United Nations World Geospatial Information Congress 联合国世界地理信息大会

Intelligent Transportation and Autonomous Vehicles

Introduction to Dr. Keqiang Li

- **Professor** of Automotive Engineering, **Tsinghua University**
- **Chairman** of Expert Committee, **CAICV** (**C**hina Industry Innovation **A**lliance for **I**ntelligent and **C**onnected **V**ehicles)
- **CTO** of **CICV** (China ICV Research Institute Co., Ltd.)
- **Research interests**: Connected and intelligent vehicles, Vehicle dynamics and control.
- Authored or co-authored over 200 peer reviewed journal papers
- Received more than 80 patents.

Organizer:

浙江省自然资源厅 测绘与地理信息管理
Department of Natural Resources of ZheJiang Province (Administration of Surveying Mapping And Geoinformation)

The Base Platform of ICV System and Its Industrialization Approach in China

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Chairman of Expert Committee, CAICV (**C**hina Industry Innovation **A**lliance for **ICV**)

November 20, 2018

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New Technology Trend of Automated Vehicles

Autonomous vehicles

Intelligent and Connected Vehicles (ICV/CAV/CAD)

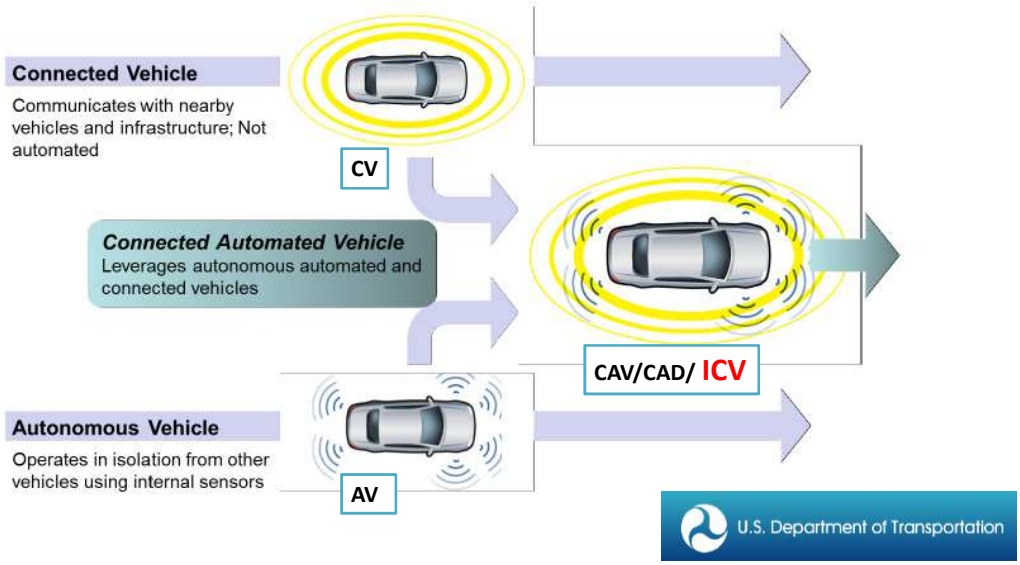
Automation

Connection

Connected vechicles

"Autonomous Vehicle" + "Connected Vehicle" = ICV

The path toward connected vehicles will ultimately lead to automated vehicles.



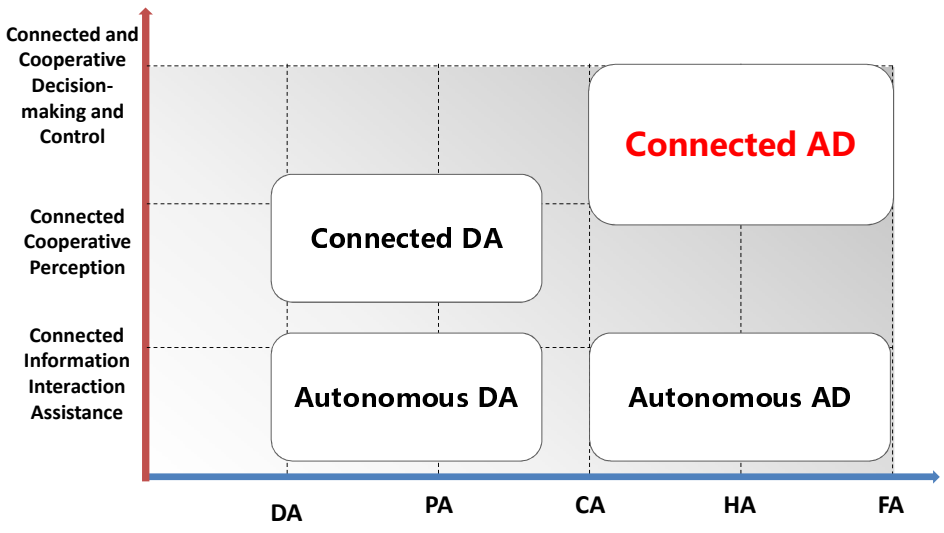
Automation Levels of ICV

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Connection Levels of ICV

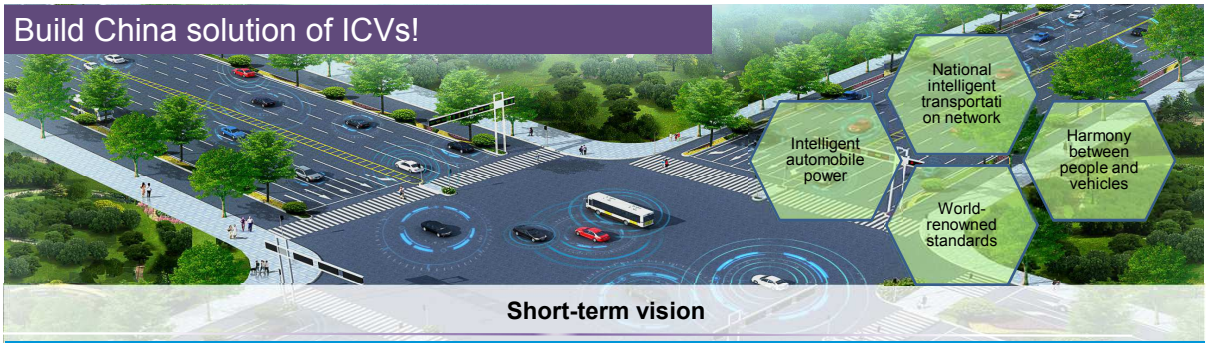
Connection Levels	Name	Narative Definition	Control	Typical Scenario	Transmission Requirement
1	**Connected Information Interaction Assistance**	Realize auxilliary data aquisition including navigation and upload of information including driving and driver operation data based on Vehicle-Road and Vehicle-Backend communication	Human	Map, traffic flow, traffic signs, fuel consumption, and mileage, etc.	**Low requirement on real time and reliability**
2	**Connected and Cooperative Perception**	Acquire real time surrounding traffic environment data based on Vehicle-Vehicle, Vehicle-Road, Vehicle-Pedestrian and Vehicle-Backend communication, infuse with perceived data by onboard sensors, and then input for self-vehicle decision-making and execution systems	Human and system	Position of surrounding vehicles/pedestrians/non-motorized vehicles, phase position of traffic light, and road pre-warning, etc.	**High requirement on real time and reliability**
3	**Connected and Cooperative Decision and Control**	Acqiure reliable surrouding traffic environment data and vehicle decision-making data based on V-V, V-R, V-P and V-B communication, transportation participants including V-V and V-R interact and infuse data, and then form collaborated decision making and control among the participants.	System	V-V, V-R collaborated control data	**Highest requirement on real time and reliability**

Classification of ICVs



National ICV Innovative Development Strategy -- Vision Goal

Long-term vision



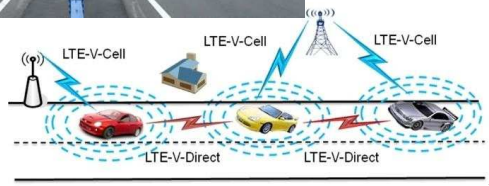
Short-term vision

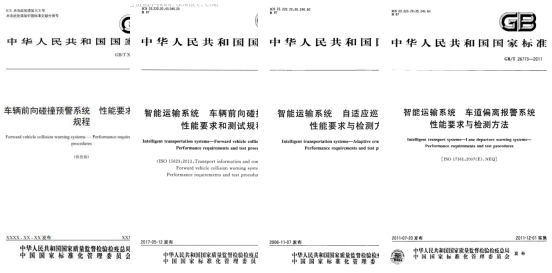
- **System Construction:** By 2020, we will take initial shape of the independent technology innovation system of intelligent vehicles, and the industrial ecological system of cross-border integration, advanced and complete road network facilities system, systematic and perfect regulations and standards system, scientific and standardized product supervision system, and comprehensive and efficient information security system. And the national intelligent vehicle innovation and development platform has basically been completed and put into substantial operation.
- **Market scale:** Intelligent vehicles account for 50% of new cars, including 10% of conditional automatic driving (L3) and above. The market share of self-brand intelligent vehicles is over 30%, and the new vehicle assembly rate of network automatic driving reaches 10%.
- **Infrastructure:** The demonstration operation of key areas has achieved positive results. And the constructions of intelligent road traffic system and vehicle network system are coordinated, in which the national coverage rate of vehicle wireless communication network LTE-V is 90%.

China Solution of ICV

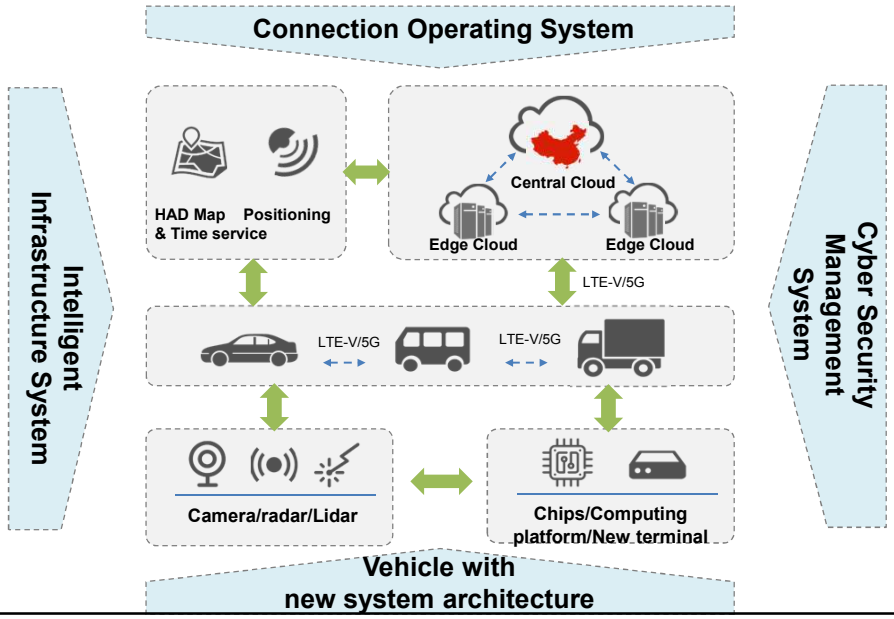
What is the China solution of ICV?

