

Global Autonomous Driving Market Research

Independent Market Research Report

For

Project Pelican

Frost & Sullivan

2025

Date : October 28, 2025

For and on behalf of
Frost & Sullivan Limited



Name: Charles Lau
Title: Executive Director



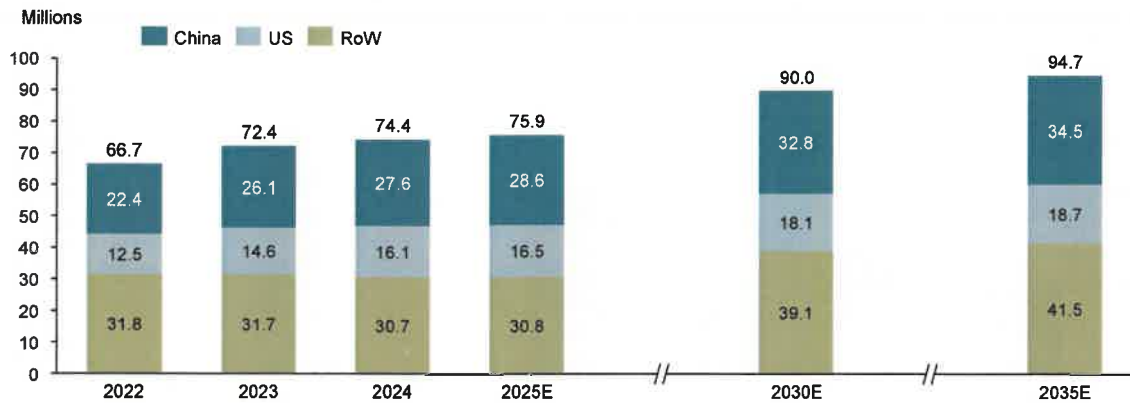
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Overview of Global Autonomous Driving Market

Global Passenger Vehicle Sales Volume, by Regions (2024 update)

Passenger Vehicle Sales Volume , Global, Breakdown by Regions

CAGR	2022-2025E	2025E-2030E	2030E-2035E
China	8.5%	2.8%	1.0%
US	7.2%	1.9%	0.6%
RoW	0.1%	4.8%	1.2%
Global	4.4%	3.5%	1.0%



Source: Industry Association, Frost & Sullivan

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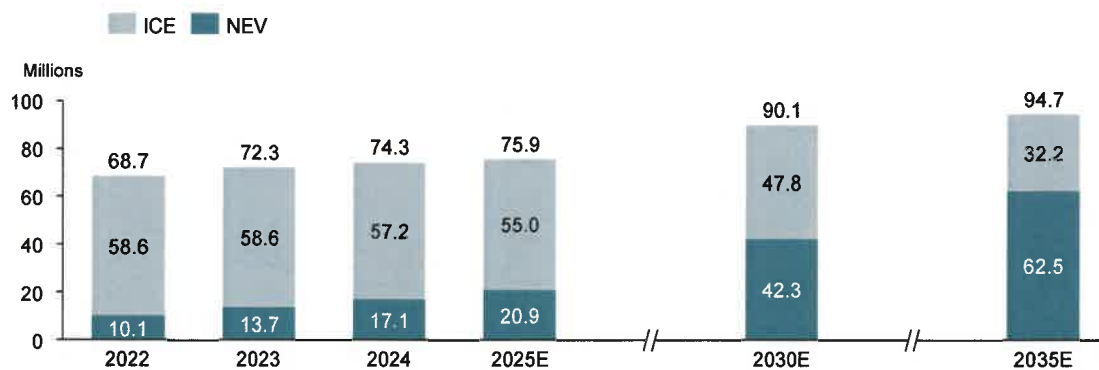
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Overview of Global and China Automotive Market

Global Passenger Vehicle Sales Volume, by Power Type (2024 update)

Global Passenger Vehicle Sales Volume, by Power Type

CAGR	2022-2025E	2025E-2030E	2030E-2035E
NEV	27.4%	15.2%	8.1%
ICE	-2.1%	-2.8%	-7.6%
Total	3.4%	3.5%	1.0%



Source: Industry Association, Frost & Sullivan

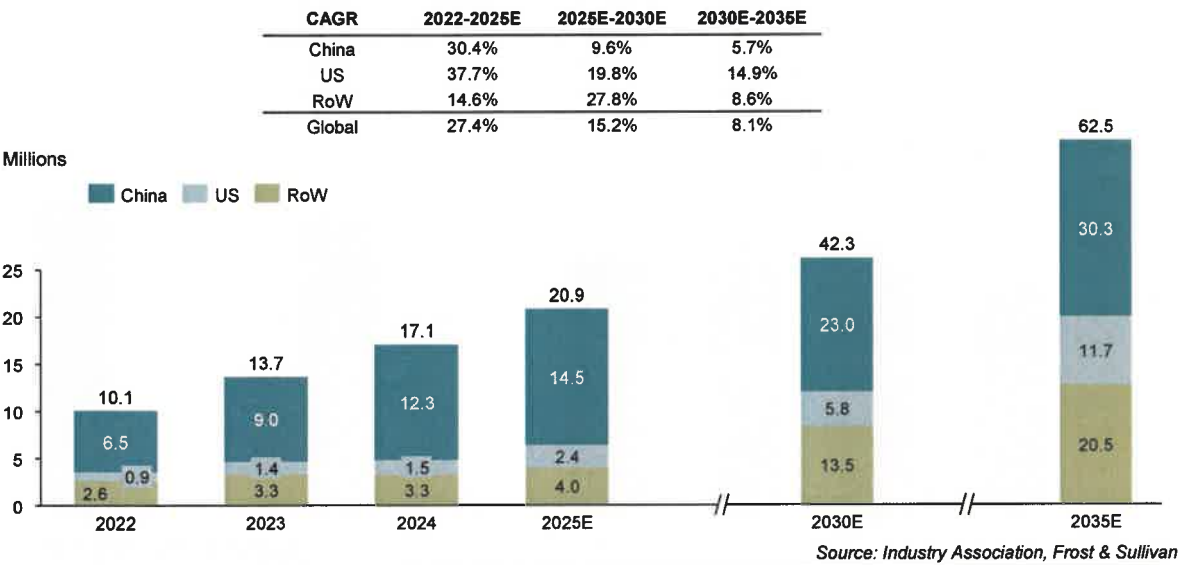
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Overview of Global Autonomous Driving Market

Global New Energy Passenger Vehicle Sales Volume (2024 update)

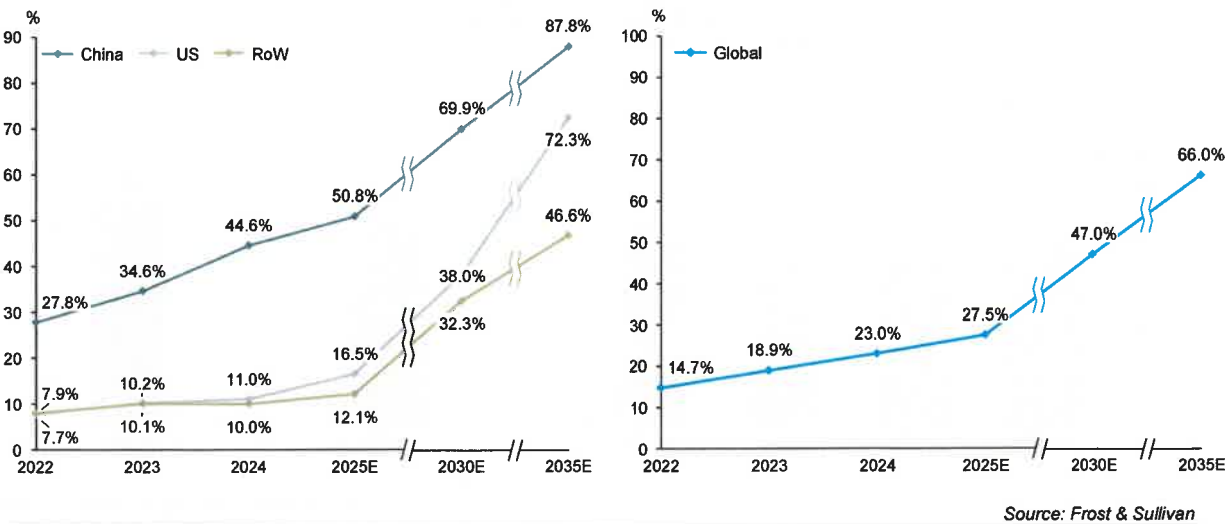
New Energy Passenger Vehicle Sales Volume , Global, Breakdown by Regions



Overview of Global Autonomous Driving Market

Global New Energy Passenger Vehicle Penetration Rate (2024 update)

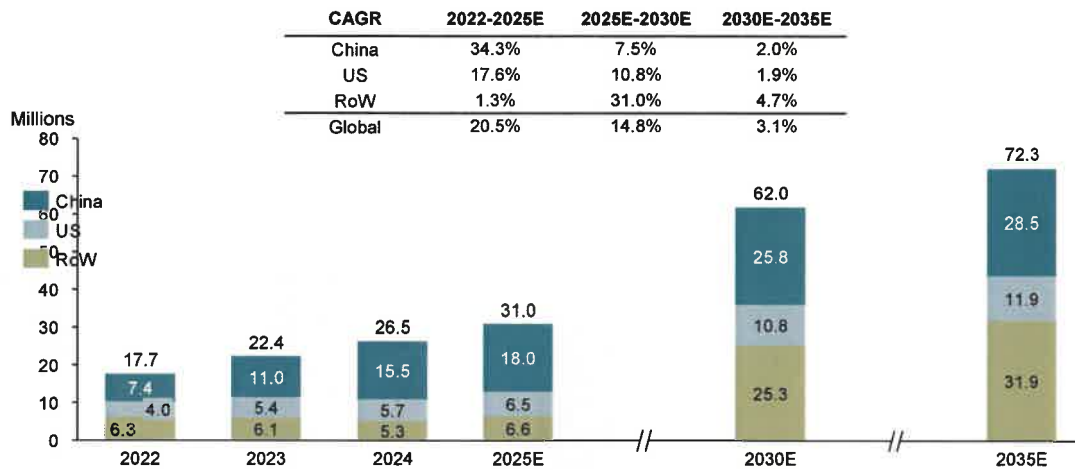
New Energy Passenger Vehicle Penetration Rate, Global, Breakdown by Regions



Overview of Global Autonomous Driving Market

Global Autonomous Driving Vehicle Sales Volume Breakdown by Level (2024 update)

ADAS (L2 & L3) Autonomous Driving Vehicle Sales Volume, Breakdown by Regions,



Note: ADAS refers to level 2 and level 3 autonomous driving technology.

Source: Industry Associations, Frost & Sullivan

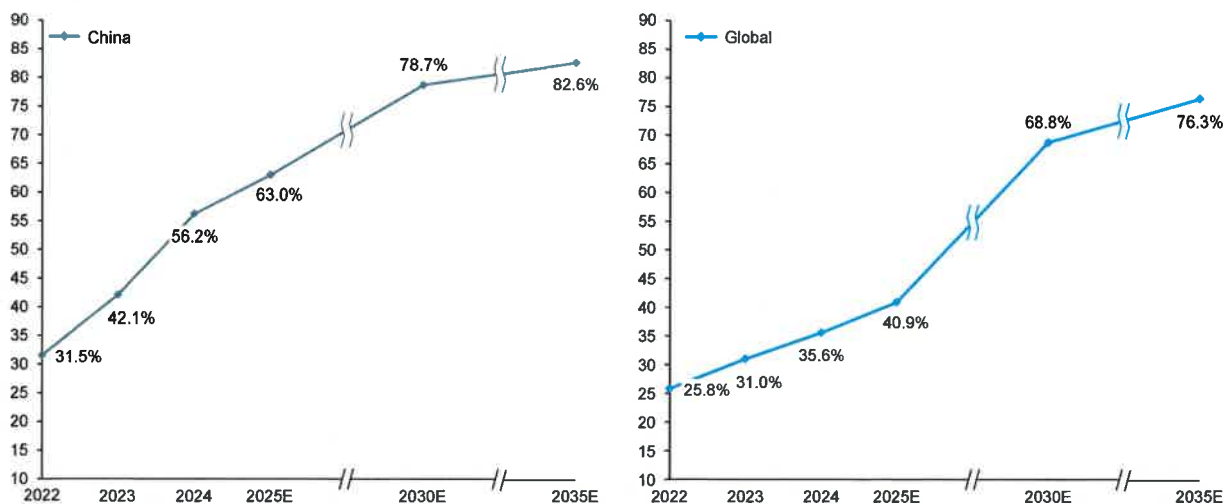
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Overview of Global Autonomous Driving Market

The Penetration Rate of Autonomous Driving in China by level (2024 update)

ADAS vehicle Penetration Rate



Note: Penetration rate refers to share of ADAS passenger vehicle sales volume in total passenger vehicle sales volume

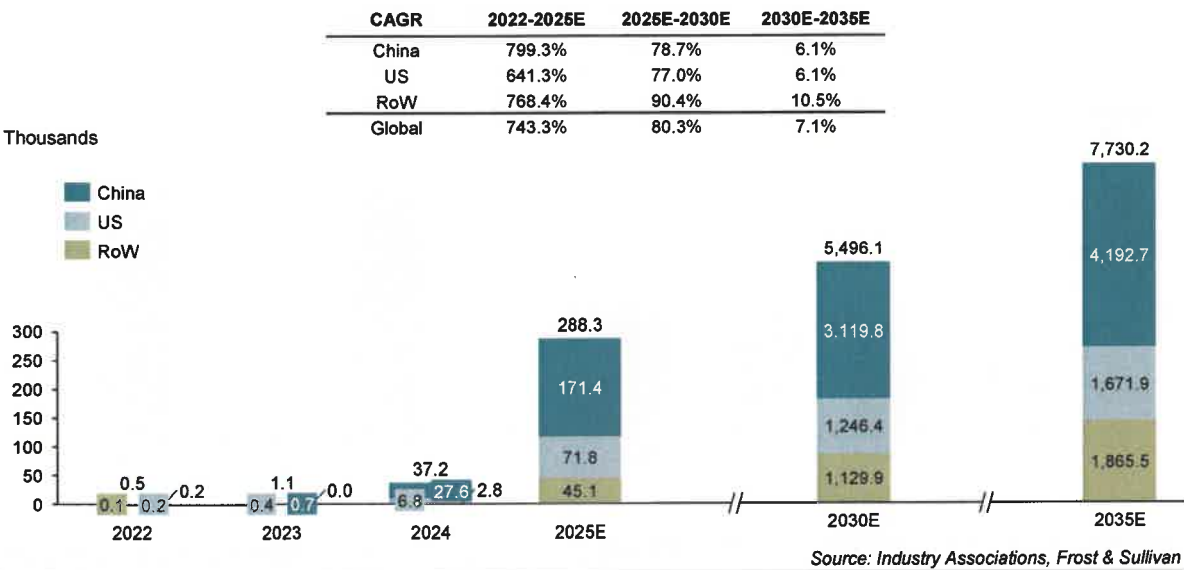
Source: Frost & Sullivan

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Overview of Global Autonomous Driving Market
Global Autonomous Driving Vehicle Sales Volume Breakdown by Level (2024 update)

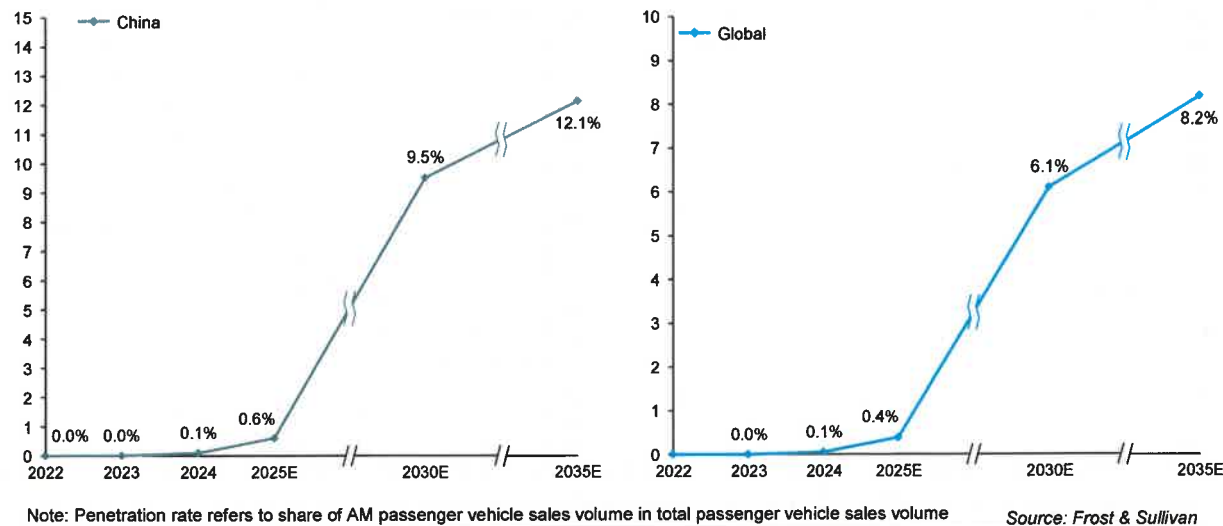
AM (L4 & L5) Autonomous Driving Vehicle Sales Volume, Breakdown by Regions,



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Overview of Global Autonomous Driving Market
The Penetration Rate of Autonomous Driving in China by Level (2024 update)

AM Vehicle Penetration Rate



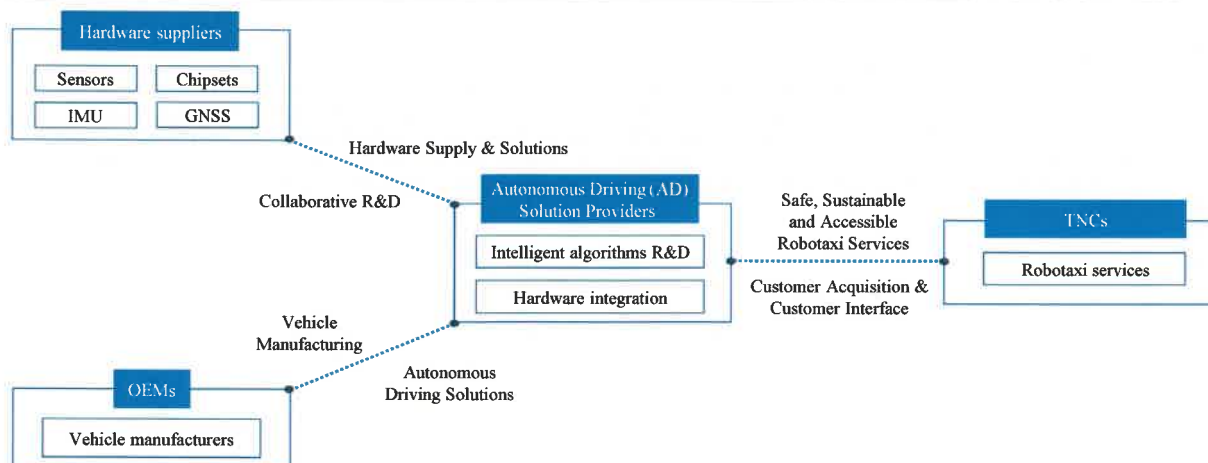
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Overview of China and Global Robotaxi Market

Value chain of Robotaxi Market

The following flowchart illustrates the respective roles of all stakeholders (including the Company) along the robotaxi services value chain:

- **Hardware Suppliers:** Autonomous driving solution providers collaborate with chip manufacturers through joint R&D initiatives to co-develop autonomous driving solutions tailored for robotaxi applications.
- **OEMs:** Autonomous driving solution providers provide integrated autonomous driving solutions to enable seamless vehicle-level integration.
- **TNCs (Transportation Network Companies):** Autonomous driving solution providers deliver safe, sustainable, and accessible robotaxi services, supporting their deployment of autonomous mobility offerings.



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Overview of China and Global Robotaxi Market

Market Drivers of Robotaxi Market (1/2)

➤ **China and global robotaxi market enjoys promising future and is expected to continue its strong momentum primarily due to the following factors.**

- Advancements in Autonomous Driving Technology.**
 Autonomous driving advances remain the key driver of robotaxi growth. Leading robotaxi companies have made substantial R&D investments and implement advanced technologies such as world model methodology and end-to-end (E2E) systems, to enhance vehicles' perception, decision-making, and control capabilities, continuously improving safety, reliability, and operational efficiency while reducing costs. Leading companies have implemented fully driverless operations and accumulated tens of millions of kilometers in testing mileage, establishing the technical foundation for future large-scale commercialization, fleet expansion and GTV growth per vehicle in the robotaxi sector.
- Government Policy Support.**
 Policy frameworks have become pivotal drivers for robotaxi development. China have integrated autonomous driving into the national "14th Five-Year Plan for Digital Economy Development", with multiple government departments jointly initiative promoting commercialization, road access, and pilot programs for autonomous driving vehicles. Municipal governments (e.g., Beijing, Shanghai, Shenzhen) concurrently implement regulatory breakthroughs, including open testing zones, liability frameworks, and commercial operation approvals, to establish clear compliance pathways. A number of overseas countries and regions (e.g., the U.S., Germany, France, Japan) are progressively refining regulations to standardize and accelerate robotaxi deployment.
- Infrastructure Enhancement.**
 The development of transportation infrastructure is accelerating robotaxi scalability. China's rapid deployment of 5G networks, high-resolution mapping, cloud-edge computing, and smart roads are establishing an optimized operational environment for robotaxis. By October 2024, over 50 Chinese cities have implemented intelligent connected vehicle testing programs across over 32,000 km of smart roads nationwide. The coming integration of smart city and transportation networks will deliver additional efficiency improvements. Meanwhile, overseas developed markets are enhancing robotaxi safety and performance through advanced traffic management systems featuring adaptive signals and embedded sensors.

Source: Frost & Sullivan

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Overview of China and Global Robotaxi Market

Market Drivers of Robotaxi Market (2/2)

- China and global robotaxi market enjoys promising future and is expected to continue its strong momentum primarily due to the following factors.

Established Cost-Reduction Pathways.

Continuous reductions in hardware and operational costs will facilitate the scaled deployment of robotaxis. Chinese robotaxi companies demonstrate particular strengths in hardware cost control, where localization of core components like LiDAR and computing platforms continues to drive down manufacturing expenses. Concurrently, innovative business models, such as OEM partnerships, optimize asset utilization and alleviate capital burdens. As operational scale expands and per-vehicle costs continue to decrease, the conditions for widespread robotaxi adoption will be further enhanced.

Rising Customer Acceptance and Demand.

China's vast population and surging mobility needs, especially in tier-1 and tier-2 cities where traffic congestion and parking limitations persist, provide ideal conditions for robotaxi implementation. As an efficient shared mobility solution, robotaxi addresses urban transportation pain points while alleviating driver shortages amid an aging population. Globally, acceptance of robotaxi is accelerating, driven by proven technology reliability, superior safety performance compared to human drivers, growing environmental consciousness and shifting consumer preference toward sustainable mobility.

Source: Frost & Sullivan

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Overview of China and Global Robotaxi Market

Threats and challenges of Robotaxi Market

Threats and Challenges

The Robotaxi industry, while showing promising technological progress, continues to face a number of threats and challenges that may affect its pace of commercialization and broader adoption.

Key Threats

- **High R&D Capital Requirements:** The development of autonomous driving technology involves a prolonged R&D cycle and substantial capital investment. Companies must have the capability to sustain long-term, stable R&D funding to remain competitive.
- **Limited Market Acceptance:** As the Robotaxi industry remains in its early stages, consumer perceptions regarding the reliability and practicality of Robotaxi services are still evolving. Broader market adoption will require continued consumer education and operational validation.

Key Challenges

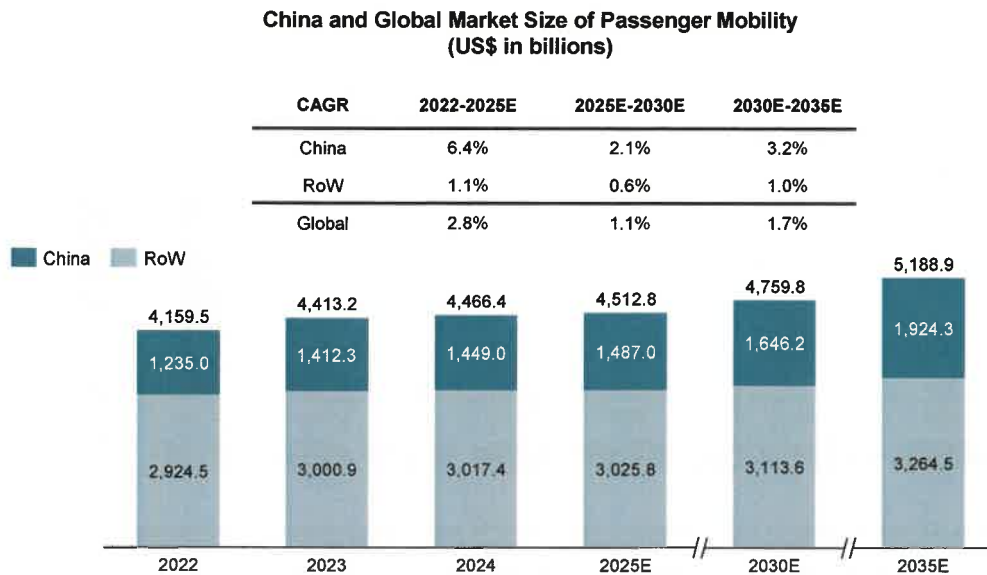
- **Incomplete Scenario Coverage:** While autonomous driving technology has advanced significantly and can handle most day-to-day driving scenarios, it still faces limitations in handling rare or extreme edge cases.
- **Early-Stage Commercialization:** Commercial deployment of Robotaxi services remains limited, primarily to first-tier and select second-tier cities. Broader commercialization efforts are needed to scale operations and demonstrate sustainable business models.

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Overview of China and Global Robotaxi Market

Passenger Mobility Market Size (2024 update)



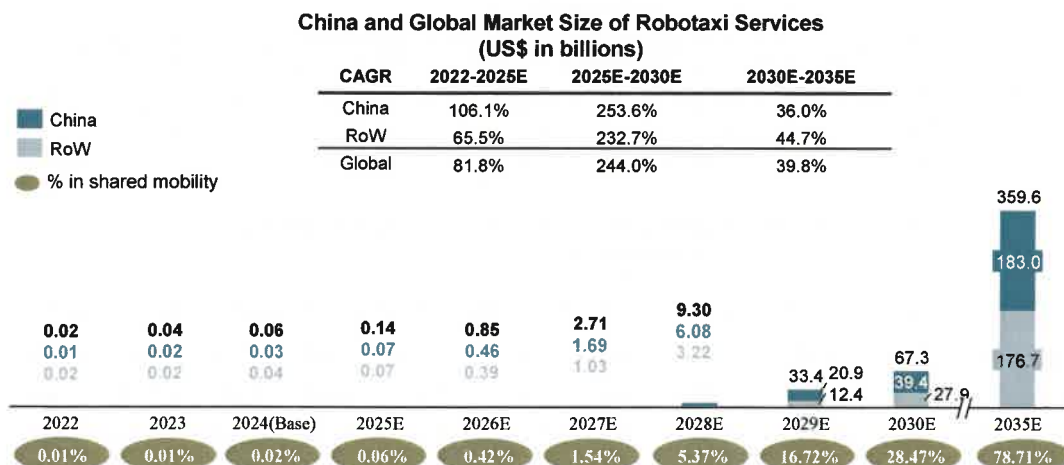
Note:

(1) RoW stands for "Rest of the World".

(2) Source: International Organization of Motor Vehicle Manufacturers (OICA), China Association of Automobile Manufacturers (CAAM), National Bureau of Statistics of China (NBS).

