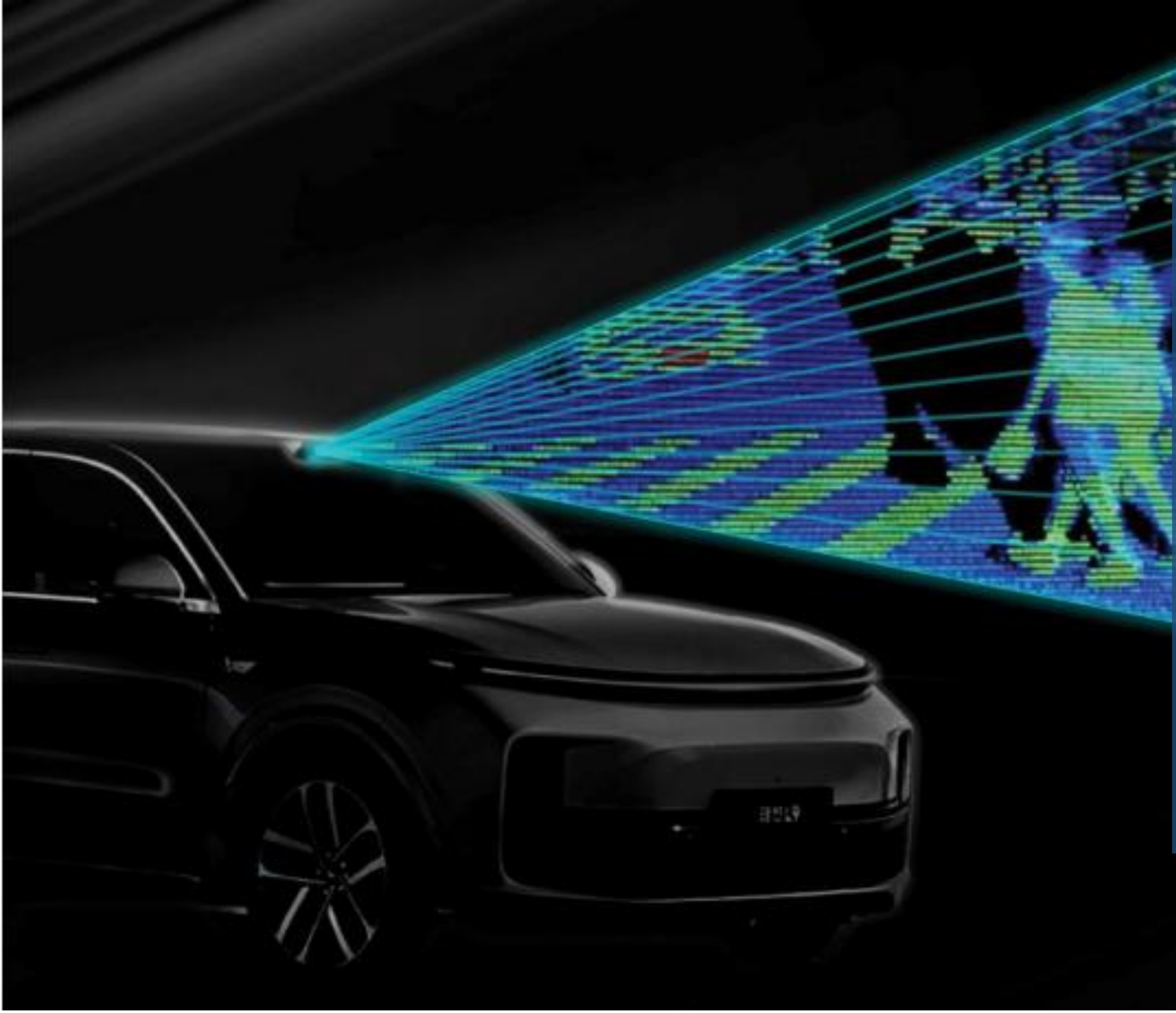


灼识咨询
China Insights Consultancy

Industry Report on Global LiDAR Industry

September, 2025

CIC introduction, methodologies and assumptions

China Insights Consultancy is commissioned to conduct research and analysis of, and to produce a report on the global LiDAR market. The report commissioned has been prepared by China Insights Consultancy independent of the influence of The Company or any other interested party.

China Insights Consultancy is an investment consulting company originally established in Hong Kong. Its services include industry consulting services, commercial due diligence, strategic consulting, and so on. Its consultant team has been tracking the latest market trends in the automobile, agriculture, chemical, user goods, marketing and advertising, culture and entertainment, energy and industry, finance and service, healthcare, TMT, transportation, and other industries, and has the most relevant and insightful market intelligence in these mentioned industries.

China Insights Consultancy undertook both primary and secondary research using various resources to construct this report. Primary research involved interviewing key industry experts and leading industry participants. Secondary research involved analyzing data from various publicly available data sources, including National Bureau of Statistics, industry associations, etc. The information and data collected by China Insights Consultancy have been analyzed, assessed, and validated using China Insights Consultancy's in-house analysis models and techniques. The methodology used by China Insights Consultancy is based on information gathered from multiple levels, which allows for such information to be cross-referenced for reliability and accuracy.

The market projections in the commissioned report are based on the following key assumptions: (i) the overall social, economic, and political environment in China is expected to remain stable during the forecast period; (ii) related key industry drivers are likely to propel continued growth in global LiDAR market throughout the forecast period, including favorable policies and wider acceptance of different levels of autonomous driving features in vehicle.(iii) there will be no extreme force majeure or unforeseen industry regulations in which the market may be affected in either a dramatic or fundamental way during the forecast period.

All statistics are reliable and based on the most recent information available as of the date of this report. Other sources of information, including governments, industry associations, or marketplace participants, may have provided some of the information on which data or its analysis is based.

All the information about the Company is sourced from either the Company's own audited report or management interviews. China Insights Consultancy is not responsible for verifying the information obtained from the Company.

Terms and Abbreviations (1/2)

Terms:

- **Advanced Driver-Assistance Systems (ADAS)**： refers to the groups of electronic technologies that assist drivers in driving and parking functions. 高级辅助驾驶系统
- **Automotive Camera:** which is mainly also know as auto camera, which majorly used to assist the driver for parking, maneuvering and assessing the vehicle performance. 汽车摄像头
- **Compound Annual Growth Rate (CAGR):** refers to the year-over-year growth rate which is calculated by taking the root of the total percentage growth rate over a specified period of time. The formula for calculating CAGR is: (ending value / beginning value)^(1/number of years)-1. 年均复合增长率
- **Detection Range**: refers to the maximum distance in which a LiDAR can detect a 2 meters x 2.5 meters object at 10% reflectivity with POD of over 50% according to the Test Methods of Automotive LiDAR drafted by China Association of Automobile Manufacturers. 探测距离
- **Field of View (FOV)**: refers to the angular size of the scene captured by a sensor, as measured in vertical and horizontal angular extent. 视场角
- **Light Detection And Ranging (LiDAR):** refers to a method for determining ranges (variable distance) by targeting an object with a laser and measuring the time for the reflected light to return to the receiver. 激光雷达
- **Millimeter Wave (mmWave) Radar:** refers to a special class of radar technology that uses short-wavelength electromagnetic waves. 毫米波雷达
- **Mass Production:** refers to the manufacturing of large quantities of standardized products, often using assembly lines or automation technology. 量产
- **Mechanical LiDARs:** refers to to LiDARs that have motorized moving parts in their scanners. 机械式激光雷达
- **Original Equipment Manufacturer (OEM):** When referring to auto parts, the term refers to the manufacturer of the original equipment, that is, the parts assembled and installed during the construction of a new vehicle. 整车厂
- **Robotaxi:** The term also known as a self-driving taxi or a driverless taxi, is an autonomous car (SAE automation level 4 or 5 passenger vehicles) operated for a ridesharing company. 无人驾驶出租车
- **Robotruck:** The term also known as an autonomous truck, or self-driving truck (SAE automation level 4 or 5 commercial vehicles), requires no human driver, similar to self-driving cars. 无人驾驶卡车
- **Fully Solid-state LiDARs:** refers to LiDARs that do not have moving parts for laser scanning or their moving parts steer only the laser beam in free space without moving any optical components. 固态式激光雷达
- **Hybrid Solid-state LiDARs**: refers to LiDARs in which TX/RX is static, but is complemented by one or more moving scanners in the LiDAR. 混合固态式激光雷达

Terms and Abbreviations (2/2)

Abbreviations:

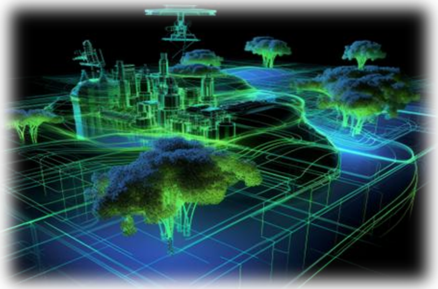
- **APD:** Avalanche Photodiode 雪崩光电二极管
- **ADAS**: Advanced Driver-Assistance System 高级辅助驾驶系统
- **AM**：Autonomous Mobility 自动驾驶车辆
- **EEL**: Edge-Emitting Laser 边发射激光器
- **EMC**: Electro-Magnetic Compatibility 电磁兼容指令
- **FMCW:** Frequency-Modulated Continuous Wave 调频连续波
- **FOV**: Field of View 视角场
- **MEMS**：Micro-Electro Mechanical System 微机电系统
- **NOA:** Navigation on Autopilot 自动辅助导航驾驶
- **OPA:** Optical Parametric Amplifier 光学相控阵
- **POD**：Probability of Detection 探测概率
- **PV:** Passenger Vehicle 乘用车
- **SiPM:** Silicon Photomultiplier 硅光电倍增管
- **SPAD:** Single-Photon Avalanche Diode 单光子雪崩二极管
- **SOP**: Start of Production 开始标准化生产
- **VCSEL:** Vertical Cavity Surface Emitting Laser 垂直腔面发射激光器
- **TOF:** Time of Flight 飞行时间法

Content

Definition of LiDAR

-LiDAR is an acronym for "light detection and ranging." It uses pulsed laser light to precisely measure the distance, speed, and altitude of objects.

Definition of LiDAR



- LiDAR is a remote sensing technology that uses pulsed laser light to precisely measure the distance, speed, and altitude of objects. It acts as the "eyes" for autonomous vehicles and helps create detailed maps of their surroundings.
- Acting as a crucial sensor alongside cameras and radar, LiDAR enables the acquisition of accurate and rapid measurements for both natural and manmade environments, and hence providing smart vehicles with a high-resolution three-dimensional vision. This enhances these vehicles' sensing abilities, allowing them to identify and track surrounding vehicles, pedestrians, animals, and other objects that may impact driving conditions, even in low-light environments.
- LiDAR provides high-precision distance measurement, advanced three-dimensional modeling, and robust resistance to interference. It has been adopted across a wide range of application scenarios, including ADAS, Robotaxi, Robobus, Robotruck, as well as other Robotics used in sectors such as warehousing and logistics, industrial manufacturing, and smart agriculture.

History of transition of LiDAR

The history of LiDAR started with mechanical LiDAR, the most common type of LiDAR. As the trajectory of LiDAR technology continues to expand, different types of LiDAR systems are beginning to differentiate themselves in various application scenarios.

Hybrid solid-state LiDAR & Fully solid-state LiDAR

- In the current context, the mature hybrid solid-state LiDAR technology has ushered in the era of mass production. As the ADAS industry continues to evolve, the demand for LiDAR technology is expected to steadily rise. The market for hybrid solid-state LiDAR is poised for continuous expansion.
- The fully solid-state LiDAR technology is gradually advancing for blind-spot detection. With the ongoing maturation of fully solid-state LiDAR technology, it is also anticipated to find widespread application in the ADAS market in the future.

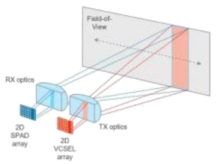
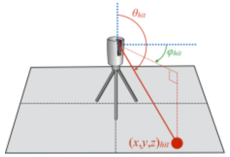
Mechanical LiDAR

- Mechanical LiDAR systems find extensive applications in the autonomous mobility and Robotics markets.
- With autonomous driving companies and OEMs continually exploring L4/L5 level autonomous driving, the significance of mechanical LiDAR is expected to increase steadily. The increasing popularity of robot applications will also create more opportunities for mechanical LiDAR systems.

Overview of Key Components and Scanning Mechanisms of LiDAR Systems

- A typical LiDAR system primarily consists of three key subsystems: the TX/RX system, the scanning system, and other supporting systems.

Key Components of a Typical LiDAR Products

Subsystem	Key Components
 **TX/RX System**	- **Laser transmitter (TX)** (e.g., VCSEL, EEL) - **Photodetector (RX)** (e.g., APD, SPAD, SiPM) - **Laser driver IC** - **Time-of-Flight (ToF) or phase measurement unit**
 **Scanning System**	- **Rotating mirror or polygon mirror** - **or MEMS mirror** - **Or Mechanical motor or shaft system**
 **Other Supporting System**	- **Optics** - **Mechanical Structures** - **Circuits** - **Firmware**

Introduction

LiDAR systems use different scanning mechanisms to generate spatial data. In 1D scanning, the laser beam is deflected along a single axis, and coverage along the other axis is typically achieved using multiple laser channels or alternative methods such as vehicle movement. This scanning mechanism is characterized by its high reliability and stability, though it involves higher cost and system complexity due to the need for additional components to achieve full-scene coverage. The 2D scanning approach, which utilizes dual-axis deflection to achieve full-scene coverage, allows a reduction in the number of lasers and detectors to improve system cost-efficiency. However, this trade-off often requires significantly increasing the emitting and receiving frequency to maintain performance, which is subject to physical and technical limitations. Due to the limited number of laser emitters, in order to achieve the same frame rate, the vibration frequency of the rotating mirror needs to be increased, which will reduce the reliability of the scanning and the lifespan of the radar. As a result, systems may encounter constraints in aggregated point frequency and may need to compromise on field of view or resolution in order to maintain adequate frame rates.

Source: CIC

Introduction and Comparison of Different Scanning Methods of LiDAR (1/3)

-LiDARs can be divided into three major types based on the scanning methods: mechanical LiDAR, hybrid solid state LiDAR and fully solid-state LiDAR.

