

Confidential

Independent Market Research on China ICV Testing, Validation and Evaluation Solution Industry Overview

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Dec, 2024

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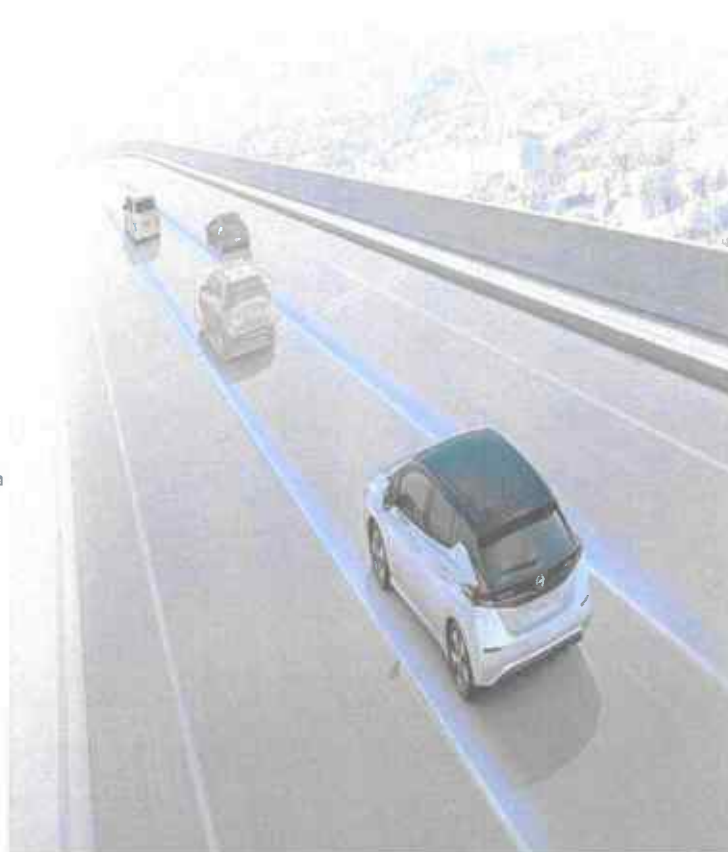
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31 December 2024

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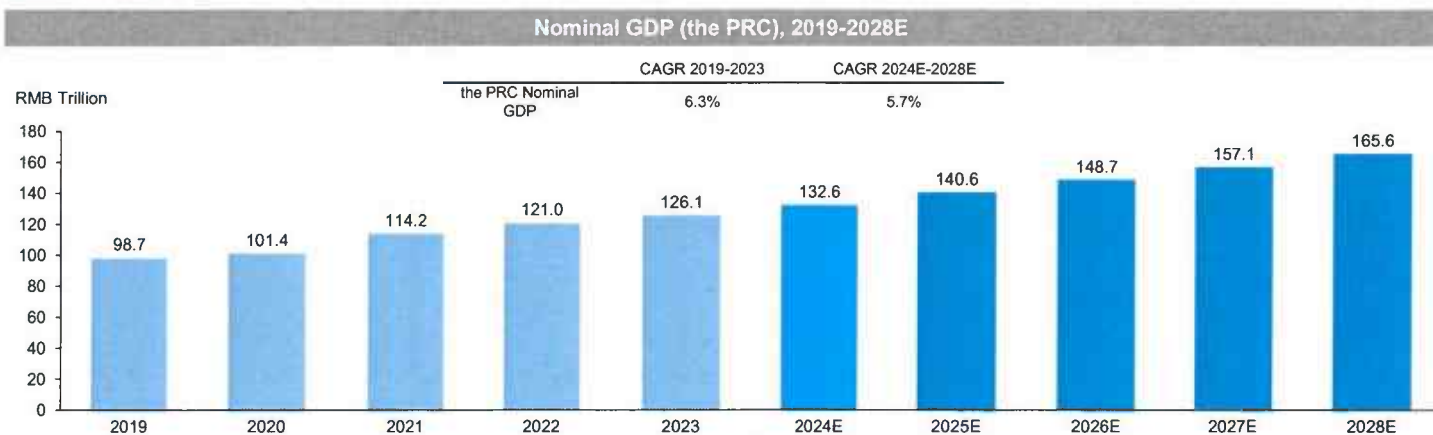
Agenda

- 1 The PRC Macro Market Overview
- 2 The PRC ICV Solution Industry Overview
- 3 The PRC ICV Testing, Validation and Evaluation Solution Industry Overview
- 4 Competitive Landscape
- 5 Appendices



The PRC Macro Economic Overview

Nominal GDP

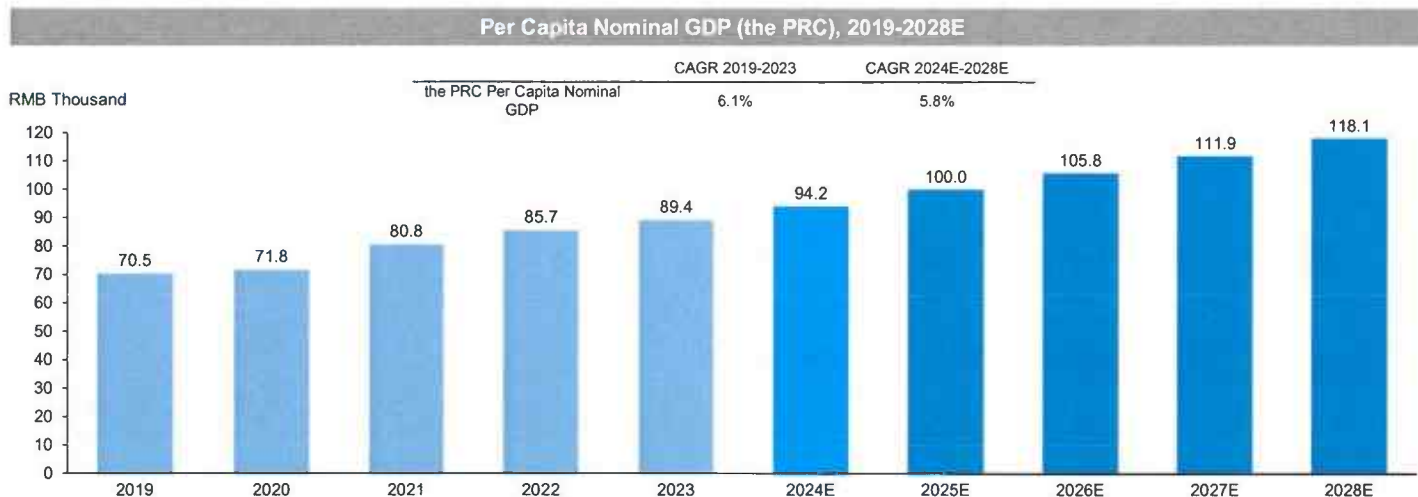


- Thanks to a series of economic stimulus policies adopted by the Chinese government, including the "Four Trillion Plan" ("四万亿计划") and the "Ten Industry Revitalization Plan" ("十大产业振兴规划"), the PRC's GDP has maintained a relatively rapid growth in the past few years. The nominal GDP increased from RMB98.7 trillion in 2019 to RMB126.1 trillion in 2023 at a CAGR of approximately 6.3%. The outbreak of COVID-19 in January 2020 has temporarily impacted the PRC's overall economy. However, with the great efforts made across the country, the PRC's economic growth has turned from negative to positive since the second quarter of 2020. Driven by a series of proactive fiscal and monetary policies by the government, the economy has gradually returned to normal, making it one of the few countries in the world to achieve positive economic growth in 2020. In the post-epidemic era, with gradual loosening of the pandemic restrictions, the PRC will further enhance its innovation capabilities, create a large domestic market, promote higher levels of reform and opening up, and achieve high-quality economic growth. From 2024 to 2028, the PRC nominal GDP is expected to maintain a CAGR of approximately 5.7%, reaching approximately RMB165.6 trillion by 2028.

Source: National Bureau of Statistics of the PRC, Frost & Sullivan

The PRC Macro Economic Overview

Per Capita Nominal GDP



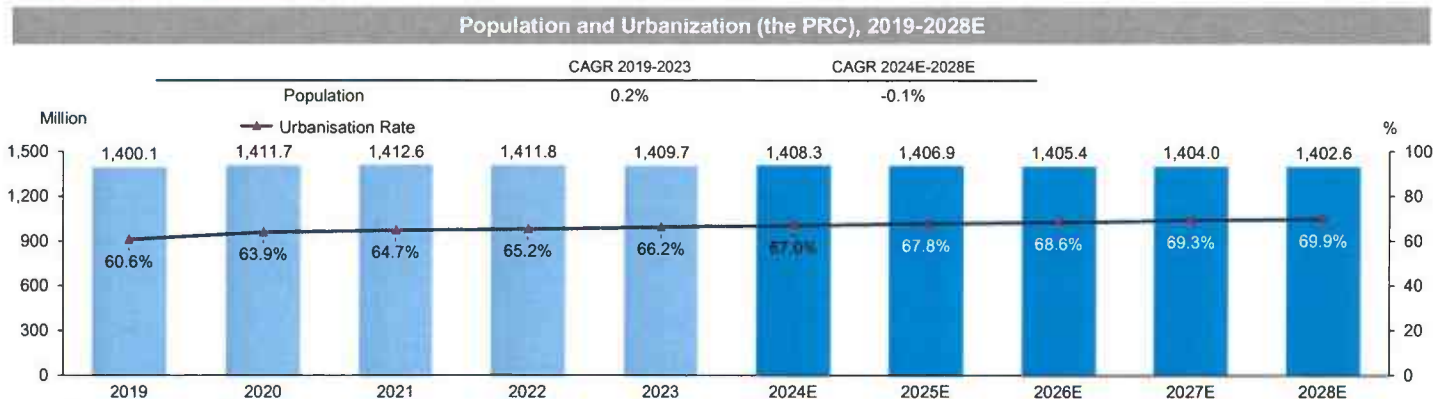
- In line with the PRC's overall economic growth, the PRC's per capita nominal GDP has maintained a rapid growth in the past few years, from RMB70.5 thousand in 2019 to approximately RMB89.4 thousand in 2023, representing a CAGR of approximately 6.1%. It took less than 20 years for a large country with a population of 1.4 billion to achieve a per capita GDP from USD1,000 in 2000 to USD10,000 in 2019, demonstrating the PRC's strong economic development momentum. The growth rate of the PRC's per capita nominal GDP in 2020 slowed down due to COVID-19. Looking forward, driven by factors such as technological innovation and consumption upgrading, the PRC's per capita GDP will maintain steady growth from 2024 to 2028, which is expected to reach RMB118.1 thousand by 2028, representing a CAGR of about 5.8%.

Source: National Bureau of Statistics of the PRC, Frost & Sullivan

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The PRC Macro Economic Overview

Population and Urbanisation



- the PRC has the world's largest population in the world. In 2022, the PRC's population shrank for the first time in recent 60 years. According to the National Bureau of Statistics of the PRC, the PRC's total population reached 1,411.8 million in 2022 and further decrease to 1,409.7 in 2023. It is expected that the PRC's population will keep a slightly decreasing tendency in line with the lowered birth rate. It is estimated that the total population will reach approximately 1,402.6 million by 2028, representing a five-year CAGR of -0.1% from 2024.
- With the in-depth development of new industrialization, informatization and agricultural modernization and the implementation of the policy of urbanization of the agricultural transfer population (农业转移人口市民化政策), the PRC's new urbanization (新型城镇化) process is progressing steadily, and the urbanization building has made historic achievements. The urbanization rate in the PRC increased from 60.6% in 2019 and reached 66.2% in 2023. With the continuous growth of urbanization, the urban population of the PRC is expected to grow further. Under the "National Plan for Promoting Healthy Urbanization" (全国促进城镇化健康发展规划) raised in 2013, new urbanization is expected to promote the urban-rural coordination and reasonable distribution. Accordingly, the urbanization rate is likely to increase gradually from 2024 to 2028, reaching 69.9% by 2028.

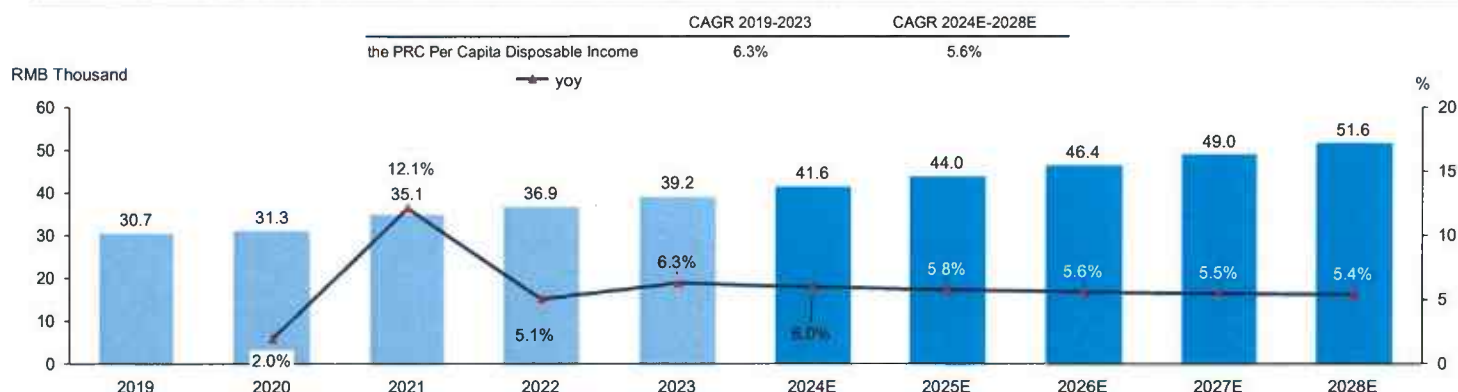
Source: National Bureau of Statistics of the PRC, Frost & Sullivan

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The PRC Macro Economic Overview

Per Capita Disposable Income

Per Capita Disposable Income (the PRC), 2019-2028E



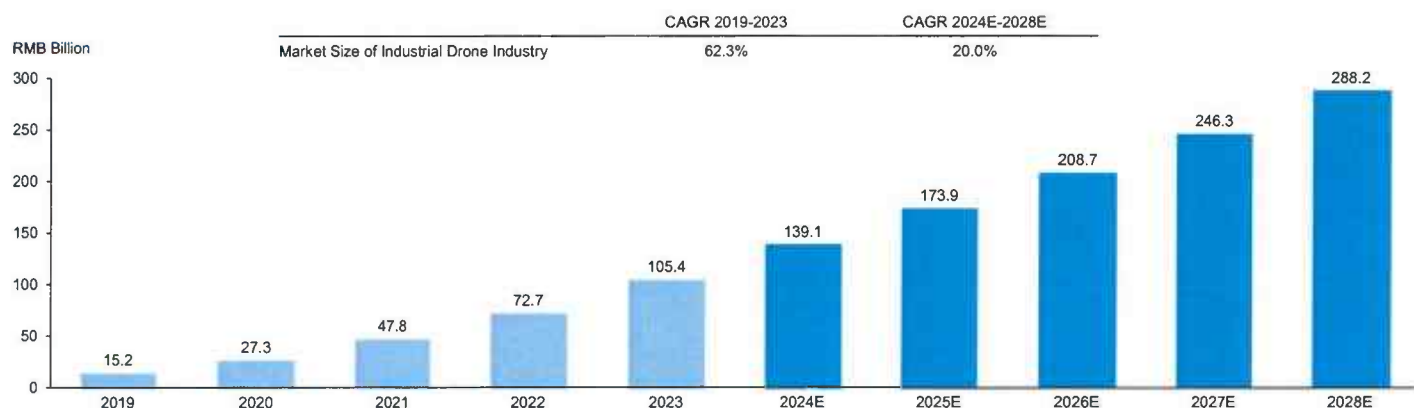
- With the overall increasing trend of per capita disposable income over the past five years, the eastern region constitutes the largest proportion, led by the rapid development of Shanghai, Beijing, Guangdong Province and Zhejiang Province, especially thanks to the high-quality development of Guangdong-Hong Kong-Macao Greater Bay Area. People living in the central region spend only less than those in the eastern region, accounting for the second largest proportion of the per capita consumption expenditure. Due to the strategic positioning of "One Center, Four Regions (一中心、四区)" of the central region brought by the State Council, the central region owns a unique geographical advantage, which is expected to lead to a take-off in per capita income. It is projected per capita disposable income of residents of the PRC reach RMB51.6 thousand in 2028, representing a CAGR of 5.6% over the next five years.

Source: National Bureau of Statistics of the PRC, Frost & Sullivan

The PRC Macro Economic Overview

Market Size of Industrial Drone Industry

Market Size of Industrial Drone Industry in terms of Sales Value (the PRC), 2019-2028E

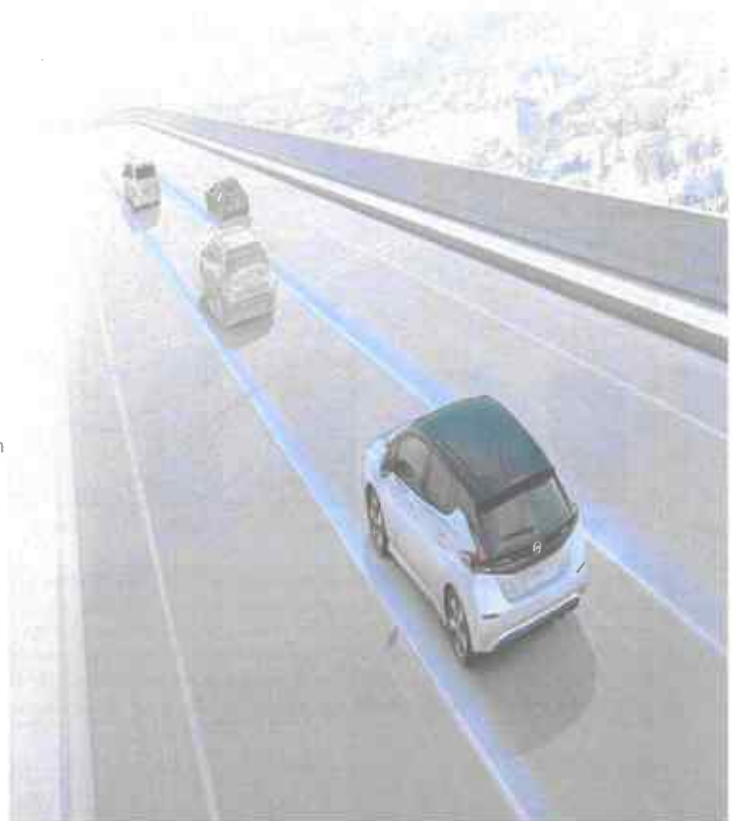


- Drones have long been used in military fields. Since the 1980s, drones have been gradually applied in civilian fields. Industrial drones are mainly used in surveying and mapping geographic information, inspection, security monitoring, agriculture, forestry and plant protection and other fields. The market size of industrial drone industry in the PRC has increased from RMB15.2 billion in 2019 to approximately RMB105.4 billion in 2023 in term of sales value, representing a CAGR of about 62.3%. As an efficient and convenient auxiliary tool, industrial drones replace the original software to serve the daily work of all walks of life. They have the advantages of low cost, high efficiency and good maneuverability, which reduce the risk of manual operation and improve the safety. In the future, 5G, cloud computing, big data and artificial intelligence will empower drones industry, and industrial drones will be used in more business scenarios. From 2024 to 2028, the market size of industrial drone industry in the PRC is expected to maintain a CAGR of approximately 20.0%, reaching approximately RMB288.2 billion in terms of sales value by 2028.

