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OVERVIEW OF VEHICLE OPTICAL SOLUTION INDUSTRY

Definition

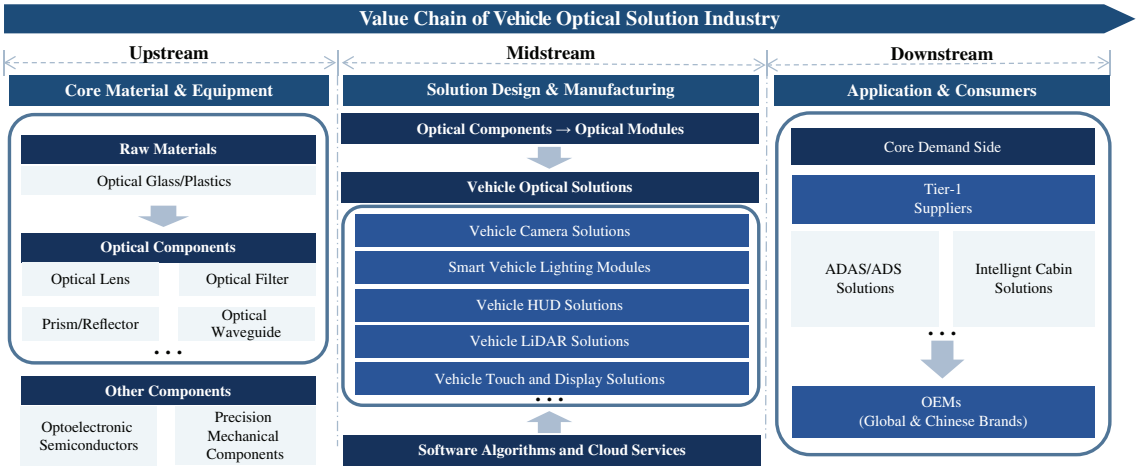
Vehicle optical solution refers to a systematic integration of product and service portfolios built within the intelligent vehicle system, with optical technology at its core, combined with electronic control, image processing, and perception algorithms. The value of this solution lies in empowering intelligent vehicles with two core functions: intelligent perception (achieving high-reliability perception and understanding of the external real world) and intelligent interaction (achieving clear, intuitive, and trustworthy information transmission and interaction between humans and vehicles). It includes vehicle camera solutions for intelligent perception and intelligent cabins, smart lighting solutions, HUD solutions, LiDAR solutions, and screen display solutions, among others. This solution is a complete system of software-hardware fusion and Opto-mechanical-electrical-algorithmic integration, dedicated to meeting stringent automotive-grade standards and intelligent requirements.

Value chain

The upstream sector comprises core optical components (e.g., Lenses), electronic components (e.g., CMOS Image Sensors, PCBA), and precision mechanical parts (e.g., Housing/Packaging). These components serve as the essential core building blocks for automotive-grade optical products.

The midstream sector is responsible for transforming upstream components into functional solutions. Vehicle optical solution providers utilize advanced optical design to integrate individual components into finished vehicle optical products. By further embedding software algorithms and providing cloud services, these providers deliver comprehensive, vertically integrated hardware-plus-software vehicle optical solutions.

The downstream sector entails the integration of optical solutions into the entire vehicle system, such as ADAS/ADS solutions and intelligent cabin solutions, to ultimately enable end-user functions. Key demand originates from Tier-1 suppliers and OEMs.



Source: F&S

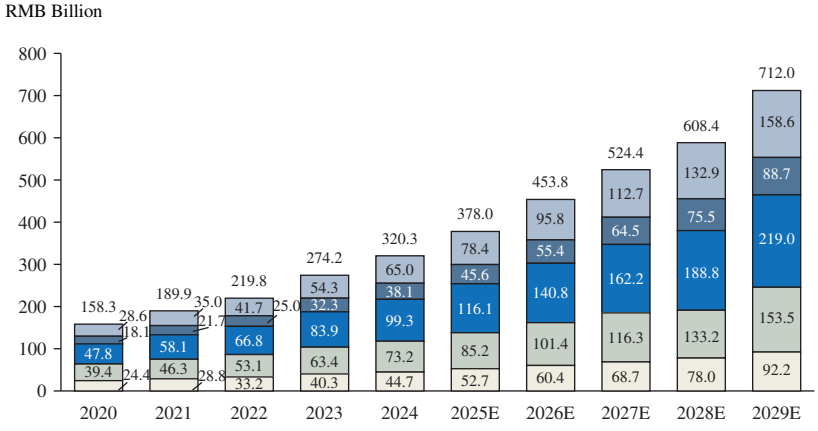
Market Size of Global Vehicle Optical Solution Industry

From 2020 to 2024, the global vehicle optical solution market size expanded from RMB158.3 billion to RMB320.3 billion, representing a CAGR of 19.3%. Regionally, the PRC market size demonstrated the most exceptional performance, surging from RMB28.6 billion to RMB65.0 billion with a CAGR of 22.8%, the highest growth rate globally. The Asia-Pacific market size (excluding PRC) grew from RMB18.1 billion to RMB38.1 billion at a CAGR of 20.5%. Meanwhile, the North American market size grew from RMB47.8 billion to RMB99.3 billion at a CAGR of 20.1%, and the European market size increased from RMB39.4 billion to RMB73.2 billion at a CAGR of 16.7%. Market size in other regions grew from RMB24.4 billion to RMB44.7 billion at a CAGR of 16.3%. This growth was primarily driven by the rising penetration of autonomous driving technology and the widespread adoption of intelligent perception and interaction.