- **Meet the infrastructure standards in China**
  Meet standards of infrastructure including road, mapping data, V2X communication and transportation rule in China.
- **Meet the connection operation standard in China**
  Meet the standards of ICV admittance qualification, network operation supervision, cyber security in China.
- **Meet the new architecture standards of automotive product in China**
  Meet the standards of new architecture of automotive product in China, such as the standards of intelligent terminal, communication system, cloud platform, gateway, driver assistance system and autonomous driving system.





The System Architecture of the China Solution ICV



China Solution of ICV

Why we need the China solution of ICV ?

- **Adapt to distinct traffic environment and driving behavior in China**
  Different from western countries, the traffic environment is complex and driving behaviors are special in China. Thus adaptability is required for ICVs.
- **Utilize the development features of integration of informatization and industrialization**
  China has the powerful ICT, Internet industry foundation and innovation capability. Deep integration of ICT and automobile industry will be the development feature of ICV in China.
- **Develop China's institutional advantages**
  Different from western countries, the governance mechanism of China will benefit in coordinating resources and promoting the development of ICVs.
- **Assure national cyber security and industrial security**
  Involved with cyber security, data security and industry security, the standard system of ICV has to be established.

The Strategic Tasks for ICV Innovative Development

1. Independent and controllable technological innovation system for ICVs
2. The crossover integrated ICV industry ecosystem
3. Advanced and complete road and IC infrastructure system for ICVs
4. Complete regulation and standard system for ICVs
5. Scientific and regulated product supervision system for ICVs
6. Comprehensive and efficient cyber security system for ICVs

In Beijing, the establishment of CICV (China ICV Research Institute Co., Ltd.) is for the national ICV innovation center.

The China ICV Industry Alliance was established on June 12, 2017. Minister of Miao Wei of MIIT served as Director of Alliance Steering Committee.
Minister Miao suggested that **the Alliance should take the lead in establishing the National ICV Innovation Center**

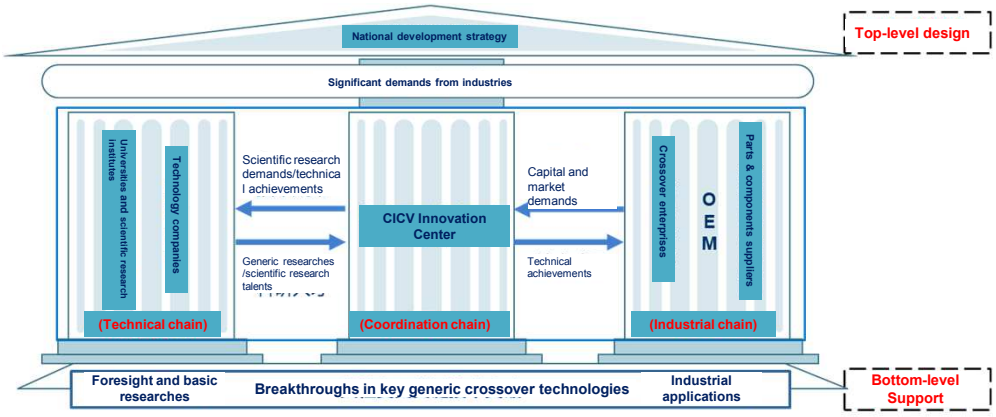
The innovation center is launched jointly by C-SAE, CAAM and the Alliance.
The relying units mainly include industrial alliances, and universities, vehicle and parts enterprises, information and communication enterprises.
The operation subject of innovation center is China ICV Research Institute Co., Ltd. (CICV).

China ICV Research Institute Co., Ltd. was established on March 19, 2018.
The registered address is Beijing Economic-Technological Development Area, with **a registered capital of 1. 05 billion Yuan** at the end of the year. The company is located in the southwest of Beijing.

The innovation center shareholder units are gradually increasing

- The 12 founding shareholders invested 600mio CNY, each with 50mio CNY, so far all investments have been in place.
- The second round of 9 investors have been reviewed and approved by the board of directors, the registered capital will rise to 1billion CNY.
- **Currently a number of international companies are in discussion with the Innovation Center** to be in the third round of investors.

Positioning of CICV - Defferentiation from Institutes, Enterprises, and Governement Agencies



- **Positioning of functions:** state-level core think tank of innovation strategies, R&D center of innovative technologies, public platform of innovative service and nurturing base of innovative talents
- **Positioning of roles:** cultivator of emerging industries (guidance), promoter of industrial development (incubation) and collaborater of corporate R&D (transfer & service)

Benefits to Partners by CICV

OEM

- **Urgently demanded basic service for the development of industries** (industrial and technological development strategy, cross-field ICV systems and structures, standards and regulations, generic database of driving scenarios)
- **Urgently demanded generic crossover system modules for the R&D of ICV** (HAD base map, base modules for intelligent terminals, intelligent base computing platform, cloud-control base platform, cybersecurity platform, HMI driving system, etc.)
- **Reduce R&D costs, improve development efficiency, bring new functions to the system** (jointly support the generalization and industrialization of non-competitive major technologies)

ICT Companies

- **Basic service for cross-sector integration** (industrial and technological development strategy, definition of vehicle products, standards and regulations, base data service, business model innovation, etc.)
- **Cross-section generic and crossover modules** (in-vehicle intelligent gateway, intelligent computing platform, HMI and co-driving modules, design proposal for test scenarios of IoV, etc.)
- **Establish a cross-sector collaboration and innovation platform, lower the industry's access threshold and improve working efficiency** ICT (Platform for technology transfer and collaborative development between ICT enterprises and automotive industry, application demands and standard interface between the automated driving and C-V2X, Big data platform of IoV, etc.)

CICV

Parts Suppliers

- **ICV industrial cooperation interfaces** (strategic cooperation platform with OEM, technological cooperation platform with research institutes, and cultivation of professional talents)
- **Urgently demanded middleware and general platforms** (HD base map, intelligent computing platform, cloud control base platform, cybersecurity platform, software & hardware interface protocol)
- **Improve product development and test validation abilities** (transportation scene data, driving behavior data, AI training data, test-reference design)

Research Institutes

- **Support of research projects**
- **Commercialization of research achievements** (promote the industrialization of research achievements)
- **Industrial innovation platforms** (Cross-industry integrated innovation platform; jointly promote innovations of generic technologies and the formulation of technical standards with different parties)
- **Professional think tank of State** (help with the top-level design, strategic planning and the division of tasks)

Initial Tasks of CICV

Principles *of* first stage tasks *selection*

- Provide *demanding support service of foresight and fundamental research for* crossover industrial development;
- Provide *cross-field common and crossover base modules, middleware units, and base platforms for various* enterprises (no competition with existing companies).

CICV Tasks (First Stage)

Break-through on 7 common technologies

- ICV Development Strategy
- ICV Cyber-Physical Systems Architecture
- ICV Technology Standards
- Level 4 ADS under Chinese Standards
- Automated Driving and Automotive AI
- Intelligent Security and HMI
- Test Assessments and Base Databases

Industria-lization support for 5 base platforms

- ICV Base Computing Platform
- ICV Base Terminal Platform
- ICV Base Cloud Control Platform
- ICV Base HAD Map Platform
- ICV Base Cybersecurity Platform

Breakthrough on 7 Common ICV Technologies

1. ICV Development Strategy

At the level of national top design, strengthen the research and guidance of ICV development strategy to promote sustainable development

2. ICV Cyber Physical System Architecture

Research in architecture of ICV. Propose layered architectures based on user service, logical framework, physical framework, application system and standards. Develop and combine multi-source information fusion technology with vehicle control, and realize collaborative control of vehicle intelligent system

3. ICV Technology Standards

Promote the establishment of ICV standard and regulation system, and facilitate the formulation and improvement of our ICV policies and regulations.

4. Test, evaluation and base database

Establish base database of ICV on different levels of driving automation systems, and meet requirements for test and evaluation from different levels of ADS

5. Intelligent driving & automotive AI

Combine AI open source algorithms, open data, and open standards of automated driving, establish base core algorithm open-source platforms and ecosystem of DL, brain-like intelligence, group intelligence, etc. Enhance coordination and cultivation of cross-disciplinary research resources

6. Intelligent security and HMI

By sharing of base data of natural driving behaviors, as well as design of common standards and general interface specifications, establish a professional package HMI proposal applied in control, security, communications and infotainment. Build a shared service platform for test and validation of performance of HMI co-driving system.

7. Level 4 automated driving system under China standards

Define function of Chinese Level 4 ADS. Carry out the research in key generic technologies for intelligent security, intelligent mobility and intelligent city. Promote and build up competences of design and development, system integration, test and evaluation of Level 4 automated driving vehicles in China

Industrialization Support for 5 Base Platforms of ICV System

1. ICV Base Computing Platform

Build Chinese standard ICV base computing platform framework, research in heterogeneous base hardware and software, and develop toolchain, realize decoupled and modularized H/S design, assure flexibility of H/S seletion and high efficiency and high quality of product development.

2. ICV Base Terminal Platform

Provide uniform interfaces for in-vehicle and external communications and HMI of ICV, simplify complexity between various modules of AD vechicles, integrate functions of modules inclduding multi-modal communications, routing gateway, multi-modal positioning and HMI, build a new generation of ICV-oriented onboard intelligent platform products.

3. ICV Base Cloud Control Platform

Provide dynamic base data including vehicle operation, infrastructure, transportation environment, and traffic control to intelligent vehicles and their users, control and service agencies, the platform has base service mechanism that covers data storage, data maintenance, big data analysis, cloud computing and cybersecurity, etc. it is a base support platform that meets practical application demands of ICV.

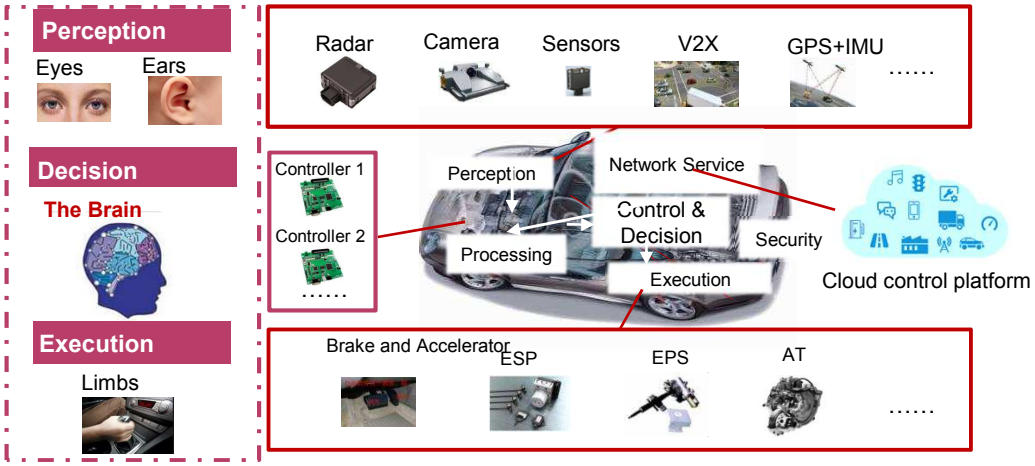
4. ICV Base HAD Map Platform

Formulate standards and norms of HAD map, research in common technologies of HAD dynamic base map generating and application, initiate SOP of HAD dynamic map base data, provide fundamental assurance for national geographic cybersecurity and ICV industry development.

