

## Abstract

In April 2021, Waymo's CEO and CFO left the company. In addition, the Chief Safety Officer, head of manufacturing and global supply and general manager of Laser Bear LiDAR business, head of Automotive Partnerships and Corporate Development have also resigned since late 2020.

Waymo's L4 development model has been set back. Its efforts to develop L4 with the model of "refitted vehicles—road test data collection—trial operation" hit a bottleneck, while companies like Tesla, Mobileye and Momenta adopt the widely-accepted "shadow model" where the data collected by L2 mass-produced vehicles are used to train a L4 algorithm model.

Except for few companies like Waymo and Uber which perform worse than expected, L4 autonomous driving firms in other fields gain momentum. Favored by capital in 2021, they make big strikes in technology and cost reduction, making a thriving market. As the saying goes, a thousand sails pass by the wrecked ship, and ten thousand saplings shoot up beyond the withered tree. L4 autonomous driving firms are in capital's good graces.

During 2020-2021, the global L4 autonomous driving industry has seen a turning point: bellwethers such as Waymo and Cruise vie for more competitive edges in Robotaxi; Uber sold its autonomous driving business to Aurora and invested USD400 million in it; technology giants like Huawei and Baidu deploy dimension reduction application of L4 autonomous driving for commercialization; WeRide and Didi Woya each have raised hundreds of millions of US dollars in 2021.

Although several of its executives have left since 2021, Waymo still raised USD2.5 billion in a new round funding in June 2021. Moreover, GM Cruise has also raised USD2.75 billion in 2021. After bouncing several times, Origin, GM Cruise's first autonomous robotaxi design, is projected to enter volume production in early 2023.



## Abstract

In 2021, L4 start-ups usher in a funding boom. TuSimple, a Chinese autonomous truck manufacturer listed its shares in the US, which took its market capitalization to more than USD10 billion. The sought-after company announced to secure orders for 6,500 units of its autonomous trucks. Its domestic peer PlusAl was listed on the New York Stock Exchange by way of special purpose acquisition company (SPAC). This signals L4 autonomous driving companies have been in the new phase of rapid development. There will be more L4 autonomous driving companies going public.

Company	Time	Amount	Investor(s)		
Waymo	Jun. 2021	USD2.5 bn	Andreessen Horowitz, AutoNation, Canada Pension Plan, Fidelity Investments, Magna, Mubadala Investment, Perry Creek Capital, Silver Lake Partners, T. Rowe Price Group, Temasek and Tiger Global		
ZongMu Technology	Jun. 2021	USD190 mln	D1 funding round led by Denso, D2 led by Cowin Capital and Highland Capital Partners, D3 led by Xiaomi Yangtze River Industry Fund		
Holomatic Technology	Jun. 2021	Unknown	Tongfang Investment (leading investor); Yulin Investment under Beautiful Year Investment Group, the old shareholder NavInfo, etc. (co-investors)		
Didi Woya	May 2021	USD300+ mln	USD200 mln invested by GAC Group (GAC Group directly invested USD100 mln and a fund under GAC Capital invested USD100 mln)		
WeRide	May 2021	Hundreds of millions of US dollars	IDG Capital, Hetral Creative, Costone Capital, Cypress Star, Sky9 Capital, K3 Ventures, etc.		
	Jan. 2021	USD310 mln	Yutong Group (leading investor); CMC Capital, China Development Bank Equipment Manufacturing Industrial Investment Fund, Hengjian Emerging Industries Fund, Huajin Capital, Flower City Ventures, etc. (co-investors)		
Autowise.ai	May 2021	RMB120 mln	SkyChee Ventures (leading investor)		
ECAR	May 2021	Tens of millions of yuan	SkyChee Ventures		
Maxieye	May 2021	RMB150 mln	Fosun Capital (leading investor); TSARI Capital (co- investor); Sharewin Capital, Zhangjiang Haocheng Venture Capital, Zhangjiang Science & Technology Investment, Lu'an Yuke Innovation Incubator, etc. (old shareholders investing for share increase)		
TuSimple	Apr. 2021	IPO	Issue price: USD40.00, expected to raise USD1.35 bn		
Cruise	Apr. 2021	USD2.75 bn	Volvo		
Momenta	Mar. 2021	RMB500 mln	SAIC, Toyota, Bosch, Temasek Capital, Yunfeng Capital (leading investors); Mercedes-Benz, Tencent, GGV Capital, Xiaomi's Shunwei Capital, Cathay Capital, etc. (co-investors)		
Haomo.ai	Mar. 2021	Hundreds of millions of yuan	Shougang Fund, Meituan, Hillhouse Capital		
QCraft	Mar. 2021	Tens of millions of US dollars			
Pony.ai	Feb. 2021	USD100 mln	Brunei Investment Agency, CPE		
Uisee Technology	Feb. 2021	RMB1 billion	National Manufacturing Transformation and Upgrading Fund set up by the Ministry of Finance of China		
Source: ResearchInChina					

