



Autonomous Driving Report

Technology Deep-Dive, Trends, M&A, Future Predictions

November 2022

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Scope of the Report

The revolution of the automobile industry is undoubtedly one of the hottest topics in the past few years. The ongoing electrification of automobiles is not only changing the power source **from gasoline to battery** but reshaping the industry **from mechanics-focused to semiconductor-focused**.

Today, innovation is pivoted around adding intelligence to an automobile's operations, developing and investing in the perception, localisation, planning, decision-making and execution of autonomous vehicles. As such, the autonomous driving industry has become a well funded sector. However, unlike in previous years where the market was filled with upbeat predictions and large corporate transactions; the news is more downbeat with delayed IPOs and the scaling back of initiatives.

This turnaround is partly due to companies confronting the enormous challenge of executing autonomous driving, but also, the hikes in interest rates that add a meaningful cost of capital, forcing investors to seek meaningful financial results. It is inevitable that some companies will fail to remain solvent, failing before achieving meaningful commercial traction. While investments in the industry will likely diminish, we believe this heightened fiscal focus will benefit the long-term health of the autonomous driving industry.

In this report we aim to provide a coherent picture of the current state of the autonomous driving industry from a long-term perspective; **covering policies, technology, the major players, investments and M&A activities**, while sharing RCL's views on the future trajectory of this industry.

The autonomous driving industry still requires a significant amount of innovation at the system-level from both a hardware and software perspective. In our analysis of the start-up landscape, we mainly focus on system-level start-ups with critical competence pivoted around AI, machine learning and software. We did not include start-ups purely positioned as sensors and ASIC vendors, which other reports might include. The data includes **170+ companies: start-ups founded after 2000, automotive Tier 1 & 2 OEMs, start-up OEMs, and other technology giants**.

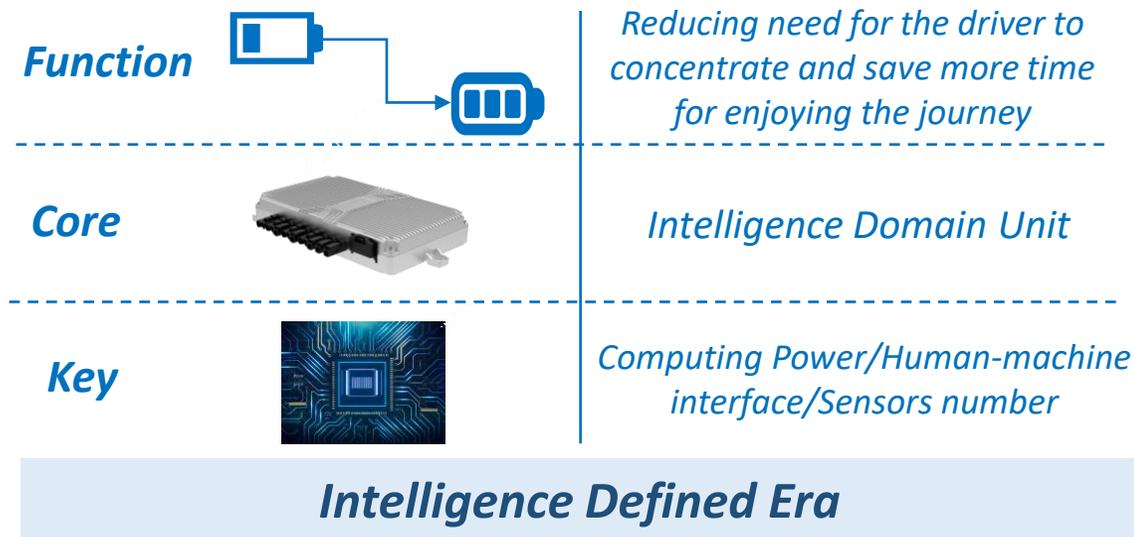
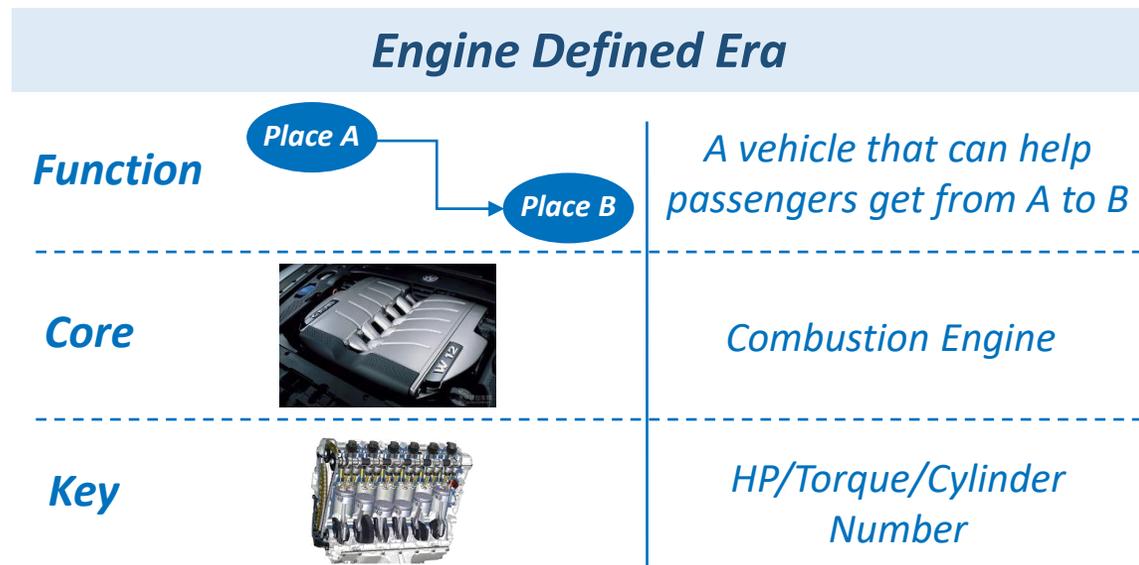


Overview and Definition

Present



- September 2019: Mercedes-Benz announces that it will stop developing combustion engines after 133 years of production
- The electrification of the automobile industry paves the way for advanced features beyond mobility



Future



- January 1886, Carl Benz applies for a patent on his 'gas-powered vehicle', the foundation for the modern car
- Since then, global major carmakers strive to provide better mobility through their proprietary engines, regarded as the core competence of carmakers

Autonomous driving requires the creation of a 3D vector space. There are two major technology paths to achieve this:
Computer Vision and Sensors Fusion

Computer Vision

Tesla's perception system uses cameras to capture images and construct a 3D vector space by leveraging neural networks

Neural Network Basic Architecture: HydraNet – Multi-task Learning

This pure vision system is composed of 8 cameras without the need of LiDAR. Tesla believes LiDAR is expensive from an economic perspective and immaterially improves performance from a technical perspective.

FSD(Full Self-Driving) Perception Capability

Transformer Neural Network: A deep learning model based on an attention mechanism. The changes of the terrain's slope, curvature and other geometric shapes can be internalized into the training parameters of neural networks to realize accurate perception data and predictions of an object's depth and relative velocity.



VS



Sensors Fusion

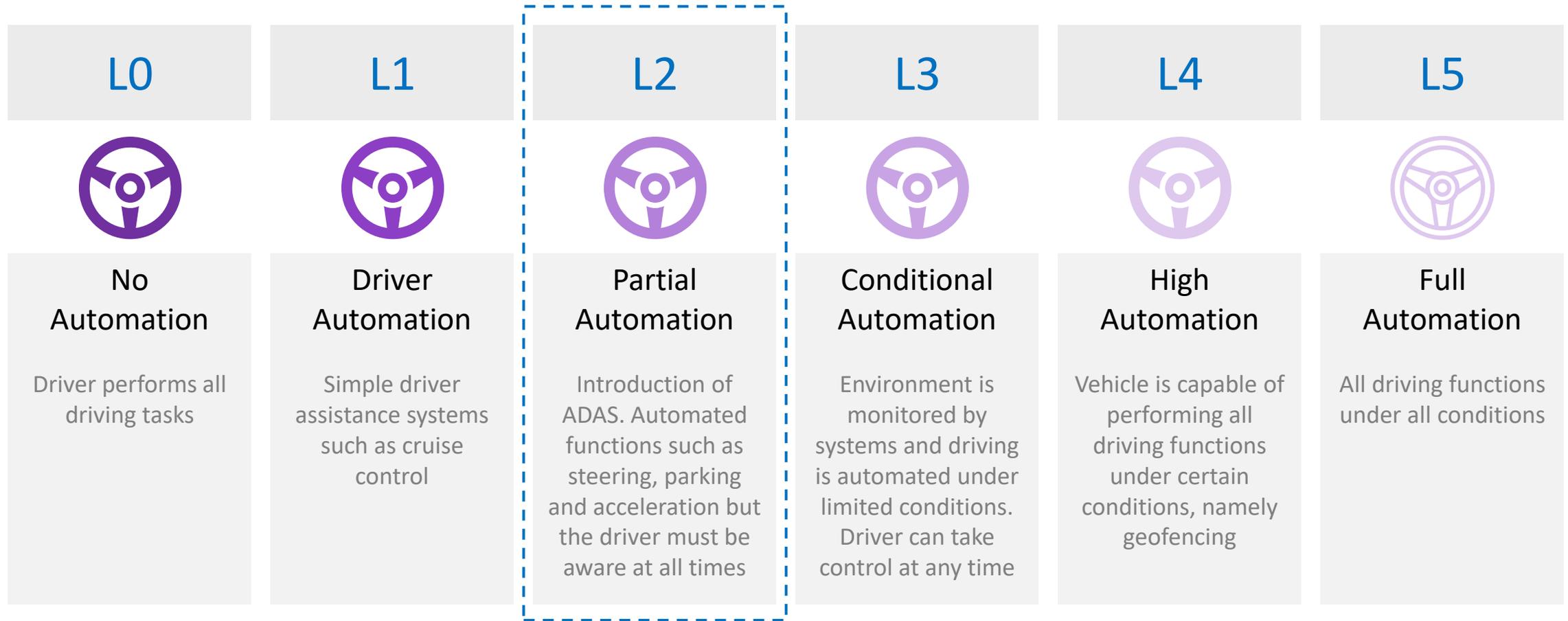
Waymo's perception system uses a combination of cameras, LiDAR and radar, most of Waymo's work is done using four LiDARs

Multi-Sensor Fusion: Post-Fusion

Multi-sensor fusion takes advantage of different sensor-types. Generally, the perception results of different sensors are aggregated in "post-fusion", that is, each sensor independently processes and generates target data, then the results are combined to create a complete picture.

Data Sets and Models

Active Learning: Each unlabeled piece of data is sent to the model for prediction, if the model is certain about its prediction, an automatic label is generated. If there is doubt, the data is sent to a human annotator. In this way, manual annotators only annotate a part of the complex data, the rest are automatically annotated.



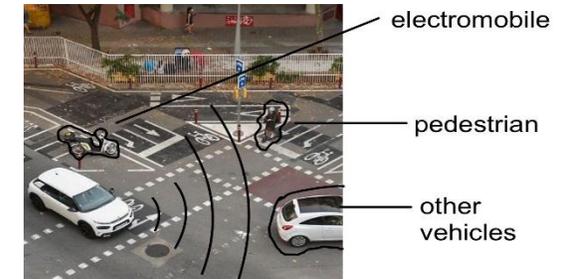
Currently L2 functions have matured and are being implemented at scale

The requirements of L3 are significantly higher than L2. Marginal improvements of existing technology are insufficient to achieve the jump from L2 from L3
To achieve L3 and above, a fundamental restructure of system architecture is needed

Three key factors differentiate the levels of driving automation: OEDR - either the ADS (autonomous driving system) or driver is responsible for reactions; ODD - where autonomous driving systems function under certain conditions; DDT - the ADS is responsible for all functions.

Object and Event Detection and Response (OEDR)

OEDR allows the ADS to detect objects that affect the safe operation of the vehicle, such as other vehicles, pedestrians, animals, trees and indicate, enhance or override driver actions.