Mechanical LiDAR

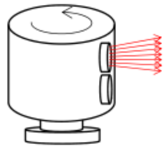
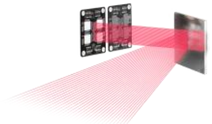
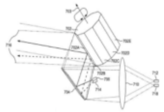
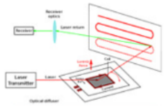
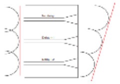
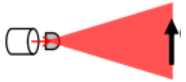
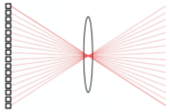
This type of lidar drives the optomechanical structure, rotating 360 degrees through a motor. It can scan the environment in all directions to form a point cloud, achieving optimal performance.

Hybrid solid-state LiDAR

Currently, mass-produced vehicles are equipped with hybrid solid-state lidar, which employs two methods: 1D Scanning and 2D Scanning. Both methods share a common feature, utilizing an internal moving mirror to change the direction of the laser.

Fully solid-state LiDAR

Fully solid-state lidar, in contrast, does not contain any moving parts internally. This type of lidar boasts a straightforward structure and achieves the highest level of integration.

Types	Illustration	Scanning	Description
Mechanical rotating LiDAR		**1D scanning**	The transceivers are arranged vertically and perform scanning through 360-degree physical rotation to fully cover the surrounding environment.
Single-axis rotating mirror		**1D scanning**	The transceivers are static, and a rotating polygon mirror realizes horizontal scan through reflecting the incoming laser beams to different directions.
Dual-axes rotating mirror		**2D scanning**	A galvo mirror realizes vertical scanning through reflection. A polygon mirror realizes horizontal scanning through reflecting the incoming laser to different directions.
MEMS		**2D scanning**	MEMS-based mirrors reflect the laser to different angles to complete the scan.
OPA		**Non-scanning**	Arrays of closely spaced optical antennas radiate coherent light in a broad angular range.
Flash		**Non-scanning**	Flashing light is produced to detect the whole surrounding area at a single point in time and analyzes the information with image sensors.
Electronic scanning		**Non-scanning**	In the electronic scanning scheme, scanning is achieved by sequentially driving different field-of-view transceivers units in chronological order.

Source: CIC

Introduction and Comparison of Different Scanning Methods of LiDAR (2/3)

-Based on differences in scanning methods and structures, different types of LiDAR will have various advantages, disadvantages, and application scenarios.

	Types	Development Status	Pros	Cons	Application Scenarios
Mechanical LiDAR	**Mechanical rotating LiDAR**	• In mass production	• 360°FOV • Detailed mapping of environment	• Large dimensions • High cost	• Robotics
Hybrid solid-state LiDAR	**Single-axis rotating mirror**	• In mass production	• Detailed mapping of environment • High reliability and stability	• Medium dimensions	• ADAS
	Dual-axes rotating mirror	• In mass production	• Detailed mapping of environment	• Medium dimensions • Limited reliability and stability	• ADAS
	MEMS	• In mass production	• Small dimensions	• Limited range • Limited reliability and stability	• ADAS
Fully solid-state LiDAR	**OPA**	• In development	• Small dimensions	• Short detection range • Immature technology	• ADAS
	Flash	• In mass production	• Small dimensions	• Short detection range • High power consumption • Strong crosstalk	• ADAS
	Electronic scanning	• In mass production	• Small dimensions • Low power consumption • High resolution • Small crosstalk		• ADAS

Introduction and Comparison of Different Scanning Methods of LiDAR (3/3)

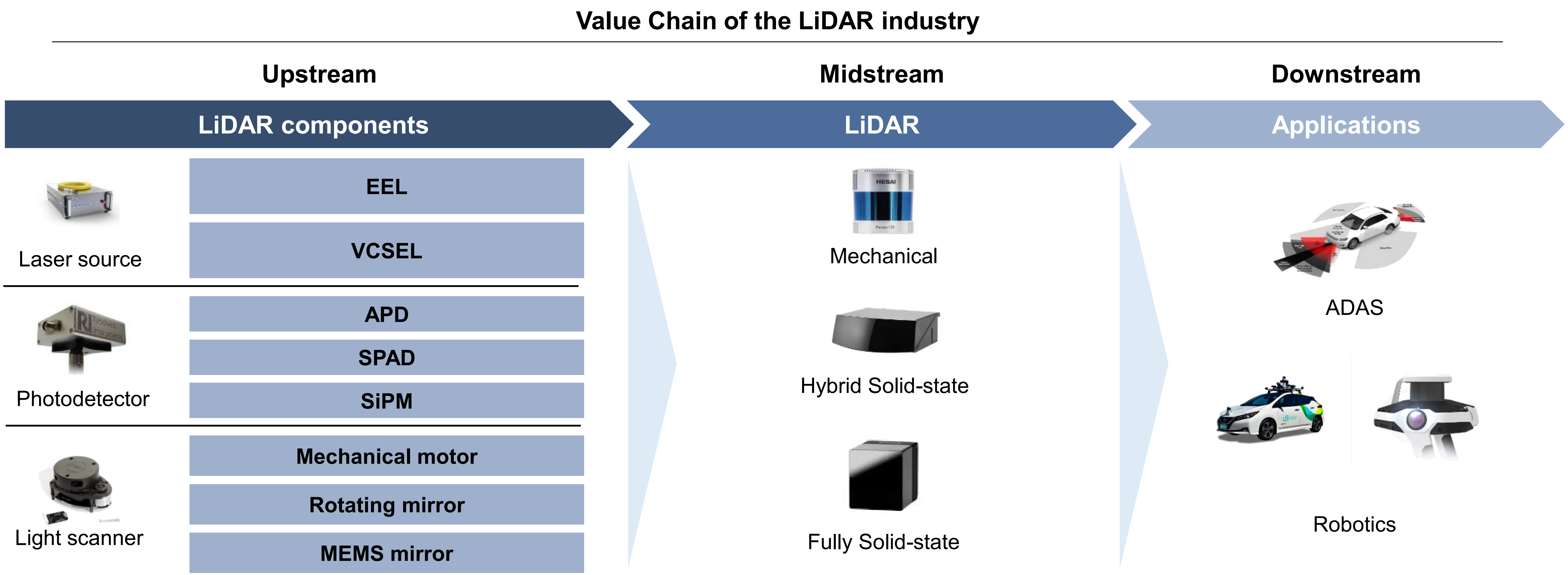
- Based on the detailed comparison of three different scanning methods of LiDAR on the preceding two pages, the primary characteristics can be summarized as follows.

	Types	Scanning	Description	Development Status	Pros	Cons
Mechanical LiDAR	**Mechanical rotating LiDAR**	**1D scanning**	The transceivers are arranged vertically and perform scanning through 360 degree physical rotation to fully cover the surrounding environment.	• In mass production	• 360°FOV • Detailed mapping of environment	• Large dimensions • High cost
Hybrid Solid-state LiDAR	**Single-axis rotating mirror**	**1D scanning**	The transceivers are static, and a rotating polygon mirror realizes horizontal scan through reflecting the incoming laser beams to different directions.	• In mass production	• Detailed mapping of environment • High reliability and stability	• Medium dimensions
	Dual-axes rotating mirror	**2D scanning**	A galvo mirror realizes vertical scanning through reflection. A polygon mirror realizes horizontal scanning through reflecting the incoming laser to different directions.	• In mass production	• Detailed mapping of environment	• Medium dimensions • Limited reliability and stability
	MEMS	**2D scanning**	MEMS-based mirrors reflect the laser to different angles to complete the scan.	• In mass production	• Small dimensions	• Limited range • Limited reliability and stability
Fully Solid-state LiDAR	**OPA**	**Non-scanning**	Arrays of closely spaced optical antennas radiate coherent light in a broad angular range.	• In development	• Small dimensions	• Short detection range • Immature technology
	Flash	**Non-scanning**	Flashing light is produced to detect the whole surrounding area at a single point in time and analyzes the information with image sensors.	• In mass production	• Small dimensions	• Short detection range • High power consumption • Strong crosstalk
	Electronic scanning	**Non-scanning**	In the electronic scanning scheme, scanning is achieved by sequentially driving different field-of-view transceivers units in chronological order.	• In mass production	• Small dimensions • Low power consumption • High resolution • Small crosstalk	

Source: CIC

Value Chain Analysis of LiDAR Industry

- The value chain of the LiDAR industry consists of LiDAR components suppliers, including laser source provider, photodetector providers and light scanner providers in the upstream, LiDAR providers in the midstream and downstream applications.



- The LiDAR industry value chain encompasses several key components. Upstream, it includes suppliers of LiDAR components such as laser source providers, photodetector manufacturers, and light scanner suppliers. In the midstream, LiDAR providers play a central role, while downstream focuses on various application scenarios.
- Currently, the primary application scenarios for LiDAR are ADAS and Robotics. LiDAR's high-precision perception and environmental modeling capabilities are essential for vehicle assistance and robot navigation. Continuous technological advancements and product optimizations have facilitated the integration of LiDAR to meet specific end-user requirements, further broadening its application landscape.

Source: CIC

Major Downstream Application Scenarios of LiDAR

- Downstream applications of LiDAR mainly includes ADAS and Robotics.

ADAS

- LiDAR in ADAS is employed for features such as adaptive cruise control, lane-keeping assistance, collision avoidance, and emergency braking.
- Due to its ability to maintain high sensing performance in various lighting conditions and achieve accuracy at long range, LiDAR has gained significant traction in the automotive market, serving as a substantial improvement to existing sensing solutions.

Robotics

- LiDAR is playing an increasingly critical role in robotic perception systems, thanks to its ability to generate 3D maps, provide high-precision distance measurements, and operate reliably in all weather conditions.
- Ubiquitous intelligent Robotics applications—represented by Robotaxi, Robobus, Robotruck, lawn-mowing robots, last-mile delivery robots, AMR, and humanoid robots, —are expanding rapidly and finding widespread use in transportation, logistics, and services.

Other Scalable Implementations

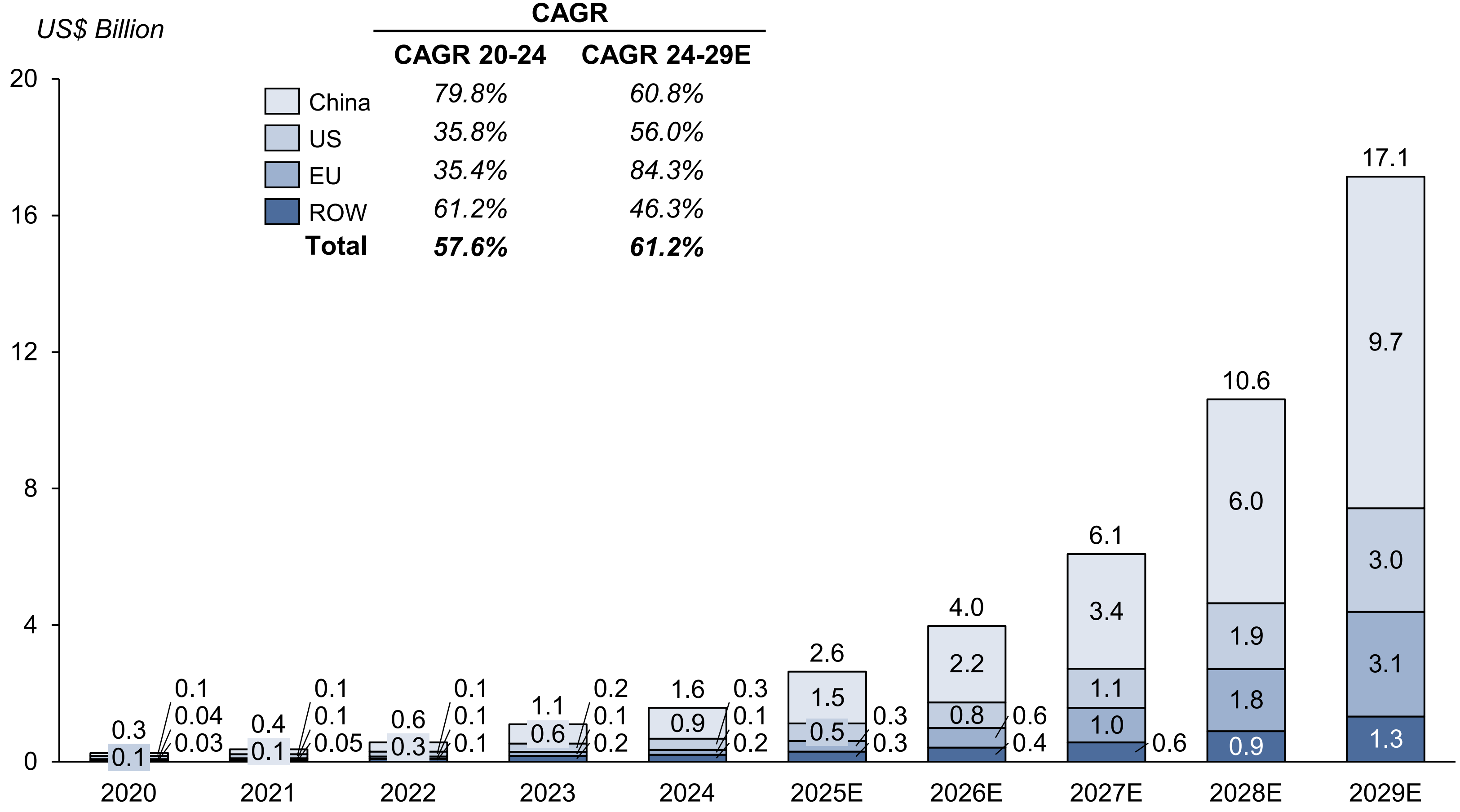
- In recent years, LiDAR's role has expanded beyond traditional applications to encompass areas such as automated inspection in industrial manufacturing and real-time monitoring and signal optimization in intelligent transportation systems.
- Furthermore, LiDAR is anticipated to play a pivotal role in emerging fields such as the metaverse, where its integration may drive the next wave of industrial transformation and technological innovation.

Source: CIC

Market Size of the Global LiDAR Industry

- The global LiDAR industry, in terms of revenues, increased from US$0.3 billion in 2020 to US$1.6 billion in 2024, with a CAGR of 57.6%, and is expected to increase to US$17.1 billion in 2029, representing a CAGR of 61.2%.