#### Financing in L4 autonomous Driving, 2021



Cost reduction" and "dimension reduction application" bring development opportunities to L4 autonomous driving companies.

Too high cost has been an inevitable practical challenge in commercialization of L4 autonomous driving. The hardware devices for a L4 autonomous vehicle generally include: 6-12 cameras, 3-12 radars, 1-3 LiDARs, 2 GNSSs/IMUs and 2 computing platforms (including the redundant one). As the technology advances, the cost of hardware is on the decline.

On one estimate, the cost of hardware for a set of L4 autonomous driving system of Toyota is RMB40,000 or so. Wherein, the main front LiDAR costs the most, roughly RMB10,000 to RMB15,000; the combined cost of the two side LiDARs stands at RMB5,000 to RMB8,000; that of the 3 ECUs is RMB12,000 to RMB14,000. The dilution of software cost is accompanied by the rising sales.

#### Hardware Cost of Toyota Automated Driving Platform

	Cost	Supplier	Product	
Main Front LiDAR	RMB10,000- RMB15,000/unit	Denso	The level of Valeo second- generation Scala, 16-channel or 32-channel design	
Side LiDAR (2)	RMB5,000- RMB8,000/set	Continental	HFL-110 Flash LiDAR	
ECU (3)	RMB12,000- RMB14,000	Renesas	ADS uses conventional non- deep learning algorithms (namely, deterministic and interpretable algorithms), and ADX is mainly based on deep learning algorithms	
Stereo system and radar	rosoar	Denso	hina com	
IMU	USD10-USD15 (the price of over 5,000 pieces)	ток	IAM-20685 up to ASIL- standard; measuring range gyroscope: ±2949bp accuracy: ±300bps; measurin range of accelerometer: ±16 ±32g to ±65g, accuracy: ±8 ±20g and ±36	

Source: ResearchInChina



In China, Baidu introduced Apollo Moon, its new-generation mass-produced Robotaxi in June 2021, with cost expected to be slashed to RMB480,000, a third of that of current L4 mass-produced autonomous models. The ARCFOX  $\alpha$ T-refitted vehicle adopts the ANP-Robotaxi architecture, and packs 13 cameras, 1 LiDAR, 5 radars and Baidu's self-developed central computing platform with computing force up to 800TOPS.

In July 2021, GAC AION and Huawei launched the cooperative project AH8 model, their first co-developed large-sized intelligent full-electric SUV based on GAC GEP3.0 Chassis Platform and Huawei Computing and Communication Architecture (CCA). The L4 autonomous car is projected to be spawned in late 2023.

As costs go down, we predict RMB300,000 autonomous vehicles with L4 autonomy will come out in the next 2 or 3 years.





At present, L4 autonomous driving technology has yet to mature. Multiple automakers and technology providers have started dimension reduction application. AVP tends to be a key L4 autonomous driving technology deployed on mass-produced vehicles. For example, starting from AVP, Baidu will progressively achieve driving automation of passenger cars in all scenarios.