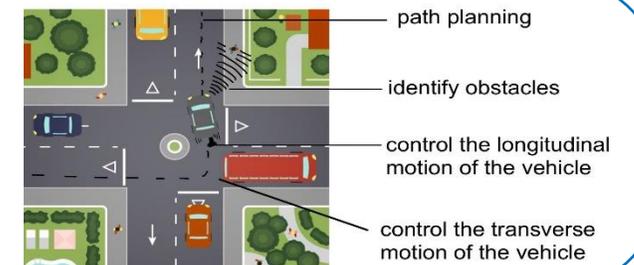
Operational Design Domain (ODD)

ODDs define where ADS functionalities can operate, such as certain environmental conditions (not in snow), geographical (not on mountain dirt roads), time of day, or the presence of certain traffic conditions.



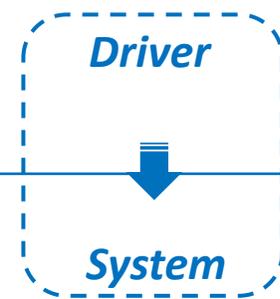
Dynamic Driving Tasks (DDT)

DDT uses all real-time operational and tactical information to operate the vehicle in on-road traffic. DDT excludes strategic functions such as trip scheduling and selection of destinations and waypoints.



Features of Autonomous Driving Grades

					DDT				
		Definition	Function Cases			Motion Control	OEDR	ODD	
DSS	L0	Driver	The driver executes all DDT	LCA	AEB	FCW	Driver	Driver	/
				TSR	DOW	BSD			
	L1	Feet off	Specific DDT sub-tasks are performed by ADS; The driver completes the remaining DDT tasks	ACC	LCC	LKA	Driver + System	Driver	Limited
	L2	Hands off	Specific DDT sub-tasks are performed by ADS; The driver completes the remaining OEDR tasks	ICA	TJA	PAS	System	Driver	Limited
	L2+			APA	HPA	AVP			
				FCTA	HWA	NOA			
ADS	L3	Eyes off	The entire DDT is executed by ADS; The driver serves as a DDT backup to complete the intervention request issued by ADS				System	System	Limited
	L4	Mind off	The entire DDT is executed by ADS; The ADS serves as a DDT backup to complete the intervention request				System	System	Limited
	L5	Passenger	The entire DDT is executed by ADS				System	System	None



	Full name	Function
L0	LCA Lane Change Assist	Detect and warn motorists about approaching cars in adjacent lanes to aid drivers in changing lanes safely
	AEB Autonomous Emergency Braking	Constantly keeps track of the road ahead and will automatically halt the vehicle if the driver fails to take action
	FCW Forward Collision Warning	Warn you of an impending collision by detecting stopped or slowly moved vehicles ahead of your vehicle .
	TSR Traffic Sign Recognition	Recognize the traffic signs
	DOW Door Open Warning	Monitor the switch and alerts the driver when it thinks one of the doors isn't closed all the way through
	BSD Blind Spot Detection	Monitor the road area behind and next to your own vehicle and warn if you try to pull out despite there being no gap
L1	ACC Adaptive Cruise Control	Adjusts the vehicle speed to maintain a safe distance from vehicles ahead
	LCC Lane Centering Control	Keeps a road vehicle centered in the lane
	LKA Lane Keeping Assist	Assist the driver in preventing the vehicle from departing the lane
L2/L2+	ICA Integrated Cruise Assist	Automatically adjusts the vehicle speed to maintain a safe distance from vehicles ahead
	TJA Traffic Jam Assistant	Measures the speed of the surrounding vehicles when Adaptive Cruise Control is switched on
	PAS Parking Assist System	An automated parking aid that helps drivers park with greater precision
	APA Auto Parking Assist	An autonomous car-maneuvering system that moves a vehicle from a traffic lane into a parking spot
	HPA Home-zone Parking Assist	Simplifies repetitive driving maneuvers into your own parking space through automation
	AVP Automated Valet Parking	Allows the vehicle to be left at the drop-off area of the parking garage without further ado , and all the driver needs to do is activate the smartphone app.
	FCTA Front Cross Traffic Alert	Monitor the left and right front diagonal areas to make sure driving in busy city streets remains a pleasure and you stay safe at all times
	HDA Highway Driving Assist	Combine adaptive cruise control with stop-and-go capability, lane-centering assistance, GPS data, and route information to reduce driver burden on limited-access highways.
NOA Highway Navigate On Autopilot	Along the highway portion of a navigation route, Navigate on Autopilot also changes lanes to prepare for exits and to minimize the driving time to your destination.	
Others	DSS Decision Support Systems	Includes L0, L1, L2/L2+
	ADS Automated Driving Systems	Includes L3, L4, L5

Is Level 3 an unattractive solution?



- Current L2 systems use an underlying architecture that is insufficient for the requirements of L3. L3 will require higher sensing and computing capability to run more sophisticated algorithms, therefore requiring an upgrade to the existing hardware most cars currently have



- Under L3 definitions, the responsibility switches back and forth between the human and the system, which can lead to unclear responsibility partitions and a poor or dangerous driving experience - our 'Uncanny Valley' in autonomous driving systems lead us to mistrust their capability



- L3 can be loosely defined as *Eyes Off, but Mind On*. Drivers are still required to concentrate somewhat as they may need to take control at any time - a driver therefore puts themself and others at risk if they focus on any other tasks (work, calls, reading, etc.)



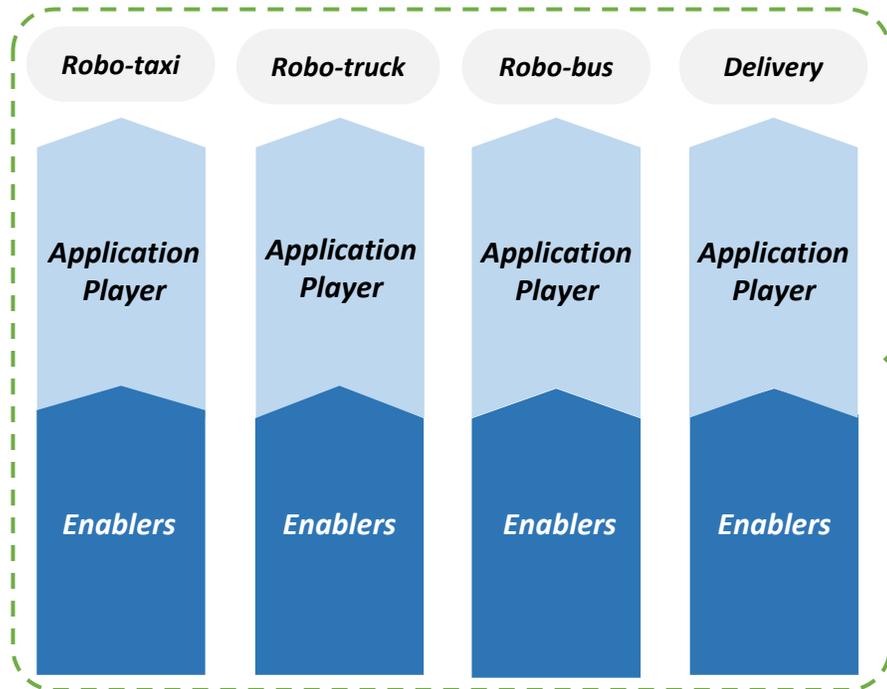
- *Eyes Off, but Mind On* provides limited value to consumers. Similarly, consumers are not willing to spend much on the limited experience improvement. This is at odds with the significantly higher cost to achieve L3



The positioning of L3 is ambiguous. From the car manufacturers perspective, the underlying architecture L2 is totally different from L3. From the customers' perspectives, L3 is difficult to interpret, as L3 requires drivers to keep the same concentration level as L2. There is significant opinion that L3 should be skipped due to the technical and regulatory difficulties. However, the gap L3 to L4 is extreme.



Looking Back:
Autonomous Driving
Landscape Development



Most start-ups in the analysis are solution providers addressing one or several specific scenarios: **Robo-taxi, Robo-truck, Robo-bus, Delivery, and others**. As **Robo-taxi** covers the broadest ODD, if a start-up covers Robo-taxi and other scenarios, we classify it as Robo-taxi in our analysis.

According to the business model, the solution providers are further divided into **Application Players** and **Enablers** :

Application Players include start-ups who sell products and provide solutions directly to end consumers. They may have in-house manufacturing capability or outsource the manufacturing from OEMs.

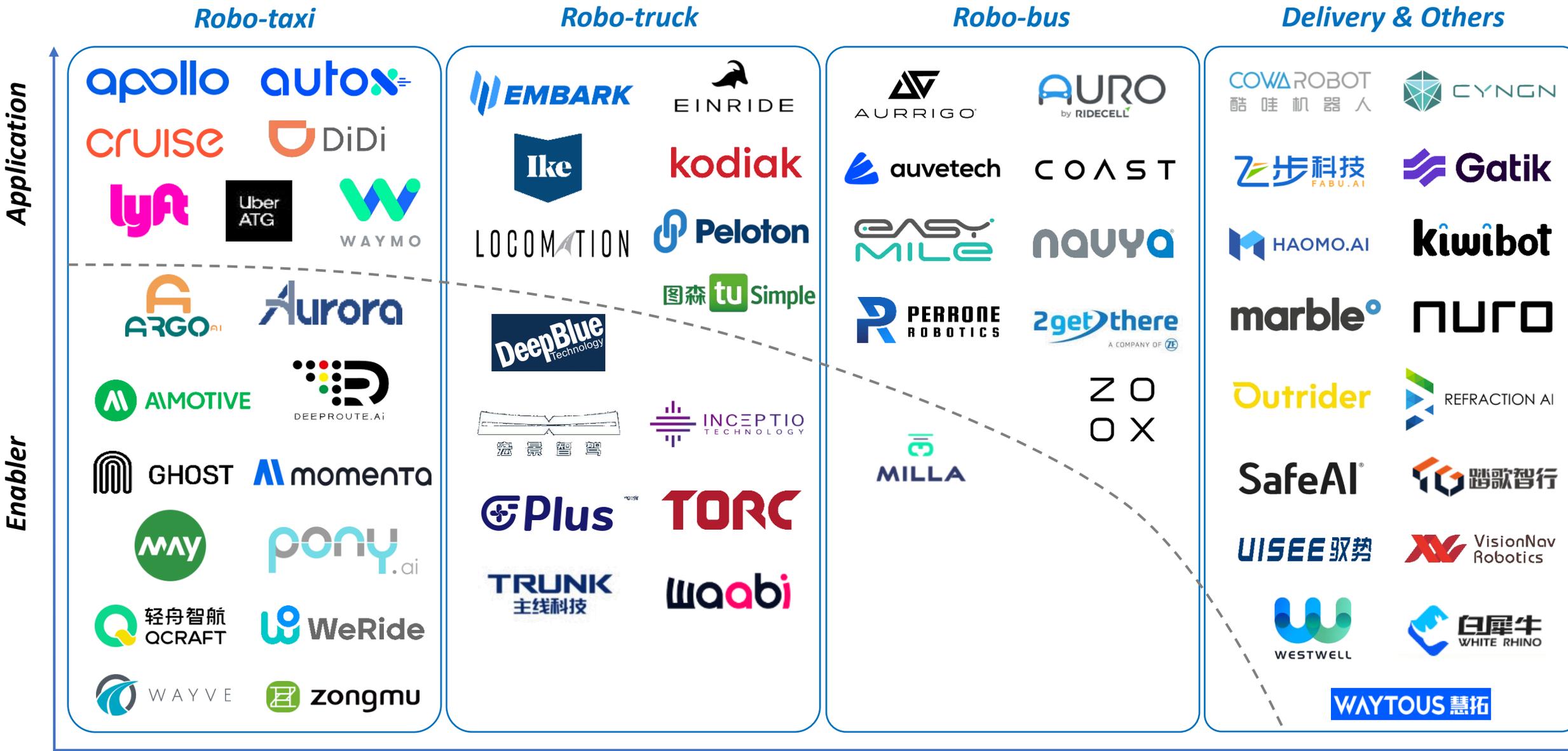
Enablers include start-ups whose revenue is mainly generated from providing system-level autonomous driving solutions to OEMs. Note, some Application Players also provide solutions to OEMS, but those companies with a two-pronged strategy are classified as Enablers in this analysis.



