The Mobility Paper

Technology Evolution

April 2025

Intelligent Vehicle Innovation in China

Unlocking the Door to Intelligent Driving and New Business Models

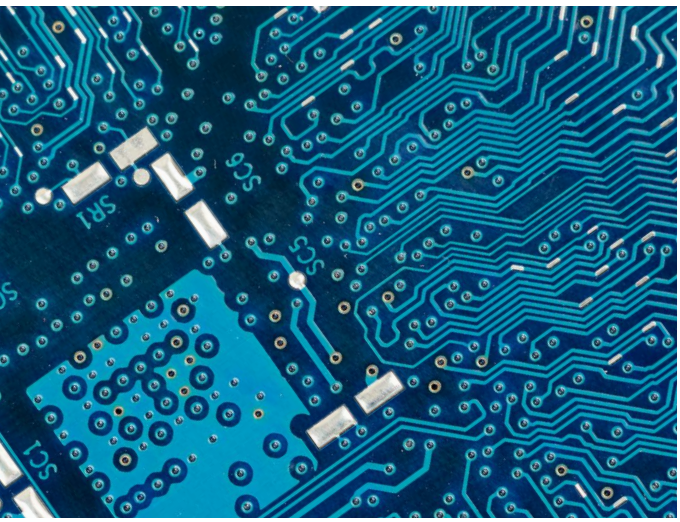
S&P Global Mobility

Executive Summary

With the evolution of the vehicle's electronic and electrical architecture, along with advancements in autonomous driving and digital cockpit applications, intelligent driving hardware has increasingly become standard. Consequently, vehicle value-add, and automaker profits are shifting toward software. Automotive software technology is gradually emerging as a key strategic battleground for automakers in the future.

What transformations are occurring in automotive intelligence technology? What are the trends in the digital connected vehicle market? What new business models will emerge from automotive software commercialization? How should the automotive supply chain respond to these developments?

This paper will delve into the key issues involved in terms of the evolution of automotive intelligence, the impact of the intelligent driving market and supply chain, and new business models.

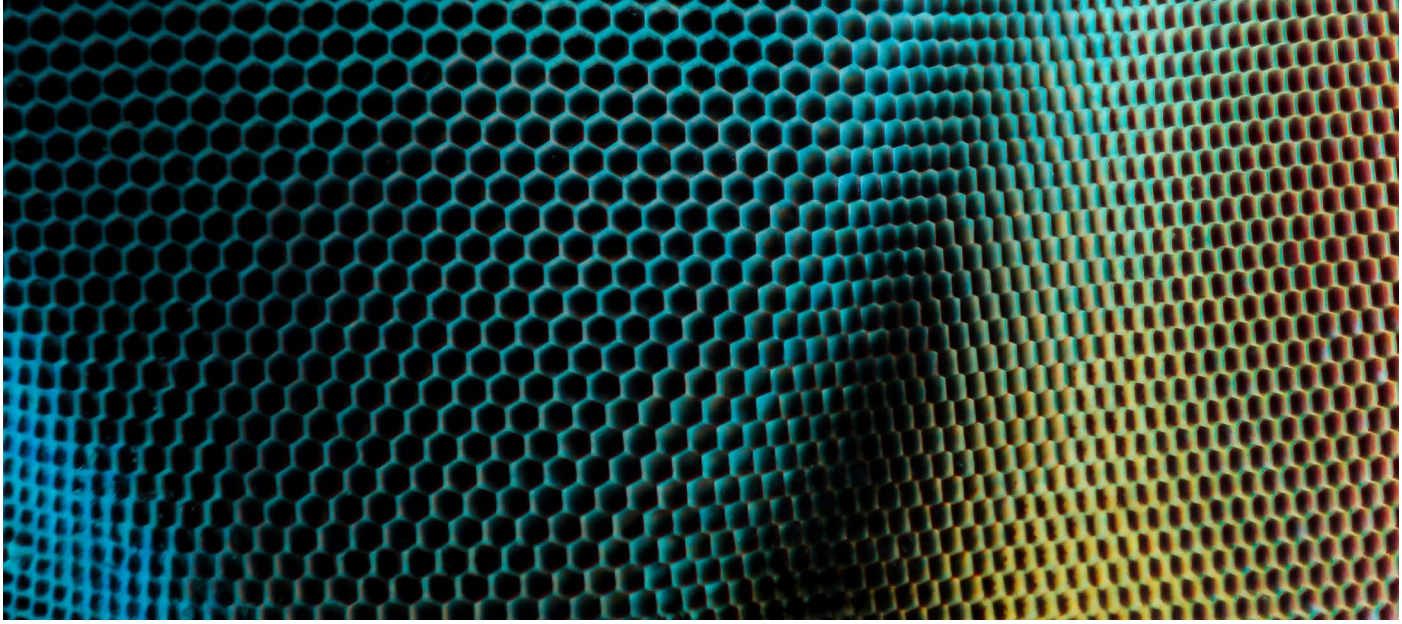


This Mobility Paper will cover:

- Decoding the Holistic Shift in Vehicle Intelligence
- Advanced autonomous driving market forecast
- Autonomous driving supply chain outlook
- The human-centered evolution of AI-driven interaction
- The future of the digital cockpit
- OEMs (Original Equipment Manufacturers)' services and new business models
- Key takeaways

The Era of Intelligent Vehicle Innovation in China

High-performance computing in vehicles demands efficient intelligent driving models. Investments in data training centers are crucial for advancing these capabilities, relying on strong software competence.



Decoding the Holistic Shift in Vehicle Intelligence

Transformation Driven by Technology

Breakthroughs in artificial intelligence (AI) have accelerated the development of intelligent driving. Technologies such as machine vision and deep reinforcement learning are widely applied across the full chain of intelligent driving systems, empowering them with stronger capabilities in environment perception, decision-making and planning, and vehicle control. For example, advanced intelligent driving is expanding its application to urban scenario. To handle more complex road conditions and address the long-tail challenges of autonomous driving, AI technologies are accelerating their integration into vehicles.

On the other hand, the deployment of high-performance computing platforms in vehicles demands more efficient intelligent driving models. Meanwhile, Infrastructure such as compute centers for data training has become a critical investment for the continuous evolution of intelligent driving capabilities, which fundamentally depend on strong software competence.

In addition, the advancement of 5G and Internet of Things (IoT) technologies enable more real-time vehicle-cloud communication, supporting ongoing software optimization and functional expansion.

AI technologies are accelerating their integration into vehicles To handle more complex road conditions and address the long-tail challenges of autonomous driving

Market Demand Fueling the Transformation

According to consumer research by S&P Global Mobility, consumers in the Chinese market demonstrate a notably high level of acceptance for emerging technologies. Compared to consumers in other countries, they exhibit stronger and more specific demands for different vehicle functions. “Ease of use” is increasingly replacing “basic usability” as the deciding factor in purchasing intelligent driving products.

Merely stacking hardware components is no longer sufficient to win over consumers—what truly matters is an intelligent driving experience that is smooth and comfortable, enabled by advanced software technologies. Simply stacking hardware features is no longer enough to win over consumers. Truly compelling intelligent driving experiences rely on advanced software to deliver smooth, intuitive, and comfortable performance.