In January 2021, Weltmeister W6, a Baidu AVP-enabled mass-produced L4 model, rolled off the assembly line. As the world's first model of such kind, the car carries 5 cameras, 12 ultrasonic radars and Baidu's autonomous driving computing platform ACU. The AVP solution consists of just cameras and ultrasonic radars, making its cost available.

In July 2021, Baidu and Great Wall Motor built in-depth cooperation on AVP. They plan to equip WEY Mocha with Baidu AVP that is based on Apollo software algorithms and up to ASIL-B functional safety standard, enabling L4 autonomous parking within visual range. It is predicted that the new model is about to be launched on market in the second half of 2021.

In addition, the auto parts giant ZF also tries hard to deploy AVP, in hope of developing future-oriented autonomous driving technologies with AVP as a starting point. In April 2021, ZF first released its AVP technology which enables automated parking via CalmCar 360° surround view perception and ultrasonic radars; in June, ZF led a USD150 million C round financing for CalmCar. They have forged a strategic partnership to develop a cost-effective AVP system, and plan to use it in mass-produced models of OEMs in China in 2022.

#### L4 autonomous driving for commercial vehicles enters the phase of cross-scenario mass production and application.

The demission of John Krafcik, Google Waymo's CEO, becomes a watershed in the industry. It indicates that it is hard to achieve commercial operation of L4 autonomous driving in real terms by depending on tests and verifications in ideal conditions. Given this, large companies have started developing multi-scenario application solutions to amass data and iterate algorithms in actual operating scenarios.

In the near future, L4 autonomous driving layout will target designated scenarios, especially shared mobility, trunk logistics, autonomous delivery, and (semi-) closed scenarios.

L4 autonomous driving providers are working hard on application of the technology in different scenarios. Examples include Baidu Apollo with technical expertise in Robotaxi, autonomous minibus and autonomous parking, and providers like Waymo and Pony.ai which turn to autonomous logistics and delivery from Robotaxi.