Besides solution-providers, this analysis also includes the start-ups providing more generic single-stack software. The **Single-Stack Players**, do not target a specific scenario but a specific function such as:

- **Algorithms** - pure software providing an industry-wide autonomous driving algorithm, such as human awareness algorithms
- **Fleet & OS** - self-driving software services to fleet management companies, as well as Operating Systems
- **Teledrive** – operation of vehicles from a remote teleoperation center
- **V2X** – exchange of information from vehicle to another entity and vice versa
- **Others** – Other use cases including high-resolution mapping and network security

Market Landscape (1/2)– Dimension by Scenarios and Business Model



Algorithm

For external general objects



For specific objects/activities



Fleet & OS



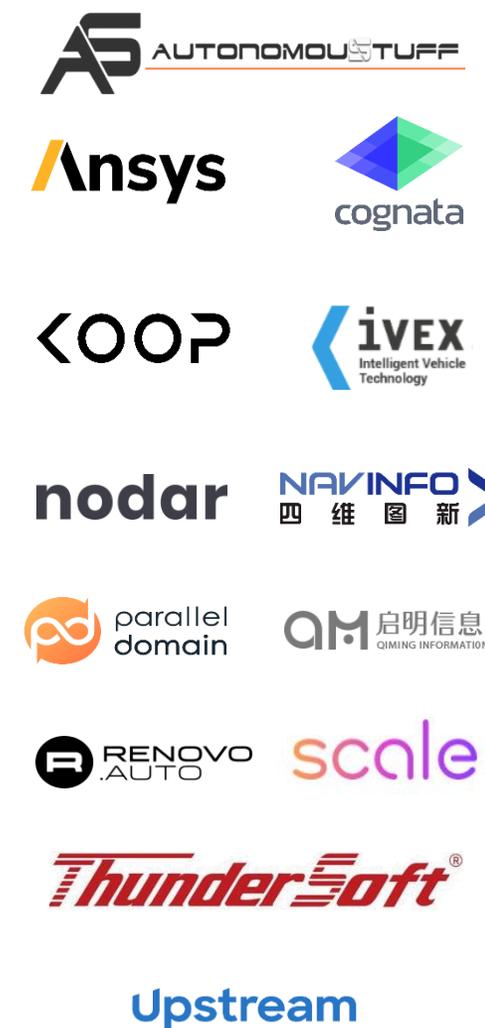
V2X



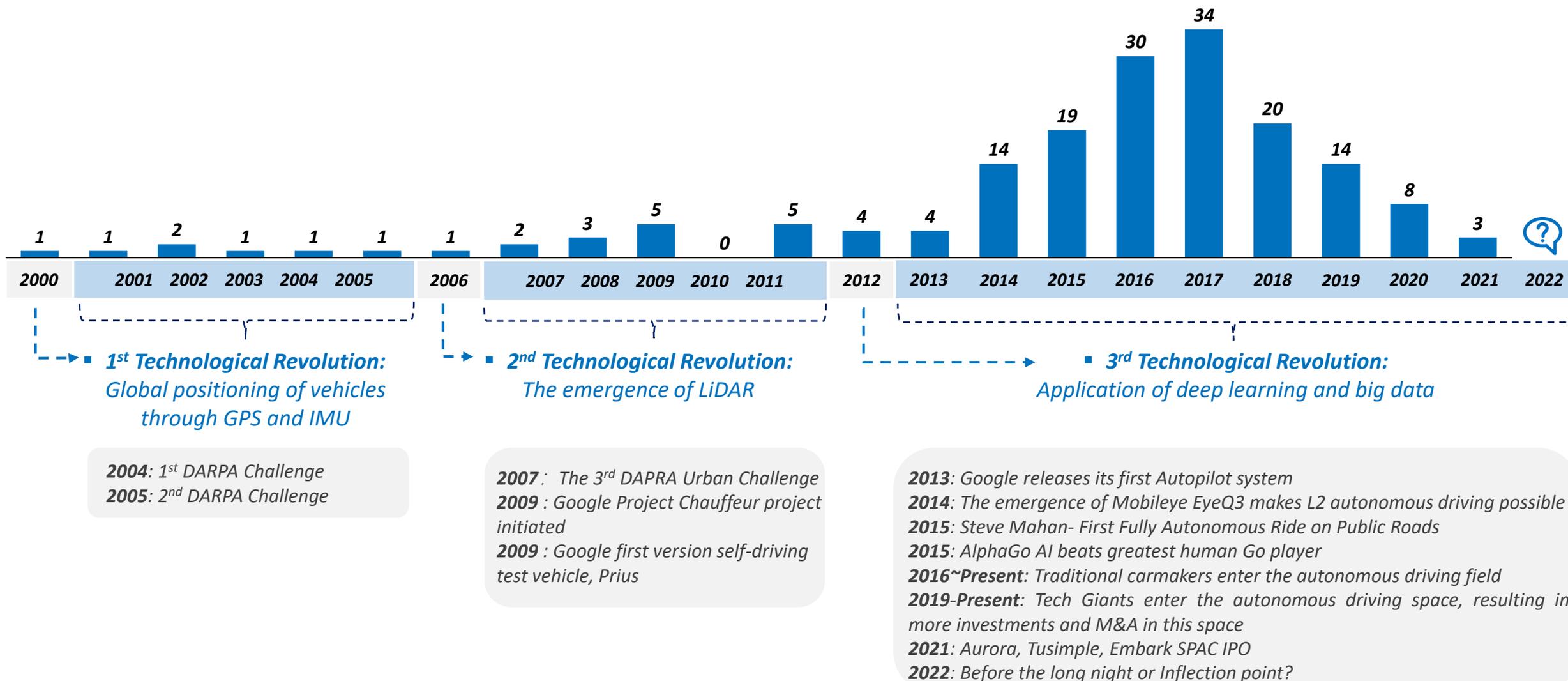
Teledrive



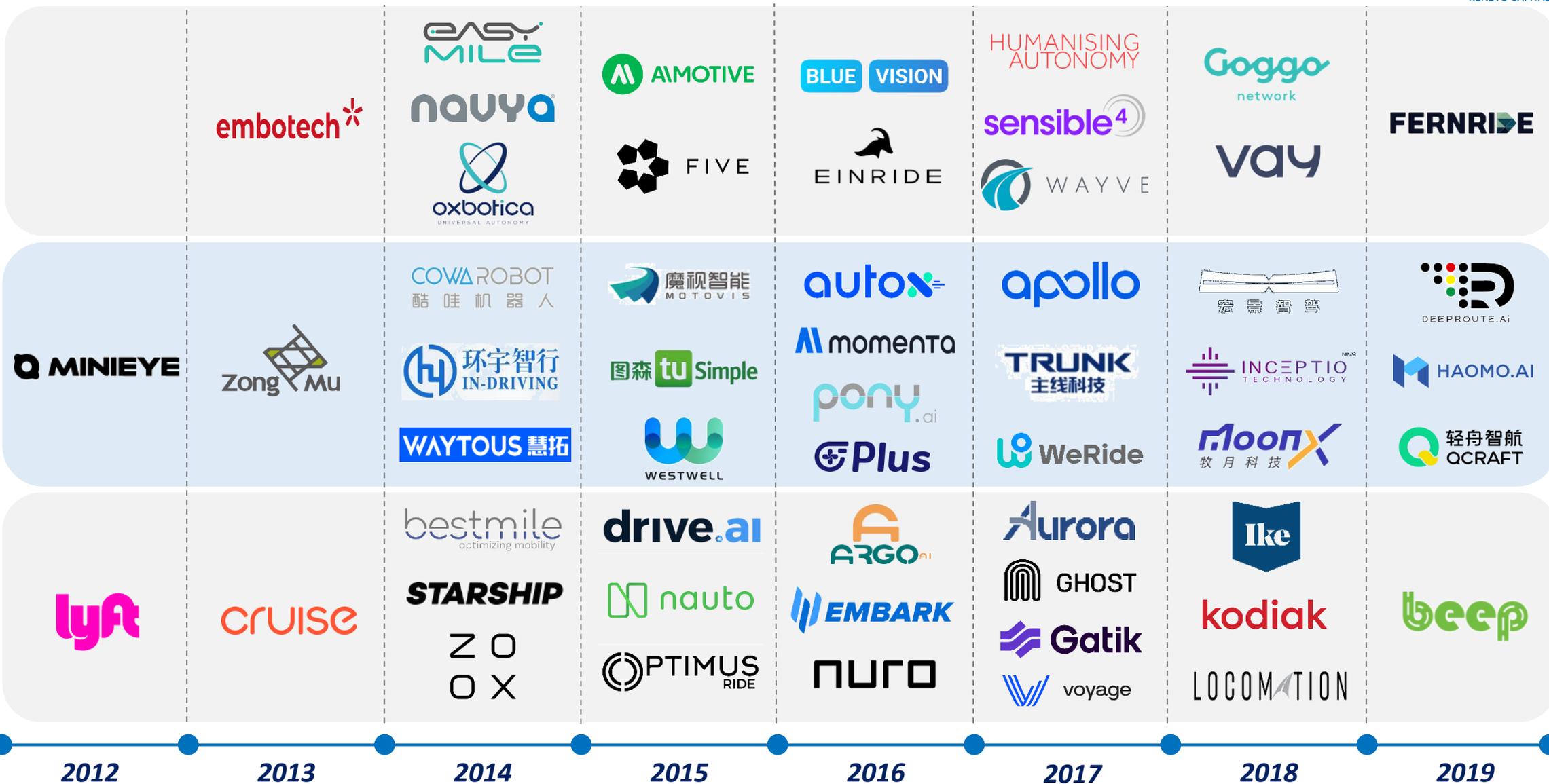
Others



Timeline of Autonomous Driving Start-ups Founded



Selected Start-ups Founded Since 2012

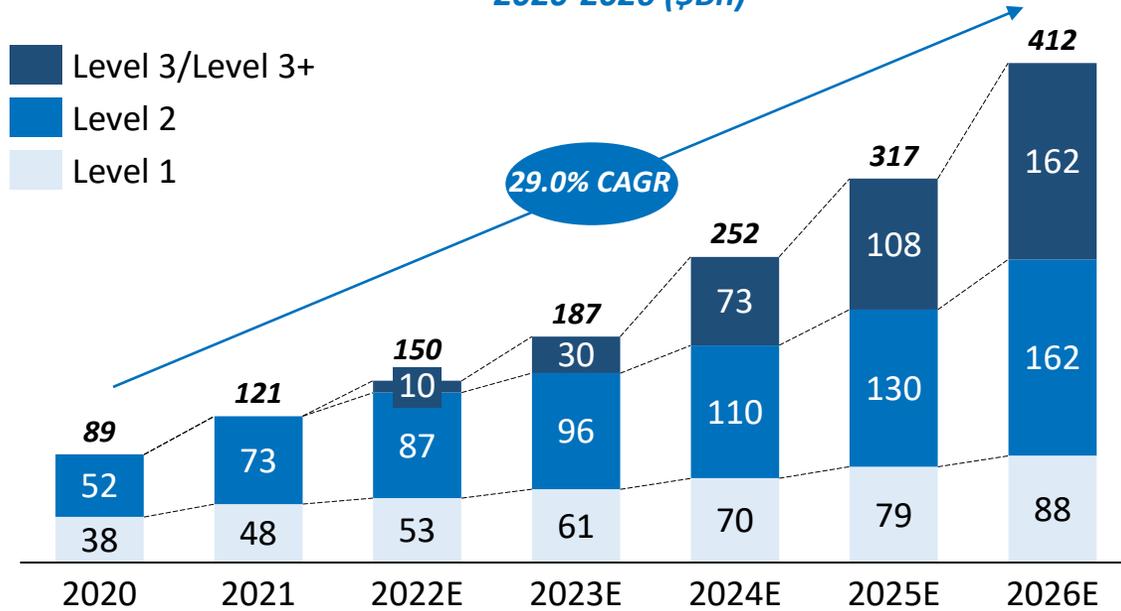




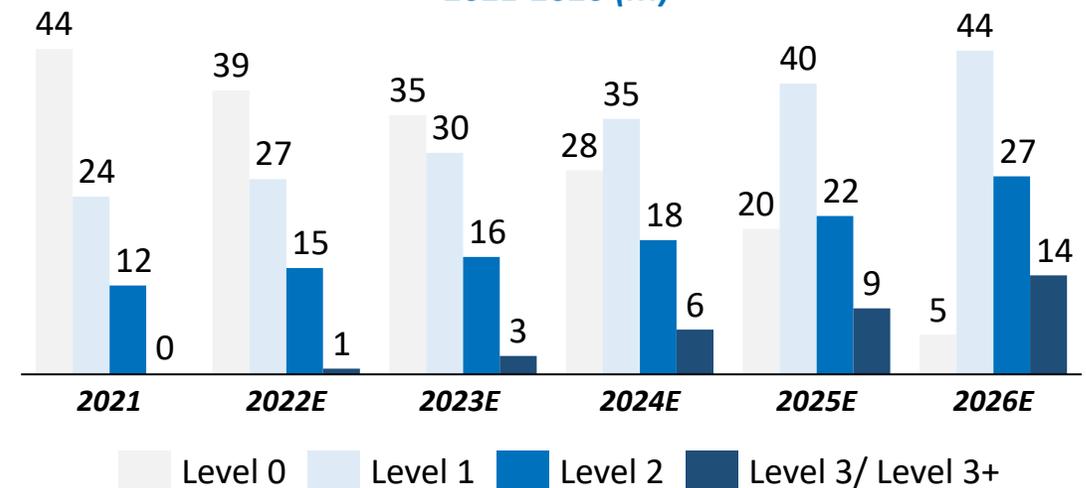
Market Observations

Autonomous Driving System Market Overview

Autonomous Driving Market Forecast, 2020-2026 (\$Bn)



