Technology Roadmap

for Intelligent & Connected Vehicles 2.0

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China Industry Innovation Alliance for the Intelligent and Connected Vehicles (CAICV)

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Introduction: CICV & CAICV

Established in 2018
Main tasks:
• Common technology research
• Technical result application and deployment

23 Shareholders
12 Chinese and abroad OEMs
9 Chinese and abroad suppliers
2 Institutes

Established in 2013
Over 500 members
Main tasks:
• Industry research
• Group standard research
• Demonstration and pilot
• Technical exchange and talent cultivation
Background

- The Technology Roadmap for Intelligent & Connected Vehicles, released in 2016 (referred to as Roadmap 1.0) as one of the research subjects of the Technology Roadmap for Energy-Saving and New Energy Vehicles, has built a technological development system and defined a technological development direction for China’s intelligent connected vehicle (ICV) industry.

- Experts are organized every year to track the technologies based on the industrial trends and form an annual evaluation report.

- The integration of the intelligence and the connection has been widely recognized by international community in the wake of the fast development of the ICV industry in recent years. And a great number of new features and trends of the technology are springing up. So on the basis of full consideration of the above changes, the compilation panel decides to launch the revision work for the Technology Roadmap for Intelligent & Connected Vehicles 2.0 (referred to as Roadmap 2.0).

In 2016, led by China Society of Automotive Engineers (China-SAE), the Roadmap 1.0 was compiled. From 2017 to 2019, experts of its writing group are organized every year to track technology based on the industrial trends and form an annual evaluation report. In 2019, the revision of the Roadmap 2.0 was started under the guidance of China-SAE.
The revision work for the Roadmap 2.0 has been highly concerned and engaged by Over 100 organizations and over 300 experts from automotive and other industry. A total of 3 vehicle application groups and 15 technical groups were set up.

### Group leaders

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Experts</th>
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<tbody>
<tr>
<td>THU</td>
<td>Li Keqiang, Professor</td>
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<tr>
<td>CAICV</td>
<td>Gong Weijie, Secretary-general</td>
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<tr>
<td>CAAM</td>
<td>Xu Yanhua, Deputy Secretary-general for Special Work</td>
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<td>JLU</td>
<td>Gao Zhenhai, Professor</td>
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<tr>
<td>TMRI</td>
<td>Sun Zhengliang, President</td>
</tr>
<tr>
<td>RIOH</td>
<td>Cen Yanqing, Vice President</td>
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<tr>
<td>CAICT</td>
<td>Wang Zhiqin, Vice President</td>
</tr>
<tr>
<td>FAW</td>
<td>Li Fengjun, former Vice President</td>
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<tr>
<td>Geely Auto</td>
<td>Liu Weiguo, former Chief Engineer</td>
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<tr>
<td>BYD</td>
<td>Yang Dongsheng, President</td>
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<td>Huawei Technologies</td>
<td>Hu Hao, Chief Director</td>
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</table>

### Group members

- Universities and research institutes: 20+
- OEMs: 20+
- Information technology enterprises: 40+
- Traditional component suppliers: 30+

Over 100 organizations and over 300 experts in and outside the industry were gathered to further study technical paths and industry objectives of ICVs.
Visions

Safety: Significantly reduce the number of traffic accidents and casualties.

Efficiency: Significantly improve the operating efficiency of mobility and transportation.

Energy conservation and emission reduction: Reduce energy consumption and emissions from road transport.

Comfort and convenience: Improve driving comfort and make the driver feel relax.

User-friendliness: Grant the elderly and the disabled with the right to travel by vehicles.
Technical architecture

- ICVs involve technologies of multiple fields such as vehicle parts and components, information and communication, intelligent transportation system and map positioning, and the technical architecture can be divided into “three horizontal and two vertical”
- “Three horizontal” means key vehicle technologies, information interaction technologies, and basis support technologies
- “Two vertical” means vehicle platform and infrastructure supporting the development of ICVs. The infrastructure, including traffic facilities, communication network, big data platform and positioning base stations
ICVs can be defined as a new generation of vehicles equipped with devices such as sensors, controllers and actuators, integrated with modern communication and network and AI technologies, and designed with functions such as complex environmental sensing, intelligent decision and collaborative control, with purposes of realizing the “safe, efficient, comfortable, and energy-saving” driving, and eventually replacing human driving through the intelligent information exchange and sharing between vehicle and X (vehicle, road, human, cloud, etc.).