5. ICV Base Cybersecurity Platform

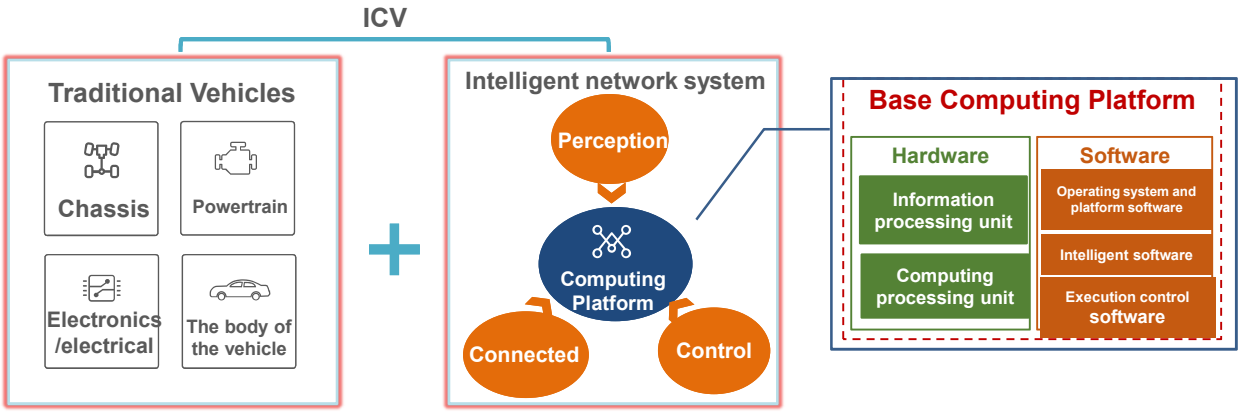
Build up terminal-to-terminal security protection and a 3-level in-depth protection system of "Clould-Tube-Terminal" for ICV in aspects of standard system, security framework, detecting technologies, monitoring technologies and supervision platform, etc.

ICV Base Computing Platform – the "Brain" of Vehicle in Future



The computing platform (software& hardware platform) perceives real-time external environment through high-performance computing technology and highly trusted software, and optimize control and decision for the vehicle, it is the core of autonomous driving technology, and the dominating position in the development of ICV.

Computing Platform is the Core of ICV

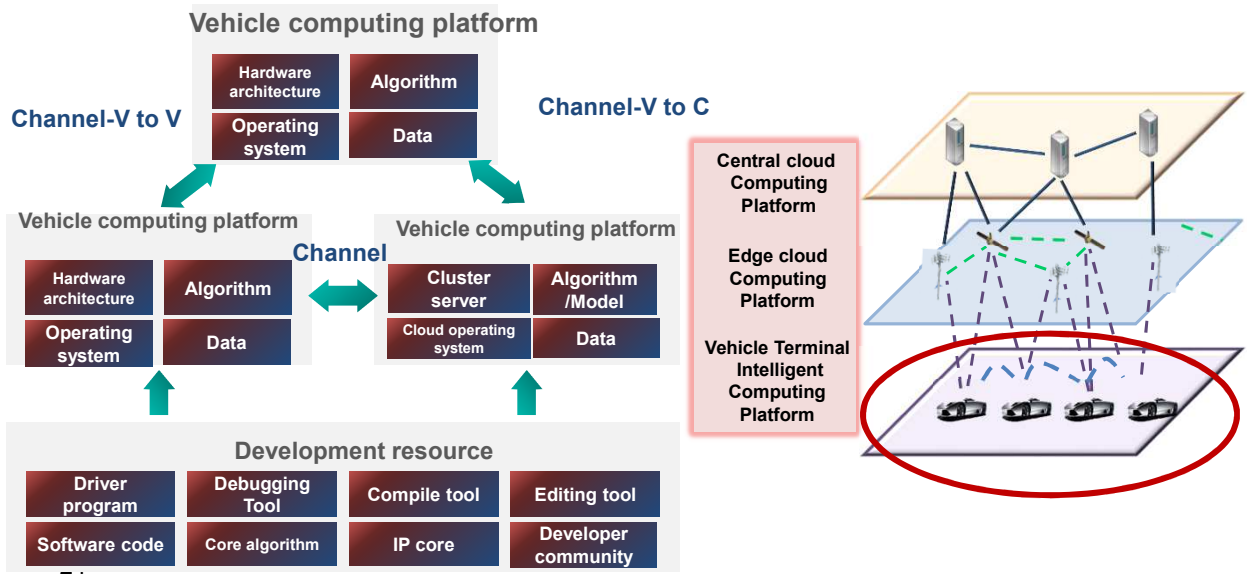


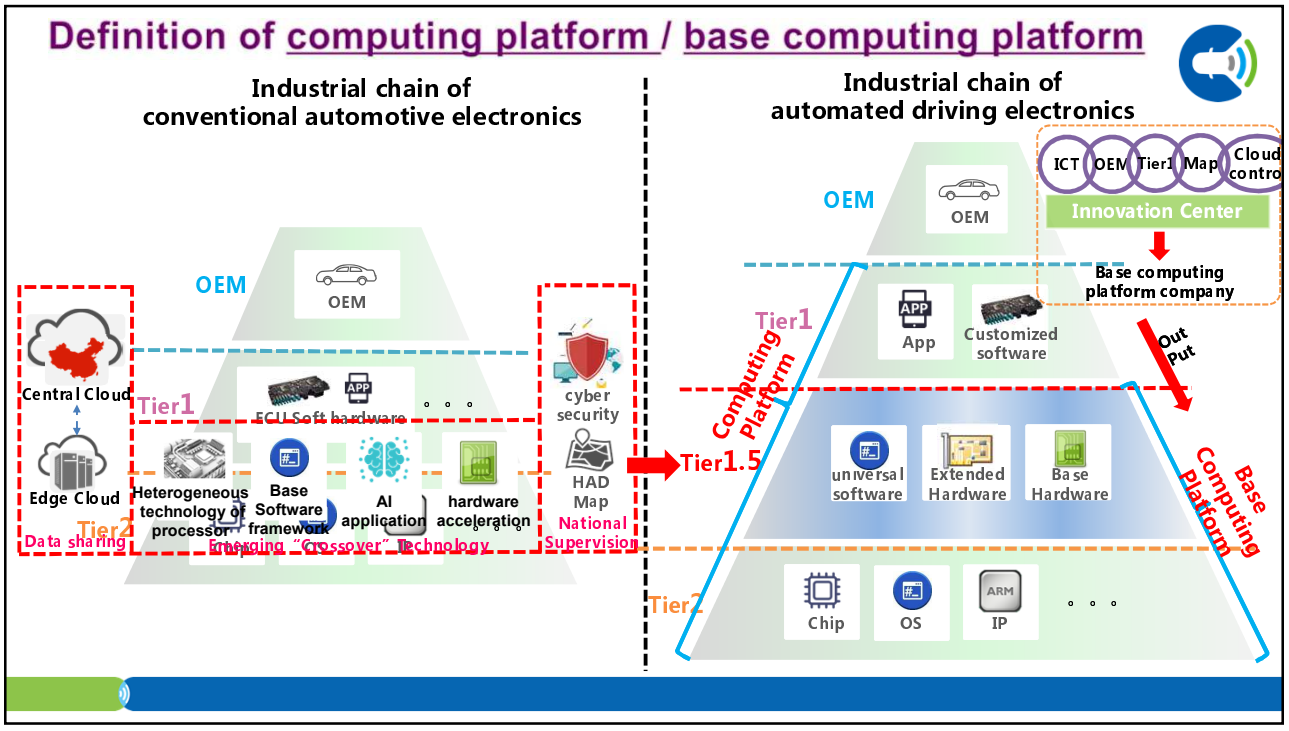
Accelerate the development of independent software and hardware computing platform

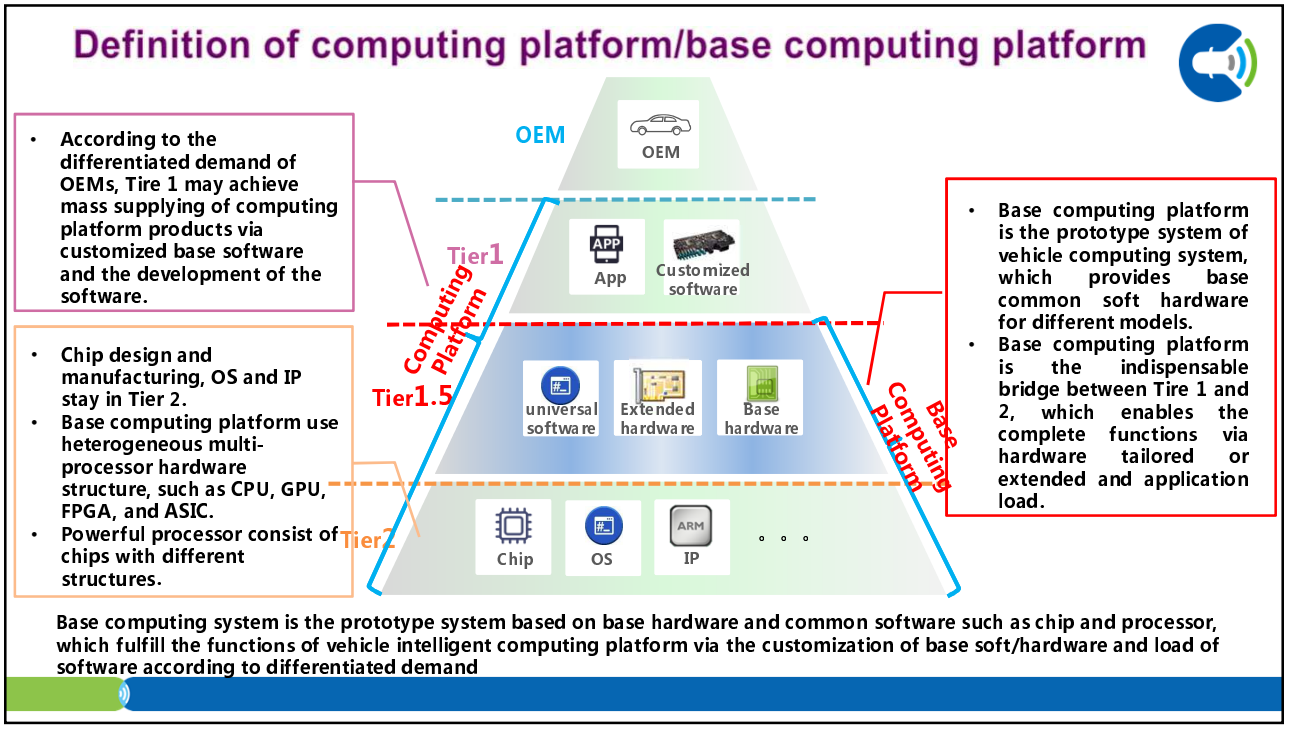
Seize the opportunity of ICV strategic development

Fill in the gap of intelligent computing network platform with China characteristics

ICV Vehicle Computing Platform Structure –"Terminal-Channel-Cloud"