Between 2024 and 2029, the global vehicle optical solution market size is expected to maintain robust momentum and projected to rise from RMB320.3 billion to RMB712.0 billion, at a CAGR of 17.3%. The PRC market size will remain the primary growth engine, expected to reach RMB158.6 billion from RMB65.0 billion at a CAGR of 19.5%. The Asia-Pacific market size (excluding PRC) is projected to reach RMB88.7 billion at a CAGR of 18.4%. The North American market size is forecasted to grow to RMB219.0 billion at a CAGR of 17.1%, while the European market size is expected to expand to RMB153.5 billion at a CAGR of 16.0%. Other regional market size is anticipated to reach RMB92.2 billion at a CAGR of 15.6%. The increasing demand from automakers for high-resolution, low-power, and integrated solutions will drive simultaneous expansion in core areas such as intelligent perception and human-machine interaction (HMI), further fostering the collaborative development of the upstream optical solution industries.

Market Size of Global Vehicle Optical Solution Industry, Breakdown by Regions, by Revenue, 2020-2029E

CAGR	2020-2024	2024-2029E
PRC	22.8%	19.5%
Asia-Pacific (Excluding the PRC)	20.5%	18.4%
North America	20.1%	17.1%
Europe	16.7%	16.0%
Others	16.3%	15.6%
Total	19.3%	17.3%



Note: The exchange rate used in the report is 1 US dollar = 7.12 RMB, according to the Chinese foreign exchange trading system.

Source: International Organization of Motor Vehicle Manufacturers (OICA), F&S

Future trends

Evolution into the "Third Space"

With the implementation of Software-Defined Vehicles (SDV) and centralized E/E architectures, the automobile is evolving from a "driving-centric transportation tool" into a mobile intelligent terminal capable of sustainable OTA updates, which is the user's "Third Space" outside the home and office. This transformation is further accelerated by the rapid commercialization of Robotaxis and autonomous trucks, which redefine vehicles as either shared service hubs or high-efficiency productivity spaces. The core requirements of the "Third Space" enhanced safety controllability, more immersive experiences, and more natural interaction. To achieve the goal of "understanding the environment and people better", the prerequisite is that the vehicle must obtain stable, high-quality visual data input. Consequently, vehicle optical solutions have become the key foundation. Simultaneously, data-driven methods such as world models and VLA are driving high-level autonomous driving from rule engineering toward large-scale data closed-loops. Training and validation rely more on the comparability and reproducibility of massive data, which necessitates that optical solutions maintain stability, consistency, verifiability, and traceability under complex conditions. Therefore, future vehicle optical solutions will continuously iterate to support the safety redundancy, immersive cabin experience, and human-machine trust construction required by the "Third Space".

Intelligent Perception & Interaction

The leading competitiveness of intelligent vehicles is evolving toward the integrated perception and interaction capability with vision as the core. On one hand, external perception emphasizes "interpreting the world"; the key lies not in the stacking of single sensors, but in full-domain coverage and fusion perception centered on multiple sensors, continuously improving the recognition accuracy of information outside the vehicle and maintaining stable input in complex situations. On the other hand, the intelligent cabin emphasizes "conveying trust"; when decisions are increasingly dominated by the system, the vehicle needs to present perception results, risk judgments, and intent expressions to drivers and passengers in a more intuitive way, such as achieving spatial alignment of navigation and hazard warnings through AR-HUD, or clearly communicating system status, handover requirements, and safety boundaries through smart lighting, thereby reducing misunderstanding and uncertainty. Therefore, the fusion of perception and interaction is driving vehicle optical hardware from "individual functional point configurations" toward "systemic configurations." Cameras are being upgraded from traditional auxiliary components such as reversing/surround-view into core information entries spanning front-view, side-view, rear-view, and in-cabin monitoring. Consequently, the single-vehicle configuration is evolving toward a multi-sensor distributed architecture and continues to improve, directly driving the simultaneous growth of the loading volume and value of vehicle optical products.

Opto-Mechanical-Electrical-Algorithmic Integration

As algorithms gradually move from single-point functional modules toward end-to-end and multimodal large models, the competition for vehicle optical solutions is upgrading from single hardware supply to a collaborative software-hardware integrated system. The industry-leading evolutionary path usually takes the algorithm and software platform as the core,

integrating optics, precision structures, electronics, and computing capabilities into a system that can be implemented at scale: the front-end improves imaging clarity and consistency through better optical design and precision structures, ensuring stable output even in complex scenarios such as night, backlight, and rain or fog; the mid-end helps data achieve long-term reliability and traceability through electronic control and sensing links; the back-end involves the algorithm dividing work and collaborating between edge and central computing power to complete perception and image enhancement, while achieving rapid reuse across vehicle models and platforms through unified interfaces and calibration frameworks. This software-hardware integrated system, with "stable and consistent visual input in complex scenarios + traceable data links + platform-based rapid reuse" as its core, supports both the safety redundancy requirements of intelligent driving and the comfort and reliability requirements of cabin interaction.