From the perspective of OEMs, industry competition will intensify further in 2025. Achieving greater differentiation and controlling overall vehicle cost will be essential. Continuously integrating new technologies into vehicles, addressing a wider range of edge cases, and refining system performance to improve user experience will demand long-term commitment from OEMs. Over time, as the scale of digital connected vehicles expands, automotive software is expected to become a stable and high-margin source of revenue.

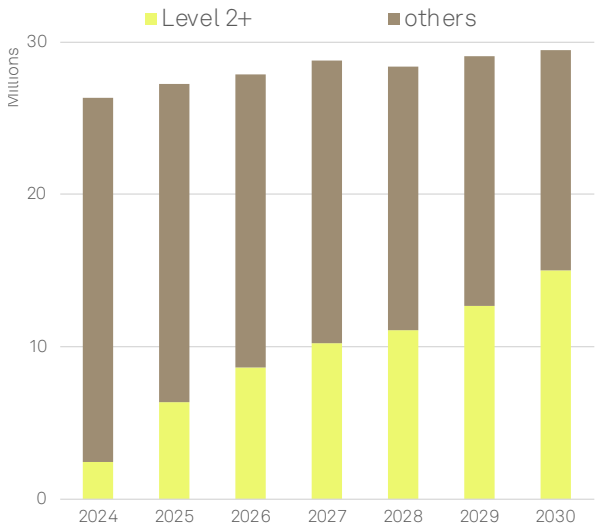
Simply stacking hardware features is no longer enough to win over consumers.

Advanced Autonomous Driving Market Forecast

At the beginning of 2025, BYD officially launched its “Di Pilot Eye” system, which will be applied across its full model lineup. Changan released its “Beidou Tianshu 2.0” strategy to drive the application and adoption of intelligent driving technologies across its product lineup. Meanwhile, Geely introduced its “Galaxy AI Drive” system, aiming to cover models across all price ranges. Collectively, these moves usher in a new era of accessible intelligent driving.

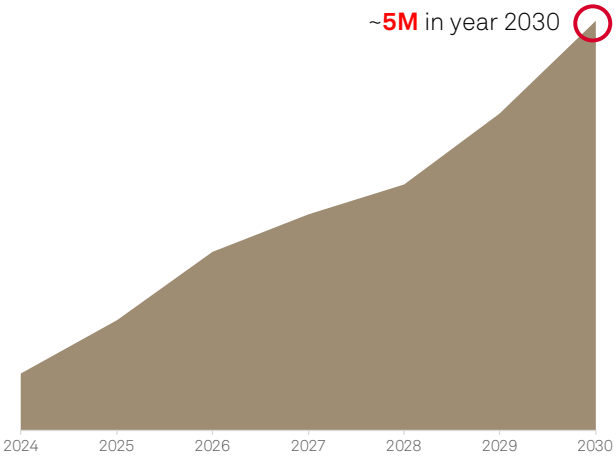
At the 4th Global Autonomous Driving Summit held on January 14, 2025, Professor Shengbo Li, Secretary of the Party Committee at the School of Vehicle and Mobility and a professor at the School of Artificial Intelligence at Tsinghua University, noted in a narrower sense, autonomous driving primarily refers to high-level intelligent driving systems designed for complex urban traffic scenarios. S&P Global Mobility defines this segment as L2+ Urban. In the face of complex urban traffic scenarios, safety has become the central challenge for autonomous driving. To address this, end-to-end autonomous driving technologies based on closed-loop data systems and neural network strategies have emerged as the dominant technical pathway. Both emerging players such as NIO, Li Auto, and Xpeng, and traditional OEMs like Great Wall and IM Motors, are increasing their investments in end-to-end solutions as they compete for leadership in urban intelligent driving.

Penetration of Level 2+ new vehicle sales in China.



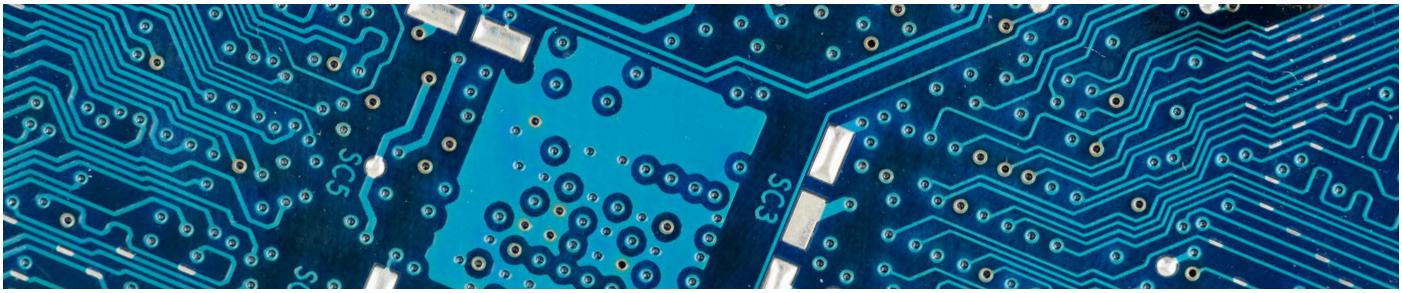
Data compile Feb. 2025, Source: S&P Global Mobility

New vehicles sales with L2+ in urban China.



“Hands-off in three years, eyes-off in five, and mind-off in ten.”

CEO Kai Yu echoed this view, forecasting that autonomous driving will evolve in three stages



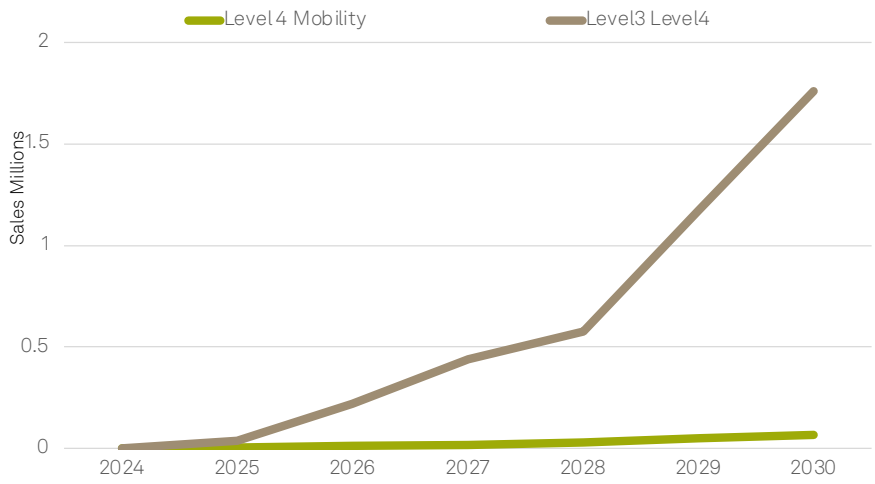
From a market perspective, prior to 2024, consumers had limited access to advanced intelligent driving models priced below RMB 200,000. The surge in mass-market intelligent driving, led by BYD, has made L2+ a standard feature across vehicles and significantly elevated product expectations. On one hand, BYD leveraged its strong sales volume to reset the tone of the intelligent driving market. On the other hand, this shift is expected to heavily influence how other OEMs plan their future product lineups.