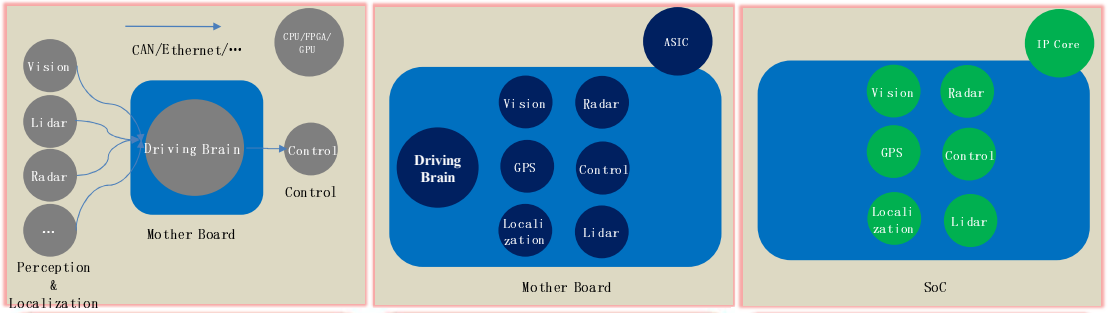

Definition of computing platform / base computing platform
Industrial chain of conventional automotive electronics
Industrial chain of automated driving electronics
OEM
OEM
Central Cloud
Edge Cloud
Tier1
Tier2
ECU Soft hardware
Heterogeneous technology of processor
Base Software framework
AI application
hardware acceleration
Data sharing
Emerging "Crossover" Technology
cyber security
HAD Map
National Supervision
Tier1.5
Computing Platform
Base Computing Platform
ICT
OEM
Tier1
Map
Cloud contro
Innovation Center
Base computing platform company
App
Customized software
Out Put
universal software
Extended Hardware
Base Hardware
Chip
OS
IP
ARM


Definition of computing platform/base computing platform
According to the differentiated demand of OEMs, Tire 1 may achieve mass supplying of computing platform products via customized base software and the development of the software.
Chip design and manufacturing, OS and IP stay in Tier 2.
Base computing platform use heterogeneous multi-processor hardware structure, such as CPU, GPU, FPGA, and ASIC.
Powerful processor consist of chips with different structures.
OEM
OEM
Tier1
Computing Platform
Tier1.5
Base Computing Platform
Tier2
App
Customized software
universal software
Extended hardware
Base hardware
Chip
OS
IP
ARM
Base computing platform is the prototype system of vehicle computing system, which provides base common soft hardware for different models.
Base computing platform is the indispensable bridge between Tire 1 and 2, which enables the complete functions via hardware tailored or extended and application load.
Base computing system is the prototype system based on base hardware and common software such as chip and processor, which fulfill the functions of vehicle intelligent computing platform via the customization of base soft/hardware and load of software according to differentiated demand

Hardware Implementation for Vehicle Base Computing Platform

Incremental integration by sustainable improvement, mid-term targets PCB-level integration, long-term chip-level integration

Function Integration → **PCB-level Integration** → **Chip-level Integration**

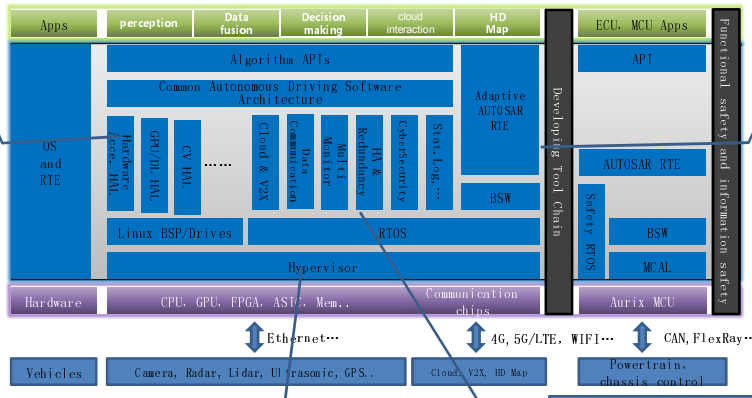


Function integration is a sufficient support for building of H/S architecture and collaborated algorithm test, etc. but It is not the final proposal for reasons of costs and power consumption

PCB-level integration is an interim proposal that adopts imported main chips, it is not fully autonomous and not controllable

Advance deployment of chip-level integration and occupy strategic dominating points of ICV computing platform

Software Architecture for ICV Vehicle Base Computing Platform



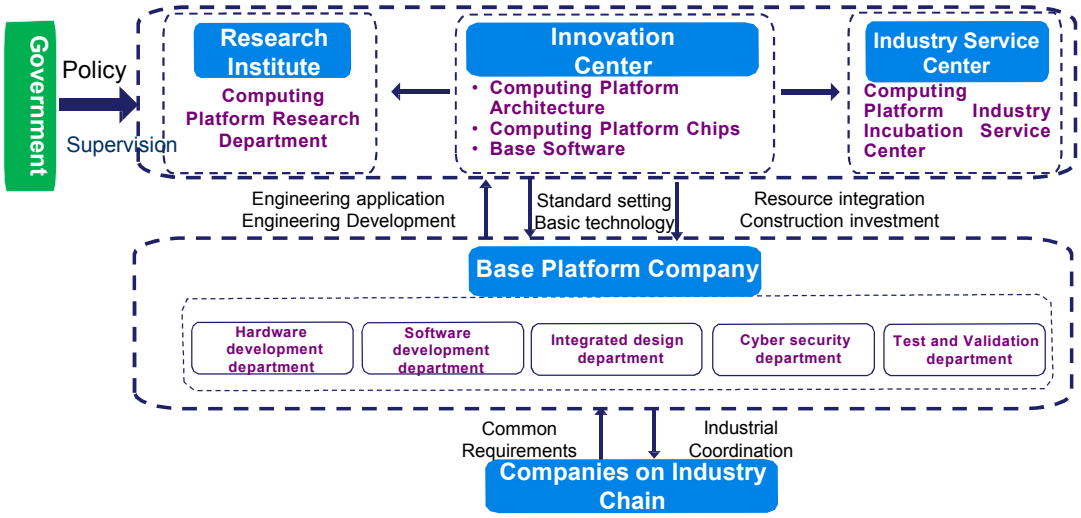
Support **basic algorithm middleware cluster** which includes algorithm API, acceleration of GPU, DL and machine vision algorithm

High performance computation adopts high-efficiency and real time architecture (such as **Adaptive AutoSAR)**, real time control supports **Classic AutoSAR** standards, and abstract and standardize **base software cluster**

With **virtualization technology** (hypervisor), support the combination of hetereogeneous multi-core processers and multi operation system, decouple and isolate impact from multi-source hetereogeneous software on system

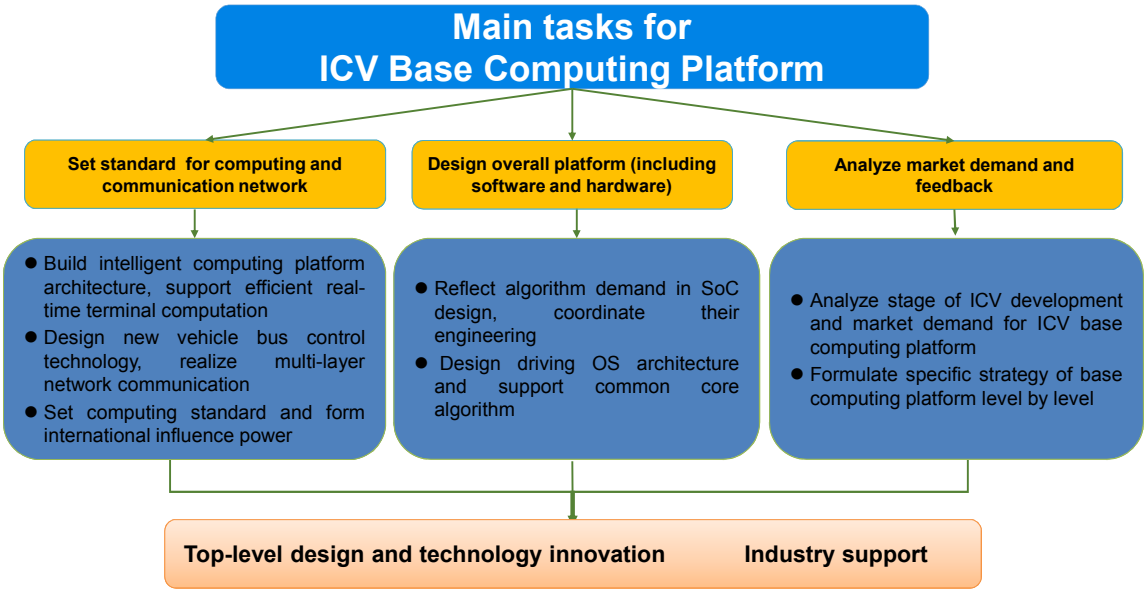
Design realtime driving OS with general system framework, including **high functional safety、cybersecurity、V2X and highly efficient communications and performance**, etc. meet the **requirement of function safety levels**

Supports from ICV Innovation Center



Establish an industrial ecosphere in which innovation center provides the coordination and support, platform company develops base products, companies on industry chain roll out and promote application.

ICV Base Computing Platform-Main Tasks



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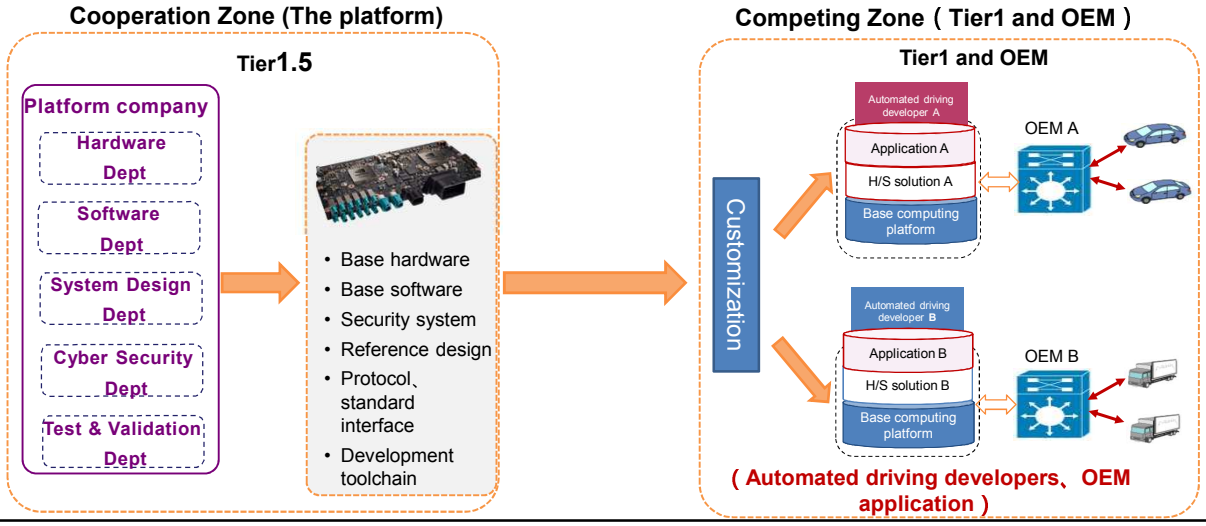
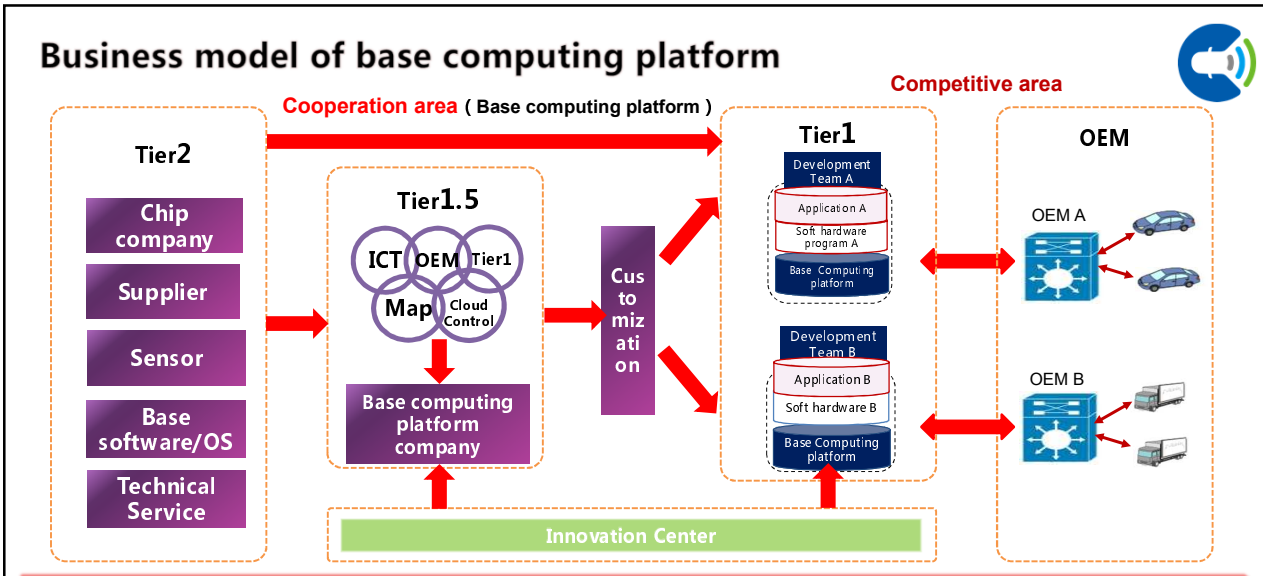
Business Model of China ICV Base Computing Platform