OVERVIEW OF VEHICLE CAMERA SOLUTION INDUSTRY

Definition

Vehicle camera solutions refer to the deep integration of optical lenses, image sensors, processing algorithms (ISP/AI), and system integration services to build a complete visual perception and interaction system for intelligent vehicles. Its core value lies in providing real-time visual data by capturing and processing environmental and in-cabin image information to support autonomous driving decisions or optimize the human-vehicle interaction experience. Vehicle camera solutions can be divided into two categories: smart sensing camera solutions and smart cabin camera solutions. Among them, smart sensing camera solutions primarily serve ADAS and intelligent driving systems, emphasizing target recognition, distance estimation, and motion perception of the external environment; they have high requirements for image sensor performance, algorithm adaptation, and system reliability. In contrast, smart cabin camera solutions focus on image display and in-cabin sensing applications, covering camera monitoring system (CMS), surround view, parking imaging, DMS, OMS, and other in-car monitoring scenarios, placing more emphasis on image quality, stability, and the human-vehicle interaction experience.

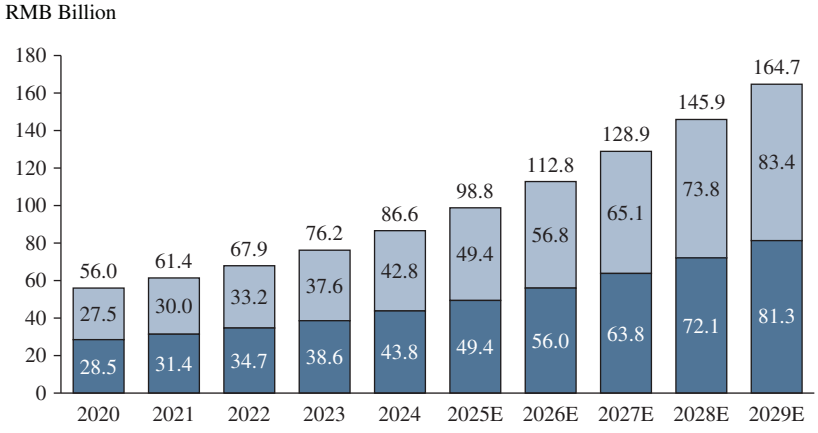
Market Size of Global Vehicle Camera Solution Industry

From 2020 to 2024, the global vehicle camera solution market size increased from RMB56.0 billion to RMB86.6 billion, representing a CAGR of 11.5%. From a segmented structure perspective, smart cabin camera solution market size grew from RMB28.5 billion to RMB43.8 billion, with a CAGR of 11.3%. This segment primarily covers application scenarios such as rearview, surround-view, side-view, DMS, and OMS, expanding steadily driven by rising installation rates and high-definition upgrades. The market size of Smart sensing camera solutions increased from RMB27.5 billion to RMB42.8 billion, with a CAGR of 11.7%, which is more closely linked to the perception requirements of front-view ADAS and multi-camera fusion. Demand in this area is rising as intelligent driving functions trickle down to mid-range vehicle models. Overall, the two major segments remain relatively balanced in scale, with industry growth driven by intelligent driving penetration, an increase in the number of cameras per vehicle, and performance upgrades such as night vision, wide dynamic range, and wide-angle capabilities.

It is expected that from 2024 to 2029, the global vehicle camera solution market size will grow from RMB86.6 billion to RMB164.7 billion, with a CAGR of 13.7%, a further acceleration compared to the previous stage. By segment, smart sensing camera solution market size is projected to increase from RMB42.8 billion to RMB83.4 billion, with a CAGR of 14.3%. The growth momentum stems mainly from the enhanced need for front-view and surround-view perception in higher-level autonomous driving, as well as the impact of multi-camera fusion on the quantity and specifications of front-end camera configurations. Smart cabin camera solution market size is expected to reach RMB81.3 billion from RMB43.8 billion, with a CAGR of 13.2%. This growth is driven by regulations and safety standards, the rising adoption of DMS and OMS, and increasing demand for in-vehicle interaction, while imaging functions like rearview and surround-view continue to become standard features. As high-pixel count, low-light imaging, and system-level integration become core competitive factors, the value of both segments is expected to rise further alongside specification upgrades and increased solution complexity.

Market Size of Global Vehicle Camera Solution Industry, Breakdown by Application, by Revenue, 2020-2029E

CAGR	2020-2024	2024-2029E
Smart Sensing Solutions	11.7%	14.3%
Smart Cabin Solutions	11.3%	13.2%
Total	11.5%	13.7%



Note: The exchange rate used in the report is 1 US dollar = 7.12 RMB, according to the Chinese foreign exchange trading system.

Source: International Organization of Motor Vehicle Manufacturers (OICA), F&S

Market Drivers

Booming Global Vehicle Market

The steady growth of the global vehicle market provides a vast strategic hinterland for vehicle camera solutions, with China serving as a core bastion and the primary engine driving this expansion. In recent years, global vehicle sales have continued to climb, reaching 95.6 million units in 2025. NEVs have emerged as the core growth pole, with sales surpassing 23.37 million units as market penetration steadily increases. This massive market base, compounded by the trends of vehicle intelligence and connectivity, has directly expanded the foundational demand for vehicle camera installations. Market data indicates that global NEV penetration has surged from 4.1% in 2020 to 21.8% in 2024, with projections reaching 47.3% by 2029. High-pixel, high-performance camera solutions precisely align with the advanced perception requirements of NEVs. Consequently, as NEV penetration rises, the industry is witnessing a continuous expansion of market share. In 2024, the average camera count per global NEV reached 4.8 units, significantly exceeding the average of 2.1 units found in traditional Internal Combustion Engine (ICE) vehicles.