Global LiDAR Industry by Revenues Breakdown by Regions*, 2020-2029E



	CAGR	
	CAGR 20-24	CAGR 24-29E
China	*79.8%*	*60.8%*
US	*35.8%*	*56.0%*
EU	*35.4%*	*84.3%*
ROW	*61.2%*	*46.3%*
Total	***57.6%***	***61.2%***

Key Analysis

- During the period from 2020 to 2024, the downstream application scenarios of LiDAR continue to diversify. With the integration of LiDAR in mass-produced vehicles, the market size is rapidly expanding.
- The market of LiDAR, in terms of revenues, is estimated to increase from a size of US$0.3 billion in 2020 to US$1.6 billion in 2024 at a CAGR of 57.6%. The market size is expected to increase to US$17.1 billion in 2028 at a CAGR of 61.2%.
- China's LiDAR technology is at the forefront globally. Due to the higher receptivity of Chinese manufacturers to new technologies, the market size and growth rate of the LiDAR industry in China significantly surpassed other regions.

*Exchange rate=7.2993RMB/USD

Source: Expert Interview, OICA, CPCA, CIC

Ranking of Major LiDAR Suppliers by Revenues and Market Share in 2024

- Hesai was the first company in the world to achieve a monthly shipment volume of 10,000 units, and the only LiDAR company globally to achieve 100,000 units shipment volume per month.

• Hesai was the first company in the world to achieve a monthly shipment volume of 10,000 units, and the only LiDAR company globally to achieve 100,000 units shipment volume per month.
• Hesai ranked No.1 in terms of total revenues and market share in the global LiDAR industry in 2024.

	Ranking	Revenue (US Million)	Market Share (%)
The Company	1	267	17.0
Company A	2	~230	14.9
Company B	3	226	14.3
Company C	4	~150	9.6
Company D	5	~90	5.8

Company A（华为） is a company established in 1987 and headquartered in China that provides various products and services across multiple industries, and started LiDAR business in 2020. Company A is a private company.
Company B（速腾） is a LiDAR and perception solutions company headquartered in China that specializes in LiDAR hardware and perception software for automobiles and robots. Established in 2014, Company B is listed on the Stock Exchange of Hong Kong.
Company C（图达通） is a LiDAR company established in 2016 and headquartered in the China that specializes in developing and producing LiDAR products for automotive and other industries. Company C is a private company.
Company D （法雷奥）is an automotive supplier headquartered in France that provides a wide range of vehicle parts and accessories. Established in 1923, it began selling LiDAR products for the automotive industry in 2016. Company D is listed on Euronext Paris.

Source: Expert Interview, Annual Report, CIC

Key Success Factors for LiDAR Providers

- ASIC-based designs boost LiDAR performance, integration, and cost-efficiency. Rapid, modular innovation helps meet evolving demands, while success depends on balancing precision, reliability, and affordability for OEMs.

Technology architecture

- A LiDAR's technological architecture significantly influences its performance, integration, mass production, and long-term competitive differentiation. An ASIC architecture can be customized for specific functions, delivering high performance and low power consumption while greatly enhancing system integration. In contrast to traditional methods that rely on numerous discrete components, ASIC-based LiDAR can integrate hundreds of laser emission, reception, and signal-processing circuits onto just a few chips. This integration reduces the number of parts and wiring complexity, resulting in smaller and more reliable LiDARs. Additionally, the ASIC approach increases assembly efficiency and lowers manufacturing costs. Companies with in-house ASIC capabilities can address current needs while also enabling future upgrades, establishing a sustainable competitive advantage.

Rapid innovation capability

- Rapid innovation is crucial for LiDAR manufacturers to establish and maintain their leading position in a competitive market. In an era of rapid technological advancement, companies must efficiently develop and launch next-generation products to meet continuously rising performance requirements and new application demands. Each product generation should enhance detection range, angular resolution, or point cloud density to align with evolving market needs. Adopting a modular strategy significantly boosts innovation efficiency, allowing each module to iterate and upgrade independently, thus driving overall performance gains. Manufacturers capable of rapid iterations can quickly translate new technologies into product advantages, sustaining their leadership.

A combination of performance, quality, and cost

- As OEMs raise their expectation for advanced ADAS systems, there is a growing demand for LiDAR hardware that integrates intelligent sensing capabilities, reliability, and cost efficiency. To stay competitive, LiDAR providers must deliver products that showcase innovation in optical design, mechanical structure, and manufacturing optimization — enhancing performance while keeping cost in check. LiDAR providers that achieve a balanced mix of precision, durability, and affordability are better positioned to meet OEM expectations and expand their presence in the rapidly evolving automotive market.

Source: CIC

Entry Barriers, Challenges and Threats for LiDAR Providers

Technology Strengths

Developing LiDAR solutions presents a multifaceted technical challenge that requires substantial expertise in software algorithms, optical components, laser emitters, and other relevant domains. New entrants often struggle to rapidly assemble a skilled R&D team and acquire the necessary regulatory knowledge, making it difficult to develop competitive, high-performance products that meet market demands.

OEMs' Stringent Certification Requirements

OEMs impose stringent certification requirements on suppliers, involving extensive and time-consuming product validation. As a result, new industry entrants face significant challenges in quickly securing OEM approval, which delays their market penetration. Established providers, with a robust customer base and reputable brand, have a clear advantage in retaining existing clients while expanding to new ones, ultimately increasing their market share.

Continuous Capital Investment

Developing and manufacturing LiDAR solutions requires significant upfront investments in costly R&D equipment and high-precision manufacturing facilities. Additionally, continuous financial support is essential to sustain technological advancements and maintain product competitiveness. This considerable capital threshold poses a major obstacle for new entrants.

Powerful Supply Chain Management Capability

The provision of LiDAR solutions relies on multiple critical components, the quality of which directly impacts product performance. Providers with strong supply chain management capabilities are better positioned to withstand fluctuations in the global supply chain, ensuring both quality and timely product delivery. In contrast, new market entrants may find it challenging to establish a stable supply chain system within a short timeframe.

Mass Production Capabilities

Providers with the capability of mass production can maintain effective control over critical manufacturing and procurement processes, utilizing their accumulated expertise and experience to drive substantial synergies. This enables them to establish significant advantages in the cost-effectiveness and competitiveness of their solutions, solidifying their market position.

Source: CIC

Content

Overview of Levels of Autonomous Driving

- The Society of Automotive Engineers (SAE) International divides driving automation into six levels based on the level of human intervention and the extent of driving assistance features.

	With driver				Without driver	
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
	No Automation	**Driver assistance**	**Partial automation** (L2 / L2+)	**Conditional automation**	**High automation**	**Full automation**
Definition	• Drivers fully control the vehicle, getting assistance from alert and protection system	• Vehicles provide either steering or brake & acceleration support	**L2:** • Vehicles provide steering and brake & acceleration support simultaneously **L2+:** • L2+ enhances overall path planning capabilities	• Driverless in certain conditions but human driver must take back the control when the system requests	• Driverless in certain conditions. The vehicle system will not require human driver to take over driving	• Driverless in all conditions
Features description	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/ acceleration support to the driver	These features provide steering AND brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		These features can drive the vehicle under all conditions
Feature examples	• Automatic emergency braking • Blind spot warning • Lane departure warning	• Lane-centering OR • Adaptive cruise control	**L2:** • Lane centering, AND • Adaption cruise control at the same time **L2+:** • Active lane change AND • Navigation on Autopilot	• Traffic jam chauffeur	• Local driverless taxi • Pedals/steering wheel may or may not be installed	• Same as Level 4, but can drive everywhere in all conditions

Source: SAE, CIC

Development of ADAS

- With continuous technological advances, ADAS no longer limited to theoretical frameworks and basic driving assistance features. ADAS is reshaping the entire transportation ecosystem, driving profound changes in personal travel and transit.

Other regions

2025+

- **2024**: EU Regulation mandates Intelligent Speed Assistance, Lane-Keeping Assistance, and Automated Emergency Braking, as standard L2+ features on all new vehicles in the EU
- **2022**: Nissan launched ProPILOT Assist 2.0, an advanced Level 2+ driver assistance system
- **2020**: All Honda CR-Vs adopted Honda Sensing(CMBS, ACC with low-speed follow, LKAS, RDM, LDW) as standard L2 equipment
- **2018**: Tesla Model 3 launched with Autopilot 2.5 hardware, offering L2 features such as Traffic-Aware Cruise Control, Autosteer, and NOA
- **2017**: Intel acquired Mobileye in a 15.3-billion-dollar deal; the industry officially entered a period of integration along the supply chain
- **2011**
- **2009**: Google started to develop the driverless car project, while Ford, Mercedes, and BMW announced plans to research autonomous cars
- **2004**: U.S. military organized cross country event for autonomous cars in the desert, further pushing the entire industry forward in real life applications
- **2003**: Toyota started to provide assisted parking functions, followed by Lexus, Ford, and BMW
- **2000**: Mobileye launched the first generation of ADAS chips, leading to the first successes in image recognition technology

China

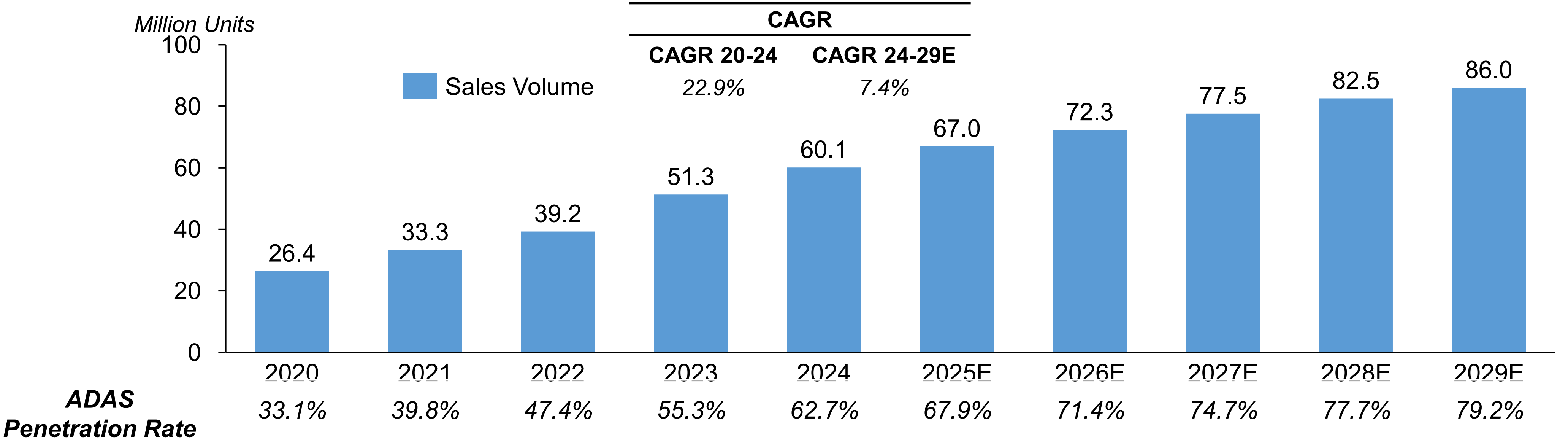
- NIO rolled out its Navigate on Pilot Plus driver-assist system, enabling Level 2+ hands-free driving on highways and urban expressways under driver supervision
- Baidu launched China's first batch of fully autonomous commercial mobility services in Wuhan
- With the delivery of smart vehicles from manufacturers such as NIO, XPeng, Li Auto, ADAS functionality has become one of the key development focuses for Chinese OEMs
- Hongqi HQ3, an autonomous vehicle jointly developed by FAW Group and the National University of Defense Technology, successfully completed a 286 km fully autonomous test on the highway

Compared to developed countries like the United States and Europe, China started its research in autonomous vehicles relatively later, commencing from the late 1980s

Sales Volume of ADAS Vehicles

- The global sales volume of ADAS vehicles increased from 26.4 million units in 2020 to 60.1 million units in 2024, with a CAGR of 22.9%, and is expected to increase to 86 million units in 2029, representing a CAGR of 7.4%.

Global Sales Volume of ADAS Vehicles, 2020-2029E



- The development of driver-assistance software has evolved from primarily imitation learning to combining deep learning and reinforcement learning for path planning and decision-making. Currently, NOA is the most advanced driver-assistance feature, enabling navigation-assisted driving in both highway and complex urban settings, and has become a focal point of competition among major OEMs. At the same time, the performance of domain controller chips that enabling driver assistance continues to improve, providing the computational capacity to run more complex models. In parallel, advancements in sensors such as LiDAR feed essential roadway-environment data for high-level features like NOA.
- In recent years, the penetration rate of NOA has significantly increased in the passenger vehicle market. This acceleration is driven by ongoing technological progress and rising demand for intelligent driving functions in complex urban settings. LiDAR plays a critical role in this technological progression, significantly enhancing environmental perception and system redundancy, which are essential for the safety and user-friendliness of L2+ features. Compared to basic ADAS systems, L2+ requires a higher degree of sensing accuracy and real-time processing capability. LiDAR generates high-precision 3D point cloud data to accurately identify shape, distance, and velocity of targets such as pedestrians and vehicles. Its strong long-range detection capability provides sufficient reaction time for emergency braking and lane changes in high-speed scenarios. Consequently, vehicles equipped with LiDAR are gaining greater market traction, and their sales volumes have shown a clear upward trend, demonstrating the increasing value of LiDAR in enabling the commercialization of more advanced driver assistance systems.

Key Drivers and Trends of the ADAS Industry (1/2)

- Key drivers and trends of the autonomous driving industry include breakout phase of accelerated penetration in high-level ADAS, increased value of perception systems, OEMs' technological readiness and regulatory expectations, consumer emphasis on travel safety, government support.

Breakout phase of accelerated penetration in high-level ADAS

- High-level ADAS has significant advancements over traditional ADAS, delivering breakthroughs in environmental perception, decision-making capabilities, and scenario coverage. By integrating multi-sensor fusion systems — including LiDAR — it supports functions such as automatic lane changing, adaptive cruise control, and automatic lane keeping. Additionally, these systems introduce active safety features like emergency avoidance, which greatly reduce accident risks. As a result, consumer willingness to opt for these configurations has markedly increased. With continuous technological advancements and reduced costs driven by economies of scale effect, high-level ADAS is becoming not only feasible on EVs but is also emerging as a core selling point for the intelligent upgrade of internal combustion engine ("ICE") vehicles.
- China's first-mover advantage and large-scale validation are quickly influencing global markets, with regions such as Europe and the U.S. accelerate ADAS integration. This shift is driving by evolving regulations and surging consumer demand. High-level ADAS is transitioning from a premium optional feature to standard equipment in mainstream models, becoming a critical battleground that will reshape the global automotive competitive landscape.