WaymoLayout: provided real robotaxi services in Phoenix in 2020, with a services in Phoenix in 2020, with a service in Phoenix in 2020, with a pratners: Spagar, Renaukt, Nissan- Phriters: Yolvo, Chryster, J.B. Hunt, etc. J.B. Hunt, etc. J.B. Hunt, etc. Artner: VMSLayout: launched a pilot groit with the logistics distribution giant UPS, Warmow Partner: Yolvo, Chryster, J.B. Hunt, etc. Artner: VMSLayout: cooperate with service in 2021Layout: toyage acquired in 2021 has operated low speed up to 25 miles/h) in service Just Partner: Yolvo, Chryster, J.B. Hunt, etc. Artner: VMSLayout: cooperate with Warman to transport parcels Partner: Yolvo, Chryster, Partner: Yolvo, Yoage acquired in 2021 has operated low scottadale, Arizona Partner: Yolvo, Chryster, Partner: Yolvo, Chryster, Partner: Yolvo, Chryster, Partner: Yolvo, Yoage has iterated its wares production during 2022-2023 and scottadale, Arizona Partner: Yolvo, Chryster, Partner: Yolvo, Chryster, Yoage activity in 2021 Partner: Yolvo, Scottadale, Arizona Partner: Yolvo, Scottadale, Arizona Partner: Yolvo, Scottadale, Arizona	Provider	Shared Mobility (Robotaxi)	Trunk Logistics	Autonomous Delivery	(semi-) Closed Scenarios (Ports, Mines, Parks, etc.)
CruiseLayout: Cruise has yet to roll out ride service, and only has a beta version of ride-haling service just penet to its staffs; penet to its staffs; period during 2023-2023 and serve Dubai in 2023UnknownLayout: cooperate with 	Waymo	Layout: provided real robotaxi services in Phoenix in 2020, with a fleet of over 600 robotaxis Partners: Jaguar, Renault-Nissan- Mitsubishi Alliance Already realize commercial operation	Layout: optimistic about the US long-distance autonomous heavy truck market, Waymo decides to develop heavy trucks, offering one-stop services from operation to order receiving. Partners: Volvo, Chrysler, J.B. Hunt, etc. Already start trial operation projects in 2021	Layout: launched a pilot project with the logistics distribution giant UPS, using Chrysler Pacifica autonomous minivan to transport parcels Partner: UPS	Unknown
BaiduLayout: already changsha, etc., Apollo GO is projected to bi implemented in 30 cities in the ext.Layout: forged a close partners: Hongqi, BAIC Arcfox, etc.Layout: forged a close partners: Apollo GO is projected to be implemented in 30 cities in the next three years, with a fleet of 3,000 units.Layout: cooperate with automakers, Tier1s and mobility platforms to deploy robotaxis, having realized commercial partners: Baiyun Taxi Group, etc. Replicate the Guangzhou Business model in Jiangsu, Henan and HubeiLayout: commercial california; the new-generation also been added in the robotaxi also been added in the robotaxi fleetLayout: forged a close forged a close partner: LionbridgeLayout: commercial vehicle smart partner: LionbridgeLayout: downLayout: dual california; the new-generation also been added in the robotaxi also been added in the robotaxi fleetLayout: service and robotaxi also been added in the robotaxi also been added in the robotaxi fleetLayout: service and robotaxi also been added in the robotaxi also been added in the robotaxi fleetLayout: service and the robotaxi also been added in the robotaxi also been added in the robotaxi fleetLayout: service and the robotaxi also been added in the robotaxi fleetLayout: service added in the robotaxi 	Cruise	Layout: Cruise has yet to roll out ride service, and only has a beta version of ride-hailing service just opened to its staffs; Partner: Chevrolet Origin robotaxi will go into mass production during 2022-2023 and serve Dubai in 2023	Unknown	Layout: cooperate with Walmart to use Cruise autonomous vehicles to deliver goods in Scottsdale, Arizona Partner: Walmart	Layout: Voyage acquired in 2021 has operated low speed robotaxi (max. speed: up to 25 miles/h) in retirement communities in San Jose Partner: Ford Voyage has iterated its autonomous vehicles to the third generation, and plans mass production in 2021
WeRide       Layout:       cooperate       with automakers, Tierls and mobility platforms to deploy robotaxis, having realized commercial operation in Guangzhou       Unknown       In 2021, Mini Robous delivers materials in the epidemic lockdown areas in the Liwan District, Guangzhou       Layout: tested and tried to operate autonomous microcirculation minibuses in Guangzhou and Nanjing Partner: Vutong Bus         Pony.ai       Layout: already land robotaxi service in Guangzhou, Beijing and California; the new-generation autonomous vehicle mass- produced in February 2021 has also been added in the robotaxi fleet Partner: Lexus Already achieve commercial       Layout: set up the Truck Division in 2020, and acquired the first autonomous truck test icense issued by Guanzhou at the end of the year; in Already achieve commercial       During the pandemic, california, Guangzhou, etc.       Unknown	Baidu	Layout: already make deployments in Beijing, Cangzhou, Changsha, etc., launching Apollo Moon in 2021, its new-generation Robotaxi Partners: Hongqi, BAIC Arcfox, etc. Apollo GO is projected to be implemented in 30 cities in the next three years, with a fleet of 3,000 units.	Layout: forged a close partnership with Lionbridge, a commercial vehicle smart service platform early in 2018, and team up with various developers and OEMs to develop intelligent trucks and trunk logistics operation solutions Partner: Lionbridge	Layout: during the COVID-19 pandemic, Baidu Apolong provided food delivery service in Beijing; Apollo 3.5-based Ford Transit Cargo Van provides autonomous delivery service; Udelv came into service in Silicon Valley in 2019 Partner: Ford	Layout: Apolong autonomous minibus with end-to-end low speed autonomous driving function is applicable to scenarios such as parks, scenic spots, airports and resorts Partner: King Long
Pony.ai       Layout: already land robotaxi service in Guangzhou, Beijing and California; the new-generation autonomous vehicle mass- produced in February 2021 has also been added in the robotaxi fleet       Layout: set up the Truck Division in 2020, and autonomous truck test license issued by Guanzhou at the end of the year; in Already achieve commercial       During the pandemic, provided autonomous truck test During the pandemic, autonomous truck test provided autonomous etc.       Unknown	WeRide	Layout: cooperate with automakers, Tier1s and mobility platforms to deploy robotaxis, having realized commercial operation in Guangzhou Partners: Baiyun Taxi Group, etc. Replicate the Guangzhou business model in Jiangsu, Henan and Hubei	Unknown	In 2021, Mini Robobus delivers materials in the epidemic lockdown areas in the Liwan District, Guangzhou	Layout: tested and tried to operate autonomous microcirculation minibuses in Guangzhou and Nanjing Partner: Yutong Bus
operation Partner: raw	Pony.ai	Layout: already land robotaxi service in Guangzhou, Beijing and California; the new-generation autonomous vehicle mass- produced in February 2021 has also been added in the robotaxi fleet Partner: Lexus Already achieve commercial operation	Layout: set up the Truck Division in 2020, and acquired the first autonomous truck test license issued by Guanzhou at the end of the year; in March 2021, unveiled a truck brand PonyTron Partner: FAW	During the pandemic, provided autonomous delivery services in California, Guangzhou, etc.	Unknown