Advancement of Vehicle Intelligence

The acceleration of vehicle intelligence, particularly the deep integration of smart sensing and smart cabins, is driving the transformation of vehicle camera solutions from basic quantity coverage toward high-level performance enhancement. In the field of intelligent sensing, autonomous driving technology is breaking through from L2 toward L3 and above. The global penetration rate of L2-level assisted driving in the passenger vehicle incremental market has risen from 16.6% in 2020 to 32.2% in 2024, and is expected to reach 44.2% in 2029; meanwhile, L3 and higher-level autonomous driving are beginning to take shape, with the industry predicting a penetration rate of approximately 2.1% in 2024 and expecting it to rise to approximately 8.4% in 2029. Against the backdrop of significantly increased perception requirements for high-level autonomous driving, vehicle cameras are accelerating their evolution toward high resolution, high dynamic range, and low-light performance to support more stable algorithmic inputs. In the field of smart cabins, the popularization of DMS and OMS further expands the application boundaries of in-cabin vision, extending it from basic monitoring to functions such as identity recognition, attention and state recognition, and health and safety-related alerts, driving simultaneous improvements in cabin interaction across dimensions of safety and comfort. Consequently, single-vehicle camera configurations are gradually upgrading from a small number of traditional functional configurations to a distributed vision architecture covering multiple scenarios such as front-view, side-view, rear-view, surround-view, and in-cabin. The number of cameras per vehicle is expected to increase from 3-5 units in 2024 to 8-12 units in 2029, forming large-scale demand growth.

Continuous Breakthroughs in Optical Technology

The iterative upgrading of core technologies, such as optical design and manufacturing processes, not only enhances camera performance but also reduces the costs of large-scale application, providing technical support for market expansion. In terms of optical design, Glass-Plastic Hybrid (GPH) lens architectures optimize cost and lightweight performance while improving image quality. The application of technologies such as automotive-grade

Variable Aperture and Spatial Frequency Response (SFR) clarity assurance further enhances product adaptability in complex scenarios. In the manufacturing domain, technologies like All-in-One high-precision housing assembly have significantly improved production efficiency, yield, and structural reliability. These core breakthroughs have birthed innovative products such as ultra-high-definition lenses and active defogging e-Mirror cameras, forming a differentiated competitive advantage while facilitating cost down through technical optimization. This allows products to penetrate mid-to-low-end vehicle segments, broadening overall market coverage.

Policy and Regulatory Drivers

Government vehicle safety standards and industrial support policies issued worldwide have provided a guarantee and a favorable environment for the popularization of vehicle camera solutions. In terms of safety regulations, mandatory standards have become a "rigid demand" engine for the growth of installation volume: the European General Safety Regulation (GSR) and the new NHTSA regulation in the United States regarding the mandatory standard configuration of AEB (Autonomous Emergency Braking) by 2029, coordinated with China's C-NCAP evaluation system, have significantly increased the requirements for active safety functions, directly driving a leap-forward increase in the installation rate of vehicle cameras as core perception units. Relying on the collaborative empowerment of multiple policies, in 2023, four departments (the Ministry of Industry and Information Technology, the Ministry of Public Security, the Ministry of Housing and Urban-Rural Development, and the Ministry of Transport) jointly issued the "Notice on Carrying out Pilot Work for Intelligent Connected Vehicle Access and On-road Communication," laying the core policy foundation for the compliant road use of high-level intelligent driving vehicles; in 2025, the General Office of the State Council issued the "Implementation Opinions on Accelerating Scenario Cultivation and Opening to Promote Large-scale Application of New Scenarios," providing policy support for the full opening of intelligent driving application scenarios, marking the official transition of the industry from "limited area pilots" to a new stage of "full-space scenario exploration"; in the same year, the first batch of domestic L3-level autonomous driving model certifications was officially implemented and issued. This milestone event further marks that intelligent connected vehicles have officially moved from the assisted driving stage to a substantive development stage of high-level autonomous driving. These policies have driven the large-scale configuration demand in the market for high-resolution, high-dynamic-range vehicle vision cameras.

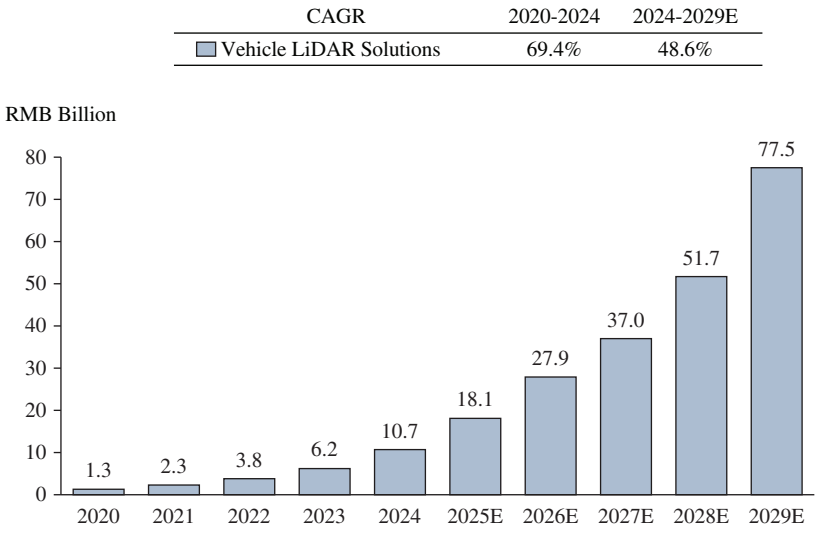
OVERVIEW OF OTHER VEHICLE OPTICAL SOLUTION INDUSTRY

Market Size of Global Vehicle LiDAR Solution Industry

From 2020 to 2024, the global vehicle LiDAR solution market size rapidly expanded from RMB1.3 billion to RMB10.7 billion, representing a CAGR of 69.4%. This stage primarily occupied the initial period transitioning from pilot verification to early mass production; although the market size remained small, growth was extremely rapid. The Chinese market achieved a breakthrough in front-loading penetration starting in 2023, with numerous automakers launching models equipped with LiDAR, propelling the overall industry from "solution verification" to "commercial deployment."