<table>
<thead>
<tr>
<th>Automation level</th>
<th>Name</th>
<th>Connectivity level</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DA</td>
<td>1</td>
<td>Auxiliary Information Interaction by connectivity</td>
</tr>
<tr>
<td>2</td>
<td>PA</td>
<td>2</td>
<td>Collaborative Perception by Connectivity</td>
</tr>
<tr>
<td>3</td>
<td>CA</td>
<td>3</td>
<td>Collaborative Decision and Control by Connectivity</td>
</tr>
<tr>
<td>4</td>
<td>HA</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>FA</td>
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</table>

**Connectivity**

- Collaborative decision and control by connectivity
- Collaborative Perception by Connectivity
- Auxiliary information interaction by connectivity

**Automation**

- Connected Autonomous Driving
- Autonomous Driving

**Diagram:**

- DA: Driver Assistance
- PA: Partial Automation
- CA: Conditional Automation
- HA: High Automation
- FA: Full Automation
Development Objectives

• By 2035, China's ICV technology and industrial system will be comprehensively built, with a sound industrial ecosystem, highly autonomous, connected vehicles are extensively applied.

<table>
<thead>
<tr>
<th>General Objectives</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
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<tbody>
<tr>
<td>Establish China’s ICV development strategy, and form an effective cross-departmental collaborative management mechanism.</td>
<td>China’s ICV program becomes an important part of the international automobile development system.</td>
<td>China’s ICV industrial system becomes even more perfect, and is deeply integrated with the industrial ecologies of intelligent transportation system and smart city. An intelligent society featuring sharing, harmony, environmental friendliness, connecting efficiency, and intelligent security shall be built to drive China to realize the goal of building an automobile power and step into the phase of automobile society. All kinds of highly autonomous, connected ICVs will run across China.</td>
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<tr>
<td>The sales of PA- and CA-level ICVs account for more than 50% of the total sales of the year. <strong>HA-level ICVs begin to appear in the market.</strong> And new vehicle assembly rate of the C-V2X terminal reaches 50%.</td>
<td>The sales of PA- and CA-level ICVs account for more than 70% of the total sales of the year. The sales of HA-level ICVs account for 20%. And new vehicle assembly at the C-V2X terminal is basically popular.</td>
<td>Vehicles integrating vehicle, road and cloud and equipped with the collaborative decision and control functions will be put on the market. <strong>HA-level ICVs will be extensively applied on highways and some urban roads on a large scale.</strong></td>
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<tr>
<td>The connected collaborative perception technology is to be applied in full swing in nodes of highways, urban roads and closed areas, and vehicles with the connected collaborative decision-making function will enter the market. HA-level ICVs becomes commercially applied in confined areas and specific scenes.</td>
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</table>
Development Milestones of ICVs

Phased development objectives and milestones are formulated for three typical vehicle types: passenger vehicles, freight vehicles and passenger service vehicles.

- **Passenger vehicles**
  - Private car
  - Robotaxi, etc.

- **Freight vehicles**
  - Trucks
  - New-type logistics distribution vehicles

- **Passenger service vehicles**
  - City bus
  - Intercity and social group buses
  - New-type commuter minibus

The research scope of the roadmap covers: passenger vehicles, freight vehicles and passenger service vehicles, for which phased development objectives and milestones are formulated.

- Intelligent connected passenger vehicles are cars, of which functions include but not limited to automation on urban roads and in parking lots.
- Intelligent connected freight vehicles include medium and large trucks, and new-type logistics distribution vehicles applied in specific areas for demonstration.
- Intelligent connected passenger service vehicles include buses such as city bus, intercity bus and social group bus, and commuter minibuses applied in specific areas for demonstration.
Development Milestones of Intelligent Connected Passenger Vehicles

• By 2025, CA-level automated passenger vehicle technology will realize a large-scale application, and HA-level automated passenger vehicle technology will begin to appear in the market.

Functional scenes:
• Traffic Jam Chauffeur (CA-level)
• Highway Chauffeur (CA-level)
• Highway Autopilot (HA-level)
• Automated Valet Parking (HA-level)
• City/Suburban Autopilot, Robotaxi (HA-level)
• Full Autopilot (FA-level)

Note: The intelligent connected passenger vehicles covered in the roadmap are cars, of which functions include but not limited to autopilot on urban roads and in parking lots.
Development Milestones of Intelligent Connected Freight Vehicles

- By around 2025, DA- and PA-level automated technology will realize a large-scale application on highways, and CA-level automated freight vehicles will begin to appear in the market. HA-level automated will realize its commercial application in confined areas, and the highway pilot platooning will be put into use.