Vehicle Shipments at each level Forecast, 2021-2026 (M)

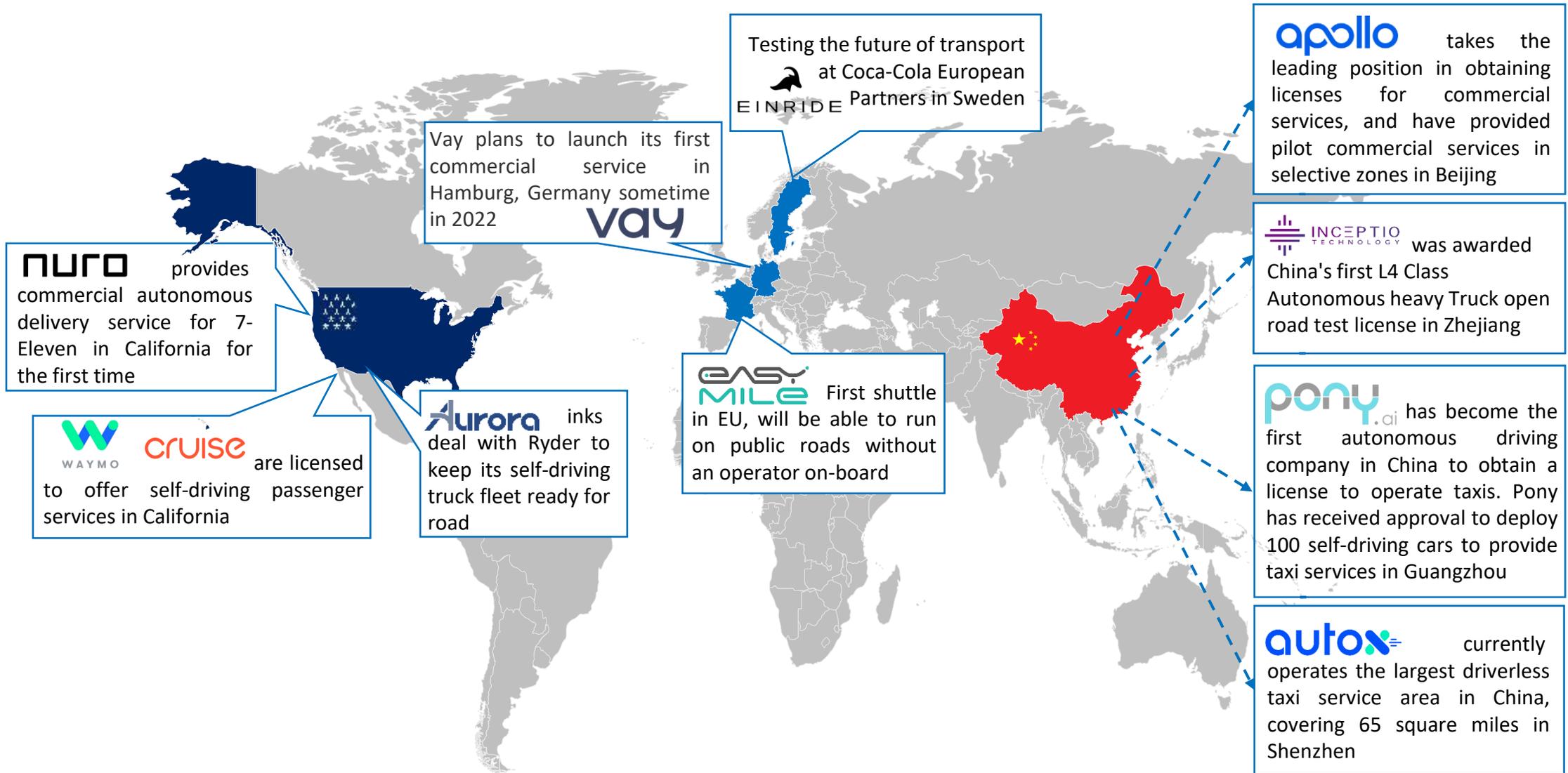


- Total annual automotive shipment, broken down by different levels automation.
- CAGR is forecasted to be 29% over the next five years, mainly driven by the increasing penetration of L2 vehicles
- The potential of L1 market growth is limited by its low value composition of autonomous driving units although the unit shipment level is ramping up
- L2 is the dominant market by value
- L3/L3+ is just an emerging market now but if it can find acceptance on price, performance and regulatory, it will be the fastest growing product category, and the dominant one in 2026/2027

Market Penetration Forecast, 2021-2026 (%)

	2021	2022E	2023E	2024E	2025E	2026E
L0	55	48	42	32	22	6
L1	30	33	36	40	44	49
L2	15	18	19	21	24	30
L3/L3+	0	1	3	7	10	15

It is forecasted the market penetration breakdown of L1 to L3+ in 2026 will broadly equal to the breakdown of L0 to L2 in 2021





Description:

A surprisingly good re-IPO for Mobileye

Overview:

Mobileye gains 38% in Year's Best Debut for Big US IPO. The market cap exceeded \$23Bn at close of **26th October 2022**, 50% above the \$15.3Bn Intel paid to take it private in 2017.

Significance:

- Intel initially targeted a \$50Bn valuation but decreased it continually before landing at \$16.7Bn list price

Description:

Ford & VW-backed firm, Argo AI shuts down

Overview:

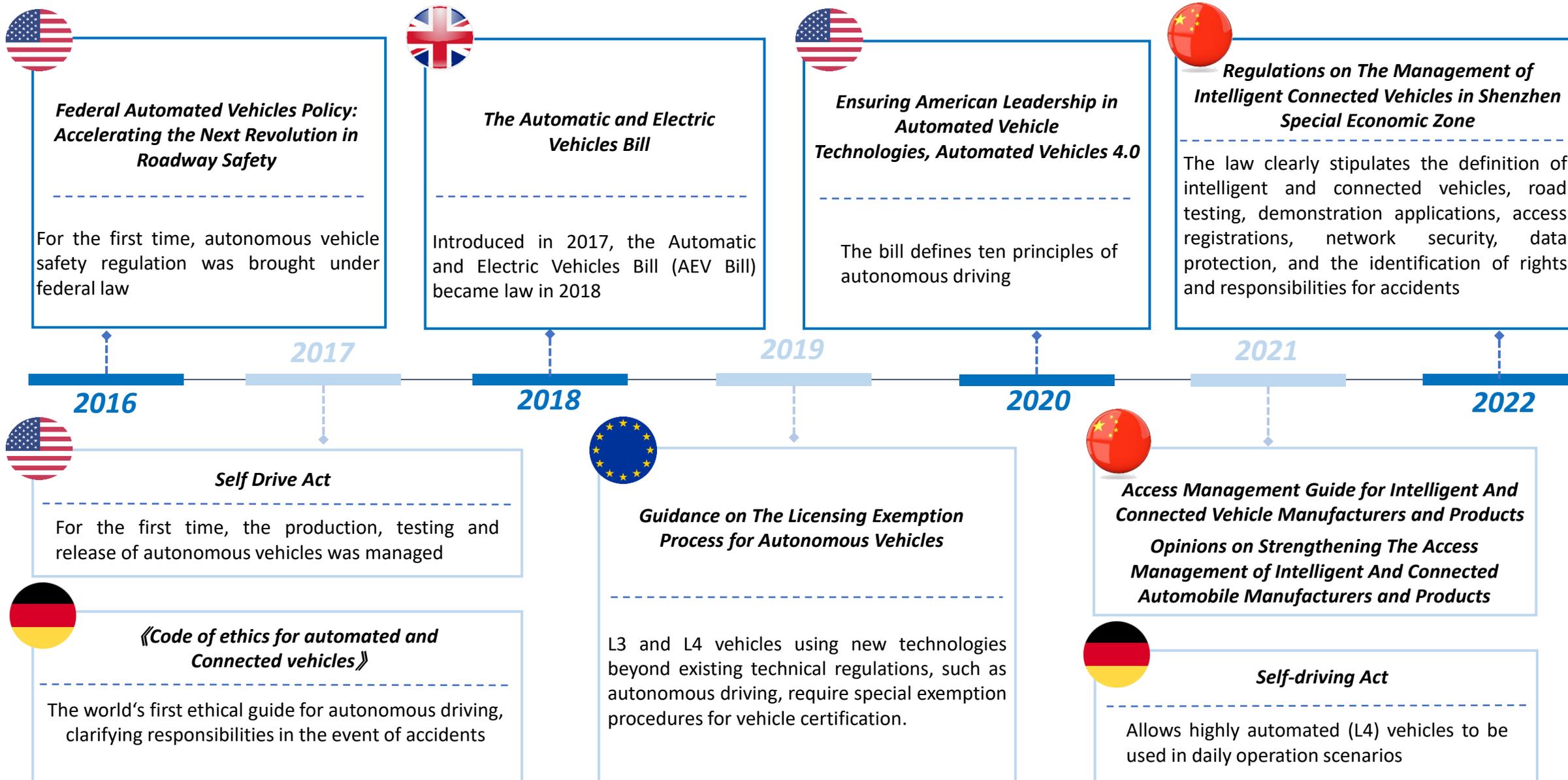
On **26th October 2022** Argo AI announced it will not continue its mission as a company. Some employees may be relocated to Ford or Volkswagen. Ford recorded an \$2.7 billion net loss in its investment in Argo AI

Significance:

- Ford said it made a strategic decision to prioritize its resources on developing L2+ ADAS. VW planned to deepen collaboration with Mobileye on autonomous driving after Argo exit