Overview of China and Global Robotaxi Market

China and Global Robotaxi Market Size (2024 update)



Note:

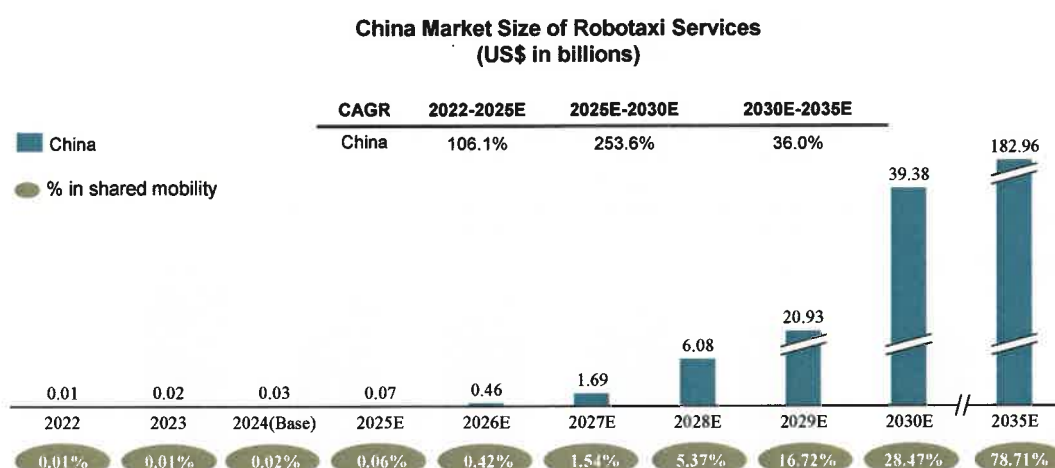
(1) Robotaxi services market size represents the total amounts of ride fare paid by passengers for robotaxi services, as measured by the GTV of such services.

(2) % in shared mobility refers to the share of China's robotaxi market size in the China's shared mobility market.

(3) Source: Public news and government statistics; Annual reports of listed companies.

Overview of China and Global Robotaxi Market

China Robotaxi Market Size (2024 update)



Note:

(1) Robotaxi services market size represents the total amounts of ride fare paid by passengers for robotaxi services, as measured by the GTV of such services.

(2) % in shared mobility refers to the share of China's robotaxi market size in the China's shared mobility market.

(3) Source: Public news and government statistics; Annual reports of listed companies.

Overview of China and Global Robotaxi Market

Global and China Robotaxi Car Parc (2024update)

China and Global Car Parc of Robotaxi
Unit: Million

		2023	2024	2025E	2026E	2027E	2028E	2029E	2030E	2035E
Robotaxi	China (tier 1 and tier 2 cities)	0.001	0.002	0.004	0.02	0.05	0.16	0.55	1.02	4.23
	RoW	0.001	0.002	0.003	0.005	0.01	0.02	0.08	0.17	0.95

China Car Parc of Traditional Taxis, Ride-hailing Vehicles and Robotaxi,
Breakdown by Cities
Unit: Million

		2023	2024	2025E	2026E	2027E	2028E	2029E	2030E	2035E
Taxi, Ride-hailing	Tier-1 Cities	1.06	1.08	1.10	1.11	1.10	1.09	1.04	0.94	0.42
	Tier-2 Cities	2.44	2.48	2.52	2.55	2.52	2.50	2.37	2.16	0.96
Robotaxi	Tier-1 Cities	0.001	0.001	0.002	0.01	0.02	0.05	0.16	0.34	1.52
	Tier-2 Cities	0.0004	0.001	0.002	0.01	0.03	0.12	0.39	0.68	2.71

The penetration rate of robotaxi in overall China ride-hailing market by fleet size
Unit: %

	2023	2024	2025E	2026E	2027E	2028E	2029E	2030E	2035E
Penetration rate of robotaxi in overall China ride-hailing market	0.02%	0.03%	0.07%	0.24%	0.72%	2.56%	8.60%	16.05%	65.36%

Note: (1) Source: Public news and government statistics; Annual reports of listed companies.

Competitive Landscape of Robotaxi Market

Competitive Landscape of Robotaxi Market in China

- Currently, only Chinese companies are participating in China's robotaxi market. Non-China-based robotaxi companies, such as Waymo and Cruise, are not operating in China. In 2024, the total fleet size of robotaxi (L4) in China market is 1748. The market ranking and competitive landscape based on robotaxi fleet size are as follows:

Competitive landscape of China robotaxi (L4) market,
with ranking and market share in terms of fleet size as of December 2024 :

Ranking	Company	Market Share, Fleet Size in 2024 (%)
1	Apollo (Company B ²)	44.9%
2	Pony AI	15.4%
3	WeRide (Company W ³)	8.1%

Note:

- (1) The ranking is based on robotaxi fleet size in China market as of December 31, 2024.
- (2) Company B is an AI company with a strong internet foundation that develops a product mix of online marketing services, cloud services, autonomous ride-hailing service, map service, and others, established in 2000 and headquartered in Beijing, China, and listed on the Stock Exchange and NASDAQ with a market capitalization of US\$29.4 billion as of December 31, 2024.
- (3) Company W is a Level 4 autonomous driving company that develops a product mix of robotaxis, robobuses, robovans, and others, established in 2017 and headquartered in Guangzhou, China, and listed on NASDAQ with a market capitalization of US\$3.9 billion as of December 31, 2024.

Competitive Landscape of Robotaxi Market

Competitive Landscape of Robotaxi Market in China

- There are 2 China-based publicly listed autonomous driving companies, and the ranking by revenue in 2024 is as follows.

Competitive landscape of China autonomous driving listed companies
in terms of revenue in 2024

Ranking	Company	Revenue in 2024, US\$ in thousands
1	Pony	75,025
2	Company W ⁽¹⁾	49,294 ⁽²⁾

Note:

- (1) Company W is a Level 4 autonomous driving company that develops a product mix of robotaxis, robobuses, robovans, and others, established in 2017 and headquartered in Guangzhou, China, and listed on Nasdaq.
- (2) Company W's revenue was converted from CNY to USD using the exchange rate prevailing on April 11, 2025 (0.1365USD/CNY).

Competitive Landscape of China Robotaxi Market

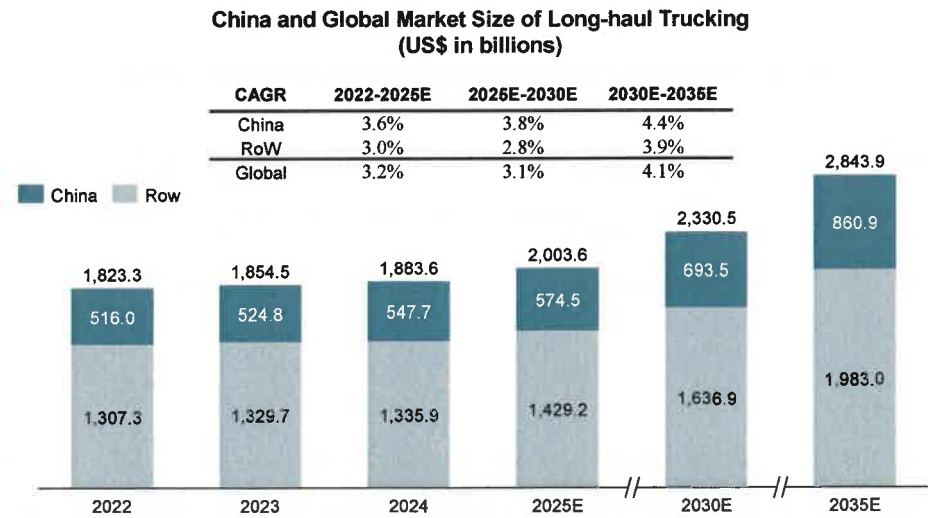
Competitive Landscape of Robotaxi Market in China - 2024 Beijing Autonomous Vehicle Road Test Report

	Pony	Company B	Company W	Company D ⁽⁵⁾
Road Test Fleet Size ⁽¹⁾	70	344	27	78 ⁽⁶⁾
Testing mileage in 2024 (ten thousand km) ⁽³⁾	320.37	580.92	47.56	178.09 ⁽⁷⁾
Accumulative testing mileage (ten thousand km) ⁽⁴⁾	842.40	2,180.60	80.42	229.27

- Note:
- (1) Source: 2024 Beijing Autonomous Vehicle Road Test Report.
 - (2) Road test fleet size refers to the number of autonomous driving test vehicles operated by participant companies in Beijing from 2018 to 2024.
 - (3) Testing mileage refers to the testing mileage completed by participant companies' autonomous driving fleet in Beijing, China in 2024.
 - (4) Accumulative testing mileage refers to accumulative testing mileage completed by participant companies' autonomous driving fleet in Beijing, China from 2018 to 2024.
 - (5) Company D is a global mobility technology platform focusing on ride-hailing and autonomous driving, established in 2012 and headquartered in Beijing, China, and listed on NYSE.
 - (6) Company D's road test fleet size includes robotruck test vehicles.
 - (7) Company D's testing mileage in 2024 includes robotruck test mileage.

Overview of China and Global Robotruck Market

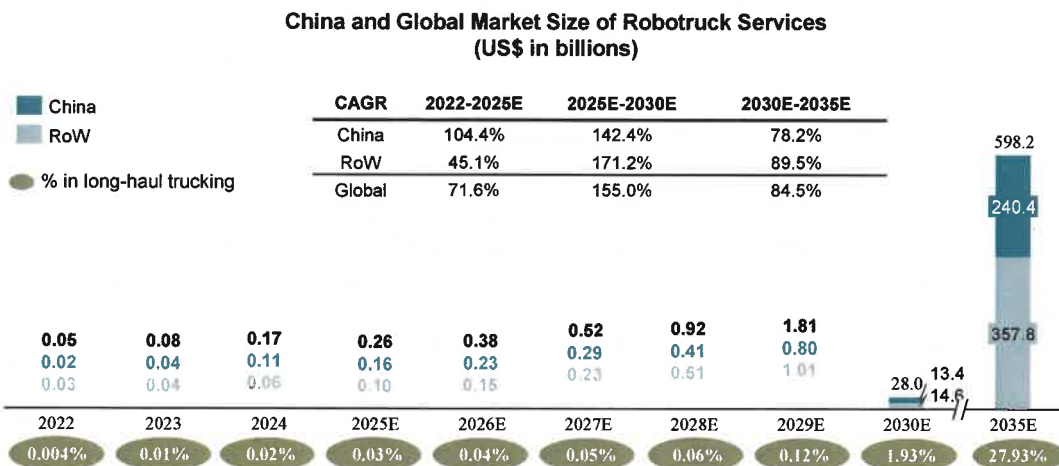
Market Size of Global Long-haul Market (2024 update)



- Note:
- (1) Long-haul trucking GTV refers to the total transaction amount of the long-haul trucking transportation services.
 - (2) International Organization of Motor Vehicle Manufacturers (OICA), China Association of Automobile Manufacturers (CAAM), National Bureau of Statistics of China (NBS)

Overview of China and Global Robotruck Market

China and Global Robotruck Market Size (2024 update)



Note:

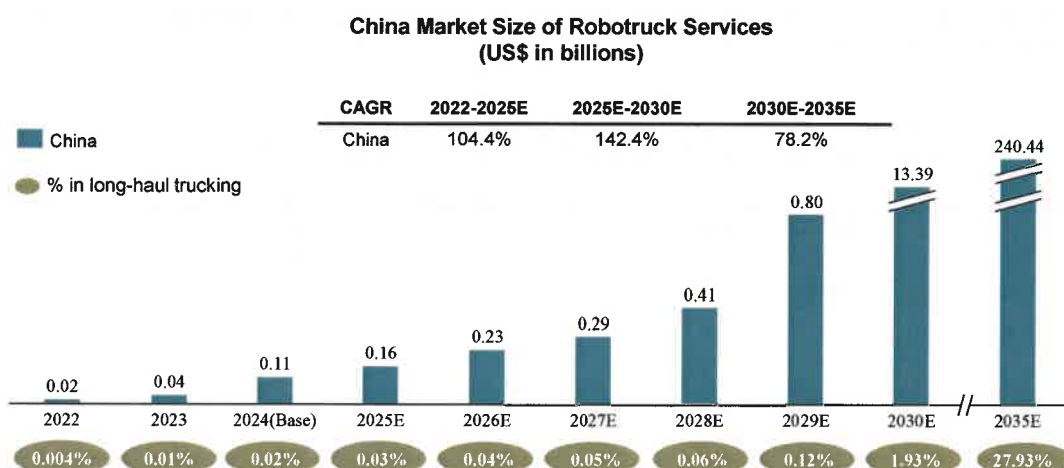
(1) Robotruck services market size represents total amounts of logistics fare paid by customers (such as logistics companies) for robotruck services, as measured by the GTV of such services.

(2) % in long-haul trucking refers to the share of the China robotruck market size in the long-haul trucking market.

(3) Source: Public news and government statistics; Annual reports of listed companies.

Overview of China and Global Robotruck Market

China Robotruck Market Size (2024 update)



Note:

(1) Robotruck services market size represents total amounts of logistics fare paid by customers (such as logistics companies) for robotruck services, as measured by the GTV of such services.

(2) % in long-haul trucking refers to the share of the China robotruck market size in the long-haul trucking market.

(3) Source: Public news and government statistics; Annual reports of listed companies.

Overview of Global Robotruck Market
China and Global Robotruck Car Parc (2024update)

China and Global Car Parc of Robotruck
Unit: Thousand

		2023	2024	2025E	2026E	2027E	2028E	2029E	2030E	2035E
Robotruck	China	0.83	1.11	1.51	2.10	2.57	3.63	7.05	116.65	1,825.00
	Overseas ⁽¹⁾	0.81	1.01	1.47	1.94	2.52	4.86	9.45	127.09	2,632.83

Note: (1) Overseas includes the United States and Europe, with the United States accounting for the largest share and the remaining countries representing a much smaller proportion.
Source: Public news and government statistics; Annual reports of listed companies.

Competitive Landscape of Robotruck Market
Competitive Landscape of Robotruck Market in China

- In 2024, the total fleet size of L4 level robotrucks and L2+ level robotrucks operated by companies with L4-level robotruck capabilities is 1,110, of which 141 are L4-level robotrucks. The market ranking and competitive landscape based on robotruck fleet size are as follows.

Competitive landscape of China robotruck (L2+&L4) market,
with ranking and market share in terms of fleet size as of December 2024:

Ranking	Company	Market Share, Fleet Size in 2024, %
1	KargoBot (Company K)	27.0%
2	Pony AI	17.2%
3	Utopilot (Company Y)	7.0%

- Note:
- (1) The ranking is based on robotruck fleet size as of December 31, 2024..
 - (2) Company K is an intelligent transportation solutions provider focusing on L2+ and L4-level robotruck and freight logistics, founded in 2021 and headquartered in Beijing, China with a registered capital of RMB 1.9 million. Backed by a prominent commercial vehicle OEM and a major technology conglomerate, Company K has developed a full-stack autonomous driving system for heavy-duty trucks and has conducted large-scale highway freight operations in northern and eastern China. As of December 31, 2024, it had deployed a fleet of over 100 robotrucks in commercial scenarios and is one of the few players in China to receive a national-level license for Level 4 testing on open roads.
 - (3) Company Y is an autonomous driving solutions and transportation services provider focusing on L2+ and L4-level robotruck and port logistics, established in 2021 and based in Shanghai, China with a registered capital of RMB 1.1 billion. It is backed by a major Chinese automotive group and a leading port operator, with a strategic focus on integrating autonomous driving technology into container transport and smart port operations. Company Y has established pilot operations in several major Chinese ports and industrial zones, and is one of the few companies in China to have launched closed-loop Level 4 operations in semi-enclosed logistics environments. .

Competitive Landscape of Robotruck Market

Competitive Landscape of Robotruck Market in China

Competitive landscape of China robotruck (L4) market,
with ranking and market share in terms of fleet size as of December 2024 :

Ranking	Company	Market Share, Fleet Size in 2024, %
1	Pony AI	36.2%
2	KargoBot (Company K)	17.8%
3	Trunk.tech (Company Z)	14.2%

Note:

(1) The ranking is based on robotruck fleet size as of December 31, 2024.

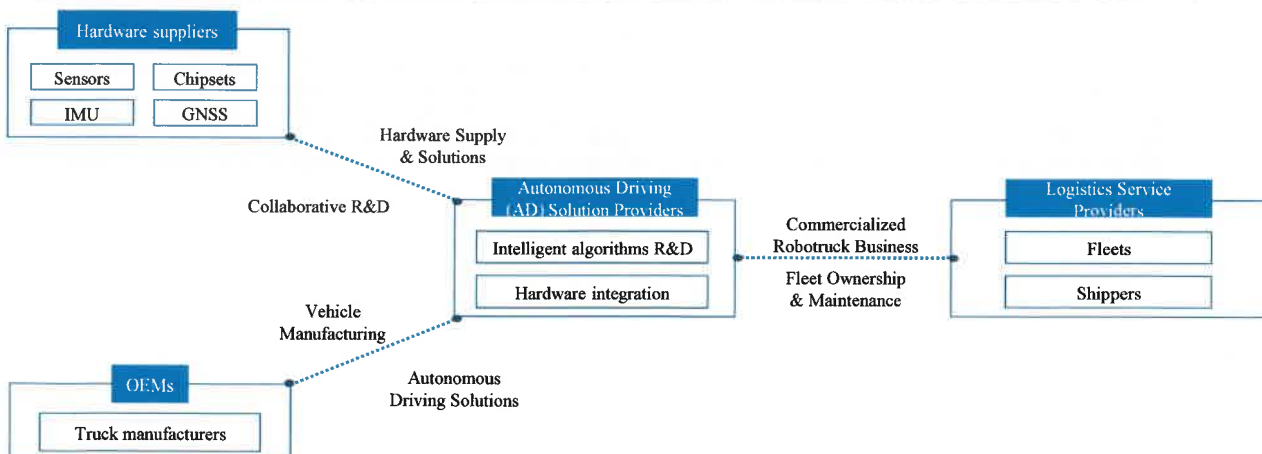
(2) Company Z is a L4-level robotruck developer for logistics networks, established in 2017 and based in Beijing, China with a registered capital of RMB 1.4 million. As one of the earliest entrants in China robotruck sector, Company Z has specialized in full-stack Level 4 software for highway scenarios and has conducted long-haul pilot operations in collaboration with major digital freight platforms and OEMs. It was among the first to receive permits for open-road testing of robotrucks in China and has deployed vehicles across multiple intercity corridors in northern and eastern China.

Overview of China and Global Robotruck Market

Value chain of Robotruck Market

The following flowchart illustrates the respective roles of all stakeholders (including the Company) along the robotruck services value chain:

- **Hardware Suppliers:** Autonomous driving solution providers engage in collaborative R&D with chip manufacturers to develop autonomous driving solutions specifically for robotruck applications.
- **OEMs:** Autonomous driving solution providers offer autonomous driving systems designed for seamless integration into commercial vehicle platforms.
- **Logistics Service Providers:** Autonomous driving solution providers deliver commercially deployed robotruck services to enhance freight transportation efficiency and reliability.



Overview of China and Global Robotruck Market

Market Drivers of Robotruck Market (1/2)

- China and global robotruck market enjoys promising future and is expected to continue its strong momentum primarily due to the following factors.



Steady Growth in Long-Haul Freight Demand.

China's robust consumer demand and the e-commerce logistics expansion continue to fuel strong road transportation demand. With the world's most extensive highway network, long-haul trucking dominates China's road freight market, accounting for approximately 70% of the country's road freight market. This provides ideal conditions for large-scale robotruck deployment. Globally, economic growth, supply chain restructuring, and regional economic integration are driving sustained logistics demand, leading to increased robotruck fleet deployments and rising per-vehicle GTV.



Breakthroughs in Autonomous Driving Technology.

Continuous advancements in sensor performance, algorithm optimization, and computing power have significantly enhanced robotruck's perception accuracy, decision-making intelligence, and complex road condition handling capabilities. Leading companies have achieved L4-level "1+N" platooning technology enabling driverless operation in following trucks, simultaneously reducing labor costs and aerodynamic drag. Notably, the robotruck sector leverages and adapts foundational autonomous driving architectures from robotaxis while implementing scenario-specific enhancements, accelerating technological maturation and commercial application.



Government Policy Support.

China has implemented comprehensive policies supporting robotruck development, including multiple government departments jointly promote innovation and application of autonomous driving technology and accelerate the road access and commercialization of robotrucks. Overseas markets are similarly advancing supportive regulations. For instance, several U.S. states permit robotruck testing and operation. The global regulatory evolution is reducing compliance costs, accelerating commercial license approvals, and enabling large-scale robotruck deployment.

Source: Frost & Sullivan

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Overview of China and Global Robotruck Market

Market Drivers of Robotruck Market (2/2)

- China and global robotruck market enjoys promising future and is expected to continue its strong momentum primarily due to the following factors.



Established Cost Reduction Pathways.

Robotruck is achieving cost optimization across their production and operational lifecycle. In China, the localization of core components like LiDAR has significantly reduced production costs, while operational innovations further enhance efficiency, such as platooning for extended range and intelligent dispatch systems for lower empty-load rates. As a transformative solution for long-haul freight, robotruck's advanced route optimization and fleet management capabilities improve logistics efficiency and revenue potential, delivering superior lifecycle economics compared to conventional trucking. With technology advances and economies of scale, further cost reductions will accelerate robotruck adoption among logistics providers.



Pain Points in Long-Haul Trucking Drive Robotruck Adoption.

Robotruck effectively addresses two critical challenges in the global long-haul freight industry: labor shortages and road safety risks. By eliminating human-related accident factors, robotruck significantly enhances transportation safety. Meanwhile, growing environmental awareness and stricter emission reduction requirements further bolster its appeal. Typically equipped with electrified powertrains, robotruck substantially reduces carbon emissions compared to traditional diesel trucks. This aligns with global sustainability goals, environmental regulations, and corporate social responsibility objectives, positioning robotruck for tremendous market potential.

Source: Frost & Sullivan

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Overview of China and Global Robotruck Market

Threats and challenges of Robotruck Market

Threats and Challenges

As an emerging segment of the autonomous driving sector, the robotruck industry encounters distinct regulatory, technical, and commercial hurdles that must be addressed to enable scaled deployment and profitability.

Key Threats

- **Regulatory Uncertainty:** As the robotruck industry is still emerging, frequent changes in laws, regulations, and technical standards create ambiguity in legal responsibilities, increasing compliance and operational risks.
- **Underdeveloped Insurance Framework:** China has yet to establish a dedicated insurance regime for robotruck operations. Most areas rely on traditional cargo vehicle insurance, which can lead to disputes over liability and compensation in the event of incidents.

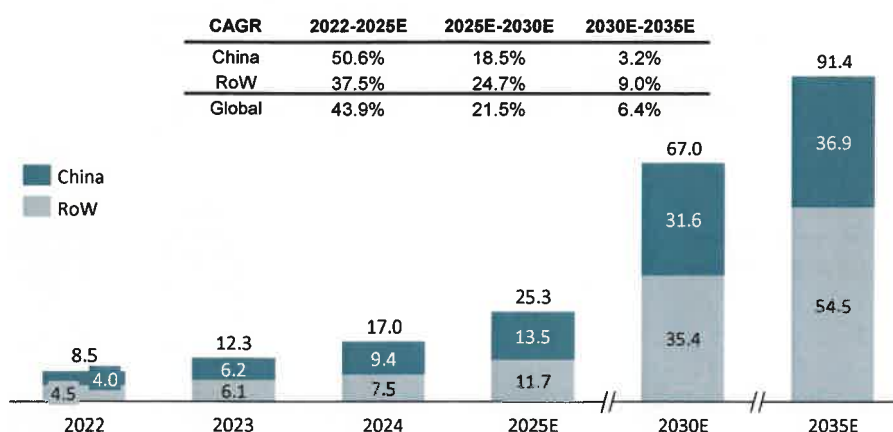
Key Challenges

- **Technical Limitations in Extreme Conditions:** Although high-speed freight scenarios are generally less complex than urban driving, robotruck operations remain challenged by extreme weather (e.g., heavy snow, strong winds) and unpredictable road conditions that complicate decision-making.
- **Commercialization Barriers:** High modification costs and an underdeveloped revenue model limit current profitability. Achieving economies of scale through expanded deployment is necessary to enhance commercial viability.

Overview of China and Global Licensing and Application Market

China and Global Market Size of Licensing and Application (2024 update)

China and Global Market Size of Licensing and Application
(US\$ in billions)



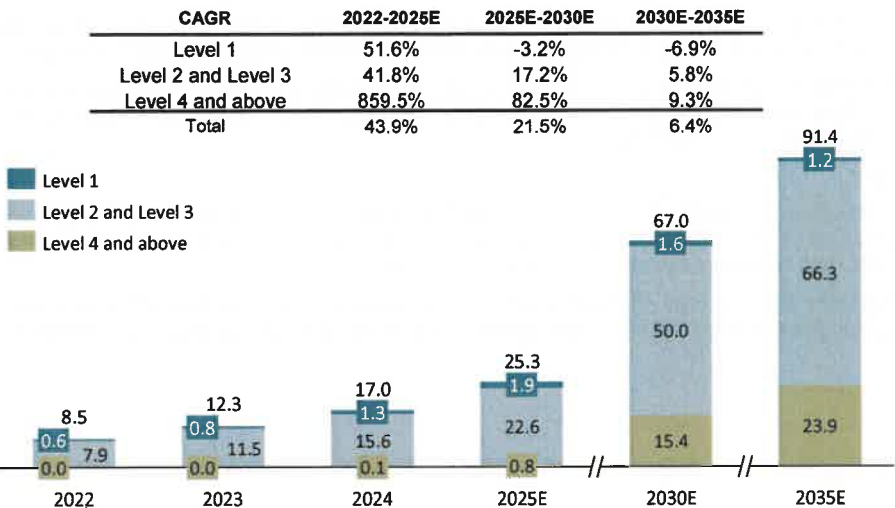
Note:

Source: International Organization of Motor Vehicle Manufacturers (OICA), China Association of Automobile Manufacturers (CAAM), National Bureau of Statistics of China (NBS)

Overview of China and Global Licensing and Application Market

Global Market Size of Licensing and Application (2024 update)

Global Market Size of Licensing and Application, Breakdown by Level of Autonomous Driving (US\$ in billions)

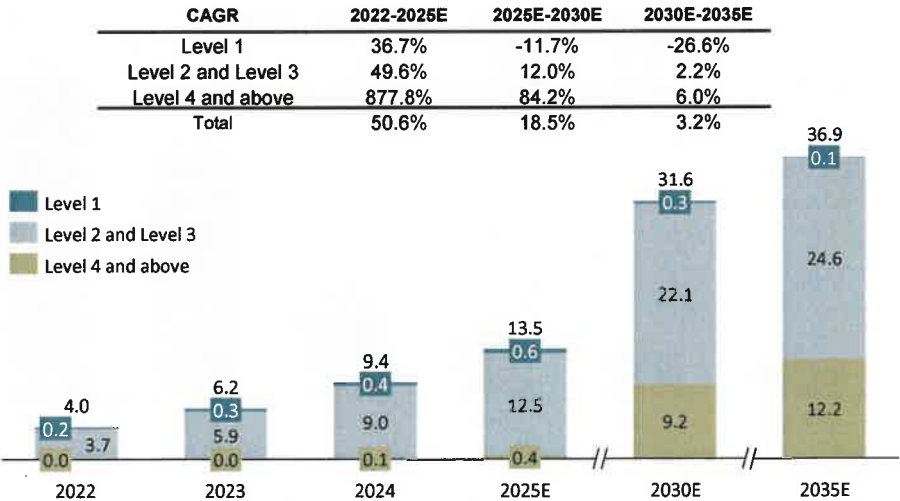


Source: Public news and government statistics; annual reports of listed companies

Overview of China and Global Licensing and Application Market

China Licensing and Application Market Size (2024 update)

China Market Size of Licensing and Application, Breakdown by Level of Autonomous Driving (US\$ in billions)



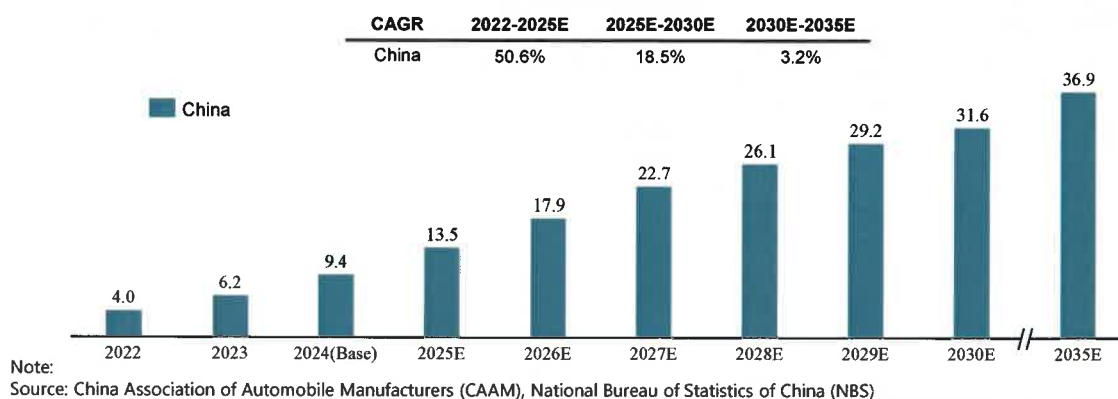
Source: Public news and government statistics; annual reports of listed companies

Overview of China and Global Licensing and Application Market

China Licensing and Application Market Size (2024 update)

- The licensing and applications market covers all levels from Level1 to Level5.
- In 2024, China licensing and application market size for Level4 and above domain controllers is \$13.7 million. the market share of the Level 4 and above domain controller market in the wider licensing and application market is 0.15% in China. Although L4 and above domain controller market account for only a small share of that market, their importance far outweighs their percentage. Owing to their high technical complexity, L4 and above domain controllers serve as the core hardware platform for L4 and above autonomous driving, and their maturity directly determines the commercialization timeline of high-level autonomous driving technology.