Source: Frost & Sullivan

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The PRC ICV Industry Overview

Definition of Intelligent Connected Vehicle



Intelligent Connected Vehicle

- Intelligent connected vehicle (ICV) refers to a new generation of vehicles that are equipped with advanced on-board sensors, controllers, actuators and other devices, and integrating advanced communication and network technologies to realise (i) the exchange and sharing of information between vehicles and different factors such as people, vehicles, roads and cloud (V2X); (ii) awareness of complex surroundings and intelligent decision making, collaborative control and other functions; (iii) "safe, efficient, comfortable, energy-saving" driving; and (iv) driving operations without human beings ultimately. Nowadays, ICVs and the intelligent driving technology are closely related. In the PRC market, ICVs are generally equipped with ADAS(L1+L2) intelligent driving technology.
- The Safety Of The Intended Functionality (SOTIF) appears under the background of the development of autonomous driving technology, and it is the demand of autonomous driving technology above L2. The absence of unreasonable risk due to hazards resulting from functional insufficiencies of the intended functionality or by reasonably foreseeable misuse by persons is referred to as the Safety Of The Intended Functionality (SOTIF). The main contents of The Safety Of The Intended Functionality are similar to functional safety standards. The functional safety standard comes from IEC61508. Its main contents include: hazard identification and assessment, functional safety concept, system safety concept, software and hardware safety concept, verification and confirmation, production, operation and maintenance scrapping.
- Functional Safety(FuSa) is mainly aimed at automotive electronics and design functions, so as to avoid dangerous situations when the normal functions of the vehicles fail. SOTIF is mainly aimed at the autonomous driving to avoid dangerous scenarios caused by misuse of the functions. The complexity of automotive electrical/electronic architecture and the diversity of application make it impossible to completely avoid the occurrence of systematic failures and random hardware failures, which are being considered with the scope of Functional Safety. But for autonomous driving systems, it is far from enough to reduce risks caused by such failures. SOTIF, as a supplement to Functional Safety, can avoid the safety risks of vehicles caused by expected insufficient functions or personnel mis operation, which is of great significance to the upgrading and development of autonomous driving technology.
- Like traditional road vehicles, ICVs also need adequate and comprehensive simulation and/or physical testing to make sure they are safe and reliable, and thus suitable for commercialization and mass production. Moreover, ICVs should also meet the relevant FuSa and SOTIF standards which form the essential safety requirements for ICVs. As such, it is essential for ICV testing, validation and evaluation software to (i) be able to perform FuSa analysis to facilitate the FuSa certification of the ICV products, and (ii) be able to conduct SOTIF analysis to help ICVs developers minimize unpredictable risks of ICVs at their design stage.
- ICV solution refers to a comprehensive spectrum of products and services that facilitate efficient human-vehicle interaction, user-friendly cockpit experience, high-speed and stable data processing and transmission with in-vehicle and external connecting elements as well as intelligent driver assistance to automobiles to improve the electrification, connectivity and intelligence of vehicles for better travel experience by integrating advanced technologies such cloud computing, big data, AI and other cutting-edge technologies as well as comprehensive hardware-software capabilities. It generally includes (i) intelligent cockpit solution, (ii) vehicle-road collaborative system, (iii) autonomous driving solution provided for the specific needs of automotive manufacturers and other vehicle industry stakeholders.



Intelligent Cockpit Solution

- Intelligent cockpit solution enables In-Vehicle Infotainment (IVI) system, which covers in-vehicle infotainment, full-LCD dashboard system, HUD, streaming media rearview mirror domain control units and DMS&OMS, and provides immersive digital automotive experience for drivers and passengers. It consists of hardware and software parts covering all major components of the intelligent cockpit, including operating system software, hypervisors, chips, domain control units (DCU), human-machine interfaces (HMI), etc., and relevant services such as cloud-based services.



Intelligent Driving Solution

- Intelligent driving solution refers to the comprehensive solution including ADAS(L1+L2) and autonomous driving (L3-L5) technologies assisting the human operator's control of the vehicle and achieving unmanned automatic driving ultimately, formed by radar sensors (millimetre wave radar, ultrasonic radar, laser radar), domain control units and cameras (front camera and surround view camera).



Vehicle-Road Collaborative System

- Vehicle-road collaborative system primarily refers to the products and services that root on 4G-V2X and 5G-V2X to form the dynamic communication network to achieve the exchange and sharing of real-time safety, trip planning, navigation information between people, vehicles, roads and cloud, so as to realise the vehicle intelligent control, intelligent traffic management control, and the intelligent dynamic information service, thus enabling automakers to deliver a more connected, enjoyable and safer driving experience

Source: Frost & Sullivan

The PRC ICV Industry Overview

Development History

- Europe and the United States launched a number of Internet of Vehicles projects to promote the development of the ICV industry. the PRC was still in the era of traditional automobile.
- The concept of intelligent cockpit was hatched from the vehicle infotainment system (the predecessor of IVI), which can be traced back to the vehicle radio in 1924.

- In 2006, the United States opened GPS for civilian use, and the navigation function based on touch screen display became a strong driving force to promote the intelligent cockpit technology.
- In 2007, six European automobile manufacturers (including BMW, etc.) set up vehicle to vehicle communication alliance to actively promote the establishment of European communication system standards and realize mutual communication between different manufacturers.
- In 2009, Japan's VICS system's loading rate reached 90%. Vehicle multimedia system, vehicle information system, vehicle IT management became hot spots.

- The development of the PRC's AI, 5G and big data analysis technology makes the ICV more practical, such as enterprise management and intelligent logistics. In addition, technologies such as ADAS can interact with external information and promote the development of the ICV industry. Traditional Internet giants, such as Baidu, Alibaba, Tencent and Huawei, began to enter the industry competition, and hundreds of electric vehicles providers were born in the PRC at this time. In this period, the industry is developing as fast as the smart phones in those years, and everyone is keen on the research and development of the ICV industry. For ICV testing, validation and evaluating solution industry, the PRC relied heavily on imported simulation testing software in the past, but now leading players have realized to independently research and develop validation and evaluating software and hardware.



Note: BATH include Baidu, Alibaba, Tencent and Huawei.

Source: Frost & Sullivan

The PRC ICV Industry Overview

Definition and Classification of Autonomous Driving

Autonomous Driving System Architecture		SAE Standard	Chinese Standard (Taxonomy of driving autonomous for vehicles, GB/T 40429-2021)
Apperceive level Environmental Sensing In-vehicle cameras Lidars Millimetre wave radars Ultrasonic radars Vehicle Body Perception Inertial navigators Satellite navigation High-resolution maps Perception Network Vehicle equipment Driving test equipment Cloud platforms	Level 0	Driver assistance	Emergency assistance
	Level 1	Driver assistance	Partial driving assistance • It is occupied with ACC (Adaptive Cruise) or LKA (Lane Keep Assist).
Execution level Chip Smart cockpit chips Automotive MCU chips Autonomous driving chips Automotive power semiconductors Algorithm Perception algorithms Decision algorithms Execute algorithms Vehicle Operating System	Level 2	Driver assistance	Combined driving assistance • It has both ACC and LKA functions.
	Level 3	Autonomous driving • The drivers need to take over the vehicles when they are requested by the system. • The autonomous driving features can drive the vehicle under limited conditions	Conditional autonomous driving • The driver needs to take over the malfunctioning vehicle when the autonomous driving system has errors or exceeds operating conditions.
Decision level Body Control Domain Controllers Steering, Brakes, Accelerator, Gear, Lights	Level 4	Autonomous driving system • The system does not require the drivers to take over. • The autonomous driving features can drive the vehicle under limited conditions	High level autonomous driving • It still belongs to autonomous driving with limited conditions, but the task of taking over when the vehicle has errors does not require human participation.
	Level 5	Autonomous driving system • The system does not require the drivers to take over. • The autonomous driving features can drive the vehicle under all conditions	Complete autonomous driving • There are no more restrictions on operating conditions, and the autonomous driving system can independently complete all operations and decisions.

At present, the core algorithm routes for autonomous driving of mainstream vehicle manufacturers are different, including visual-based graphic recognition technology routes and lidar-based technology routes. Both of the two technologies currently have their advantages and disadvantages in terms of accuracy, usage scenarios, and cost, and technological further breakthroughs are still needed in the future.

Source: Frost & Sullivan

The PRC ICV Industry Overview

Market Size of ICV Industry

Market Size of ICV Industry by Revenue (the PRC), 2019-2030E



- The PRC government has been actively promoting the development of ICV industry and regards it as an important means to solve the problems of traffic safety, road congestion, energy consumption and environmental pollution, so as to drive the technological change and accelerate the upgrading of the automotive industry. The market size of the PRC ICV industry grew from approximately RMB63.6 billion in 2019 to approximately RMB165.3 billion in 2023, illustrating a CAGR of approximately 27.0%, and is expected to increase to approximately RMB659.6 billion in 2030 at a CAGR of approximately 20.1% from 2024.
- There are two main types of vehicle networking communication technology standards: DSRC (dedicated short range communication, or IEEE 802.11p) standard, cellular vehicle-to-everything (cellular vehicle-to-everything, C-V2X) standard. However, DSRC has the problems of large communication delay and low reliability when the vehicles are dense. Based on cellular communication technology, C-V2X has V2X pass-through communication capability through technological innovation, which can not only solve the problems of low-latency and high-reliability communication in V2X applications, but also use the existing mobile network to deploy and support information services, which can reduce costs by utilizing the industrial economies of scale of mobile communications. Therefore, compared with IEEE 802.11p, C-V2X has formed an obvious surpassing situation in international technology and industrial competition. In November 2020, the Federal Communications Commission (FCC) officially voted that the United States would officially turned to C-V2X from DSRC, which means that the PRC's C-V2X standard will become a worldwide recognized industry standard. In the future, increasing OEMs are expanding their business into ICV industry. The ICV will provide more diversified services and penetrate into O2O and automobile after-sale services market, with increasingly significant cross-border cooperation and service innovation.

Source: Frost & Sullivan

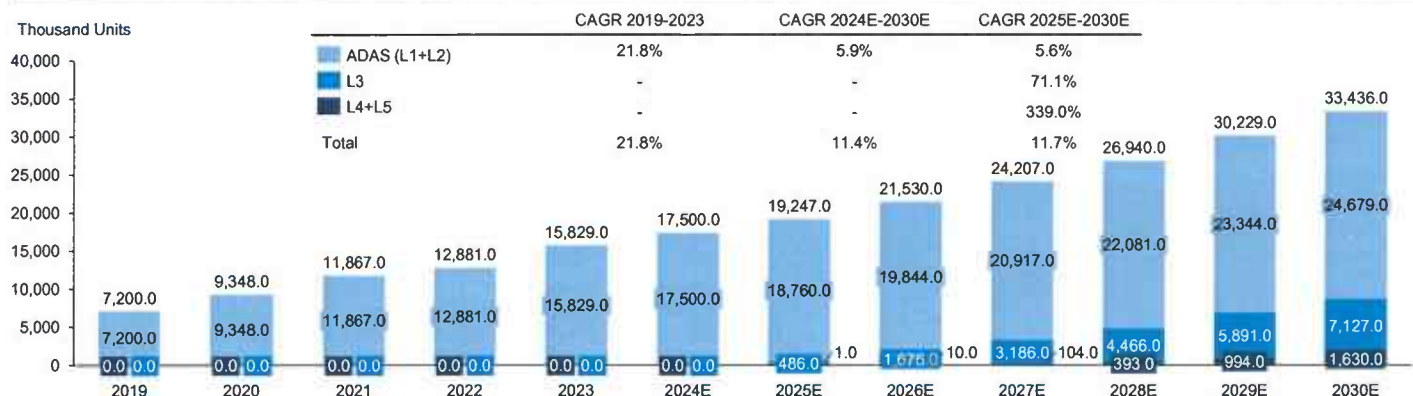
Note: The market size of ICV industry refers to the market size in terms of ICV related solution.

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The PRC ICV Industry Overview

Market Size of ICV Industry

Market Size of ICVs by Sales Volume by Level of Intelligent Driving Technology (the PRC), 2019-2030E



- At present, the PRC intelligent driving technologies are still in the developing stage. Vehicles equipped with ADAS driving technology have realised commercialised massive production. ICVs equipped with L3 driving technology can be gradually operated on the road for demonstration in 2025. ICVs equipped with L4 and L5 autonomous driving technologies can only operate in the specific experimental or demonstration scenarios. The sales volume of ICVs equipped with only ADAS driving technologies in the PRC increased from approximately 7,200 thousand units in 2019 to approximately 15,829 thousand units in 2023 at a CAGR of approximately 21.8%, and is expected to increase from approximately 17,500 thousand units in 2024 to approximately 24,679 thousand units in 2030 at a CAGR of approximately 5.9%. With the improvement of the technology and the issuance of autonomous driving technology access policies, the vehicles at L3 are expected to be sold in the second half of 2025 and their sales volume in the PRC is expected to reach approximately 7,127 thousand units in 2030. The vehicles at L4 and above are expected to be sold before the end of 2025 in the PRC market and the sales volume of ICVs at L4 and above in the PRC is expected to increase to approximately 1,630 thousand units in 2030. The ICV industry is currently very fragmented in the PRC. Promoted by the increasing penetration of ADAS and higher levels of autonomous driving, it is expected that the number of players in the ICV industry will further expand as well.

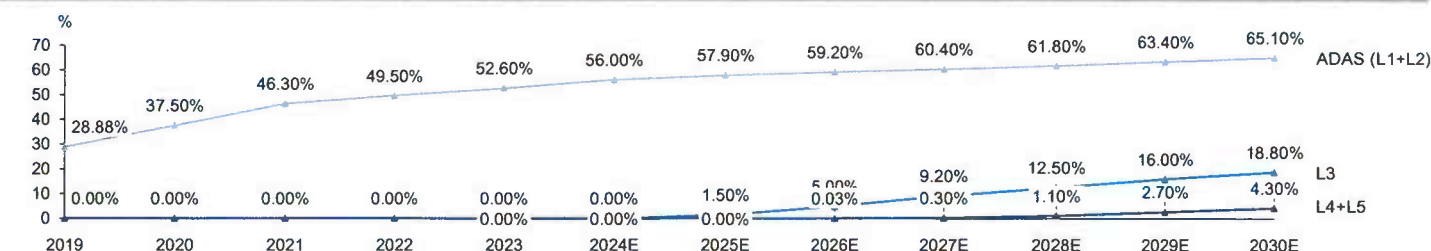
Source: Frost & Sullivan

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The PRC ICV Industry Overview

The Penetration Rate by Level of Intelligent Driving Technology

Penetration Rate by Level of Intelligent Driving Technology (the PRC), 2019-2030E



- The PRC has formulated a series of policies and regulations to promote the development of ICV industry. "Medium- to long- term development plan of automobile industry" (汽车产业中长期发展规划) promulgated by the PRC government points out that by 2025, the penetration rate of intelligent driving technology in the new models of ICV industry is expected to reach over 80% and more than 25% of the new issued ICVs are expected to carry driving technologies of L2 and L3. ICVs are expected to achieve wide-spread acceptance of consumers by multisensory in-vehicle human-machine interactions and out-vehicle connections empowered by advanced technologies, such as AI, connectivity, cloud-based data storage, intelligent driving, etc., which makes driving more convenient and comfortable for drivers. For example, features such as automated parking and lane departure warning systems can reduce the amount of effort required from the driver and make driving less stressful. With the continuous improvements of the technologies, vehicles are becoming intelligent terminals, which not only will change the behaviours and habits of human driving, but also promote the development and progress of the whole society in terms of traffic safety, transportation cost, vehicle efficiency, etc.
- In addition, government regulations around the world are also pushing original equipment manufacturers ("OEMs") to incorporate intelligent driving technology in their ICV models. For example, in the U.S., the National Highway Traffic Safety Administration (NHTSA) has made it mandatory for all new vehicles to have rear-view cameras from May 2018, and it is likely that other intelligent driving technologies will be required in the future. The MIT issued the Guidelines for the Construction of the National ICV Industry Standard System (2022 Edition) (国家车联网标准体系建设指南(智能网联汽车)(2022年版)) in September 2022, proposing that by 2025, more than 100 relevant standards for ICVs should be formulated and revised. Compliance with these regulations can help improve public transportation safety. Last but not least, OEMs who are early adopters of intelligent driving technology can gain a competitive advantage over their competitors by offering cutting-edge features that appeal to consumers.
- From 2024 to 2030, L1, L2 and L3 will still remain the mainstream of intelligent driving technologies in the PRC. The penetration rate of ADAS is expected to reach approximately 65.1% in 2030, whilst the penetration rate of autonomous driving (L3-L5) is expected to reach approximately 23.1% by 2030.

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Source: Frost & Sullivan

The PRC ICV Industry Overview

Drivers and Trends Analysis of ICV Industry (1/2)

The Key Drivers and Trends of ICV Industry

Favorable Policies from Government

Multiple stimulus policies and measures ensure the stable development of ICV industry in the PRC. The PRC government promulgated the Smart Vehicle Innovation and Development Strategy (智能汽车创新发展战略), Autonomous Driving Classification (汽车驾驶自动化分级), Medium- to Long-Term Development Plan of Automotive Industry (汽车产业中长期发展规划) and other policies and regulations to stimulate the industry. The guidance and policy support of the government, wide application of advanced technologies, development of cloud platforms and the construction of road infrastructure all help to lay a healthy and mature foundation for the development of ICV industry. In the future, the PRC ICV industry will maintain a rapid development, and the intelligent technologies of vehicles will gradually penetrate from high-end vehicles models to low-end vehicle models.

The value chain will be restructured

The development of the ICV industry usually revolves around the development of intelligent cockpit and autonomous driving technologies. At the software level, mobile applications and human-computer interaction are gradually transplanted into the intelligent cockpit, and some ADAS functions are integrated into the intelligent connected vehicles.

The role of the participants in the value chain will be enriched and redefined. The development of the ICV industry puts forward strict requirements for the processing capacity of the chips. An intelligent and connected vehicle chip needs to deal with most of the functions inside and outside the vehicles in the future. With the chip integration ability improving, its computing power will be stronger. As the functions of nowadays software and hardware become more comprehensive, their reliability is also becoming greater. Only by deeply grasping the users' needs and architecture ability, the players can carry out personalized and customized products and services, and improve the product innovation and user stickiness. Under the background of "software defined automobile", automakers will actively seek the trend to transformation. Automotive manufacturers and technology companies focusing on developing the high generation of automotive and technologies are willing to build their own autonomous simulation validation and driving data platform, extend their existing simulation technologies and embrace new technologies to develop or upgrade their virtual simulation testing platforms.

The Chinese governments have actively promoted the development of ICV industry in recent years. Given that the ICV industry in the PRC is at the early development stage, the public sector will need assistance from leading ICV testing, validation and evaluation solution providers to lay the foundation and set the standard for the requisite solutions for ICV testing, validation and evaluation as a benchmark for the other local governments and private sector customers to adopt in the next few years. It is expected there will be more demand for ICV testing, validation and evaluation solution from both public and private sectors. All parts in the value chain will be deeply integrated and enriched, and participants in the ICV industry will continue to expand their business to cover more fields of the industrial chain.

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Source: Frost & Sullivan

The PRC ICV Industry Overview

Drivers and Trends Analysis of ICV Industry (2/2)

The Key Drivers and Trends of ICV Industry

Redefinition of the Relationship between People and Vehicles

With the increasing demand of people for superior driving experience, vehicles are changing from traditional travel tools to mobile living space. Drivers and passengers can give instructions to the ICVs through voice, gesture and other ways. The ICVs also have intelligent perception functions, which can more accurately judge the user's intention. In addition, the integration of the ICV value chain will help to jointly collect and process a large amount of real-time traffic information and data through the combination of the internal and external information of the ICVs. In the future, the ultimate interactive development direction of ICVs should be vehicle to person active live interaction. The upgrading iteration of ICVs will lead the transformation and upgrading of the automotive industry and reshape the people's experience of automotive travel.

Note:IoT, the internet of things is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

The PRC ICV Industry Overview

Policy and Regulation Analysis (1/2)

Policies and Regulations	Release Date	Issuing Agency	Main Content
Autonomous Vehicle Transportation Safety Service Guidelines (Trial) 《自动驾驶汽车运输安全服务指南（试行）》	2023.12	Ministry of Transport	The policy specifically regulated the commercial operation requirements of autonomous vehicles, and put forward specific requirements in terms of scope of application, basic principles, application scenarios, autonomous transportation operators, transportation vehicles, staffing, safety assurance, supervision and management, etc.
Notice on Carrying out Pilot Work on Access and Road Access of Intelligent Connected Vehicles 《关于开展智能网联汽车准入和上路通行试点工作的通知》	2023.11	Ministry of Industry and Information Technology, Ministry of Public Security, Ministry of Housing and Urban-Rural Development, Ministry of Transport	The notice set out specific requirements for the access specifications for L3 and L4 autonomous driving, which means that China's L3 and L4 autonomous vehicles have officially entered the road pilot stage.
Outline of the Mid- and Long-term Development Plan for Scientific and Technological Innovation in the Transportation Sector (2021-2035) 《交通领域科技创新中长期发展规划纲要（2021—2035年）》	2022.01	Ministry of Transport, Ministry of Science and Technology	The document promoted the research and development and application of autonomous driving technology and strengthened research on legislation related to autonomous driving.
Autonomous Driving Classification 《汽车驾驶自动化分级》	2021.8	Ministry of Industry and Information Technology	The document stipulated the principles, grading elements, definition of each level and technical requirement framework for the classification of vehicle driving automation, aiming to solve the normative problems of the PRC's vehicle driving automation classification.
Notice on Determining the First Batch of Pilot Cities for the Collaborative Development of Smart City Infrastructure and Intelligent Connected Vehicles 《关于确定智慧城市基础设施与智能网联汽车协同发展第一批试点城市的通知》	2021.5	Ministry of Housing and Urban-Rural Development, Ministry of Industry and Information Technology	Six cities including Beijing, Shanghai, Guangzhou, Wuhan, Changsha, and Wuxi have been identified as the pilot cities for the coordinated development of smart city infrastructure, and intelligent connected vehicles.
National Vehicle Networking Industry Standard System building Guide (Intelligent Transportation Related) 《国家车联网产业标准体系建设指南（智能交通相关）》	2021.3	Ministry of Transport, Ministry of Industry and Information Technology, National Standardization Management Committee	The standard formulated and revised more than 20 urgently needed plans for intelligent transportation in the fields of intelligent transportation infrastructure, traffic information assistance, etc., and initially established a standard system to support Internet of Vehicles applications and industrial development by the end of 2022.