Increased importance of perception systems

- As ADAS technology advances towards higher levels of intelligence, the demand for precise, real-time and reliable environmental perception in intelligent vehicle is growing. This demand drives a sustained increase in the technological sophistication of perception systems. Unlike traditional ADAS, high-level ADAS vehicles require the deployment of more high-performance sensors, complemented by advanced fusion algorithms and powerful computational chips.
- This combination enables accurate recognition and dynamic understanding of the surroundings. The integration of these hardware components with supporting algorithms not only enhances the overall performance and safety of autonomous driving but also substantially elevates the importance of perception systems, rendering them one of the most critical competitive and commercially valuable modules in future intelligent vehicles.

Source: CIC

Key Drivers and Trends of the ADAS Industry (2/2)

- Key drivers and trends of the autonomous driving industry include breakout phase of accelerated penetration in high-level ADAS, increased value of perception systems, OEMs' technological readiness and regulatory expectations, consumer emphasis on travel safety, government support.

OEMs' technological readiness and regulatory expectations

- Leading OEMs have made substantial investments in ADAS over the years, amassing extensive expertise in areas ranging from perception algorithms to control systems and vehicle integration. They also possess strong commercialization capabilities. As the relevant legal frameworks are become more liberalized and testing standards are refined, it is anticipated that autonomous driving technology will accelerate its transition from limited to comprehensive scenarios, paving the way for large-scale deployment and commercial viability.

Consumer focus on safety

- Most traffic accidents are caused by human error, leading consumers to recognize the importance of ADAS in enhancing safety. ADAS integrates multiple sensors and intelligent algorithms to perceive and make precise decisions about the surroundings in real-time. As demand for safety features grows, autonomous driving technology is being iteratively improved and scaled up to meet the public's expectations for safe and efficient travel.

Government support

- Governments worldwide are prioritizing the development of autonomous driving, fostering consensus, and innovating policy frameworks to support this advancement. They are actively promoting industry growth by establishing pilot zones, enabling road testing, and enacting forward-looking legislation. For example, China has introduced national pilot programs and technical standards for intelligent connected vehicles, while the E.U. has implemented regulations for Level 4 vehicles and type-approval frameworks. International organizations such as the UNECE and ISO play a crucial role in coordinating global standards, addressing areas like functional safety, data logging, and cybersecurity, thereby laying a solid foundation for cross-border consistency and large-scale deployment.
- Recently, the MIIT released the "2024 Key Points of Automotive Standardization Work (《2024年汽車標準化工作要點》)," which emphasizes strategic emerging fields such as new energy vehicles and intelligent connected vehicles. This policy proposes new international standard projects and cultivation plans for these domains, promoting the development of international standards comprehensively. It includes the responsibility of convening working groups focused on automotive perception sensors and autonomous driving test scenarios, and leading the formulation of nearly 20 international standards related to automotive exterior protection, fuel cell electric vehicles, electromagnetic compatibility, and automotive-grade radar and LiDAR solutions. This policy provides essential standardized support for the application of technologies, such as LiDAR, in smart vehicles, promoting their standardized use within the automotive industry.

Source: CIC

Regulatory Policy in the ADAS Industry (1/2)

- In recent years, governments worldwide, especially China, have been giving strong policy support to facilitate the development of autonomous vehicles.

- *Various Chinese government bodies, such as the State Council, the National Development and Reform Commission, the State Administration for Market Regulation, and the Ministry of Transport, have introduced policies explicitly addressing the autonomous driving and intelligent connected vehicle industry. These policies aim to secure policy guidance and financial incentives, demonstrating a commitment to fostering and supporting strategic emerging industries at the national level.*

Chinese policies and regulations

Policy / Regulation	Authority	Issuing date	Policy content
Notice on Conducting Pilot Program for Intelligent Connected Vehicles *《關於開展智能網聯汽車准入和上路通行試點工作的通知》*	Ministry of Industry and Information Technology, Ministry of Public Security, Ministry of Housing and Urban-Rural Development, and Ministry of Transport	November, 2023	• The “Notice” outlines that the four departments will select intelligent connected vehicle products equipped with autonomous driving capabilities, suitable for mass production, to initiate a pilot access phase. These approved vehicles will conduct trial runs within designated areas. Vehicles used for transportation operations must meet the qualifications and operational management requirements set by transportation authorities.
Outline of the Medium- to Long-Term Development Plan for Scientific and Technological Innovation in the Transportation Field (2021-2035) *《交通領域科技創新中長期發展規劃綱要(2021-2035年)》*	Ministry of Transport; Ministry of Science and Technology	April, 2022	• The “Outline” encourages advancing research, development, and implementation of autonomous driving technology. It emphasizes breakthroughs in integrating perception, vehicle-road information interaction, and the online evolution of perception-decision-control functions. The goal is to promote the extensive use of autonomous and assisted driving in road freight, urban distribution, and city public transportation.
The Outline of the 14th Five-Year Plan for Economic and Social Development and Long-Range Objectives Through the Year 2035 of the People's Republic of China *《第十四個五年規劃和2035年遠景目標綱要》*	State Council	March, 2021	• The “Outline“ promotes the construction of several autonomous driving and intelligent shipping test bases and pilot application projects during the 14th Five-Year Plan period. • It emphasizes improving automated sorting facilities, autonomous warehousing, autonomous vehicles, and drone deliveries.

Source: CIC

Regulatory Policy in the ADAS Industry (2/2)

- In recent years, governments worldwide, especially China, have been giving strong policy support to facilitate the development of autonomous vehicles.

Policies and regulations overseas

	Policy / Regulation	Policy content
U.S.		**ADAS**
	ADS-Equipped Vehicle Safety, Transparency, and Evaluation Program	• AV STEP is a voluntary NHTSA framework for manufacturers and operators of vehicles with Automated Driving Systems (Levels 1–4). Participants would submit detailed safety assessments, real-world operational data, and incident reports to enhance public transparency and inform future rulemaking
	Automated Vehicles Comprehensive Plan	• The United States Department of Transportation (USDOT) will promote access to transparent and reliable information to its partners and stakeholders, including the public, regarding the capabilities and limitations of Automated Driving Systems (ADS). • USDOT will also modernize regulations to remove unintended and unnecessary barriers to innovative vehicle designs, features, and operational models and develop safety-focused frameworks and tools to assess the safe performance of ADS technologies.
European Union		**ADAS**
	Software Update and Software Update Management System	• Effective July 2022 for new types and July 2024 for all vehicles, R156 mandates a Software Update Management System covering over-the-air (OTA) and workshop updates. It specifies organizational processes, security measures, and user-notification requirements to ensure that ADS and safety-critical software remain up-to-date and tamper-resistant
	Vehicle General Safety Regulation	• The EU's new Vehicle General Safety Regulation has been applied since July 2022. It introduces a range of mandatory advanced driver assistant systems to improve road safety and establishes the legal framework for approving automated and fully driverless vehicles in the EU.

Source: CIC

Introduction on Sensor Technologies and Market Applications in ADAS and Robotics

- LiDAR's major advantages are its detection distance, precision, and 3D imaging capabilities.

Comparison between LiDARs, Millimeter Wave Radars, Ultrasonic Radars, and Cameras

	Detection distance 100 200 300	3D Imaging	Weather adaptability	Night vision	Price range
 LiDARs	✓ ✓ ✓	Great, able to draw complete obstacle image	Limited, operate poorly in rainy or foggy weather	Great, not affected by darkness	$200 ~ $8,000
 Millimeter wave radars	✓ ✓ ✓	Unable to draw 3D images with high resolution	Highly adaptive to all weather conditions	Great, not affected by darkness	$50 ~ $150
 Ultrasonic radars	✗ (1)	Unable to detect size and shape of obstacles	Adaptive to some weather conditions	Great, not affected by darkness	$10 ~ $15
 Cameras	✓ ✓ ✓	Need to rely on 2D image to draw 3D	Limited, cannot operate under strong light intensity	Limited, detection distance decrease	$25 ~ $100

- In addition to LiDAR, various non-LiDAR sensors are widely utilized in the ADAS market to enhance vehicle perception and assist with driving tasks. Cameras are the primary tool for visual recognition, enabling lane detection, traffic sign identification, and object classification, although their performance can be affected by lighting conditions. Millimeter wave radars are suited for mid- to long-range detection in all weather conditions and are commonly used in adaptive cruise control and blind spot monitoring. Ultrasonic radars, while limited to short distances and lower resolution, are widely used for low-speed maneuvers such as parking assistance and obstacle proximity warnings.

- While both the ADAS and robotics markets rely on a combination of sensing technologies to enable autonomous functions, their performance priorities and application environments differ significantly. ADAS systems are primarily designed for on-road vehicle operation, focusing on safety, reliability, and long-range perception in high-speed driving conditions. In contrast, robotics applications often take place in complex, unstructured, and dynamic environments, such as warehousing, logistics, industrial manufacturing, and smart agriculture, where real-time navigation, obstacle avoidance, and fine-grained spatial understanding are critical.

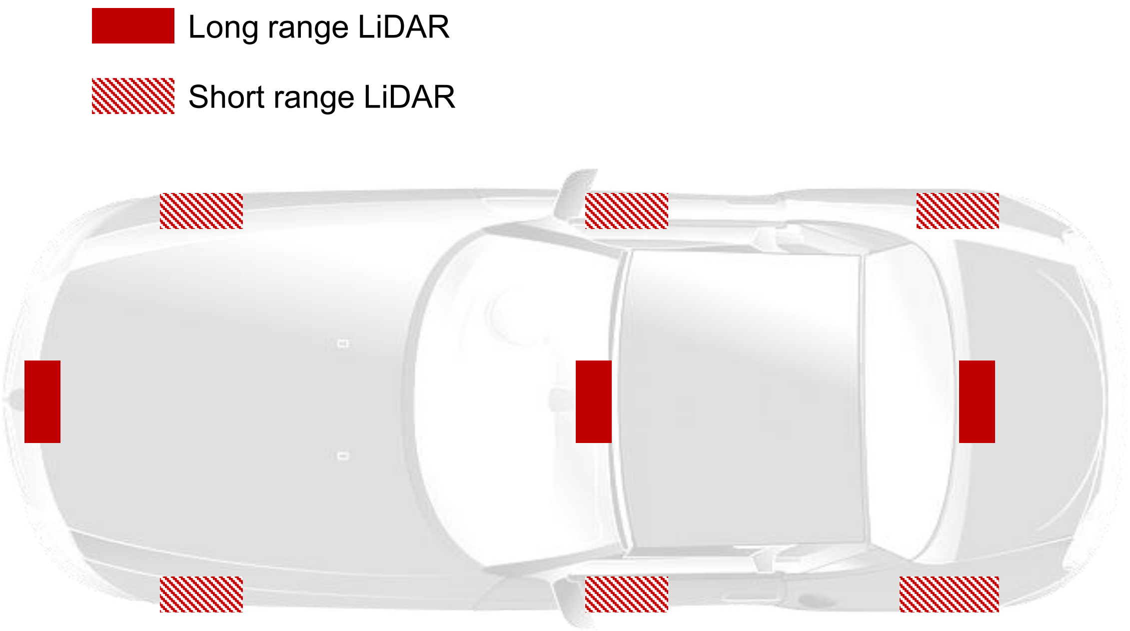
As a result, LiDAR is emerging as a high-value sensor in both markets, playing a central role due to its high-resolution 3D perception and mapping capabilities. As technological maturity advances, the integration of LiDAR alongside cameras, radar, and other sensors is expected to accelerate in both markets, supporting a broader range of autonomous functions.

Note: (1) Ultrasonic radars are generally used for short-range detection, typically within a few meters and not suitable for distances over 100 meters.

The Application of LiDAR in ADAS Vehicles

- OEMs need to consider the exterior of their vehicle model. Spots for LiDAR installation are limited, and typically, LiDAR is installed on the front grille or bumper, in-cabin, side mirror or door, headlight or taillight, and wheel well or undercarriage.

Available spot for LiDAR installation on ADAS vehicles



LiDAR installation on ADAS vehicles

- A vehicle has multiple feasible locations where LiDAR can be strategically placed. The choice of installation zones can impact the effectiveness of the LiDAR system in terms of coverage, field of view, and overall performance.
- **Spots for LiDAR installation on ADAS vehicles include:**
  - **Front grille or bumper:** Integrating LiDAR into the front grille or bumper area can provide a forward-facing perspective, aiding in obstacle detection and collision avoidance. This placement is standard in ADAS vehicles and can supplement other sensors like cameras and radar.
  - **In-cabin:** LiDAR can be installed inside the vehicle's cabin and behind the windshield.
  - **Side mirrors or door:** LiDAR can be integrated into headlights or taillights, blending seamlessly with the vehicle's design. This placement can contribute to aesthetics while providing practical front and rear sensing coverage.
  - **Headlight or taillight:** Incorporating LiDAR into headlights or taillights can provide a discreet and integrated solution. This placement offers front and rear coverage while maintaining the aesthetic design of the vehicle.

Current status and future trends of LiDAR on ADAS vehicles*

- OEMs currently adopt **a single LiDAR on their model**, while some models are equipped with 2-3 LiDARs to enhance environmental sensing.
- By increasing the number of LiDAR sensors, vehicles can enhance their field of view, capture more precise environmental data, and improve driver safety by detecting and reacting to obstacles with greater precision. Therefore, the number of LiDAR units incorporated into individual ADAS vehicles is anticipated to rise over time.

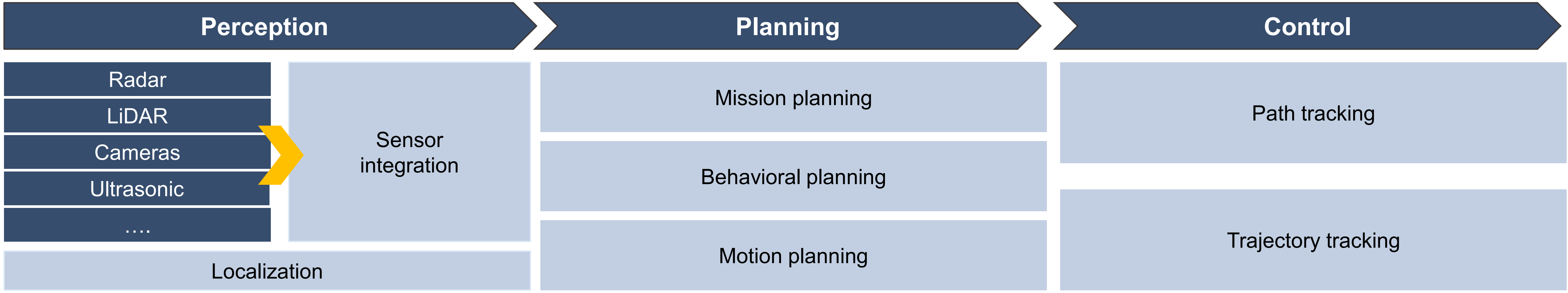
**ADAS vehicles equipped with LiDAR*

Source: CIC

LiDAR as a Key to enable Autonomous Driving (1/3)

- At the core of autonomous driving are three major components: perception, planning, and control.