China Market Size of Licensing and Applications
(US\$ in billions)



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Competitive Landscape of Licensing and Application Market

Competitive Landscape of Licensing and Application Market in China

- For the Level1 to Level5 licensing and applications market, the leading players include: Desay SV (德赛西威), Bosch (博世), Joyson Electronics (均胜电子), Huawei (华为), Neusoft (东软集团), HiRain Technologies (恒润科技), iMotion (知行科技), In-Driving (创时智驾), Hongjing Technology (宏景智驾), Freetech (福瑞泰克).
- For the Level4 and above level licensing and applications market, in 2024, the market size for L4 and above domain controllers was \$13.7 million. And the leading players include: Pony AI, TZTEK (天准科技) and Miivii (米文动力).

Competitive landscape of China L4 and above level autonomous driving domain controller Market with ranking and market share in terms of revenue:

Ranking	Company	Market Share, Revenue in 2024, %
1	Pony AI	64.3%
2	TZTEK (Company T)	1.3%
3	Miivii (Company M)	1.0%

Note:

- (1) Company T is machine vision equipment platform company focusing on industrial intelligent equipment, founded in 2005 and headquartered in Suzhou, China, and listed on the SSE STAR Market.
- (2) Company M is an intelligent computing solutions provider for applications in robotics, industrial vision, and autonomous vehicles, founded in 2015 and headquartered in Beijing, China.

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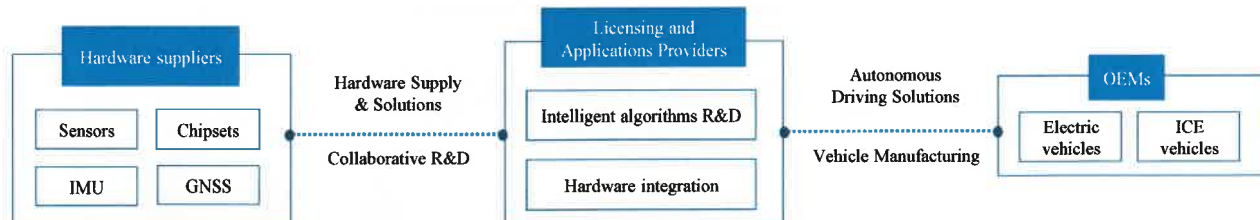
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Overview of China and Global Licensing and Application Market

Value chain of Licensing and Application Market

The following flowchart illustrates the respective roles of all stakeholders (including the Company) along the licensing and application services value chain:

- **Hardware Suppliers:** Autonomous driving solution providers collaborate with chip and sensor manufacturers through joint R&D efforts to co-develop advanced autonomous driving technologies.
- **OEMs:** Autonomous driving solution providers provide comprehensive autonomous driving solutions that support system integration and application across multiple vehicle platforms.



Overview of China and Global Licensing and Application Market

Threats and challenges of Licensing and Application Market

Threats and Challenges

The intelligent driving domain controller segment, critical to the advancement of higher-level autonomous systems, is subject to substantial technical and market-related pressures that impact development and deployment.

Key Threats

- **Stringent R&D Requirements:** The domain controller market, particularly for Level 4 systems, is highly technology-intensive. It demands strong R&D capabilities, rapid iteration, and stable, highly skilled engineering teams to meet evolving performance requirements.

Key Challenges

- **Scenario Handling Limitations:** Although domain controllers can now interpret and respond to most routine driving scenarios through AI models, perception and decision-making challenges remain in extremely complex or unfamiliar conditions.
- **Incomplete Domestic Substitution:** High-performance chips, as the core computational units in domain controllers, remain dominated by international brands. While domestic alternatives have made progress, gaps in performance and market penetration still exist, requiring further technological advancement and adoption.

Appendix

1. In year 2023, long-haul trucking accounted for 70% of China's road freight market.
2. In year 2021, China has the longest network of highways and the largest size of heavy-duty truck fleet.
3. In 2023, the average age of Chinese truck drivers was around 40 years old. Driver under 30 years old accounted for about 7%, while those born in the 1970s were gradually retiring. This has led to a serious "age gap" in the industry. The reasons for this include the long and difficult process of obtaining a truck driver's license, the health issues associated with long hours of driving in long-haul freight, unstable wages, and the fact that some logistics companies engage in malicious wage arrears, wage deductions, and failure to pay social security. As a result, young people are more inclined to choose other professions.
4. There are no non-China-based companies among the players in China's robotaxi market. And the major China-based autonomous driving companies mainly include Baidu Apollo, WeRide, DiDi Autonomous Driving.
5. Since year 2023, the production capacity of global automotive-grade chips has gradually recovered, with new production capacity driving a shorter average delivery cycle, increased inventory, and a gradual improvement in supply. In terms of supply-demand coordination, major automotive-grade chip manufacturers such as Nvidia have established stable cooperation with autonomous driving and new energy vehicle companies, fostering the technological development and supply-demand balance of automotive-grade chips. Therefore, the risk of the shortage of automotive-grade chips in the global market is relatively low in the short term.
6. According to public information, the company remains the only autonomous driving technology company to have obtained all regulatory permits available at the latest practicable date.
7. Automated Driving Classification for Vehicles (GB/T 40429-2021) in the PRC is consistent with the SAE levels (J3016_202104) in terms of definition and scope of automated driving levels.
8. Pony AI is the first in China to receive approval for driverless robotruck platooning tests on cross-provincial high-ways in December 2024.

Appendix

1. Limited conditions denote the limited conditions and environments where autonomous driving are available to operate, such as traffic jam chauffeur in Level 3 and local driverless taxi in Level 4.
2. The difference between Level 3 and Level 4 is that drivers must drive when the requested conditions of automated driving are not met in Level 3, when the automated driving features will not require drivers to take over driving in Level 4.
3. As confirmed by industry researches, the insurance coverage of company is in line with market practice.
4. The official definitions of each level of autonomous driving is as following:
 - Level 0 denotes the driving automation system limited to provide warnings and momentary assistance, including automatic emergency braking, blind spot warning and lane departure warning.
 - Level 1 denotes the driving automation system providing steering or brake/acceleration support to the driver, including lane centering or adaptive cruise control.
 - Level 2 denotes the driving automation system providing steering and brake/acceleration support to the driver, including lane centering and adaptive cruise control at the same time.
 - Level 3 and Level 4 denote the driving automation system which can drive the vehicle under limited conditions and will not operate unless all required conditions are met, including traffic jam chauffeur in Level 3 and local driverless taxi in Level 4.
 - Level 5 denotes the driving automation system which can drive vehicle under all conditions everywhere in all conditions.
5. Supportive regulatory developments are propelling the commercialization of driverless vehicles well beyond the initial stages of road testing. In November 2021, Beijing became the first city in China to launch a commercial pilot program for robotaxis, with an official policy allowing operators to charge the public for autonomous ride services. In December 2022, the Ministry of Industry and Information Technology (MIT) issued a notice encouraging the deployment of driverless vehicles with mass production capabilities for pilot projects. This initiative aims to facilitate the establishment and refinement of regulatory frame works governing the production and road safety of autonomous vehicles.
6. Pony AI is among the selected few (no more than four) companies in China permitted to operate fare-charging robotaxis during rush hours.

Appendix

1. Pony AI were among the first in China to secure licenses for fully driverless robotaxi operations in designated areas of all four Tier-I cities and remain the only autonomous driving technology company to have obtained all regulatory permits available and required to provide public-facing robotaxi services in these cities: where our peers currently have not yet obtained all such permits in these cities.
2. Pony AI's autonomous driving technology is integrated with the largest number of vehicle models in China, which amounted to seven as of December 31, 2024 as compared to six for their major competitors as of the same date.
3. Pony AI were among the first in building an "asset light" model that has the potential to rapidly expand its robotaxi fleet size by fostering a network of third-party fleet operators.
4. Pony AI has established in-depth collaboration and mass production arrangements with multiple global and Chinese OEMs, while our peers have not had any mass production arrangements with global and Chinese OEMs.
5. The market size of robotaxi services in China is expected to embrace an exponential growth at a CAGR of 314.1% to US\$20.9 billion by 2029, and the market size of robotaxi services for the rest of the world is expected to grow at a CAGR of 267.24% to US\$12.4 billion by 2029. market size of robotruck services in China is expected to grow at a CAGR of 49.6% to US\$0.8 billion by 2029, and the market size of robotruck services for the rest of the world is expected to grow at a CAGR of 78.4% to US\$1.0 billion by 2029.
6. The average daily orders received per full-time online ride-hailing vehicle reached over 20 and average daily orders received per taxi reached approximately 25 in Tier-1 cities in 2024.
7. BOM costs are mainly comprised of approximately one-third of autonomous driving computation ("ADC"), approximately one-third of LiDAR, and the rest of other sensors and hardware. The next generation of ADK could achieve approximately 30% of cost reduction mainly driven by the upgraded automotive-grade ADC due to uplifted popularity and shift to adopt domestic ADC, unit cost reduction in LiDAR due to expansion and mass production of domestic LiDAR products, and overall optimization in cost due to enhanced integration of different ADK components. And, BOM costs for robotruck will further reduce in the long term mainly driven by the cost optimization of ADC and LiDAR.
8. Only companies with the ability to maintain long-term and stable funding for research and development can maintain the competitive edge in the industry.

Appendix

1. Extreme weather conditions such as strong winds and heavy snow, as well as sudden changes in road conditions, can make difficult for robotrucks under high-speed driving decision-making more autonomous transportation scenarios.
2. Pony AI were also among the first to offer fully driverless fare-charging, public-facing robotaxi services, delivering safety benefits and a satisfactory passenger experience.
3. Customer adoption driven by cost efficiency. Customer adoption of tucking logistics services is primarily driven by the compelling cost-efficiency and operational advantages offered by service providers, rather than any over-reliance on a particular commercial relationship. In the tucking logistics sector-particularly in standardized long-haul freight operations-price remains a critical factor influencing customer decisions. Autonomous driving technologies offer a significant competitive edge by reducing logistics costs. For example, in long-distance transport scenarios, autonomous trucks can optimize energy consumption through algorithmic control, mitigating inefficiencies caused by human driving behavior and thereby lowering fuel and energy expenses. Furthermore, Level 4 autonomous trucks support innovative models such as one-driver-led platooning, where a single human driver leads multiple Level 4 trucks in a convoy.
4. With respect to the licensing and application markets in China, such services generally refer to autonomous driving solution providers licensing a suite of comprehensive technical solutions and supporting service to OEMs.
5. By 2030 and 2035, domain controllers are expected to account for approximately 70% of the total market, reflecting their increasing importance in enabling high-level autonomous driving functionalities.

Appendix

1. Level 0 to Level 2+ solutions known as driving assistance solutions which has entered into mass-produced stage and has been large-scaled delivered to OEMs for integration into vehicle models available for sale. On the other hands, Level 3 to Level 5 solutions, are currently in the stages of road trial and designated area application.
2. The difference between Level 3 and Level 4 is that drivers must drive when the requested conditions of automated driving are not met in Level 3, when the automated driving features will not require drivers to take over driving in Level 4.
3. The official definitions of each level of autonomous driving: Level 0 denotes the driving automation system limited warnings and momentary assistance, mainly achieving basic warning functions such as LDW(Lane Departure Warning) and FCW(Forward Collision Warning). Level 1 denotes the driving automation system continuously performing either lateral or longitudinal vehicle control tasks, such as ACC(Adaptive Cruise Control) or LKA(Lane Keeping Assist). Level 2 denotes the driving automation system that simultaneously performs both lateral and longitudinal vehicle control tasks, like combining ACC and LKA, but require constant driver supervision and intervention when necessary. Level 3 and Level 4 denote the driving automation system which can drive the vehicle under limited conditions and will not operate unless all required conditions are met, including traffic jam chauffeur operated by system autonomously in Level 3 and local driverless taxi in Level 4. Level 5 denotes the driving automation system which can drive vehicle under all conditions everywhere in all conditions.
4. In the current early stage of robotaxi commercialization, MAU is constrained by the limited fleet availability and may exhibit significant volatility, making it rarely adopted as a performance metric in the industry.
5. Improvements in logistics infrastructure and advancements in freight platform technologies, coupled with intensified competition within the logistics industry, have led to an overall decline in freight transportation prices.
6. Level 2+ is a term used in the autonomous driving industry to describe system that requires constant human supervision and can offer functions surpassing Level 2 but not fully reaching Level 3, such as highway and urban NOA, while it is not officially defined under relevant industry standards.
7. As of July 2025, the global semiconductor chip supply had returned to normal levels. And the risk of a global shortage of automotive-grade chips in the short term to be relatively low, according to Frost & Sullivan.

Appendix

1. While Sinotrans is widely recognized for its extensive network and strong capabilities in ocean freight, it historically lacked comparable strength in ground transportation, particularly in meeting the growing demand for efficient “hub-to-hub” freight movement.
2. Customer adoption of trucking logistics services is primarily driven by the compelling cost-efficiency and operational advantages offered by service providers, rather than any over-reliance on a particular commercial relationship.
3. In particular, the China robotruck services market is estimated to reach US\$13.4 billion by 2030 due to the increasing demand and technical maturity.
4. Customer satisfaction in robotaxi ride-hailing services depends on numerous intangible factors - including ride comfort, vehicle model, UI/UX of the app, traffic conditions, and even novelty perception - which vary widely across users and cities.
5. Engaging licensed third-party mapping providers is a standard and effective industry practice for robotaxi companies, particularly in jurisdictions like China where mapping activities are subject to strict licensing and approval regimes.
6. Compared with other well-known domestic companies, the volume of negative management-related reviews of Pony AI on such social media is relatively low: in particular, there are virtually no negative comments directed at senior management or specific managers.
7. In 2024, Pony AI became the largest provider of Level 4 autonomous driving solutions by revenue among China-based publicly listed companies, while achieving the lowest net loss.

Agenda

1	Introduction of the Research
2	Overview of Autonomous Driving
3	Overview of Global Robotaxi Market
4	Overview of Global Robotruck Market
5	Overview of Autonomous Driving Licensing Market
6	Competitive Landscape of Robotaxi and Robotruck Market
7	Appendix

Scope

■ The project scope is defined as follows:

Research Period	• Historical Year: 2022 • Base Year: 2023 • Forecast Year: 2024E-2025E, 2030E, 2035E
Geographic Scope	• Global • China
Industry Scope	• Global Robotaxi Market • Global Robotruck Market • Global Autonomous Driving Licensing Market

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China

Technological innovations of Pony AI

- The Company is at the forefront of utilizing the world model methodology to train its autonomous driving system. The world model approach has enabled the Company to attain the safest driving records among autonomous vehicle operators in China, leading to accelerated commercialization.
- The Company pioneered the application of game theory to model and analyze interactions between autonomous vehicles and other road agents, such as pedestrians and cyclists, enabling vehicles to determine optimal decisions that minimize conflicts, improve safety, and enhance efficiency
- The Company is the world's first and only autonomous driving technology company to develop autonomous vehicles with automotive-grade, factory-installed sensors and hardware (including LiDAR and SoC-chip) seamlessly integrated.
- The Company is the first in the world to develop an autonomous computing unit for its vehicle model based on NVIDIA DRIVE Orin, an automotive-grade processor specifically designed for high-performance and scalable autonomous vehicle computing.
- The Company is a pioneer in adopting an end-to-end (E2E) approach to develop its autonomous driving solutions.

Competitive Landscape of Robotaxi and Robotruck Market

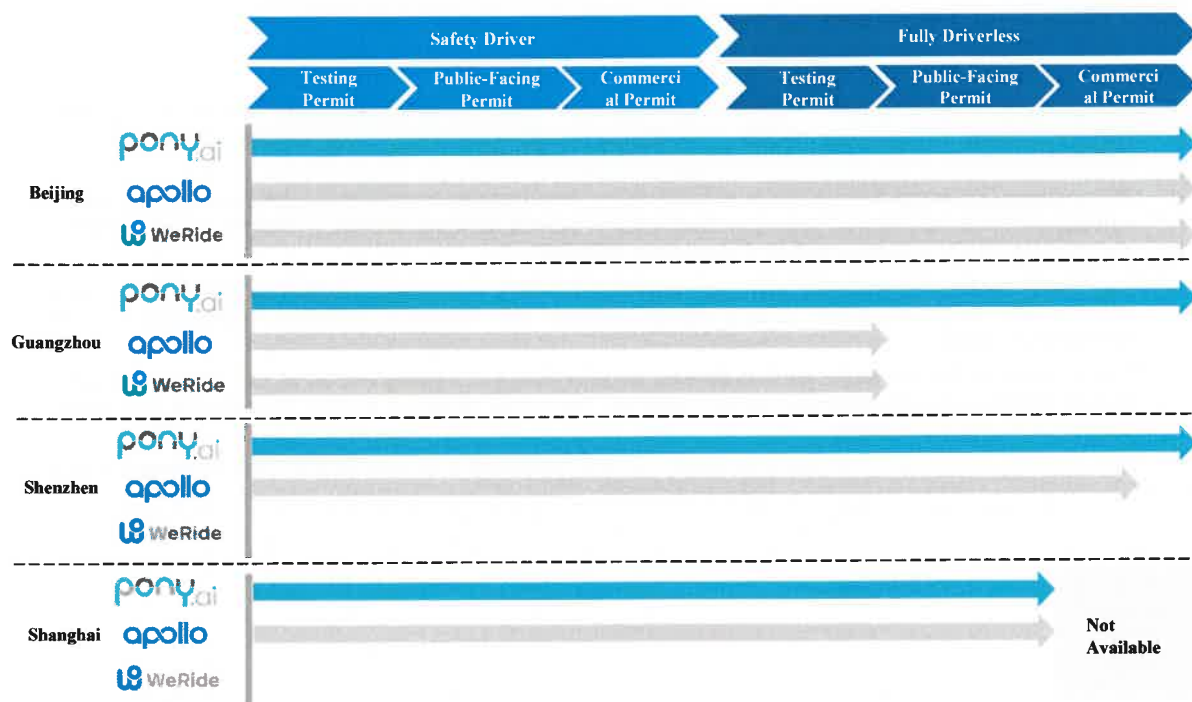
Competitive Landscape of Robotaxi Market in China

Permits highlights of Pony AI

- The Company is among the first in China to secure licenses for fully driverless robotaxi operations across all four Tier-1 cities and remains the only autonomous driving technology company to have obtained all regulatory permits available and required to provide public-facing robotaxi services in these cities. Additionally, the Company has obtained all 23 permits whereas Apollo and WeRide, two of the Company's major competitors within the industry, each obtained 21 and 10 permits, respectively.
- Pony AI is the only autonomous driving technology company to have obtained all types of robotaxi permits available across the four Tier-1 cities in China (As of December 31, 2024, fully driverless public-facing fare-charging robotaxi permit is not available in Shanghai).
- With 23 regulatory permits obtained across Tier-1 cities in China, the Company holds the largest number of robotaxi permits among its peers.
- In December 2020, the Company became the first to obtain the robotruck road testing permit in Guangzhou.
- In January 2024, the Company received the very first cross-provincial robotruck road demonstration application permit in China, and began testing on the highway freight network across the Beijing-Tianjin-Hebei region.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China



Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China

Commercial highlights of Pony AI

- The Company is the first autonomous driving technology company to launch robotaxi services in China.
- The Company has grown to become the largest robotaxi operator in Tier-1 cities in terms of fleet size.
- The Company has established China's largest network of TNC partners.
- As a pioneer of the robotaxi model, the Company is the only autonomous driving technology company with in-depth collaboration and mass production arrangements with multiple global and Chinese OEMs.
- The Company's autonomous driving technology is integrated with the largest number of vehicle models in China, underscoring its leadership in the industry.
- The Company was among the first in building an "asset-light" model that has the potential to rapidly expand its robotaxi fleet size by fostering a network of third-party fleet operators.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China

Commercial highlights of Pony AI

	Pony AI	Apollo	WeRide
Time of launching robotaxi services in China	2018	2019	2019
Number of Tier-1 cities where it operates robotaxi	4 (Beijing, Shanghai, Guangzhou, Shenzhen)	4 (Beijing, Shanghai, Guangzhou, Shenzhen)	2 (Beijing, Guangzhou)
Number of robotaxi vehicle models compatible with the autonomous driving technology	7	6	6
Number of robotaxi TNC partners in China	6	5	4
Form of collaborations	In-depth collaboration: formed joint ventures with Sinotrans and Toyota.	Mostly collaboration by modules, where partners provide products or solutions.	Mostly collaboration by modules, where partners provide products or solutions.

Note: As of December 31, 2024.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China

- In China, leading autonomous driving technology companies have been actively expanding their robotaxi business in recent years, with robotaxi services already being commercially implemented in four Tier-1 cities and certain Tier-2 cities. Key indicators including fleet size, regulatory permits and ecosystem cooperation are crucial for gaining a competitive edge in the robotaxi services market. The comparison between the company and its peers is summarized as follows:

	Pony	Company B ⁽¹⁾	Company W ⁽²⁾
Fleet size of robotaxi in four Tier-1 cities in China ⁽³⁾	270	<200	<150
Number of robotaxi permits obtained in Tier-1 cities in China ⁽³⁾	23	21	10
Number of Tier-1 cities in China where fully driverless public-facing fare-charging robotaxi permits were obtained ^{(3) (4)}	4 (Beijing, Guangzhou, Shenzhen, Shanghai)	3 (Beijing, Shenzhen, Shanghai)	1 (Beijing)
Number of robotaxi vehicle platforms compatible with the autonomous driving technology ⁽⁵⁾	7	6	6
Number of robotaxi TNC partners in China ⁽⁵⁾	6	5	4

Note:

(1) Company B is an AI company with a strong internet foundation, established in 2000 and headquartered in Beijing, China.

(2) Company W is a Level 4 autonomous driving company that develops a product mix of robotaxis, robobuses, robovans, and others, established in 2017 and headquartered in Guangzhou, China, and listed on NASDAQ.

(3) As of December 31, 2024. Under the current regulatory framework, each of the four Tier-1 cities in China issues two categories of robotaxi permits: one for robotaxis operating autonomously with a safety driver present, and another for fully driverless robotaxis. Within each category, there are three specific types of permits: testing permits, public-facing permits and fare-charging permits. Tier-1 cities usually grant robotaxi permits in stages, with each successive stage imposing stricter technical and operational requirements such as test mileage and disengagement rate. The initial permit is a testing permit which allows an autonomous driving technology company to test its autonomous vehicle within testing areas. Then the company could apply for public-facing permits that allow testing vehicles to carry passengers without charges. When reach the most advanced stage, an autonomous driving company could obtain a fare-charging permit which allows it to operate autonomous vehicles for commercial services (such as ride-hailing service). The Company is the only autonomous driving technology company to have obtained all types of robotaxi permits available across the four Tier-1 cities in China (As of December 31, 2024, fully driverless public-facing fare-charging robotaxi permit is not available in Shanghai).

(4) Fully driverless public-facing fare-charging robotaxi permits are by far the most comprehensive, advanced and stringent permits granted by regulatory authorities of Tier-1 cities in China. Such permits allow companies to operate fully driverless autonomous vehicles as part of a commercial service. The Company remains the only autonomous driving technology company to have obtained all regulatory permits available to provide fully driverless public-facing fare-charging robotaxi services in Tier-1 cities (As of December 31, 2024, fully driverless public-facing fare-charging robotaxi permit is not available in Shanghai).

(5) As of December 31, 2024.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China

- Among all China-based publicly listed autonomous driving companies, the Company is the largest provider of Level 4 autonomous driving solutions by revenue in 2023 and in the nine months ended September 30, 2024.
- Pony AI, Apollo, and WeRide are the major players in China's Level 4 autonomous driving solution industry, each of which has pursued different business strategies. Pony AI focuses on providing robotaxi services in Tier-1 cities, including Beijing, Shanghai, Guangzhou, and Shenzhen. Apollo mainly provides robotaxi services in Tier-2 cities, with its focus in Wuhan, Hubei. WeRide has developed a diverse portfolio of autonomous driving vehicles, including robotaxi, robobus, robovan, and robosweeper, yet WeRide has generated relatively small amount of revenue from offering of robotaxi rides through its car-hailing app WeRide Go.
- The fierce competition in the robotaxi industry goes hand in hand with the promising growth of addressable markets in China. China is expected to become the largest market for robotaxi services, with an estimated market size by GTV of **US\$0.16 billion** in 2025 and **US\$39.0 billion** in 2030, respectively, accounting for approximately 58.5% of the global robotaxi services market in 2030.

	Pony AI	WeRide
Total revenue in 2023 (US\$ in thousands)	71,899	55,296
Total revenue in the nine months ended September 30, 2024 (US\$ in thousands)	39,509	31,394

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China - 2024 Guangzhou Intelligent Connected Vehicle Innovation and Practice Report

	Pony	Company B	Company W
Accumulative testing mileage (ten thousand km) ^{(1) (2)}	122.17	166.98	23.63
Accumulative autonomous driving testing mileage (ten thousand km) ^{(3) (2)}	121.48	156.50	23.62
Proportion of autonomous driving (%) ^{(1) (4)}	99.44%	93.72%	99.94%
Accumulative operating mileage (ten thousand km) ^{(1) (5)}	121.77	_(6)	_(6)
Total mileage (ten thousand km) ^{(1) (7)}	243.94	166.98	23.63
KMPI (kilometers) ⁽⁸⁾	1,451.28	<150	812.31
Number of approved vehicle models for demonstration operation ^{(1) (9)}	6	0	0

Note:

- (1) Source: 2024 Guangzhou Intelligent Connected Vehicle Innovation and Practice Report. Regulatory authorities of other Tier-1 cities did not publicly disclose such testing data and report.
- (2) Accumulative testing mileage refers to accumulative testing mileage completed by participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2024.
- (3) Accumulative autonomous driving testing mileage refers to accumulative autonomous driving testing mileage completed by participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2024.
- (4) Proportion of autonomous driving is calculated by dividing accumulative autonomous driving testing mileage by accumulative testing mileage.
- (5) Accumulative operating mileage refers to accumulative operating mileage completed by participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2024.
- (6) As of December 31, 2024, Company B and Company W have not yet launched public-facing operation in Guangzhou.
- (7) Total mileage refers to the sum of accumulative testing mileage and accumulative operating mileage.
- (8) KMPi refers to the number of kilometers an autonomous vehicle can travel before disengagement/intervention completed by participant companies' Level 4 autonomous driving fleet in general third-level testing roads in Guangzhou, China in 2024.
- (9) As of December 31, 2024, Guangzhou had cumulatively approved eight vehicle models for demonstration operation, among which six vehicle models belong to Pony AI.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi Market in China - 2022 Guangzhou Intelligent Connected Vehicle Road Testing and Demonstration Application Report

- In China, a number of cities are now conducting road tests and trial operations of robotaxis, with Beijing, Shanghai, Guangzhou, and Shenzhen currently leading in policy and commercial exploration. Guangzhou local government is highly committed to the commercialization of robotaxi, making it a hub for numerous top-tier companies in the industry. Guangzhou began issuing road testing licenses for robotaxis in 2019 and has opened 433 testing roads, covering six administrative regions, with a cumulative testing mileage of over 9.6 million kilometers as of the end of 2022. In 2022, Guangzhou officially started to grant licenses for operating robotaxi services. This landmark decision marks a significant milestone for China's burgeoning robotaxi industry as it marks the transition from testing phase to commercial operation phase.
- Built upon its continued efforts to develop and commercialize autonomous driving technology, the local government in Guangzhou released the 2022 Guangzhou Intelligent Connected Vehicle Road Testing and Demonstration Application Report, which exhibited the testing results and operational data of autonomous passenger vehicles tested in Guangzhou by a number of autonomous driving companies as summarized below:

	Pony	Company B	Company W
Accumulative testing mileage ⁽⁶⁾ (ten thousand km)	278.03	232.14	27.01
Average testing speed ⁽⁷⁾ (km/h)	38.44	24.29	11.44
Kilometers per disengagement/intervention ⁽⁸⁾ (KMPI)	100%	<18%	93%

Note:

(6) Accumulative testing mileage refers to accumulative testing mileage completed by participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2022.