#### Multi-scenario Layout Solutions of L4 Autonomous Driving Providers



### Abstract



**Waymo:** by the end of 2020, Waymo has boasted a fleet of more than 600 Robotaxi. In 2021, Waymo plans to introduce a fleet of 100 Jaguar I-PACE autonomous vehicles equipped with the latest fifth-generation software and hardware.

In terms of autonomous commercial vehicles, following its in-depth cooperation with Volvo in 2020, Waymo partnered closely with Fiat Chrysler Automobiles (FCA) to manufacture autonomous commercial trucks, and introduced Waymo Via trucking service tested on roads in two states of the US.



**Motional:** in March 2020, Hyundai and Aptiv set up a joint venture, a L4/L5 autonomous vehicle developer that integrated the resources of NuTonomy. The founding of this joint venture noticeably quickened their pace of deploying autonomous driving.

In October 2020, Motional and Lyft announced the resumption of their self-driving mobility service in Las Vegas; in March 2021, Motional indicated it will select Ambarella CVflow? SoC family for its autonomous vehicles; in June 2021, Motional said it will launch nuPlan, an extended public dataset.



**Pony.ai:** in February 2021, Pony.ai's first Robotaxis with the latest system rolled off its standard production line; in April 2021, Pony.ai upgraded PonyPliot+ Robotaxi service in all aspects; in May 2021, the Robotaxi service was landed in Yizhuang, Beijing.

As for autonomous commercial vehicles, Pony.ai set up its Truck Division in 2020 and acquired its first autonomous truck test license issued by Guangzhou at the end of the year; in March 2021, it introduced its truck brand—PonyTron.



Although the whole highly automated driving industry still faces a range of challenges such immature supply chain, very high cost, not enough safety, and unsound laws and regulations, and needs some time for commercial application in all scenarios, L4 autonomous driving technology is getting rapid upgrade and the overall cost is dropping, which makes the commercial use in designated scenarios an expectation.

Our Global and China L4 Autonomous Driving and Start-ups Report, 2021 highlights the following:

- Autonomous driving industry (main technologies, status quo of autonomous driving test, investment and financing, policies, standards, etc.);
- L4 autonomous driving market (size, competitive pattern, technology trends, etc.);
- Development of L4 autonomous driving technologies (computing platform, high-precision positioning, etc.) in China (technical solutions of providers, mass production plans of OEMs, etc.);
- Implementation of L4 autonomous driving (business models, main application scenarios (Robotaxi, autonomous delivery, etc.), etc.);
- Main Chinese and foreign L4 autonomous driving technology providers (layout, application, etc.).



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