Based on technology and base layer product by computing platform company, automatic driving providers and OEMs build their application products, and thus formulate China's own ecosystem of computing platform supply chain.

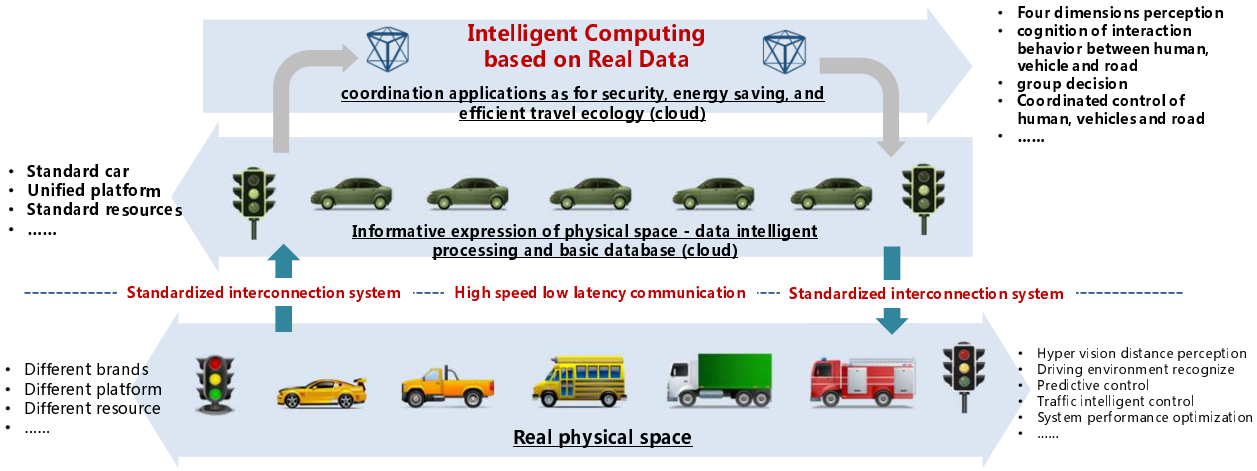


Business model of base computing platform



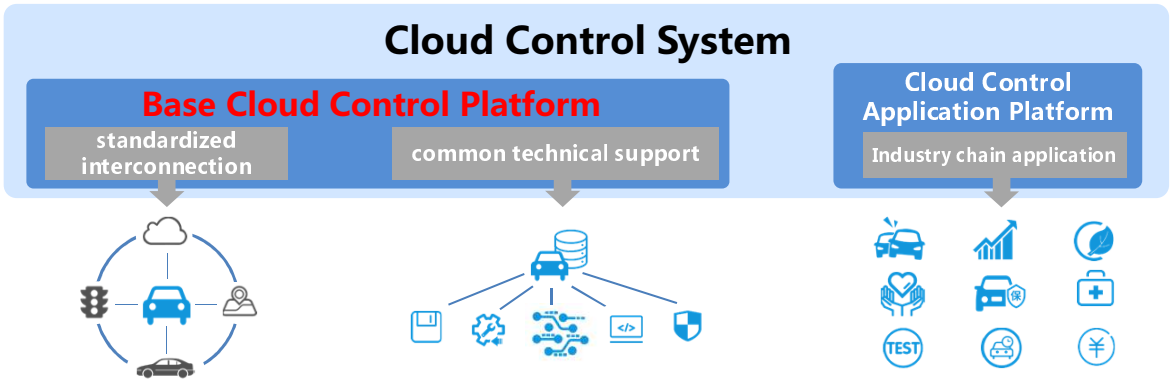
With the broad industrial resources of Tier 2, access to base technology of platform company, and the open third-party developing platform, suppliers of automated driving program, Tier 1, and OEMs could establish top-level application, demonstration, verification environment, so to develop Chinese eco-industrial chain of computing platform.

Cloud Control Platform System — Based on CPS Principle



using sensing, communication, computing, control and other technologies, realize the correspondence of vehicles, traffic, environment and other elements between physical space and information space based on standardized communication protocols, and using the big data computing of cloud ability to solve systemic resource optimization and configuration problems, promote on-demand response, rapid iteration, dynamic optimization of pedestrian-vehicle-road system, and finally achieve collaborative automated driving.

Definition of Base Cloud Control Platform

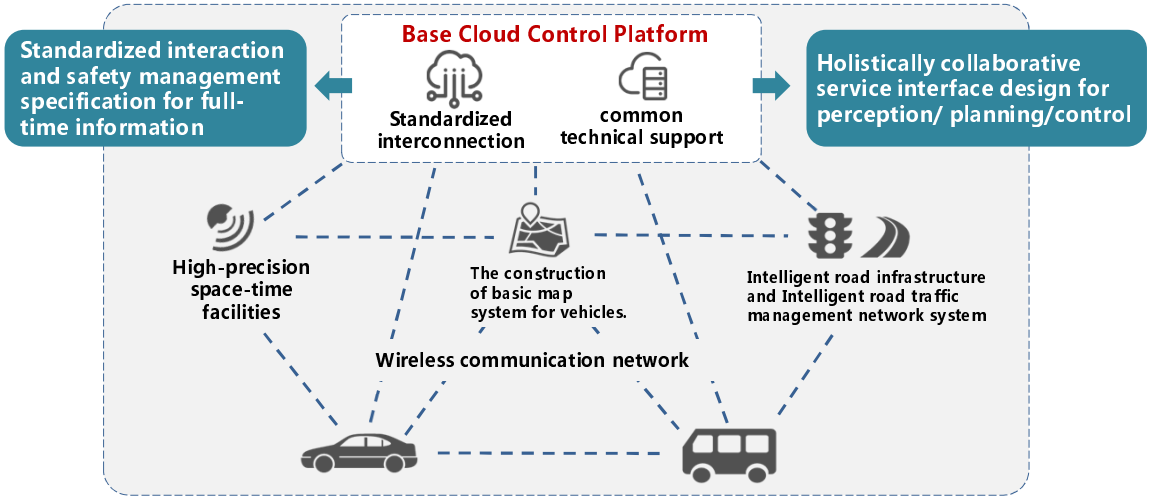


- Standardized communication protocol, reduce the difference in understanding when multi-domain collaboration is achieved.
- Design standardized infrastructure system deployment and segmentation implementation path for the practical application requirements of vehicle and various resources interconnection.

- Provide basic and common technical services for the specific application of ICV, including data security management, storage, operation and maintenance, big data calculation, simulation and test evaluation technology, etc.
- Provide a series of standardized development interfaces and toolsets to address business needs such as heterogeneous integration and interoperability

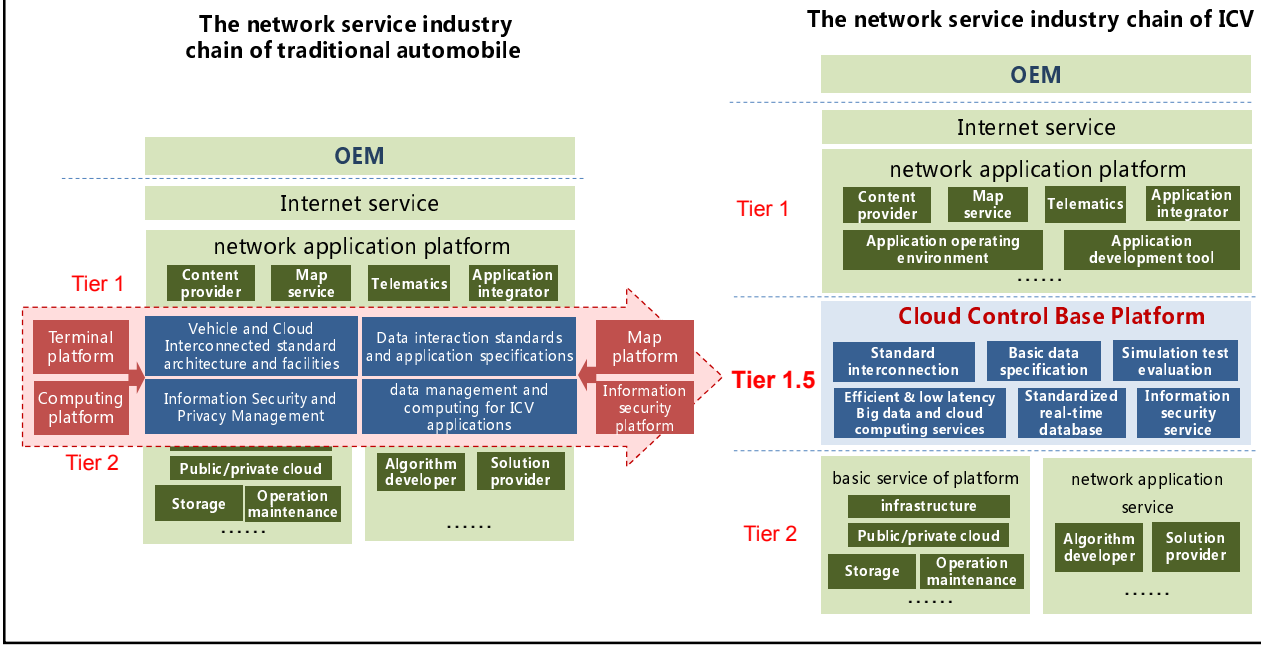
- Provides intelligent, efficient, energy-saving ICV driving applications, as well as a series of new automotive applications including shared cars and electronic payment.
- Provide collaborative business applications for test development systems, public service systems, insurance systems, and healthcare systems.