(7) Average testing speed refers to the average autonomous driving speed of participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2022.

(8) Kilometers per disengagement/intervention (KMPI) refers to the number of kilometers an autonomous vehicle can travel before disengagement/intervention completed by participant companies' Level 4 autonomous driving fleet in Guangzhou, China in 2022. Pony's KMPI is considered as 100%, serving as a benchmark for representing KMPI of other peers.

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotaxi and Robotruck Companies

- Pony.ai has robust and continuously advancing R&D capabilities regarding robotaxi and robotruck. The following table sets forth Pony.ai's R&D expenses to revenue ratio and the number of registered patents against those of its peers.

	Pony AI	Weride ⁽²⁾	Apollo ⁽⁴⁾
R&D expenses to revenue ratio (January 1, 2023 to December 31, 2023)	1.71	2.63	-
R&D expenses to revenue ratio (January 1, 2024 to June 30, 2024)	2.38	3.44	-
Number of registered patents	Total 636: 317 registered patents in China and 191 registered patents overseas, 128 pending patents in China and overseas ⁽¹⁾	Total 1031: 420 issued patents and 611 pending patent applications globally ⁽³⁾	Over 5,000 ⁽⁵⁾

Note:

(1) As of December 31, 2024.

(2) Source: SEC filings.

(3) As of June 30, 2024.

(4) Source: public information

(5) As of December 31, 2024.

Source: Frost & Sullivan

Competitive Landscape of Robotruck Market

Competitive Landscape of Robotruck Market

- The competitive landscape is less clear for robotruck service, primarily due to limited publicly available information and differentiated commercialization strategies, according to Frost & Sullivan. Specifically, the robotruck industry is still at relatively early stage of developments and industry participants have disclosed limited information about their operation to the public. In addition, the industry has not developed a unified set of benchmark to evaluate the performance of each robotruck provider. The commercialization strategies also vary among major players.
- Market player's commercial operations of robotrucks largely relied on their partners in the logistics industry and their scales remained relatively limited. As a result, it is difficult to develop objective and comparable metrics to compare the participants with different business models in this industry segment. Finally, the policies and regulations on robotruck are evolving constantly. Some robotruck providers have temporarily paused their robotruck service and shifted their focus to different autonomous vehicle sector, making it difficult to assess the full competitive landscape.
- Leveraging its core Virtual Driver technology, Pony.ai launched hub-to-hub autonomous freight solutions in March 2021 to address significant opportunities in China's truck freight market. To date, Pony.ai operates a fleet of over 190 robotrucks, both independently and in collaboration with Sinotrans, China's largest freight logistics company according to CIFA.

Source: Frost & Sullivan

FROST & SULLIVAN

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Overview of Global Autonomous Driving Market

Barriers to Entry the Autonomous Driving Industries (1/2)

- **The autonomous driving industry is a transformative sector that is redefining traditional transportation. Entering the autonomous driving industry, particularly in segments such as robotaxi, robotruck, and licensing and applications, presents several significant barriers. These challenges stem from technological, regulatory, operational, and commercial complexities, which collectively create a high threshold for new entrants. Below are the key barriers:**

 Substantial R&D Investment Driven by Advanced Technology Requirements.

The autonomous driving industry is highly technology-intensive, requiring massive upfront investment in research and development (R&D). Developing a reliable autonomous driving system demands continuous innovation, particularly in ensuring safety and addressing complex real-world driving scenarios because ensuring safety is a complex challenge due to the myriad of corner cases, such as unusual scenarios and unexpected obstacles. Leading companies must accumulate vast amounts of real-world road-testing data and conduct extensive simulations to identify and resolve edge cases, thereby validating and improving the capabilities of autonomous systems. This process is both time-consuming and costly, creating a significant barrier for new players who lack the resources or technological expertise to compete with established leaders.

 Regulatory Permits for Operations and Commercialization.

Operating autonomous vehicles legally and responsibly worldwide, particularly in China, requires obtaining regulatory approval, which is essential for both road testing and facilitating the commercialization of driverless vehicles. Regulatory approval is contingent upon demonstrating compliance with stringent safety and operational standards. For example, in November 2021, Beijing became the first city in China to launch a commercial pilot program for robotaxis, allowing operators to charge the public for autonomous mobility services, but only after operators met rigorous requirements. Navigating the complex regulatory landscape and securing permits can be a lengthy and resource-intensive process, further raising the entry barrier for new entrants.

Source: Frost & Sullivan

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Overview of Global Autonomous Driving Market

Barriers to Entry the Autonomous Driving Industries (2/2)

- The autonomous driving industry is a transformative sector that is redefining traditional transportation. Entering the autonomous driving industry, particularly in segments such as robotaxi, robotruck, and licensing and applications, presents several significant barriers. These challenges stem from technological, regulatory, operational, and commercial complexities, which collectively create a high threshold for new entrants. Below are the key barriers:

⊙ **Challenges in Large-Scale Deployment and Mass Production.**

Scaling autonomous driving solutions from prototypes to large-scale deployment is another formidable challenge. Leading companies have already made strides in pre-installed solutions and mass-production capabilities, offering significant cost advantages and production efficiencies. Achieving mass-production requires not only advanced manufacturing capabilities but also the ability to validate and refine autonomous systems at scale, which involves extensive testing, supply chain optimization, and partnerships with automotive manufacturers. For new entrants, the lack of experience and resources to scale production and deployment poses a significant challenge, further solidifying the dominance of established players.

⊙ **Developing a Viable Commercialization Roadmap and Profitability Plan.**

Developing a viable commercialization roadmap is crucial for sustained growth in the autonomous driving industry. Companies must identify and establish clear revenue streams and business models, whether through robotaxi services, autonomous trucking, or other mobility-as-a-service (MaaS) offerings. Achieving profitability in this capital-intensive industry requires not only technological innovation but also strategic partnerships, efficient operations, and the ability to adapt to market demands. For instance, robotaxi operators must balance high operational costs with competitive pricing to attract users, while autonomous trucking companies need to demonstrate cost savings and efficiency gains to win over logistics providers. New entrants often struggle to establish a clear path to profitability, making this another significant barrier to entry in the autonomous driving sector.

Source: Frost & Sullivan

Appendix

1. According to Frost & Sullivan, it is uncommon for autonomous driving companies to publish the absolute value of KMPCI.
2. The Company operates the safest autonomous vehicles in China, measured by industry-leading metrics including Kilometers Per Disengagement / Intervention (KMPI).
3. According to Frost & Sullivan, our autonomous driving technology is integrated with the largest number of vehicle models in China, underscoring our leadership in the industry.
4. Pony's world model methodology strengthens its industry leadership in both technology development and commercialization.
5. Pony positioned itself at the forefront of the industry as a pioneer in implementing a world model methodology.
6. The efficacy of Pony's world-model-trained autonomous driving system is evidenced by the regulatory validations, along with the industry most comprehensive safety statistics, underscore its unquestioned leadership in technological innovation and capabilities.
7. Pony operates an innovative business model as the industry early mover and trendsetter in terms of both service and commercialization innovations. Operating in a groundbreaking sector with potential to revolutionize transportation, Pony is spearheading the development of Level 4 solutions.
8. Pony is implementing an innovative business model with the potential to revolutionize future mobility through disruptive transportation options.
9. Pony also outpaced its major competitors in China by introducing robotaxi to the market within the shortest period of time after inception.
10. Pony has established itself as the frontrunner in securing key regulatory permits to provide public-facing robotaxi services in China.
11. Pony has successfully established a viable and innovative business model.

Appendix

12. The autonomous driving industry is highly competitive. Pony faces competition against a large number of both established competitors and new market entrants. If Pony is not able to compete effectively with others, its business, financial condition and results of operations may be materially and adversely affected.

13. In March 2025, Pony was among the first to launch fare-charging robotaxi service at a major railway hub in urban Beijing, connecting Beijing South Railway Station and Yizhuang, the southeast suburb of Beijing. As one of the first companies to receive approval to test autonomous vehicles on highways in Beijing.

14. In February 2025, Pony launched paid robotaxi services from multiple locations in Guangzhou city center to Guangzhou Baiyun International Airport and Guangzhou South Railway Station, becoming the first and only company approved to provide robotaxi services on these high-demand routes in Guangzhou.

15. Specifically, the successful development of our autonomous driving technologies involves many challenges and uncertainties, including:

achieving sufficiently safe autonomous driving performance and earning recognition from regulatory agencies, partners, users and the general public;

finalizing autonomous driving system design, specification, and vehicle integration;

successfully completing system testing, validation, and safety approvals;

obtaining additional approvals, licenses or certifications from regulatory agencies, if required, and maintaining current approvals, licenses and certifications;

building and maintaining business partnerships for R&D and commercialization activities;

complying with laws and regulations that constantly evolve, such as laws and regulations with respect to accidents and product liabilities;

preserving intellectual property rights; and

continuing to fund and maintain our technology development activities.

Appendix

16. Demands for the autonomous driving technology depend to a large extent on general, economic, political, and social conditions in a given market.

17. Despite the fact that the automotive industry has engaged in considerable effort to research and test Level 2 and Level 3 autonomous vehicles, technology targeting Level 4 autonomous vehicles requires significant investment and may never be commercially successful on a large scale, or at all.

18. Traditional carriers operating with human drivers are still the predominant operators in the market. Because of the long history of such traditional transportation companies serving the transportation market, there may be many constituencies in the market that would resist a shift towards autonomous transport, which could include lobbying and marketing campaigns, particularly because Pony's technology will displace taxi and truck drivers. In addition, the market leaders in the automotive industry may start, or have already started, pursuing large-scale deployment of autonomous driving technology on their own. These companies may have more operational and financial resources than Pony does.

19. The industry in which Pony operates is subject to rapid technological changes and is evolving quickly with technological innovation.

20. The market for automotive industry in China is affected by general business and economic conditions, the global semiconductor chip shortage, and inflationary pressures.

21. Notably, Pony is among the selected few companies in China permitted to operate robotaxis during rush hours, underscoring its technological leadership and commercialization potential.

22. Leveraging Pony's strong partnerships with leading TNCs such as OnTime Mobility, Amap and Alipay, Pony was also among the first to offer fully driverless fare-charging, public-facing robotaxi services, delivering substantial safety benefits and a compelling passenger experience, according to Frost & Sullivan.

23. As China is one of the largest ride-hailing markets globally, these four Tier-1 cities present the greatest commercialization potential.

24. Pony has an early mover advantage that well positions it to further expand its market share in these existing markets and to penetrate into new markets.

Appendix

25. According to Frost & Sullivan, Pony is the world's first and only autonomous driving technology company to design and manufacture autonomous vehicles with automotive grade, factory-installed sensors and hardware (including LiDAR and SoC-chip) seamlessly integrated.
26. According to the report, Pony's autonomous vehicles have achieved the safest operational metrics in the industry, including leading KMPI (kilometers per disengagement/intervention) performance, significantly outpacing competitors and reaffirming its status as the safest and most advanced autonomous driving solution in China.
27. According to Frost & Sullivan, users' demands for mobility services during rush hours account for approximately 40% of the day, and taxi fare usually increases by 30% to 50% in inclement weather conditions.
28. These achievements solidify Pony's position as the only autonomous driving technology company to secure all available regulatory permits essential for providing public-facing robotaxi services in all four Tier-1 cities in China, according to Frost & Sullivan.
29. Empowered by Pony's strong partnerships with leading TNCs, such as OnTime Mobility, Amap and Alipay, Pony was among the first to offer fully driverless fare-charging, public-facing robotaxi services with substantial safety benefits and compelling passenger experience, according to Frost & Sullivan.
30. Pony's business and results of operations are affected by a number of general factors that impact its ability to capitalize on the growth of our total addressable market, including overall economic growth in China and globally, technological advancement, public perception towards its technology, geopolitical relations, regulatory oversight and competitive landscape within the industry.
31. Emile Weber is Luxembourg's leading mobility solutions provider.
32. Achieving mass-production requires advanced manufacturing capabilities and the ability to validate and refine autonomous systems at scale, which involves extensive testing, operational excellence, supply chain optimization, and partnerships with automotive manufacturers.
33. The deployment scale of robotaxi in China will continue to expand with both fully driverless robotaxi and safety-driver-enabled robotaxi operating together.

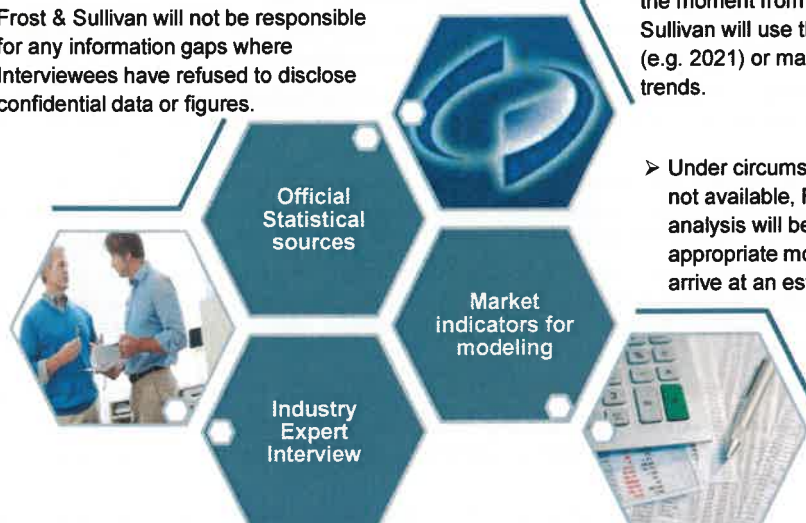
Appendix

34. It is projected that by 2035, robotaxis will consist a substantial portion of the overall fleet of shared passenger vehicles operating in China, thereby establishing China as the largest robotaxi services market and capture more than half of the global market share, according to Frost & Sullivan.
35. As of the end of 2024, Guangzhou has opened 1,298 testing roads, covering eight administrative regions, with a cumulative testing mileage of over 22.9 million kilometers.
36. Under the current regulatory framework, each of the four Tier-1 cities in China issues two categories of robotaxi permits: one for robotaxis operating autonomously with a safety driver present, and another for fully driverless robotaxis. Within each category, there are three specific types of permits: testing permits, public-facing permits and fare-charging permits. Tier-1 cities usually grant robotaxi permits in stages, with each successive stage imposing stricter technical and operational requirements such as test mileage and disengagement rate. The initial permit is a testing permit which allows an autonomous driving technology company to test its autonomous vehicle within testing areas. Then the company could apply for public-facing permits that allow testing vehicles to carry passengers without charges in all open road. When reach the most advanced stage, an autonomous driving company could obtain a fare-charging permit which allows it to operate autonomous vehicles for commercial services (such as ride-hailing service).

Limitations

■ Source of Information

- Interviews with industry experts and competitors will be conducted on a best-effort basis to collect information in aiding in-depth analysis for this report.
- Frost & Sullivan will not be responsible for any information gaps where interviewees have refused to disclose confidential data or figures.



- The study took 2022 as the base year and 2022E-2025E, 2030E, 2035E as the forecast period. However, as the point of this study being 2022, some of the figures of 2022 may not be available at the moment from public statistical sources. Frost & Sullivan will use the latest information available (e.g. 2021) or make projections based on historical trends.

- Under circumstances where information is not available, Frost & Sullivan in-house analysis will be leveraged using appropriate models and indicators to arrive at an estimate.

- Source of information will be stated in the right hand corner at the bottom on each slide for easy reference.

Agenda

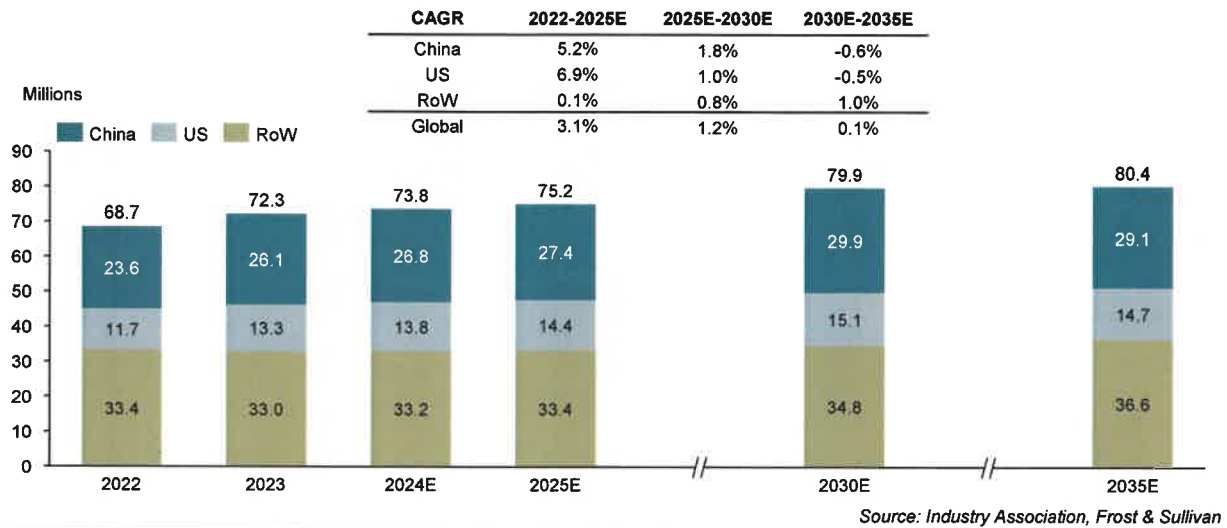
- 1** Introduction of the Research
- 2** Overview of Autonomous Driving
- 3** Overview of Global Robotaxi Market
- 4** Overview of Global Robotruck Market
- 5** Overview of Autonomous Driving Licensing Market
- 6** Competitive Landscape of Robotaxi and Robotruck Market
- 7** Appendix

Overview of Global Autonomous Driving Market

Global Passenger Vehicle Sales Volume, by Regions

- In 2023, the global sales volume of passenger vehicle reached 72.3 million units. China is the largest market with a sales volume of 26.1 million units in 2023, representing 36.1% of the global market. The US achieved a sales volume of 13.3 million units in 2023, representing 18.4% of the global market.
- The global passenger vehicle sales volume is expected to have a steady growth but with a slower rate. After 2030, global sales volume is expected to gradually reach the saturation point with a CAGR of 0.1% from 2030 to 2035.

Passenger Vehicle Sales Volume , Global, Breakdown by Regions



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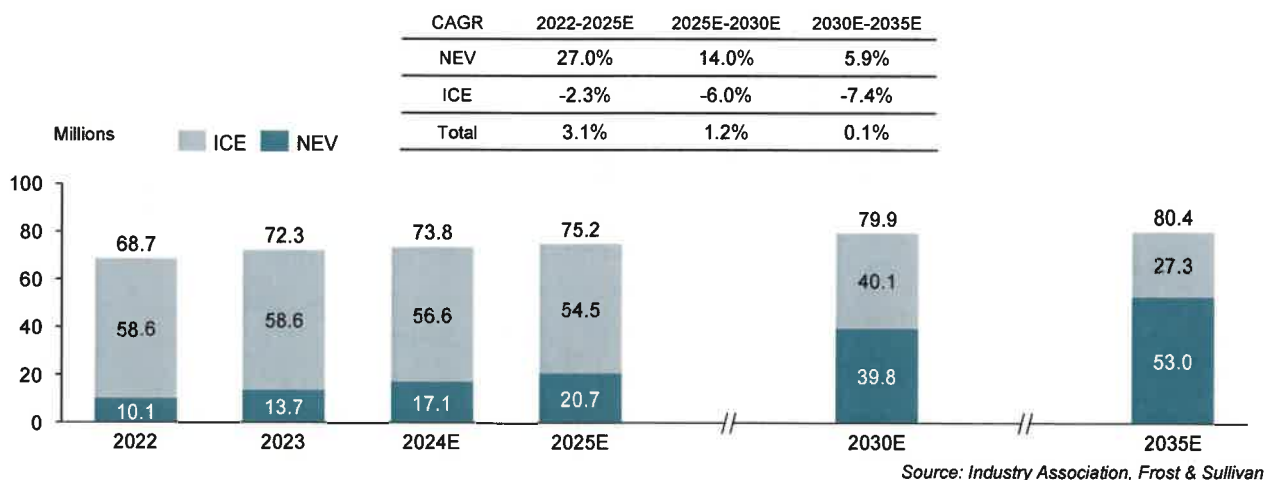
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Overview of Global and China Automotive Market

Global Passenger Vehicle Sales Volume, by Power Type

- ICE (Internal Combustion Engine) vehicles still account for the largest share in the global passenger vehicle market. The sales volume of ICE vehicles is expected to drop from 58.6 million in 2022 to 54.5 million in 2025, mainly caused by the rapidly increasing penetration of NEVs (New Energy Vehicle). It is forecasted that ICE vehicles sales volume will decrease at a CAGR of -6.0% from 2025 to 2030. By 2030, the sales volume of ICE vehicles is estimated to further decrease to 40.1 million units.
- The past several years have witnessed a growth of NEVs. The NEV segment is still estimated grow from 2022 to 2025 to at a CAGR of 27.0% and reach 39.8 million units by 2030, driven by increasing popularity and global carbon neutrality policy.

Global Passenger Vehicle Sales Volume, by Power Type



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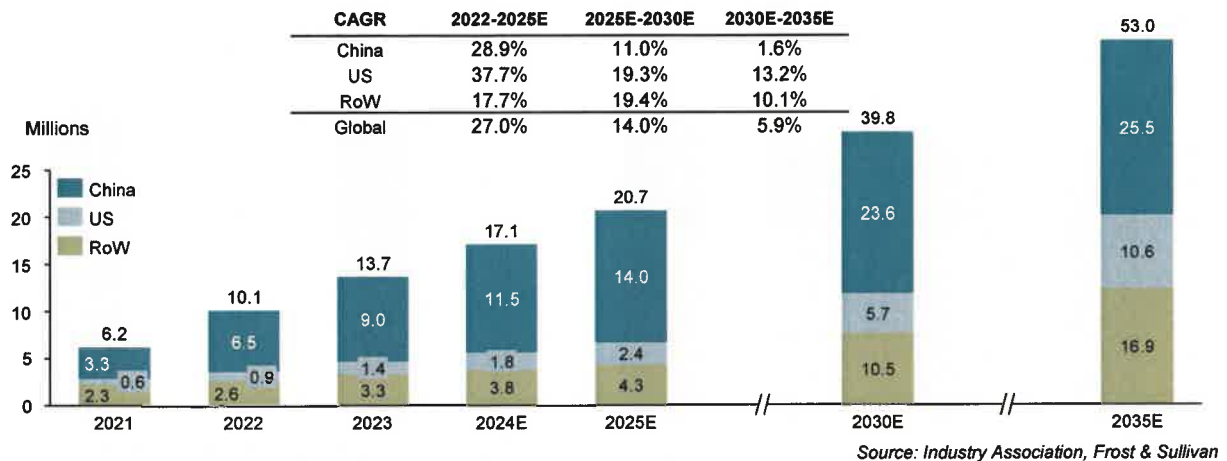
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Overview of Global Autonomous Driving Market

Global New Energy Passenger Vehicle Sales Volume

- Electrification have become the most notable trends in the global automobile industry. Global NEV sales are expected to grow at a CAGR of 27.0% from 2022 to 2025. The increasing momentum is estimated to continue in long term, and the global NEV sales volume rate is expected to reach 39.8 million by 2030 and 53.0 million by 2035.
- Due to the change of customer preference, government supports, competitiveness products provided by OEMs, China has become the largest NEV market with a sales volume of new energy passenger vehicles of 9.0 millions with the penetration rate of 34.6%. With further policy support and technological development, consumer preference, NEV sales volume is expected to reach 14.0 million by 2025, 23.6 million by 2030, 25.5 million by 2035.

New Energy Passenger Vehicle Sales Volume , Global, Breakdown by Regions



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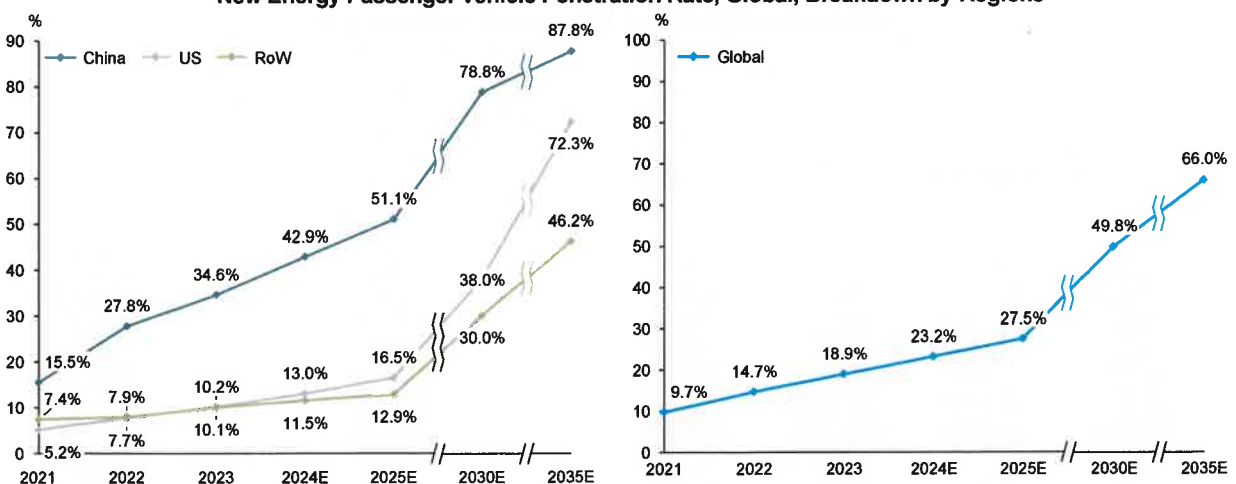
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Overview of Global Autonomous Driving Market

Global New Energy Passenger Vehicle Penetration Rate

- In recent years, the new energy vehicle industry has experienced rapid development in China, with a penetration rate of 34.6% in 2023, making China the world's largest new energy vehicle market. In 2023, China's new energy vehicle sales accounted for 65.7% of the world's total sales. The European new energy market is also developing rapidly, while the United States lags behind in new energy vehicle sales market, with a penetration rate of only 10.1% in 2023. However, against the backdrop of global energy transformation and carbon neutrality policies, almost all countries have set targets for developing new energy vehicles. It is expected that by 2035, the global penetration rate of new energy will reach 66.0%, with China's penetration rate reaching 87.8%.

New Energy Passenger Vehicle Penetration Rate, Global, Breakdown by Regions



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Overview of Global Autonomous Driving Market

Development of Autonomous Driving

- Road transportation is of significance to the economic growth and people's lives, with more than 1.4 billion vehicles transporting annually worldwide. Though the road infrastructure has been improving worldwide, traditional human-driven road transportations are still facing increasing challenges from safety risk, high cost and low efficiency. As a result of the adoption of electric vehicles and advancements in AI technologies, autonomous driving is developed to transform the traditional mobility. Autonomous driving advantages the traditional mobility in various aspects:

Enhance safety.

Enhance safety: Every year approximately 1.3 million people's lives were taken in the world by road traffic crashes, which are mostly caused by human error. Road traffic injuries are causing considerable economic losses to individuals, their families, and to nations as a whole. Autonomous driving technologies can make more comprehensive judgments and precise control in a short time frame to cope potential accidents and under emergency situations, thus effectively ensuring individuals' safety.

Reduce cost.

Labor costs account for the largest proportion of operating expenses in the passenger mobility and logistics industry. The operating cost can be reduced by around 45% and 25% for passenger mobility and logistics industry, respectively, if running driverless through advanced autonomous driving technology. In addition, by leveraging better route planning and more reasonable vehicle movement control, autonomous driving can make a considerable contribution to fuel economy as well as emission reduction, especially for long-haul trucking whose fuel cost accounts for around 30% of the total operational cost and still face challenges to realize electrification transition.