Driven by brands like BYD, the adoption of advanced intelligent driving features is expected to accelerate rapidly. In 2025, sales of new vehicles equipped with L2+ capabilities in the Chinese market are projected to exceed 6 million units, reaching 15 million by 2030. Compared to 2024, sales of vehicles supporting L2+ Urban are expected to double in 2025 to 1.4 million units and are forecast to reach 5 million by 2030.

With the advancement of end-to-end technologies, Level 3 (L3) and Level 4 (L4) autonomous driving will also accelerate toward deployment. L3 is expected to begin rolling out in 2025, with some models—such as those developed in collaboration with Huawei—already pre-installed with the necessary hardware. Over the next few years, L3 is likely to become the dominant design reference for autonomous driving in China, while L4 will remain a long-term technology objective. At Horizon Robotics' 2025 Intelligent Driving Tech Day, founder and CEO Kai Yu echoed this view, forecasting that autonomous driving will evolve in three stages: "hands-off in three years, eyes-off in five, and mind-off in ten."

Breakthrough in software bring Level 3 and level 4 into practice on road

L4 MAAS and autonomous driving for private vehicles increase in parallel (China)



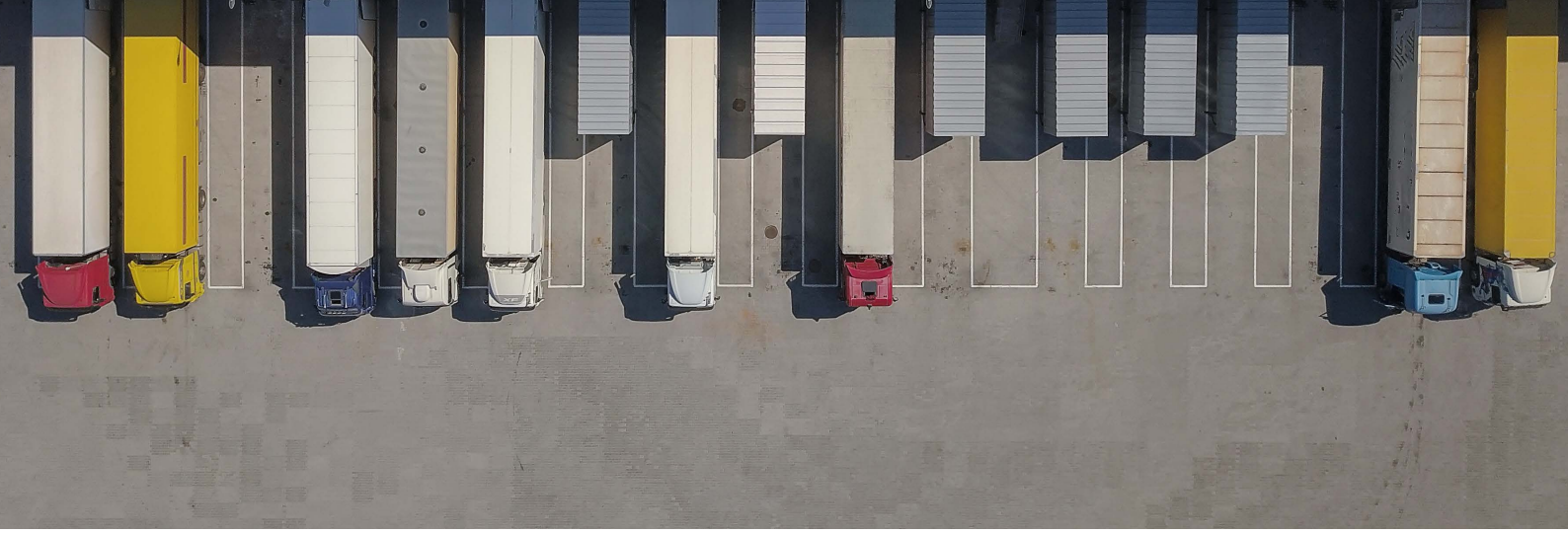
Data compile Feb. 2025, Source: S&P Global Mobility

Level 3 autonomous driving will launch in China market in this year, with limited volume in demonstration cities.

Level 3 will be the major product design of autonomous driving in China in next years, Level 4 is long-term technology target instead.

Cost reduction will be the key premise of massive deployment for Robotaxi. Tesla is supposed to be important player of autonomous driving fleet service.

Robotaxis represent another major application of autonomous vehicles. According to S&P Global Mobility, robotaxi sales in China are expected to reach the scale of 100,000 units by 2030. Cost control is a critical prerequisite for large-scale deployment, while the maturity of the technology is equally essential for gaining consumer acceptance.



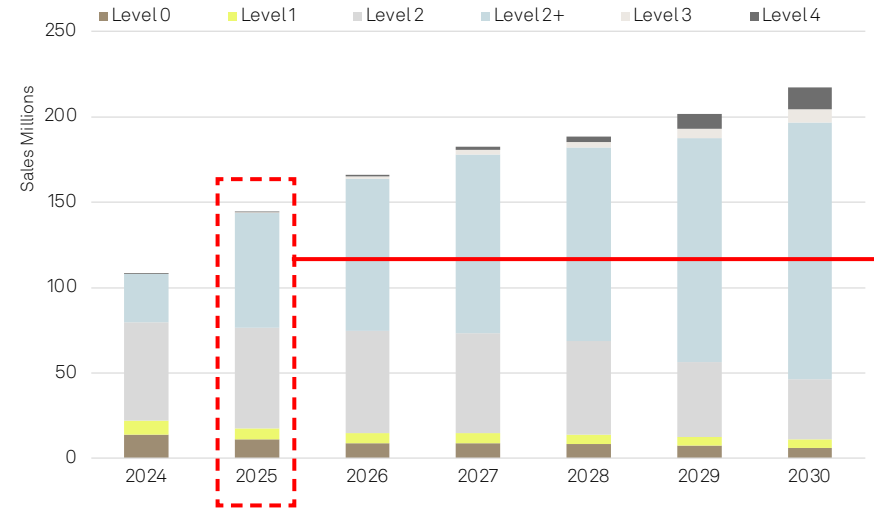
Autonomous Driving Supply Chain Outlook

The rise of accessible intelligent driving is further accelerating the development of the industry value chain and its supporting supply networks.

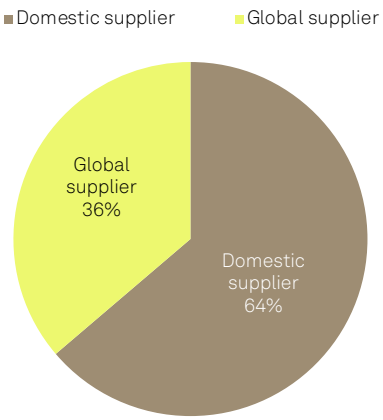
According to S&P Global Mobility, over 100 million in-vehicle cameras were installed in 2024. The figure is expected to rise to 150 million in 2025, with domestic independent suppliers accounting for approximately 64 percent of the market. The market share of camera module manufacturers originating from the consumer electronics sector is also projected to expand further.