Functional scenes:
- Highway Chauffeur (CA-level)
- Highway Autopilot (HA-level)
- Highway Pilot Platooning (HA-level)
- Confined Areas Autopilot (HA-level)
- City Autopilot (HA-level)
- Full Autopilot (FA-level)

Note: Intelligent connected freight vehicles covered in the roadmap include medium and large trucks, and new-type logistics distribution vehicles applied in specific areas for demonstration.
Development Milestones of Intelligent Connected Passenger Service Vehicles

- By around 2025, CA-level automated technology will be put into commercial application on buses (e.g. BRT) in confined areas; and HA-level automated technology will enter its commercial application on shuttle buses in confined areas.

Functional scenes:
- Confined Areas Chauffeur (BRT, CA-level)
- Confined Areas Autopilot (HA-level)
- City Autopilot (HA-level)
- Highway Autopilot (HA-level)
- Full Autopilot Mobile Platform (FA-level)

Note: Intelligent connected passenger service vehicles covered in the roadmap include buses such as city bus, intercity bus and social group bus, and new-type commuter minibuses applied in specific areas for demonstration.
Technology Roadmap for Intelligent & Connected Vehicles

One horizontal means **key vehicle technologies**, including environmental perception, intelligent decision, control execution, system design (electronic and electrical architecture, human-machine interaction, intelligent computing platform).

### Key vehicle technologies
- **Environmental perception**
- **Intelligent decision**
- **Control execution**
- **System design**

### Key information interaction technologies
- Special communication and network
- Big data cloud platform
- Vehicle-road collaboration
- AI
- Safety
- High-precision mapping and positioning
- Test and evaluation
- Standards and regulations

### Key basic support technologies

#### Environm ental perception
- Achieve breakthroughs in multi-source collaborative perception technology, fully meet the requirements of the CA-level system, and the HA-level system in partial areas. Obstacle detectability >200m.

#### Intelligent decision
- Provide CA- and HA-level intelligent decision technology covering 80% of roads throughout China. Realize the multi-vehicle collaborative control through connected auxiliary information interaction.

#### Control execution
- Establish an electronic and electrical architecture platform based on domain controllers and a base platform based on domestic domain controllers, and achieve a software system that conforms to the AUTOSAR standard.

#### Electronic and electrical architecture
- New technologies such as virtual display, eyeball tracking, and sight tracking are to be applied to cockpit interaction. Build China’s database of drivers’ natural driving behavior and vehicle control system.

#### Human-machine interaction
- Build a vehicle platform architecture based on the integration of vehicle, road and cloud, and realize the application of high-speed vehicle network wire harness and components.

#### Intelligent computing platform
- The power consumption hashrate ratio of the hardware platform will be more than 10TOPS/W, and an independently controllable development and application ecosystem will be established.

### 2025
- Achieve breakthroughs in multi-source collaborative perception technology, fully meet the requirements of the CA-level system, and the HA-level system in partial areas. Obstacle detectability >200m.
- Provide CA- and HA-level intelligent decision technology covering 80% of roads throughout China. Realize the multi-vehicle collaborative control through connected auxiliary information interaction.
- Establish an electronic and electrical architecture platform based on domain controllers and a base platform based on domestic domain controllers, and achieve a software system that conforms to the AUTOSAR standard.

### 2030
- Meet the requirements of FA-level autopilot system. Obstacle detectability >1000m.
- Provide HA-level intelligent decision technology applicable for FA. The intelligent decision capability exceeds the level of human drivers.
- Build a platform architecture based on the integration of vehicle, road and cloud, and realize the application of high-speed vehicle network wire harness and components.

### 2035
- Popularize new interaction techniques on a large scale, realize seamless connection between autopilot and artificial takeover, and achieve the coupled human-machine co-driving technology.
- The power consumption hashrate ratio of the hardware platform will be more than 10TOPS/W, and an independently controllable development and application ecosystem will be established.

### Key technologies
- **In 2025**, technologies such as complex environmental perception, computing decision and control execution will meet the design requirements of CA-level automation system and HA-level automation system in specific scenes;
“One horizontal” means key information interaction technologies, including special communication and network, big data base cloud computing platform, and vehicle-road collaboration, etc.