*At the core of autonomous driving are three major components: **perception, planning, and control.***



- **Perception,** within the context of autonomous driving systems, encompasses a multifaceted capability. It involves the fundamental ability to detect, identify, and classify objects along the road and extends to developing a contextual understanding of the dynamic environment. This ability allows the system to interpret the complex interplay of various elements in real-time, enabling it to navigate the road with heightened awareness.

- **Planning** is a crucial phase that utilizes the wealth of data gathered through sensing. This intricate process goes beyond mere data interpretation; it involves the strategic generation of a step-by-step sequence of actions the vehicle must execute to navigate the route and ultimately reach its intended destination. The planning stage integrates various factors, including real-time environmental conditions, traffic dynamics, and the specific characteristics of the road network.

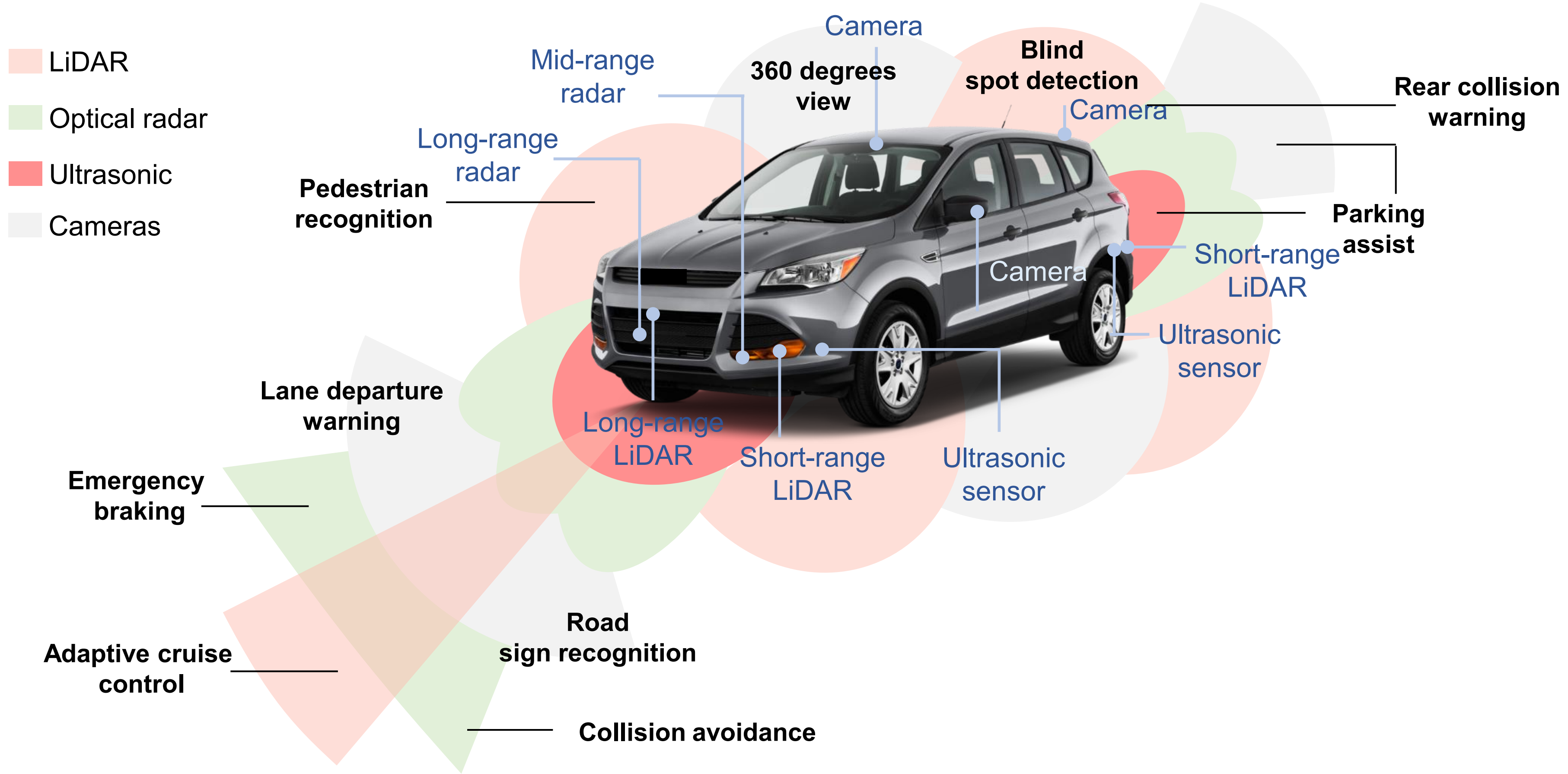
- **Control** is the pivotal stage where meticulously planned actions come to fruition. It encompasses the actual execution of the predetermined steps, translating the strategic decisions made during the planning phase into tangible vehicle movements.
- During control execution, the autonomous system relies on real-time feedback from sensors and environmental monitoring to ensure that the vehicle adheres to the planned trajectory while responding dynamically to any unforeseen circumstances.

LiDAR as a Key to enable Autonomous Driving (2/3)

- Sensors enable different autonomous driving features. As a high-precision sensor, LiDAR is critical to enable autonomous driving.

Various sensing devices, including radar, ultrasonic sensors, cameras, and LiDAR, collect sensing data and enable different autonomous driving features.

Sensors enable different autonomous driving features



- LiDAR systems produce precise data with a resolution surpassing that of radar and ultrasonic sensors. Unlike cameras, which use deep learning algorithms to infer depth information, LiDAR allows for the direct measurement of distance and the real-time reconstruction of the surrounding environment. This capability provides a significantly more reliable method for recognizing and classifying objects in the environment.

LiDAR as a Key to enable Autonomous Driving (3/3)

- When autonomous driving technology advances to L2, especially L2+ and beyond, traditional sensors alone are inadequate to meet the sensing requirements. The utilization of LiDAR technology becomes especially vital in this context.

Autonomous driving above L2+

Starting from L2+ and beyond, autonomous driving systems begin to possess the capability for local or global path planning, placing higher demands on sensors. The higher autonomous driving level places further demands on sensor performance. The precision and accuracy requirements for sensors are higher, and they should be capable of covering a broader range. Meanwhile, adaptability to environmental conditions must also be enhanced.

Sensor requirement for L2+ and above

	L2+	L3	L4	L5
Cameras	3-13	8-16	>14	>14
Millimeter wave radars	2-4	8-12	10-14	10-14
Ultrasonic radars	6-8	8-14	8-14	8-14
Long range LiDAR	0-1	1-2	1-2	1-2
Short range LiDAR	0-3	2-4	4-6	4-6

- Starting from L2+ and advancing to higher levels of autonomous driving, traditional sensors face increasing limitations in delivering the required functionalities. As the autonomous driving levels progress, the adoption rate of LiDAR technology steadily rises. Simultaneously, to achieve more precise environmental perception, short-range LiDAR, in addition to long-range LiDAR, is gradually becoming essential sensor in autonomous driving solutions. The variety and quantity of sensors continue to increase to meet the evolving demands.

- In recent years, various automotive manufacturers have been actively exploring the path towards L2+ and higher levels of autonomous driving. Many emerging OEMs have introduced their own L2+ autonomous driving solutions, and since 2023, there has been a continuous increase in the production of vehicles equipped with L2+ functionality. Meanwhile, in China, some OEMs have obtained approvals for L3 autonomous driving road test permits, which will further propel the development and implementation of L3 autonomous driving technology.

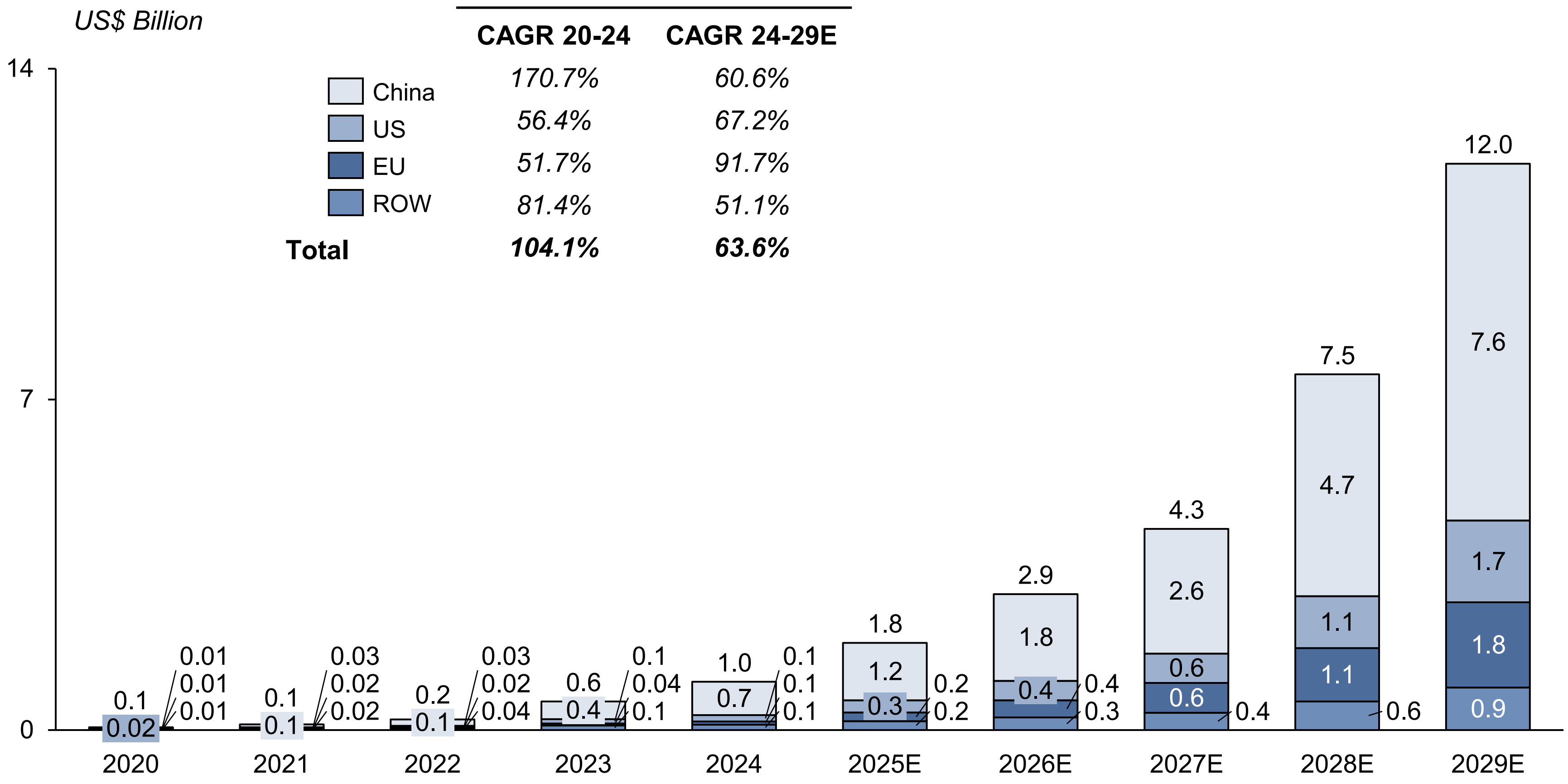
Source: CIC

Market Size of Global LiDAR Application in ADAS Industry, 2020-2029E

- Revenues of LiDARs for the ADAS market increased from US$0.1 million in 2020 to US$1.0 billion in 2024, at a CAGR of 104.1%, and is expected to reach US$12.0 billion in 2029, representing a CAGR of 63.6%.

Market Size of Global LiDAR Application in ADAS Market, 2020-2029E

	CAGR	
	CAGR 20-24	CAGR 24-29E
China	*170.7%*	*60.6%*
US	*56.4%*	*67.2%*
EU	*51.7%*	*91.7%*
ROW	*81.4%*	*51.1%*
Total	***104.1%***	***63.6%***



Key Analysis

- As OEMs race to deploy NOA, LiDAR not only enhances overall system safety redundancy but also serves as an indispensable perception backbone for the evolution of driver-assistance functions to higher levels.
- Revenues of LiDARs for the ADAS market increased from US$0.1 million in 2020 to US$1.0 billion in 2024, at a CAGR of 104.1%, and is expected to reach US$12.0 billion in 2029, representing a CAGR of 63.6%.
- As NOA functionality becomes more complex, some vehicle models have begun adopting multi-LiDAR setups. The average number of LiDAR units installed per vehicle is expected to rise significantly in the future. In addition to main LiDAR, ancillary LiDAR will be required to cover blind spots, creating substantial incremental demand in the ADAS LiDAR market.

*Exchange rate=7.2993RMB/USD

Source: OICA, CPCA, CIC

Competitive Landscape of the Global LiDAR Applications in the ADAS and Robotics Market

- Hesai ranked No. 1 in terms of revenue in the global LiDAR applications in the robotics market in 2024.

Ranking of Major LiDAR Suppliers in the ADAS Market by Revenue in 2024

Ranking	Company	Revenue (US Billion)	Market Share (%)
1	Company A	~0.23	23.6%
2	Company B	0.18	18.4%
3	The Company	0.17	17.6%
4	Company C	~0.15	15.2%
5	Company D	~0.09	9.4%

Ranking of Major LiDAR Suppliers in the Robotics Market by Revenue in 2024

Ranking	Company	Revenue (US Billion)	Market Share (%)
1	The Company	0.09	16.2%
2	Company E	~0.09	15.6%
3	Company B	0.03	4.8%

- Hesai ranked No. 3 in terms of revenue in the global LiDAR applications in the ADAS market in 2024.
- Hesai ranked No. 1 in terms of revenue in the global LiDAR applications in the robotics market in 2024.

Company E (Ouster) is a LiDAR company established in 2015 and headquartered in the U.S. that develops high-resolution, digital 3D LiDAR sensors for use in autonomous vehicles, industrial robotics, drones, mapping, defense, and security systems. Company E is listed on the Nasdaq.