The PRC ICV Industry Overview

Policy and Regulation Analysis (2/2)

Policies and Regulations	Release Date	Issuing Agency	Main Content
Guidance on Promoting the Development and Application of Road Traffic Self-driving Technology 《关于促进道路自动驾驶技术发展和应用的指导意见》	2020.12	Ministry of Transport	By 2025, major progress should be made on the theoretical research on autonomous driving. Important breakthroughs should be made on development, validation, and verifications of key technologies such as intelligent road infrastructure and vehicle-road collaboration.
New Energy Automotive Industry Development Plan (2021 to 2035) 《新能源汽车产业发展规划（2021-2035）》	2020.11	State Council	By 2025, the competitiveness of Chinese new energy vehicle market will be significantly enhanced, breakthroughs have been made in key technologies such as power batteries, drive motors, vehicle operating systems. The average power consumption of electric passenger vehicles will be reduced to 12.0 kWh/100 kilometers. The sales of new energy vehicles will reach about 20% of the total sales of new vehicles. Highly autonomous vehicles will be commercialized in limited areas and specific scenarios. The convenience of the battery swap service has been significantly improved.
Smart Vehicle Innovation and Development Strategy 《智能汽车创新发展战略》	2020.2	National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Science and Technology	By 2025, the technological innovation, industrial dynamics, infrastructure, regulations and standards, product supervision and network security system of Chinese standard smart vehicles will be formed. Active progress has been made in the intelligent transportation system and related infrastructure of smart cities, the LTE-V2X wireless communication network has achieved regional coverage, and the 5G-V2X new-generation vehicle wireless communication network has been gradually applied in some cities and highways.

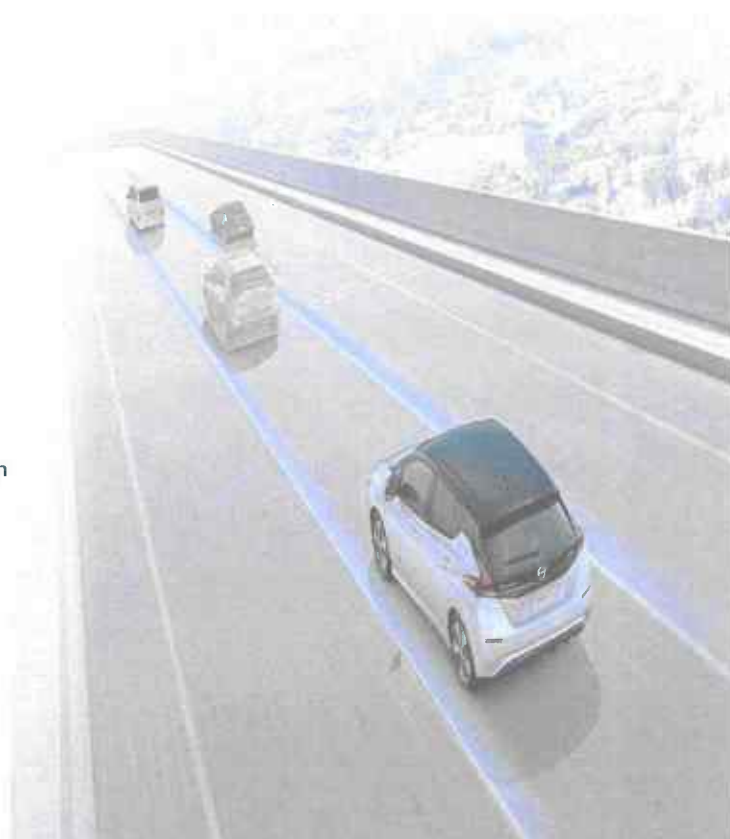
Source: Frost & Sullivan

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Agenda

- 1 The PRC Macro Market Overview
- 2 The PRC ICV Industry Overview
- 3 The PRC ICV Testing, Validation and Evaluation Solution Industry Overview
- 4 Competitive Landscape
- 5 Appendices



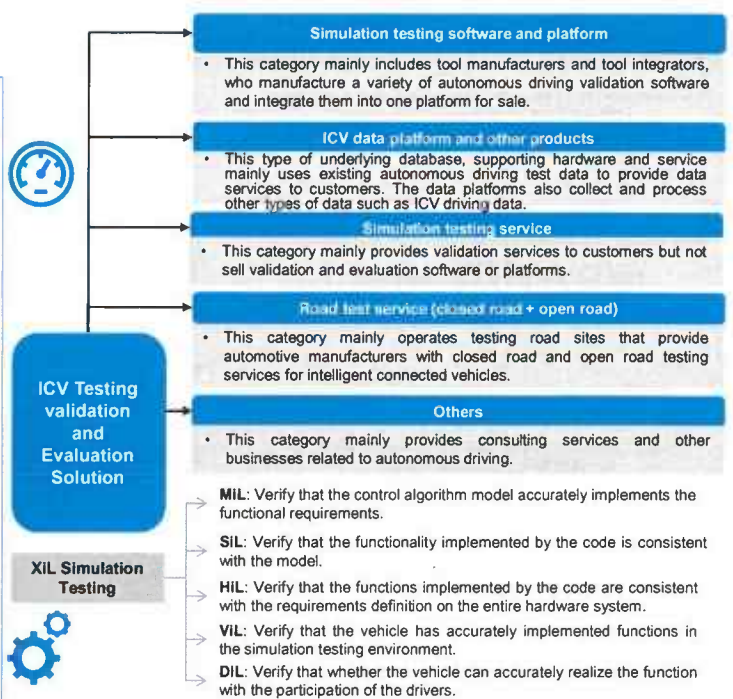
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The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Definition and Classification

Definition and Classification

- Like traditional vehicles, ICVs also need adequate and comprehensive simulation and/or physical testing to ensure the safety and reliability, for commercialisation and mass production. The ICV testing, validation and evaluation solution is to test and evaluate the actions like sensing, making decisions, and executing the intelligent driving system's full-time continuous operation under different scenarios. It achieves a stable confidence level by testing and validating the intelligent driving system from multiple dimensions and angles, and judges the level of the equipped intelligent driving technology.
- Simulation testing is one of the most important parts in the ICV testing, validation and evaluation solution, which can be used to test and verify the intelligent driving functions and safety level of ICV products (in particular for L3 and above autonomous driving products) through Model in Loop (MiL) tests, Software in Loop (SiL) tests, Hardware in Loop (HiL) tests, Vehicle in Loop (ViL) tests and Driver in Loop (DiL) tests, or collectively, X in Loop (XiL) tests, depending on the testing targets.
- Functional Safety (FuSa) and the Safety of the Intended Functionality (SOTIF) are of great significance to the upgrading and development of ICVs. FuSa is mainly aimed at ICVs' electronics and design functions, so as to avoid dangerous situations when the normal functions of the ICVs fail. SOTIF is mainly aimed at the intelligent driving to avoid dangerous scenarios caused by misuse of the functions.
- Compared with traditional internal combustion engine vehicles, the architecture of electric vehicles is more suitable for carrying more advanced intelligent driving technologies. At present, with the increasing awareness of consumers for the ICVs, the automotive manufacturers are focusing more on the high-level (L3 and above) intelligent connectivity and intelligent driving technologies to gain more competitive advantages, which stimulates the demand for the ICV testing, validation and evaluation solutions.
- The competitive advantages of simulation testing include: (i) Creating a virtual environment to test the algorithms and their related key components of the intelligent driving systems of ICVs in various scenarios including extreme and dangerous scenarios in a safe manner without risks of physical harm or damage. (ii) Enabling repeated testing in specific scenarios in an extremely short time. (iii) Achieving testing in a large volume of scenarios concurrently, allowing for extensive testing in a shorter timeframe as compared to road testing.
- The competitive advantages of road testing include: (i) Providing real-world road environments and traffic conditions to test ICVs and validate the simulation testing results. (ii) Enabling the validation of critical connectivity feature of ICVs, such as vehicle to vehicle and vehicle-to-infrastructure communication so as to enhance the overall safety and optimise traffic flows in cities. (iii) Enabling the collection of valuable data of behaviours of ICVs and their performance metrics, which may not be fully captured in simulation testing environment.



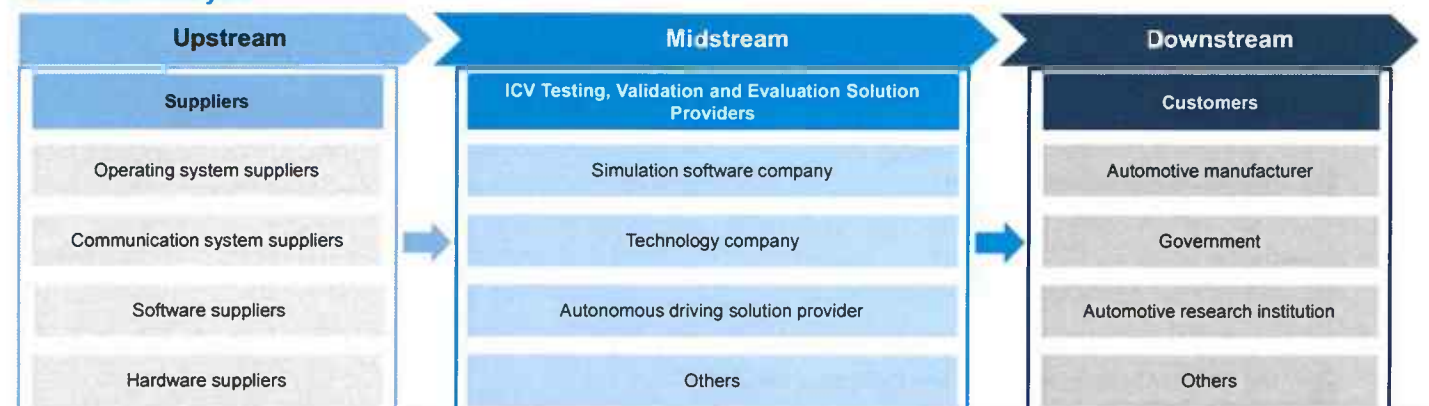
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Source: Frost & Sullivan

The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Value Chain Analysis



- The upstream of ICV testing, validation and evaluation solutions industry mainly includes operating system suppliers, communication service suppliers, software and hardware suppliers that provide fundamental support for the ICV testing, validation and evaluation. Their contribution lies in creating a robust foundation for the development of ICV testing, validation, and evaluation solutions, ensuring the availability of necessary infrastructure.
- The midstream mainly comprise ICV testing, validation, and evaluation solutions providers, providing standard or customised solutions to downstream customers. The solutions encompass a range of offerings like ICV simulation testing software and platforms, ICV data platforms and other products, simulation testing services, road testing services (closed-course site tests and open-road tests) and others. Their contributions ensure the safety and reliability of ICVs and drive innovation and integration of intelligent driving technologies.
- The downstream customers are from both public and private sectors. For private sector, automotive manufacturers and technology companies focusing on developing the high generation of automobiles and technologies are willing to build their own ICV testing platforms and data platforms, extend their existing simulation technologies and embrace new technologies. By utilising the ICV testing, validation, and evaluation solutions, the ICV manufacturers contribute to the value chain by, on one hand, optimising the performance and technologies of ICV products, and on the other hand, providing valuable feedback on the software's applicability and effectiveness for enhancing the ICV testing, validation, and evaluation solutions to meet the evolving industry requirements. Technology companies play a dual role as end customers and intermediaries (such as solutions integrators). As end customers, they use ICV simulation testing platform for their own R&D so as to promote the technological development of ICV-related technologies industries. They also play a role as intermediaries by utilising the technologies of the ICV testing, validation and evaluation solutions providers to enhance their own solutions which will be ultimately used by ICV manufacturers to improve their ICV products. For example, they may act as solutions integrators by integrating the ICV simulation testing products with other technical solutions to be sold to end customers, such as ICV manufacturers. This collaborative approach fosters a mutually beneficial relationship, advancing the capabilities and adoption of simulation testing software in the ICV technology landscape. Public sector customers include SOEs, local governments, universities, automotive research institutions and other government authorities, who purchase the solutions ultimately for the government's administrative and public usage purposes. The public sector customers contribute to government initiatives, public safety and regulatory compliance in ICV industry.

Note: The others in the midstream mainly include advisory services, etc.

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Source: Frost & Sullivan

Introduction of Major ICV Test Demonstration Areas in the PRC

- Saimo operates the Shunyi Testing Site which is a high-level ICV closed-course testing ground under the local government of Shunyi District, and provides ICV simulation testing platforms for Hunan (Changsha) National Vehicle Network Pilot Area operation.

Chongqing
Chongqing Smart Car Integrated System Test Area (i-VISTA)
国家智能汽车集成系统实验区 (i-VISTA)
Chongqing (Liangjiang New Area) National V2X Pilot Area
重庆 (两江新区) 国家级车联网先导区
Automonomous Driving Closed Field Test Base (Chongqing)
自动驾驶封闭场测试基地 (重庆)

Hubei
National ICV (Wuhan) Test Demonstration Area
国家智能网联汽车（武汉）测试示范区
Xiangyang City V2X Road Test Closed Test Site
襄阳市智能网联汽车道路测试封闭试验场

ICV (Shanghai) Pilot Demonstration Area
网联汽车（上海）试点示范区

an (Changsha) National Vehicle Network Pilot Area
(长沙) 国家车联网先导区

Smart Transportation Application Demonstration Area
智慧交通应用示范区

Source: the PRC Automotive Industry Development Annual Report 2021, Internet of Vehicles Innovation Ecological Development Report 2022, Frost & Sullivan

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Introduction of Major ICV Test Demonstration Areas in the PRC

	Established	Simulation Test	Closed Road Test	Open Road Test	Operation Entity	Awarded Authority
National ICV Application (North) Demonstration Area* 国家智能网联汽车应用（北方）示范区*	2018.7	√	√	√	Qiming Information Technology Co., Ltd. 启明信息技术股份有限公司	MIIT 工业和信息化部
National Intelligent Vehicle and Intelligent Transportation (Beijing-Hebei) Demonstration Area* 国家智能汽车与智慧交通（京冀）示范区*	2018.11	√	√	√	Beijing Intelligent Vehicle Industry Innovation Center, Great Wall Motor Company Limited 北京智能网联产业创新中心、长城汽车股份有限公司 Beijing Saimo Technology Co., Ltd. 北京赛目科技股份有限公司（Shunyi Testing Site）	MIIT 工业和信息化部
Autonomous Driving Closed Field Test Base (Beijing) 自动驾驶封闭场地测试基地（北京）	2018.7	×	√	×	Research Institute of Highway Ministry of Transport 交通运输部公路科学研究院	MOT 交通运输部
Tianjin (Xiqing) National V2X Pilot Area 天津（西青）国家级车联网先导区	2019.12	√	√	√	the PRC Automotive Data Co., Ltd. 中汽数据有限公司	MIIT 工业和信息化部
Jiangsu (Wuxi) National V2X Pilot Area 江苏（无锡）国家级车联网先导区	2019.5	[N/A]	√	√	Wuxi Zhilui Transportation Technology Co., Ltd. 无锡智汇交通科技有限公司	MIIT 工业和信息化部
National Intelligent Transportation Comprehensive Test Base (Wuxi) 国家智能交通综合测试基地（无锡）	2017.9	√	√	√	Traffic Management Research Institute of the Ministry of Public Security 公安交通管理部门研究所	MIIT, MPS 工业和信息化部，公安部
ICV Autonomous Driving Closed Field Test Base (Taiding) 智能网联汽车自动驾驶封闭场地测试基地（泰兴）	2019.9	×	√	×	National ITS Center Intelligent Driving and Intelligent Transportation Research Institute 国家ITS中心智能驾驶及智能交通研究院	MIIT, MOT 工业和信息化部，交通运输部
National ICV (Shanghai) Pilot Demonstration Area 国家智能网联汽车（上海）试点示范区	2016.6	√	√	√	Shanghai Songhong Intelligent Vehicle Technology Co., Ltd. 上海淞虹智能汽车科技有限公司	MIIT 工业和信息化部
Shanghai Lingang ICV Comprehensive Test Demonstration Area 上海临港智能网联汽车综合测试示范区	2019.9	[N/A]	√	√	Shanghai Lingang Intelligent and Connected Vehicle Research Center Co., Ltd. 上海临港智能网联汽车研究中心有限公司	MIIT, MOT 工业和信息化部，交通运输部
Zhejiang 5G V2X Application Demonstration Area* 浙江5G车联网应用示范区*	2015.9	[N/A]	√	[N/A]	CETHIK Group Co., Ltd., Alibaba Cloud Computing Co. Ltd 中电海康集团有限公司、阿里云计算有限公司	MIIT 工业和信息化部
National ICV (Changsha) Test Area 国家智能网联汽车（长沙）测试区	2018.6	√	√	√	Hunan Xiangjiang Intelligent Technology Innovation Center Co., Ltd. 湖南湘江智能科技创新中心有限公司	MIIT 工业和信息化部
Hunan (Changsha) National Vehicle Network Pilot Area 湖南（长沙）国家级车联网先导区	2020.9	√	√	√	Hunan Xiangjiang Intelligent Technology Innovation Center Co., Ltd. 湖南湘江智能科技创新中心有限公司	MIIT 工业和信息化部
Guangzhou ICV and Smart Transportation Application Demonstration Area 广州智能网联汽车与智慧交通应用示范区	2018.3	[N/A]	√	√	Guangzhou ICV Demonstration Zone Operation Center, Ministry of Industry and Information Technology No. 5 Electronics Institute (Saiaba Laboratory) 广州市智能网联汽车示范区运营中心：工信部电子五所（赛宝实验室）	MIIT 工业和信息化部
Autonomous Driving Closed Field Test Base (Xi'an) 自动驾驶封闭场地测试基地（西安）	2018.7	×	×	×	Chengdu ICV Technology Development Co., Ltd. 成都智能网联汽车科技发展有限公司	MOT 交通运输部
Chengdu the PRC-German ICV V2X Sichuan Test Base 成都中德合作智能网联汽车车联网四川试验基地	2017.11	×	×	×	the PRC Automotive Engineering Research Institute Co., Ltd. 中国汽车工程研究院股份有限公司	MIIT 工业和信息化部
Chongqing Smart Car Integrated System Test Area (I-VISTA) 国家智能汽车集成系统试验区 (I-VISTA)	2016.11	√	√	√	Li Jiangling Smart Urban Investment 两江智慧城投公司	MIIT 工业和信息化部
Chongqing (Liangjiang New Area) National V2X Pilot Area 重庆（两江新区）国家级车联网先导区	2020.12	√	√	√	the PRC Merchants Chongqing Vehicle Validation Research Institute Co., Ltd. 招商局重庆车辆检测研究院有限公司	MOT 交通运输部
Autonomous Driving Closed Field Test Base (Chongqing) 自动驾驶封闭场地测试基地（重庆）	2018.7	×	√	×	Wuhan Economic & Technology Development Zone 武汉市经济开发区政府	MIIT 工业和信息化部
National ICV (Wuhan) Test Demonstration Area 国家智能网联汽车（武汉）测试示范区	2019.9	√	√	√	Dongfeng Motor Engineering Research Institute 东风汽车工程研究院	MIIT, MOT 工业和信息化部，交通运输部
Xiangyang City V2X Road Test Closed Test Site* 河南省智能网联汽车道路测试封闭测试场*（南阳）	2018.12	×	√	×		

Note: Information is sourced from public information as of Feb 18th, 2022
*: operated or co-operated by non-government third-party

Source: Frost & Sullivan.

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the PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Global Standards of ICV Testing, Validation and Evaluation

- Testing, validation and evaluation is an important and indispensable part of the R&D and commercial launch of intelligent connected vehicles. With the rapid development of autonomous driving technology as well as other emerging technologies, some countries and regions have introduced corresponding laws and regulations to promote the standard validation of autonomous vehicles, covering simulation validation, road validation, safety standards, market access, operation and use regulations, insurance and liability regulations for autonomous driving vehicles.