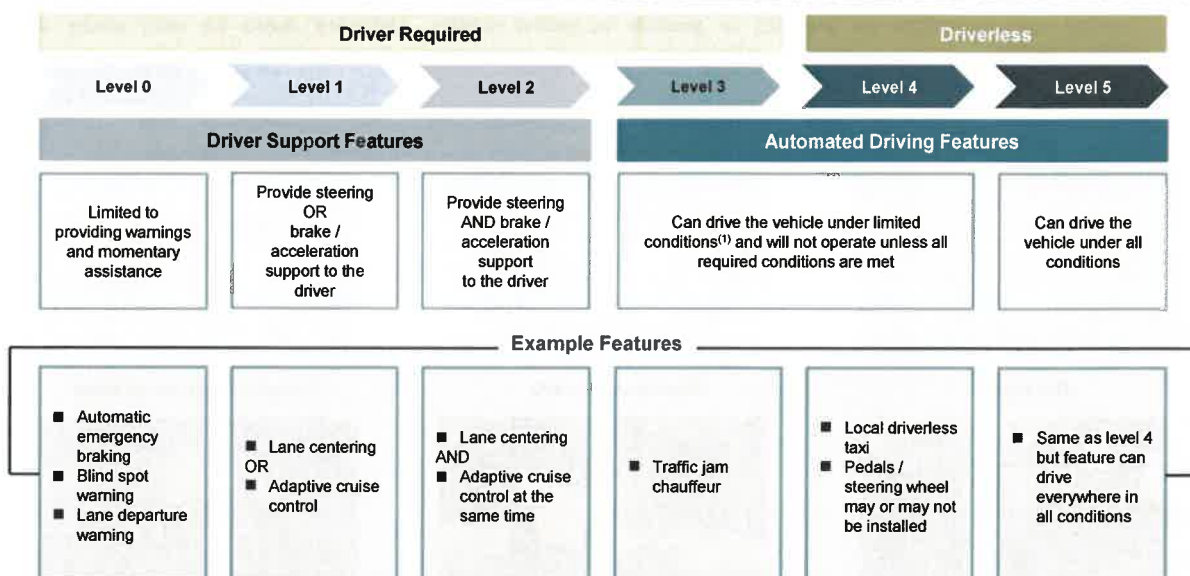
Improve efficiency.

Human driving is restrained under punitive regulations and self-supervision, while driving autonomous are maneuvered in a more disciplined manner controlled and monitored by computers. Mass deployment of autonomous driving can optimize traffic environment to a great extent and free human resources to be redeployed in other industries.

Overview of Global Autonomous Driving Market

The definition of Autonomous Driving (1/2)

- Autonomous driving refers to a complete set of software and hardware that acts as "Virtual Driver" to enable an autonomous vehicle to drive without the intervention of a human driver. According to SAE International, the levels of driving autonomy can be categorized into driver required and driverless, as illustrated below.



Note: (1) Limited conditions denote the limited conditions where automated driving are available to operate, such as traffic jam chauffeur operated by system autonomously in Level 3 and local driverless taxi in Level 4.

Source: SAE, Frost & Sullivan

Overview of Global Autonomous Driving Market

The definition of Autonomous Driving (2/2)

- Autonomous driving refers to a technology that can allow an autonomous vehicle to drive itself without the intervention of a human driver through ability to sense its surroundings. SAE J3016™ report provides a taxonomy with detailed definitions for six levels of driving automation, ranging from no driving automation (level 0) to full driving automation (level 5).

SAE Level	Narrative Definition	DDT		DDT fallback	ODD (Operational Design Domain)	
		Sustained lateral and longitudinal vehicle motion control	OEDR (Object and Event Detection and Response)			
Driver performs part or all of the DDT(dynamic driving task)						
0	No Automation	The performance by the driver of the entire DDT, even when enhanced by active safety systems.	Driver	Driver	Driver	N/A
1	Driver Assistance	The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.	Driver and System	Driver	Driver	Limited
2	Partial Driving Automation	The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the OEDR subtask and supervises the driving automation system.	System	Driver	Driver	Limited
Automated driving system ("system") performs the entire DDT (while engaged)						
3	Conditional Driving Automation	The sustained and ODD-specific performance by an automated driving system ("system") performs the entire DDT (while engaged) of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.	System	System	Fallback-ready user (becomes the driver during fallback)	Limited
4	High Driving Automation	The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.	System	System	System	Limited
5	Full Driving Automation	The sustained and unconditional (i.e., not ODD-specific) performance by an automated driving system of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.	System	System	System	Unlimited

Source: SAE, Frost & Sullivan

Overview of Global Autonomous Driving Market

Autonomous Driving Application Scenario

- Driverless technology, defined as Level 4 and Level 5 autonomous driving, has the potential to revolutionize on-road transportation across various use cases such as robotaxi for passenger mobility, robotruck for road freight transportation, driverless buses, and robotic vehicles used in various transportation use cases. Among them, robotaxi and robotruck take up the majority of the market share and embrace the greatest market potential. Furthermore, autonomous driving technology licensing and applications are expected to generate substantial revenue, particularly during the early stages of commercialization.

ADAS



Robotaxi



Robotruck



Robobus



Driverless delivery



Driverless special vehicles



Source: Frost & Sullivan

Overview of Global Autonomous Driving Market

Market Drivers and Future Trends of Autonomous Driving

- Global autonomous driving enjoys promising future and is expected to continue its strong momentum primarily due to the following factors.

- ① **Rising customer acceptance for autonomous driving technology.**
ACC (Adaptive Cruise Control), AEB (Autonomous Emergency Braking), LDW (Lane Departure Warning), etc. are typical driving automation has been realized. As driving autonomy highlights the advantage of safety, efficiency and user-experience, consumers show a great interest in driving and riding vehicles with advanced automation functions, which in turn, encourages the entire automotive industry to invest more in developing automotive-grade software and hardware to pursue the higher-level autonomous.
- ② **The certainty of vehicle electrification provides a broad application platform for autonomous driving.**
Compared with internal combustion engine vehicles, electric vehicles highlight the advantages of high control accuracy, low latency, and a more comprehensive redundant system. As a result, electric vehicles are regarded as the best carrier of autonomous driving technology. In 2022, over 6.5 millions of electric passenger vehicles are sold in China, representing a penetration rate of 27.8%. The sale volumes are expected to be 13.3 millions, which will account for 53.7% of the passenger vehicles by 2025, and then achieve penetration rates of 77.3% by 2030, 91.7% by 2035. A wide range of autonomous driving vehicles deployment in the future is underpinned by the booming of vehicle electrification.
- ③ **Advancement in software and hardware lays the foundation for realization of autonomous driving.**
The autonomous driving vehicle senses the vehicle state and external environment through the support of multiple sensors, such as lidar, camera, radar, GPS, IMU, etc., while the processing of the sheer volume of data requires high-performance computing systems. Benefited by the advancement and availability of automotive-grade sensors and chipsets in recent years, leading autonomous driving technology companies equipped with advanced software algorithms capabilities can leverage multi-layered sensors and other hardware to achieve perception, prediction, planning, and control of vehicles in a more precise and comprehensive manner.
- ④ **In-depth industrial collaboration encourages the commercialization of autonomous driving.**
Autonomous driving realization is on the back of deep integration of software and hardware on vehicles that requires in-depth collaborations among companies. For instance, through close collaboration with OEMs, autonomous driving companies can implant autonomous driving hardware and software during the vehicle design and production phase instead of modifying the vehicle post-production phase, thus effectively improving the reliability and reducing the cost of the vehicle integration.

Source: Frost & Sullivan

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Overview of Global Autonomous Driving Market

Barriers to Entry the Autonomous Driving Industries (1/2)

- The autonomous driving industry is a transformative sector that is redefining traditional transportation. Entering the autonomous driving industry, particularly in segments such as robotaxi, robotruck, and licensing and applications, presents several significant barriers. These challenges stem from technological, regulatory, operational, and commercial complexities, which collectively create a high threshold for new entrants. Below are the key barriers:

- ① **Substantial R&D Investment Driven by Advanced Technology Requirements.**
The autonomous driving industry is highly technology-intensive, requiring massive upfront investment in research and development (R&D). Developing a reliable autonomous driving system demands continuous innovation, particularly in ensuring safety and addressing complex real-world driving scenarios because ensuring safety is a complex challenge due to the myriad of corner cases, such as unusual scenarios and unexpected obstacles. Leading companies must accumulate vast amounts of real-world road-testing data and conduct extensive simulations to identify and resolve edge cases, thereby validating and improving the capabilities of autonomous systems. This process is both time-consuming and costly, creating a significant barrier for new players who lack the resources or technological expertise to compete with established leaders.
- ② **Regulatory Permits for Operations and Commercialization.**
Operating autonomous vehicles legally and responsibly worldwide, particularly in China, requires obtaining regulatory approval, which is essential for both road testing and facilitating the commercialization of driverless vehicles. Regulatory approval is contingent upon demonstrating compliance with stringent safety and operational standards. For example, in November 2021, Beijing became the first city in China to launch a commercial pilot program for robotaxis, allowing operators to charge the public for autonomous mobility services, but only after operators met rigorous requirements. Navigating the complex regulatory landscape and securing permits can be a lengthy and resource-intensive process, further raising the entry barrier for new entrants.

Source: Frost & Sullivan

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Overview of Global Autonomous Driving Market

Barriers to Entry the Autonomous Driving Industries (2/2)

- The autonomous driving industry is a transformative sector that is redefining traditional transportation. Entering the autonomous driving industry, particularly in segments such as robotaxi, robotruck, and licensing and applications, presents several significant barriers. These challenges stem from technological, regulatory, operational, and commercial complexities, which collectively create a high threshold for new entrants. Below are the key barriers:

Challenges in Large-Scale Deployment and Mass Production.

Scaling autonomous driving solutions from prototypes to large-scale deployment is another formidable challenge. Leading companies have already made strides in pre-installed solutions and mass-production capabilities, offering significant cost advantages and production efficiencies. Achieving mass-production requires not only advanced manufacturing capabilities but also the ability to validate and refine autonomous systems at scale, which involves extensive testing, supply chain optimization, and partnerships with automotive manufacturers. For new entrants, the lack of experience and resources to scale production and deployment poses a significant challenge, further solidifying the dominance of established players.

Developing a Viable Commercialization Roadmap and Profitability Plan.

Developing a viable commercialization roadmap is crucial for sustained growth in the autonomous driving industry. Companies must identify and establish clear revenue streams and business models, whether through robotaxi services, autonomous trucking, or other mobility-as-a-service (MaaS) offerings. Achieving profitability in this capital-intensive industry requires not only technological innovation but also strategic partnerships, efficient operations, and the ability to adapt to market demands. For instance, robotaxi operators must balance high operational costs with competitive pricing to attract users, while autonomous trucking companies need to demonstrate cost savings and efficiency gains to win over logistics providers. New entrants often struggle to establish a clear path to profitability, making this another significant barrier to entry in the autonomous driving sector.

Source: Frost & Sullivan

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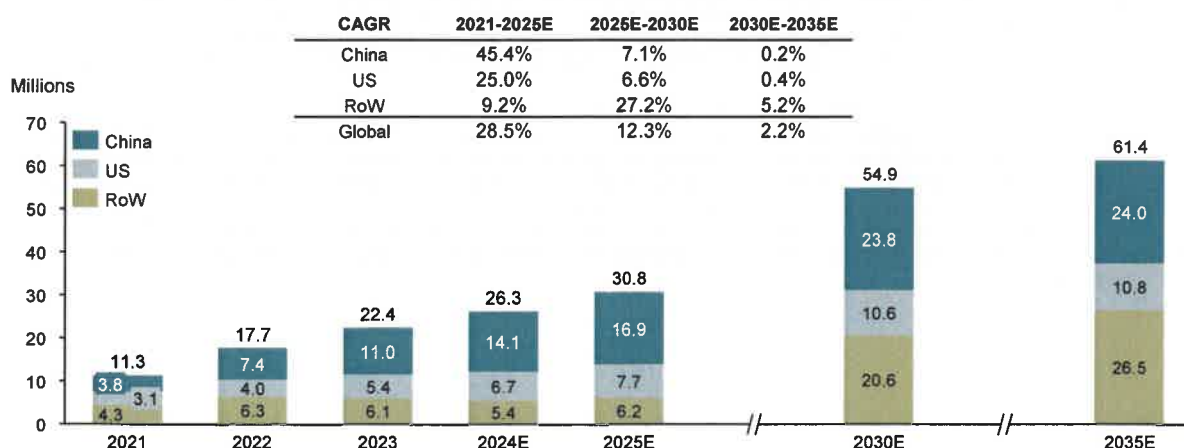
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Overview of Global Autonomous Driving Market

Global Autonomous Driving Vehicle Sales Volume Breakdown by Level

- With the technology maturity, vehicles equipped with ADAS technology are highly recognized among OEMs and consumers. It is expected that ADAS vehicles will gain a steady growth from 2021-2030, but almost stop growing after 2030 since the expansion of AM vehicles.
- China is vigorously developing autonomous driving. In addition to traditional car companies, Internet giants and a large number of emerging companies are vigorously developing autonomous driving technology. As the infrastructure has been gradually improved, and people have a high acceptance of high-tech products, which are suitable for the promotion of autonomous driving, China has promoted ADAS vehicle rapidly in recent years and will remain such trend in the future.

ADAS (L2 & L3) Autonomous Driving Vehicle Sales Volume, Breakdown by Regions,



Note: ADAS refers to level 2 and level 3 autonomous driving technology.

Source: Industry Associations, Frost & Sullivan

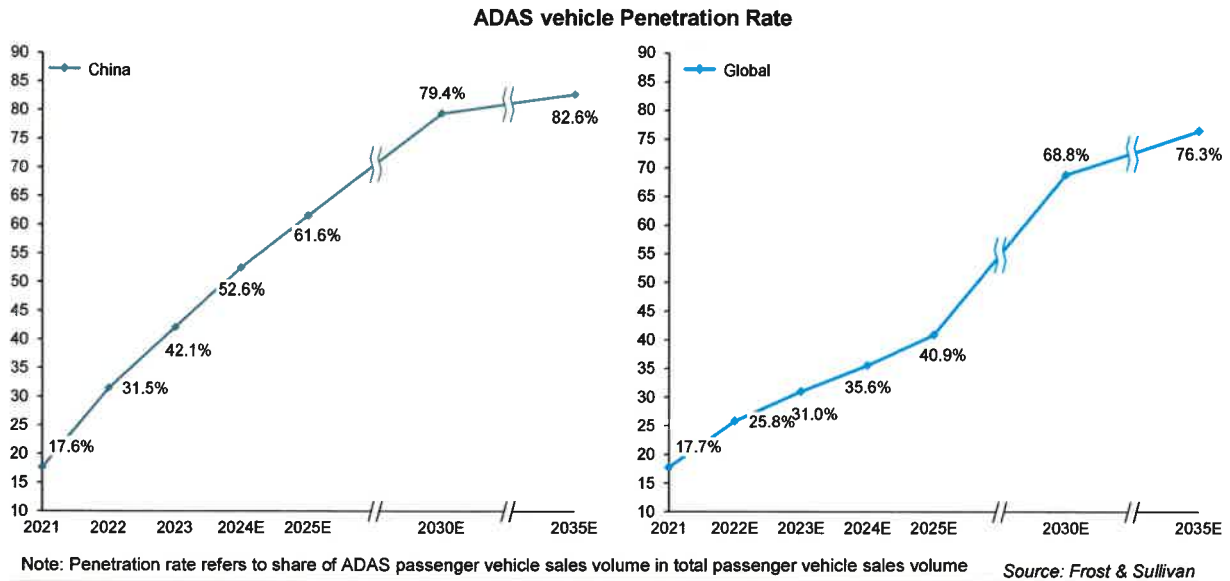
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Overview of Global Autonomous Driving Market

The Penetration Rate of Autonomous Driving in China by level

- With advances in artificial intelligence technology, decreasing sensor and chip costs, and consumer preferences, the ADAS penetration rate of major regions worldwide has rapidly increased in the past 1-2 years. Among them, China's ADAS vehicle penetration rate increased significantly to 42.1% in 2023. It is expected that the ADAS vehicle penetration rate will continue to rise in the next 10 years. However, after 2030, due to the commercial deployment of autonomous driving technology, some consumers may purchase vehicles with level 4 technology, resulting in a smaller increase in ADAS penetration rates in China and the United States.



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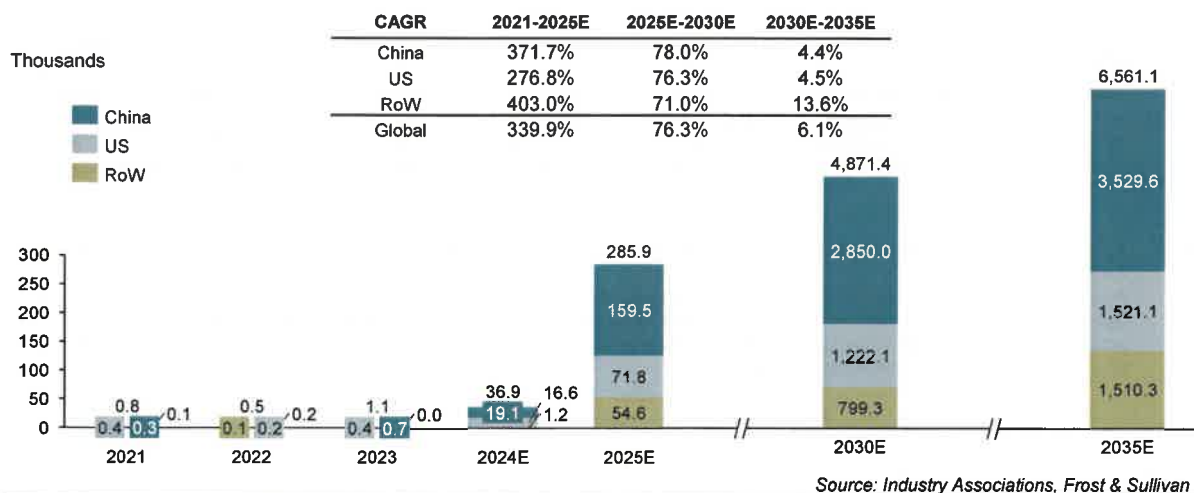
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Overview of Global Autonomous Driving Market

Global Autonomous Driving Vehicle Sales Volume Breakdown by Level

- AM (autonomous mobility), or L4/L5 autonomous driving, has the capability that enables vehicle driving without any human drivers, which could revolutionize the automotive industry. Due to high technical difficulty, AM vehicles are still in testing stage and pilot projects around the world. AM vehicles are expected to be commercialized in around 2025/2026, realizing a sales volume of 285.9 thousand by 2025, 4871.4 thousand by 2030, 6561.1 thousand globally. China is at the leading position globally for AM technology, the AM vehicles sales volume in China are expected to reach 0.3 million in 2026 with a penetration rate of 1.3%, and further increase to 2.9 million in 2030 with a penetration rate of 9.5%.

AM (L4 & L5) Autonomous Driving Vehicle Sales Volume, Breakdown by Regions,



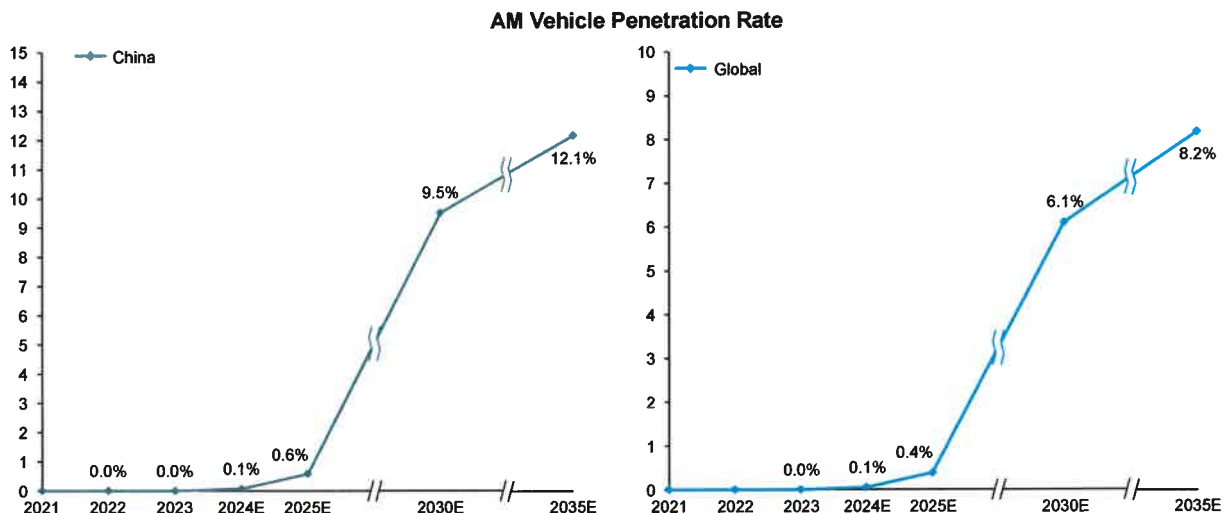
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Overview of Global Autonomous Driving Market

The Penetration Rate of Autonomous Driving in China by level

- China and the United States are in an absolute leading position in the AM technology globally, and a group of technology companies are striving to promote the commercial deployment of autonomous driving technology. It is expected that China and the United States will be the first to enter the commercialization of AM technology and achieve mass production and sales of AM vehicles. The AM vehicle penetration rate in China is expected to reach 9.5% and 12.1% in 2030 and 2035 respectively. The AM vehicle penetration rate in the United States is expected to reach 8.1% and 10.3% in 2030 and 2035 respectively. The scale deployment of AM in other parts of the world is relatively lagging behind, and the penetration rate is expected to reach 2.9% and 4.7% in 2030 and 2035 respectively.



Note: Penetration rate refers to share of AM passenger vehicle sales volume in total passenger vehicle sales volume

Source: Frost & Sullivan

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Overview of Global Autonomous Driving Market

Market Drivers and Future Trends of Robotaxi and Robotruck (1/2)

- Robotaxi and robotruck will keep riding on the upward industry trend and rapidly approaching to commercialization on the back of following factors:

- Continuous efforts in advancing autonomous driving technology to enhance safety performances.**
Driving safety is an uppermost priority but complicated problem with numerous corner cases including unusual circumstances and unexpected challenges. Leading companies are accumulating vast amounts of simulation and real-world road-testing data to capture corner cases, which validate and improve the capabilities of autonomous driving. This growing effort is bringing autonomous driving closer to our daily lives than ever.
- Improving profitability in robotaxi and robotruck operations underpinned by continued and rapid progress made in cost reduction.**
Leading companies have realized pre-installed solution and even mass-production capability, offering greater cost advantages and production efficiency compared to modified vehicles previously used. Moreover, the sensors and hardware used in vehicles equipped with L2 autonomous driving features are also compatible with driverless vehicles to some extents, further driving down the cost of hardware for L4 autonomous driving as the sales volume of L2 autonomous driving vehicles rapidly increases.
- Widespread deployment of robotaxi services to revolutionize urban transportation and improve the overall traffic environment.**
A single robotaxi provides safer and more efficient driving, while a large-scale implementation can greatly enhance the orderliness and efficiency of urban traffic. Additionally, the deployment of robotaxi services may also reshape urban traffic planning by reducing public parking lots to free up more urban space. As robotaxi services further develop, they are expected to contribute to the development of smarter cities.

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Overview of Global Autonomous Driving Market

Market Drivers and Future Trends of Robotaxi and Robotruck (2/2)

- The robotruck market, as a segment of the truck freight market, is poised to rapidly develop with the support of standard vehicles and establishments of logistics networks with fixed hubs.**
Leveraging this mature infrastructure, players in the robotruck market are expected to retrofit vehicles with more standardized functions to transport freight and implement digital fleet management to further optimize the overall efficiency of the logistics network, reducing costs and improving safety. Large-scale deployment of robotrucks has the potential to significantly optimize the trucking logistics system.
- Regulatory endorsements and policy headwinds to facilitate the commercialization of driverless vehicles far beyond road testing.**
In November 2021, Beijing became the first city in China to establish a commercial pilot of robotaxis with a published policy approving operators to charge the public for their robotaxi mobility service. In December 2022, the Chinese Ministry of Industry and Information Technology (MIIT) issued a notice proposing the admission and on-road operation of driverless vehicles with mass production capabilities to conduct pilot projects. The notice aims to promote the establishment and improvement of management systems for the production admission of autonomous driving vehicles and road traffic safety. Major governments such as the United States, Germany, Japan, South Korea, and the United Kingdom have also published favorable policies to actively create an industrial and social environment that promotes the development of autonomous driving.

Overview of Global and China Autonomous Driving Vehicle Market

Global Autonomous Driving Policy and Regulation (1/2)

Policy	Issue time	Country	Department	Main contents
<i>Occupant Protection Safety Standards for Vehicles Without Driving Controls</i>	2022.3	U.S.	NHTSA	Updates the occupant protection Federal Motor Vehicle Safety Standards to account for vehicles that do not have the traditional manual controls associated with a human driver and assures the same high level of occupant crash protection is maintained for passengers of vehicles equipped with automated driving systems
<i>SB-500: Autonomous vehicles: zero emissions</i>	2021.9	U.S.	California Senate	Prohibits the operation of certain new autonomous vehicles that are not zero-emission vehicles, as defined. Prohibits the Department of Motor Vehicles from commencing rulemaking for the adoption of regulations implementing this provision until a specified date.
<i>Revise the Road Traffic Law and Compulsory Insurance Law- Autonomous Driving Law</i>	2021.05	German	German Bundestag	The legislation will allow driverless vehicles on public roads by 2022, laying out a path for companies to deploy robot taxis and delivery services in the country at scale. While autonomous testing is currently permitted in Germany, this would allow operations of driverless vehicles without a human safety operator behind the wheel. The bill specifically looks at vehicles with Level 4 autonomy. Level 4 autonomy is a designation by the Society of Automobile Engineers (SAE) that means the computer handles all the driving in certain conditions or environments. In Germany, these vehicles will be limited to geographic areas.
<i>Draft autopilot law</i>	2021.05	German	German Federal Council (adopted but not published)	The generation has been adopted but not yet published. L4-class fully driverless cars are allowed to appear on German public roads in 2022 without having to equip them with drivers or safety guards. First of all, self-driving cars must drive in designated areas of German public roads and remain remotely ready to take over at all times. Secondly, if the self-driving company carries on the commercial operation, must purchase the corresponding liability insurance.
<i>HB 2813</i>	2021.3	U.S.	Arizona Senate	HB 2813 passes codifying much of Executive Order 2018 into state law. It Establishes a regulatory framework for the operation of autonomous vehicles in Arizona, such as allows a fully autonomous vehicle to operate on public roads without a driver.
<i>Automated Vehicles Comprehensive Plan</i>	2021.1	U.S.	Department of Transportation	Building upon the principles stated in AV 4.0, the Automated Vehicles Comprehensive Plan defines three goals to achieve USDOT's vision for Automated Driving Systems (ADS), including Promote Collaboration and Transparency, Modernize the Regulatory Environment, Prepare the Transportation System.
<i>Decision Authorizing Deployment of Drivered And Driverless Autonomous Vehicle Passenger Service</i>	2020.11	U.S.	California Public Utilities Commission	The decision approved Deployment of Drivered Autonomous Vehicles and Driverless Autonomous Vehicles Passenger Service. And permit approved companies to offer autonomous ride services and autonomous ride-sharing services for a fee.