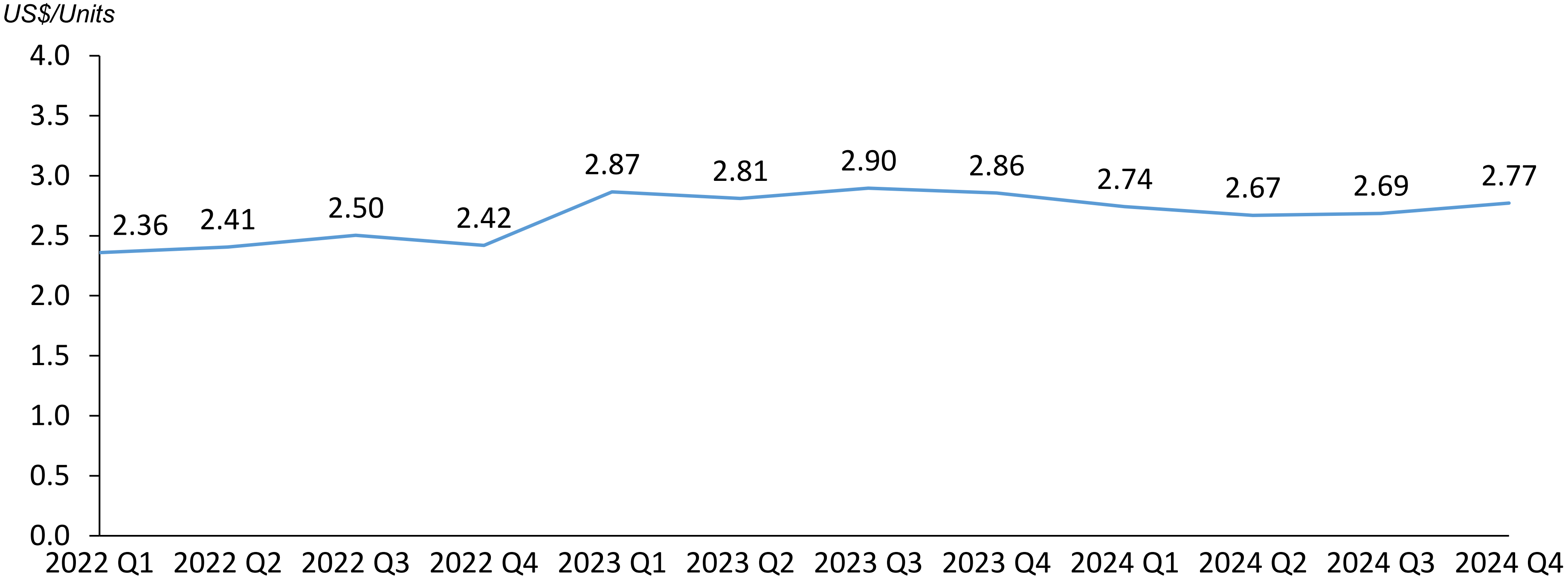
Source: Expert Interview, Annual Report, CIC

Price Trend of Semiconductor Chips

- Automotive MCUs are a key raw material in LiDAR. The prices of chips used as raw materials in LiDAR have remained stable and are expected to stay steady in the foreseeable future.

The chart illustrates the historical price trend of global automotive MCUs from Q1 2022 to Q4 2024. Automotive MCUs are selected as a representative indicator of semiconductor cost trends in LiDAR systems primarily due to their central functional role and substantial cost contribution. In a typical LiDAR hardware setup, multiple types of chips — such as MCUs, FPGAs, and PMICs — are used. Among them, automotive MCUs serve as the control center, managing signal processing, system coordination, and interface logic. Moreover, since LiDAR is deployed in automotive-grade environments, these MCUs must meet strict reliability and safety standards, making them more costly and impactful on the overall system cost. Therefore, tracking automotive MCU prices provides a meaningful gauge of raw material cost dynamics in LiDAR production.

Global Average Selling Price of Automotive MCUs (by Quarter)



Source: WSTS, CIC

Key Drivers and Trends for LiDAR Applications in the ADAS Market (1/4)

- Advancements in sensing and computing are driving broader adoption of L2+ ADAS. LiDAR, with its precision and all-weather capability, is key to enhancing safety and enabling higher autonomy.

Technological evolution accelerates high-level ADAS penetration

- The rapid development of perception algorithms, sensor hardware, and computing platforms is enabling more advanced driver-assistance functions such as NOA and automated lane changes. These capabilities require higher sensing precision and system reliability, prompting OEMs to adopt enhanced ADAS configurations. Meanwhile, features such as driver assistance and intelligent parking are increasingly embraced by consumers in daily use, significantly boosting driving convenience which drives sustained growth in downstream demand. As a result, adoption of L2+ systems are expanding beyond premium models, with LiDAR-equipped vehicles gaining traction in the broader market. This trend reinforces OEM investment in intelligent hardware to support higher-level autonomy.

LiDAR as a key sensor for all-weather active safety, enhancing advanced driver assistance and driving safety

- LiDAR, with its high precision, all-weather adaptability, and 3D spatial perception capabilities, is an indispensable core perception sensor for achieving active safety and advanced driver-assistance functions. Unlike passive sensors such as cameras, LiDAR actively emits laser pulses and maintains stable, reliable detection in challenging conditions such as nighttime, backlight, and rain, snow, or fog — significantly improving system robustness and environmental adaptability. In high-level ADAS functions like NOA, LiDAR accurately identifies road boundaries, obstacles, and dynamic objects, providing critical inputs for path planning and decision-making. As perception and decision-making systems increasingly rely on high-resolution, structured environmental data, LiDAR's strategic value within autonomous driving systems continues to rise. It plays a vital role in enabling OEMs to achieve L2+ and higher-level autonomy, while enhancing vehicle safety, fault tolerance, and system redundancy.

Key Drivers and Trends for LiDAR Applications in the ADAS Market (2/4)

- LiDAR is rapidly advancing in performance and integration, meeting the evolving demands of mainstream ADAS applications. Cost reductions from mass production and technological improvements are making LiDAR viable for broader adoption, including mid-range and mass-market vehicles.

Technological maturity drives LiDAR advancements meeting ADAS demands

- With continued technological evolution, LiDAR is making consistent advancements in perception accuracy, detection range, interference resistance, size, and power efficiency, gradually fulfilling the performance requirements for integration into mainstream vehicle models. Progress in key components, such as laser emitters, photodetectors, scanning systems, and signal processing chips, has resulted in increasingly mature system solutions. Leading manufacturers have launched mass- produced, chip-based, and miniaturized LiDAR products, significantly enhancing integration and stability for automotive applications. Automakers are also shifting from focusing solely on long-range detection to a more comprehensive assessment of blind spot coverage, field of view, and all-weather performance. Consequently, LiDAR products are evolving toward full-scenario capability to meet these diverse needs.

Economies of scale propels LiDAR into Mass-market vehicles

- Driven by mass production and technological advancements, the manufacturing costs of LiDAR have dropped significantly, realizing broader adoption across mass vehicle models. Chip-based design, modular standardization, and automated production lines are aligning LiDAR with mass-production requirements and OEMs' platform-based vehicle development models. This makes LiDAR economically viable for mid-range models and even mass-market vehicles. With growing production capacity, maturing manufacturing processes, and increased efficiency across the supply chain, LiDAR is increasingly meeting OEM requirements, which drives exponential growth in its market penetration.

Source: CIC

Key Drivers and Trends for LiDAR Applications in the ADAS Market (3/4)

- LiDAR adoption is rising as OEMs standardize it in more models, driven by strong sales and strategic investment in intelligent features. Growing consumer demand for safety and tech-driven convenience further boosts its appeal and integration.

Rapid growth in LiDAR-equipped vehicle sales and increasing OEM willingness to standardize deployment

- In recent years, the demand for LiDAR- equipped intelligent electric vehicles have surged, becoming a major driver of LiDAR adoption. Leading OEMs are prioritizing the integration of LiDAR in high-end intelligent models, accelerating the industry trend towards sensor standardization. As a result, LiDAR is transitioning from an optional add-on to a standard configuration — particularly among mid- to high-end models, where standardization rates have significantly increased. With OEMs increasing their strategic investments in LiDAR-reliant scenarios such as urban NOA and parking assistance, the importance of LiDAR continues to grow. Major automakers are now incorporating LiDAR into new vehicle development frameworks and establishing stable supply chains to support multi-platform, multi-model deployment, creating long-term growth opportunities for the LiDAR market.

Growing consumer demand for tech-driven safety and convenience accelerates LiDAR adoption

- Consumer expectations are shifting from traditional mechanical performance to intelligent driving experiences. Technology appeal, safety, comfort, and travel convenience have become key factors in purchasing decisions. In this context, intelligent driving features powered by LiDARs offer futuristic driving experiences and enhanced safety, attracting strong consumer interest. LiDAR supports high-demand use cases such as NOA, highway automatic lane changes, and parking assistance — greatly reducing driving workload, enhancing operational convenience and providing consumers with more driving options. Among tech- savvy and highly engaged user groups, sensor configurations are becoming a visible and influential factor in purchase decisions. As consumer awareness continues to grow, the “perception-driven selling point” of LiDAR will be further amplified, steadily driving up both its installation rate and depth of application.

Source: CIC

Key Drivers and Trends for LiDAR Applications in the ADAS Market (4/4)

- LiDAR adoption is rising as OEMs standardize it in more models, driven by strong sales and strategic investment in intelligent features. Growing consumer demand for safety and tech-driven convenience further boosts its appeal and integration.

Policy Support for LiDAR Commercialization in ADAS Applications

- The Chinese government has introduced a number of policies that directly support the adoption and commercialization of LiDAR in ADAS applications. For example, on February 10, 2020, the NDRC and other ten PRC governmental authorities jointly promulgated the Smart Car Innovation Development Strategy, which provides that the PRC government shall promote the development and industrialization of automotive high-precision sensors, automotive-grade chips, smart operating systems, automotive smart terminals, and smart computing platforms, and build an industry cluster for smart automotive key parts. And the “Notice on Conducting Pilot Program for Intelligent Connected Vehicles” issued in November 2023 also proposes that based on the previous road test and demonstration application of intelligent connected vehicles, the PRC government will select intelligent connected vehicles equipped with automatic driving functions that have the conditions for mass production, and will launch a pilot scheme, where the chosen intelligent connected vehicles would be allowed to carry out road access pilots in a limited area.

Source: CIC

Content

Analysis of Key Robotics Functions and Applications

-Robotic devices refer to fully unmanned machines, including last-mile delivery, commercial cleaning, logistics, and home service robots.

- As technological advancements and societal norms evolve, people's lifestyles undergo significant transformations. This shift is anticipated to gradually increase the prevalence of robots in our daily lives. This ongoing trend will result in a deeper integration of robotic technology into various aspects of our daily existence, offering increased convenience, efficiency, and innovation. The commercial applications of Robotics are set to expand into a broader array of industries, while domestic Robotics will also assume more complex responsibilities. Embracing and adapting to these technological shifts, robots will play a more pivotal role in assisting with task completion, automating processes, and enhancing overall quality of life.
- As robots handle increasingly complex tasks, the demand for precision in sensor perception is expected to rise continuously. In the future, LiDAR is poised to play a more pivotal role in Robotics applications. Both the adoption rate of LiDAR technology and the intrinsic value it provides to individual robots are expected to see significant enhancements.

Role of LiDAR

- Help autonomous mobile robots understand surrounding information in unknown environments.
- Utilizing robots equipped with LiDARs can improve safety in the working environment while reducing labor costs.
- LiDAR technology provides robots with strong environmental recognition capabilities for positioning and navigation and abilities to realize intelligent powered mobility.

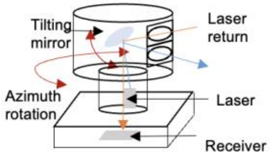
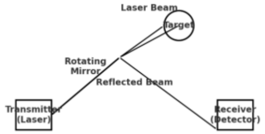
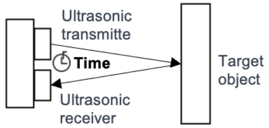
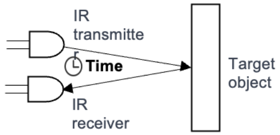
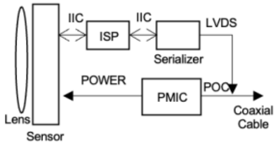
Robot Types

	Robots	Function	Example	Number of LiDAR
Robo Vehicles	Robotaxi	Provide on-demand transportation services without a human driver. It uses sensors and advanced algorithms for navigation, real-time decision-making, and safety.	 Apollo Go robotaxi	6 LiDARs
Commercial Robots	Last-mile delivery robots	Transport packages from distribution centers to their final destinations within a short distance, offering potential efficiency and cost-saving benefits.	 Meituan Last-mile delivery robots	3 LiDARs
	Logistics robots	Used in warehouses, distribution centers, and manufacturing facilities to automate the movement and sorting, streamlining logistics and supply chain operations.	 ArcBest Vaux Vision	2 LiDARs
Household Robots	Lawn-mowing robots	Utilize sensors and automated navigation to perform grass-cutting tasks with minimal human oversight.	 MOVA JT series robotic lawn mower	1 LiDAR

Source: CIC

Analysis of LiDAR in the Robotics Industry

- Robots typically employ multiple sensors, including LiDAR, ultrasonic radar, infrared sensors, and cameras. LiDAR plays an increasingly crucial role in this context.