The global vehicle LiDAR solution market size is expected to grow from RMB10.7 billion to RMB77.5 billion between 2024 and 2029, with a CAGR of 48.6%. With the implementation of L3 and above autonomous driving, LiDAR will become an essential sensing unit for achieving high-precision environmental perception. In the coming years, adoption is expected to penetrate down from high-end models to the mid-range market, driving an increase in the number of units per vehicle and the optimization of cost structures. By 2029, vehicle LiDAR is expected to evolve from an emerging feature into a key standard component of intelligent driving systems.

Market Size of Global Vehicle LiDAR Solution Industry, by Revenue, 2020-2029E



Note: The exchange rate used in the report is 1 US dollar = 7.12 RMB, according to the Chinese foreign exchange trading system.

Source: International Organization of Motor Vehicle Manufacturers (OICA), F&S

Market Drivers of Vehicle LiDAR Solution Industry

Perception Requirement Upgrades for High-Level Autonomous Driving

With the popularization of intelligent driving, systems are placing higher requirements on long-range detection, 3D reconstruction, and complex operating conditions. Consequently, the industry is gradually introducing "Vision + LiDAR" multi-sensor fusion solutions to enhance safety redundancy in scenarios such as nighttime, backlight, and dense clusters of complex traffic participants. In terms of installation configuration, the LiDAR deployment on mass-produced passenger vehicles is evolving from single-point forward-facing configurations toward multi-point distributed layouts. The coverage area is extending from forward long-range detection to near-range blind-spot filling around the vehicle body, aimed at improving the integrity of 3D environmental modeling and reducing perception uncertainty.

Rising Supply Chain Thresholds and Solution Innovation

The mass-production of automotive-grade LiDAR must overcome high thresholds for automotive-grade reliability, environmental adaptability, and long-term stability. OEMs demand more than just standard certifications like IATF 16949; they prioritize robust performance under extreme weather conditions. This has prompted suppliers to innovate in system designs such as transceivers and scanning products, ensuring the all-weather reliability of LiDAR in harsh operating environments.

Economies of Scale and Domestic Supply Chain Substitution

While enhancing intelligent driving capabilities, OEMs have increased their requirements for single-vehicle costs and supply stability. As the installation scale expands, the procurement bargaining power and economies of scale for LiDAR have driven down unit costs; meanwhile, the localization of the supply chain for key components, manufacturing processes, and local delivery systems has further reduced comprehensive costs, shortened delivery cycles, and enhanced rapid iteration capabilities.

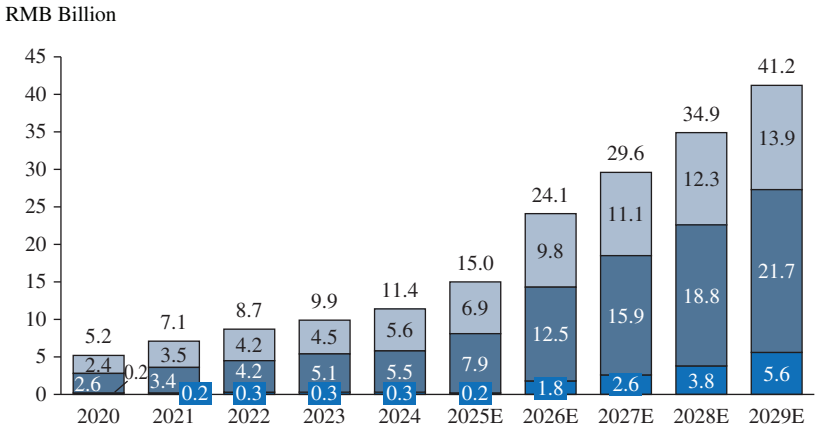
Market Size of Global Vehicle HUD Solution Industry

From 2020 to 2024, the global vehicle HUD solution market size grew from RMB5.2 billion to RMB11.4 billion, representing a CAGR of 21.7%. Within this market, the AR-HUD market size increased from RMB 2.6 billion to approximately RMB 5.5 billion, with a CAGR of 20.6%. Its increasing share reflects the growing demand from OEMs for immersive displays in scenarios such as navigation visualization and ADAS information fusion. During the same period, the W-HUD (Windshield Head-Up Display) market size grew from RMB 2.4 billion to approximately RMB 5.6 billion, with a CAGR of 23.6% from 2020 to 2024, primarily benefiting from its high maturity and controllable costs. Other HUD formats accounted for a minimal share at this stage, primarily including the early C-HUD (Combiner HUD) and a small number of P-HUD (Panoramic HUD) solutions.