Overview of Global and China Autonomous Driving Vehicle Market

Global Autonomous Driving Policy and Regulation (2/2)

Policy	Issue time	Country	Department	Main contents
<i>Ensuring American Leadership in Automated Vehicle Technologies (Automated Vehicles 4.0)</i>	2020.1	U.S.	Department of Transportation, National Science & Technology Council	AV 4.0 details 10 U.S. Government principles to protect users and communities, promote efficient markets, and to facilitate coordinated efforts to ensure a standardized Federal approach to American leadership in AVs. It also presents ongoing Administration efforts supporting AV technology growth and leadership, as well as opportunities for collaboration including Federal investments in the AV sector and resources for AV sector innovators.
<i>Autonomous driving safety standards</i>	2020	Korea	Ministry of Land, Infrastructure and Transport	Specific guidelines for L3 autonomous driving, lane keeping for L3 autonomous driving, monitoring of drivers in emergencies, automatic deceleration when humans do not take over, activation of emergency braking signals, etc.; In emergency situations such as highway exits and road construction ahead, the human driver will be prompted to take over 15 seconds in advance.
<i>Road Traffic Act</i>	2020	Japan	The Japanese Cabinet	proposed that if the driver can quickly resume manual driving, he/she can use the mobile phone or watch the on-board TV during the automatic driving process, which is regarded as the legal on-road right granted by the L3 level autonomous vehicles by the state.
<i>H.R.3388: SELF DRIVE Act</i>	2017.7	U.S.	House of Representatives	H.R. 3388 would clarify the federal role in regulating vehicles that can drive without a person controlling the vehicle. Those vehicles are defined in the bill as Highly Automated Vehicles (HAVs). The bill would require the National Highway Traffic Safety Administration (NHTSA) to complete several rulemakings, establish an advisory council on HAVs, and create a publicly available database about manufacturers that receive exemptions from current law.
<i>"Road Traffic Law" and the "Road Transport Vehicle Law"</i>	2017	Japan	the Japanese government	The laws include traffic accidents during autonomous driving in the compensation items of auto insurance, in response to the attribution issue of liability for accidents caused by autonomous vehicles.

Overview of Global and China Autonomous Driving Vehicle Market

China Autonomous Driving Policy and Regulation (1/3)

Policy	Issue time	Department	Main contents
<i>Notice of Implementing the Pilot Program of Applying "Vehicle-Road-Cloud Integration" to Intelligent Connected Vehicles</i>	2024.1	MIIT	It aims to promote the construction of networked cloud control infrastructure, exploring the multi-scenario application of autonomous driving technology based on efficient coordination of vehicles, roads, networks, clouds and maps, and accelerating the technological breakthrough and industrial development of ICVs(Intelligent Connected Vehicles).
<i>Notice of Implementing the Pilot Program of Access and On-road Traffic of Intelligent Connected Vehicles</i>	2023.11	MIIT	It proposed to select ICVs equipped with autonomous driving functions(including level-3 driving automation and level-4 driving automation functions) that are eligible for mass production to implement the pilot program of on-road traffic within the designated areas.
<i>Guidelines for the Construction of the National Internet of Vehicles Industry Standard System (Intelligent Connected Vehicles) (2023)</i>	2023.7	MIIT	It aims to form a standard system for ICVs that can support the common functions of combined driving assistance and autonomous driving by 2025, and completely form a standard system for ICVs that can support the coordinated development of single-vehicle intelligence and network empowerment.

Overview of Global and China Autonomous Driving Vehicle Market

China Autonomous Driving Policy and Regulation (2/3)

Policy	Issue time	Department	Main contents
<i>Notice on Carrying out the Pilot Work of Intelligent Connected Vehicle Access and On-road Communication</i>	2022.11	MIIT	The Ministry of Industry and Information Technology and the Ministry of Public Security select qualified vehicle manufacturers and intelligent networked vehicles equipped with autonomous driving engineering and mass production conditions to carry out access pilot; For the intelligent connected vehicles that have passed the access pilot, they will be carried out test driving in the restricted public road area of the pilot city
<i>Transportation Safety Service Guide of Autonomous Driving Vehicles</i>	2022.08	Ministry of Transport	On the premise of ensuring transportation safety, it is encouraged to use AD vehicles to engage in bus transport business in scenarios such as closed rapid bus transit systems, use AD vehicles to engage in taxi transport business in scenarios with simple traffic conditions and relatively controllable conditions, and use AD vehicles to engage in road cargo transport business in scenarios such as point-to-point trunk highway transportation and relatively closed roads.
<i>Detailed Implementation Rules for the Pilot Management of the Commercialization of Autonomous Driving Travel Services in the Pilot Zone of the Beijing Intelligent Connected Vehicle Policy</i>	2021.12	Beijing Autonomous Driving Demonstration Zone Work Office	Standardize the commercial Robotaxi services from the aspects of application review, pilot management, network data security, service supervision and violation management, etc. Under the premise of ensuring the principle of fair competition in the market, enterprises can adopt a market-based pricing mechanism, and only start to experience charging services on the premise of clarifying the charging principles, payment methods and other information to passengers.
<i>Beijing's "14th Five-Year Plan" period advanced industry development plan</i>	2021.8	People's Government of Beijing	It aim to adhere to the development of autonomous driving technology, promote the revolution of vehicle-side intelligence, road-side intelligence and travel, and accelerate the transformation of traditional vehicles to intelligent network connection. Build a high-level autonomous driving demonstration area, making breakthroughs in key areas such as sensors, chips, and operating systems; encourage fully-verified autonomous vehicles to take the lead in trial operation and commercial operation services in policy-leading areas.
<i>Shanghai Implementation Plan for Accelerating the Development of New Energy Vehicle Industry (2021-2025)</i>	2021.2	People's Government of Shanghai	Promote the construction of highly automated driving (L3+ and above) demonstration zones, and build a national-level intelligent vehicle innovation and development platform. Significantly reduce the comprehensive cost of autonomous driving testing, and accelerate the implementation of demonstration projects in typical scenarios such as robotruck, robotaxi services, driverless sweepers for elevated roads, and autonomous parking in parking lots.

Overview of Global and China Autonomous Driving Vehicle Market

China Autonomous Driving Policy and Regulation (3/3)

Policy	Issue time	Department	Main contents
<i>Guiding Opinions on Promoting the Development and Application of Autonomous Driving Technology in Road Traffic</i>	2020.12	MOT	It proposed, by 2025, positive progress will be made in autonomous driving technology, and important breakthroughs will be made in key technologies such as road infrastructure intelligence and vehicle-road coordination, as well as in product development and testing; a number of key standards for autonomous driving will be introduced; Achieve a number of national-level autonomous driving test bases and pilot projects, as well as, large-scale applications in some scenarios to promote the industrialization of autonomous driving technology.
<i>Intelligent vehicle innovation and development strategy</i>	2020.2	NDRC, MOST, MIIT	It proposed, by 2025, the technological innovation, industrial ecology, infrastructure, regulatory standards, product supervision and network security systems of Chinese standard smart cars will be basically formed. Realize the large-scale production of intelligent vehicles with conditional automatic driving, and realize the market application of intelligent vehicles with high-level automatic driving in specific environments. Looking forward to 2035 to 2050, China intelligent vehicle system will be fully completed and more perfect.
<i>Medium and long-term development plan for the automotive industry</i>	2017.4	NDRC, MOST, MIIT	It proposed, by 2020, the assembly rate of new cars with DA (driving assistance), PA (partially autonomous driving), and CA (conditional autonomous driving) systems will exceed 50%, and the assembly rate of connected driving assistance systems will reach 10%, meeting the requirements for the construction of smart transportation cities. By 2025, the DA, PA, CA new car assembly rate will reach 80%, of which the PA and CA class new car assembly rate will reach 25%, and highly and fully autonomous vehicles will begin to enter the market.

Agenda

- 1** Introduction of the Research
- 2** Overview of Autonomous Driving
- 3** **Overview of Global Robotaxi Market**
- 4** Overview of Global Robotruck Market
- 5** Overview of Autonomous Driving Licensing Market
- 6** Competitive Landscape of Robotaxi and Robotruck Market
- 7** Appendix

Overview of Global Robotaxi Market

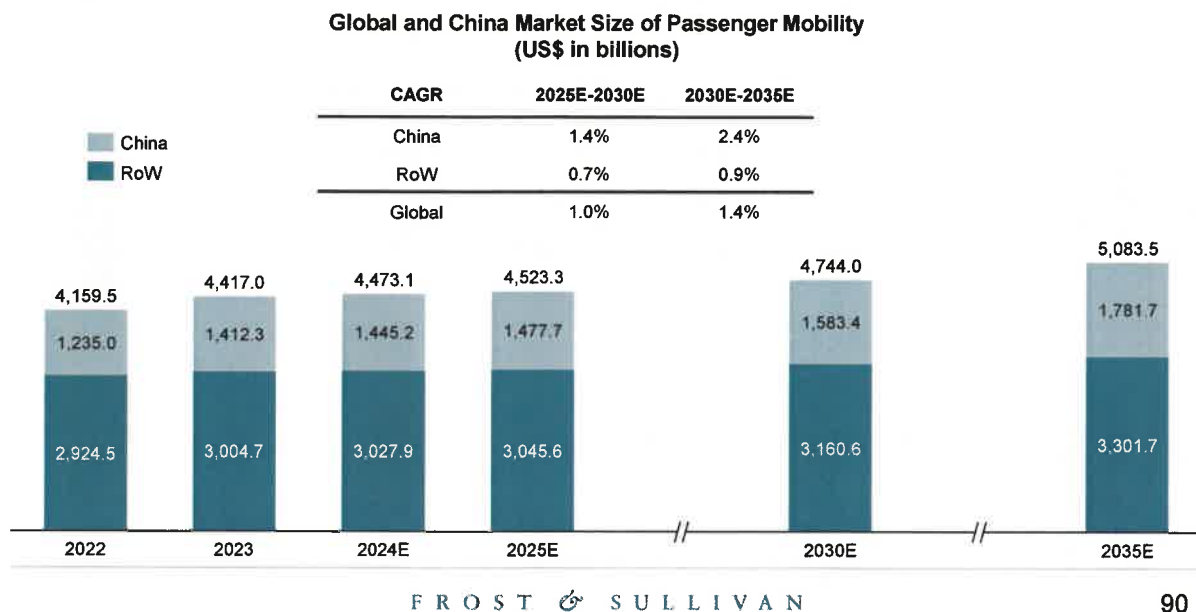
Passenger Mobility Market Size (1/2)

- Passenger mobility is defined as passenger travel by shared mobility and private cars. Through the progress of urbanization with the increasing number of densely populated cities, and increasing number of growing regional economies, global passenger mobility poises great market potential by providing flexibility and quality transportation experience to passengers.
- Shared mobility, which includes online ride-hailing and traditional taxi services, has experienced rapid growth in the last decade, fueled by the emergence of online ride-hailing services and the expansion of regional economies. Shared mobility market size represents the total amounts of ride fare paid by passengers for shared mobility services, as measured by the GTV of such rides. China, in particular, has a strong and growing demand for passenger mobility, driven by increasing affluence, rising business activities, rapid urbanization, consumption upgrades, and growing expenditure on discretionary travel. However, China's private car ownership rate, measured by the number of private cars per thousand people, remains significantly lower than that of major developed nations. As of 2023, China's private car ownership rate was 184 per thousand people, compared to 793 in the U.S. This has resulted in high levels of consumer adoption of shared mobility services in China, and has led to a market size that far exceeds that of other countries. The China's shared mobility market size was US\$119.1 billion in 2023 and expected to reach US\$228.9 billion by 2035. In 2023, China's shared mobility market accounted for around 40% of the global market and was approximately twice the size of the U.S. market.
- The increasing passenger mobility demands could be better addressed by shared mobility for its flexibility. Therefore, the global shared mobility market is expected to maintain growth. Additionally, the active exploration of commercialization of high-level autonomous driving technology in the shared mobility market is expected to bring sustainable growth momentum by attracting individuals shifting from private cars mobility sector in the long run.

Overview of Global Robotaxi Market

Passenger Mobility Market Size (2/2)

- The passenger mobility market size represents the total value of consumer spend on shared mobility and private cars traveling. The China's passenger mobility market size was US\$1,412.3 billion in 2023 and expected to reach US\$1,781.7 billion by 2035. In 2023, China accounted for 32.0% of the global market share.

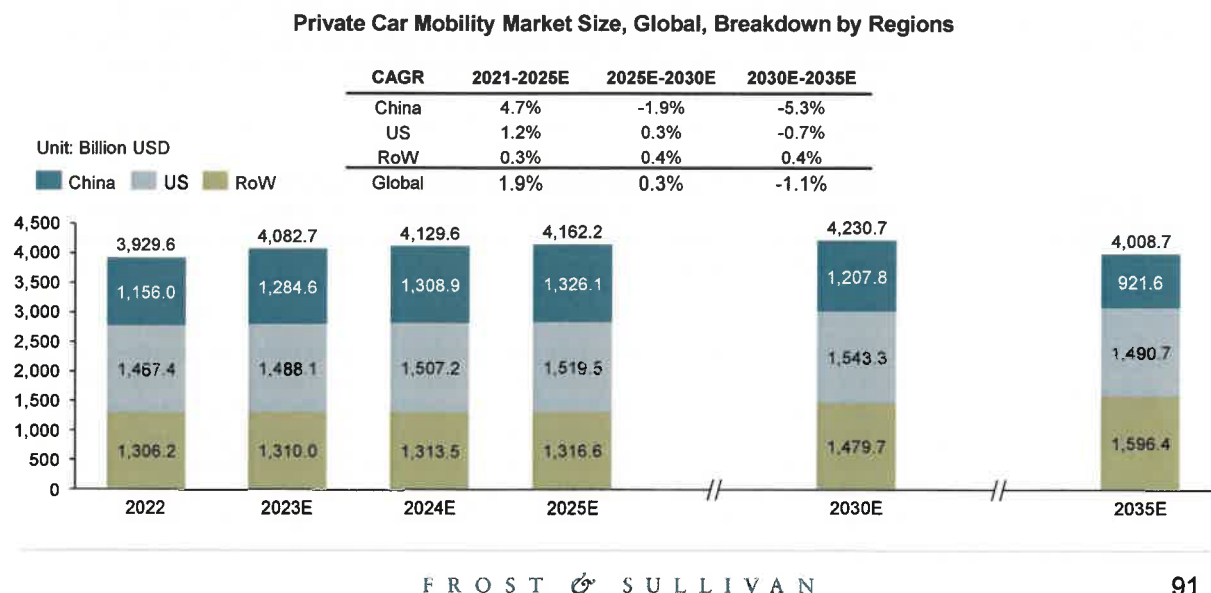


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Overview of Global Robotaxi Market

Private Car Mobility Market Size, by Regions

- Private car mobility market refers to the summation of GTV or total expenditure of fuel, electricity, depreciation, maintenance, repairing, insurance, and others when driving private cars. China and the United States have a high ownership of passenger cars and large land areas, which makes them the largest private car travel markets. The single kilometer expenditure and per capita driving mileage of US people are higher than those of China, therefore establishing a higher market size for US. Due to the rise of shared mobility, the growth rate of private car travel continues to decline. More and more people choose shared mobility, especially after 2030, with the emergence of autonomous driving technology, which will greatly attract private car users to switch to shared mobility, resulting in a decline in the size of the private car travel market.



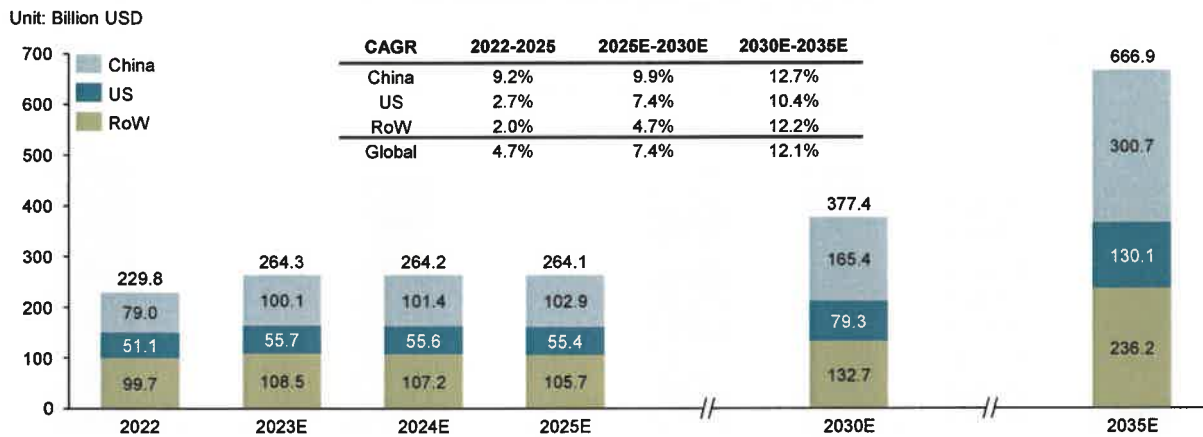
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Overview of Global Robotaxi Market

Market size of Global Sharing Mobility Market Breakdown by Region

- Shared mobility, including online ride-hailing and traditional taxi services, has experienced rapid growth in the last decade, fueled by the emergence of online ride-hailing services and the expansion of regional economies. The application of automated driving technology in shared mobility will become a core factor in maintaining long-term growth momentum for shared mobility in the future.
- The market size of shared mobility globally, in terms of GTV, is expected to reach US\$ 666.9 billion by 2035. Due to the largest population base, fast-growing regional economy, optimizing transportation infrastructure and leading position in commercializing automated driving technology, China is expected to be the largest shared mobility market with market size of 300.7 billion USD, or 45.1% of the global market by 2035. US is expected to be second largest market with market size of 130.1 billion USD by 2035.

Shared Mobility Market Size, Global, Breakdown by Regions



Source: Frost & Sullivan

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Overview of Global Robotaxi Market

Pain points of the Traditional Sharing Mobility Market

- With the progress of urbanization with the increasing number of densely populated cities, global shared mobility enjoys great market potential by providing flexibility and quality transportation experience. Passengers are presented with more convenient and comfortable mobility options on passenger vehicles. As the rise of the shared mobility globally, the pain points of traditional human-driven mobility becomes more obvious.

HIGH COST

- Driver salary takes up around 50% in terms of the total operating cost of a passenger vehicle in both China and the US. Such cost structure directly leads a high expenditure per mileage for passengers that alienated a large group of people who actually has potential demands on shared mobility. Moreover, high share of driver cost also adversely impacts on the shared mobility operators to gain higher profit margin.

LOW EFFICIENCY

- There are over 68 millions passenger cars were sold globally in 2022. Increasing number of cars enter into the market, challenging the urban road traffic with slower driving speed and frequent traffic congestion. In addition, undisciplined human driving behavior further deteriorated the traffic environment, traffic congestion caused by traffic accident and illegal driving are commonly seen.

SAFETY RISK

- Traffic accidents caused by human behaviors, such as undisciplined driving, fatigue driving, blurred vision, and unskilled driving are commonly seen. Every year the lives of approximately 1.3 million people are cut short as a result of a road traffic crash. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury, as reported by WHO. Road traffic injuries are causing considerable economic losses to individuals, their families, and to nations as a whole.

Source: Frost & Sullivan

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Overview of Global Robotaxi Market

Definition of Robotaxi and Benefits

Definition

- Robotaxi is defined as a driverless mobility vehicle with built-in Level 4/ Level 5 autonomous driving technology. As one of the most promising applications of autonomous driving technology, robotaxi differentiates by offering more affordable, safer, and more efficient services to passengers.

Benefits

- ◆ Driverless Robotaxi can provide more affordable mobility services by reducing driver cost. Compared to human-driven vehicles, the total operational cost of running a robotaxi can be reduced almost by half, thus offering a more flexible pricing strategy. On one hand, by charging less per mile, an increasing number of private car and public transportation users would adopt robotaxi as the alternate travel option. On the other hand, favorable profit margins would encourage traditional shared mobility operators to shift to operating robotaxi fleets.
- ◆ Mass deployment of Robotaxi can optimize traffic environment to a great extent. Human driving is restrained under punitive regulations and self-supervision, while robotaxi could drive in a more disciplined manner controlled and monitored by computers. Moreover, private vehicle ownerships are expected to drop as increasing people shift to robotaxi due to the cost and safety benefits. Such benefits from robotaxi operation can substantially purify the urban road traffic.
- ◆ Safety risk will be reduced with "virtual driver" in place to navigate complex city-level road conditions. Sensors are capable to achieve a more accurate and wider range of environmental perception than human senses. Combining with the high-power computing system, robotaxi can make more comprehensive judgments toward coming danger, and control the vehicle body attitude in a short time, thus effectively ensuring individuals' safety.

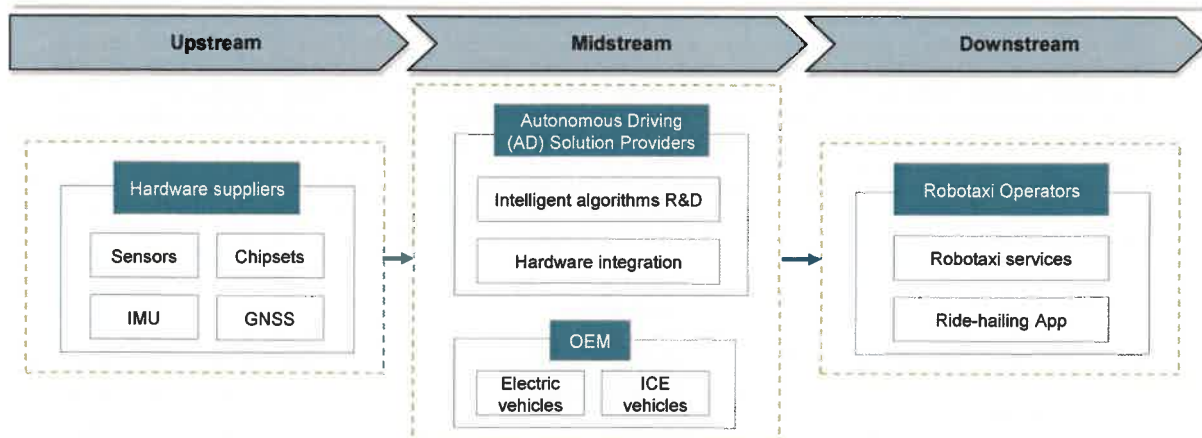
Source: Frost & Sullivan

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Overview of Global Robotaxi Market

Value Chain and Business Mode of Robotaxi



- Hardware suppliers can provide necessary sensors (lidar, radar, camera), chipsets, IMU, GNSS and etc. to AD Solution Providers.
- OEM can either provide the common vehicles to AD Solution Providers, so that the common vehicle can be modified to the driverless-level vehicle or directly produce the driverless-level vehicle under the support of AD Solution Providers with Intelligent algorithms and hardware integration solutions.
- AD Solution Providers are responsible for developing driverless-level AD technology through Intelligent algorithms R&D and Hardware integration. Currently, most AD Solution Providers purchased vehicles from OEMs and then make modifications. In the future, with in-depth cooperation with OEMs, AD Solution Providers tend to outsource the vehicle modification to OEMs, so that the hardware integration and algorithms build-in can be achieved at the vehicle production phase, which so-called pre-installed vehicle.
- Robotaxi operators are companies who commercially operate the Robotaxi business. The operators can be Autonomous Driving Solution Providers or traditional ride-hailing companies that purchase the full set of driverless solution

Source: Frost & Sullivan

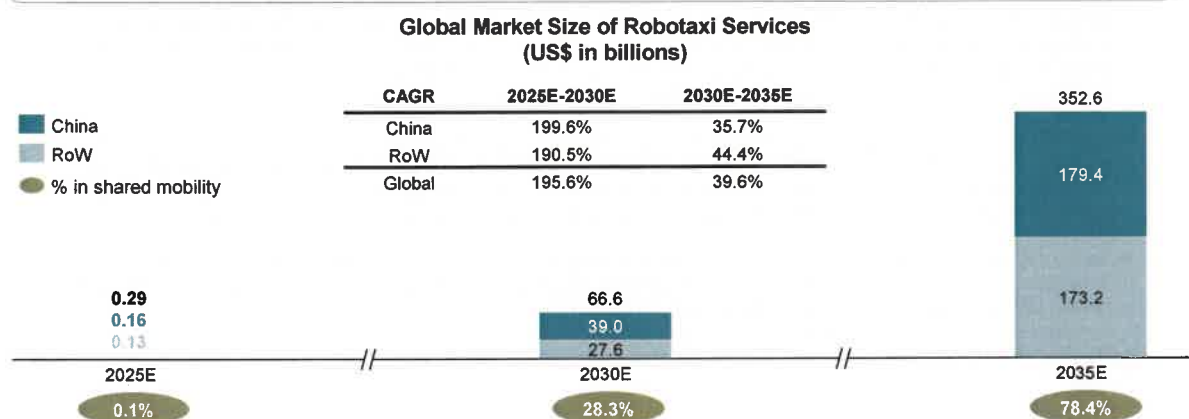
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Overview of Global Robotaxi Market

Global and China Robotaxi Market Size

- Driven by technological advancement, supportive policies, and falling hardware costs, robotaxi is expected to realize commercialization and grab considerable market share in the passenger mobility market in the future. Highlighted by great safety enhancement, as well as the pricing advantage due to lower operating costs, robotaxi is expected to penetrate shared mobility market at its initial stage of the commercialization. Tangible benefits of profitability and affordability brought by robotaxi will continuously drive the expansion of market. Such scale effect will promote the cost reduction and improvement of riding efficiency, attracting private car users to shift to robotaxi.
- The China's market size of robotaxi services is expected to reach US\$0.16 billion by 2025, and embrace an exponential growth to further reach US\$39.0 billion by 2030 and US\$179.4 billion by 2035, according to Frost & Sullivan. For the overseas market, the market size of robotaxi services is expected to reach US\$0.13 billion by 2025, and further to reach US\$27.6 billion by 2030 and US\$173.2 billion by 2035.



Note:

(1) Robotaxi services market size represents the total amounts of ride fare paid by passengers for robotaxi services, as measured by the GTV of such services.

(2) % in shared mobility refers to the share of China's robotaxi market size in the China's shared mobility market.

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Overview of Global Robotaxi Market

Global and China Robotaxi Car Parc

- With continuous increase in production capability and unparalleled advantages in terms of cost, affordability, and efficiency, the deployment scale of robotaxi is expected to rapidly expand around 2030. It is projected that by 2035, robotaxis will consist a substantial portion of the overall fleet of shared passenger vehicles operating in China, thereby establishing China as the largest robotaxi services market and capture more than half of the global market share, according to Frost & Sullivan. Among all cities in China, Tier-1 cities, including Beijing, Shanghai, Guangzhou, and Shenzhen, are major places to develop robotaxis initially. The number of robotaxis in Tier-1 cities is expected to reach 0.28 million in 2030, and further to 1.38 million in 2035. Subsequently, the application of robotaxis expands to Tier-2 cities, which include 31 cities. The number of robotaxis in Tier-2 cities is expected to reach 0.73 million in 2030, and further to 2.77 million in 2035. For the overseas market, the number of robotaxis is expected to reach 0.17 million by 2030, and further to 0.93 million by 2035.

Global and China Car Parc of Robotaxi
Unit: Million

		2025E	2030E	2035E
Robotaxi	China (tier 1 and tier 2 cities)	0.006	1.01	4.15
	RoW	0.001	0.17	0.93

China Car Parc of Traditional Taxis, Ride-hailing Vehicles and Robotaxi, Breakdown by Cities
Unit: Million

		2025E	2030E	2035E
Taxi, Ride-hailing	Tier-1 Cities	1.10	0.94	0.42
	Tier-2 Cities	2.52	2.16	0.96
Robotaxi	Tier-1 Cities	0.001	0.28	1.38
	Tier-2 Cities	0.005	0.73	2.77

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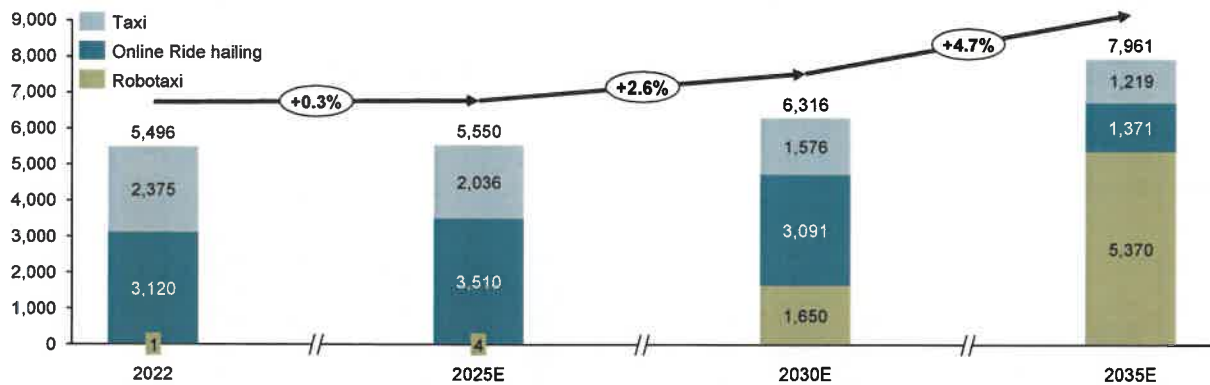
Overview of Global Robotaxi Market

Accumulative Number of Commercially Operational Passenger Vehicle in China

- In 2022, China had about 5.5 million commercially operated passenger cars, including approximately 3.12 million ride-hailing cars and 2.38 million taxis. It is expected that before 2025, the total number of vehicles will hardly increase, but in terms of vehicle structure, the number of ride-hailing cars will further increase while the number of taxis will continue to decline. After 2025, it is expected that due to the commercial deployment of robotaxis, the total number of commercially operated passenger cars will start to increase. By 2030, it is expected that there will be approximately 1.65 million robotaxis operating in China. It is estimated that by 2035, there will be about 5.37 million robotaxis in China, accounting for 67.5% of the commercially operated passenger cars.