Regulations	Issuer	Issuing Date	Main Content
ISO 34501	ISO/TC22 (led by the PRC)	2019	Autonomous driving system test scenario terminology and general information
ISO 34502	ISO/TC22 (led by Japan and German)	2019	Scenario engineering framework setting for the purpose of safety certification of autonomous driving vehicles
ISO 34503	ISO/TC22 (led by the UK and Japan)	2019	Classification of design operation domains for autonomous driving systems
ISO 34504	ISO/TC22 (led by German and Netherlands)	2019	Scene characteristics and scene classification definition
ISO 34505	ISO/TC22 (led by the PRC and the UK)	2019	Evaluation system for scenario-based autonomous driving systems
Framework Document for Autonomous Vehicles	UNECE/WP.29	2019.06	It established the key principles of safety and security for L3 and higher level autonomous vehicles.
"multi-pillar method" (多支柱法)	UNECE/WP.29	2019	It includes a multi-level ICV validation system consisting of audit and certification, virtual simulation testing, field validation, and road validation. It was introduced in the "Proposal for the Future Certification of Automated/Autonomous Driving Systems" submitted by the experts from International Organization of Motor Vehicle Manufacturers in 2019, demonstrating the level of safety and reliability which allows for safe market introduction of automated/autonomous vehicles.
(ALKS), Cybersecurity, Software Updates	UNECE/WP.29	2020.06	ALKS sets stringent requirements in the five areas: system safety and fail-safe response, human-machine interface, OEDR, DSSAD, information security, and software upgrades.
OpenX	ASAM, German	2019.10	Cybersecurity and Software Upgrade help address security risks by establishing clear performance and audit requirements for automakers. OpenX mainly consists of five sections: OpenDRIVE , OpenSCENARIO , Open Simulation Interface (OSI) , OpenLABEL and OpenCRG . In the overall process of simulation validation, OpenDRIVE and OpenSCENARIO unify different data formats for simulation scenarios; OpenLABEL will provide a unified calibration method for the raw data and scenarios; OSI connects autonomous driving functions with simulation software and integrates various sensors; OpenCRG realizes the interaction between the physical road information and static road scenes.
ASIL D (based on ISO26262)	ISO/SGS	2011.11	ISO26262 is an international authoritative automotive functional safety standard. The standard covers functional safety requirements planning, design, implementation, integration, verification, configuration, etc., throughout the entire product life cycle. ASIL (Automotive Safety Integration Level) is a classification system based on the ISO26262 standard. There are four levels of A, B, C, and D. ASIL D is the most stringent level. The SGS Global Functional Safety Technology Center is an automotive functional safety training, consulting and certification organization authorized by DaKKS in Germany. Martin Schmidt, the head of the technology center, is the initiator and drafter of ISO 26262. At present, SGS has more than 80 automotive functional safety experts and has issued more than 340 ISO 26262 functional safety certification certificates to the global clients.

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the PRC ICV Testing, Validation and Evaluation Solution Industry Overview

the PRC Standards of ICV Testing, Validation and Evaluation

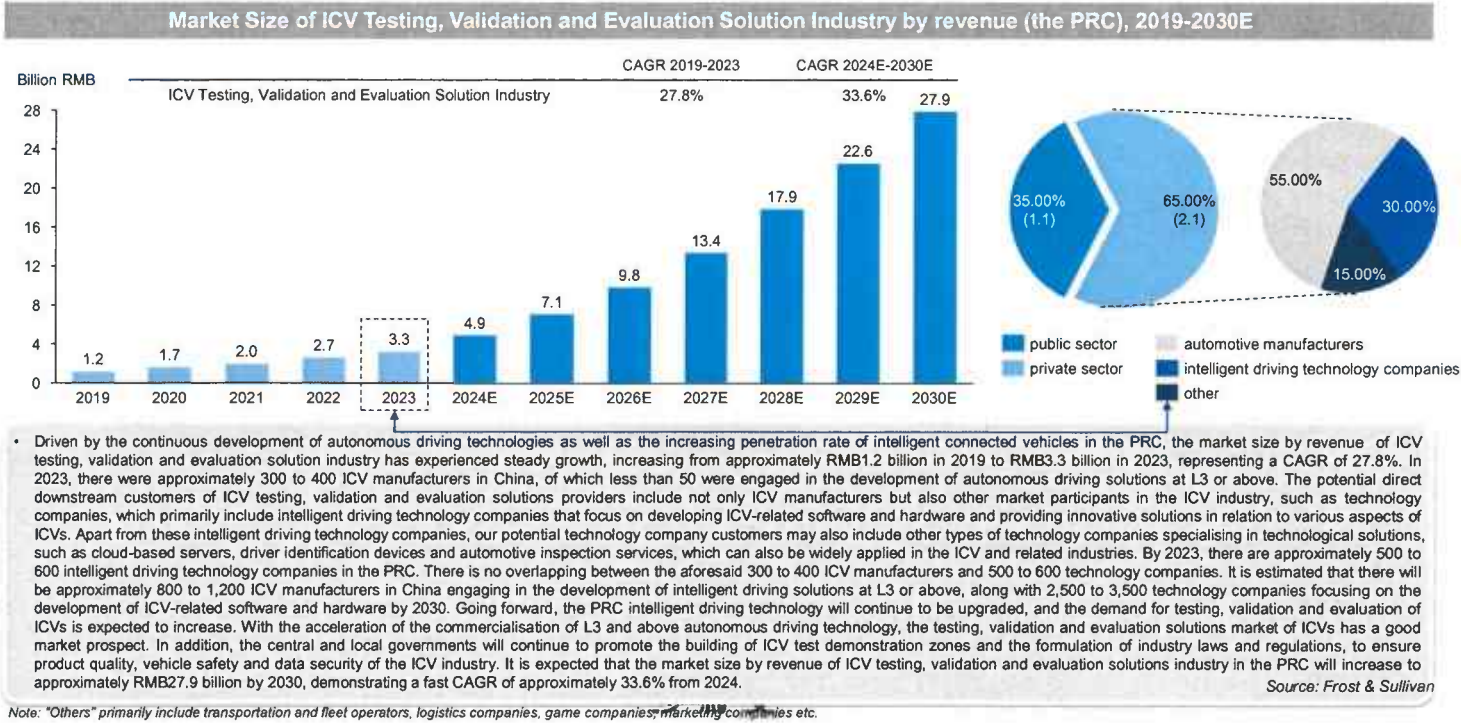
- Over the past few years, a series of standards related to the validation and evaluation of the intelligent connected vehicles have been promulgated in the PRC and nearly 30 provinces, cities and regions across the country have issued road test implementation rules. However, the validation and evaluation of intelligent connected vehicles in the PRC still faces problems such as the test standards are not unified, the test results cannot be mutually recognized, and the obstacles of data sharing and utilization. The issue of the Opinions on Strengthening the Management of Access to ICV Manufacturing Enterprises and Products (《关于加强智能网联汽车生产企业及产品准入管理的意见》) in 2021 will promote the commercialization of domestic advanced autonomous driving vehicles to the ground, with different stakeholders in the industry working together to promote the establishment of a sound ICV testing, validation and evaluation standard system.

Regulations	Issuer	Issuing Date	Main Content
Opinions on Strengthening the Management of Access to ICV Manufacturing Enterprises and Products 《关于加强智能网联汽车生产企业及产品准入管理的意见》	Ministry of Industry and Information Technology	2021.07	It proposed that enterprises producing automotive products with autonomous driving functions should ensure that the automotive products meet at least the requirements for validation and verification of system failure identification and safety response, human-machine interaction, data recording, process assurance and simulation. It encourages third-party service organizations and enterprises to strengthen the capability of validation and evaluation.
T/CMAA 121-2019 Technical Requirement for Automatic Driving Vehicle Simulation Test Platform in Beijing 《北京市自动驾驶车辆测试平台技术要求》	中关村智能交通产业联盟	2019.10	It is the PRC's first industry standard relating to simulation testing of autonomous driving vehicles, which is mainly used to guide the standardized construction of intelligent connected vehicles and autonomous vehicle simulation test platforms.
C-ASAM	CATARC, ASAM	2019.09	CATARC and ASAM jointly issued a statement to set up the C-ASAM working group. Based on the ASAM OpenX simulation testing scenario standard, C-ASAM working group will integrate the PRC's ICVs and cooperate with international partners to promote the establishment of the PRC's ICV standard validation and evaluation standards.
Specifications for the Management of ICV Road Validation 《智能网联汽车道路测试管理规范(试行)》	Ministry of Industry and Information Technology, The Ministry of Public Security of the PRC, Ministry of Transport of the PRC	2018.04	It specified the test subjects, test vehicles, and the license application process.
Test Protocol for Automatic Driving Function of Intelligent Connected Vehicles 《智能网联汽车自动驾驶功能测试规范(试行)》	CICV, NTCAS	2018.04	It proposed the corresponding test scenarios, test protocols and passing conditions for each test item.

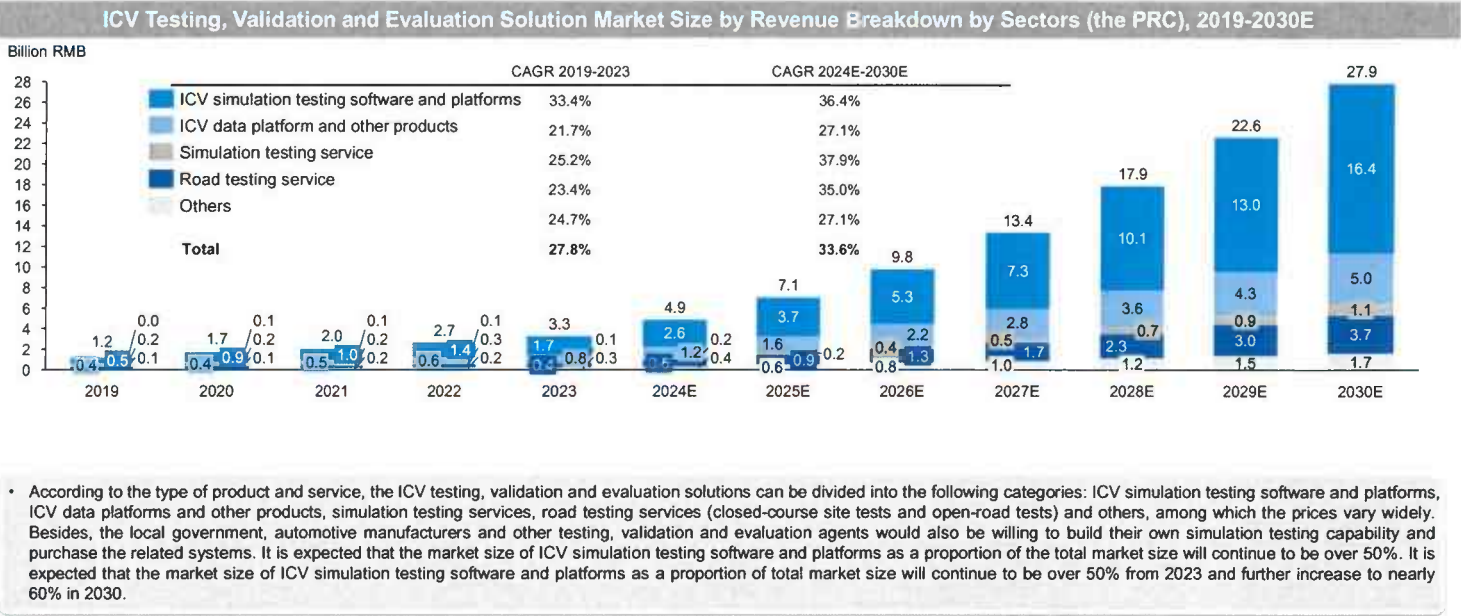
Source: Frost & Sullivan

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The PRC ICV Testing, Validation and Evaluation Solution Industry Overview
Market Size of the PRC ICV Testing, Validation and Evaluation Solution Industry



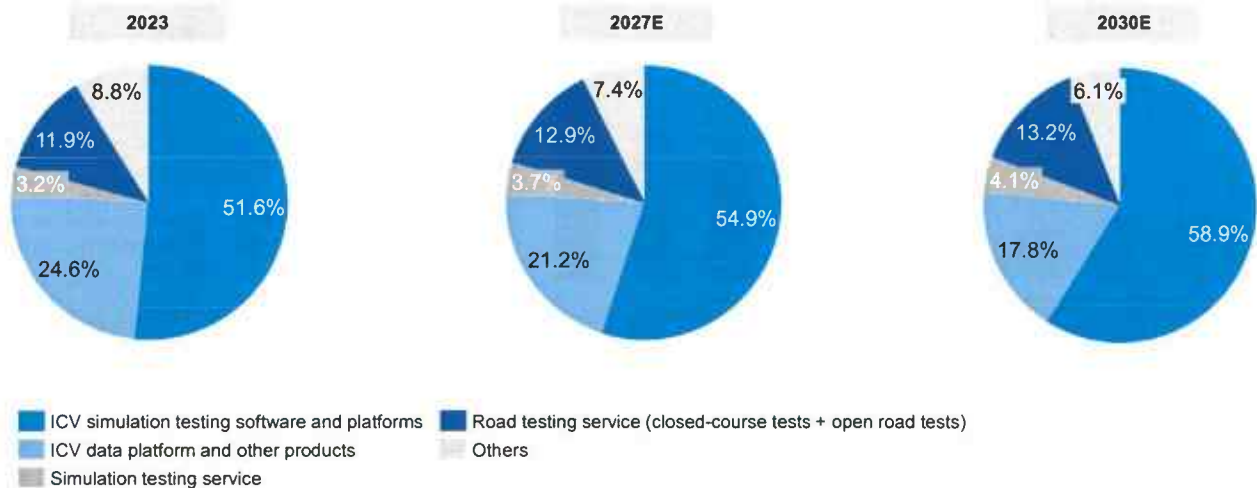
The PRC ICV Testing, Validation and Evaluation Solution Industry Overview
Market Size of the PRC ICV Testing, Validation and Evaluation Solution Industry



The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Market Size of ICV Testing, Validation and Evaluation Solution Industry

Market Size of ICV Testing, Validation and Evaluation Solution Industry Breakdown by Sectors (the PRC), 2023, 2027E, 2030E



Note: "Others" mainly include advisory services, etc.

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Source: Frost & Sullivan

The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Key Drivers and Trends of the ICV Testing, Validation and Evaluation Solution Industry(1/3)

Accelerated Development of ICV Industry

- With the growing acceptance of the concept of "software defined vehicle", the leading technology companies, intelligent driving software companies and automotive manufacturers in the PRC have continuously dedicate a large amount of investment to R & D of advanced intelligent driving technologies and ICVs to gain more market shares. At the same time, the PRC government is actively promoting the development of ICV industry. In November 2022, the MIIT, together with the MPS, the MHURD and the MOT, issued the Pilot Notice, aiming to improve the performance and safety of ICVs and promote the healthy and standard development of the ICV industry. With the continuous development of intelligent and automation technologies, vehicles are becoming intelligent terminals. At present, the ICVs equipped with intelligent driving technologies have gradually entered the stage of commercial operation in the PRC, which will bring huge growth potential for the ICV testing, validation and evaluation solutions industry. At the same time, relevant central and local competent authorities have successively issued road test management specifications and implementation rules to create a good environment in terms of project support, construction and application of test demonstration areas. By the end of 2021, the PRC government had awarded a total of 20 ICV test demonstration areas, which are located in the provinces and municipalities of Jilin, Beijing, Tianjin, Jiangsu, Shanghai, Zhejiang, Hunan, Guangdong, Hubei, Chongqing, Sichuan, and Shaanxi. Driven by the government's active deployment of ICV test demonstration areas, the demand for the ICV testing, validation and evaluation solutions of the automotive manufacturers, technology companies, public institutions, governments, universities, etc. will keep increasing. Some local governments provide subsidies to ICV market participants for operations and R&D, including Beijing, Guangzhou, Shenzhen, Chongqing, Wuhan, Suzhou, etc., which accelerates the development of the ICV industry. As the number of ICV manufacturers keeps increasing, the demand for testing, validation and evaluation solutions after mass production is considerable.

Strengthening and Standardization of the New and Evolving Market Regulation

- Energy Automotive Industry Development Plan (2021 to 2035) (《新能源汽车产业发展规划》) promotes the development of ICVs as they are the core foundation to the regulation of ICVs' product quality and the administration of data security in the ICV industry. The "multi-pillar method" consisting of simulation tests, closed-course tests, and open road tests issued by the United Nations in 2019 has been widely recognized in the world. The European Union, the United States, the PRC, and Japan have clearly stated that the "multi-pillar approach" is an important method for ICV testing, validation and evaluation and serves as a guidance document.
- The ICV testing, validation and evaluation technologies are urgently needed strategic technologies in the PRC, given their importance in ensuring the safe operation and commercialisation of ICVs. The PRC government has in recent years published a number of policies and regulations which set the ICV-related technical standards and emphasised the need to develop ICV testing, validation and evaluation technologies, including (i) the Smart Vehicle Innovation and Development Strategy (《智能汽车创新发展战略》) issued by 11 ministries of the PRC national government in 2020; (ii) the New 制 (2021-2035年) issued by the State Council in 2020, and (iii) the MIIT Opinions issued by the MIIT in 2021. These policies and regulations are relatively new and may be constantly optimised but they have laid solid foundation for the rapid and continuous development of the ICV testing, validation and evaluation solutions industry in the PRC. Some local governments also published a series of policies and incentives to help the development of the market. For instance, according to Article 4 of the Fifteen Initiatives to Support the Innovation-led Development of the ICV Industry in Zhongguancun Science City* (《关于支持中关村科学城智能网联汽车产业创新引领发展的十五项措施》) issued by the People's Government of Haidian District, Beijing* (北京海淀区人民政府) on 5 June 2019, the local government in Beijing encourages leading ICV-related enterprises to set up headquarters or R&D centres in Haidian District and provides support to these enterprises on a "case-by-case basis". For leading and unicorn enterprises, the government will provide all-round policy support in terms of talents, funds, and other aspects. Looking forward, with the continuous improvement of the intelligent driving technology and the issue of the national unified access standards, there will be more mass-produced intelligent connectivity software/systems that need to undergo the ICV simulation and road tests to enter the market, which will stimulate the expansion of the industry.

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Source: Frost & Sullivan

The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Key Drivers and Trends of the ICV Testing, Validation and Evaluation Solution Industry(2/3)

Demand for Sophisticated Data Platform

- The establishment of data platform and the application in the field of ICV is of great significance to promote industry development and innovation. The foundation of ICV testing, validation and evaluation solution is data collection and sharing. On the government side, the establishment of the data platform can make scattered and isolated vehicle data into a collection of comprehensive data systems, and help the government carry out effective market management. On the ICV manufacturer side, the data platform can help to promote the integration of technology, business and data, break through the information barriers within the group to better understand the market changes and launch updated ICV models. In August 2020, the State Council of the PRC issued "New Energy Automotive Industry Development Plan (2021-2035)" (《新能源汽车产业发展规划(2021-2035)》) which put forward the national plan for the automotive industry and related industries to build a comprehensive cross-region and cross-industry data platform. The data platform is conducive to enhance the capabilities of data collection and sharing and promote ICV industry development and innovation.

Increasing Competitiveness of Domestic Players

- With the rise of domestic alternatives in the ICV testing, validation, and evaluation solutions market, an increasing number of automotive manufacturers in the PRC are showing a preference for domestic suppliers. These suppliers offer ICV testing-related products and services that are comparable to those provided by international market players in terms of technological capabilities, product quality, reliability, customisation to local needs, cost-effectiveness, and compliance with local industry standards. The concerns regarding user-friendliness and data security of foreign ICV simulation testing software as well as the uncertainties in foreign partnerships due to political relations also drive the increasing competitiveness of the domestic market players.

Closer Cooperation of the Industry Participants

- The ICV testing, validation and evaluation solution providers will further cooperate closely with the upstream and downstream participants of the industrial chain, strengthen independent R&D, and accelerate the speed of upgrading of the ICV industry, and gradually build a comprehensive service closed loop of the whole process of ICV testing, validation and evaluation. It is beneficial to reduce the test cost and test difficulty of enterprises, and improve the test efficiency to serve more customers with test needs. Leading automotive manufacturers and technology companies have started to cooperate with third-party ICV testing, validation and evaluation solution providers to evaluate their new generation of V2X, intelligent driving technology, etc. In addition, governments, universities, scientific research institutions, and vehicle business service providers also actively cooperate with ICV testing, validation and evaluation solution providers to ensure the consistency with the latest standards of the industry, aiming to enhance the performance and reliability of the latest ICVs.

Source: Frost & Sullivan

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The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Key Drivers and Trends of the ICV Testing, Validation and Evaluation Solution Industry(3/3)

Increasing Demand for Cloud-based Solutions

- At present, the demand for cloud-based ICV testing, validation and evaluation solutions is increasing. With cloud-based ICV testing, validation and evaluation solutions, downstream customers are capable of resolving the limitations of non-cloud-based simulation testing solutions in their lower speed and efficiency of testing and validating intelligent driving solutions by performing massive simulation tests concurrently in a faster manner and larger scale through parallel and accelerated computing. In addition, cloud-based solutions can effectively reduce labour costs and the purchase and maintenance costs of relevant hardware, which would further stimulate the demand of the ICV market participants for cloud-based ICV testing, validation and evaluation solutions.