Looking ahead, the global vehicle HUD solution market size is expected to grow from RMB11.4 billion to RMB41.2 billion between 2024 and 2029, with a CAGR of 29.3%. From a segmentation perspective, AR-HUD will emerge as the most critical growth engine, with its market size projected to expand from RMB5.5 billion to approximately RMB21.7 billion, representing a CAGR of 31.6% from 2024 to 2029. Its advantages in wide-field-of-view projection, multi-layer information overlay, and synergy with intelligent driving systems will continue to be realized. Overall, the HUD product structure is shifting from a W-HUD focus toward AR-HUD, and the industry is accelerating its evolution toward high-value and system-integrated solutions.

Market Size of Global Vehicle HUD Solution Industry, Breakdown by Projection Method, by Revenue, 2020-2029E

CAGR	2020-2024	2024-2029E
W-HUD	23.6%	19.9%
AR-HUD	20.6%	31.6%
Others	10.7%	79.6%
Total	21.7%	29.3%



Note:

1) The exchange rate used in the report is 1 US dollar = 7.12 RMB, according to the Chinese foreign exchange trading system.

2) Others include C-HUD and P-HUD

Source: International Organization of Motor Vehicle Manufacturers (OICA), F&S

Market Drivers of Vehicle HUD Solution Industry

Evolution of Intelligent Cabin Solutions

Within the macro-trend of Intelligent Cabin expansion, the role of the HUD has evolved from a simple "information readout" to a critical hub for cabin interaction and emotional experience, leading to a profound redefinition of its value. Moving beyond a mere replacement for traditional instrument clusters, the HUD now integrates in-cabin perception data with lifestyle service information, translating them into low-latency, intuitive visual feedback. This necessitates more robust image processing and real-time rendering capabilities to support dynamic Cabin HMI interactions, positioning the HUD as a core lever for OEMs to cultivate a unique competitive edge in the "Mobile Third Space."

Rising Demand for High-Performance AR-HUD

Massive environmental perception information (such as lane lines, navigation, and obstacles) needs to be transmitted to the driver in a more efficient and less distracting way. AR-HUD has become the ideal form for achieving this goal by deeply integrating virtual information with real-world road scenes. From the perspective of installation progress, AR-HUD is currently applied mainly in high-end models, with a penetration rate of only 4.8%; it is expected that by 2029, its penetration rate will increase to over 20.0%, with a compound annual growth rate of the penetration rate of approximately 33.1% during this period, reflecting accelerated penetration and space for large-scale expansion. Meanwhile, AR-HUD is developing toward a large FOV, long Virtual Image Distance (VID), and cinema-grade immersion, which places extremely high requirements on the performance of its core imaging component, the PGU.

Supply Chain Maturity and Cost Reduction

The accelerated penetration of HUD solutions across a broader range of vehicle segments is fundamentally driven by the continuous cost optimization of core components and the maturation of the global supply chain. The increasing maturity and scaled production capacities of diverse technological pathways, specifically TFT, DLP, and LCoS, directly dictate the overall cost reduction of HUD systems and the expansion of their performance boundaries.

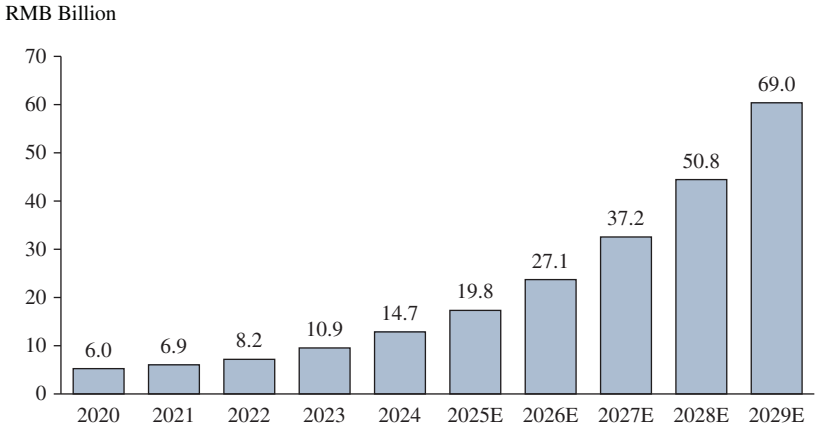
Market Size of Global Smart Vehicle Lighting Solution Industry

From 2020 to 2024, the global smart vehicle lighting solution market size increased from RMB6.0 billion to RMB14.7 billion, representing a CAGR of 25.1%. This growth was primarily driven by the continuous rise in LED penetration and the intelligent upgrading of vehicle lighting systems. The popularization of technologies such as Adaptive Driving Beam (ADB), matrix LED, and dynamic projection lights has propelled the evolution of vehicle lights from traditional illumination to intelligent control and human-vehicle interaction.

Looking ahead, the global smart vehicle lighting solution market size is expected to grow from RMB14.7 billion in 2024 to RMB69.0 billion by 2029, with a CAGR of 36.2%. This expansion will be fueled by the rising proportion of NEVs and intelligent driving models, leading to the accelerated adoption of intelligent headlamps and interactive lighting systems. In the future, smart vehicle lighting will further integrate with perception and display systems, becoming a vital component of the vehicle's overall perception and interaction framework. The industry will evolve toward high integration, intelligent perception, and the seamless fusion of human-machine interaction.

Market Size of Global Smart Vehicle Lighting Solution Industry, by Revenue, 2020-2029E

CAGR	2020-2024	2024-2029E
Smart Vehicle Lighting Solutions	25.1%	36.2%



Note: The exchange rate used in the report is 1 US dollar = 7.12 RMB, according to the Chinese foreign exchange trading system.