Level 2+ smart driving is the major drive of camera installation growth

L4 MAAS and autonomous driving for private vehicles increase in parallel (China).



2025 vehicle camera supplier market share, (China)



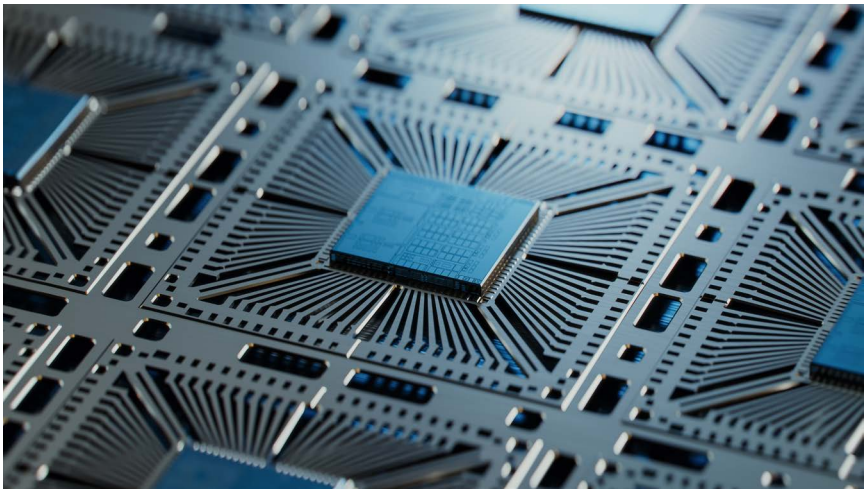
Data compile Feb. 2025, Source: S&P Global Mobility

In recent years, vision-only solutions for high-level autonomous driving have gained market acceptance. However, demand for LiDAR remains strong, especially in flagship and premium vehicle segments. At the same time, the need for greater safety redundancy in advanced autonomous driving applications such as L2+ Urban, L3, and L4 is driving a second wave of growth in the LiDAR market.

Over 100 million in-vehicle cameras were installed in 2024. The figure is expected to rise to 150 million in 2025, with domestic independent suppliers accounting for approximately 64 percent of the market.

Compared to global suppliers, domestic vendors have shown stronger performance in both technology maturity and supply chain security. As a result, despite the overall momentum in the global LiDAR market, international suppliers may face stagnating market share or even replacement by local players. Robosense, Hesai, and Huawei, the top three LiDAR suppliers in China, are expected to shape the trajectory of both the domestic and global LiDAR markets. According to S&P Global Mobility, total LiDAR installations on new vehicles in China are projected to exceed 2 million units by 2025.

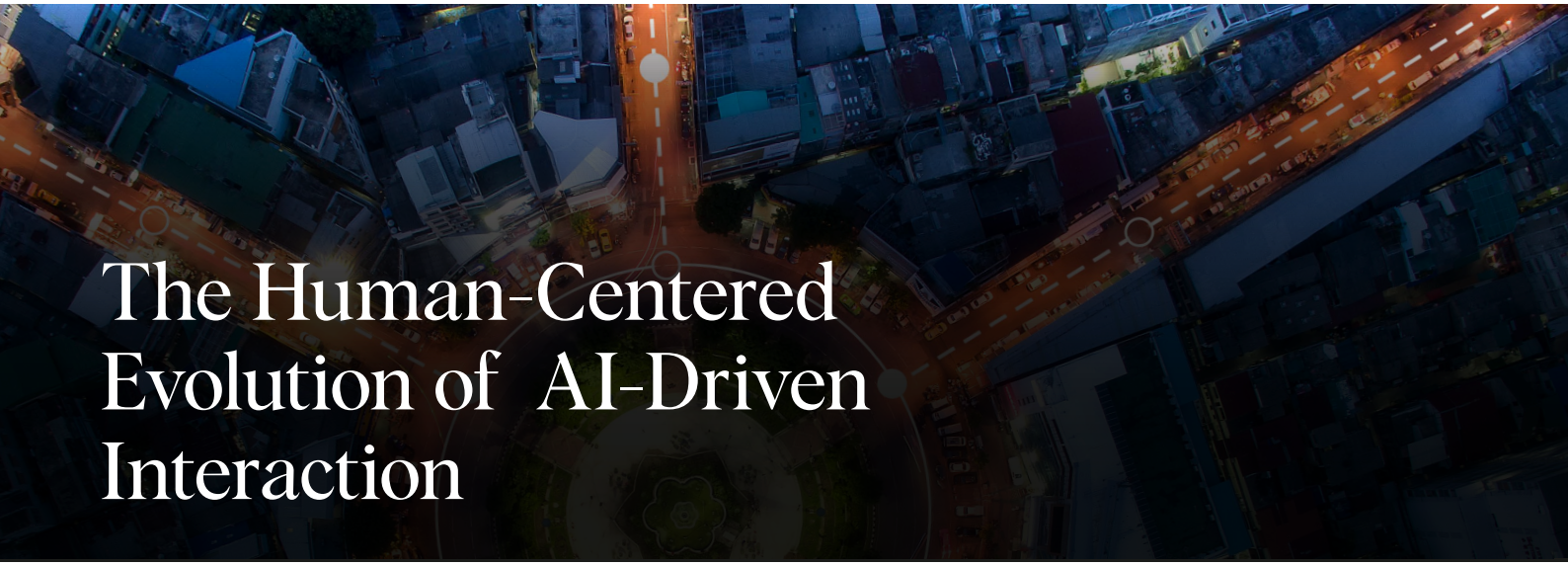
In the domain of intelligent driving domain controllers, the increasing complexity of in-vehicle software is raising new demands for onboard computing power. Most L2+ vehicles in China are currently equipped with a single domain controller. In 2024, the market size was approximately 4 million units. According to S&P Global Mobility, that figure is expected to double in 2025, reaching 8 million units. The top five suppliers are projected to hold around 60 percent of the market. However, a large portion of BYD's domain controllers is self-produced. Excluding BYD, the market remains relatively fragmented. Given the high unit cost and strong margins of domain controllers, this segment is expected to remain highly competitive moving forward.



According to S&P Global Mobility, by 2025, total LiDAR installations on new vehicles in China are projected to exceed

2 million

units



The Human-Centered Evolution of AI-Driven Interaction

Large-scale AI models are significantly shaping both the functional identity and added value of vehicles, positioning them as either mobile living spaces or intelligent systems. Acting as the cognitive core, these multimodal models integrate data from in-vehicle and external sensors to create personalized intelligent agents that understand user needs and deliver precise recommendations. Ideally, AI will be able to dynamically reshape both the physical and digital environments inside the vehicle, evolving into a smart companion for family travel. As technology continues to advance, human-vehicle interaction features will undergo ongoing iterations, ultimately enabling a more natural and efficient user experience.