Accumulative Number of Commercially Operational Passenger Vehicle in China, Breakdown by Type

Unit: thousand unit



Note: Taxi refers to traditional taxis and unregulated taxis.

Source: Frost & Sullivan

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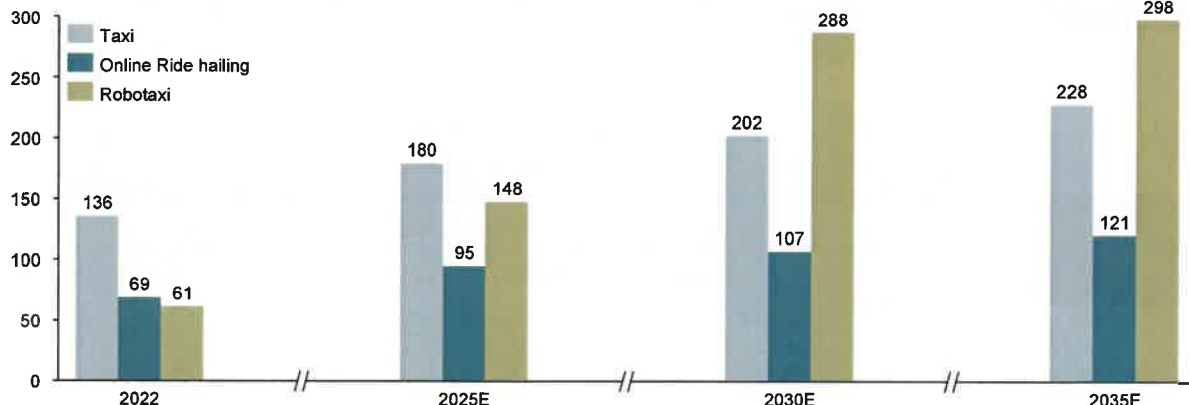
Overview of Global Robotaxi Market

Average Annual GTV Generated by Single Vehicle in China

- Due to the fact that taxi drivers are usually full-time and a taxi is typically manned by two drivers who take turns, taxis have the longest operating hours and can therefore generate higher per-vehicle GTV compared to other vehicles. Although ride-hailing services are more efficient, they usually only have one driver and a large number of part-time drivers, resulting in a lower average per-vehicle GTV. Currently, robotaxis have limited operating areas and fewer operating days per year, resulting in lower per-vehicle GTV. However, in the future, with relaxed regulations and the scaling up of robotaxi deployment, robotaxis will lead other vehicle types in terms of operating efficiency and operating time. It is expected that by 2035, a single robotaxi in China can generate nearly RMB 300,000 in annual GTV.

Average Annual GTV Generated by Single Vehicle in China, Breakdown by Type

Unit: thousand RMB



Note: Online ride-hailing includes human driven vehicles and driverless vehicles (robotaxi).

Source: Frost & Sullivan

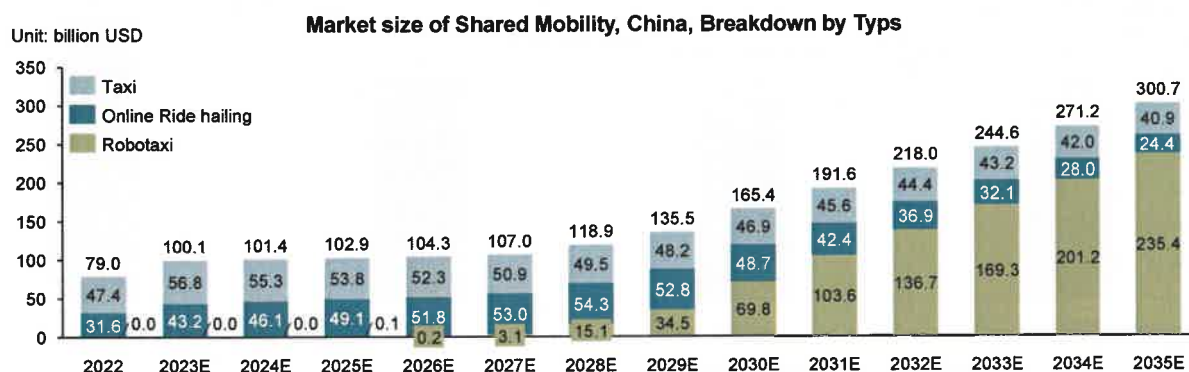
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Overview of Global Robotaxi Market

Robotaxi Market Size in China

- With nearly 1.4 billion people, China's transportation sector is facing the challenge of meeting the increasing demand for safe, efficient, and sustainable passenger mobility. Currently, the number of shared passenger vehicles in commercial operation in China is approximately 5.5 million, with expectations for a growth to around 8 million by 2035, driven by the growing demand for shared mobility. As the world's largest shared mobility market and one of the countries with highest population density, China is well positioned to leverage the benefits of robotaxi for future mobility solutions.
- Thanks to substantial investments in research and development, as well as ongoing regulatory improvements, the commercial deployment of robotaxi in China is projected to commence as early as 2025-2026 with both fully driverless robotaxi and safety-driver-enabled robotaxi operate in mixed traffic. With continuous increase in production capability and unparalleled advantages in terms of cost, affordability, and efficiency, the deployment scale of robotaxi is expected to rapidly expand between 2025 and 2030. It is projected that until 2035, in China robotaxis will command a substantial portion of the overall fleet of shared passenger vehicles in operation, thereby establishing China as the largest robotaxi market and capture more than half of the global market. The market size is expected to reach \$69.8 billion by 2030 and \$235.4 billion by 2035.



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Overview of Global Robotaxi Market

Market Drivers and Future Trends of Robotaxi (1/2)

- Robotaxi will keep riding on the upward trend on the back of safety enhancement, traffic optimization, cost reduction and policy supports.

Safety enhancement

- Continuous efforts on advancing autonomous driving technology to enhance the safety performance of robotaxi. Driving safety is a "long tail" problem consisting of massive corner cases which are unusual circumstances and unexpected challenges. Combination of continuous efforts on case simulation and road-testing data collections are of significance to catch those corner cases and validate the capability of autonomous driving.

Traffic optimization

- Large-scale of deployment of robotaxi will overturn the deteriorating urban traffic environment. Single robotaxi offers safer and more disciplined driving, while a large-scale deployment of robotaxi can make the entire urban traffic more efficient and more orderly. Moreover, urban traffic planning could be re-shaped by robotaxi, such as reducing the number of public parking lots to free up more urban space. Robotaxi is expected to contribute to the construction of a smarter city environment as the penetration rate of robotaxi increases.

Source: Frost & Sullivan

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Overview of Global Robotaxi Market

Market Drivers and Future Trends of Robotaxi (2/2)

Cost reduction

- Significant cost reduction continues to enhance the profitability of robotaxi. LiDAR is widely regarded as the core sensor to achieve autonomous driving, but with the highest cost. With the establishment of automatic production lines of LiDAR manufacturers, and the advancement of solid-state LiDAR technology, the cost of LiDAR has significantly declined by 84% from 2017 to 2021. In terms of vehicle integration, pre-installed and mass-produced autonomous vehicles have been realized by leading robotaxi companies, which offer greater cost advantages and production efficiency than modified vehicles which are commonly seen in the past. The large-scale production of Robotaxi is bound to further drive the overall cost reduction, which in turn, accelerates the commercialization of robotaxi.

Supportive policy

- Supportive policy and regulatory environment facilitate the robotaxi commercialization exploration from test demonstration. In November 2021, Beijing became the first city in China to establish the commercial pilot of robotaxi with a published policy to approve operators to charge the public for their robotaxi mobility service. In March 2022, NHTSA finalized Occupant Protection Safety Standards for Vehicle Without Driving Control, which made a historic step to assure the same high level of occupant crash protection is maintained for autonomous driving vehicles that do not have the traditional manual controls associated with a human driver. Major governments including Germany, Japan, South Korea, the United Kingdom, etc., have also released favorable policies to actively establish an industrial and social environment in promoting the continued development of autonomous driving.

Source: Frost & Sullivan

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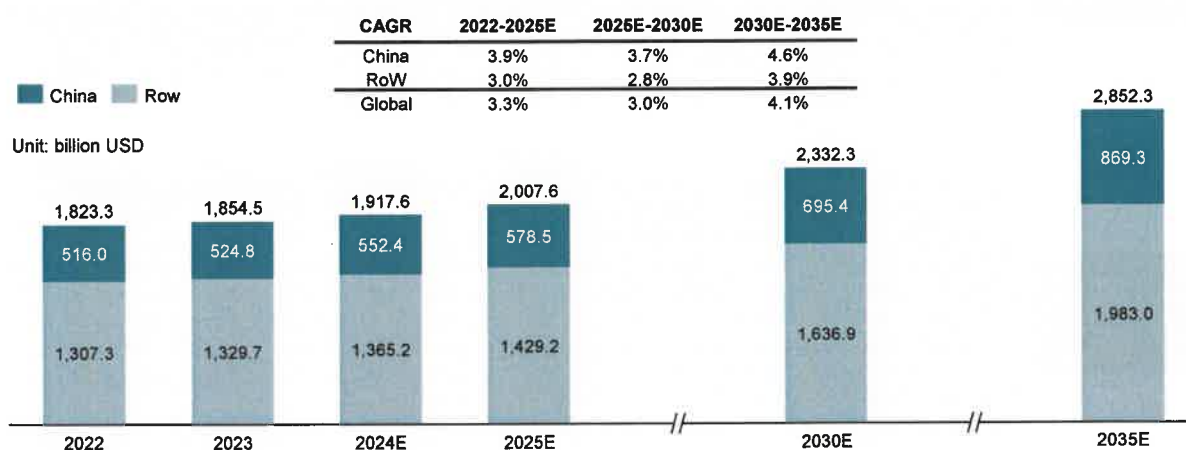
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Overview of Global Robotruck Market

Market Size of Global Long-haul Market

- Freight transportation is a key factor to drive global economic growth. Within the global logistics industry, long-haul trucking is the most commonly used means of transportation between hubs. With the economic growth and continuously development of logistics demand, long-haul trucking is becoming increasingly vital and takes around 70% of the global road freight market. The global long-haul trucking services market size, in terms of GTV, was US\$1,854.5 billion in 2023 and expected to reach US\$2,852.3 billion by 2035.

Market Size of Global Long-haul Market, Breakdown by regions



Note: Long-haul trucking GTV refers to the total transaction amount of the long-haul trucking transportation services.

Overview of Global Robotruck Market

Pain Points of Traditional Truck Freight Market

- Currently, the truck freight industry is facing substantial challenges in several areas including safety, efficiency, and gas emission. Specific industry challenges include:

HIGH COST

- Labor and fuel costs are the two largest expenses in truck freight, and are rising increasingly faster in recent years, exerting pressure on manufacturers and retailers. Labor and fuel costs currently accounted for 40% and 20% of total expenses of truck freight, respectively.

LABOR SHORTAGE

- Driver shortages and high driver turnover continue to place upward pressure on the availability of reliable truck freight capacity. In the U.S, the industry in 2021 had a record 80 thousand driver shortage, according to the American Trucking Associations (ATA), and long-haul drivers are in especially short supply.
- In addition, thousands of truck drivers are leaving this job every year and the COVID-19 made the driver shortage worse. In China, there are about 30 million truck drivers in the country, but in terms of the speed of logistics development, the gap of truck drivers is increasing.

SAFETY RISK

- A 2016 study by the National Highway Transportation Safety Administration (NHTSA) found that human error accounts for anywhere between 94% to 96% of all auto accidents. Human error like fatigue or blurred vision especially during long-haul truck freight often leads to severe accidents resulting by long hours of driving or extreme weather condition, increasing safety risks of human drivers and economic losses of assets

Source: Frost & Sullivan

Overview of Global Robotruck Market

Definition and Benefits of Robotruck

Definition

- Robotruck refers to an autonomous truck built-in with Level 4 and Level 5 autonomous driving technology to achieve driverless freight transportation. Robotruck has superior advantages in contrast with traditional truck.

Benefits

- ◆ Human error accounts for anywhere between 94% to 96% of all auto accidents. By removing human error, Robotruck offer relatively stable driving experience even in extreme weather conditions and can endure long hours of driving without break. Complete set of autonomous driving technologies are available to provide Robotruck with the ability to monitor potential barriers or obstacles on right directions from hub-to-hub freight transportation. The autonomous technology in trucking will significantly reduce the number of accidents caused by distracted or fatigue, regimenting safer driving routines and operating more predictably.
- ◆ Labor and fuel costs are the two largest expenses in truck freight, and are rising increasingly faster in recent years, exerting pressure on manufacturers and retailers. Labor and fuel costs currently accounted for 40% and 20% of total expenses of truck freight, respectively. Cost of Robotruck is significantly lower as compared to traditional truck. Besides, through digitalizing the whole freight transportation network including the deployment and operation of Robotruck, the fuel cost can be optimized through reasonable and efficient planning, making the truck freight market more sustainable and cost-effective.

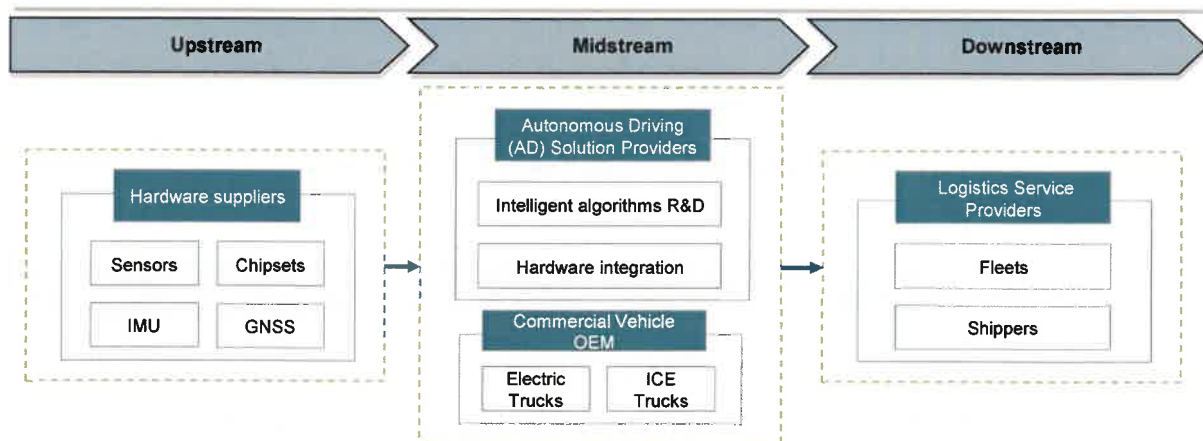
Source: Frost & Sullivan

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Overview of Global Robotruck Market

Robotruck Stakeholder Introduction



- Hardware suppliers can provide necessary sensors (lidar, radar, camera), chipsets, IMU, GNSS and etc. to AD Solution Providers.
- AD Solution Providers are responsible for developing driverless-level AD technology through Intelligent algorithms R&D and Hardware integration. Currently, most AD Solution Providers purchased vehicles from OEMs and then make modifications. In the future, with in-depth cooperation with OEMs, AD Solution Providers tend to outsource the vehicle modification to OEMs, so that the hardware integration and algorithms build-in can be achieved at the vehicle production phase, which so-called pre-installed vehicle.
- The downstream applications can be compromised by two main models: one is the AD company partners with truck OEMs to develop an integrated hardware and software solution alongside OEMs to fleets; or the AD company acts as a fleet, by operating its own vehicles and responsible for logistics services to shippers.

Source: Frost & Sullivan

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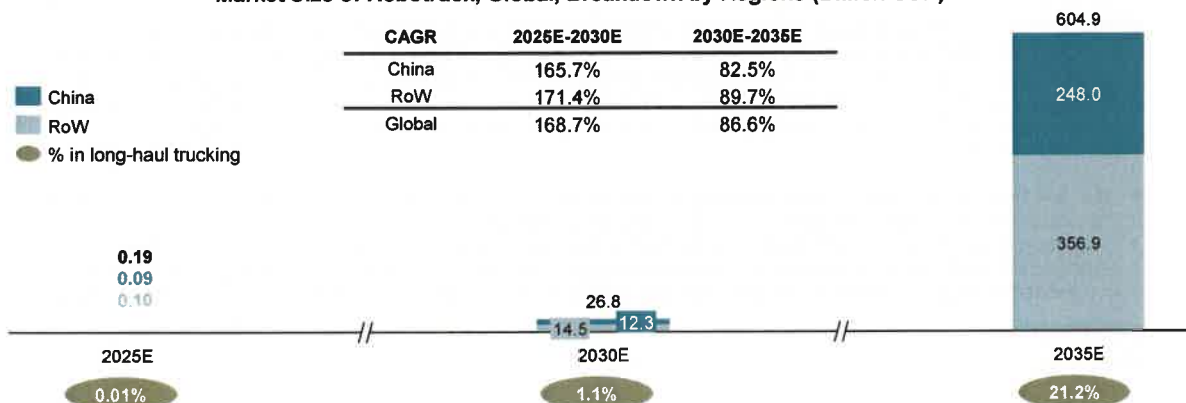
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Overview of Global Robotruck Market

Global Robotruck Market Size, by Regions

- Robotruck refers to a driverless truck with built-in autonomous driving technology to achieve driverless freight transportation. Robotruck has superior advantages in contrast with traditional truck especially for the long-haul trucking considering its transportation application scenarios are mainly from hub to hub. The global long-haul trucking market will witness a trend of increasing penetration of robotruck since it can solve the driver shortage and safety issue with lower cost. According to the Frost & Sullivan Report, due to the increasing demand and technical maturity, the global robotruck market is estimated to reach US\$0.19 billion by 2025, US\$26.8 billion by 2030 and US\$604.9 billion by 2035.

Market Size of Robotruck, Global, Breakdown by Regions (Billion USD)



Note:

(1) Robotruck services market size represents total amounts of logistics fare paid by customers (such as logistics companies) for robotruck services, as measured by the GTV of such services.

(2) % in long-haul trucking refers to the share of the global robotruck market size in the long-haul trucking market.

Overview of Global Robotruck Market

Robotruck Car Parc

Global Car Parc of Robotruck, Breakdown by Regions

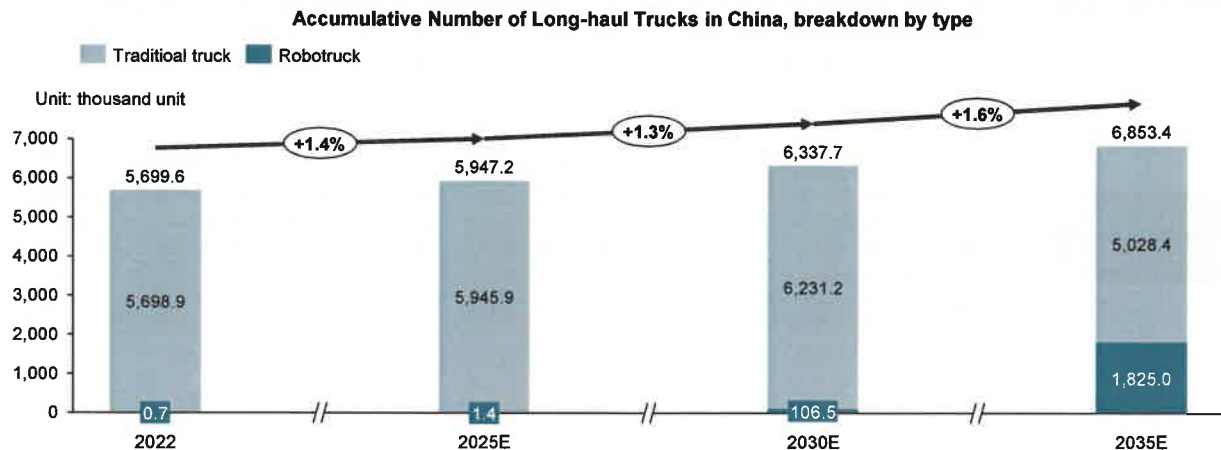
Unit: Thousand

		2024E	2025E	2026E	2027E	2028E	2029E	2030E	2035E
Robotruck	China	1.06	1.36	1.75	2.27	3.33	6.80	106.50	1,825.00
	Overseas	1.06	1.45	1.94	2.52	4.86	9.45	126.08	2,626.22

Overview of Global Robotruck Market

Accumulative Number of long-haul trucks in China

- China develops the world's longest network of highways and the largest size of heavy-duty truck fleet. Currently, around six million trucks are dedicated to long-haul freight transportation in China, and the number is expected to grow to seven million by 2035. Robotrucks have the potential to address labor shortage issue and excessive operating costs. In addition, compared with traditional trucks, robotrucks' superior route planning and fleet dispatching capabilities enable logistics companies to enhance operational efficiency and generate higher income. Upon deployment, robotrucks will swiftly emerge as a pivotal cost-saving and efficiency-boosting option for logistic fleets, and establishing themselves as the premier choice for new vehicle procurement or replacement. As the penetration rate of robotrucks steadily rises, robotrucks will comprise a substantial share of the long-haul logistics trucking fleet and perform a greater volume of freight transport duties. The robotruck services market in China is expected to expand to \$12.26 billion by 2030, and further grow to reach \$248.02 billion by 2035, representing approximately 28.5% of China's long-haul trucking market.



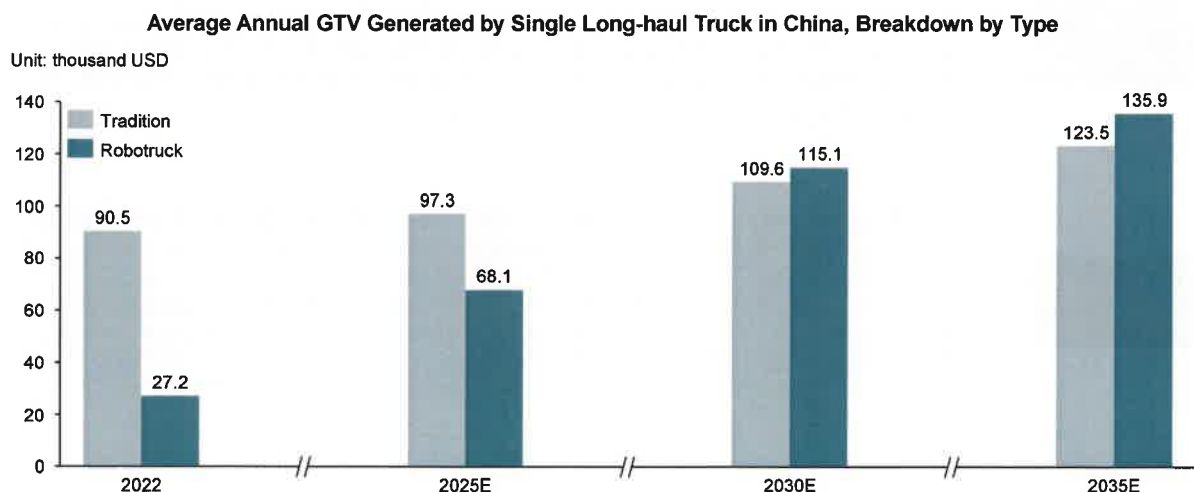
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Overview of Global Robotruck Market

Average Annual GTV Generated by Single Long-haul Truck in China

- In 2022, the average GTV (Gross Transaction Value) of China's mainline trucks is about \$90.5 thousand, and it is expected to slightly increase in the future. Due to limited operating areas and time, the GTV of Robotruck's single vehicle is only \$27.2 thousand. However, as Robotruck is commercially deployed and scaled up, its operating range and efficiency will surpass that of traditional trucks, thus creating a larger GTV per vehicle. It is expected that by 2035, the single vehicle GTV of Robotruck can reach \$135.9 thousand.



Source: Frost & Sullivan

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Overview of Global Robotruck Market

Market Drivers and Future Trends of Robotruck Market

- Robotruck has promising market prospect and is expected to commercialize in the foreseeable future supported by companies with strong autonomous driving technology capability, standardized functions and intelligent logistic network as well as favorable regulatory environment.

Technology Advancement

- By removing human error, robotruck offer safer and more efficient driving experience even in extreme weather conditions and can endure long hours of driving without break. Complete set of autonomous driving technologies are available to provide robotruck with the ability to monitor potential barriers or obstacles on right directions from hub-to-hub freight transportation. The autonomous technology in trucking will significantly reduce the number of accidents caused by distracted or fatigue, regimenting safer driving routines and operating more predictably.

Efficiency Improvement

- Mature autonomous driving technology stack offers a complete set of software and hardware which can be applied to different types of vehicles including robotruck but requires higher caliber on vehicle integration considering its large and more complex physical structure. Companies with strong technology background in software, hardware and vehicle integration will benefit from the development of robotruck and seize the booming market.

Source: Frost & Sullivan

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Overview of Global Robotruck Market

Market Drivers and Future Trends of Robotruck Market

- Robotruck has promising market prospect and is expected to commercialize in the foreseeable future supported by companies with strong autonomous driving technology capability, standardized functions and intelligent logistic network as well as favorable regulatory environment.

Efficiency Improvement

- Robotruck market, as part of truck freight market, will rapidly develop on the back of standard vehicles and established logistic network with fixed hubs. By leveraging mature infrastructure, players in robotruck market are expected to retrofit more standardized functions on vehicles to transport freight and further implement digital management to optimize the overall efficiency of the logistic network to reduce cost and accident rate.

Supportive policy

- Favorable policies and regulations have been promulgated to support development of robotruck market, which promotes efficient logistic network and address the growing concern on truck driver shortage. For example, driverless trucks and autonomous platooning is permitted in California, Florida required a study on the use and safe operation of driver-assistive truck platooning technology, allowing for a pilot project upon conclusion of the study. The Florida Department of Transportation is currently in the process of developing a pilot project to demonstrate driver assistive truck platooning.

Source: Frost & Sullivan

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Licensing and Application Market

Definition of Licensing and Application

Definition

- Licensing and application service refers to that autonomous driving solution providers license out to OEM a suite of comprehensive technical solutions and supportive services designed to enable personally-owned vehicles to achieve advanced autonomous driving capabilities, typically consists of application algorithms, autonomous driving domain controllers and tool chains. The software mainly refers to functional modules and application algorithms for autonomous driving. The autonomous driving domain controllers perform as the central brain of autonomous driving to achieve decision-making. The toolchain assists OEM in achieving the mining, collection, analysis, and maintenance of massive data.

Drivers

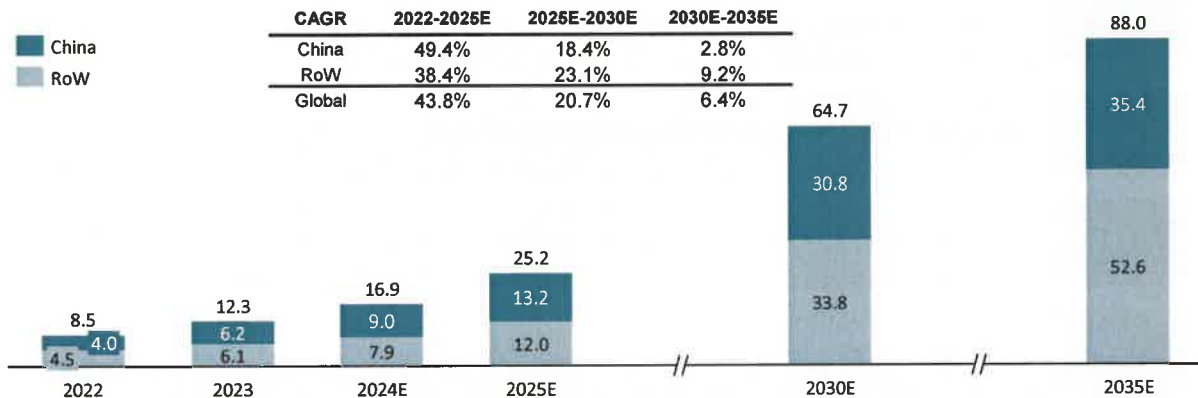
- Autonomous driving technology offers improved safety features and superior user experiences. In 2022, the global autonomous driving industry experienced significant growth, with 17.7 million passenger vehicles equipped with ADAS (level 2 & level 3 autonomous driving) capabilities sold worldwide, achieving a penetration rate of 25.8%. As the electrification of automobiles continues to progress, China has emerged as a leading contributor to the development of ADAS technology and expansion of ADAS vehicle market. China's sales of 7.4 million level 2 autonomous driving passenger vehicles in 2022 accounted for a 31.5% penetration rate. It is projected that by 2025, 2030, and 2035, the ADAS penetration rates will increase to 64.5%, 83.2%, and 85.7%, respectively.
- Level 2+/++ denotes an advanced level 2 autonomous driving technology capable of performing more complex driving tasks. For instance, Navigate on Autopilot (NOA) is a typical level 2++ feature that enables vehicles to drive automatically from the start to the endpoint by following a driver-set navigation route, offering a driving experience that approaches level 3 autonomous driving. Fueled by technological advancements and the ability to significantly enhance the driving experience, vehicles equipped with level 2+/++ features embrace significant growth in 2022.