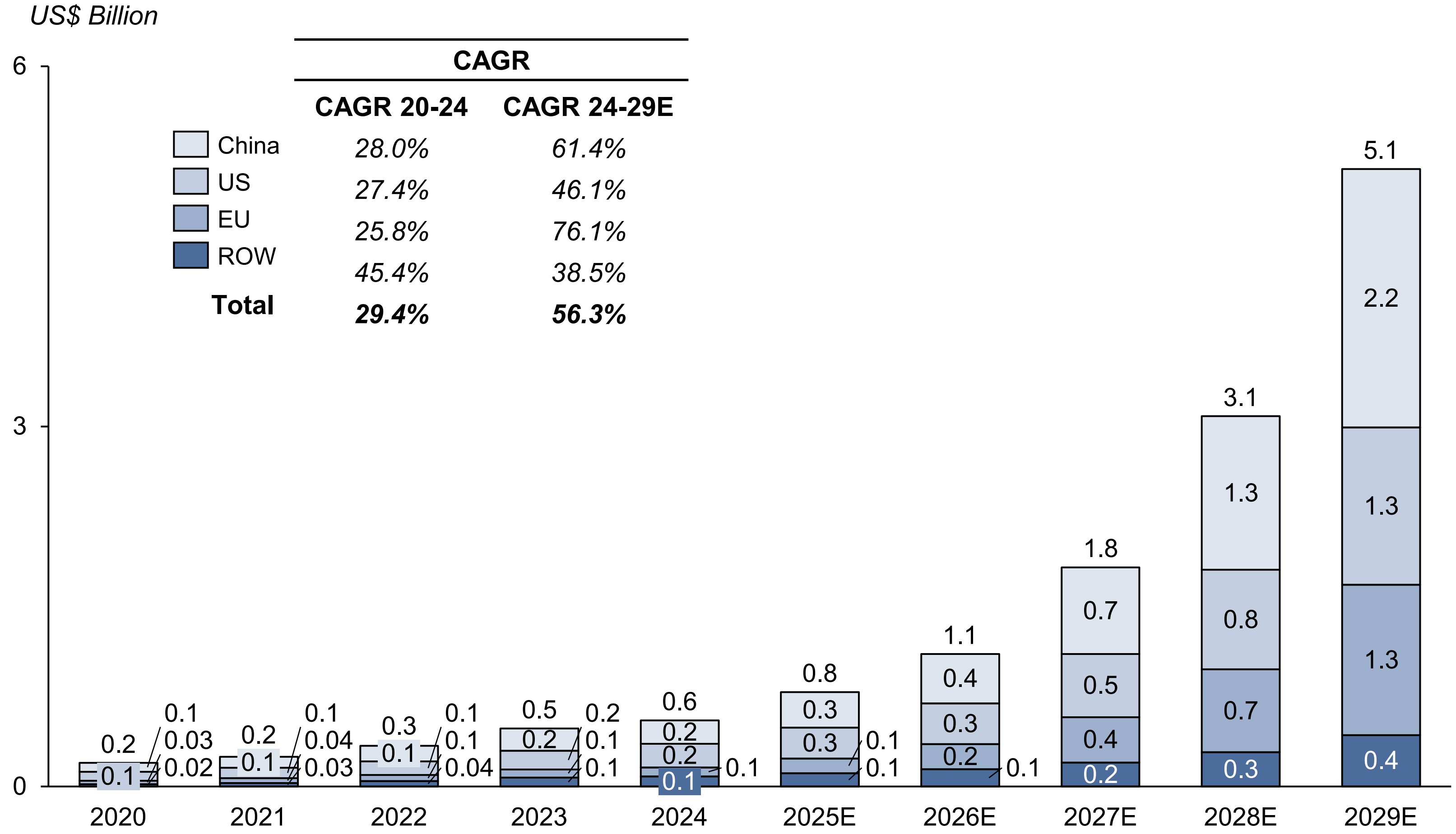
Sensor Type	Technical Principle	Price Range	Precision	Resolution	Adaptability	Future Trends	Robotics Applications
 LiDAR		$200 ~ $4,000	●	◕	◕	As the demand for detection accuracy, resolution, and reliability in robots improves, the use of LiDAR technology is expected to increase.	LiDAR, Single-beam LiDAR, ultrasonic radar, infrared sensors, and cameras form a complementary relationship in the application of Robotics. In commercial scenarios, robots increasingly encounter complex situations where a single sensor cannot meet their external sensing needs. Thus, combining multiple sensors is essential for making timely, accurate decisions and ensuring safe operation. For household robots, the penetration rate of LiDAR is also on the rise. In the future, robots will rely on this combination of sensors to cope with complex environments and tasks, ensuring their efficient operation in different scenarios.
 Single-beam LiDAR		$10 ~ $50	◕	◑	◕	Single-beam LiDAR adoption will rise with growing needs for precision, resolution, and reliability in robotics.	
 Ultrasonic Radar		$3 ~ $15	●	◔	◑	Ultrasonic radar utilization will continuously grow in the low-cost and consumer-grade robots' sectors.	
 Infrared Sensor		$3 ~ $10	◑	◔	◑	As robotics technology advances, the adoption of infrared sensors is anticipated to grow continuously.	
 Cameras		$20 ~ $150	◑	●	◑	Cameras will maintain a high penetration rate among various sensors. As Robotics applications expand, the number of cameras integrated into individual robots will increase.	

Low ◔ → High ●

Market Size of Global LiDAR Application in Robotics Industry, 2020-2029E

- Revenues of LiDAR's for the Robotics market increased from US$0.2 million in 2020 to US$0.6 billion in 2024, at a CAGR of 29.4%, and is expected to reach US$5.1 billion in 2029, representing a CAGR of 56.3%.

Market Size of Global LiDAR Application in Robotics Market, 2020-2029E



	CAGR	
	CAGR 20-24	CAGR 24-29E
China	*28.0%*	*61.4%*
US	*27.4%*	*46.1%*
EU	*25.8%*	*76.1%*
ROW	*45.4%*	*38.5%*
Total	***29.4%***	***56.3%***

Key Analysis

- The global Robotics industry is currently entering a phase of rapid growth, with the large-scale adoption of industrial robots reshaping enterprise cost structures and enabling greater efficiency and cost reduction.
- Revenues of LiDAR's for the Robotics market increased from US$0.2 million in 2020 to US$0.6 billion in 2024, at a CAGR of 29.4%, and is expected to reach US$5.1 billion in 2029, representing a CAGR of 56.3%.
- LiDAR's high-resolution point cloud data supports complete spatial modeling in high-difficulty tasks such as multi-layer spatial perception, operation in narrow environments, and human-robot collaboration, enabling more precise mobility and task execution.

**Exchange rate=7.2993RMB/USD*

Key Drivers and Trends for LiDAR Applications in the Robotics Market (1/2)

- LiDAR adoption in Robotics is growing rapidly, driven by the need for precise 3D spatial perception in dynamic environments. As robots expand across industries, LiDAR enables accurate localization, navigation, and obstacle avoidance, becoming a core component of intelligent autonomy.

Thriving Robotics Industry Expands LiDAR Adoption Opportunities

- The global robotics industry is rapidly growing, driven by advancements in automation, artificial intelligence, and edge computing. Robots are being deployed across various scenarios, including warehousing and logistics, industrial manufacturing, and smart agriculture. This increasing demand for precise, real-time environmental awareness is creating new opportunities for LiDAR integration, as robots operating in dynamic, unstructured environments rely on high-resolution spatial perception to perform tasks safely and efficiently. As adoption scales, LiDAR is becoming a key enabler of intelligent autonomy across diverse robotic applications.

Robotic Intelligence Requires 3D Spatial Data to Understand the Physical World

- As robotic applications expand into complex and dynamic unstructured environments, the need for 3D spatial perception continues to grow. Unlike imagery and simple distance measurements offered by 2D, 3D structured data provides a comprehensive understanding of depth, volume, contours, and spatial layout — essential for environmental perception, object recognition, and interactive control. LiDAR, through active laser ranging, generates high-density, high-precision 3D point clouds that help robots understand the geometric structure and real-time dynamic changes of their surrounding environment. In applications such as dynamic obstacle avoidance, multi-target tracking, and human-robot collaboration, 3D perception directly impacts task performance efficiency and operational safety. As robotic intelligence advances, 3D spatial data is becoming an essential link in the “perception — cognition — decision” loop, driving the depth and breadth of LiDAR adoption.

LiDAR becomes a Core Perception Sensor for Robot Localization, Navigation, and Obstacle Avoidance

- In real-world applications, robots must navigate in complex and dynamic environments efficiently and autonomously, requiring highly accurate localization, navigation, and obstacle avoidance capabilities. LiDAR has become a core sensor for these functions due to its millimeter-level ranging accuracy, wide field of view, and ability to operate independent under ambient lighting conditions. In SLAM systems, LiDAR provides stable, real-time data for 3D mapping and precise localization. In path planning and dynamic obstacle avoidance, it accurately detects obstacle positions and contours in all directions, enabling safe and efficient motion control. Compared with vision-only approaches, LiDAR offers greater robustness and adaptability, particularly in crowded, narrow, or poorly lit environments, gradually evolved from a supplementary sensor into a foundational module in robotic perception.

Source: CIC

Key Drivers and Trends for LiDAR Applications in the Robotics Market (2/2)

- As robotic applications grow more complex, demand for advanced sensing like multi-LiDAR setups is increasing. Combined with policy support and expanding commercial use, LiDAR is shifting from pilot projects to large-scale deployment, driving market growth.

Maturing Technology and Rising Application Demands Drive Growth in LiDAR Adoption and Value

- LiDAR technology is becoming increasingly mature, with improvements in lasers, receivers, scanning mechanisms, and point cloud processors. These improvements make LiDAR more suitable for robotic integration. Simultaneously, advancements in robotic hardware and system integration are accelerating demand for high-performance sensors. On the one hand, LiDAR installation rates continue to rise, with widespread deployment in use cases like Robotaxi, Robobus, Robotruck, lawn-mowing robots, autonomous delivery robots, AMRs, and humanoid robots. In addition, as robotic tasks become more complex, the needs for precision and dynamic recognition are also increasing, driving a trend toward multi-LiDAR setups per robot and significantly boosting per-unit sensor value. Looking ahead, the adoption of multiple-LiDAR configurations will further boost demand, positioning LiDAR as a key growth driver in the market.

Policy Support and Commercial Deployment Provide External Momentum for LiDAR in Robotics

- Globally, governments are prioritizing robotics and intelligent sensing into national strategic agendas, introducing a range of supportive policies to advanced-technology-related industries. In China, initiatives such as the "Robot+ Application Action Plan"(《"機器人+"應用行動實施方案》) and the "2024 Annual Application Guidelines for the "Intelligent Sensors" Key R&D Program"(《"智能傳 感器" 重點專項2024年度項目申報指南》) offer policy guidance and funding support for the robotics market. Western countries are also promoting high-end manufacturing and autonomous navigation systems through research grants and tax incentives. Meanwhile, commercial deployment of Robotaxi and Robotruck are providing real-world operating scenarios for high-level autonomous robots, reinforcing demand for high-performance LiDAR. In complex environments like logistics and urban mobility, LiDAR's precision sensing and redundancy capabilities make it a standard-fit sensor in commercial solutions. This dual momentum — policy support and real-world deployment — is accelerating large-scale LiDAR adoption in robotics, pushing the market from the "validation phase" into the "growth phase."

Content

The Company's Innovative Elements, Leadership Facts and Market Description (1/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- Hesai was the No.1 LiDAR supplier globally in each of 2022, 2023 and 2024 in terms of revenue.
- Hesai delivered robust financial performance in the global LiDAR industry. Hesai achieved the highest gross margin and gross profit among LiDAR companies worldwide in 2022, 2023, and 2024.
- Hesai was the first LiDAR company in the world to achieve a full-year non-GAAP net profit in 2024.
- Hesai recorded full-year positive operating cash flow in both 2023 and 2024, making Hesai the first publicly listed LiDAR company to generate operating cash inflow.
- Hesai is also the first Chinese LiDAR company chosen by a prestigious global OEM for its global models to be distributed worldwide, establishing Hesai as the first Chinese LiDAR provider for global model vehicles. From July 2022, when Hesai began volume shipment, and up to December 31, 2024, Hesai ranked the second in terms of accumulated shipment volume in the global ADAS market.
- Hesai ranked No.1 in terms of revenue scale in the global Robotics market in each of 2022, 2023 and 2024. Hesai built its undisputed leadership in the Robotics market early on with a wide range of mechanical LiDAR products. Hesai was the first LiDAR company globally to achieve 20,000 units shipment volume per month for Robotics applications. Hesai was also a global leader in the global Robotaxi market, a sub-segment of Robotics market, with a market share of over 55% in each of 2022, 2023 and 2024 in terms of revenue.
- Hesai is the first in the LiDAR industry to establish a dedicated R&D team for ASICs as early as in 2017.
- Hesai remains the only LiDAR company in the industry that has in-house developed all seven key components. Hesai's extensive knowledge paved the way for a remarkable industry milestone: Hesai is the first to successfully implement an ASIC approach for both the TX module and the RX module, the heart of a LiDAR product.
- Hesai was the first in the industry to adopt VCSELs for automotive long-range LiDAR, pioneering an unconventional product architecture that was later followed by industry peers.
- Hesai was the first in the industry to implement one-dimensional electronic scanning on ASICs.
- The combination of one-dimensional scanning with rotational mirror in horizontal direction and ASIC-based solid-state electronic scanning in vertical direction provides superior reliability, significantly reduces power consumption, and minimizes optical crosstalk. This approach enhances point cloud image quality and is currently the optimal scanning method available in the industry.
- Hesai launched its flagship AT128 in July 2021, with the start of production, or SOP, in July 2022. AT128 was the first LiDAR product to leverage ASIC-based technology to integrate 128 VCSEL laser arrays, enabling genuine 128-channel scanning. Prior to AT128, similar technological architecture was only capable of achieving a modest 16-line scanning. In addition, while most industry peers apply ASIC approach only to their ADAS LiDAR products.
- Amid the rising trends in intelligent electric vehicles sales and ADAS penetration rates, the demand for LiDAR products from OEM customers has been growing concurrently. This has heightened the requirements for LiDAR suppliers in terms of delivery timeliness, cost efficiency, and product quality.
- Hesai was the first to adopt in-house manufacturing from day one and remains the only player in the market to consistently follow this approach from day one.
- Hesai ranked No.1 in the LiDAR's ADAS market in terms of number of design wins.
- Hesai has been a pioneer in introducing new technologies to the LiDAR industry and consistently set industry trend with its technological leadership and breakthrough during the development of the LiDAR industry. Hesai became the only LiDAR company in the industry that have developed all key components in-house.
- Hesai has navigated the complexity of manufacturing and high capital investment to become the only LiDAR company to engage in automated in-house manufacturing from day one.
- Hesai's LiDAR products cater to short-, medium-, and long-range applications, with industry-leading detection range, resolution, interference rejection technology, and reliability.
- Today, automobile manufacturers have begun to integrate LiDARs into ADAS to better visualize the changing environments encountered by their vehicles. LiDARs for ADAS share certain requirements with LiDARs for Robotics, such as detection range and resolution. At the same time, LiDARs for ADAS normally prefer forward-facing configurations for adaptive cruising and traffic assist functions. In addition, automobile manufacturers and Tier 1 suppliers require LiDARs with proper form factors to be embedded into their vehicles, in addition to automotive grade reliability and robustness.