Increasing Demand for Highly Customizable Applications and Solutions

- At present, downstream automotive manufacturers tend to design and develop intelligent driving systems that align with their brand positioning, vehicle model development strategies, and driving environments of their target sales markets. These factors vary significantly among different manufacturers. Additionally, the developed intelligent driving systems need to be adapted to other related vehicle systems, which also differ among different vehicle models and manufacturers. Thus, the diverse demands of downstream automotive manufacturers have led to a trend in the ICV testing, validation, and evaluation solutions industry towards highly customisable applications and solutions.

Government Support on the Domestic ICV Industry

- In recent years, the Chinese government's focus on developing an independent and controllable ICV industry, which reflects its strategic priorities in technological advancement and national security. For example, The "Three Year Action Plan for the High Quality Development of Guangzhou's Intelligent Internet Connection and New Energy Vehicle Industry Chain (2022-2024)" (《广州市智能网联和新能源汽车产业链高质量发展三年行动计划(2022-2024年)》) sets specific goals for the development of the ICV industry in Guangzhou. By 2024, the plan aims to create a robust industrial cluster that encompasses intelligent Internet connection and new energy vehicles, with a focus on fostering enterprise innovation. This initiative highlights the government's commitment to promoting local innovation and self-reliance in the ICV sector.
- Furthermore, the "Outline of Building a Strong Transportation Country" (《交通强国建设纲要》) emphasizes the importance of the R&D of ICVs, autonomous driving, and vehicle-road collaboration. The goal is to cultivate an independent, controllable, and complete industrial chain for the ICV industry. This strategic approach aims to enhance China's capabilities in key technologies, reduce reliance on foreign companies, and ensure national security in the transportation sector.
- By promoting an independent and controllable ICV industry, the Chinese government seeks to achieve several objectives. Firstly, it aims to bolster technological innovation and develop cutting-edge capabilities in the ICV field, positioning China as a global leader in this emerging sector. Secondly, it aims to strengthen the country's economic competitiveness by nurturing a robust domestic supply chain and fostering collaboration among industry stakeholders. Lastly, it seeks to enhance national security by reducing dependence on foreign technologies and protecting sensitive data related to intelligent transportation systems.

Source: Ernst & Sullivan

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The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Entry Barriers



- The technology capability is critical for the ICV testing, validation and evaluation solutions providers. Leading market players with comprehensive R&D capability and rich industry experiences benefit from their long-time technology accumulation, which allows them to have continuously optimised and iterated their technologies to earn and maintain market recognition. Their extensive technology portfolios also enable them to offer a comprehensive set of ICV testing, validation and evaluation solutions covering a wide spectrum of different simulation testing scenarios to their customers. Additionally, leading market players with high technology capability can usually have more opportunities to advise on setting industry regulations, policies and standards which new entrants must comply with, resulting in additional adaptation costs for new entrants. Moreover, the stringent safety and reliability certifications impose high standards on ICV testing, validation and evaluation solutions, while new market players without such certifications may be unable to compete effectively in the industry. For example, the simulation tools with international certificates such as ISO 26262 Functional Safety Certification launched by the leading market players would further enhance their customers' loyalty and the reliability of the testing results. Furthermore, leading market players with high technology capability generally have abundant intelligent properties in this industry, creating a barrier for potential entrants to develop their own proprietary technologies.
- The customers of ICV testing, validation and evaluation solution providers usually have stringent criteria and lengthy process to select partners, which makes it harder for new entrants to enter into the market. For the sake of time cost and opportunity cost, once the ICV testing, validation and evaluation solution providers enter the recognized list of downstream customers, the cooperation relationship will generally maintain for a long time. Some downstream customers will require ICV testing, validation and evaluation solution providers to have multiple large-scale project experience, which makes it difficult for new entrants to become their suppliers. Therefore, for enterprises newly entering the industry, obtaining stable customer relationship is a key barrier.
- The high-calibre talents with extensive industry knowledge and rich experience play an important role in the successful operation of the ICV testing, validation and evaluation solution industry. The talents not only help the company to handle the daily business operations, but also offer customized services and distinctive support to the customers. Moreover, visionary management teams with rich experience are also critical for further improvement and expansion of the company. New entrants have a relatively limited reserve of high-quality professionals with extensive knowledge and experienced R&D capability, which will take a certain amount of time for training and learning.
- Since the ICV testing, validation and evaluation solution industry needs to validate and evaluate the safety of autonomous driving and the actual effect of intelligent connectivity functions, which are all based on high-tech software, the industry has huge R&D investment barriers. New entrants without sufficient R&D investment are difficult to enter and compete in this industry. With the rapid development of the market, players without enough R&D reserves to cope with the changes in the market is difficult to expand the market share of the enterprise.

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Source: Frost & Sullivan

The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Policy and Regulation Analysis(1/2)

Policies and Regulations	Issuing Agency	Issuing Date	Main Content
Management Specification for Road Test and Demonstration Application of Intelligent and Connected Vehicles (Trial) 《智能网联汽车道路测试与示范应用管理规范（试行）》	Ministry of Industry and Information Technology, Ministry of Public Security, Ministry of Transport	2021.8	<ul style="list-style-type: none"> • The notice required that the vehicles should be tested in a specific area such as the testing area (field) before conducting the road tests. The test sites are required to comply with relevant national and industry standards. The test requirements issued by the relevant competent authorities of the provincial and municipal governments and the test evaluation procedures for road test subjects. • The document added requirements for demonstration applications based on road tests and clarifies the definitions of road tests, demonstration applications and test areas (fields). The document expanded the scope of application from limited roads to limited areas and clarifies the highways that can be used as roads for road validation and demonstration applications. The document included prefecture-level cities as provinces and cities that could formulate detailed implementation rules and organize road tests and demonstration applications.
Notice on Determining the First Batch of Pilot Cities for the Coordinated Development of Smart City Infrastructure and Intelligent Connected Vehicles 《关于确定智慧城市基础设施与智能网联汽车协同发展第一批试点城市的通知》	Ministry of Housing and Urban-rural Development, Ministry of Industry and Information Technology	2021.5	<ul style="list-style-type: none"> • Six cities including Beijing, Shanghai, Guangzhou, Wuhan, Changsha and Wuxi were identified as the first batch of pilot cities for the coordinated development of smart city infrastructure and intelligent connected vehicles.
Key Points of Standardization of Intelligent Connected Vehicles in 2020 《2020年智能网联汽车标准化工作要点》	Ministry of Industry and Information Technology	2020.4	<ul style="list-style-type: none"> • The document promoted the connection between the standard system of intelligent connected vehicles and industrial needs and improves the building and evaluation mechanism of the standard system. The document promoted the formulation of general-purpose standards and automotive intelligence standards. The document called for strengthening coordination with international standards and regulations.
Intelligent Vehicle Innovation and Development Strategy 《智能汽车创新发展战略》	Development and Reform Commission	2020.2	<ul style="list-style-type: none"> • By 2025, the technological innovation, industrial ecology, infrastructure, regulations and standards, product supervision and network security system of Chinese standard smart vehicles will be formed.

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Source: Frost & Sullivan

The PRC ICV Testing, Validation and Evaluation Solution Industry Overview

Policy and Regulation Analysis(2/2)

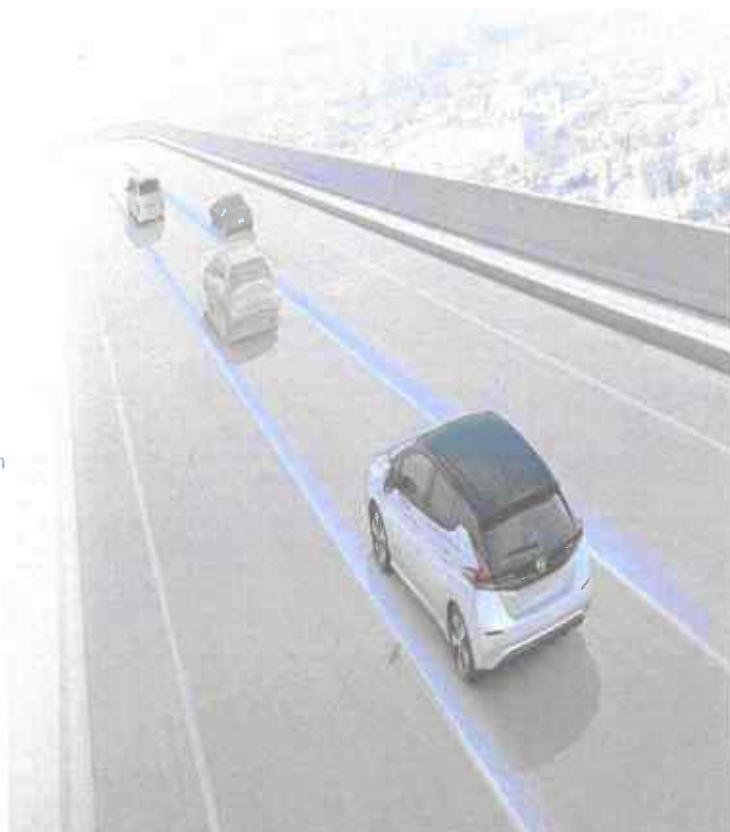
Policies and Regulations	Issuing Agency	Issuing Date	Main Content
Digital Transportation Development Planning Outline 《数字交通发展规划纲要》	Ministry of Communications	2019.7	<ul style="list-style-type: none"> The document promoted the research and development of autonomous driving and vehicle-road coordination technologies and develops the building of special test sites. The document encouraged the widespread application of technologies such as IoT and autonomous driving in logistics parks, ports, railways and airport vehicle go terminals.
Technical Guidelines for the building of Autonomous Driving Closed Sites (Interim) 《自动驾驶封闭场地建设技术指南(暂行)》	Ministry of Communications	2018.5	<ul style="list-style-type: none"> The first normative document on the building technology of closed test sites for autonomous driving was issued by the national ministries and commissions.
Management Specification for Road Test of Intelligent and Connected Vehicles (Trial) 《智能网联汽车道路测试管理规范(试行)》	Ministry of Industry and Information Technology, Ministry of Communications, Ministry of Public Security	2018.4	<ul style="list-style-type: none"> The document clarified the management requirements and division of responsibilities for road validation and standardized and unified basic validation items and validation procedures in various localities.
Intelligent Vehicle Innovation and Development Strategy (Draft for Comment) 《智能汽车创新发展策略(意见征求稿)》	National Development and Reform Commission	2018.1	<ul style="list-style-type: none"> The document elevated the development of smart vehicles to a national strategic level.
National Development Plan for New Generation Artificial Intelligence 《新一代人工智能国家发展规划》	The State Council	2017.7	<ul style="list-style-type: none"> The document placed a high priority on autonomous driving applications for connected vehicles.
"Internet +" Artificial Intelligence Implementation Plan for Three-Year Action 《“互联网+”人工智能实行三年行动实施方案》	National Development and Reform Commission, Ministry of Science and Technology, Ministry of Industry and Information Technology	2016.5	<ul style="list-style-type: none"> The document called for accelerating the research and development and application of key technologies for intelligent and connected vehicles while strengthening intelligent and connected vehicles and related standardization work.

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Source: Frost & Sullivan

Agenda

- 1 The PRC Macro Market Overview
- 2 The PRC ICV Solution Industry Overview
- 3 The PRC ICV Testing, Validation and Evaluation Solution Industry Overview
- 4 Competitive Landscape
- 5 Appendices



Competitive Landscape

Competitive Landscape Analysis(1/2)

- The simulation testing solution based on mass virtual scenarios is the main way to solve the challenge of ICV testing, validation and evaluation. Autonomous driving simulation tests have been widely accepted by industry around the globe. At present, over 90% of the autonomous driving tests in terms of testing mileage are conducted through the simulation testing in the PRC and approximately 10% in the road tests. Compared with simulation tests, the cost building of road test is extremely high and the validation period is relatively long. The simulation testing platform can complete mass tests in a short time and simulate more extreme situations. Nowadays, the mileage tests, multi-scenario tests and extreme situation tests are of great significance in the field of intelligent connected vehicles due to the increasing and diversified functions. Compared with road tests, simulation tests can meet the different test demands of intelligent connected vehicles.
- The PRC is one of the biggest automotive markets in the world. With the acceleration of the R&D process of ICVs and intelligent driving technology, the demand for ICV simulation and road tests is increasing. It is of great significance for the PRC-based market players to realise independent R&D in order to gain competitiveness in the global market. Resources such as customers, data, and road test sites are particularly important to market players.
- The competitive advantage of the PRC-based ICV testing, validation and evaluation solution industry players against foreign players mainly include the followings:
- The PRC was the world's largest PV (passenger vehicle) market in 2023 with a sales volume of 26.1 million units. As the world's leading automotive manufacturing country with a complete industrial chain, the sales volume of PVs in the PRC is expected to reach 32.3 million units in 2030, ranking the first in the globe. The rapidly growth of the automotive market in the PRC has brought huge development potential to the PRC ICV testing, validation and evaluation solution industry, especially for local companies. In addition, the Chinese government is also actively promoting the development of domestic simulation software and software. the PRC-based players are more conducive to develop local businesses with less limitation.
- ICVs at L3 and above level required more sophisticated simulation testing software and software to tackle challenges of autonomous driving testing, including high testing costs, low testing efficiency, lack of safety tests in extreme and dangerous scenarios, and the constantly changing road conditions, traffic environments and driving behaviors.
- As the downstream customers pay more attention to big data analysis, the requirements for data platform building service are increasing. The establishment of enterprise-level and government-level data platforms is becoming popular. Enterprises and governments gradually prefer to look for third-party companies to build data platforms with more efficient and comprehensive solutions. At present, the data platform building service industry is relatively fragmented. Major market share are dominated by information technology companies. Leading enterprises rely on their deep accumulation and understanding of specific industries, and use innovative technologies and consulting services to conduct personalized analysis solutions on the characteristics of various business sectors.

Source: Frost & Sullivan

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Competitive Landscape

Competitive Landscape Analysis(2/2)

- At present, foreign ICV testing, validation and evaluation solution providers mainly provide simulation testing software. ICVs at L3 and above generally require more sophisticated testing and safety validation methods and software which have been dominated by those developed by foreign developers with decades of industry experience. In contrast, leading the PRC-based companies can provide one-stop customized ICV testing, validation and evaluation solution for downstream customers including simulation testing software and platform, ICV data platform and other products, simulation testing services, road testing services (closed-course tests + open road tests) and others in order to improve their competitiveness in the globe. Domestically developed ICV simulation solutions better cater to the specific circumstances in the PRC, such as the road and traffic environment in the PRC and driving habits of Chinese drivers, which can be customized for the special needs of the PRC-based customers. the PRC's road construction and traffic regulations are quite different from those of foreign countries. From the aspect of the scenario database, the PRC-based companies have advantages over foreign companies in building scenario database according to the actual conditions. The business coverage of the PRC-based companies are welcomed by increasing downstream customers.
- There are many players in Chinese ICV testing, validation and evaluation solution market. Resources such as customers, data, and road test sites are particularly important to industry players. For simulation testing software and platform sector, the main market share is dominated by some top players, such as Saimo, TASS International, Ansys, Prescan, AV Simulation, etc. Built-in scenarios database, cloud function, simulation and safety combination, etc., are key competitiveness of leading simulation software. Players such as VIREs, Prescan and AV Simulation usually do not provide building and maintenance of simulation testing platform services, who are unable to meet the demand of downstream market for self-built platforms. Saimo is one of the few companies that could provide complete ICV testing, validation and evaluation solutions including sales of software, platforms, simulation testing services, advisory services, etc.
- The ICV testing, validation and evaluation industry has been divided into different echelons according to the ability to manage and integrate resources. Companies, including Saimo, with the background of ICV testing, validation and evaluation service providers and "Internet giants" are in the first echelon and are strengthening the ability of resource integration and improving enterprise competition barriers. The competitiveness of small to medium-sized companies is relatively weak. These enterprises are expected to improve the competitiveness of the industry through technical and ecological cooperation.
- At present, the demand for ICV data platforms and other products in the ICV industry continues to increase. The ICV data platforms and other products market is relatively fragmented. The major service providers are the leading data and technology companies, for whom the automotive related ICV data platforms and other products business only accounts for a small proportion of their overall business. For customers in the public sector, due to data security and other reasons, the PRC-based market players have more competitiveness.



Source: Frost & Sullivan

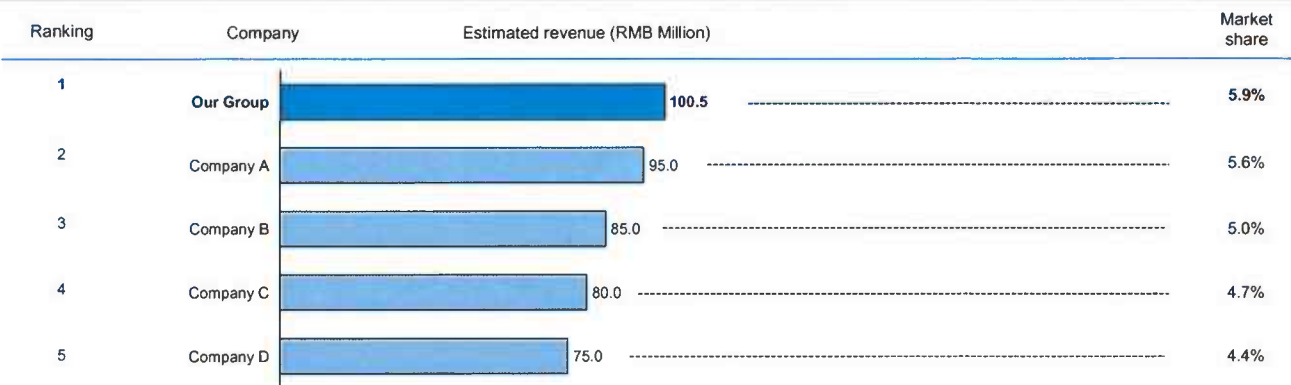
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Competitive Landscape Analysis

Ranking

Top Five Companies in the PRC ICV Simulation Testing Software and Platforms Industry by Revenue, 2023

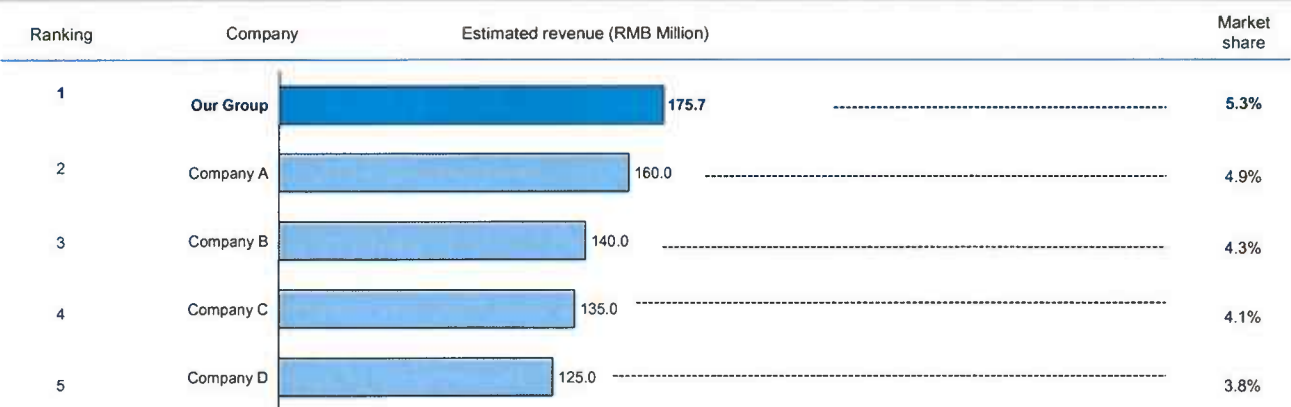


The market size of the PRC ICV simulation testing software and platform market reached approximately RMB1.7 billion in 2023. The top five players contributed to 25.7% of the entire market in terms of revenue. Saimo ranked first in the PRC ICV simulation testing software and platform market with a revenue of RMB100.5 million. VIREs, TASS International, Ansys do not provide ICV simulation testing platforms in the PRC whereas their ICV simulation testing products sold in China are typically specific software of the ICV simulation testing and related solutions rather than platform-based integrated solutions in China. These products generally have no or minimal level of customisation. In addition, they generally do not support concurrent access by multiple or unlimited users and do not include adaptation, debugging and related customized maintenance services. Saimo was also the largest provider of ICV simulation testing solutions in the PRC in 2023, with a market share of 5.9%. VIREs, TASS International, Ansys do not provide ICV simulation testing platforms in China mainly due to high investment and operational costs associated with customization, adaptation, and debugging services. Usually, these platforms require extensive customization, add-on development, and ongoing optimization to meet customer needs, which necessitates local R&D teams. Additionally, the evolving and complex regulatory framework in China discourages foreign competitors from substantial investment in ICV simulation testing platforms, leading them to offer standardized ICV simulation testing software instead.