Licensing and Application Market

Market Size of Licensing and Application

- With the rapid development of the intelligent automotive market, the Licensing and Application market has also entered an explosive period, creating an urgent demand in the automotive market for technology suppliers and service providers who can offer complete and advanced autonomous driving solutions.
- The expansion of the licensing and application market is closely tied to the growth of autonomous driving vehicle sales. In 2023, the global licensing and application market was valued at US\$12.3 billion, and is projected to reach US\$25.2 billion, US\$64.7 billion, and US\$88.0 billion by 2025, 2030, and 2035, respectively. Driven by rapid popularity of level 2 vehicles and the potential to be the first region to achieve large-scale application of high-level autonomous driving, China's licensing and application market is expected to take a considerable share of the global market. As of 2023, licensing and application market in China has reached US\$6.2 billion, accounting for 50.8% of the global market share. It is expected that China market will grow to US\$13.2 billion by 2025, accounting for 52.5% of the global market share. Then the market is projected to reach US\$30.8 billion, and US\$35.4 billion by 2030, and 2035, respectively.

Licensing and Application Market, Global, Breakdown by Regions (Billion USD)



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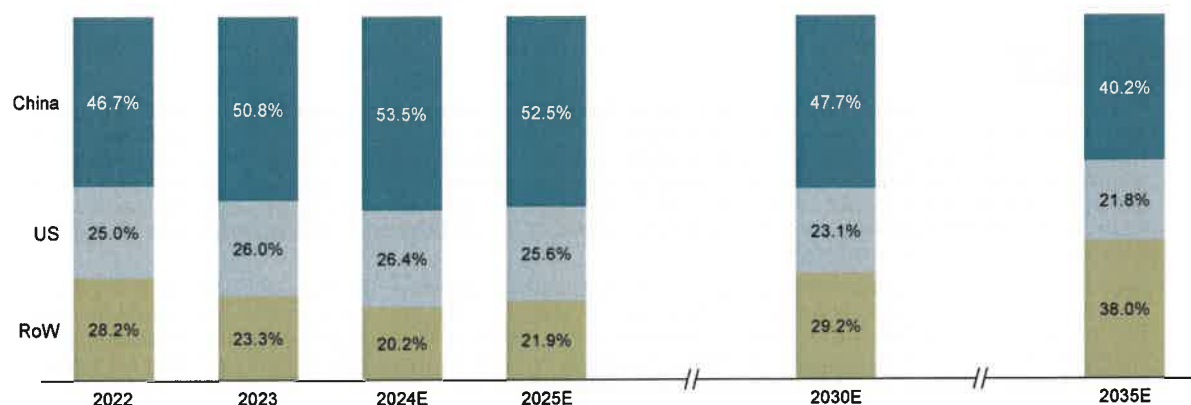
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Licensing and Application Market

Definition of Licensing and Application

- China has the highest sales volume of L2 passenger cars globally, and Chinese OEMs are actively pursuing higher-value L2+/++ solutions, which has made China the largest licensing and application market in the world. In 2023, China held 50.8% of the global market, and it is expected to hold 52.5% of the global market by 2025. However, as other regions of the world make progress in autonomous driving technology, improve the industry chain, and increase related vehicle sales, China's share of the global market will gradually decline. By 2035, China is expected to hold 40.2% of the global market.

Licensing and Application Market Share, Global, Breakdown by Regions



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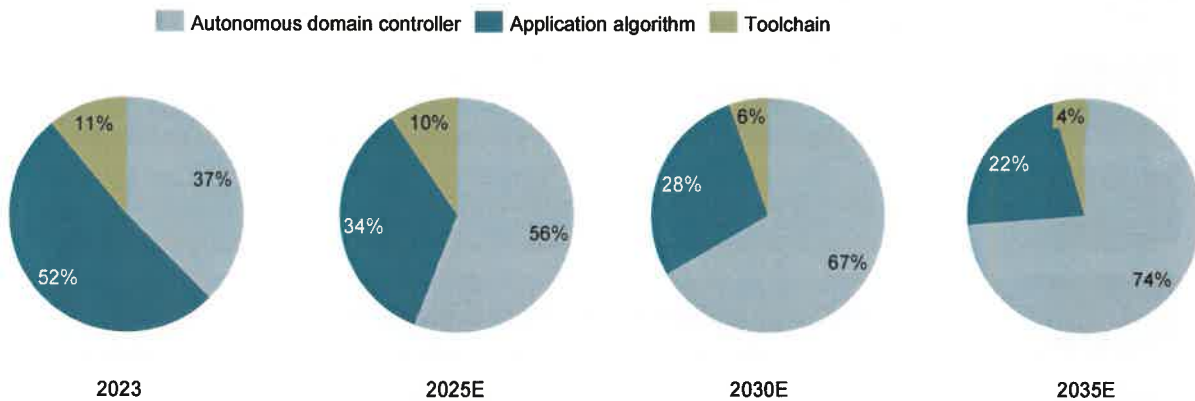
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Licensing and Application Market

Market Size of Licensing and Application

- In 2023, application algorithms held a 52% share in the licensing and application market. The main reason for this is that most application algorithms are currently based on the front camera module rather than the domain controller. However, the automotive electronic and electrical architecture is becoming one of the most important trends, shifting from traditional distributed systems to domain-centered systems. The domain controller market is expected to rapidly expand in the future and become the absolute dominant force in the licensing and application market. By 2030 and 2035, it is expected that domain controllers will account for about 70% of the licensing and application market.

Market Structure of Licensing and Application, Breakdown by Products



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Overview of Autonomous Driving Licensing Market

Market Drivers and Future Trends of Licensing

- Autonomous driving licensing market is expected to take a unique position in autonomous driving application market on an upward trend, mainly driven by the following factors.

Rapid adoption of AD functionality

- The rapid adoption of autonomous driving functionality and the fast expansion of the licensing and application market worldwide are driven by the improvement of autonomous driving chip performance, advancement of sensor capabilities, cost reduction of hardware, and progress in algorithms. On one hand, these developments lead to comprehensive cost reductions and enable incorporation of rich level 2 features into mid-end to entry-level vehicle models. On the other hand, high-end vehicles are actively promoting level 2+/++ features, especially in China, where OEMs are accelerating the launch of NOA features. Moreover, with the advent of commercialized driverless technology in the future, there is a potential for sales growth of personally-owned vehicles built-in with level 4 autonomous driving technology, heralding a new growth opportunity for licensing and application market.

R&D outsource

- Technological difficulty and long-term investment encourage OEMs to outsource autonomous driving technology development. Advanced autonomous driving technology realization is complex and systematic engineering with high technological barriers, requiring constant R&D and capital investment in the long term. Just as in the current automotive industry, OEMs outsource most parts and technologies to low-tier suppliers, and most OEMs in the future are unlikely or incapable to develop autonomous driving technology internally. On the back of pursuing advantages of development cost and period, automakers are expected to have a strong motivation to purchase autonomous driving licensing services to enhance their competitiveness in the car sales market.

Source: Frost & Sullivan

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Competitive Landscape of Robotaxi and Robotruck Market

DMV Road Test Statistics

- In order to encourage innovation and gain a better understanding of both the efficiency and the limitations of autonomous vehicles, the Department of Motor Vehicles (DMV) started testing autonomous vehicles in 2014 under the Autonomous Vehicle Tester (AVT) Program. Autonomous vehicle manufacturers that are testing vehicles in the program are required to submit annual reports to share how often their vehicles disengaged from autonomous mode during tests. Below are information for top ten companies in terms of the Total testing mileage in 2022.

Ranking	Company	Testing Fleet Size	Total testing mileage (miles)	Total times of Disengagement	MPI
1	Waymo	384	2900144	170	17059
2	Cruise	350	863122	9	95900
3	ZooX	105	552133	21	26290
4	Pony	34	280413	20	14020
5	Apple	48	125096	5982	21
6	Nuro	19	94983	15	6333
7	Veride	14	64561	3	21533
8	Benz	38	52976	38	1395
9	AutoX	15	49314	1	49300
10	DiDi	10	38265	2	19150

Note:

1. Disengagement refers to that the test driver/operator take manual control of the vehicle to operate safely because of technology failure or emergency situations.

2. MPI refer to miles per disengagement, which calculated by total testing mileage divided by total times of disengagement.

Source: Frost & Sullivan

Competitive Landscape of Robotaxi and Robotruck Market

Competitive Landscape of Robotruck Companies

	Pony.ai	TuSimple	Plus.AI	Aurora
Operation Region	China	U.S., China	U.S., China	U.S.
OEM Partnership	SANY FAW Group	Traton Penske	FAW Group IVECO	Paccar Volvo Toyota
Logistics Partnership	Sinotrans Limited	U.S.Xpress Penske	Full Truck Alliance Amazon	Uber Freight Werner
Hardware Partnership	Hesai Technology	Navistar	Aeva NVIDIA	Denso
Business Model	/	Subscription Service Self-operated fleet	Subscription Service	Subscription Service
Fleet Size	~140 (including L2+/++)	~120	~150	~20

Note: Estimated data as of 2023.3.

Source: Frost & Sullivan

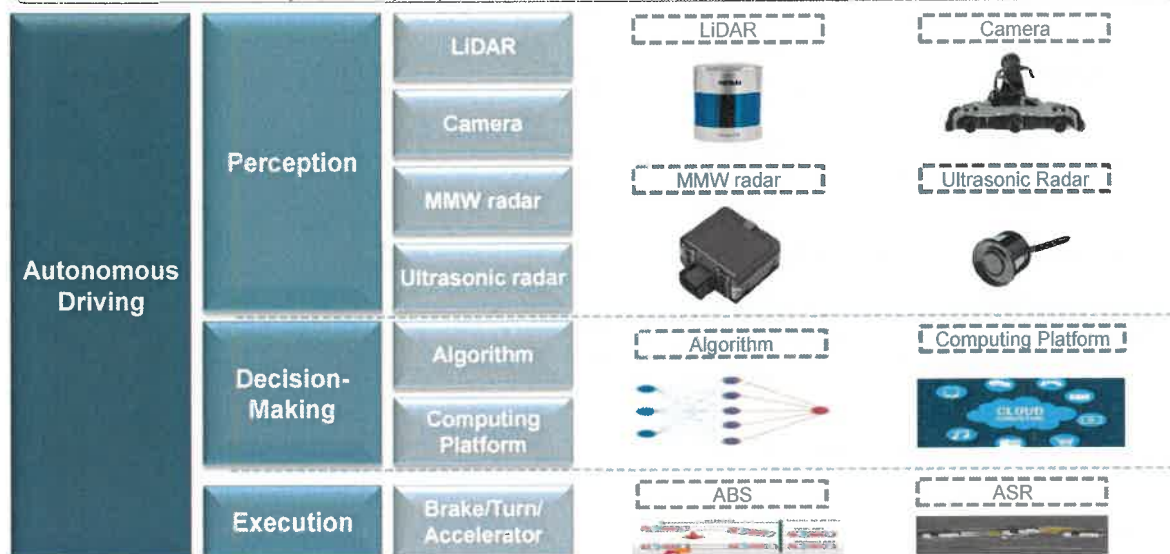
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Appendix.A

Sensors Mainly Used for Autonomous Driving

- From a theoretical perspective, the autonomous driving system which consists of sensors, controllers and actuators, simulates human driving mode, and corresponds to three functional modules, namely perception, decision-making and execution.
- The sensors on the perception of autonomous driving typically include LiDARs, cameras, MMW (Milli Meter Wave) radars and ultrasonic radars.
- With continued advancements in sensor technologies especially LiDAR, autonomous driving technologies will be developed faster and achieve mass production quickly.



Source: Frost & Sullivan

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Appendix.B

Introduction of Main Sensors

LiDAR

- LiDAR is a system that emits laser beams to detect targets. LiDAR transmits a detection signal (laser beam) to the target, and then compare the received signal (target echo) from the target with the transmitted signal. The relevant information of the target such as range reflectivity velocity can be obtained directly. The wavelength used by LiDAR is between 250nm and 11μm. Since the laser beam has a small divergence angle and good coherence, LiDAR can achieve a high resolution and has a unique advantage for detecting small objects.

Camera

- And as primary sensors in visual image processing systems, cameras are common used in autonomous driving systems. However, cameras cannot directly measure velocity and depth, which are essential for perception. To break this limitation, the OEMs and Tier-1 suppliers have developed many additional components and algorithms which bring increasing costs, and such algorithms sometimes can cause errors which may miss the objects. Another problem with cameras is its sensitiveness to ambient light interference. Cameras only accept external visible light information, so when the environment gets too dark or too bright the cameras may fail in recognizing external objects.

MMW radar

- MMW radar was used in the military field, and gradually spread to the automotive with the decrease of cost. The advantages of millimeter wave radar are small size, light weight, long detection range, strong obstacle recognition ability, night work ability and strong adaptability to bad weather. At present, millimeter-wave radars used in vehicles are mainly divided into 24GHZ, 60GHZ and 77GHZ, among which 77GHZ millimeter-wave radars have better performance and smaller size.

Ultrasonic radar

- Ultrasonic radar measures the distance by calculating the time between the emitting and receiving of ultrasonic waves. Ultrasonic radar has a low cost, a detection range of 0.1-3 meters, and high accuracy. Therefore, it is mainly used for low-speed and close-range functions such as parking assistance and blind spot monitoring in autonomous driving.

Source: Frost & Sullivan

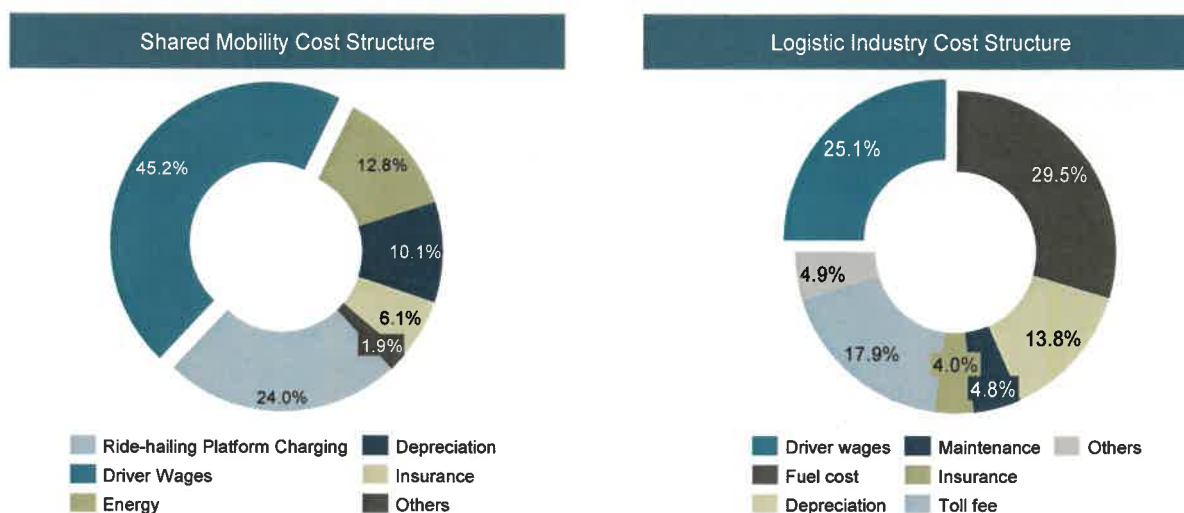
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Appendix.D

Cost Structure Analysis of Traditional Shared Mobility and Truck Freight

- In terms of cost structure of traditional shared mobility and truck freight, the labor cost are noteworthy. The labor wages accounted for 45% and 25% of the total operation cost for shared mobility and truck freight, respectively



Note: Logistic Industry refers to truck freight industry.

Source: Frost & Sullivan

Appendix.E

- Pony was among the first to offer fare-charging, public-facing robotaxi services. Pony was among the first in China to obtain licenses to operate fully driverless vehicles in all four tier 1 cities in China.
- With regulatory endorsement and technological leadership, Pony was among the first to offer fare-charging public-facing robotaxi services with safety drivers in China and was among the first in China to obtain licenses to operate fully driverless vehicles in all four tier 1 cities in China.
- Pony was among the first to offer fare-charging public-facing robotaxi services with safety drivers in China and was among the first in China to obtain licenses to operate fully driverless vehicles in all four tier 1 cities in China. Pony is the only autonomous driving company in China that has obtained licenses to operate fully driverless vehicles in Beijing and Guangzhou.
- Users' demands for mobility services during rush hours in a day account for a vast majority of the day, and taxi fare usually increases by 30% to 50% in adverse weather conditions.
- Pony is the global leader in achieving large-scale commercialization of autonomous mobility.
- According to China international freight forwarders association (CIFA), Sinotrans is the China's largest freight logistics company in 2022, in terms of revenue.
- In December 2022, Pony was one of the two robotaxi operators (Pony and Baidu) to further receive a fully driverless autonomous vehicle road testing permit in Beijing.
- In December 2020, Pony became the first to receive the autonomous truck testing license in Guangzhou.
- Pony has established an industry-leading infrastructure for our simulation system, which guarantees the reproducibility of cases encountered during our public road testing within the simulation environment.
- In August 2023, Pony became the first and only autonomous driving technology company to receive a permit in Shenzhen for operating public-facing robotaxi services without safety drivers in Shenzhen's core commercial area, Qianhai.

Appendix.F

1. Obtaining a regulatory permit represents a critical milestone of an autonomous driving company's technological and operational readiness towards commercialization. In China, local regulators have established rigorous, comprehensive criteria to ensure the safety and commercial viability of autonomous vehicles before granting permits for road testing and commercial operations. These criteria take into account a wide range of highly specialized and technical metrics and indicators, including the proportion of autonomous driving mileage, critical intervention and accident rate performances, simulation and other road testing results, the quality of safety drivers and remote control / assistance capabilities, contingency plans, and the number of passenger orders. By carefully evaluating these factors, regulators assess the technological and operational readiness of autonomous driving companies to safely and effectively operate vehicles on public roads. Therefore, the regulatory permit review and approval process serves as a critical safeguard to ensure that only the most advanced and reliable autonomous driving technologies are allowed to be tested and deployed on public roads.
2. The development of autonomous driving technology heavily relies on data and involves multiple stages, such as data analytics, data mining, code development, data labeling, model training, simulation-based evaluation, continuous integration/continuous delivery (CI/CD), and feature release.

Appendix.G

Market Opportunities

The global autonomous driving market has been growing rapidly driven by technological advancement and innovation. In particular, China has emerged as a significant market for autonomous driving solutions with the rise of electric and intelligent vehicles. The regulatory endorsements, technology enablers as well as increasing customer acceptance have significantly accelerated the development and penetration of autonomous driving in China. China is the best starting place for us to drive the future of autonomous driving given its massive market and the potential to spearhead the large-scale deployment of autonomous vehicles.

The Robotaxi Services Market

The size of the global passenger mobility market in terms of GTV was US\$4.2 trillion in 2022 and is expected to reach US\$4.4 trillion by 2025 and further grow to US\$4.6 trillion by 2030, with a high penetration rate of robotaxi services translating into significant market opportunities, according to Frost & Sullivan. Driven by technological advancement, favorable regulatory environment and improved cost efficiency, robotaxi services are expected to achieve large-scale commercialization in 2025, and gain a considerable market share in the global passenger mobility market in the future. Underpinned by favorable and long-term regulatory tailwinds, increasing penetration of electric and intelligent vehicles as well as increasing market acceptance, China is expected to become the largest market for robotaxi services, with an estimated market size by GTV of US\$0.1 billion in 2025 and US\$69.8 billion in 2030, respectively, accounting for approximately 57.8% of the global robotaxi services market in 2030.

The Robotruck Services Market

The size of the global long-haul trucking market in terms of GTV was US\$1.8 trillion in 2022 and is expected to grow to US\$2.0 trillion by 2025 and further expand to US\$2.3 trillion by 2030, according to Frost & Sullivan. Driven by the increasing needs for safety and efficiency, robotruck services are expected to achieve commercialization at scale in 2024 with a high level of customer acceptance and technological maturity. Sophisticated road transportation infrastructure provides a strong foundation for the rapid growth of China's robotruck services market, with its market size by GTV expected to reach US\$0.2 billion in 2025 and US\$57.7 billion in 2030, respectively, accounting for 36.1% of the global robotruck services market in 2030.

The Licensing and Applications Market

The size of the global licensing and applications market for autonomous driving was US\$8.5 billion in 2022 and is expected to grow to US\$23.8 billion by 2025 and further expand to US\$56.5 billion by 2030, according to Frost & Sullivan. Driven by the popularity of Level 2 autonomous vehicles, China has emerged as a leading contributor to the global licensing and applications market and will continue to drive the growth, with its market size expected to reach US\$12.2 billion by 2025 and US\$27.3 billion by 2030, respectively, accounting for 48.3% of the global licensing and applications market in 2030.

Appendix.H

1. In January 2024, Pony obtained the first-ever robotruck road testing permit with safety drivers for cross-provincial truck transport between Beijing and Tianjin.
2. Built upon their extensive industry expertise and robust partnerships, Pony distinguish themselves as the sole autonomous driving technology company that designs and manufactures their autonomous vehicles, integrating with auto-grade, factory-installed sensors and hardware.
3. Pony was among the first in China to obtain licenses to operate fully driverless robotaxis in all four tier 1 cities in China (namely Beijing, Shanghai, Guangzhou and Shenzhen), and Pony was the only autonomous driving technology company that has obtained all available regulatory permits essential for providing public-facing robotaxi services within these tier 1 cities.
4. Pony is the only autonomous driving technology company to secure all available regulatory permits essential for providing public-facing robotaxi services in all four tier-1 cities in China.
5. With all available regulatory permits essential for providing public-facing robotaxi services received in all four tier-1 cities in China, namely Beijing, Shanghai, Guangzhou and Shenzhen, Pony is the frontrunner in advancing commercialization of public-facing robotaxi services in China.
6. Users' demands for mobility services during rush hours account for the vast majority of the day, and taxi fare usually increases by 30% to 50% in inclement weather conditions.
7. Pony was among the first to offer fully driverless fare-charging, public-facing robotaxi services with substantial safety benefits and compelling passenger experience.
8. With regulatory endorsement and technological leadership, Pony was among the first to offer fare-charging public-facing robotaxi services without safety drivers in China.
9. In December 2020, Pony was the first to obtain the robotruck road testing permit in Guangzhou. In July 2021, Pony expanded their road testing footprints to include Beijing and were allowed to test their robotrucks on national open highways. In January 2024, Pony received the very first cross-provincial robotruck road testing permit in China, and began testing on the highway freight network across the Beijing-Tianjin-Hebei region.

Appendix.I

1. "tier 1 cities" refers to Beijing, Shanghai, Guangzhou and Shenzhen.
2. "tier 2 cities" refers to 31 cities classified by the National Bureau of Statistics, such as Hangzhou, Chengdu, and Wuhan.
3. "tier 2 cities" refers to Tianjin, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Dalian, Changchun, Harbin, Nanjing, Hangzhou, Ningbo, Hefei, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Zhengzhou, Wuhan, Changsha, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, Urumqi.
4. The global passenger mobility market size was US\$4,417.0 billion in 2023 and expected to reach US\$5,083.5 billion by 2035. In 2023, China accounted for 32.0% of the global market share.
5. As of 2023, China's private car ownership rate was 184 per thousand people, compared to 793 in the U.S.
6. In 2023, China's shared mobility market accounted for around 40% of the global market and was approximately twice the size of the U.S. market.
7. Driven by technological advancement, supportive policies, and falling hardware costs, robotaxi is expected to realize commercialization around 2026.
8. It is expected that around 2030, robotaxi services will enter a mature stage of commercialization with deployment in major regions worldwide.
9. large-scale commercial deployment of robotaxi in China is projected to commence as early as 2026.
10. With continuous increase in production capability and unparalleled advantages in terms of cost, affordability, and efficiency, the deployment scale of robotaxi is expected to rapidly expand around 2030.
11. Among all cities in China, tier 1 cities, including Beijing, Shanghai, Guangzhou, and Shenzhen, are major places to develop robotaxis initially.
12. With the growth of robotaxi services, the number of traditional taxis and ride-hailing vehicles will gradually decrease.

Appendix.J

The Robotaxi Services Market

The size of the global passenger mobility market in terms of GTV was US\$4.4 trillion in 2023 and is expected to reach US\$4.5 trillion by 2025 and further grow to US\$4.7 trillion by 2030, with a high penetration rate of robotaxi services translating into significant market opportunities, according to Frost & Sullivan. Driven by technological advancement, favorable regulatory environment and improved cost efficiency, robotaxi services are expected to achieve commercialization around 2026, and gain a considerable market share in the global passenger mobility market in the future. Underpinned by favorable and long-term regulatory tailwinds, increasing penetration of electric and intelligent vehicles as well as increasing market acceptance, China is expected to become the largest market for robotaxi services, with an estimated market size by GTV of US\$0.2 billion in 2025 and US\$39.0 billion in 2030, respectively, accounting for approximately 58.5% of the global robotaxi services market in 2030, according to Frost & Sullivan.

The Robotruck Services Market

The size of the global long-haul trucking market in terms of GTV was US\$1.9 trillion in 2023 and is expected to grow to US\$2.0 trillion by 2025 and further expand to US\$2.3 trillion by 2030, according to Frost & Sullivan. Driven by the increasing needs for safety and efficiency, robotruck services are expected to achieve commercialization at scale in 2024 with a high level of customer acceptance and technological maturity. Sophisticated road transportation infrastructure provides a strong foundation for the rapid growth of China's robotruck services market, with its market size by GTV expected to reach US\$0.09 billion in 2025 and US\$12.3 billion in 2030, respectively, accounting for 45.8% of the global robotruck services market in 2030, according to Frost & Sullivan.

The Licensing and Applications Market

The size of the global licensing and applications market for autonomous driving was US\$12.3 billion in 2023 and is expected to grow to US\$25.2 billion by 2025 and further expand to US\$64.7 billion by 2030, according to Frost & Sullivan. Driven by the popularity of Level 2 autonomous vehicles, China has emerged as a leading contributor to the global licensing and applications market and will continue to drive the growth, with its market size expected to reach US\$13.2 billion by 2025 and US\$30.8 billion by 2030, respectively, accounting for 47.7% of the global licensing and applications market in 2030, according to Frost & Sullivan.

Appendix.K

1. The robotruck services market in China is expected to expand to US\$12.3 billion by 2030, and is expected to further grow to reach US\$248.0 billion by 2035, representing approximately 28.5% of China's long-haul trucking market.
2. The number of robotrucks in China is expected to reach 106.5 thousand in 2030, and further to 1,825.0 thousand in 2035. And the number of robotrucks overseas is expected to reach 126.1 thousand by 2030, and further to 2,626.2 thousand by 2035.
3. In 2023, the global autonomous driving industry experienced significant growth, with 22.4 million passenger vehicles equipped with ADAS capabilities (namely, Level 2 and Level 3 autonomous driving features) sold worldwide, achieving a penetration rate of 31.0%.
4. China's sales of 11.0 million Level 2 autonomous driving passenger vehicles in 2023 accounted for 42.1% penetration rate.
5. In 2023, licensing and applications market in China reached US\$6.2 billion, accounting for 50.8% of the global market share. It is expected that the China market will grow to US\$13.2 billion by 2025, accounting for 52.5% of the global market share.