**Key vehicle technologies**
- Environmental perception
- Intelligent decision
- Control execution
- System design

**Key information interaction technologies**
- Special communication and network
- Big data cloud platform
- Vehicle-road collaboration

**Key basic support technologies**
- AI
- Safety
- High-precision mapping and positioning
- Test and evaluation
- Standards and regulations

**Three horizontal and two vertical** technical architecture

**2025**
- Complete research on the NR-V2X frequency spectrum, the coexistence of NR-V2X and NR-V2X equipment, and the NR Uu-controlled LTE straight-through link. The multi-edge computing power will meet the short delay business requirements of automated vehicles.
- Build a region-level base cloud computing platform, explore demonstrated operation in pilot sections of highways, and collect driving data of no less than 500,000 vehicles on the regional platform.
- Conditional automation based on vehicle-road digital information sharing will come into use, and vehicle-road integrated environmental perception technology will be applied at important intersections, road sections, closed parks and highways;

**2030**
- NR-V2X 6GHz above millimeter wave technology will grow to be mature, and a world-leading test and evaluation system will be built. Full scene support of multi-edge computing power for ICV business
- Build a state-level base cloud computing platform, provide data operation in all areas/sections of multiple cities and highways, and collect driving and perception data of no less than 500,000 vehicles on a single city-level platform.
- The automation technology based on vehicle-road collaborative decision will be applied in important intersections, road sections and closed parks.

**2035**
- V2X technology will support the commercial requirements of HA-level and above, automation have a widely distributed edge cloud capability, and meet the technical requirements of vehicle-road-cloud collaborative decision and control.
- The base cloud computing platform covers all regions of the first- and second-tier cities and all sections of highways throughout China.
- The automation technology based on the integration of vehicle, road and cloud will be applied.

**In 2025,** NR-V2X frequency spectrum will be finished; the region-level base cloud computing platform will be built; and vehicle-road integrated perception technology will be applied at important intersections, road sections, closed parks and highways;
### Technology Roadmap for Intelligent Connected Vehicle

**“One horizontal” means key basic support technologies, including artificial intelligence, information safety, functional safety and SOIF, high-precision map and positioning, test and evaluation, standards and regulations.**

#### Key vehicle technologies
- Environmental perception
- Intelligent decision
- Control execution
- System design
- Special communication and network
- Big data cloud platform
- Vehicle-road collaboration

#### Key information interaction technologies
- Electrical and electrical architecture
- Human-machine interaction
- Intelligent computing platform
- Information security
- Functional safety
- Safety of intended functionality(SOTIF)

#### Key basic support technologies
- Artificial intelligence
- Informatio n safety
- Functional safety and SOIF
- High-precision map and positioning
- Test and evaluation
- Standards and regulations

#### “Three horizontal and two vertical” technical architecture
- **2025**
  - Improve the AI environmental perception algorithm using the integration of multi-source heterogeneous information, and achieve breakthroughs in key technologies of multilingual speech synthesis, recognition, and semantic comprehension.
  - Establish the vehicle development and production process management of information safety, and realize the vehicle-vehicle, vehicle-road, vehicle-human, and vehicle-cloud safety communication and the safety protection of proprietary center cloud and edge cloud.
  - Establish an information safety protection system for HA-level above system, and improve the emergency response mechanism and guarantee and supervision system for information safety.
  - Form a relatively complete shared database of China’s typical driving scenarios shared in the industry by levels; build a subjective and objective test and evaluation system in line with the characteristics of China’s traffic environment, and form a test and evaluation system for FA-level ICVs.
  - Complete the building of a Chinese standard system with advanced technologies, reasonable structure and complete contents to meet the development of different technical routes.

- **2030**
  - Achieve breakthroughs in the deep integration technology of multi-sensor environmental perception algorithm, and independently develop data processing chips and AI chips, with domestic market share reaching above 50%.
  - Improve the functional safety design processes of vehicle, system and chips of ICVs; establish the design and analysis process for SOIF.
  - Realize the pilot application of standards for functional safety and SOIF on automation systems.
  - Form a test and evaluation system for FA-level ICVs, and certification specifications and processes is to be mature and complete.

- **2035**
  - Fully realize the AI control for HA-level automated vehicles.
  - Fully implement the information safety protection system of ICVs, and build a supervision system integrating traffic safety, information safety and network safety.
  - Fully realize the application of standards for functional safety and SOIF on FA-level vehicle, system and components.
  - The map data precision will approach the centimeter level, covering the road networks throughout China; the dynamic data will be updated per second. The global indoor and outdoor high-precision positioning will meet the requirements of the FA-level system.

#### In 2025, the AI environmental perception algorithm will be improved; the design and analysis process of information safety, functional safety, and SOIF will form; the high-precision dynamic map data will be upgraded per hour; positioning accuracy by Beidou Satellite and multi-source sensors will reach the centimeter level; more than 100 national standards will be enacted, and group standards will form for forward-looking technologies;
Thank you for your attentions.

We’re now working on the Application Roadmap for different type ICVs.

We’ll be happy to have more discussion with international peers.

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