DeepSeek gained rapid attention for its low cost and highly efficient capabilities in understanding and logical reasoning

In 2025, DeepSeek gained rapid attention for its low cost and highly efficient capabilities in understanding and logical reasoning. Although still in the early stages of development, many companies have already announced plans to integrate the DeepSeek API. Drawing from DeepSeek's reasoning framework, some OEMs are exploring how to leverage existing computing bandwidth to deliver stronger performance. Within the digital cockpit, AI technologies represented by DeepSeek are enhancing the interactivity of virtual assistants, making them more proactive and capable of offering personalized service recommendations. These advancements are paving the way toward an intelligent agent–based service model in the future.

Another example is Volcano Engine's Doubao large language model, which has been applied in the digital cockpit to enhance in-vehicle interaction. Doubao breaks down interaction scenarios into three core stages: input, reasoning and generation, and output. Its interaction scenarios are divided into three stages: input, reasoning and generation, and output. The reasoning stage is especially complex. Most mainstream approaches rely on a multi-model architecture, where an intent recognition model classifies user input before triggering specific actions. However, such a layered structure tends to reduce efficiency. To address this, Volcano Engine has proposed two evolutionary paths. The first is cognitive attribution, which enables cross-domain coordination and unified information management. The second is sensory unification, which minimizes information loss and supports more natural, emotionally rich interactions.

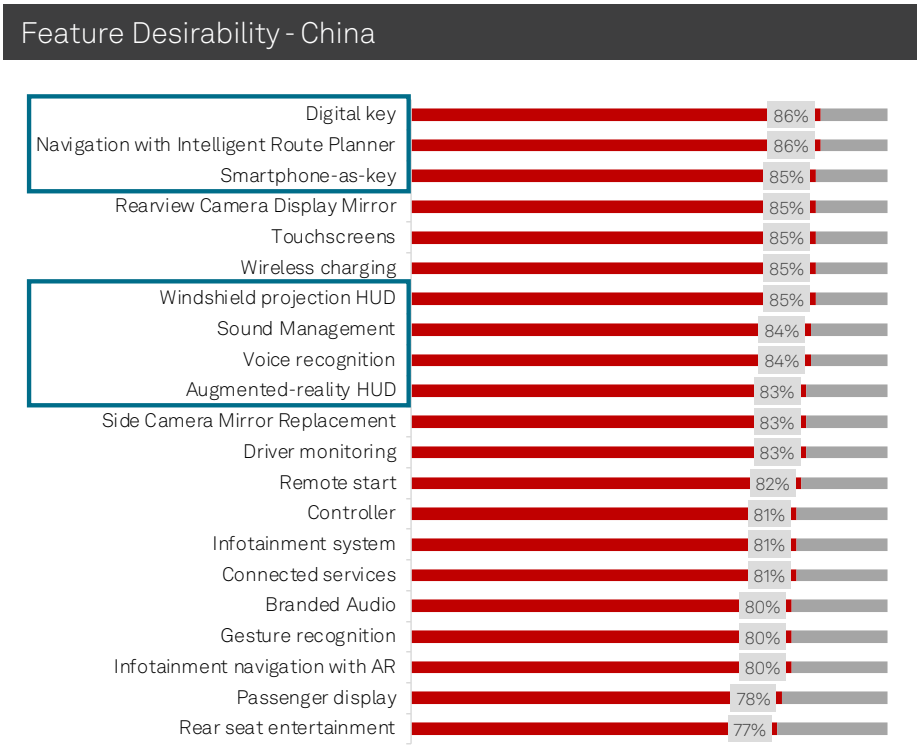
"What you see is what you can use, what you say is what you get" approach, centered on users' real-time needs and aimed at reshaping the model of human-vehicle interaction.

In addition, Volcano Engine has introduced the concepts of slow thinking and fast thinking to address both real-time response and deep reasoning demands. It continues to refine its models by incorporating better training cases, enabling continuous learning and avoiding emotionally flat interactions. According to Volcano Engine, future AI-powered interaction products should follow a "what you see is what you can use, what you say is what you get" approach, centered on users' real-time needs and aimed at reshaping the model of human-vehicle interaction.

The Future of the Digital Cockpit

According to S&P Global Mobility's 2024 consumer survey, Chinese consumers show a high level of acceptance toward new technologies in digital connected vehicles. The most popular features include digital keys, real-time navigation, and smartphone-based car keys. In addition, functions such as head-up displays, personalized sound management, voice assistants, and augmented reality (AR) recognition are also highly favored among Chinese consumers.

Chinese consumers are more enthusiastic about adopting new technologies,a stronger preference for digital |experience and smartphone connection in vehicles



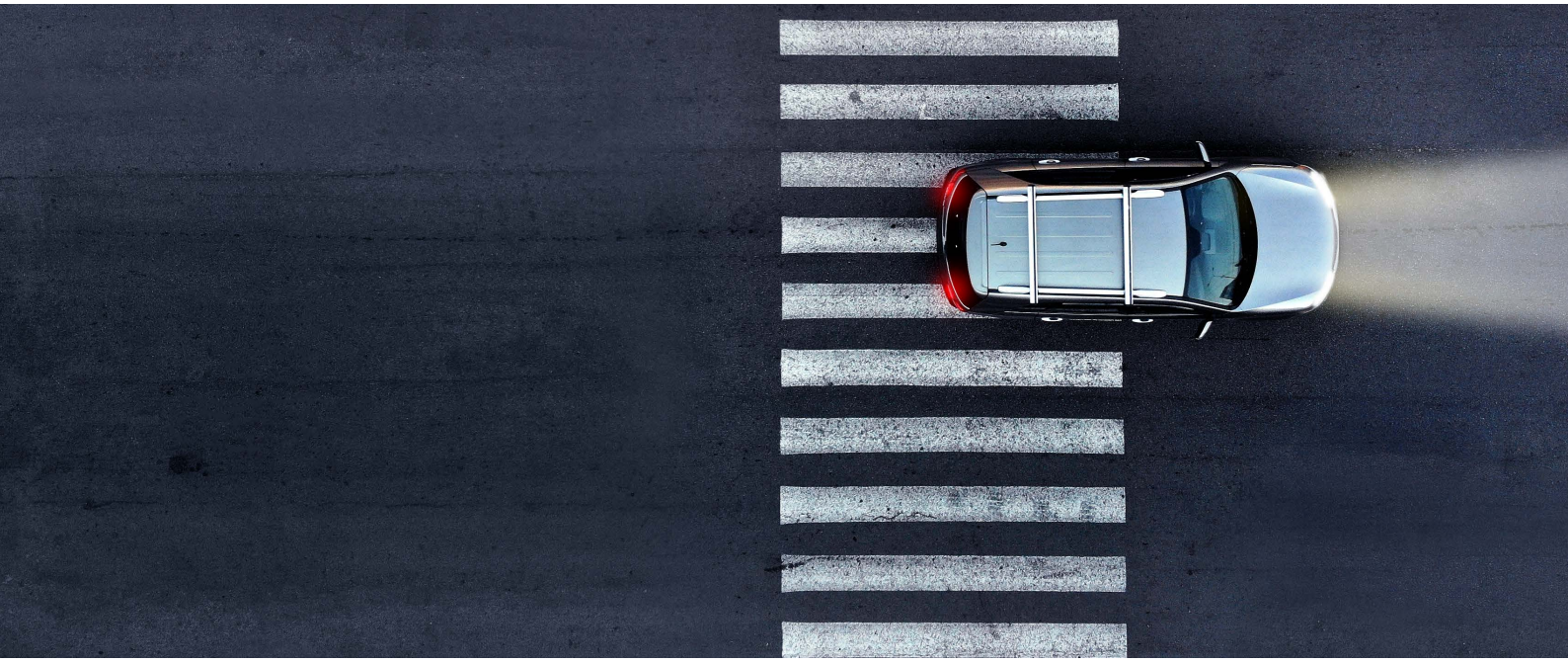
Chinese consumers show a high level of acceptance toward new technologies in digital connected vehicles