Competitive Landscape Analysis

Ranking






Top Five Companies in the PRC ICV Testing, Validation and Evaluation Solutions Industry by Revenue, 2023



In 2023, the total market size of the ICV testing, validation and evaluation solutions industry by revenue in the PRC was approximately RMB3.3 billion. The Company aggregated a total revenue in the ICV testing, validation and evaluation solution of approximately RMB175.7 million, ranked the first with a market share of 5.3%. With Sim Pro and Safety Pro, Saimo become one of the few market players in China capable of providing integrated solutions that combine safety analysis and simulation testing functions. The products sold in the PRC by the other four top five market players in China's ICV simulation testing software and platforms market in terms of revenue in 2023, namely VIREs Simulations technologie GmbH, IPG Automotive GmbH, TASS International B. V. and ANSYS, Inc (collectively, the "Four Major Competitors"), except for IPG Automotive GmbH are usually a particular software of the ICV simulation testing and related solutions instead of platform-based integrated solutions. Their ICV simulation testing products sold in China are usually a particular software of the ICV simulation testing and related solutions instead of platform-based integrated solutions. These products are in relation to products with no or minimal level of customisation and do not allow concurrent access by multiple or unlimited users. Further, such products generally do not include adaptation and debugging services and related customised maintenance services. These products are generally standardised products with no or minimal level of customization and do not allow concurrent access by multiple or unlimited users. Further, such products generally do not include adaptation and debugging services and related customized maintenance services.

Competitive Landscape Analysis

Company Profile

Company	Software	Established Year	Company Profile
 Beijing Saimo Technology Co., Ltd.	Sim Pro & Safety Pro	2014	Beijing Saimo Technology Co., Ltd. is an enterprise specializing in R&D based on intelligent connected vehicles. It aims to provide full-stack testing, validation and evaluation solutions to promote the development of the ICV industry.
 VIRES Simulationstechnologie GmbH	VTD	1996	VIRES Simulationstechnologie GmbH (Parent company: HEXAGON) provides simulation solutions for the automotive, railroad, aerospace, shipping, mining, and farming industries and is providing its excellence for over 20 years. VIRES Simulationstechnologie GmbH is located in Southern Germany with an office in Wiener Neustadt, Austria.
 IPG Automotive GmbH	CarMaker	1984	IPG Automotive GmbH Develops simulation solutions consisting of software as well as hardware components for virtual vehicle development. With comprehensive solutions, it is equipping the entire mobility industry, from OEMs to suppliers, and support customers all around the globe to advance innovations and digitalize development processes.
 TASS International B. V.	Prescan	2013	TASS International (Parent company: Siemens) supports the global automotive industry in the creation of safer and smarter vehicles and is known for its unique development methodology, offering tailor made engineering solutions and state-of-the-art testing and certification facilities and services, with the aim to improve integrated safety systems of vehicles and boost the development of highly automated- and connected driving.
 ANSYS, Inc.	Ansys	1970	Ansys, Inc. is an American company based in Canonsburg, Pennsylvania. It develops and markets CAE/multiphysics engineering simulation software for product design, testing and operation and offers its products and services to customers worldwide.

- The top five companies in the PRC ICV simulation testing software and platform industry are well-known technology companies in the world who are either a listed company itself or belong to or are associated with a listed group whose shares are listed on various stock exchanges.
- Saimo is the pioneer of the integration of ICVs simulation testing and cloud platform technologies.

Source: Frost & Sullivan

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Competitive Landscape

The Main Players of the Simulation Testing Softwares Comparison

Software	Sim Pro&Safety Pro	VTD	CarMaker	Prescan	Ansys
Company	Saimo	VIRES	IPG	TASS International	Ansys
Major Business Coverage	Simulation testing software; Simulation testing platform; ICV data platform and other products; Simulation testing services; Road testing services (closed-course tests + open road tests), stimulation consulting service, etc.	Simulation testing software; Simulation software maintenance; Stimulation consulting service, etc.	Simulation solutions consisting of software as well as hardware components for virtual vehicle development.	Simulation testing software; Simulation software maintenance; Simulation testing services; Stimulation consulting service, etc.	Simulation testing software; Simulation software maintenance; Stimulation consulting service, etc.
Headquarter	the PRC	Germany	Germany	Netherlands	U.S.A
Cloud Function	Supporting	Supporting	Supporting	Supporting	Supporting
SOTIF	Supporting			Supporting	Supporting
Self-owned Scenario Database	Supporting	Supporting	Supporting	Supporting	Supporting
International Certificate	ISO 26262 (ASIL)-D	ISO 9001	ISO9001	ISO17025	ISO 9001 ISO 26262
Major Application of Simulation Testing Software	Automotive	Automotive, Aerospace, Railway, Mining, Farming, etc.	Automotive	Automotive	Aerospace, Automotive, Defense, Energy, Healthcare, High Tech, Industrial Equipment, etc.

- Saimo is one of the few industry players in the PRC capable of providing ICV testing, verification and evaluation solutions with FuSa and SOTIF analysis.

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Source: Frost & Sullivan

Competitive Landscape

Analysis of Cooperation Mode between Third-party Solution Providers and Government

- The autonomous driving technology requires plenty of simulation and road tests before commercialization. However, as an emerging technology, the autonomous driving technology still faces a lot of problems to overcome, such as the increasing cost of the tests, the lack of laws and regulations, the safety test of extreme scenarios and dangerous conditions, the changing road and traffic environment and different habits of drivers. In addition, low confidence level in the autonomous driving among the general public, safety and security issues and the resulting difficulties in widespread deployment and commercialization of ICVs remain some of the greatest challenges to autonomous driving or ICVs. the PRC is one of the biggest countries to manufacture automotive in the world. With the acceleration of the research and development process of automatic driving technology, the demand for vehicle simulation and road tests is increasing. The Chinese government maintains a cautious attitude towards the application of autonomous driving technology, which makes it important to conduct simulation and road tests of autonomous driving functions. The government usually purchased the relevant validation and evaluation software and services from third parties to meet the exuberant test demand of the market.
- The ICV testing, validation and evaluation can be further divided into simulation testing scenario tests and road tests. From the perspective of the road tests, the closed road scenario of the validation and evaluation has a variety of road demonstration scenes and communication networks to provide customers with validation and evaluation services of intelligent vehicles. In this case, government usually cooperates with third-party ICV testing, validation and evaluation solution and service providers. The government generally provides specific testing areas, the building of testing sites. The provision of corresponding validation and evaluation services are usually outsourced to the third-party service providers. For example, Saimo is one of the few authorised providers in the PRC to provide government-recognised third-party testing and other services across multiple cities including Beijing, Hangzhou, Shaoxing, Suzhou. With the help of cooperation relationship against some government sectors and demonstration sites equipped with simulation tests, close road tests, open road tests, etc., Saimo has competitive advantages over other market players.
- In the field of simulation testing scenario validation, companies with the advantages of software, hardware and service integration capability will be more favored by government and related agencies. Through close cooperation with the government, the ICV testing, validation and evaluation solution providers can participate in the national market supervision and policy formulation of ICV testing, validation and evaluation, and help the government realize effective policy guidance. In the future, the division of labor in the ICV testing, validation and evaluation solution industry will be clearer. The governments will pay more attention to the supervision and policy guidance, and tends to outsource services such as platform building, operation, validation and evaluation services to the third parties. The ICV test and evaluation software and platforms would collect and use relevant personal information. Therefore, for the sake of data security, the Chinese government are mainly responsible for the data classification management, and plays a key role in the security control of industry data. The government is one of the main simulation validation and evaluation data platform users of the industry and occupies an important position in the value chain.
- The cooperation between the government and third-party testing, validation and evaluation solution providers can realize the complementarity of advantages and resources and help the healthy development of the ICV testing, validation and evaluation industry.

Agency	Advantages
Government	Policy control, data control, financial support, rich road resources, etc.
Third-party Institution	Data collection and analysis ability, validation and evaluation capability, validation and evaluation platform building ability, software R & D capability, test place operation and management capability, etc.

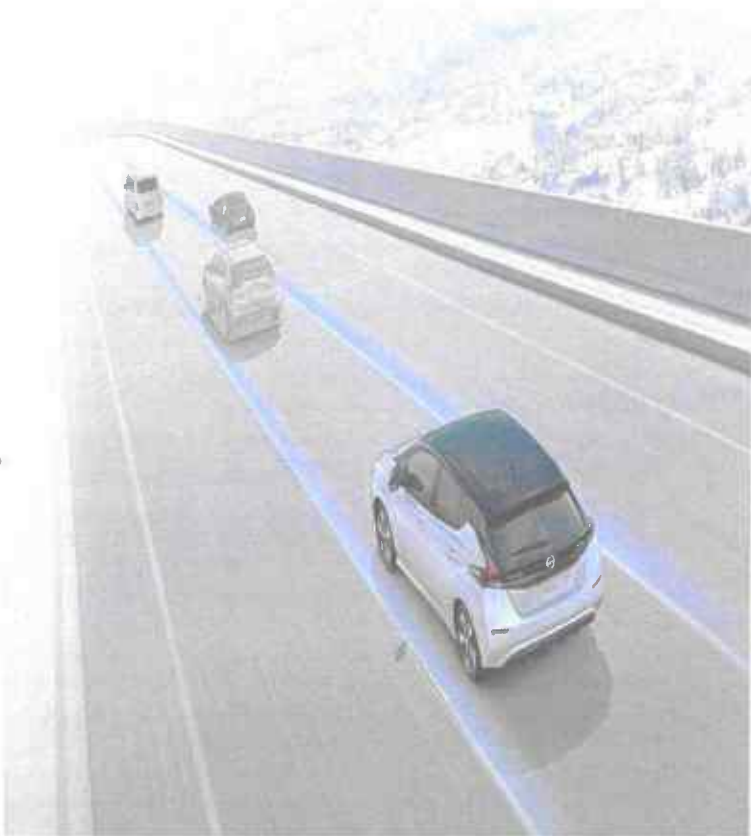


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Source: Frost & Sullivan

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Appendices

Overview of European ICV Testing, Validation and Evaluation Solution Industry

- Europe was the second largest automotive market in the world, accounting for approximately 23.1% of the overall global passenger vehicle sales in 2021. Meanwhile, Europe is a region with an early start of development of NEVs, and has formulated relatively strict carbon emission standards and a number of incentive policies for NEVs. Driven by supportive policies such as subsidies, the NEV market in Europe experienced a rapid development. The sales volume of NEVs in Europe reached around 1,703.4 thousand units in 2021. As the consumers' awareness of NEVs continues to increase, local European automotive manufacturers are gradually shifting their development focus from traditional ICE vehicles to the NEVs to better meet the demands of the consumers. In addition, some European countries have set a clear target year for the ban on the sale of fuel vehicles. It is expected that the sales of NEVs in Europe will enter a rapid development period, increasing from 2,212.9 thousand units in 2022 to 5,594.7 thousand units in 2026 at a CAGR of approximately 26.1%. The penetration rate of NEVs in sales volume of PVs in Europe will also witness a remarkable growth, increasing from 14.9% in 2022 to 33.9% in 2026. Driven by the continuous growth of European automotive market, the European ICV testing, validation and evaluation solution industry has large development potential.
- CCAM (Connected, Cooperative, Autonomous and Automated Mobility), a term widely adopted in Europe to describe intelligent connected vehicles, has great potential to improve traffic management, road safety, liveability and comfort. Therefore, all over Europe companies and governments are preparing for the implementation of CCAM. On 17 May 2018, the European Commission adopted a Communication "On the road to automated mobility: An EU strategy for mobility of the future, whereby the Commission announced its intention to establish a single EU-wide platform grouping all relevant public and private stakeholders to coordinate open road testing of Connected and Automated Mobility (CAM) and make the link with pre-deployment activities. Meanwhile, targets and initiatives regarding CCAM have been set by the European Governments as well. According to the "Sustainable and Smart Mobility Strategy" issued in 2020 by the European Commission, it is aimed that automated mobility will be deployed at large scale in EU by 2030. The European Road Transport Research Advisory Council (ERTRAC), the European Technology Platform (ETP) for Road Transport recognized and supported by the European Commission, also published the latest "Connected, Cooperative and Automated Mobility Roadmap" in February, 2022, in which objectives and visions of the long-time development of CCAM in Europe were explained.
- In terms of ICV testing, large scale testing program has been carried out in Europe. For example, L3Pilot, a project uniting over 30 partners (including automotive manufacturers, suppliers, research, SMEs, insurers, one authority and one user group), has performed large-scale piloting of automated driving with developed SAE Level 3 and Level 4 functions in passenger vehicles in over 10 European countries since 2017. At the end of February 2021, the European L3Pilot project completed the test of ADF(Automated Driving Functions) on public roads. In addition to European automotive manufacturers, companies from other places such as Tesla and Panasonic have conducted automated driving testing in Europe. Furthermore, some leading Chinese players such as Saimo, in the ICV testing, validation and evaluation solution industry have prepared to expand their business to Europe and cooperate with more overseas partners, which can coordinate the resources globally and together promote the development of the industry. Driven by factors such as policy support, technology advance, and industrial cooperation, it is expected that the European ICV testing, validation and evaluation solution industry will maintain a rapid development trend in the future.

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- Saimo has the database with one of the most scenarios in the PRC.
- Saimo has first mover advantage in the ICV testing, validation and evaluation industry among the PRC players.
- Sim Pro was the first ICV simulation testing, validation and evaluation tool chain in the world to have obtained the ISO 26262 ASIL D certification.
- Sim Pro is one of the only few simulation solutions in the PRC to support all of the three simulation methods: (i) traditional simulation method; (ii) scenario restoration method; and (iii) simulation through driving simulator.
- The scenario generalization and effectiveness analysis algorithms of Sim Pro are industry-leading features of simulation solutions.
- Safety Pro is one of the only few safety analysis software around the world that support SOTIF analysis.
- Saimo is one of the few simulation solutions providers in the PRC capable of providing self-developed safety analysis tool so as to realise the simulation testing and safety analysis.
- The Company is one of the first industry players in the PRC to provide one-stop ICV testing, validation and evaluation solutions for ICVs.
- Cloud-based simulation testing solutions represent an upcoming trend for ICV simulation testing technologies.
- The development of proprietary and localised simulation testing software also aligns with the PRC's national strategy of "independent and controllable" development, which was put forward in the Outline of the People's Republic of the PRC 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035* (中華人民共和國國民經濟和社會發展第十四個五年規劃和2035年遠景目標綱要).
- Sim Pro emerged as a significant domestic alternative to imported ICV simulation testing software and with it, the PRC no longer needed to rely heavily upon the ICV simulation testing software developed by foreign enterprises.
- According to F&S, ICVs require massive scenario-based testing in their R&D process as well as for the purpose of satisfying mass-production and market access standards in the future, but the construction of self-owned scenario databases is costly and time-consuming.
- According to F&S, Europe is the second largest automotive market in the world, accounting for approximately 23.1% of the overall sales of global passenger vehicles in 2021. It is also an region with an early development of ICVs.

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- The ICV and ICV testing, validation and evaluation industries are evolving at a fast pace with rapid technological advancement and changing customer needs.
- It is generally accepted among the global ICV testing, validation and evaluation industry that ICVs need to drive millions or billions of test miles to demonstrate that they are safe and reliable.
- Although it is sufficient for ADAS-level autonomous driving functions of ICVs to be tested in limited and specific scenarios, massive testing scenarios are required to test and validate autonomous driving at L3 or above.
- ICVs, like traditional vehicles, is highly regulated in the PRC. Although ICVs are still at a preliminary development stage and the relevant laws, rules, regulations and policies relating to ICVs are still evolving, it is expected that the ICV industry will be subject to a more stringent regulatory environment when such laws, rules, regulations and policies are formally promulgated.
- Going forward, the PRC government will continue to promote the establishment ICV Demonstration Areas and the formation of ICV related laws, regulations and standards to ensure the product quality, vehicle safety and data security of the ICV industry.
- Customers of ICV testing, validation and evaluation products and services usually have stringent criteria and lengthy processes for selection of suppliers.
- With the development of the ICV testing, validation and evaluation solution industry, the testing, validation and evaluation solutions are expected to be applied in more new industries such as drones, digital city twin and agricultural machinery, etc.
- Breakthroughs in simulation technology are pivotal to the intelligent transformation and upgrade of the PRC's automotive industry. Simulation technology is the simulation modelling technology that employs simulation hardware and software and utilises mathematical methods to digitally imitate the characteristics and behaviours of real-world systems or processes. Simulation software belongs to a subsegment of industrial software, and is the key technology to promote the transformation and upgrade of the automotive industry.
- With the enhanced intelligence level of automobiles, the R&D processes of automobiles' technologies are becoming increasingly complex, and the pressure on controlling the automobile's development costs and the product cycle is increasingly high. The traditional testing, validation and evaluation methods are no longer sufficient to support the R&D of many new technologies associated with automotive safety, which requires the development of simulation testing, validation and evaluation software and software applicable to the entire product cycle of intelligent automotive products.
- Europe and South Korea host a significant number of automotive manufacturers, giving rise to the emergence of many ICV-related technology.

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- Vehicle simulation testing uses technologies such as sensor simulation, vehicle dynamic model simulation, advanced graphics processing, traffic flow simulation, and road modelling to simulate testing environments, and with the addition of algorithms, to construct relatively realistic driving scenarios.
- Generally speaking, the development of an intelligent driving system of an automobile needs to go through each of XiL simulation testing (comprising MiL, SiL, HiL, ViL and DiL), testing at closed-course sites, and finally, large-scale road testing at open roads.
- As such, the development of and breakthroughs in simulation technologies are imperative to the design, R&D and manufacturing of intelligent vehicles. Further, the vehicle simulation industry in the PRC has been dominated by Germany and the U.S. for a long time. The development of domestic reliable simulation software is, therefore, crucial for the intelligent transformation and upgrade of the PRC's vehicle industry.
- SOTIF is key to ensure the safety of ICVs. According to the statistics of the National Highway Traffic Safety Administration of the U.S., a vast majority of traffic crashes are caused by human error; hence, it is of great significance for intelligent vehicles to replace human drivers with machines to improve the driving safety. However, existing technologies are still insufficient to fully achieve the safety benefits of intelligent vehicles. Further, new safety issues such as SOTIF issues have emerges alongside the introduction of intelligent vehicles. SOTIF specifically refers to the mitigation of safety risks resulting from insufficiencies, limitations or weaknesses in the design or intended functionalities of the vehicles when they encounter external triggering events (such as environmental disturbances or human misuse). As the intelligence and complex level of intelligent automotive systems keeps growing and their driving environments become increasingly complex and challenging, SOTIF has become the key issue in ensuring the safety of ICVs.
- Effective SOTIF analysis software can help developers identify and analyse potential functional deficiencies, triggering events and SOTIF-related hazards of intelligent vehicles in known and unknown driving scenarios in a much more efficient, thorough and scientific manner, which will help them greatly improve the safety and reliability of the intelligent vehicles.
- Currently, the traditional vehicle industry has entered into transformation period and there has been accelerated pace of technological and product innovation in the PRC's intelligent vehicle industry.
- ICV developers equipped with the capability to perform ICV simulation tests, generally also have the demand for collecting real-life road data and generating road acquisition scenarios on their own.
- According to F&S, the ICV testing, validation and evaluation solutions market in the PRC has a thirsty demand for quality scenario generalisation and optimisation software that could help ICV developers achieve high levels of scenario coverage with low levels of scenario usage.

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- According to F&S, it is the industry norm for software developers in the PRC to partner with distributors to sell software products to end users.
- We are a leading technology-driven company in the PRC focusing on independent innovation of simulation technologies, and primarily engaged in the design and R&D of ICV simulation testing products and the provision of related testing, validation and evaluation solutions.
- Safety Pro is one of the only few safety analysis software in the world that is capable of supporting SOTIF analysis.
- In 2018, Saimo was appointed as Hangzhou's one of the very few ICV third-party testing institutions, and subsequently in 2020, Saimo's core product Sim Pro was designated as Beijing's one of the very few qualified ICV simulation testing platforms. Based on such appointments, Saimo became qualified to provide government-recognised ICV testing and related services to enterprises in their applications for ICV open-road test licences in relevant cities. Saimo has recently also been appointed as Shaoxing's one of the very few ICV third-party testing institutions, making it capable of providing similar services in Shaoxing starting from November 2022. According to F&S, Saimo is one of the few government-authorised providers in the PRC to provide testing and other services in relation to and in support of ICV open-road tests in multiple cities in the PRC.
- Sim Pro became the world's first ICV simulation testing, validation and evaluation tool chain that had passed the highest-level functional safety product certification (ISO 26262 ASIL-D certification) in June, 2021.
- Compared with traditional internal combustion engine vehicles, the architecture of electric vehicles is more suitable for carrying more advanced intelligent driving technologies. At present, with the increasing awareness of consumers for the ICVs, the automotive manufacturers are focusing more on the high-level (L3 and above) intelligent connectivity and intelligent driving technologies to gain more competitive advantages, which stimulates the demand for the ICV testing, validation and evaluation solution.
- The demand of ICV road testing services in the PRC is expect to grow in the future.
- With rich and expandable interfaces, Sim Pro can support the testing of ICVs' intelligent driving solutions through different XiL testing methods ranging from MiL, SiL, HiL, DiL to ViL.