The Base Cloud Control Platform is the "Cloud Brain" for the operation of ICV



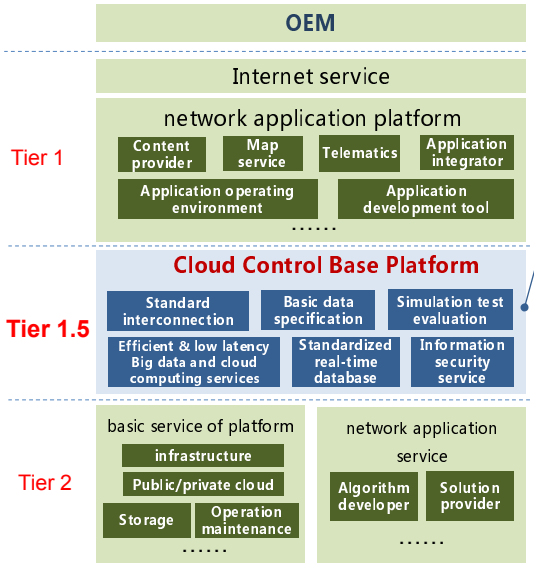
The Cloud Control Base Platform is a **data collaboration center, the computing center and resource optimization configuration center** that supports the practical application of ICV

Definition of cloud control platform/ base cloud control platform



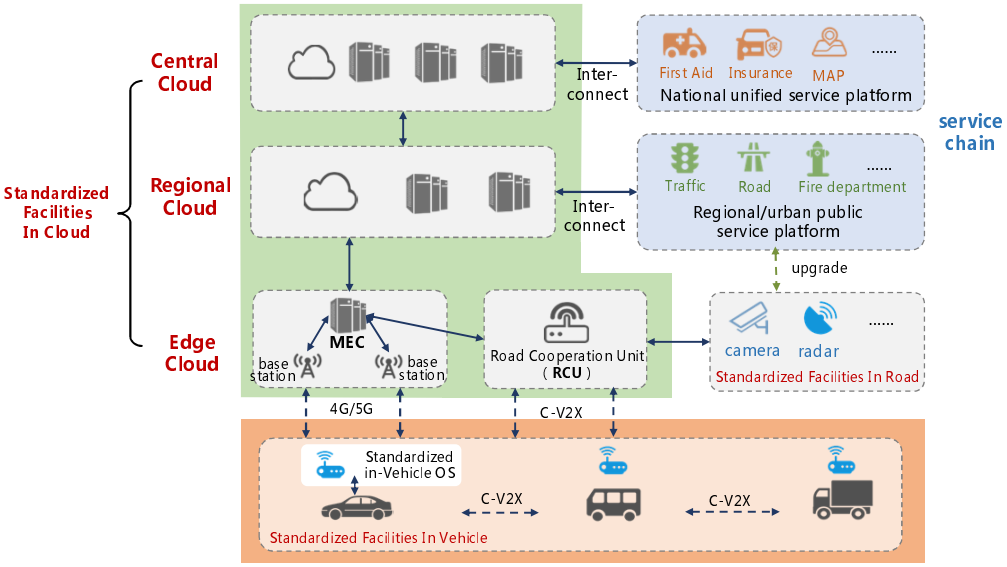
Definition of cloud control platform/ base cloud control platform

The network service industry chain of ICV

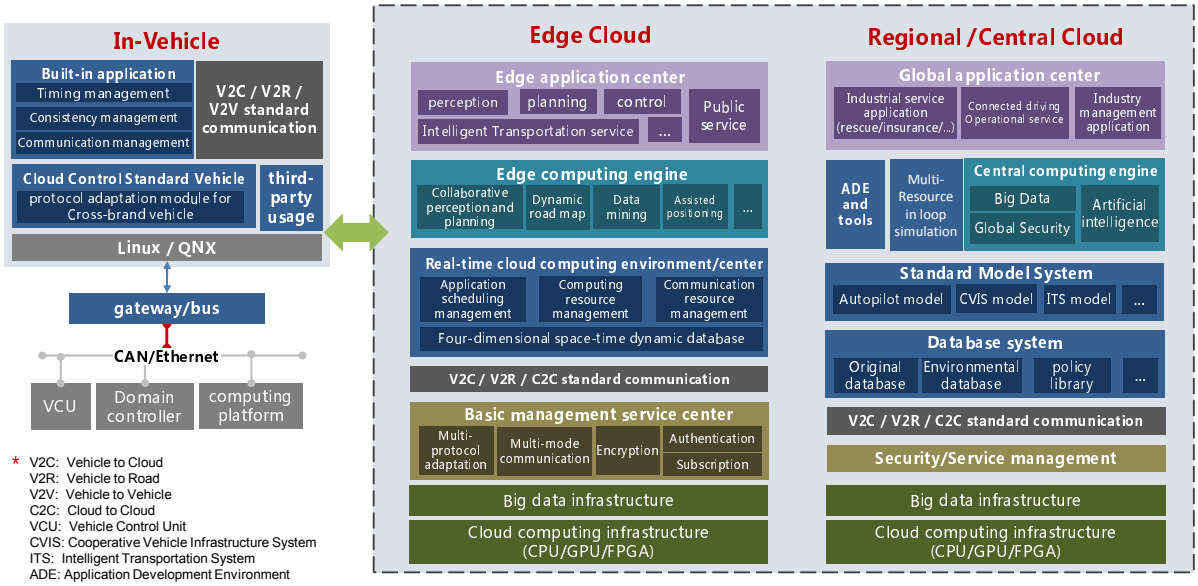


- The **Cloud Control Base Platform** is the basic support platform for all kinds of network connection application services of ICV. It provides **dynamic basic data** such as vehicle operation, infrastructure, traffic environment and traffic management for ICV and their users, management and service organizations. It has **basic service mechanisms** such as high-performance information sharing, high real-time cloud computing, big data analysis, information security and test evaluation.
- The **Cloud Control Base Platform** is an **indispensable chain** for the construction of the whole ICV industrial ecology. It is the **basic condition** for Tier1 and Tier2 to realize the upgradation of their service for the new demand of the industry of automatic driving, and to improve production efficiency and reduce service cost.
- Through resource collaboration and authorization, the **Cloud Control Base Platform** is the core supporting technology for collaborative autopilot and its application and operation.

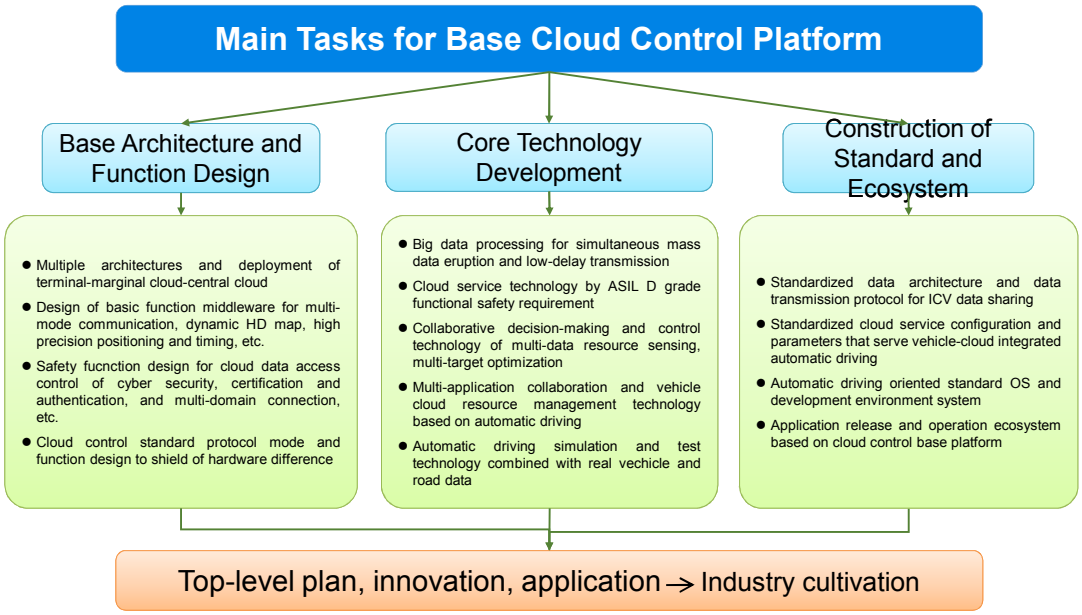
The Architecture of Base Cloud Control Platform



The functional architecture of Cloud Control Base Platform

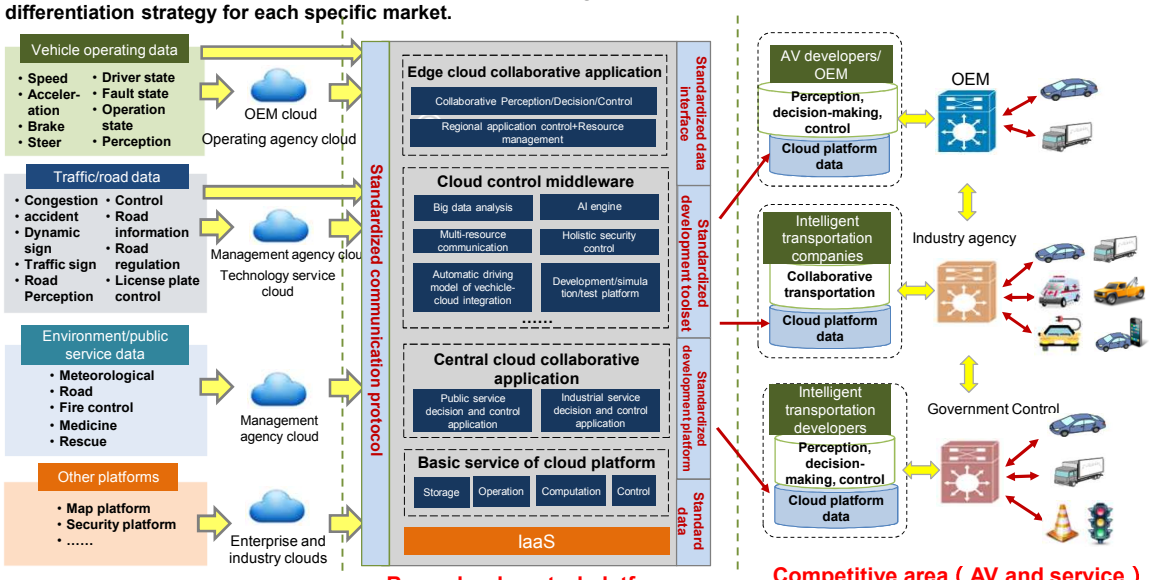


ICV Cloud Control Base Platform—Main Tasks



ICV Base Cloud Control Platform—Business Model

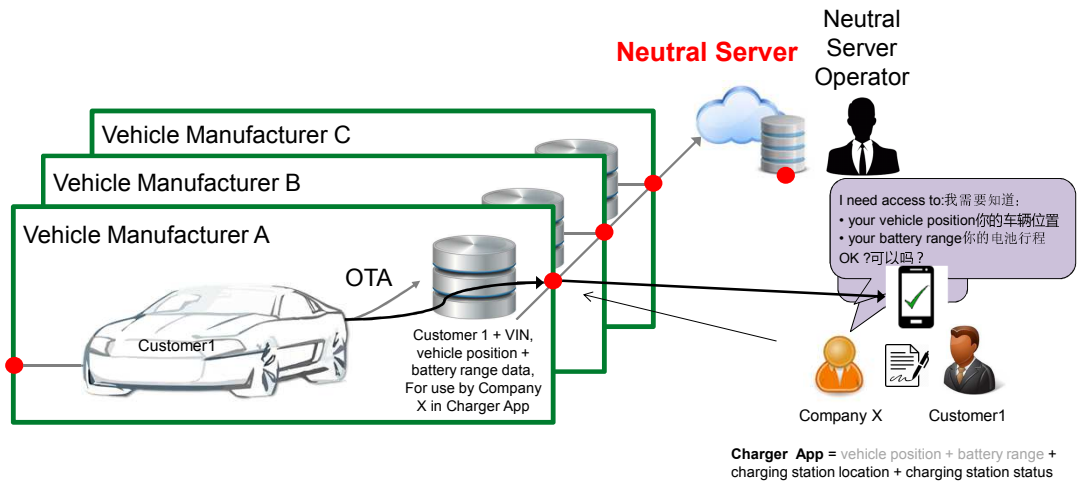
Base Cloud Control Platform provides multiple types of base data and network service support for ICVs and government supervision. With the data and service, AV developers, intelligent transportation companies and developers can adopt the differentiation strategy for each specific market.