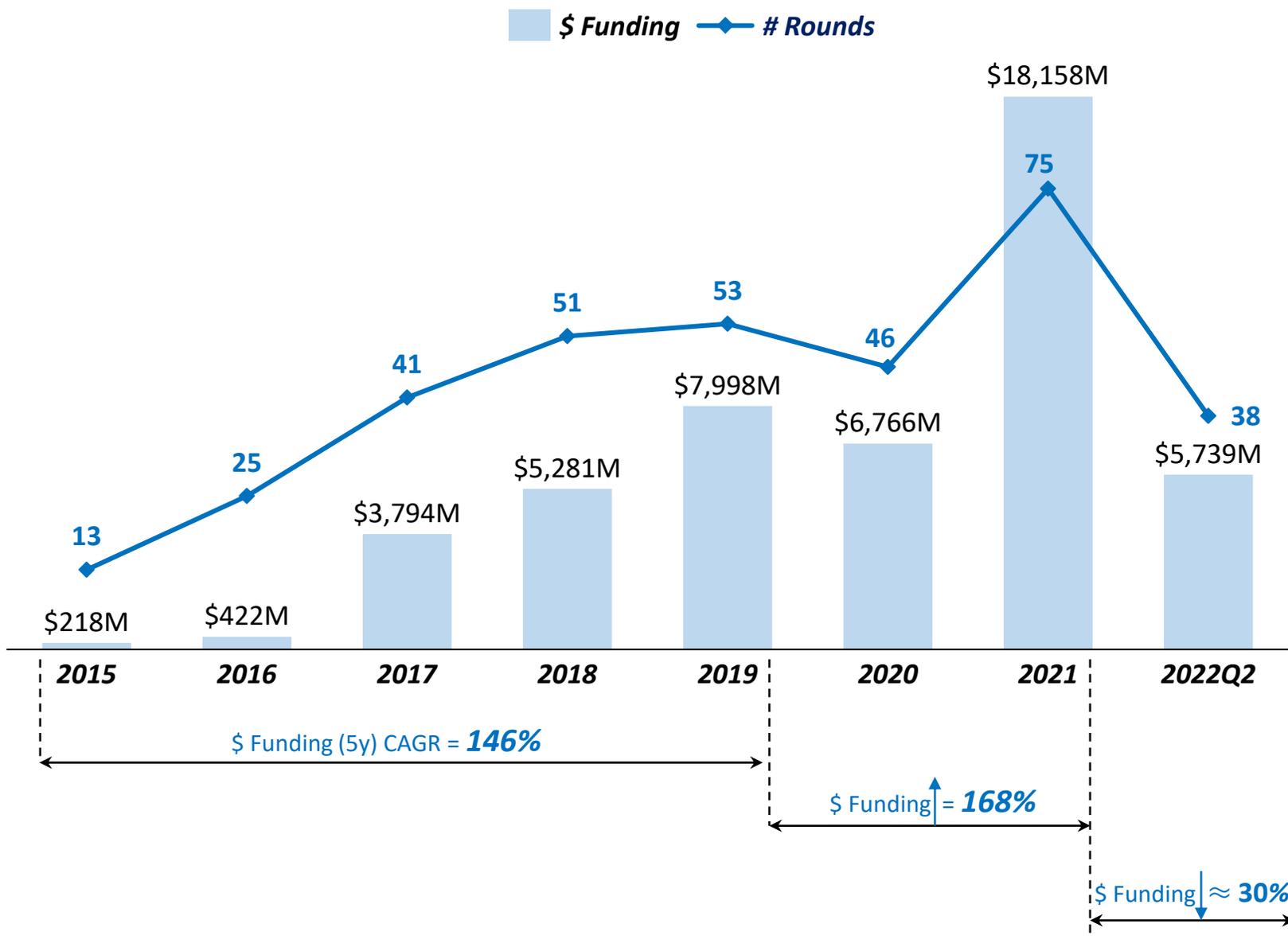
- Enjoying the loose monetary environment in the past, companies in both L2+ ADAS and L4+ Robo solution raised significant funds at very high valuation. Now with the federal funds rate hike, both L2+ and L4+ players suffer, but L4+ players are in a worse situation
- Investors and industrial players now tend to give up the optimism to achieve L4+ solution in the short term but be focused on more feasible goal by a progressive approach
- There is an argument it is either a long-term appropriate judgement and right decision from technical point of view or a short-term forced compromise due to the abnormal speedy interests and financial cost rise from financial point of view





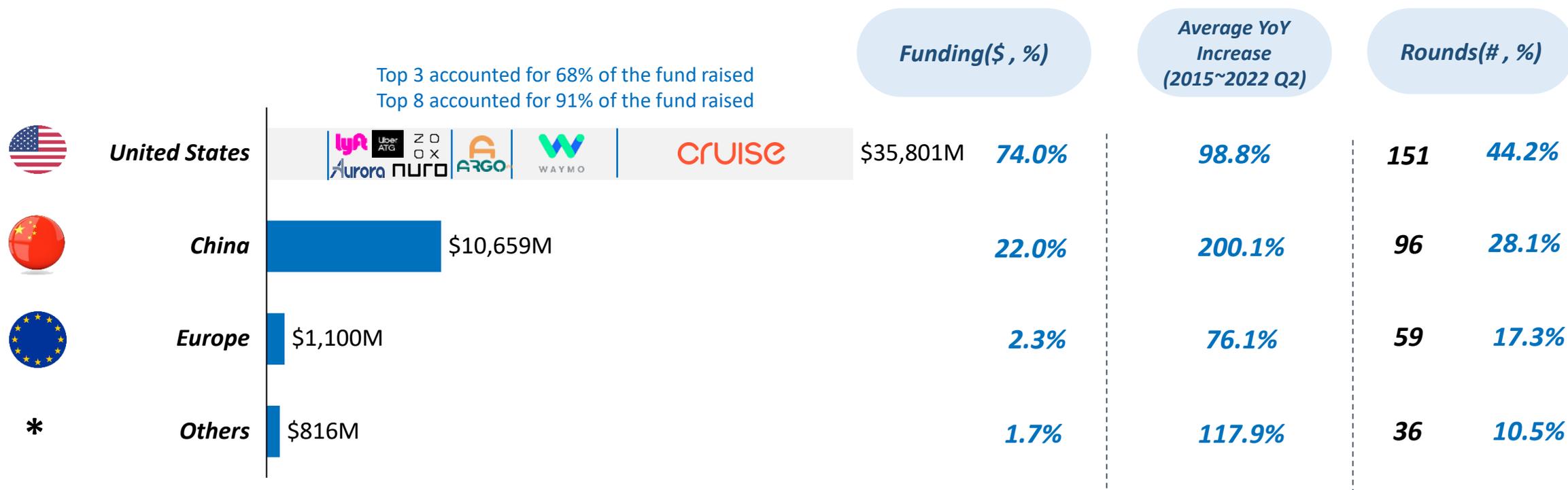
Investment and M&A Trends

Funding Analysis by Years



- ✓ Encouraged by deep learning and big data computation in 2012, people believe fully autonomous driving is possible. Since the launch of Google’s autopilot system in 2013, an increasing number of start-ups emerge and lead the explosion of the fundraising from 2015 onwards
- ✓ Autonomous driving fundraising recovered swiftly and hit the recorded high in 2021 after the impact of COVID breakout in 2020 lead to the first year since 2015 to show a decrease
- ✓ Due to the impact of extreme external circumstances such as increasing inflation and interest rates, stock market volatility and concerns of global recessions, it forecasted the total funding amount in 2022 is expected to be at least 30% lower than in 2021

- From 2015 to 2022Q2, the United States was the most active market receiving over \$35 billion of investment which accounts for 74% of the total global funding with only 44% of investment rounds, due to the concentration of leading US start-ups
- China is the second largest geography, but holds the fastest average YoY increase in investment
- The dollar per investment round in Europe and other areas is relatively small due to Europe's start-ups targeting single-stack solutions, which typically require a lower capital injection



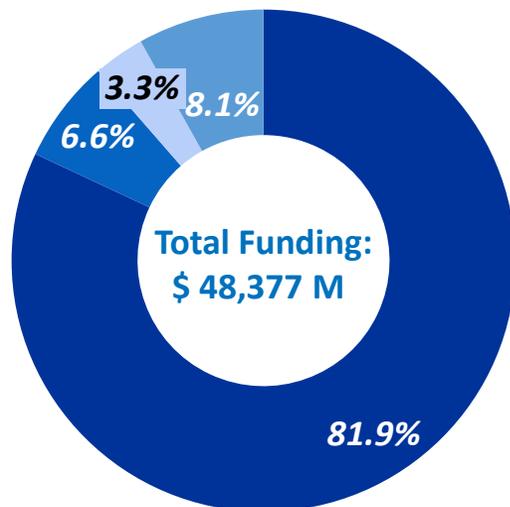
* Time Range: From 2015 to 2022(Q2)

* "Others" represents countries other than US, China and Europe, like Japan, Korea, Israel etc.