The Company’s Innovative Elements, Leadership Facts and Market Description (2/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- AT128 is the first LiDAR product to leverage ASIC-based technology to integrate 128 VCSEL laser arrays, enabling genuine 128-channel scanning. It is the milestone product in the ADAS market, setting a benchmark architecture for high-performance, low-cost LiDARs, leading industry peers to gradually adopt a similar technological path.
- AT1440 family. Hesai launched AT1440 family at the CES in January 2025, which incorporates its proprietary ASIC and features the most channels among all LiDARs.
- At the CES in January 2025, Hesai announced its next-generation solid-state FTX LiDAR, an automotive grade solid-state LiDAR with the widest field-of-view globally.
- Pandar128 is one of the most advanced and commercially successful mechanical LiDAR products available in the world and one of the most competitive LiDAR in the Robotics market.
- Pandar40P is the first multi-line mechanical rotating LiDAR with all Hesai’s three key technologies in the Mechanical LiDAR Era imbedded.
- Pandar128 is one of the most competitive LiDAR in the Robotics market.
- OT128 is the world’s only mechanical LiDAR product which implemented an ASIC approach for both the TX and RX systems. While most industry peers apply ASIC approach only to their ADAS LiDAR products,
- By the end of 2024, Hesai has deployed approximately 100 million proprietary chips in its LiDAR products, the highest in the industry, and 100 times more than the second highest industry player.
- Hesai has achieved and maintained the highest integration rate of ASICs among its peers since 2023.
- Traditionally, Vertical-Cavity Surface-Emitting Lasers (VCSELs) were limited to short-range applications due to their low power density and restricted range. However, Hesai’s proprietary high-power VCSEL was the first in the industry to be utilized in long-range automotive LiDAR applications, which are more cost-efficient achieving an optimal balance of performance, quality, and cost.
- Hesai’s ASIC-based architecture has established itself as a mainstream technology pathway. Major industry players have been shifting from their original technological approaches to adopt a LiDAR architecture similar to Hesai’s ASIC-based design in their latest products.
- AT128 not only addresses the market gap for high-performance yet cost-effective LiDAR solutions but also advances autonomous driving perception systems toward higher accuracy and enhanced reliability. AT128 was the first LiDAR product to leverage ASIC-based technology to integrate 128 VCSEL laser arrays, enabling genuine 128-channel scanning. Prior to AT128, similar technological architecture was only capable of achieving a modest 16-line scanning.
- Hesai outperformed its peers and set a benchmark for high-performance, high quality and low-cost LiDARs, leading to significant revenue and market share growth thereafter.
- Hesai introduced platform thinking in 2017, one of the earliest among the industry peers.
- Hesai also holds certifications from SGS, a globally renowned third-party certification entity, as the first achiever of ISO 26262 ASIL-B functional safety product certification in the LiDAR sector. Additionally, Hesai has garnered recognition as the first in the LiDAR sector to receive ISO/ Society of Automotive Engineers (SAE) 21434 cybersecurity product certification from TÜV Rheinland, a leading independent technical testing organization in Germany.
- Hesai has developed and applied numerous other “industry first” technologies to its core business, including interference rejection technology and intelligent point cloud engine (IPE), which have disrupted the industry and contributed to its success.
- Hesai was the first in the industry to develop interference rejection technology that encrypts each laser pulse to minimize interference between LiDAR units.
- Hesai’s development of this groundbreaking technology marked a significant milestone in the LiDAR industry as with the number of LiDAR-equipped vehicles increased on the road, interference among these vehicles became a major safety issue.
- Hesai developed the world’s first IPE.
- Hesai is the only LiDAR company in the industry with a balanced mix of revenue generated from mainland China and other regions.
- Hesai is a leading LiDAR company globally in terms of commercialization and financial performance.

The Company’s Innovative Elements, Leadership Facts and Market Description (3/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- Hesai is one of the few world-leading companies that have shipped LiDAR products in volume to the ADAS and autonomous vehicle fleet. Hesai was the first LiDAR company globally to achieve 10,000 units shipment volume per month in September 2022 and the only LiDAR company globally to achieve 100,000 units shipment volume per month in December 2024; additionally, Hesai was the first LiDAR company globally to achieve 20,000 units shipment volume per month in December 2024 for Robotics applications.
- Hesai is the only Chinese LiDAR company chosen by a prestigious global OEM for its global models to be distributed worldwide, establishing Hesai as the first Chinese LiDAR provider for global model vehicles.
- Hesai’s products have received five industry first ISO certifications, being the largest number among LiDAR companies.
- Hesai was the first LiDAR company to establish a dedicated R&D center for ASICs in 2017, and as of the Latest Practical Date, Hesai continues to maintain one of the top ASIC R&D teams among the industry peers.
- ASIC approach simplifies product architecture, optimizes design, which thereby boosts automation in production and lowers manufacturing costs.
- Hesai was the first LiDAR company to utilize VCSELs for long-range application. Traditionally, vertical-Cavity Surface-Emitting Lasers were limited to short-range applications due to their low power density and restricted range. However, Hesai’s proprietary high-power VCSEL was the first in the industry to be utilized in long-range automotive LiDAR applications, which are more cost-efficient achieving an optimal balance of performance, quality, and cost.
- Hesai was the first LiDAR company to develop single-board integration technology (in 2017) that integrated the transmission and receiver architecture onto fewer circuit boards, which boosts manufacturing efficiency, lowers production costs, and ensures consistent product quality.
- Hesai was the first LiDAR company to develop an intelligent point cloud engine (in early 2018), which results in enhanced image quality and improved reliability of LiDAR.
- Hesai was the first LiDAR company to offer in-cabin LiDAR solution (in 2023), which minimizes external interference and contributes to a sleek vehicle design.
- Hesai has obtained the largest number of ISO certifications among LiDAR companies, including being the first in the LiDAR industry to obtain ISO 26262 ASIL B functional safety certification (in September 2021), ISO/SAE 21434 cybersecurity certification (in May 2023), and ISO 21448 (SOTIF) safety of the intended function process certification (in September 2024).
- Hesai is leading the global ISO automotive LiDAR working group comprising industry giants such as Valeo, BMW, Bosch, Sony, and Volkswagen, to develop the world’s first international standards for LiDAR (ISO AWI 13228).
- Hesai initiated the formulation of the world’s first safety-related standard for LiDAR (UL 4740).
- Hesai is the only LiDAR company participating in the formulation of China’s national laser safety standard GB/T 7247.1-2024.
- Hesai has led the setting of the largest number of industry standards among LiDAR companies.
- In addition to Hesai, the key players in this era were the top four mechanical LiDAR companies by revenue: RoboSense, Velodyne, and Ouster.
- Hesai was the first in the industry to develop interference rejection technology that encrypts each laser pulse to minimize interference between LiDAR units. It remains the only one that can achieve a 100% interference rejection rate, ensuring superior point cloud quality and reliability.
- Hesai introduced the industry’s first vehicle-mounted long-range LiDAR using VCSEL, with its innovative laser design and optimized system configuration. Before this breakthrough, VCSEL lasers were typically limited to short-range applications due to low power density and restricted range.

The Company's Innovative Elements, Leadership Facts and Market Description (4/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- Hesai has successfully lowered the per-channel cost to under $0.25, far below the $5 industry average for LiDARs in 2023, enabling cost-effective one-dimensional electronic scanning with high channel counts.
- Hesai was the first in the industry to develop interference rejection technology that encrypts every laser pulse to reduce interference across different LiDAR units and ambient light interference, and made it a standard feature across its LiDAR product series.
- Hesai has achieved and maintained the highest integration rate—namely, the percentage of components that have been self-developed and vertically integrated on ASICs—since 2023, with its groundbreaking 4th-generation ASICs consolidating all seven key components: lasers, detectors, laser drivers, analog front-end, ADC, digital signal processors (DSP), and controllers. Hesai remains the only LiDAR company in the industry that has developed all key components in-house.
- Hesai's VCSEL output power surpasses competing products by 35% per unit, making long-range VCSEL-based LiDAR commercially viable.
- Hesai is the first LiDAR company in the world to develop polarized VCSELs for automotive LiDAR.
- Hesai's design-to-production and implementation cycle can be completed in just 4–5 months, more than 50% faster than the industry average.
  The average iteration time for Hesai's products is only 6 months, 50% faster than the industry average.
- With 12 of the top 15 global autonomous driving companies adopting Hesai's LiDARs by December 31, 2021, Hesai secured its position as the leading solution provider in terms of purchase dollar for each company's current fleet.
- Hesai has significantly more registered patents and patent applications, and more registered patents in key technologies compared to its industry peers as of June 30, 2024.
- Mainland China currently has the largest LiDAR market globally, accounting for approximately 50% of the total market size in 2024.
- Hesai's self-developed Intelligent Point Cloud Engine (IPE) is the world's first engine of its kind.
- The markets for sensing technology in autonomous solutions for the automotive and Robotics sectors are highly competitive.
- Hesai faces competition from numerous companies, including direct competitors offering LiDAR products and indirect competitors attempting to address similar challenges with alternative technologies. Hesai faces competition from camera and radar companies, other LiDAR developers, and various technology, automotive, and Robotics supply companies, some of which possess significantly greater resources.
- In the automotive market, competitors have commercialized both LiDAR- and non-LiDAR-based ADAS technologies that have achieved market adoption and strong brand recognition, and they may continue to enhance their offerings. Other competitors pursuing commercialization of autonomous driving technologies, whether independently or through partnerships, often have substantial financial, marketing, distribution, research and development, and other resources.
- In markets beyond the automotive sector, such as the Robotics industry, both Hesai and its competitors seek to develop new sensing applications. Even in these emerging markets, Hesai faces substantial competition from numerous players striving to prove the value of their technologies. Additionally, certain customers in the ADAS and Robotics markets have announced development initiatives or acquisitions aimed at creating their own LiDAR-incorporated or alternative sensing technologies, which would compete directly with Hesai's solutions.

The Company's Innovative Elements, Leadership Facts and Market Description (5/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- As a core perception component in ADAS, LiDAR is increasingly recognized as a critical foundation for enabling high-level functions such as NOA, cruise control, and automatic parking assist. Its robust and high-precision sensing capabilities set it apart from cameras and other sensors. Unlike passive sensors such as cameras, LiDAR actively emits laser pulses, maintaining stable detection performance even in complex or extreme conditions such as nighttime, strong backlighting, rain, snow, or fog — significantly enhancing the environmental adaptability of vehicles. In addition, its high-resolution 3D point cloud imaging allows for structured modeling of the surrounding environment, enabling accurate identification of road structures, obstacle shapes, and dynamic changes. This capability provides precise input for path planning and decision-making. As OEMs race to deploy NOA, LiDAR not only enhances overall system safety redundancy but also serves as an indispensable perception backbone for advancing driver-assistance functions to higher levels. Furthermore, as production scales up and supply chain matures, the LiDAR industry is starting to benefit from economies of scale. This development has enabled better alignment of core specifications with customer needs, making LiDAR more suitable for mass-market vehicles, particularly in ADAS applications.
- The global Robotics industry is currently entering a phase of rapid growth, driven by widespread commercial deployment that enhances efficiency across enterprises, organizations, and individuals. This transformation is also reshaping the cost structure of societal operations, with an increasing number of stakeholders embracing Robotics as one of the most promising segments within the broader intelligent services ecosystems. Ubiquitous intelligent Robotics applications — represented by Robotaxi, lawn mowing robots, delivery robots, autonomous mobile robots, and humanoid robots — are expanding rapidly and finding widespread use in transportation, logistics, and services.
- At the policy level, governments in many countries have recognized Robotics as a strategic development priority, accelerating infrastructure investment and real-world deployment. On the technology front, advancements in AI and edge computing are enabling stronger autonomous perception, intelligent decision-making, and task execution. The convergence of multi-scenario deployment, high reusability, and strong intelligence, is increasingly driving the reliance of robots on high-precision sensing systems. This trend fuels the growing demand for sensors with robust spatial perception and localization capabilities, high stability, compact size, and low power consumption — creating favorable conditions for LiDAR penetration in this field. LiDAR is playing an increasingly critical role in robotic perception systems due to its ability to generate 3D point clouds, provide high-precision distance measurements, and operate reliably in all weather conditions. Unlike traditional sensors, LiDAR does not rely on ambient lighting and can function stably in complex environments with varying lighting and dense obstacles, both indoors and outdoors. As a core sensor in key modules such as simultaneous localization and mapping (the "SLAM"), dynamic obstacle avoidance, and path planning, LiDAR significantly enhances robots' autonomous navigation and environmental adaptability.
- In particular, LiDAR's high-resolution point cloud data supports complete spatial modeling in challenging tasks, such as multi-layer spatial perception, operation in narrow environments, and human-robot collaboration, enabling more precise mobility and task execution. By emitting laser pulses and measuring the ToF of reflected signals, LiDAR allows robots to generate accurate 3D point clouds of their surroundings, identify obstacles in real time, and perform precise localization and path planning. These capabilities are essential for safe and efficient navigation, particularly in dynamic or unstructured environments like warehouses, unrestricted roads, and outdoor construction sites. With continued advancements in miniaturization and low power consumption, LiDAR is becoming increasingly compatible with robotic platforms. In the future, it is expected to achieve large-scale deployment across a wide range of robot types, emerging as a major new growth engine for the LiDAR industry following its ADAS applications.

Source: CIC

The Company’s Innovative Elements, Leadership Facts and Market Description (6/6)

- Hesai is a pioneer in introducing new technologies to the LiDAR industry.

- Despite considerable efforts by the automotive industry to research and test LiDAR products for ADAS and autonomous vehicle applications, there is no assurance that LiDAR products will be widely deployed at a large commercial scale.
- While LiDAR products remain relatively new, it is possible that other sensing modalities—or disruptive technologies based on new or existing modalities, including combinations of technologies—may gain greater acceptance or industry leadership in the ADAS and autonomous driving sectors.
- Hesai is a leader in LiDAR-incorporated systems for the autonomous vehicle market.
- The market for LiDAR technology outside automotive applications is still relatively new, rapidly developing, and unproven across many industries.
- Although Hesai intends to invest substantial resources to maintain its technological leadership, ongoing technological changes in sensing technology, LiDAR, and related markets—including the ADAS and Robotics industries—could adversely impact the adoption of LiDAR and/or Hesai’s products, either generally or for particular applications.

Source: CIC