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- Depending on users' testing requirements, Sim Pro can utilise different scenarios, evaluation criteria and/or interfaces through test management to achieve different testing purposes. Sim Pro can also be embedded into cloud infrastructures so as to achieve larger-scale and faster simulation testing through parallel computing (i.e. the function to run multiple simulation tests simultaneously) and accelerated computing (i.e. the function to speed up the testing work), which substantially improve testing efficiency. Specifically, for large-scale testing, Sim Pro can collect and generate samples for specific scenarios from a full set of generalised scenarios, so as to achieve the appropriate level of scenario coverage (such as typical scenarios, dangerous scenarios and extreme scenarios) while at the same time minimising the number of scenario samples used for testing.
- According to F&S, Saimo's simulation solutions have one of the largest scenario databases in the PRC in terms of the volume of scenarios.
- SOTIF is governed by the international standard ISO 21448 published in June 2022. It is an indispensable requirement for high-level autonomous driving at L3 and above, where the responsibilities to ensure safety are assigned to the autonomous driving systems instead of human drivers.
- According to F&S, based on the FuSa and SOTIF analysis capability enabled by Safety Pro, Saimo is one of the few industry players in the PRC capable of providing ICV simulation testing, validation and evaluation solutions with FuSa and SOTIF analysis functions.
- According to F&S, although it is sufficient for ADAS-level intelligent driving functions of ICVs to be tested in limited and specific scenarios, massive testing scenarios are required to test and validate high-level autonomous driving at L3 or above. As such, the traditional standalone simulation testing becomes limited due to the lower computing capabilities and inability to perform accelerated testing, which ultimately result in lengthy testing cycles and lower testing efficiency.
- As one of the innovation and technology hubs in the PRC, Hangzhou houses a number of intelligent driving technology giants. It has been a pioneer city in promoting the development of ICV and related industries in the PRC, according to F&S.
- In recent years, there has been increasing recognition of the benefits and importance of big data platforms in promoting data collection and sharing, and the innovation and development of the ICV industry. Specifically, solution providers may compile and collect scattered and isolated vehicle data into comprehensive data platforms and therefore help regulators to effectively track and regulate the data as well as the market overall. In August 2020, the State Council issued New Energy Automotive Industry Development Plan (2021-2035)(新能源汽车产业发展规划(2021-2035年)) which puts forward the national plan for the automotive and related industries to build a comprehensive cross-region and cross-industry big data platform to facilitate the data collection and sharing in the ICV industry and promote the development and innovation of ICVs.

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- According to F&S, the ICV data platform and other products are also beneficial to private sector players in the ICV industry to help them break the information barrier between different internal departments and achieve better information management within the organisation and the integration of technology, business and data. Such platform building projects require both hardware components and software solutions to be integrated in a single platform.
- Going forward, apart from the MIIT's initiative as described above, it is expected that other provincial governments in the PRC will also successively issue similar policies to promote the development of ICV data platform systems at regional level. In the private sector, customers in the ICV industry will gradually expand their business which requires the conduct of more data analysis and require more cloud services, hence further boosting the demand for ICV data platform and other products.
- Saimo is a pioneer in the ICV testing, validation and evaluation solution industry in the PRC. Saimo is an industry pioneer with in-depth industry knowledge and experience as well as familiarity with industry laws, regulations and standards.
- The use of drones in different industries such as surveying and mapping, security monitoring, agriculture, forestry and plant protection is increasing.
- ICV testing, validation and evaluation solution providers do not generally enter into any long-term agreements for the provision of their services with customers, and only entered into written contracts with them on a project-by-project basis, which is in line with industry practice according to F&S.
- After all the implementation and installation works are completed, the project deliverables will be subject to a thorough inspection by the customer itself or a third party inspection team (generally an expert panel engaged by public sector customers, which is not uncommon in the industry).
- The ICV testing, validation and evaluation solution industry in the PRC is still at the preliminary development stage and it is not uncommon for the market players to have a limited number of customers. However, with the development of the ICV market, the demand from both private and public sectors will increase.
- Through years of rapid development, our ICV testing, validation and evaluation solutions have been widely known to or used by top-tier market players in the field of ICVs in the PRC. According to F&S, customers of ICV testing, validation and evaluation solutions usually have stringent criteria and lengthy processes of selecting suppliers. Therefore, they tend to maintain high loyalty to their selected suppliers.
- Specifically, Saimo is the only the PRC-based ICV simulation testing software and platforms provider among the top five players in the PRC in terms of revenue in 2021 according to F&S. Being the domestic pioneer in the PRC ICV simulation testing, validation and evaluation industry, Saimo is able to obtain the first hand information regarding the policies and standards adopted by the PRC authorities and to provide customized and localised solutions for domestic automotive manufacturers to respond to their varying demand to cater for the development of ICVs in the PRC.

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- According to F&S, it is the industry norm for software developers in the PRC to partner with distributors to sell software products to end users.
- According to F&S, with an aim to pushing forward the commercialisation of ICVs in the PRC, the PRC government authorities, including the MIIT and the MPS, have pledged to accelerate amending traffic laws to establish a comprehensive legal framework with inclusive technical standards for research and development, testing, delivery, and public use of ICVs by 2025. The PRC government encourages collaboration with and active participation of private enterprises in the development, commercialisation and standardisation process for the ICV sector in the PRC.
- The hardware and certain software components that ICV testing, validation and evaluation solution providers purchased externally for building ICV simulation testing platforms and ICV data platforms are generally generic products which are readily available from numerous hardware manufacturers and software developers in the market.
- SGS Group is a world-leading testing, inspection and certification entity providing independent inspection, verification, testing and certification services for a wide array of industries including ICV industry.
- Huawei is a leading global information and communications technology solutions and smart devices provider, and has in recent years expanded its business into the ICV industry.
- Beijing Brston, being an established software-related service provider focusing on the automotive industry in the PRC.
- Digital city twin is a digitized copy of a city in the real world. As a completely virtual scale model, it allows the simulation of city development plans, which helps city planners perform city planning and problem analysis through data-rich digital models of the city.
- Sim Pro, which is the first simulation tool chain in the world to have met the highest functional safety level (i.e. ASIL D) under the international standard ISO 26262.
- The development of ICVs at L3 or above lags behind ADAS levels ICVs principally because the industry has historically lacked detailed and recognized policy and standards necessary for the establishment of an infrastructure for the systematic development of the L3 or above ICV autonomous driving industry, which also creates business uncertainty for automotive manufacturers intending to invest in such autonomous level of ICVs. Against that background, ICV testing, validation and evaluation solution providers usually focused more on public sector customers in the early part of their development which is naturally the first group of customers in an industry at its early stage of development for the purpose of implementing the infrastructure necessary for its future development and participation by the private sector players.

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- Automotive manufacturers and technology companies in the ICV industry have, to different degrees, slowed down their R&D activities and plans amidst COVID-19, resulting in lower demand for ICV simulation testing solutions; and as a result of the lockdowns, travel restrictions and other limitations adopted by the PRC government in many cities in the PRC, especially Chongqing and Shanghai, activities, such as business meetings, client visits and contract negotiations, are affected, causing delays in contract signing in ICV industry.
- According to F&S, with a market share of approximately 5.9%, we are the fourth largest player in the PRC's ICV simulation testing software and platforms market and the largest the PRC-based player in such market in terms of revenue in 2021, as the other four out of the top five market players are all foreign enterprises.
- The outbreak of a respiratory illness caused by novel coronavirus disease 2019, later known as COVID-19, has affected the PRC and many parts of the world in recent years. On 30 January 2020, the WHO declared the COVID-19 outbreak a public health emergency of international concern, and on 11 March 2020, the WHO declared the global COVID-19 outbreak a pandemic. Since then, there has continued to be significant uncertainties and risks amidst the COVID-19 pandemic, including in respect of the spread and mutation of the virus, public health threats of the disease, the possibility of the continuance and reoccurrence of outbreaks, numerous measures taken by government authorities in the PRC and globally to contain the pandemic, and the scope and length of the resulting disruption of domestic and global economies, and many others. More recently, since early 2022, the Omicron and other new variants have become the dominant variants in the PRC and has led to local outbreaks in various cities and areas in the PRC, including Beijing, Shanghai, and Hangzhou. As a result, the PRC local governments have adopted a series of prevention and containment measures to control the spread of COVID-19.
- Specifically, due to the recent waves of the COVID-19 resurgences and stringent containment measures adopted by the government in Beijing and other cities in the PRC, automotive manufacturers and technology companies in the ICV industry have, to different degrees, slowed down their R&D activities and plans, resulting in lower demand for ICV testing services in the industry as a whole.
- The Shunyi Testing Site was established with the backing of the local government in Shunyi District, Beijing to support the development of the local ICV industry and is an ICV testing site equipped with close-course and related ICV testing capabilities in Beijing.
- It is common for government's ICV testing sites to be outsourced to industry players for management and operation.
- Hangzhou is also a pioneer city in promoting the development of ICV and related industries in the PRC.

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- ICV testing, validation and evaluation solution providers usually do not enter into any long-term agreements with their suppliers and mainly enter into written contracts with their suppliers on a project-by-project basis which is in line with industry practice according to F&S.
- The adverse impact of COVID-19 include (i) the fact that automotive manufacturers and technology companies in the ICV industry have, to different degrees, slowed down their R&D activities and plans amidst COVID-19, resulting in lower demand for ICV simulation testing solutions; and (ii) the impacts of the COVID-19 containment measures adopted by the PRC government in many cities in the PRC, especially Chongqing and Shanghai.
- The growth of the market of L3 or above ICVs is poised to gather strong momentum in the next five to 10 years, according to F&S.
- The aforesaid issue together with the customer concentration of Saimo are not uncommon in the ICV testing, validation and evaluation solutions industry in the PRC.
- One of Saimo's customers was one of the largest cloud-based simulation testing platforms in the PRC up to 2022 on the expected test miles the platform could achieve per day (i.e. 11 million km).
- A third party inspection team, generally an expert panel engaged by public sector customers, which is not uncommon in the industry according to F&S.
- Saimo is also one of the several top-ranking market players capable of providing one-stop ICV testing, validation and evaluation solutions in the PRC.
- There were thousands of market players in Europe and South Korea in 2022 which engaged in the business of software development, IT outsourcing services and algorithm development with relevant proprietary technologies and intellectual property rights and could be the potential targets of strategic investment and acquisition for Saimo.
- The ICV testing, validation and evaluation market is characterised with relatively high entry barriers for new entrants to the market according to F&S.
- According to F&S, such hardware and software components are generally readily available with high replaceability in the market.
- The PRC economy has been adversely affected by the outbreak of the COVID-19 pandemic since the first quarter of 2020 and is expected to continue to experience a short-term economic slowdown.
- Further, it is expected that the market share of ICV simulation testing software and platforms in terms of revenue in the PRC's ICV testing, validation and evaluation solutions market will maintain over 50% in 2022 and further increase to over 75% in 2030.

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- According to F&S, ICV data platform and other products are also beneficial to private sector market players in the ICV industry to achieve better information management within their organizations and the integration of technology, business and data. Such platform building projects generally require both hardware components and software solutions to be integrated in a single platform.
- Saimo's self-developed ICV simulation testing, validation and evaluation tool chain Sim Pro is the first of its kind in the world to have obtained the ISO 26262 certification at the highest functional safety level (i.e. ASIL D) in 2021, which signifies recognition of the high confidence-level of Sim Pro.
- Simulation software developed by most other domestic and international ICV simulation solutions providers in China is generally single-tool solution, which usually only incorporates one or only a few.
- Except for the Company, none of the other top five market players in the ICV simulation testing software and platforms market in terms of revenue in China in 2021, namely, VIREs, TASS International, Ansys and AVSimulation, is also qualified or designated to provide government-recognised ICV third party testing services in China.
- Over 90% of the autonomous driving tests are completed through simulation testing conducted with the help of simulation testing platforms or software and only less than 10% through road testing conducted at closed-course testing sites or open roads.
- Europe is the second largest automotive market in the world, accounting for approximately 23.1% of the overall sales of global passenger vehicles in 2021. It is also a region with an early development of ICVs. In terms of ICV testing, validation and evaluation solutions market in Europe, it is relatively fragmented, with multiple players operating in the market and compete on the basis of product offerings, pricing, customer service, etc. Established local players have strong reputation and customer bases. With the increasing focus on safety and emissions compliance, there is a growing demand for specialized testing and validation services, creating opportunities for new players to enter the market. In recent years, Chinese ICV testing, validation, and evaluation solutions companies are increasingly looking for opportunities to expand their presence in the overseas market. Leading domestic market players need to keep investing in research and development, comply with Europe local regulations, and build trust and credibility with European customers to be successful in the long run.
- There is demand from the downstream customers in the ICV testing, validation and evaluation solutions industry for self-owned ICV simulation testing platforms and ICV data platform and other products.
- The major foreign market participants of ICV testing, validation and evaluation solutions market, including the four foreign market players among the top five market players in the ICV simulation testing software and platforms market in China in 2021, usually focus on a particular tool or software of ICV simulation testing and related solutions and do not provide ICV simulation testing platforms and ICV data platform and other products in China and are therefore unable to meet the demand of the downstream market for such solutions.
- Domestic ICV simulation testing and safety analysis solutions, including Sim Pro and Safety Pro, are generally easier to use for domestic customers as compared to those of the foreign peers, which is primarily attributable to the fact that domestic solutions (including their built-in scenarios) are more compatible with the driving environment and driver habits in China.

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- Generally, for private sector customers such as technology companies and automotive manufacturers, it is more cost-effective to purchase ICV simulation testing software and platforms from suppliers of dedicated technologies compared to developing their own; it therefore forms an industry practice for private sector customers in the ICV simulation testing, validation and evaluation solutions industry to purchase ICV simulation testing software from third parties rather than developing their own.
- It is respectfully submitted that pursuant to the Distribution Agreement, Saimo is responsible providing after-sales services (including repair of defects, software upgrade, technical support, training, etc.) in respect of the software products sold by Beijing Brston to its customers, as Beijing Brston does not have the relevant technical capabilities to provide such services, which is in line with the industry practice for distributors.
- The progressive discounts of 15% to 50% Saimo offered to its distributor, Beijing Brston, on the price of Saimo's software products purchased by Beijing Brston is an industry norm in the ICV simulation testing software market in the PRC.
- Simulation software developed by most of the other domestic and international ICV simulation solutions providers in China is generally single-tool solution, which usually only incorporates one or only a few models and hence is only able to provide a limited coverage of functionalities.
- It is estimated that there were only five to ten ICV testing service providers in the PRC qualified to provide government-recognized ICV third party testing services in China.
- There are less than 50 ICV manufacturers are engaged in the development of L3 or above autonomous driving solutions.
- The ICV testing, validation and evaluation solutions industry does not have substantial seasonal characteristics and it is not an industry norm for ICV testing, validation and evaluation solutions providers tending to deliver more products and services in the second half of a given year.
- Although road testing is much more costly, time-consuming and dangerous as compared to simulation testing, it is still indispensable for the testing, validation and evaluation of ICVs as road testing provides the vehicles with realistic driving scenarios that the vehicles will inevitably encounter when they are launched on real roads in the future. Whereas closed-course site testing does not require enterprises to obtain any licence as a prerequisite for the testing of their ICVs at the closed-course testing sites and is therefore more flexible, open-road testing can offer more testing scenarios and such scenarios are more realistic than the testing scenarios manually constructed at the closed-course testing sites. As such, both forms of the road testing are necessary for comprehensive ICV testing, validation and evaluation.
- One of Saimo's customers was one of the largest cloud-based simulation testing platform in the PRC up to 2022 on the expected test miles the platform could achieve per day (i.e. 11 million km).
- The ICV simulation testing software of some of the Four Major Competitors, such as VIREs Simulationstechnologie GmbH, TASS International B.V. and AVSimulation, can perform VIL testing.
- The Group's duration for a substantial upgrade and iteration of ICV standalone product is in line with the industry norm.
- The price of the extended warranty services of ICV simulation testing platforms and ICV data platforms is expected to be fixed at approximately 5% to 10% of the original contract value of the platforms each year, which is in line with the industry norm.

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- The potential downstream customers of ICV testing, validation and evaluation solutions providers include not only ICV manufacturers but also other market participants in the ICV industry (such as technology companies), whose business encompasses vehicle design, engineering, prototyping, manufacturing, technology R&D and quality control. By 2022, there are approximately 500 to 600 technology companies in the PRC which are engaged in the development of ICV-related software and hardware and play a crucial role in providing innovative solutions in relation to various aspects of ICVs. It is estimated that there will be approximately 800 to 1,200 ICV manufacturers in China engaging in the development of intelligent driving solutions at L3 or above, along with 2,500 to 3,500 technology companies focusing on the development of ICV-related software and hardware by 2030.
- The ICV testing, validation and evaluation solutions provider generally grants licences with no limitation on the period of use in respect of its standalone software products sold, which is in line with the industry practice.
- The ICV simulation testing software and platforms undergo substantial upgrade and iteration once every three to five years.
- There are no universally accepted definitions for "ICV simulation testing platforms" and "ICV simulation testing software" within the ICV testing, validation and evaluation solutions industry.
- Some of the major foreign competitors (including the Four Major Competitors) do not provide ICV simulation testing platforms in the PRC, which involve high level of customization and provision of adaptation and debugging services, primarily due to the following reasons:

(i) High investment and operational costs

Generally, building an ICV simulation testing platform requires high level of customisation (such as developing customised modules and functions) and provision of adaptation and debugging services in relation to the ICV simulation testing platforms in a timely and responsive manner. To meet the customers' needs for high level of customisation, an ICV simulation testing platform provider is required to (i) work closely and maintain frequent communication with its customers to understand their needs; (ii) perform substantial add-on development works based on the customers' initial requests; and (iii) further optimise and enhance the ICV simulation testing platforms based on the ongoing communication with the customers and changes in their requests. In addition, due to the fact that ICV simulation testing platforms involve more modules and specific hardware, customers generally require the assistance of ICV simulation testing platform providers to adapt and integrate the ICV simulation testing platform into the customers' IT infrastructure and provide debugging services to ensure compatibility of software and hardware. As such, having a local R&D team with expertise in algorithm and coding, and a deep understanding of local market conditions and customer preferences is essential to the provision of ICV simulation testing platform in the PRC. Apart from staff costs and necessary software and equipment for R&D, an ICV simulation testing platform provider would also need to invest in other aspects of their local operations, including but not limited to procurement, sales and marketing, customer retention and after-sales product maintenance. Compared to the provision of ICV simulation testing software, where the products and services are ready-made with no or minimal level of customisation and the local operations can be kept at relatively small scale, the costs of providing ICV simulation testing platform is significantly higher for the foreign competitors.

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(ii) New and evolving PRC regulatory framework

ICV simulation testing software and platforms providers are expected to have a thorough understanding of local ICV-related laws, regulations, policies and standards ("ICV-related Regulatory Requirements") to ensure that their products, especially their ICV simulation testing platforms, can help customers fulfil the ICV-related Regulatory Requirements. However, according to F&S, the regulatory framework governing ICV and ICV testing, validation and evaluation solutions markets in the PRC is complex and still evolving, the uncertainties of which may therefore deter foreign market players from making substantial investment to establish operations for the provision of ICV simulation testing platforms in the PRC. Instead, foreign market players choose to offer their standardised ICV simulation testing software, which allow them to tap into the relevant market in the PRC while keeping a limited or relatively low level of the additional investment costs. In contrast, given the Group has been dedicated to the in-depth research of ICV-related Regulatory Requirements of the PRC since 2018, the Group has a good understanding in such regard and hence is able to update its ICV simulation testing software and platforms in response to the latest development in the ICV-related Regulatory Requirements in an efficient manner.

Generally ICVs are yet to be in mass production when open-road test licences are sought. ICV manufacturers often build prototypes of the ICVs by way of modifying existing vehicles. In addition, they often build more than one prototype of the same ICV model affect the criteria and scope of ICV simulation tests and closed-course site tests.

ICVs equipped with L3, L4 and L5 autonomous driving technologies are currently not allowed to be sold to the public and can only operate in the specific scenarios for the purpose of experiment and demonstration, as there are still no promulgated laws, regulations or standards regarding their market entry in China.