Funding Analysis by Scenario & Business Model

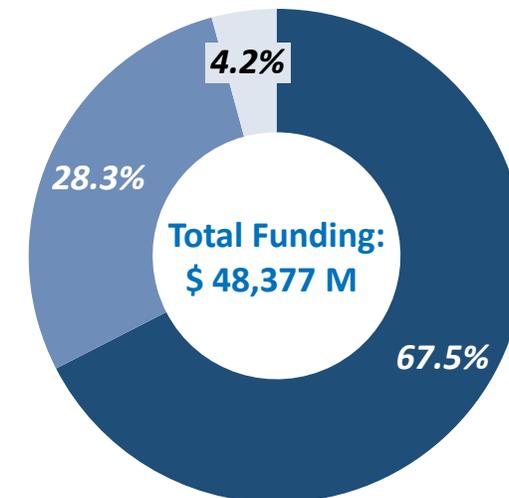
By Scenario

- Robotaxi
- Robotruck
- Robobus
- Delivery+Others

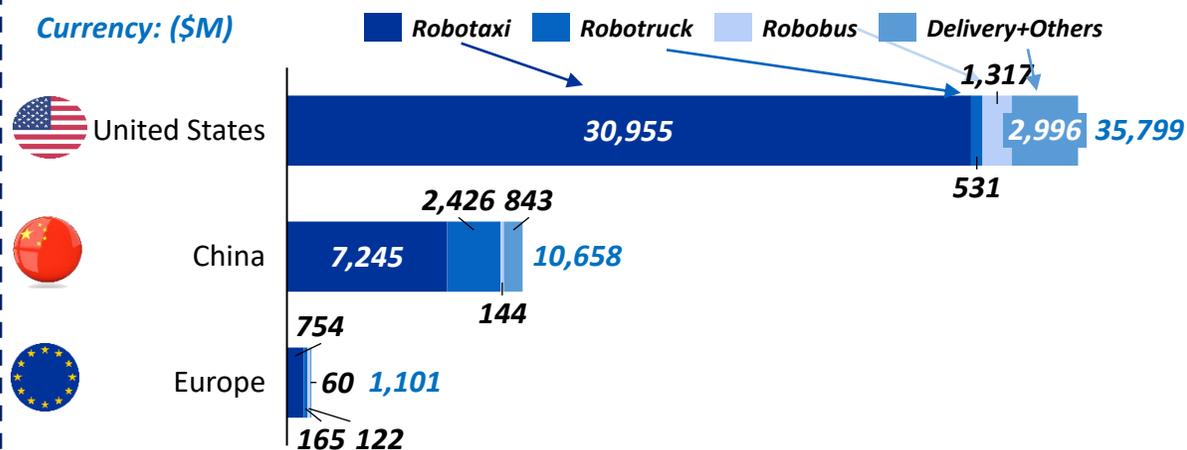


By Business Model

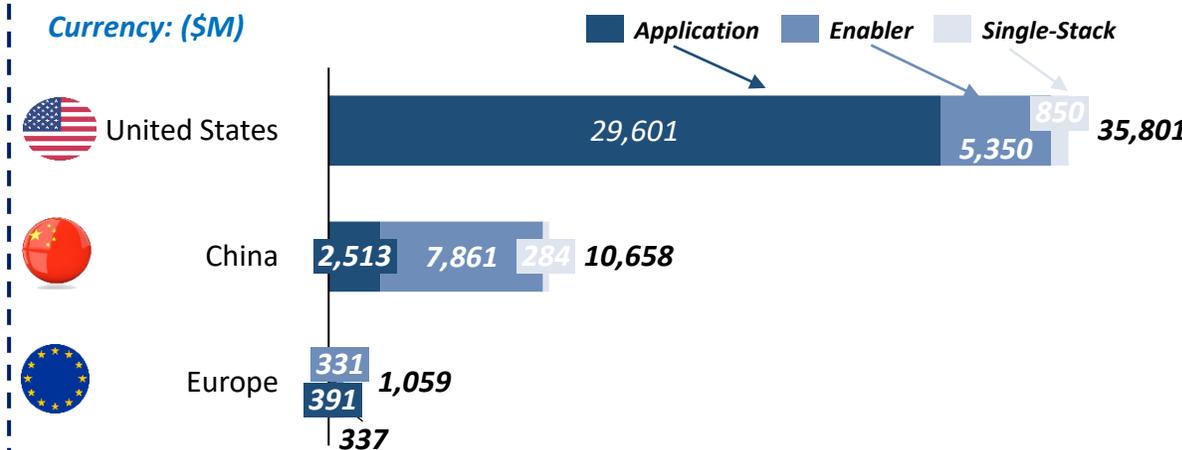
- Application
- Enabler
- Single-Stack



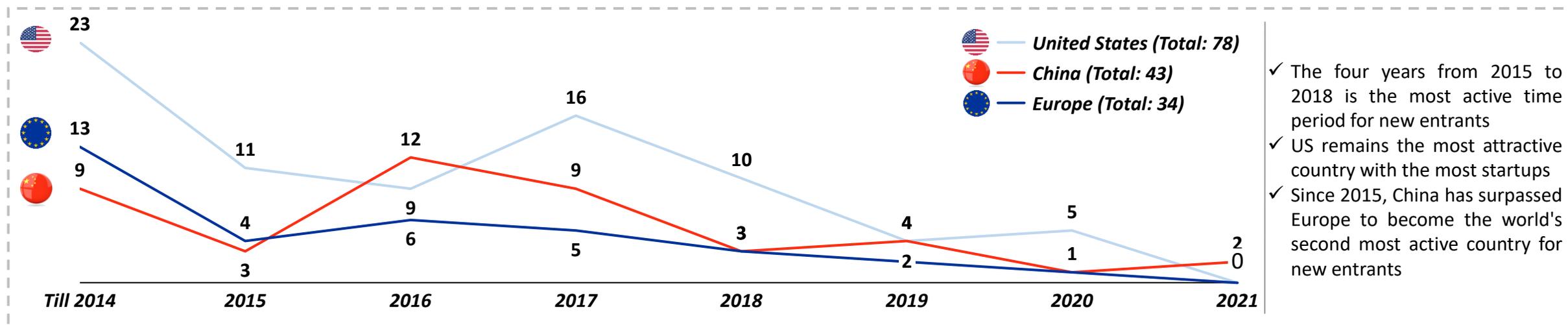
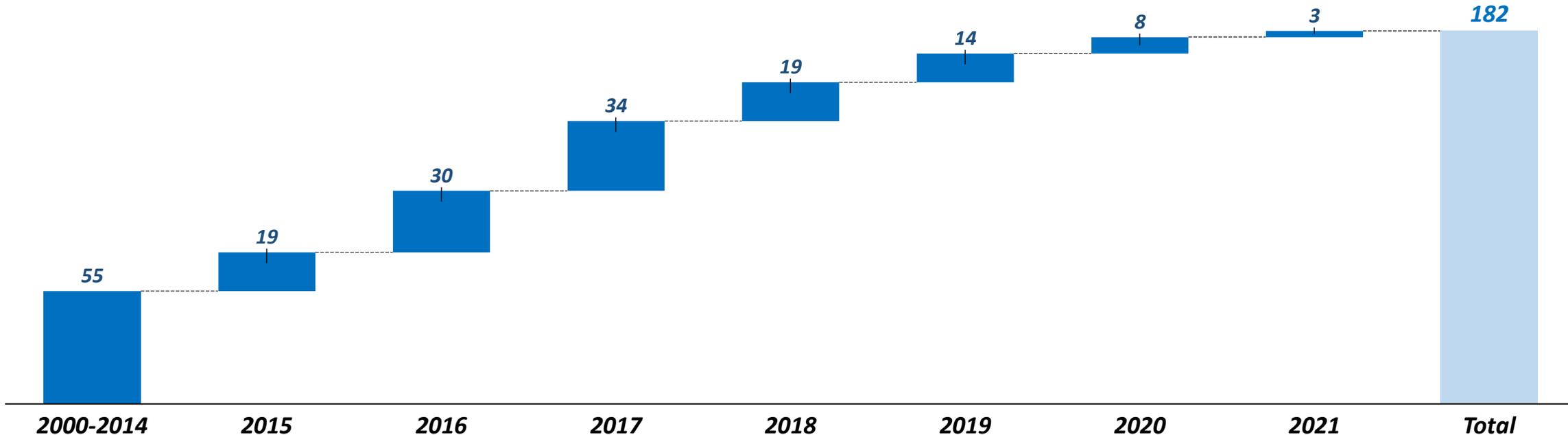
Currency: (\$M)



Currency: (\$M)



New Entrants to Autonomous Driving Market



New Entrants to Autonomous Driving Market



United States



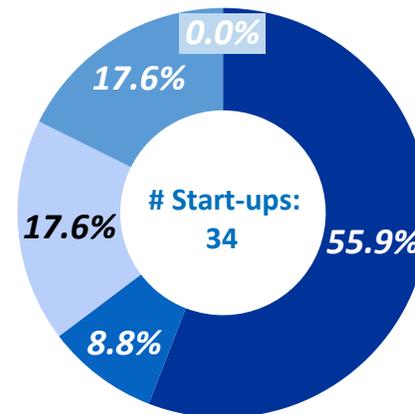
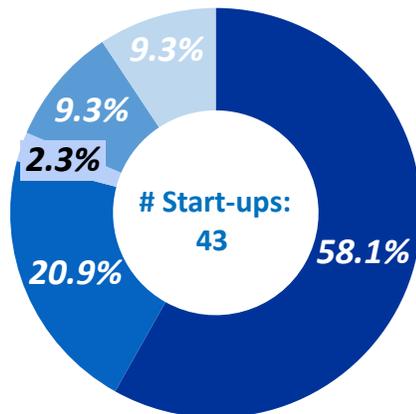
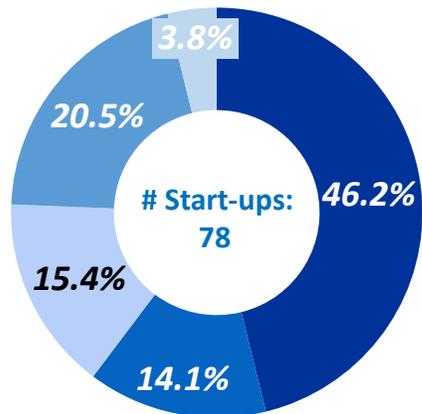
China



Europe

By Scenario

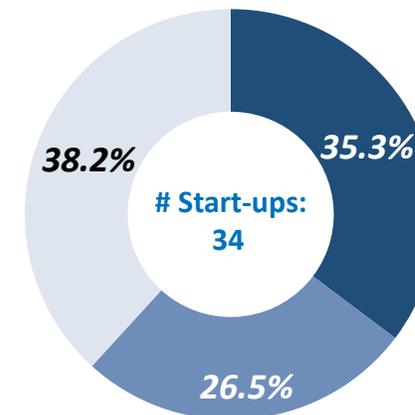
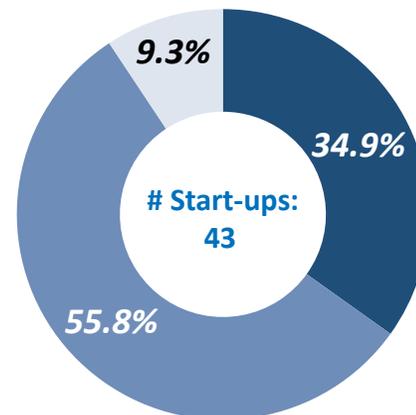
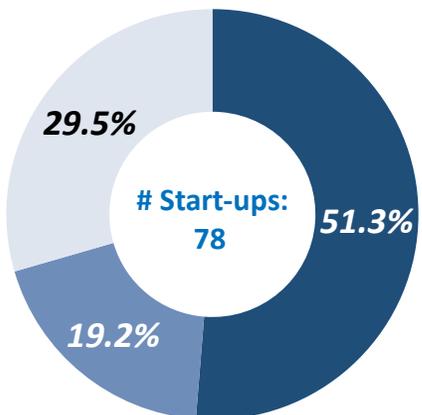
- Robotaxi
- Robotruck
- Robobus
- Delivery
- Others



- ✓ Robo-taxi is the most attractive in all three regions
- ✓ There are significantly fewer Robo-bus start-ups in China due to the heavy investment in underground public transport services

By Business Model

- Application
- Enabler
- Single-Stack



- ✓ “Application” is the dominant business model led by tech-giants investing in start-ups
- ✓ In China, by contrast, “Enabler” is the most popular business model due to its strong supply chain systems
- ✓ Europe has a quite even split, but “Single-Stack” leads slightly

Financing of Major Participants

Currency: (\$mn)

Company	2017	2018	2019	2020	2021	2022(Q2)
Aurora	Founded	90	600	400	2500*	
Tusimple	75		215	350	1400*	
Embark Trucks	15	30	70		614*	
Nayva		34.6*				
Cruise		2800	1200		7750	3500
Nuro		92	940	500	600	
Wayve	Founded, 3		20	19.8	13.6	200
Einride	7.3	4	25	10	110	
Autobrains			Founded	undisclosed	126	19
Ghost	Founded, 9.2	15	32.7		100	
AutoX	51		127	80		
Oxbotica	11	18.4	15		45	
Stradvision	3.5	11.7	27	undisclosed	33.4	54
Weride	Founded			200	815	400
Pony.ai		215	50	730	100	
Momenta	57	141		undisclosed	1500	
Plus		undisclosed	200	100	570	
Inceptio Tech		Founded		220	270	188
Zongmu Tech	14.55	undisclosed	14.6		190	157

*Indicates Fundraise was through IPO

Current Status for listed Company

图森 **tu** Simple

Market Cap at SPAC Listed (\$B): 8.5
Market Cap(\$B) : 0.63
Valuation Falls: **92.6%**

Aurora

Market Cap at SPAC Listed (\$B): 12.5
Market Cap(\$B) : 2.10
Valuation Falls: **83.2%**

EMBARK

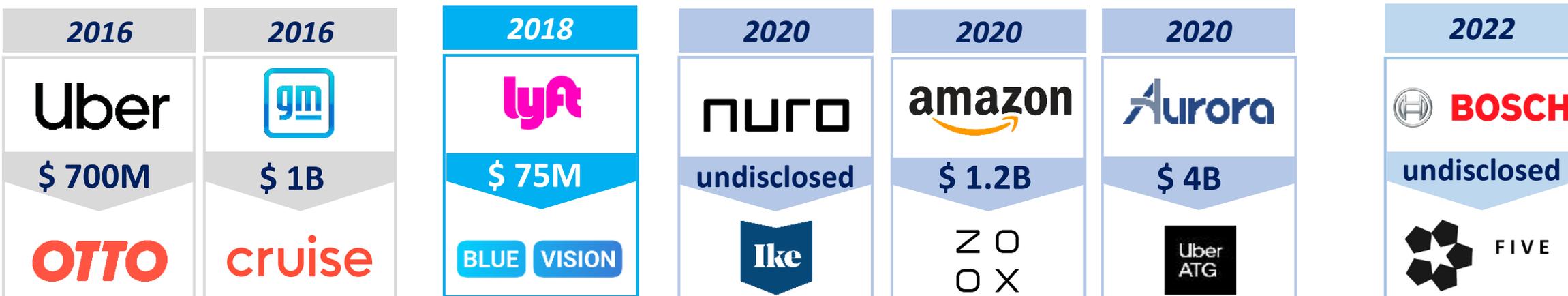
Market Cap at SPAC Listed (\$B): 3.8
Market Cap(\$B) : 0.12
Valuation Falls: **96.7%**

NAVYA

Market Cap at IPO (€m): 190
Market Cap(€m) : 13.35
Valuation Falls: **93.0%**

2021 was an extremely hot year for the autonomous driving industry in terms of both private and public financing. However, it has been overshadowed by 2022's crash of tech stocks. It is worth noting that all four of the companies that SPAC listed in 2021 are trading at a fraction of their initial market cap.

Notable M&A Transactions



*: Lyft sold its self-driving unit to Woven Planet (operating subsidiary of Toyota Motor Corp.)