The method of access to vehicle generated data

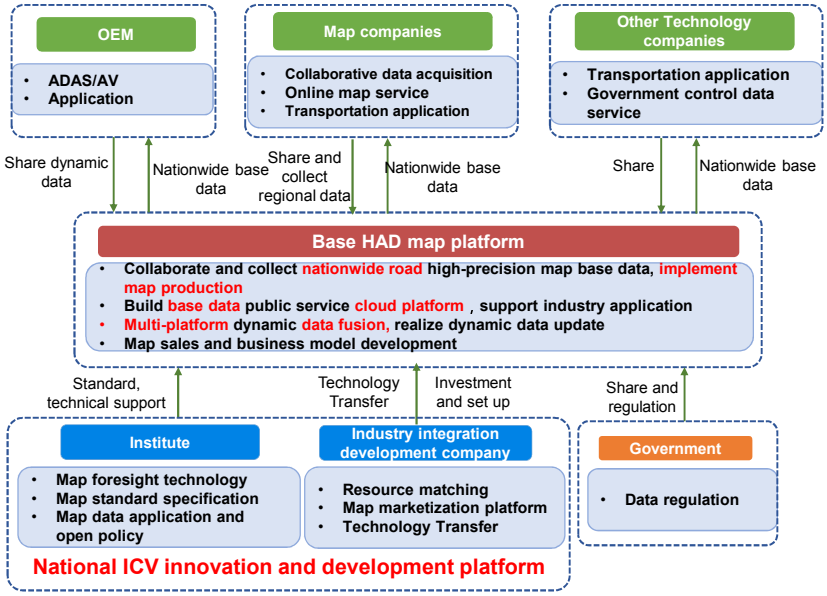
Role of the neutral server

VDA

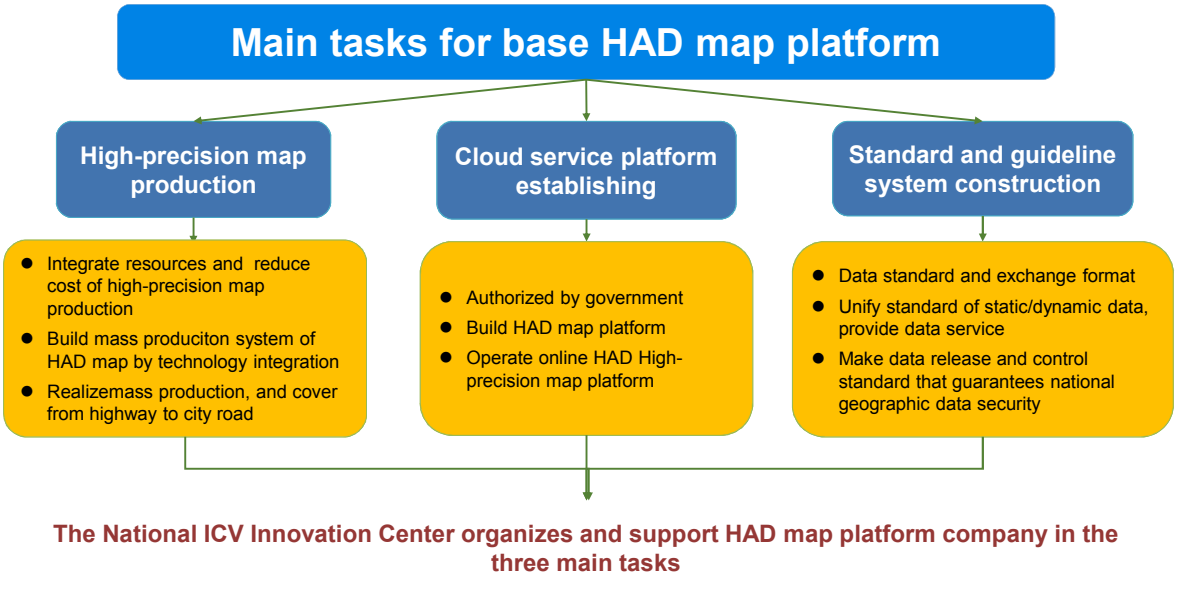


Charger App = vehicle position + battery range + charging station location + charging station status

Base HAD Map Platform—Industrialization



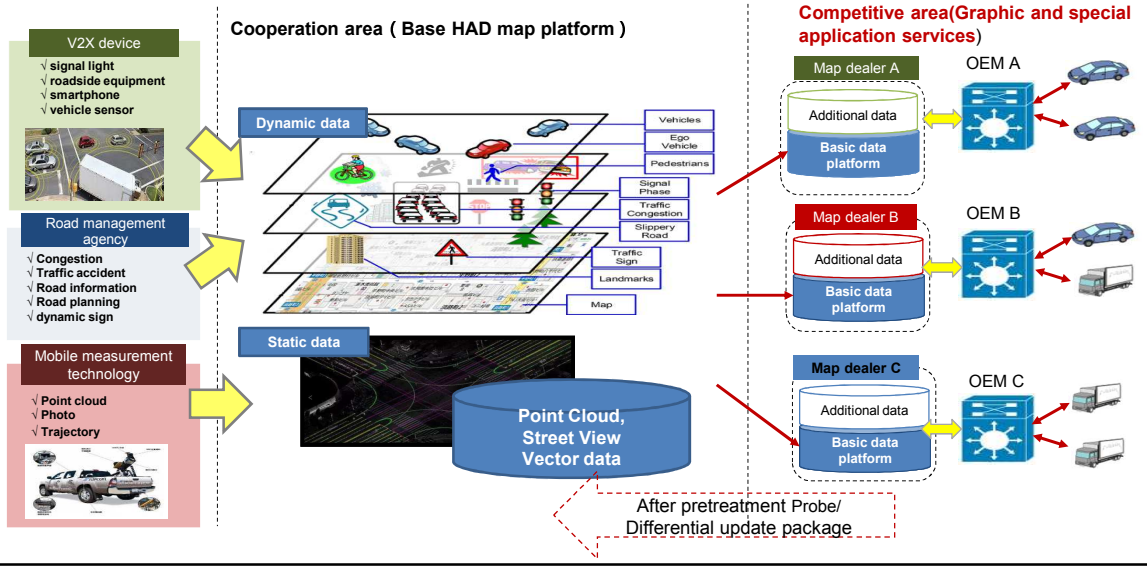
Base HAD map platform—Main Tasks



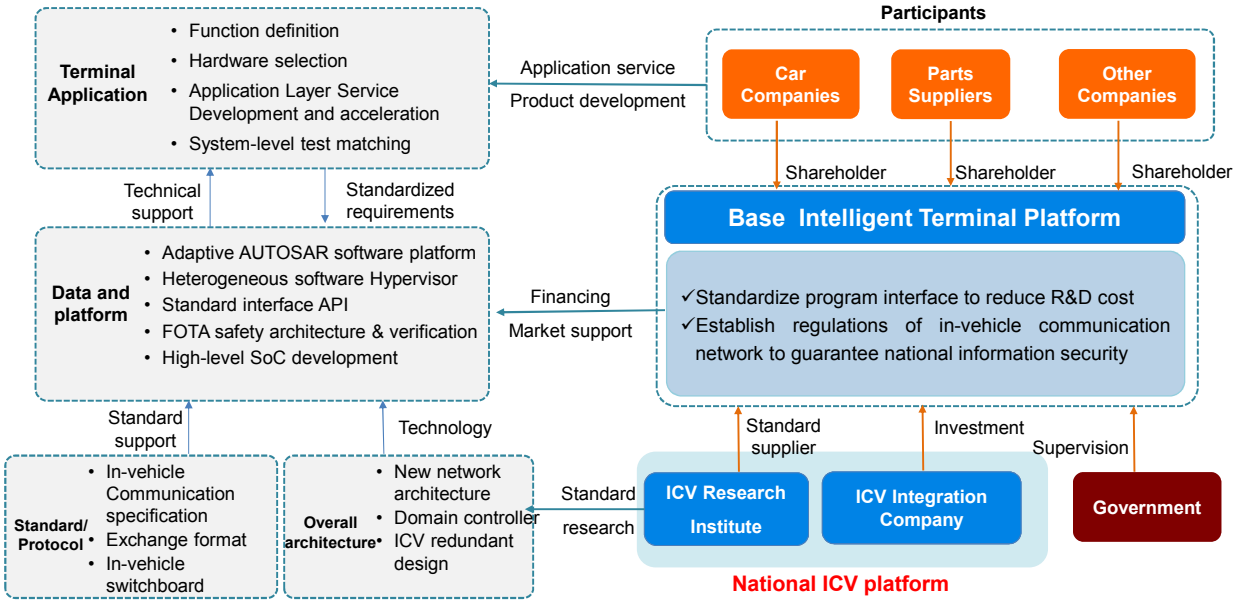
The National ICV Innovation Center organizes and support HAD map platform company in the three main tasks

Base HAD map platform—Business Model

Take autonomous driving as an example , map platform completes base data acquisition and releases , while various planners/OEMs keep upper-level operation and maintenance for the business.