Source: International Organization of Motor Vehicle Manufacturers (OICA), F&S

Market Drivers of Smart Vehicle Lighting Solution Industry

Lighting Technology Iteration and Intelligent Function Integration

To meet consumer demands for safety, personalization, and interactive experiences, OEMs are continuously driving disruptive innovations in vehicle lighting technology. Smart lighting is upgrading from static light sources into programmable "intelligent visual terminals." Its core lies in achieving advanced functions such as dynamic beam adjustment, adaptive lighting, and road projection through high-precision optical design and electronic control. Based on these functions, the role of vehicle lighting has extended from unidirectionally "illuminating the road" to becoming an important medium for information interaction between the vehicle and the outside world. By conveying intentions to pedestrians and surrounding vehicles through projection prompts, dynamic light signatures, and adaptive beam patterns, it not only enhances driving safety in various scenarios but also serves as a key means for OEMs to build brand technology labels through differentiated styling and interactive design, continuously driving the increase of product added value.

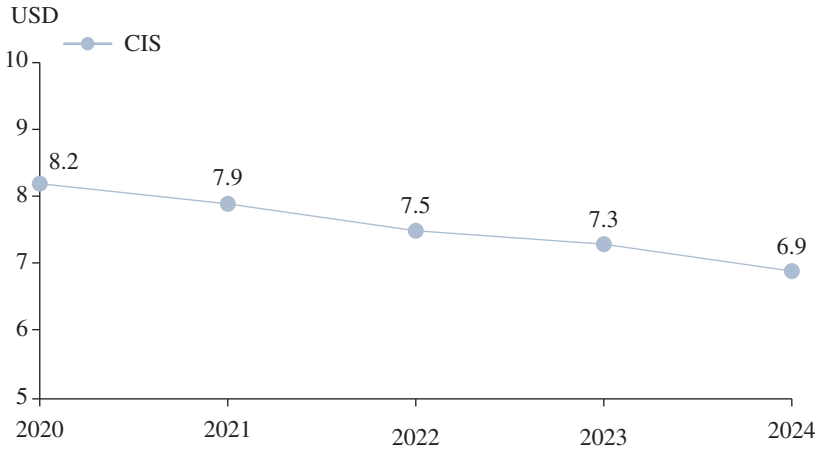
Performance Advantages and Value Enhancement of Smart automotive Lighting

Compared to traditional lighting systems, smart automotive lighting offers significant advantages in functional scalability. Its deep integration with vehicle sensors and autonomous driving systems transforms lighting into a critical medium for Exterior Interaction, enhancing driving safety while enriching human-vehicle engagement. Consequently, smart automotive lighting is experiencing accelerated penetration in mid-to-high-end vehicle models. The heightened technical complexity and inherent premium of these systems are directly propelling the growth of the Content per Vehicle (CPV) for vehicle lighting systems.

Main Cost Analysis of Vehicle Camera Solutions

The cost structure of vehicle camera solutions exhibits a distinct tiered distribution, with electronic components accounting for the highest proportion at roughly 55%, within which the CIS holds a dominant position as the core component responsible for image acquisition and processing. Based on average market procurement prices, the cost of CIS decreased from USD8.2 in 2020 to USD6.9 in 2024. Driven by the expansion of production scale, localized technological progress, and intensified market competition, the average selling price of vehicle camera hardware has shown a downward trend over the past few years.

Main Cost Analysis of Vehicle Camera Solutions, 2020-2024



Source: F&S

COMPETITIVE LANDSCAPE

Rankings

1. Ranking of Global Vehicle Camera Solution Companies, by Market Share Measured by Shipments (2024)

Ranking	Company	Market Share in Global Vehicle Camera Solution Industry, 2024
1	***The Company***	***16.2%***
2	Company A[1]	6.6%
3	Company B[2]	6.0%
4	Company C[3]	5.8%
5	Company D[4]	4.7%
	Top 5 Subtotal	**39.3%**

Notes:

(1) Headquartered in Germany and founded in 1886, it is one of the world's largest vehicle supplier providing advanced LiDAR, multi-purpose cameras, and radar-vision fusion solutions for intelligent driving.

(2) Headquartered in France and founded in 1923, it is a global leader in ADAS and the first supplier to mass-produce automotive-grade LiDAR for high-level autonomous driving.

(3) Headquartered in the PRC and founded in 1998, it is a leading supplier of high-definition vehicle lenses and optical components, specializing in high-precision glass aspherical lens manufacturing.

(4) Headquartered in Canada and founded in 1957, it is a top-tier global supplier offering integrated vision systems, digital rearview mirrors, and comprehensive ADAS perception solutions.

Source: Annual reports, F&S

2. Ranking of Global Vehicle Smart Sensing Camara Solution Companies, by Market Share Measured by the Shipments (2024)

Ranking	Company	Market Share in Global Vehicle Smart Sensing Camara Solution Industry, 2024
1	***The Company***	***16.0%***
2	Company B	6.6%
3	Company A	5.2%
4	Company C	4.5%
5	Company E[1]	4.4%
	Top 5 Subtotal	**36.7%**

Notes:

(1) Headquartered in Germany and founded in 1915, it is a global leader in driveline and chassis technology as well as active and passive safety systems, providing integrated camera and radar-based sensing solutions for automated driving.