The report identifies several key trends in the development of the digital cockpit. These include seamless integration between vehicles and smartphones, steadily increasing penetration of navigation systems and integrated central displays, more intelligent voice assistants enabled by large language model integration, and a continuous rise in data-intensive streaming applications such as music, video,
and gaming. The introduction of intelligent agents is also seen as a major
direction for the future of the digital cockpit. Among digital connected vehicles, the penetration rate of models equipped with both navigation systems and integrated central displays is expected to grow from 40 percent in 2024 to 70 percent by 2030.

For software-defined vehicles, one of the most critical capabilities is the ability to support continuous over-the-air (OTA) updates. OTA upgrades play animportant role in keeping advanced driver assistance systems (ADAS) up to date, reducing recalls, and ensuring vehicle safety.

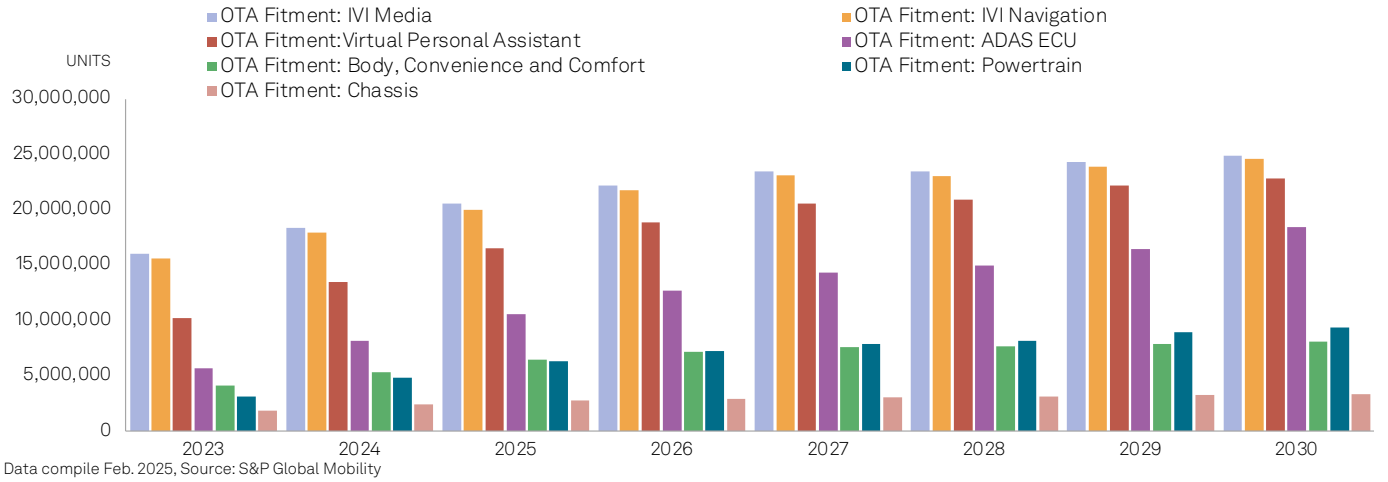
According to S&P Global Mobility, by 2030, more than 85 percent of new vehicles in the Chinese market are expected to support OTA functionality. Key focus areas for updates currently include infotainment systems, navigation, and voice assistants. While OTA updates for driver assistance systems are still limited today, rapid growth is anticipated in the coming years, with updates expected to extend to other domains such as the vehicle body, powertrain, and chassis.

Head-up displays, personalized sound management, voice assistants, and augmented reality (AR) recognition are highly favored among Chinese consumers.



More than 85% of new car will have OTA capabilities by 2030

China market new vehicles with over the air updates capability



Data compile Feb. 2025, Source: S&P Global Mobility

Increasing demand for infotainment, navigation, and virtual assistants reflects growing consumer expectations for connectivity, entertainment, and convenience inside vehicles.

Greater investment in ADAS is driven by both technological advancements and regulatory mandates for improved road safety. OTA updates will play an important role in keeping ADAS systems up-to-date, reducing recalls, and ensuring vehicles safety.

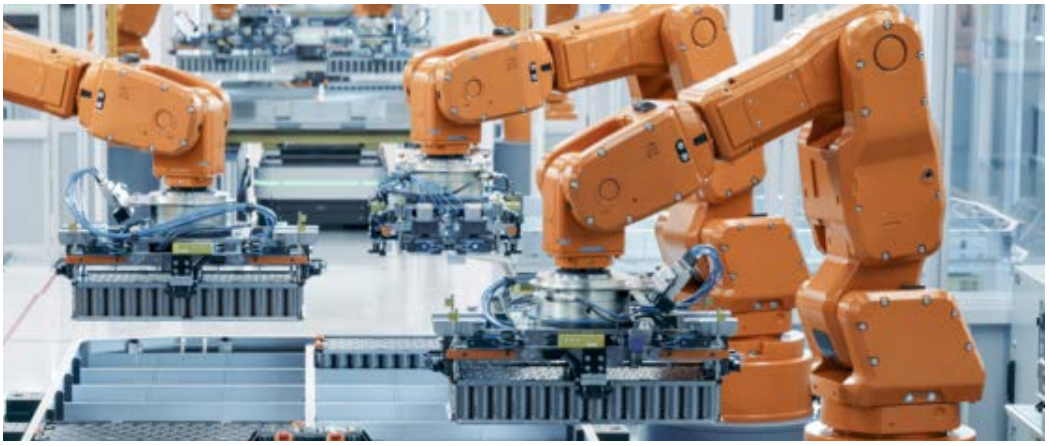
Transition to software first business model, Cross-Domain integration through OTA is essential to ensure seamless coordination between infotainment, powertrain, ADAS, and comfort systems

An analysis of OTA update frequency across different brands in 2024 by S&P Global Mobility reveals notable differences in update strategies. Emerging automakers typically provide updates monthly, while traditional Chinese brands average once every two months. In contrast, most international OEMs update their vehicles only once or twice a year. The study also shows that each brand follows a distinct OTA strategy. In the Chinese market, updates tend to focus on urban intelligent driving and the digital cockpit. Even within the same automotive group, different brands prioritize different update domains.

