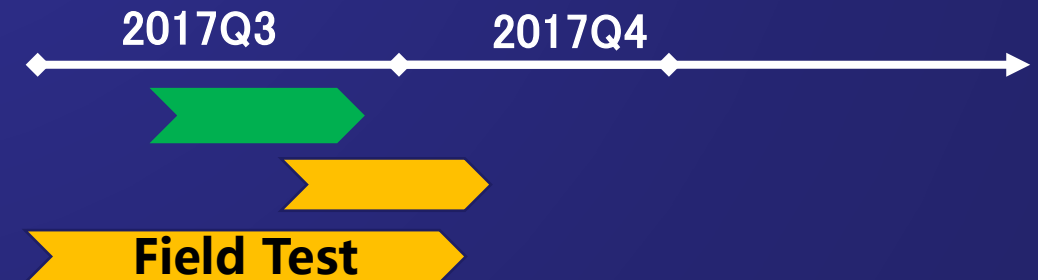
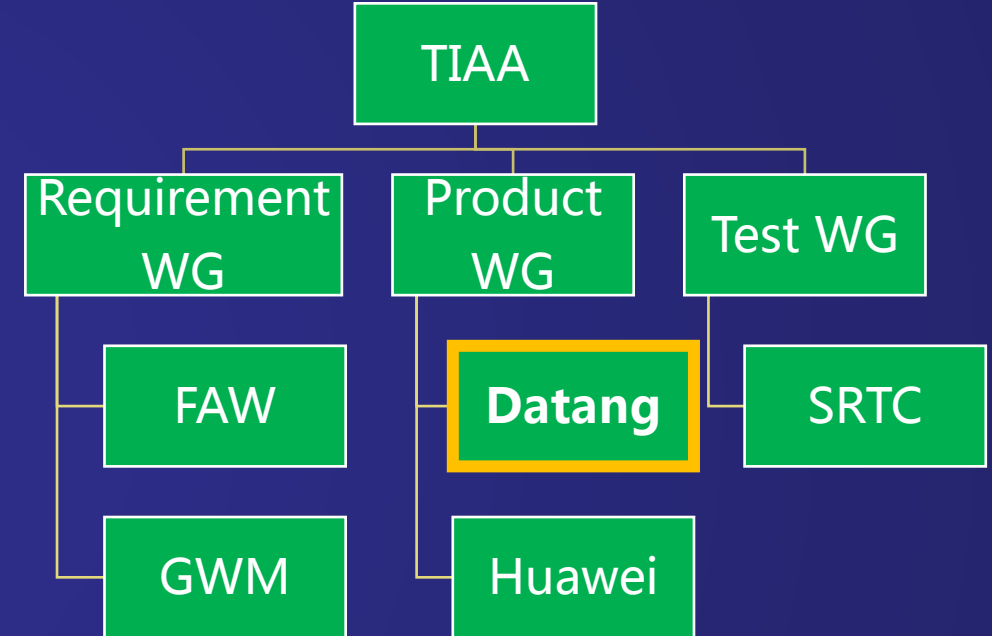


# China's Future Testing Plan for LTE-V2X

## ▪ LTE-V2X Protocol Agreement Test



## ▪ LTE-V2X Frequency Test





**Thanks for your attention**