It is not uncommon in the industry for distributor to purchase ICV sim testing software where return of products or refund is not allowed.

公司的经营模式是根据公司的实际经营情况、行业发展情况以及客户使用需求等因素确定的。影响公司经营模式的的关键因素包括公司发展战略、行业相关法律法规及政策、行业供求状况以及行业技术发展水平等。

Among the several methods of ICV testing, validation and evaluation, simulation testing is the most commonly used method to test ICVs, as over 90% of the autonomous driving tests are now conducted through simulation testing. Simulation technology employs simulation hardware and software and utilises mathematical methods to digitally imitate the characteristics and behaviours of real-world systems or processes. Vehicle simulation testing uses such simulation technology to construct relatively realistic driving scenarios to test and validate the functional completeness and safety of the vehicles in simulated testing environments. As compared to physical vehicle testing at closed-course sites or open roads, simulation testing can achieve massive vehicle tests in shorter time, in more corner or extreme scenarios, and in a safer environment.

According to F&S, during the period from 2015 to 2022, the ICV simulation testing technology had been steadily developing outside China with more systematic standards and specifications published in various industry publications.

It is estimated that approximately 300 to 400 ICV manufacturers in China in 2022.

As at the Latest Practicable Date, it is estimated that there were only 5 to 10 ICV testing service providers in the PRC who are qualified to provide government-recognised ICV third party testing services in China. Further, except for Saimo, none of the other top five market players in the ICV testing, validation and evaluation solutions industry and the ICV simulation testing software and platforms market in terms of revenue in China in 2022 is also qualified or designated to provide government-recognised ICV third party testing services in China.

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As compared to physical vehicle testing at closed-course sites or open roads, simulation testing can achieve massive vehicle tests in shorter time, in more corner or extreme scenarios, and in a safer environment.

Saimo generally grant licences with no limitation on the period of use in respect of our standalone software products sold, which is in line with the industry practice.

Once an ICV testing, validation and evaluation solution provider enters the recognised list of suppliers of downstream customers, the cooperation relationship will generally last for a long time.

Saimo's R&D expenditure is in the normal range in the industry.

Some of the Saimo's major foreign competitors (including the Four Major Competitors) do not provide ICV simulation testing platforms in the PRC, which involve high level of customisation and provision of adaptation and debugging services, primarily due to the following reasons:

(i) High investment and operational costs

Generally, building an ICV simulation testing platform requires high level of customisation (such as developing customised modules and functions) and provision of adaptation and debugging services in relation to the ICV simulation testing platforms in a timely and responsive manner. To meet the customers' needs for high level of customisation, an ICV simulation testing platform provider is required to (i) work closely and maintain frequent communication with its customers to understand their needs; (ii) perform substantial add-on development works based on the customers' initial requests; and (iii) further optimise and enhance the ICV simulation testing platforms based on the ongoing communication with the customers and changes in their requests. In addition, due to the fact that ICV simulation testing platforms involve more modules and specific hardware, customers generally require the assistance of ICV simulation testing platform providers to adapt and integrate the ICV simulation testing platform into the customers' IT infrastructure and provide debugging services to ensure compatibility of software and hardware. As such, having a local R&D team with expertise in algorithm and coding, and a deep understanding of local market conditions and customer preferences is essential to the provision of ICV simulation testing platform in the PRC. Apart from staff costs and necessary software and equipment for R&D, an ICV simulation testing platform provider would also need to invest in other aspects of their local operations, including but not limited to procurement, sales and marketing, customer retention and after-sales product maintenance. Compared to the provision of ICV simulation testing software, where the products and services are ready-made with no or minimal level of customisation and the local operations can be kept at relatively small scale, the costs of providing ICV simulation testing platform is significantly higher for the foreign competitors.

(ii) New and evolving PRC regulatory framework

ICV simulation testing software and platforms providers are expected to have a thorough understanding of local ICV-related laws, regulations, policies and standards ("ICV-related Regulatory Requirements") to ensure that their products, especially their ICV simulation testing platforms, can help customers fulfil the ICV-related Regulatory Requirements. However, according to F&S, the regulatory framework governing ICV and ICV testing, validation and evaluation solutions markets in the PRC is complex and still evolving, the uncertainties of which may therefore deter foreign market players from making substantial investment to establish operations for the provision of ICV simulation testing platforms in the PRC. Instead, foreign market players choose to offer their standardised ICV simulation testing software, which allow them to tap into the relevant market in the PRC while keeping a limited or relatively low level of the additional investment costs. In contrast, given the Group has been dedicated to the in-depth research of ICV-related Regulatory Requirements of the PRC since 2018, the Group has a good understanding in such regard and hence is able to update its ICV simulation testing software and platforms in response to the latest development in the ICV-related Regulatory Requirements in an efficient manner.

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Simulation testing

Simulation testing provides a virtual environment to test ICVs in various scenarios without the risk of physical harm or damage. Therefore, it is capable of achieving ICV testing in extreme and dangerous scenarios in a safe manner. Furthermore, simulation testing enables repeated testing of ICVs in specific scenarios, thus facilitating the assessment of system consistency and reliability and increasing the cost-effectiveness of ICV testing. In addition, simulation testing can achieve testing in a large volume of scenarios concurrently, allowing for extensive testing in a shorter timeframe as compared to road testing.

Road testing

Despite the prevalence of simulation tests, questions persist regarding the validity of testing results obtained in virtual environments due to current technological constraints. Consequently, tests conducted in real-world road environments and traffic conditions remain significant for assessing intelligent driving technology. In November 2023, the PRC government initiated pilot projects for the access and road use of ICVs, which further emphasises the importance of physical road testing in the real world. The PRC government selects ICVs with autonomous driving capabilities meeting mass production criteria for pilot projects, highlighting the pivotal role of road testing in ensuring the safety and functionality of intelligent connected vehicles.

According to Article 4 of the Fifteen Initiatives to Support the Innovation-led Development of the ICV Industry in Zhongguancun Science City* (關於支持中關村科學城智能網聯汽車產業創新引領發展的十五條措施) issued by the People's Government of Haidian District, Beijing* (北京海淀區人民政府) on 5 June 2019, the local government in Beijing encourages leading ICV-related enterprises to set up headquarters or R&D centres in Haidian District and provides support to these enterprises on a "case-by-case basis". For leading and unicorn enterprises, the government will provide all-round policy support in terms of talents, funds, and other aspects. Our Company is headquartered in Haidian District. Therefore, pursuant to the aforementioned regulation, we received talent rent subsidies in the amount of approximately RMB2.5 million during the Track Record Period. Furthermore, during the Track Record Period, we received approximately RMB1.3 million for the collaboration project with the government in accordance with The New Energy Automotive Industry Development Plan (2021-2035)* (新能源汽車產業發展規劃(2021-2035年)), and has received approximately RMB0.4 million for the collaboration project with the government in accordance with the Intelligent Vehicle Innovative Development Strategy* (智能汽車創新發展戰略).*

Company B, Company C and Company D do not provide ICV simulation testing platforms in the PRC whereas their ICV simulation testing products sold in China are typically specific software of the ICV simulation testing and related solutions rather than platform-based integrated solutions in China. These products generally have no or minimal level of customisation. In addition, they generally do not support concurrent access by multiple or unlimited users and do not include adaptation, debugging and related customised maintenance services. They are therefore unable to meet the demand of the downstream customers for their own testing platforms.

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These three companies do not offer ICV simulation testing platforms in China mainly due to the following reasons:

High investment and operational costs – Generally, building an ICV simulation testing platform requires high level of customisation (such as the development of customised modules and functions) and provision of adaptation and debugging services in a timely manner. In order to meet the customisation needs of customers, an ICV simulation testing platform provider must closely collaborate and maintain frequent communication with customers to understand their needs. They are also required to perform substantial add-on development works and further optimise the ICV simulation testing platforms based on the initial requests of and ongoing communication with the customers. In addition, customers generally require the assistance from ICV simulation testing platform providers to adapt and integrate the platform into customers' IT infrastructure, and provide debugging services to ensure compatibility of software and hardware. As such, it is essential for an ICV simulation testing platform provider operating in the PRC to establish a local R&D team with expertise in algorithm and coding, and a deep understanding of local market conditions and customer preference. Apart from staff costs and other R&D expenditure, an ICV simulation testing platform provider would also need to invest in other aspects of their local operations, including but not limited to procurement, sales and marketing, customer retention and after-sales product maintenance. In comparison to the provision of ICV simulation testing software, which are ready-made and require no or minimal customisation, so local operations are at relatively small scale, the costs associated with offering ICV simulation testing platforms is significantly higher for our foreign competitors. New and evolving regulatory framework in the PRC – ICV simulation testing software and platforms providers are required to have comprehensive knowledge of the local ICV-related laws, regulations, policies and standards ("ICV-related Regulatory Requirements") to ensure that their products, particularly ICV simulation testing platforms can help customers comply with these requirements. However, the regulatory framework governing ICV and ICV testing, validation and evaluation solutions markets in the PRC is evolving. As such, foreign market players opt to offer their standardised ICV simulation testing software, allowing them to enter into the PRC market with limited investment costs. In contrast, given that our Group has been dedicated to conducting in-depth research on the ICV-related Regulatory Requirements in the PRC since 2018, this enables our Group to have comprehensive understanding in this regard and to update our ICV simulation testing software and platforms in response to the latest developments in the ICV-related Regulatory Requirements.

At present, the demand for ICV data platforms and other products in the ICV industry continues to increase. The ICV data platforms and other products market is relatively fragmented. The major service providers are the leading data and technology companies, for whom the automotive related ICV data platforms and other products business only accounts for a small proportion of their overall business. For customers in the public sector, due to data security and other reasons, the PRC-based market players have more competitiveness.

ICVs can be traditional fossil fuel vehicles and electric vehicles. Among the several methods of ICV testing, validation and evaluation, simulation testing is the most commonly used method, as over 90% of the autonomous driving tests in the PRC are now conducted through simulation testing.

It is not uncommon for some market players, in particular those offering ICV testing, validation and evaluation products and services which involve a high degree of customisation, like Saimo, to experience seasonal fluctuations in their operating results.

The automotive industry in the PRC has entered the mature period after decades of development. The automotive sales volume in the PRC reached approximately 30.1 million units in 2023, accounting for approximately 36.1% of the global sales volume, making it the largest automotive market in the world. Looking forward, driven by the electrification of vehicles and increase in consumer demand, the growth of the PRC's automotive industry is expected to maintain a steady upward trend. The automotive sales volume in the PRC is expected to reach approximately 35.7 million units in 2028, and China is expected to remain the world's largest automotive market with its market share reaching approximately 38.3% until 2028.

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Some of Saimo's major foreign competitors, including three of the four foreign market players among the top five ICV simulation testing software and platforms providers in China in 2023, do not provide ICV simulation testing platforms and ICV data platforms in China whereas their ICV simulation testing products sold in China are typically specific software of the ICV simulation testing and related solutions rather than platform-based integrated solutions in China. These products generally have no or minimal customisation. In addition, they generally do not support concurrent access by multiple or unlimited users and do not include adaptation, debugging and related customised maintenance services. They are therefore unable to meet the demand of the downstream customers for their own platforms in the PRC.

ICVs can be traditional internal combustion engine vehicles and new energy vehicles. ICVs at L3 are expected to be sold in the second half of 2025 in China.

Among the several methods of ICV testing, validation and evaluation, simulation testing is the most commonly used method, as over 90% of the autonomous driving tests (including simulation tests, closed-course site tests and openroad tests) in the PRC are now conducted through simulation testing.

As compared to physical vehicle testing at closed-course sites or open roads, simulation testing can achieve a large number of vehicle tests in shorter time, in more extreme scenarios, and in a safer environment.

Saimo assists its customers in building their own ICV simulation testing platforms and ICV data platforms. This gives Saimo a competitive advantage over its major foreign competitors (including three of the four foreign players out of the top five market players in China's ICV simulation testing software and platforms market in 2023) which do not provide ICV simulation testing platforms and ICV data platforms in China whereas their ICV simulation testing products sold in China are specific software of the ICV simulation testing and related solutions rather than platform-based integrated solutions in China. These products generally have no or minimal level of customisation. In addition, they generally do not support concurrent access by multiple or unlimited users and do not include adaptation, debugging and related customised maintenance services. Further, Saimo is able to deliver its ICV simulation testing software and platforms in the form of cloud solutions by adopting the cloud infrastructure of third party providers, which is in line with the industry trend for cloud-based ICV simulation testing technologies.

It is not uncommon and commercially justifiable for some market players, in particular those offering ICV testing, validation and evaluation products and services which involve a high degree of customisation.

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XIL	Definitions	Features
Model in the Loop (MiL)	A type of simulation testing that tests control algorithms of [ICV intelligent driving solutions] using computer-based mathematical models instead of physical systems.	MiL is used in the early development stage of [ICV intelligent driving solutions] (before any software is generated or hardware is available) and thus allows early identification of errors and bugs in the control algorithms. MiL is conducted entirely in a simulated environment, i.e. based on simulations of vehicle and its driving environment.
Software in the Loop (SiL)	A type of simulation testing that tests the functionality, performance and reliability of embedded software.	SiL is conducted after MiL and uses the same test cases, a technical term meaning [a set of actions or instructions for testers to perform to test a system, software or an application], used in MiL to test the embedded software so as to validate the MiL test results. Same as MiL, it tests the embedded software entirely in a simulated environment.
Hardware in the Loop (HiL)	A type of simulation testing that tests the functionality, performance and reliability of electronic control units, a technical term meaning [the electronic devices on a vehicle that control the electrical systems or subsystems (such as the engine) of the vehicle], by replacing some physical components of the vehicle with computer simulations.	HiL comes at a later stage after SiL and is conducted based on simulation of part (but not the whole) of the vehicle as well as the driving environment.
Vehicle in the Loop (ViL)	A type of simulation testing that tests the functionality, performance and reliability of complete vehicle systems in a computer simulated environment.	ViL is the next step of HiL. As the purpose of ViL is to test complete vehicle systems, vehicle simulation is no longer required. Real-world driving environment is created in simulation for the purpose of ViL, which enables testing of complete vehicle systems in simulation instead of testing such systems in vehicles on physical roads in real world.
Driver in the Loop (DiL)	A type of simulation testing that tests the performance, safety and adaptability of intelligent driving technologies by simulating real-world driving scenarios and the driver's behaviours and reactions in a computer simulated environment.	DiL is generally conducted in conjunction with another type of the closed-loop testing (e.g. HiL) by introducing vehicle-human (driver) interactions to the testing process, creating simulated driving environment which is closer to real-world driving situations.

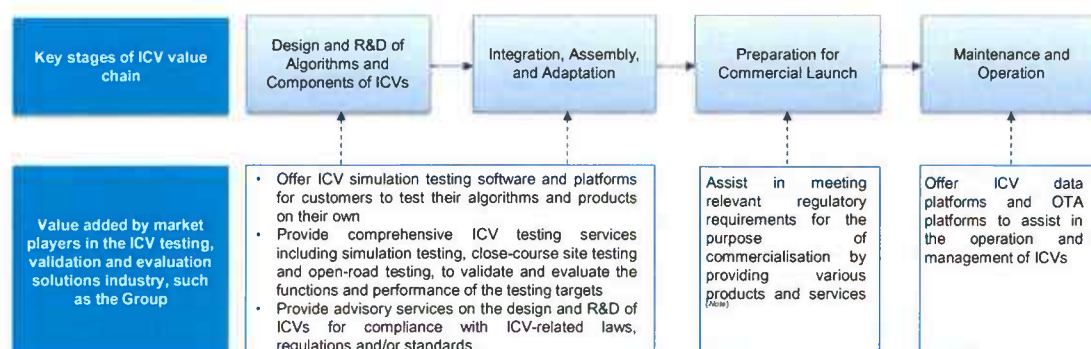
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	Definitions
HUD (Head-up Display)	HUD is a display that presents data without requiring users to look away from their usual viewpoints.
DMS (Driving Monitoring System)	The driving monitoring system includes camera-based driver monitoring systems pointed at the driver's face which provides a real-time evaluation of the presence and the state of the driver.
OMS (Occupancy Monitoring Systems)	The occupancy monitoring systems includes camera-based driver monitoring systems to realize face, age, identity, emotion recognition, object (legacy) detection, customized intelligent service and interaction, etc.
AI (Artificial intelligence)	Artificial intelligence is intelligence demonstrated by machines that mimic and display "human" cognitive skills associated with the human mind.
ADAS (Advanced Driver-assistance System)	An advanced driver-assistance system is any of a groups of electronic technologies that assist drivers in driving and parking functions.
C-V2X (Cellular - Vehicle to Everything)	Cellular - Vehicle to Everything purposes to connect transport participants through modern communication technologies. In the field of automotive electronics, C-V2X can be divided into: V2V (Vehicle to Vehicle), vehicle-to-vehicle communication and interconnection; V2I (Vehicle to Infrastructure), vehicle and roadside facilities (traffic lights, roadside perception, etc.) communication and interconnection; V2P (Vehicle to Pedestrian), vehicle-pedestrian interconnection and V2N (Vehicle to Network), vehicle-cloud platform communication interconnection.
O2O	The O2O model of auto service is a sales model that combines offline business with the Internet.

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Company name	The Group	VIRES Simulationstechnologie GmbH	TASS International B.V.	ANSYS, Inc.	AVSimulation
Software name	Sim Pro	VTD	Prescan	Ansys	SCANeR
Visual database (可視化數據庫)	Yes	Yes	Yes	Yes	Yes
Simulation scenario construction (仿真場景搭建)	Yes	Yes	Yes	Yes	Yes
Scenario generalisation (場景泛化)	Yes	Yes	Yes	Yes	Yes
Scenario library (場景庫)	Yes	Yes	Yes	Yes	Yes
Open interface (接口開放)	Yes	Yes	Yes	Yes	Yes
Physical sensor model -- Camera (物理傳感器模型-攝像頭)	Yes	Yes	Yes	Yes	Yes
Physical sensor model -LiDAR (物理傳感器模型-激光雷達)	Yes	Yes	Yes	Yes	Yes
Physical sensor model - Millimeter wave radar (物理傳 感器模型-毫米波雷達)	Yes	Yes	Yes	Yes	Yes
Road environment (道路環境)	Yes	Yes	Yes	Yes	Yes
Traffic environment (交通環境)	Yes	Yes	Yes	Yes	Yes
Weather environment (天氣環境)	Yes	Yes	Yes	Yes	Yes
Rendering effect (渲染效果)	Yes	Yes	Yes	Yes	Yes
ViL (車輛在環)	No	Yes	Yes	No	Yes

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Note: The PRC government issued the Pilot Notice towards the end of 2023, which launched the Pilot Programme to allow qualified L3 and L4 ICVs to, subject to restrictions on, among others, validity period and implementation areas, access and drive on designated open roads in qualified pilot cities. However, participation in the Pilot Programme per se does not mean that the Pilot ICVs are allowed for unrestricted market launch in the PRC at the present stage. The Pilot Notice is still at the premature stage of pilot implementation, and it is still uncertain as to the formal requirements and procedures for ICVs to ultimately achieve unrestricted market launch in the PRC, which may be subject to new laws, regulations, policies or guidelines to be published by the PRC government.

Research Methodologies

- Frost & Sullivan is an independent global consulting firm, which was founded in 1961 in New York. It offers industry research and market strategies and provides growth consulting and corporate training. Its industry coverage includes automotive and transportation, chemicals, materials and food, commercial aviation, consumer products, energy and power systems, environment and building technologies, healthcare, industrial automation and electronics, industrial and machinery, and technology, media and telecom.
- The Frost & Sullivan's report includes information on global and the PRC ICV testing, validation and evaluation solution industry.
- Frost & Sullivan has conducted detailed primary research which involved discussing the status of the industry with certain leading industry participants and conducting interviews with relevant parties. Frost & Sullivan has also conducted secondary research which involved reviewing company reports, independent research reports and data based on its own research database. Frost & Sullivan has obtained the figures for the estimated total market size from historical data analysis plotted against macroeconomic data as well as considered the above-mentioned industry key drivers.
- Frost & Sullivan's Market Engineering Forecasting Methodology integrates several forecasting techniques with the Market Engineering Measurement-based System. It relies on the expertise of the analyst team in integrating the critical market elements investigated during the research phase of the project. These elements include:
 - ✓ Expert-opinion forecasting methodology
 - ✓ Integration of market drivers and restraints
 - ✓ Integration with the market challenges
 - ✓ Integration of the Market Engineering Measurement trends
 - ✓ Integration of econometric variables
- In compiling and preparing the Report, Frost & Sullivan has adopted the following assumptions:
 - ✓ The social, economic and political environment of the world and the PRC is likely to remain stable in the forecast period
 - ✓ Related industry key drivers are likely to drive the market in the forecast period