For instance, BYD's Qin Plus and Song Plus models concentrate OTA upgrades on the digital cockpit, whereas flagship models like the Tang and Han offer comprehensive updates across all five major domains of the vehicle. Premium sub-brands such as Fangchengbao and Yangwang pursue different capabilities, with OTA updates covering powertrain and chassis functions.

By 2030, more than 85 percent of new vehicles in the Chinese market are expected to support OTA functionality

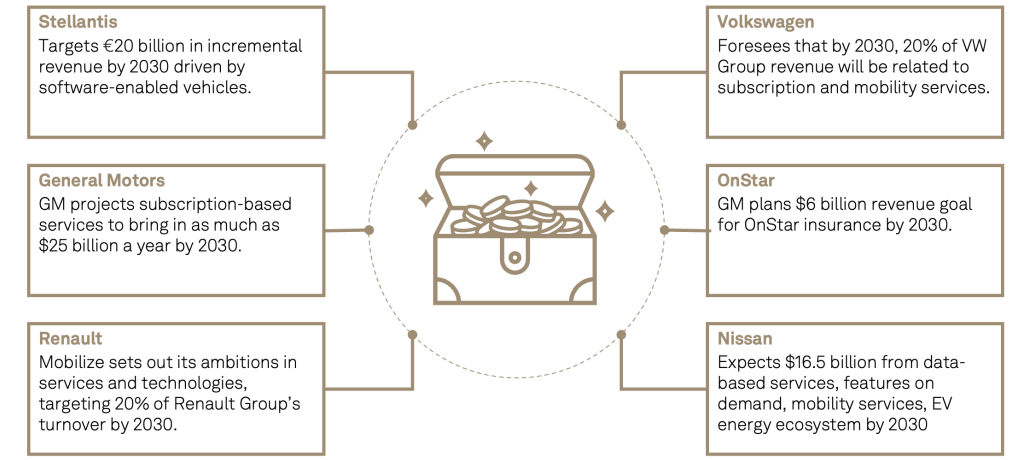
OEMs Services and New Business Models



In the area of software and service revenue, many global OEMs had already released their 2030 strategies as early as 2020, with most setting aggressive targets for service-based income. The achievement of these goals largely depends on two key factors: the scale of digital connected vehicles and the rate of service subscription.

Connected Service Strategy

The promise of high margin, recurring revenues on top of vehicle sales



OTA = over-the-air.
Sources: General Motors; Stellantis; Renault; Volkswagen; General Motors; Ford.

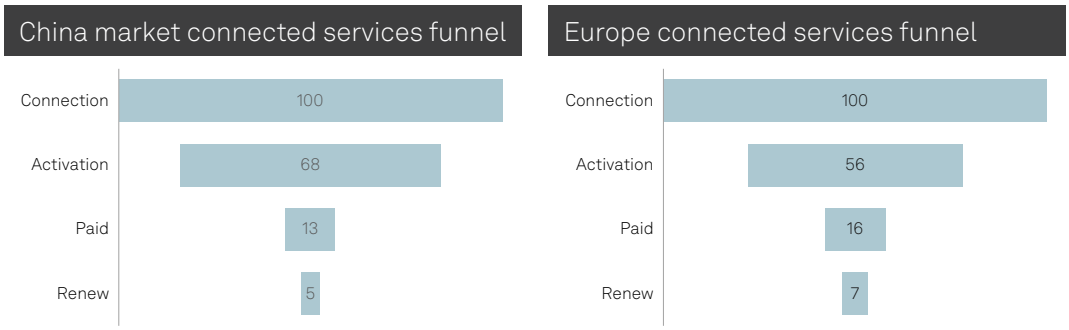
OEMs' strategies to reach goals include:

- Different bundled services
- Stand-alone service and paid vehicle feature with free trial
- Pricing strategy: One-time, annual/month subscription

Turning to the Chinese market, S&P Global Mobility's research shows that compared to Europe, China has a higher activation rate for automotive software services, but lower repurchase and subscription rates. This is largely due to the early stage of industry development, during which automakers typically offer consumers two to three years of complimentary basic connected services.

Connected service funnel

Higher activation rate with low paid rate in China



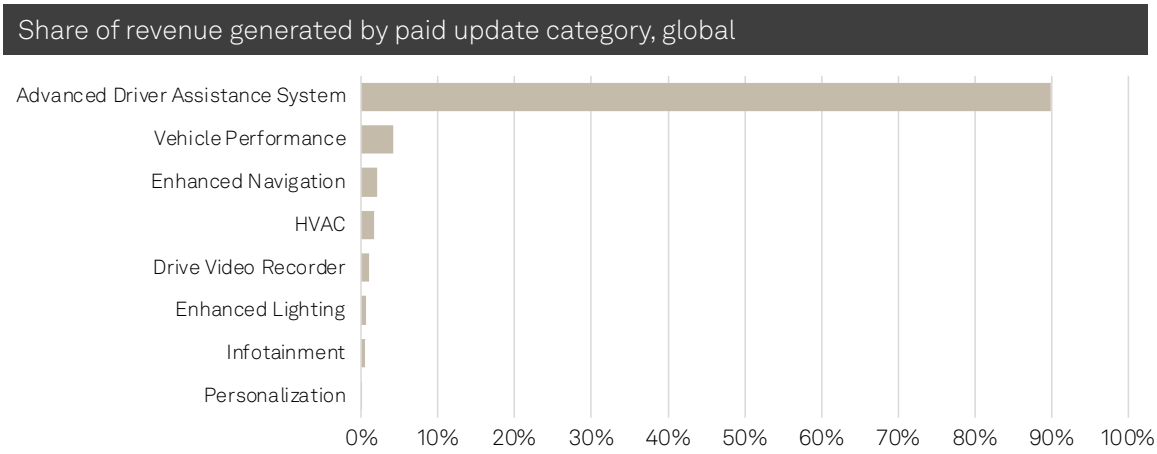
Basic connected services will be offered for 2-3 years to consumers who purchase a new vehicle

Data compile Feb. 2025, Source: S&P Global Mobility

Currently, the commercialization of automotive software in the Chinese market remains in a trial phase. In the context of emerging business models such as paid OTA upgrades, S&P Global Mobility believes that advanced driver assistance systems offer the strongest commercial potential.

Autonomy/ADAS applications is promising for new revenue streams

Consumer appeal appears to exist for the use case



Data compiled August 2024.
Source: S&P Global Mobility Connected Services and Paid Updates (CVIO) Forecast.

Strategies are still being defined; many paid updates are either very new or still in trial periods

This view is supported by market evidence. In the intelligent driving sector, most automakers currently deliver autonomous driving systems based on vehicle configuration, while a smaller number are experimenting with software subscription models. Globally, Tesla remains the front-runner in software commercialization. By the end of 2024, Tesla had deployed 7 million digital connected vehicles worldwide. Through its Full Self-Driving (FSD) offering, the company generated $326 million in software revenue in 2024, with most of that revenue coming from the North American market. In China, brands such as NIO and AITO have also introduced advanced driver assistance feature packages, showing solid performance. In the digital cockpit space, virtual assistants similar to ChatGPT are generally offered through monthly subscription models by international automakers, whereas most Chinese brands continue to provide them free of charge.