Europe



North America

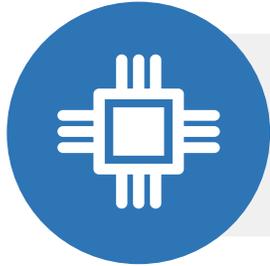


APAC



Looking Forward: Three Considerations

- *Integration of Technology and Functions*
- *Smartphone Industry as A Lesson and A Predict*
- *Reshaping of the Automotive Industry Chain*



Integration of Technology and Functions

- ✓ ***Fundraisings select and screen start-ups at the early stage and promote the leading companies to the potential consolidators of other technologies in the medium-term***
- ✓ ***In the long term, through M&A, leading companies are likely to be able to deliver integrated turn-key autonomous driving solution from both hardware and software perspective***



Smartphone Industry as A Lesson and A Predict

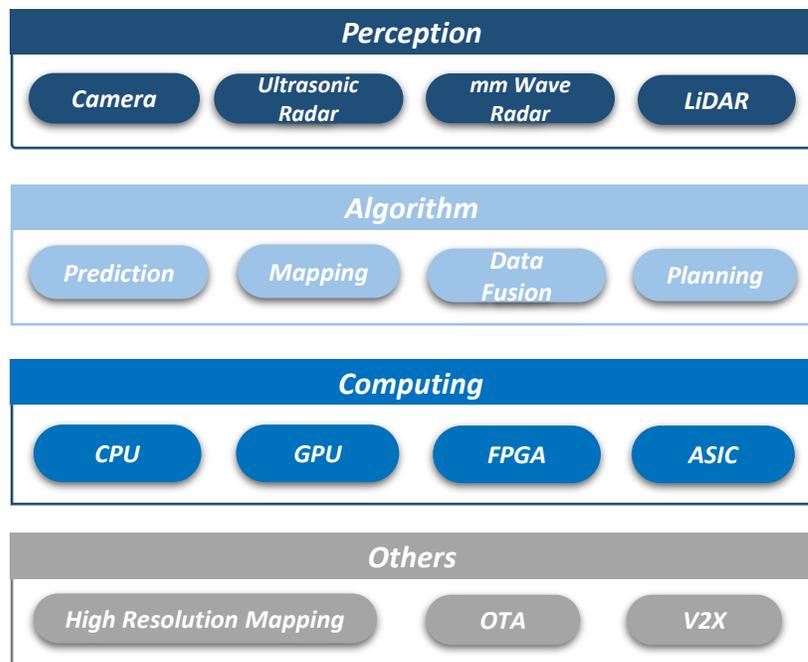
- ✓ ***New entrants won't completely disrupt the traditional carmakers unlike the disruption of traditional cellphone players in the early 2000's smartphone revolution***
- ✓ ***With the potential merge of automobile and smartphone industries, the leading suppliers serving clients in both markets may benefit from this trend and transition***



Reshaping of the Automotive Industry Chain

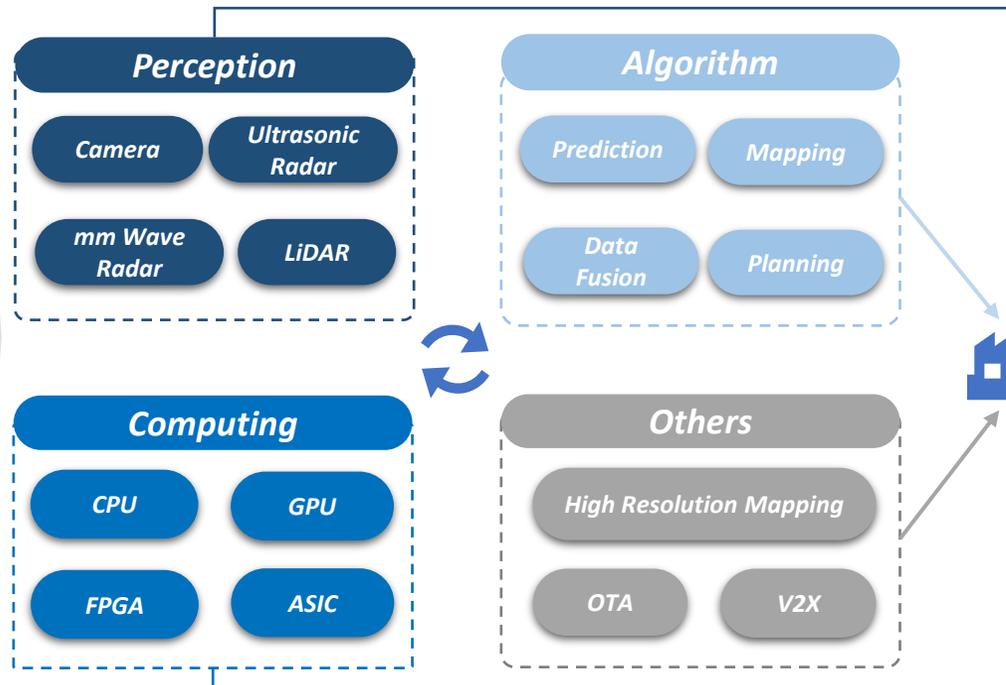
- ✓ ***Dynamic among OEM Tier 1/Tier 2 suppliers, cross-industry tech giants and autonomous driving start-ups are reshaping the automobile industry chain. The traditional boundaries among the players will be disrupted.***
- ✓ ***The parties with greater integrated capabilities will dominate the automobile industry. M&A will become a critical approach for exogenous growth.***

Phase I: Tech & Functions Develop



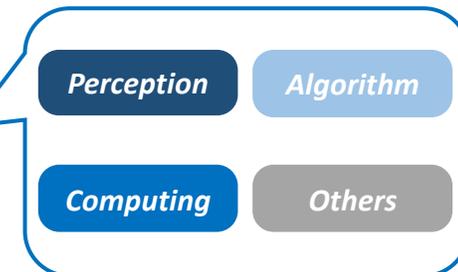
- In phase one, start-ups and industries are learning and verifying together the optimal architecture and critical functions of autonomous vehicles
- Multiple technology paths emerge for a particular function. Investors choose among different paths and the best start-ups within the particular path.

Phase II: Tech & Function Combines



- ✓ In phase two, *technologies* and *business models* will gradually *mature*. After successful market validation, the *balance of technology and product function* will unveil the optimal solution. In phase two, M&A activities will become the main theme within a single field - technology and function will assimilate.
- ✓ In phase three, customers and investors will choose the leading companies, these will have the ability to integrate various autonomous driving technologies and functions including perception, computing, algorithms and others. In this period, *cross-industry M&A* will be mainstream.

Phase III: Cross-Industry Fusion



Time of start-ups and fundraising

Time of fundraising and M&A in single field

Time of cross-industry M&A

Integration of Technology and Functions



- ✓ *Fund raisings play the role of screening of start-ups at the early stage and promote the leading companies to the potential consolidators of other technologies in the medium-term*
- ✓ *In the long term, through M&A, leading companies are likely to be able to deliver integrated turn-key autonomous driving solution from both hardware and software perspective*

Smartphone Industry as A Lesson and A Predict



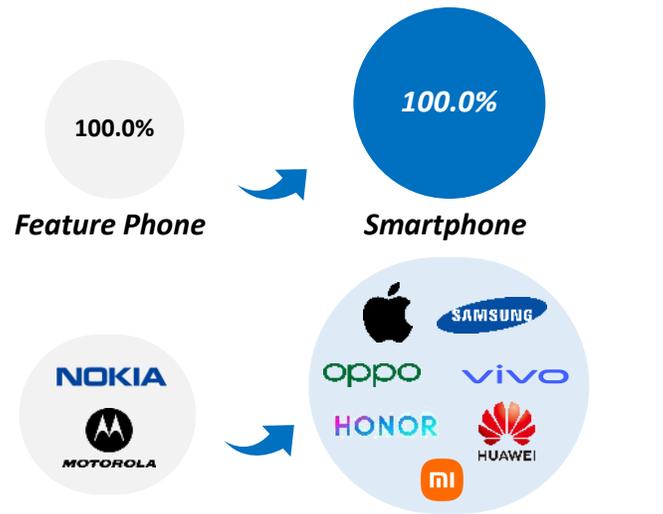
- ✓ ***New entrants won't completely disrupt the traditional carmakers unlike the disruption of traditional cellphone players in the early 2000's smartphone revolution***
- ✓ ***With the potential merge of automobile and smartphone industries, the leading suppliers serving clients in both markets may benefit from this trend and transition***

Reshaping of the Automotive Industry Chain



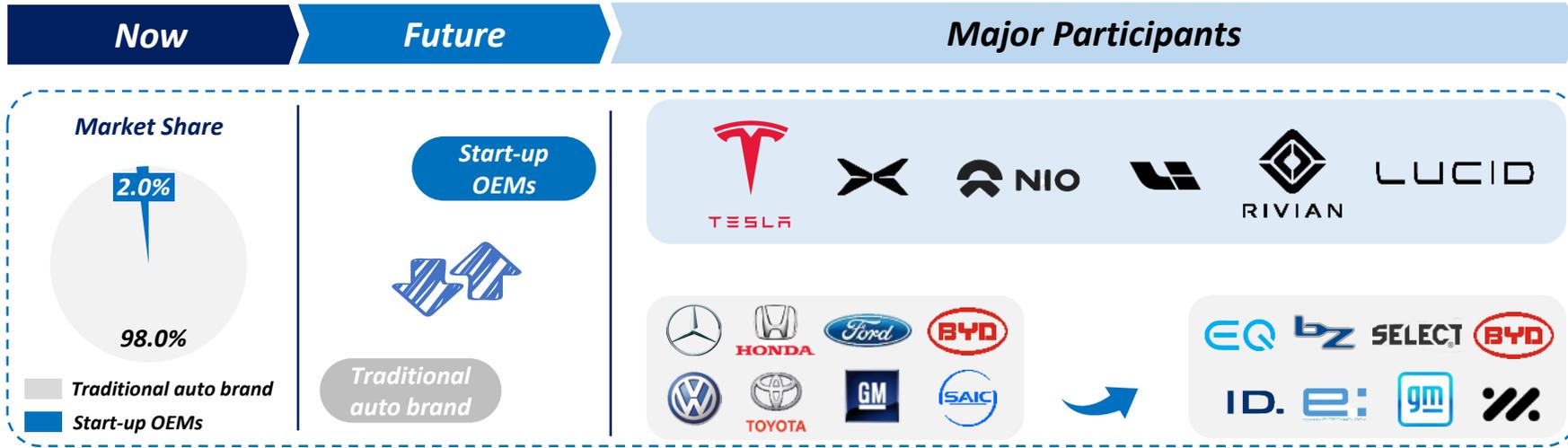
- ✓ *Dynamic among OEM Tier 1/Tier 2 suppliers, cross-industry tech giants and autonomous driving start-ups are reshaping the automobile industry chain. The traditional boundaries among the players will be disrupted.*
- ✓ *The parties with greater integrated capabilities will dominate the automobile industry. M&A will become a critical approach for exogenous growth.*

Smartphone Revolution



Today, traditional cellphone brands are almost non-existence. The emergence of smartphones has completely overshadowed consumers' memory of old cellphones. *After a transition period of market popularization*, smartphones completely disrupted traditional cellphones.

Market Analysis for traditional carmakers and start-up OEMs



- In the current market, **traditional carmakers still account for 98% of global car shipments**, but Start-up OEMs have succeeded in gaining a foothold in the market and expected to take up more market share in the future
- Looking at the smartphone revolution, *the market popularization stage* is extremely important. Most of current market leaders in smartphone industry stepped into the market at that stage and build up the market share subsequently
- Despite this, we believe **the Start-up OEMs will not completely disrupt traditional carmakers like what happened in smartphone industry**, due to the differences outlined below

RCL Analysis		The difference between smart car and smartphone industries	
	More Complicated		More stringent industry requirement
	Longer transition times		More sensitive to changing market
	Importance of certain stable mechanics		

Automotive vehicle's manufacturing is more complex than smartphone

ASIL(Automotive Safety Integrity Level): a functional safety standard for automotive industry

Compared with smartphone 1 to 2 years transition times, automotive has longer transition space

Current players are more sensitive to market dynamics in terms regulation technology and demand

Electronic component is important for AV evolution, but there is significant automotive IP in mechanics

Prediction: A potential crossover of Automobile and Smartphone Industries?