Source: Annual reports, F&S

3. Ranking of Global Vehicle Smart Cabin Camara Solution Companies, by Market Share Measured by the Shipments (2024)

Ranking	Company	Market Share in Global Vehicle Smart Cabin Camara Solution Industry, 2024
1	***The Company***	***16.3%***
2	Company B	7.9%
3	Company A	7.1%
4	Company C	6.2%
5	Company E	5.8%
	Top 5 Subtotal	**43.3%**

Source: Annual reports, F&S

The Competitive Landscape of Other Vehicle Optical Solutions

The competitive landscape of other vehicle optical solutions, including LiDAR, HUD, and Smart Lighting, is currently characterized by a high degree of fragmentation as these industries remain in their relatively early stages of market penetration. The ecosystem features a diverse array of participants, ranging from specialized technology startups and traditional Tier-1 suppliers to vertically integrating OEMs. Due to the lack of established market dominance, the competitive field is characterized by intense technological rivalry and diverse

architectural approaches. Moving forward, the market is expected to undergo consolidation, where enterprises possessing robust opto-mechatronic-algorithmic integration capabilities, superior cost-control through economies of scale, and strong ecosystem partnerships are projected to capture a dominant share of the global market.

Entry Barriers

Technical Barrier

Vehicle optical solutions are required to meet stringent automotive-grade technical and manufacturing process standards, forming significant technical barriers, which are mainly reflected in three aspects. First is optical design capability: structural design and material selection must be tailored to extreme operating conditions such as high and low temperatures, intense vibrations, sand, dust, rain and snow. Second is precision manufacturing processes, including coating, key optical component processing and high-precision assembly and adjustment. Third is the full-cycle reliability verification and simulation system. The development of vehicle optical products is not a single testing phase, but requires the establishment of a simulation design and verification system covering the entire lifecycle from R&D and product development to large-scale mass production. Leading enterprises have established patent portfolios and mature process systems, and new entrants cannot break through core technical and process bottlenecks in the short term.

Qualification Barrier

The vehicle industry is characterized by exceptionally high entry thresholds, primarily due to prolonged and stringent certification cycles that present significant hurdles for new entrants. Vehicle optical products are categorized as critical safety components, necessitating compliance with the industry's highest quality assurance standards (such as IATF 16949 and ISO 26262). Navigating these rigorous auditing and validation processes typically requires several years of intensive technical refinement.

Customer Barrier

Established suppliers benefit from formidable customer barriers forged through long-term strategic alignment with Tier-1 suppliers and OEMs. Top-tier suppliers often secure their market position by engaging in joint pre-research and development (R&D) cycles, where they collaborate with customers to define the parameters of next-generation optical solutions years before mass production. This "deep-bonding" mechanism makes it exceedingly difficult for new entrants to displace incumbent suppliers in flagship vehicle programs.

Capital Barrier

The vehicle optical solutions industry requires continuous high capital investment, placing significant financial pressure on new entrants. On one hand, the proportion of R&D investment remains consistently high, necessitating the long-term retention of professional technical teams. On the other hand, the cost of building automotive-grade production capacity is substantial (including clean rooms, high-precision manufacturing equipment, etc.). Initial investment scales will be even larger if production capacity is deployed across multiple regions.

SOURCE OF INFORMATION

In connection with the [**REDACTED**], we have engaged Frost & Sullivan to conduct a detailed analysis and prepare a market research report on the vehicle optical solution industry. Frost & Sullivan is an independent global market research and consulting company which was founded in 1961 and is based in the U.S. Services provided by Frost & Sullivan include market assessments, competitive benchmarking, and strategic and market planning for a variety of industries. The agreed fee paid to Frost & Sullivan for the preparation and use of the Frost & Sullivan Report is RMB500,000. The payment of such amount was not contingent upon our successful [**REDACTED**] or on the results of the Frost & Sullivan Report. Except for the Frost & Sullivan Report, we did not commission any other market research report in connection with the [**REDACTED**]. We have included certain information from the Frost & Sullivan Report in this document because we believe such information facilitates an understanding of the vehicle optical solution industry. Unless otherwise indicated, market estimates or forecasts in this section represent Frost & Sullivan's view on the future development of the vehicle optical solution industry.

In preparing the Frost & Sullivan Report, Frost & Sullivan has relied on its in-house database, independent third-party reports, and publicly available data from reputable industry organizations. Where necessary, Frost & Sullivan contacts companies operating in the industry to gather and synthesize information in relation to the market, prices, and other relevant information. Frost & Sullivan has exercised due care in collecting and reviewing the information so collected and believes that the basic assumptions used in preparing the Frost & Sullivan Report, including those used to make future projections, are factual, correct, and not misleading. Frost & Sullivan has independently analyzed the information, but the accuracy of the conclusions of its review largely relies on the accuracy of the information collected. In compiling and preparing the research, Frost & Sullivan assumed that the social, economic, and political environments in the relevant markets are likely to remain stable in the forecast period, which ensures the stable and healthy development of the vehicle optical solution industry. In addition, Frost & Sullivan has developed its forecast on the following bases and assumptions: (i) the economy in the global range is likely to maintain stable growth in the next decade, and (ii) the vehicle optical solution industry is expected to grow based on the macroeconomic assumptions of the economy. Frost & Sullivan's research may be affected by the accuracy of these assumptions and the choice of these primary and secondary sources. Except as otherwise noted, all data and forecasts in this section come from the Frost & Sullivan Report.