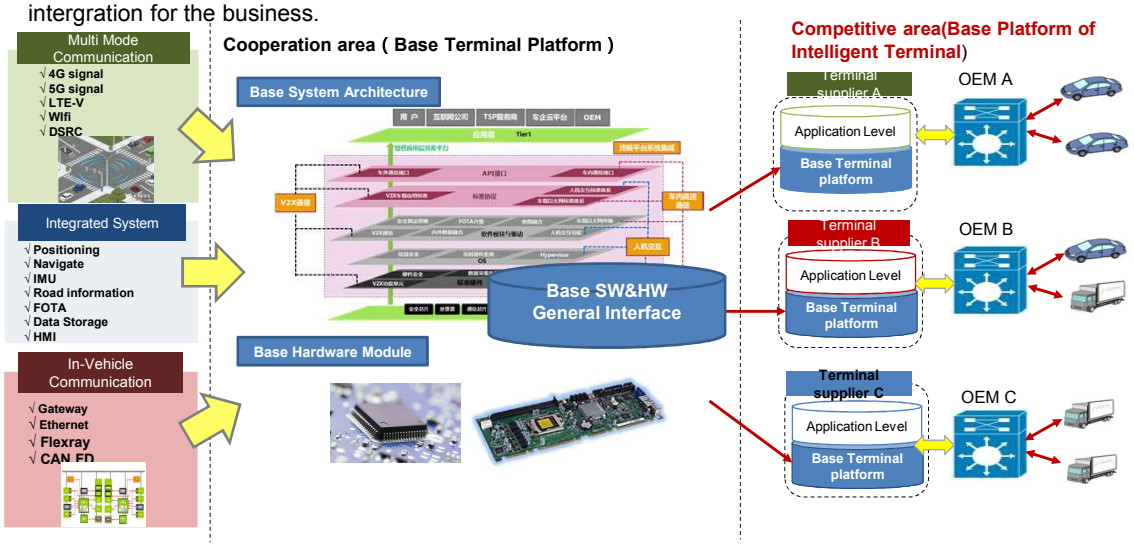


Base Intelligent Terminal Platform—Industrialization

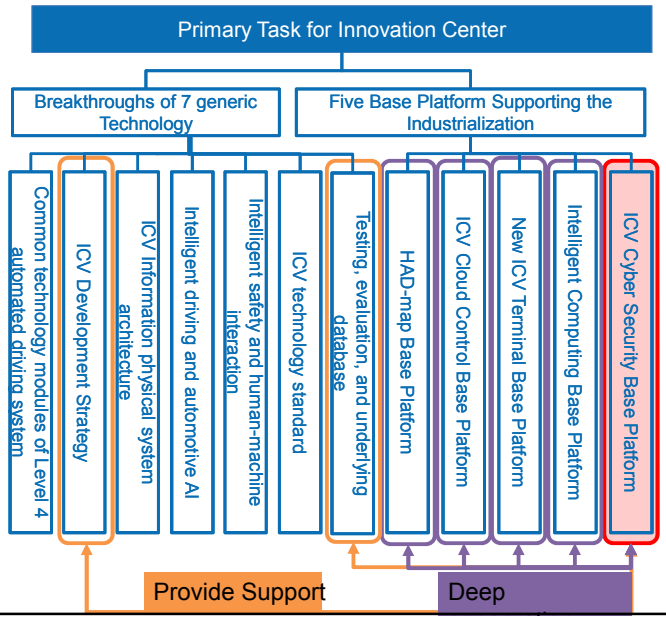


Base Intelligent Terminal Platform—Business Model

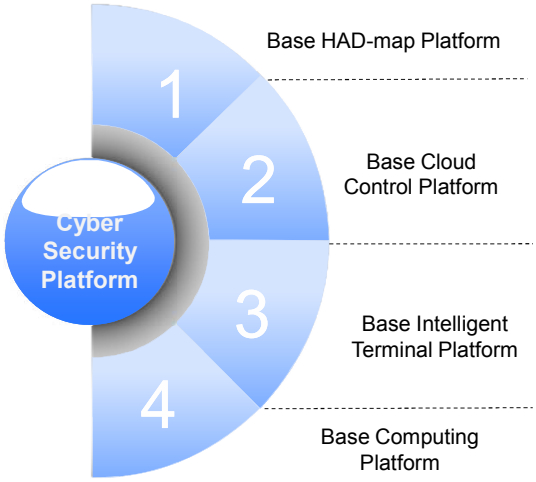
Base Intelligent terminal plateform completes base SW&HW and general interface(based on cyber security and functional safety design) , while various Tier1 suppliers/OEMs keep upper-level application and intergration for the business.



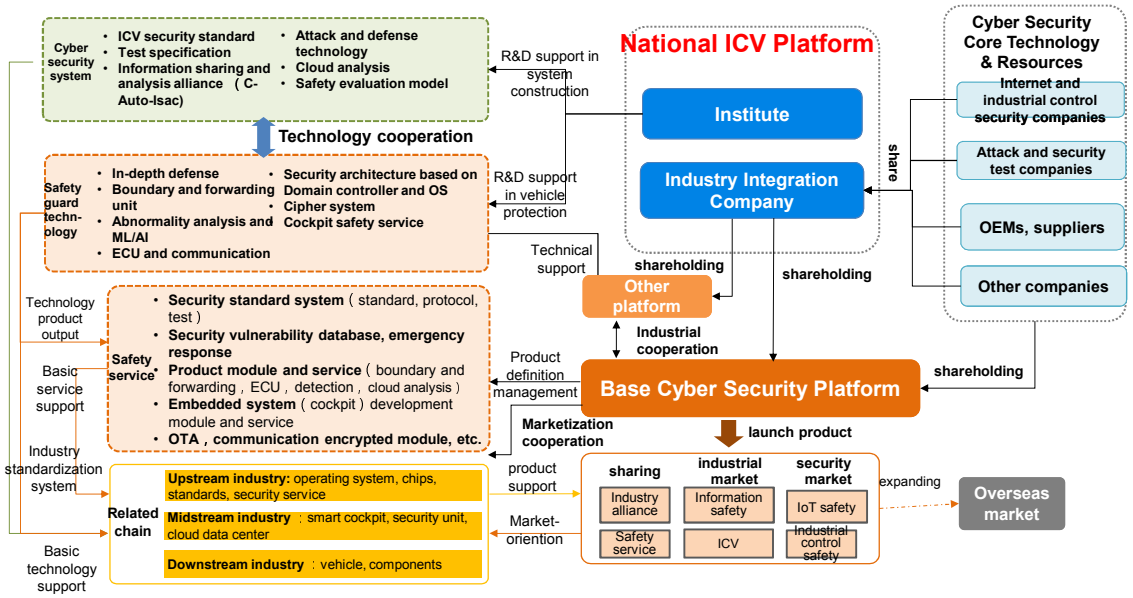
Industrialization of ICV Base Cyber Security Platform



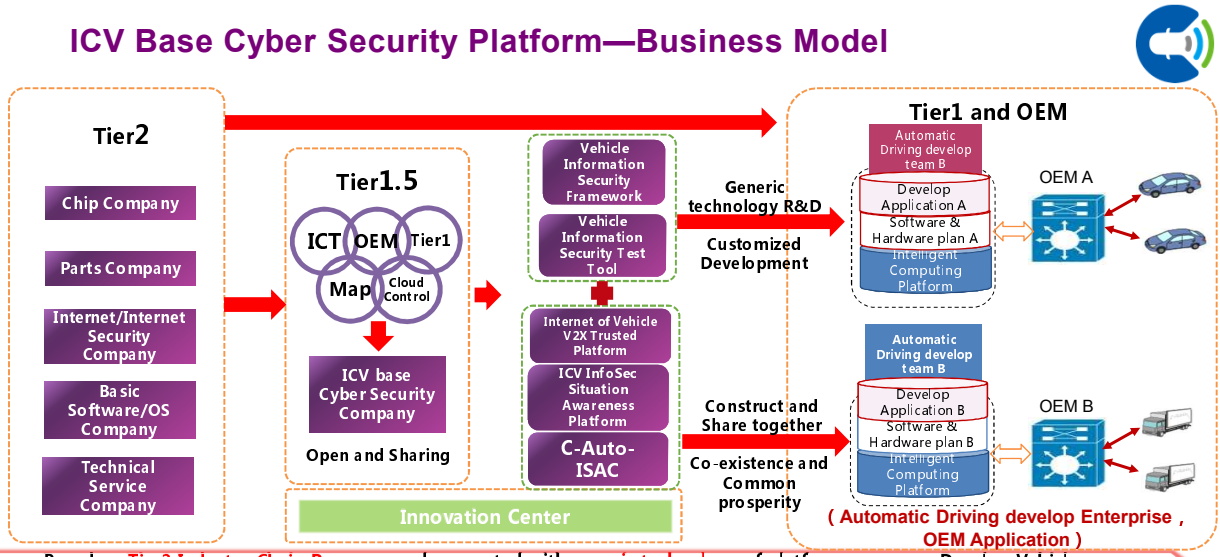
- Cooperate deeply with other platforms in the innovation center.
- Collaborate with 7+5, develop security service



ICV Base Cyber Security Platform—Industrialization

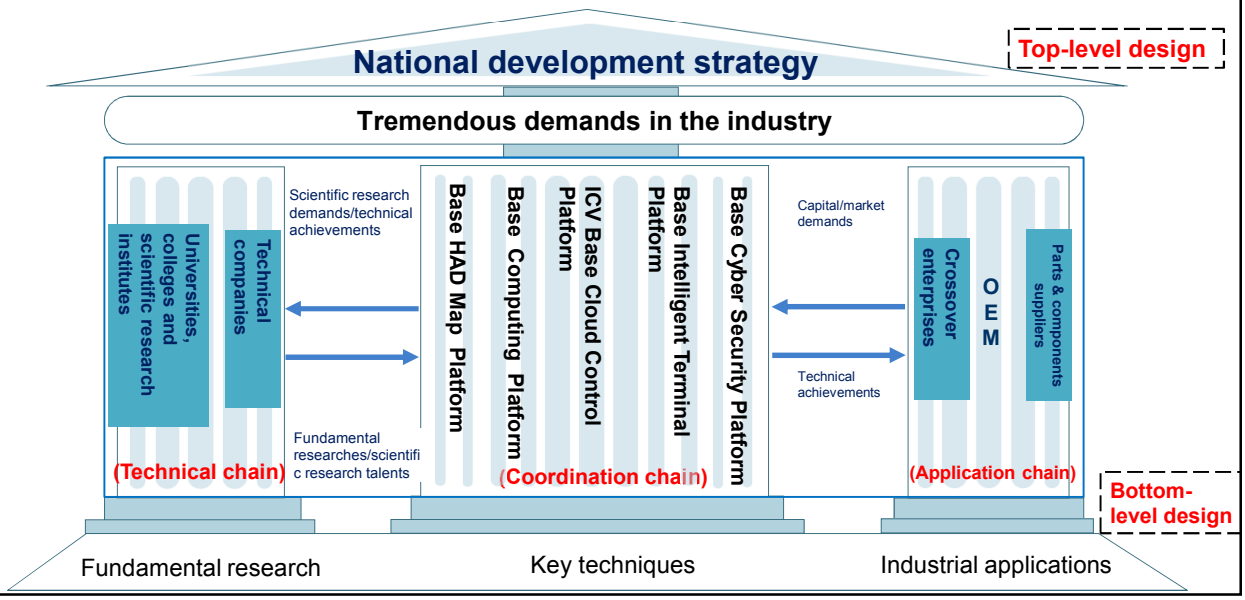


ICV Base Cyber Security Platform—Business Model



Based on Tier2 Industry Chain Resource and connected with generic technology of platform company; Develop Vehicle Information Security Framework and Test Tools; Construct and Share Security application security platform; Considering their requirements, Solution provider of Automatic Driving, Tier1 and OEM construct Vehicle Information Security Defense Framework, Assess Platform of Security Service that form the Eco-environment of China autonomic Vehicle Information Security Industry Chain

Synergies by Industrialization of the Five Base Platforms



The end

Thank you for your attention