By 2025, the door to mass-market intelligent driving has quietly opened. Scalable and sustained software investment, whether through the launch of new features or continuous iteration and updates across multiple domains, along with the exploration of new business models to deliver value-added services, has become the core focus in the next phase of smart mobility competition for both OEMs and suppliers.

Key Takeaways

The official launch of BYD's "Di Pilot Eye" and related developments mark the beginning of a new era of accessible intelligent driving.

Scalable and sustained software investment, including the rollout of new features and continuous updates across multiple domains, has become the central focus in the next phase of smart mobility competition.

Cost control is a key prerequisite for the large-scale deployment of robotaxis, while technological maturity is equally essential for gaining consumer acceptance.

The rise of accessible intelligent driving is creating new opportunities for domestic suppliers of in-vehicle cameras, LiDAR, and intelligent driving domain controllers.

Empowered by AI technologies, human-vehicle interaction functions will continue to evolve, ultimately enabling natural and efficient intelligent agent experiences.

Infotainment systems, navigation, and voice assistants are currently the focus areas for OTA updates. In the future, OTA coverage is expected to expand rapidly in driver assistance systems and extend into vehicle body, powertrain, and chassis domains.

Among emerging business models such as paid OTA upgrades, advanced driver assistance systems show the greatest commercial potential.

Quotations

"S&P Global Mobility forecasts that by 2025, the number of vehicles capable of supporting urban smart driving is expected to exceed 1.4 million. Looking ahead to 2030, the number of new vehicles in the Chinese market that will support urban intelligent driving will be around 5 million."

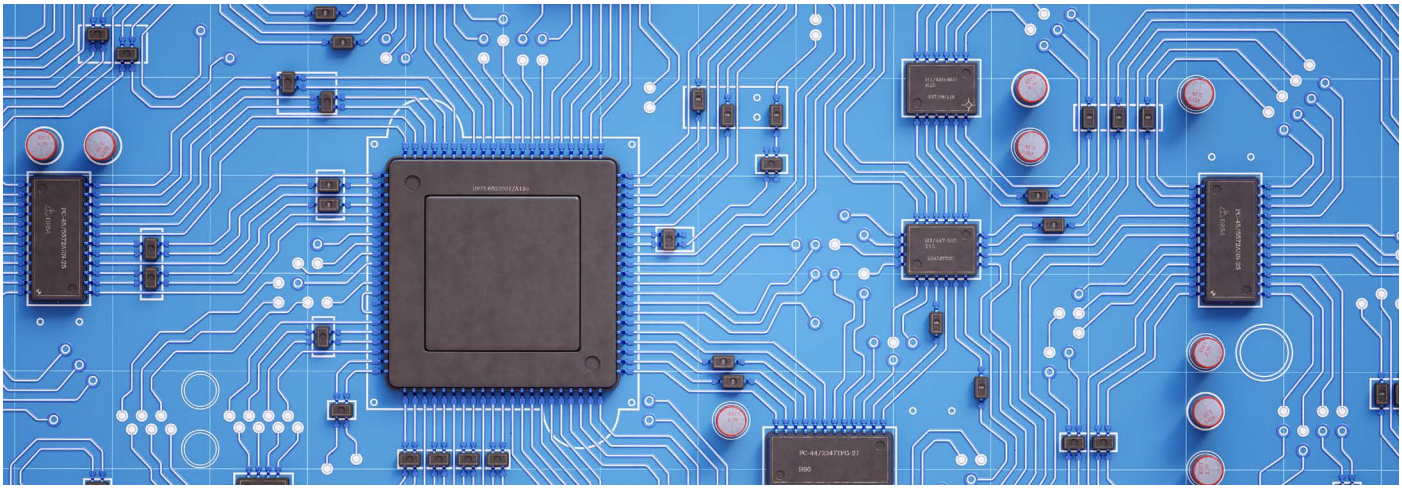
Daokuan Lu
Senior Research Analyst,
Automotive Insights
S&P Global Mobility

"2025 is the right time point to expand L2+ deployment in more price classes vehicles."

Daokuan Lu
Senior Research Analyst,
Automotive Insights
S&P Global Mobility

"It is expected that by 2030, more than 85% of new cars in the Chinese market will have OTA upgrade capability."

Fanni Li
Principal Research Analyst,
Automotive Supply Chain & Technology
S&P Global Mobility



Editor

Daokuan Lu

Senior Research Analyst, Automotive Insights

Daokuan Lu is a senior research analyst in field of autonomy at S&P Global Mobility

Daokuan joined S&P Global Mobility autonomy team in February 2022 as a Senior Research Analyst, base in Shanghai. He is responsible for supporting to maintain and enhance autonomy forecast in China. His research interests include Chinese emerging autonomous driving technologies and relevant supply chain, autonomy strategies of local and global OEMs.

Prior to joining S&P Global Mobility, Daokuan worked in an automotive engineering consultant company.

Daokuan hold the Master degree in field of automotive engineering from Karlsruhe Institute of Technology (KIT) in Germany and the bachelor degree from Tianjin University in China.

Fanni Li

Principal Research Analyst, Automotive Supply Chain & Technology

Fanni Li is Principal Research Analyst with expertise in Connected Car within S&P Global Mobility & is based out of Shanghai.

Fanni is Principal Research Analyst focused on Connected Car and related technology at S&P Global Mobility. Her responsibilities include China market research and analysis of digital cockpit and connected car, as well as global market analysis of over the air updates, connected services and vehicle software paid updates.

Fanni has more than 10 years working experience in automotive industry with engineering background. Prior to joining S&P Global, she worked for global OEM engineering center in China for several years focusing on project management and product development of infotainment domain products.

Fanni holds a Master of Engineering in Mechatronic System from University of Technology of Compiegne in France, along with an MBA from University of Canberra.

Interviewee

Jiazhong Mu

Director of Cockpit Large Model Solutions, Volcano Engine

Mr. Mu is deeply engaged in the smart cockpit industry, with rich experience in AI product experience design and practice in natural language interaction, multimodal interaction, intelligent Q&A and content generation.
Having worked at New-age Automakers, he was the first in the industry to bring big model experience into the cockpit and push it to mass production.

Citations

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3. Presenters: Fanni Li | Daokuan Lu | Jiazhong Mu – Feb 28,2025
2025 Solutions Webinar ——The Road Ahead: Vehicle Software Evolution and New Business Models
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At S&P Global Mobility, we provide invaluable insights derived from unmatched automotive data, enabling our customers to anticipate change and make decisions with conviction. Our expertise helps them to optimize their businesses, reach the right consumers, and shape the future of mobility. We open the door to automotive innovation, revealing the buying patterns of today and helping customers plan for the emerging technologies of tomorrow.

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