RCL Insight

- Companies in both automobile and smartphone industries start to realize they share numerous key capabilities
- Seeking economies of scale and maintaining their leading positions, players cross the border into the adjacent industry
- This transition brings significant innovation and opportunity, but competition intensifies
- Some leading players may dominate both markets in the future
- By extension, the corresponding suppliers often serve clients across both markets, they may benefit the most from this trend and transition



Recent Developments: Suppliers

Qualcomm

SUNNY OPTICAL TECHNOLOGY

FOXCONN

LG

LUXSHAREICT

BOE

Qualcomm Technologies completed the acquisition of the Arriver business of Veoneer and has the capability to provide full solutions

Sunny Optical formed a vehicle optical lens processing, assembly, and module packaging of the whole industrial chain layout

Hon Hai (Foxconn) released five models of EV in a year and already has the capacity to manufacture complete vehicles

LG Electronics recently entered the automotive micro controller unit (MCU) development business

Luxshare and Chery Group are planning to develop and manufacture electric vehicles

BOE partners with Chery Group to develop smart in-car cockpit solutions



Recent Developments: Smartphone Giants

Leading smartphone players are entering the automobile industry by leveraging their accumulated technology

Company

News



Apple accelerates work on their car project, developing a fully autonomous vehicle

SONY

Honda and Sony form a partnership to develop and sell electric vehicles



Xiaomi announced that it plans to launch its first electric car in the first half of 2024



Recent Developments: Auto Giants

Leading automakers are entering smartphone industry in order to achieve better intelligence and users' experience

Company

News



Tesla is rumored to release a smartphone in 2023

NIO

NIO is taking a step into hardware by developing its own smartphone



GEELY completed the acquisition of Meizu



Prediction: Increasing Revenue of Leading Smartphone Suppliers from Automobile

FOXCONN

Both companies have strong capabilities in electronics manufacturing

LUXSHARE ICT

Foxconn has been an automobile supplier since 2013, offering a wide range of electronic products such as dashboard displays, printed circuit boards and a range of mechanical and plastic parts

Entry

Luxshare supplied automobile wiring harnesses, automobile appliances and other products to major automakers. In 2022H1, the automobile-related business accounts for 2.57% of whole company's revenue

M&A: In November 2021, Foxconn bought the Ohio manufacturing plant of Lordstown Motors, for \$230 million
JV: Fixtron (Joint Venture with Yulon Motor)

ACTIONS

Investment: In February 2022, Chery Holdings \$1.5B
JV: with Chery New Energy

Foxconn set up Fixtron (JV with Yulon Motor) to launch a development platform of customized full solutions, which offers OTA and open source to automakers

STATUS

Luxshare and Chery New Energy will form a JV to cover EV design, manufacturing and full solutions. The platform will be available to all automobile brands



Both will provide comprehensive solutions to the automakers as well as offer manufacturing



Smartphone OEMs are facing a huge market opportunity and an exponentially growing Total Addressable Market. The cash generated from their mature smartphone business may be put towards automobile and AI capability, gained through investment and M&A activities.



Integration of Technology and Functions

- ✓ *Fund raisings play the role of screening of start-ups at the early stage and promote the leading companies to the potential consolidators of other technologies in the middle term*
- ✓ *In the long term, through M&A, leading companies are likely to be able to deliver integrated turn-key autonomous driving solution from both hardware and software perspective*



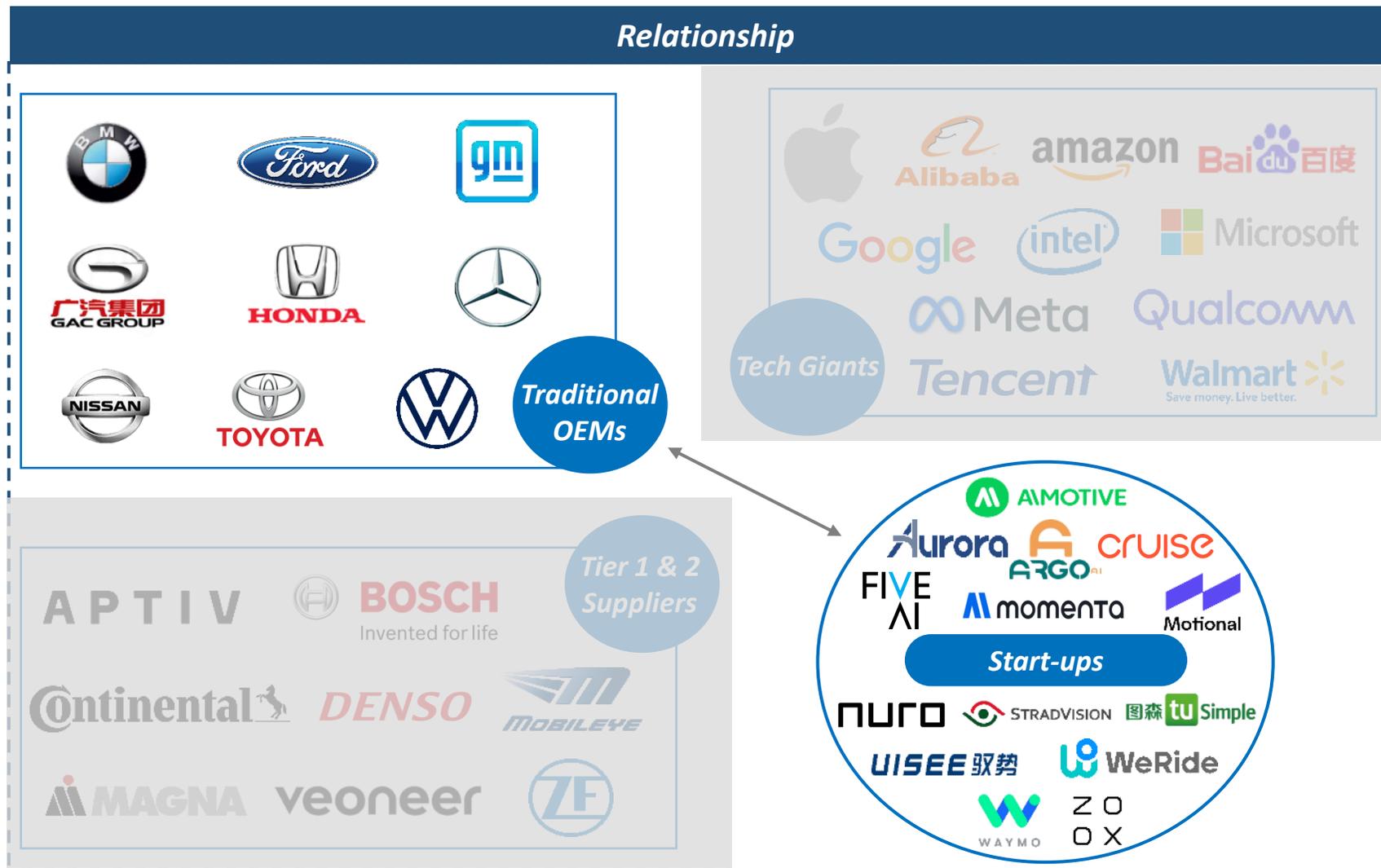
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Reshaping of the Automotive Industry Chain

- ✓ ***Dynamics among OEM, Tier 1/Tier 2 suppliers, cross-industry tech giants and autonomous driving start-ups are reshaping the automobile industry chain. The traditional boundaries among the players will be disrupted.***
- ✓ ***The parties with greater integrated capabilities will dominate the automobile industry. M&A will become a critical approach for exogenous growth.***





GM invested over \$10Bn and holds the majority stake; Honda invested \$750M for a minority stake

Ford & VW Invested \$1Bn each

GM plans to leverage Cruise’s autonomous driving capability to accelerate the development of its AV offering. Honda aims to co-develop AV and eventually deploy ride-sharing fleets globally

Ford plans to develop an AI virtual driver system to fulfill its fully self-driving car. Argo merged with Volkswagen's autonomous driving unit in the form of an acquisition

ACTIONS

Cruise unveiled its first driverless car ‘Origin’ in 2020, but slow progress since with an announcement of an 8% job cut in 2022

After years and billions in time & investment, Ford and Volkswagen lose patience and refuse to provide Argo with more capital

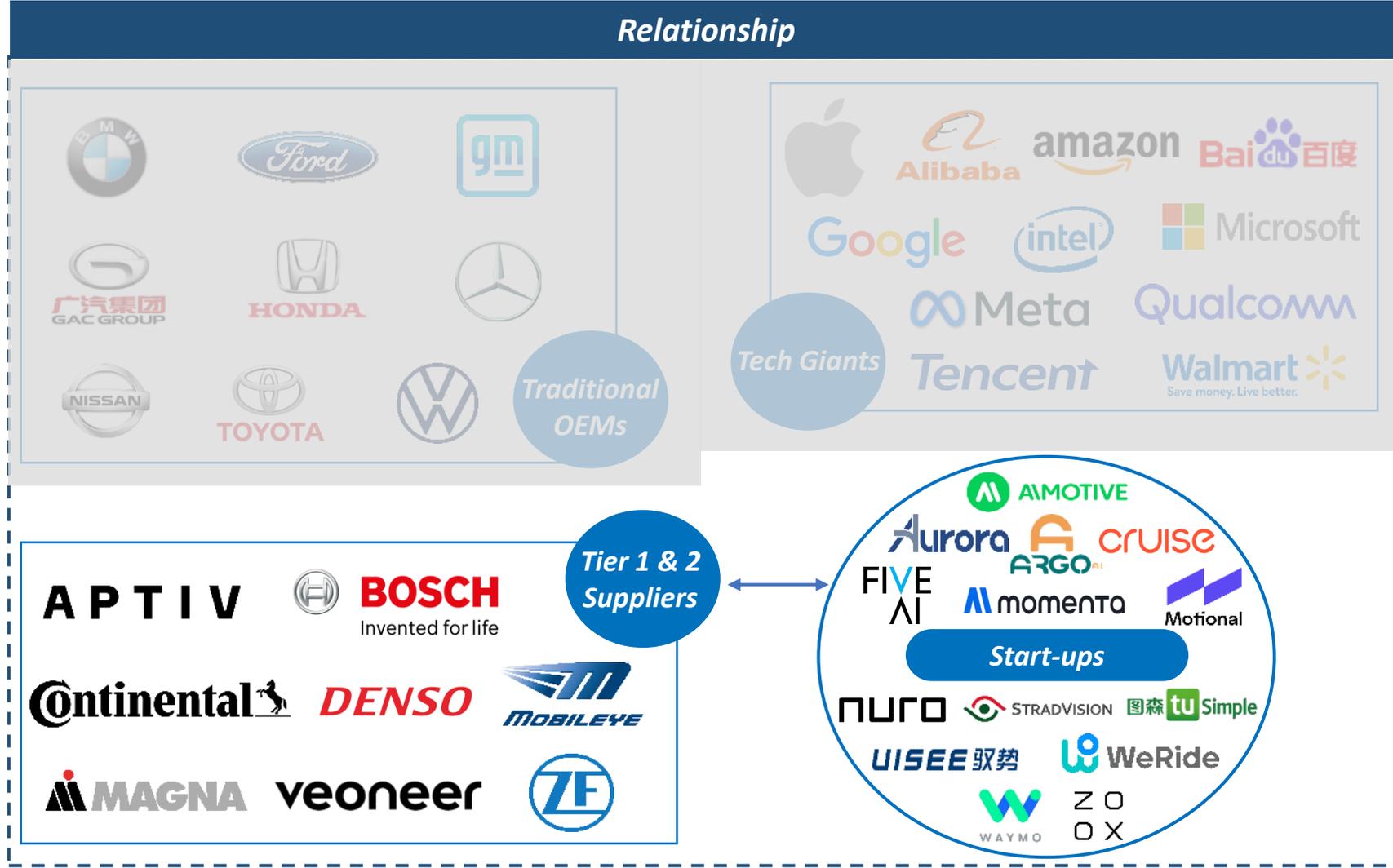
STATUS

Despite encountering difficulties in developing a Robotaxi solution in the short-term, GM has benefited from the partnership having equipped ‘Super Cruise’ (L2 ADAS) to the Cadillac brand.

With the investment in Argo an overall failure, both Ford and Volkswagen need to find another approach to fulfill its autonomous driving goal

IMPACTS

Traditional OEM giants across the US, Germany and Japan have decidedly planted a stake in the autonomous driving industry. High level automation is clearly harder to achieve than initially thought - now OEMs seek a more progressive approach to achieve L2 ADAS solutions - through investment in the technology



Tier 1 & 2 Suppliers: Strategic or Transformational



Investment: WeRide, Momenta, Uisee, Almotive
M&A: FiveAI

M&A: Ottomatika, nuTonomy
Spin-off: Aptiv
JV: Motional

Bosch cooperates extensively with industry players, mostly in the form of strategic investment and joint development, including hardware, software and other supply chain components

ACTIONS

Aptiv was spun off from Delphi to commercialize ADAS and AMoD (*Autonomous Mobility-on-Demand*) systems, JV with Hyundai to combine design, engineering and manufacturing with Aptiv's solutions

Each of the investee companies works independently with Bosch on autonomous driving projects

STATUS

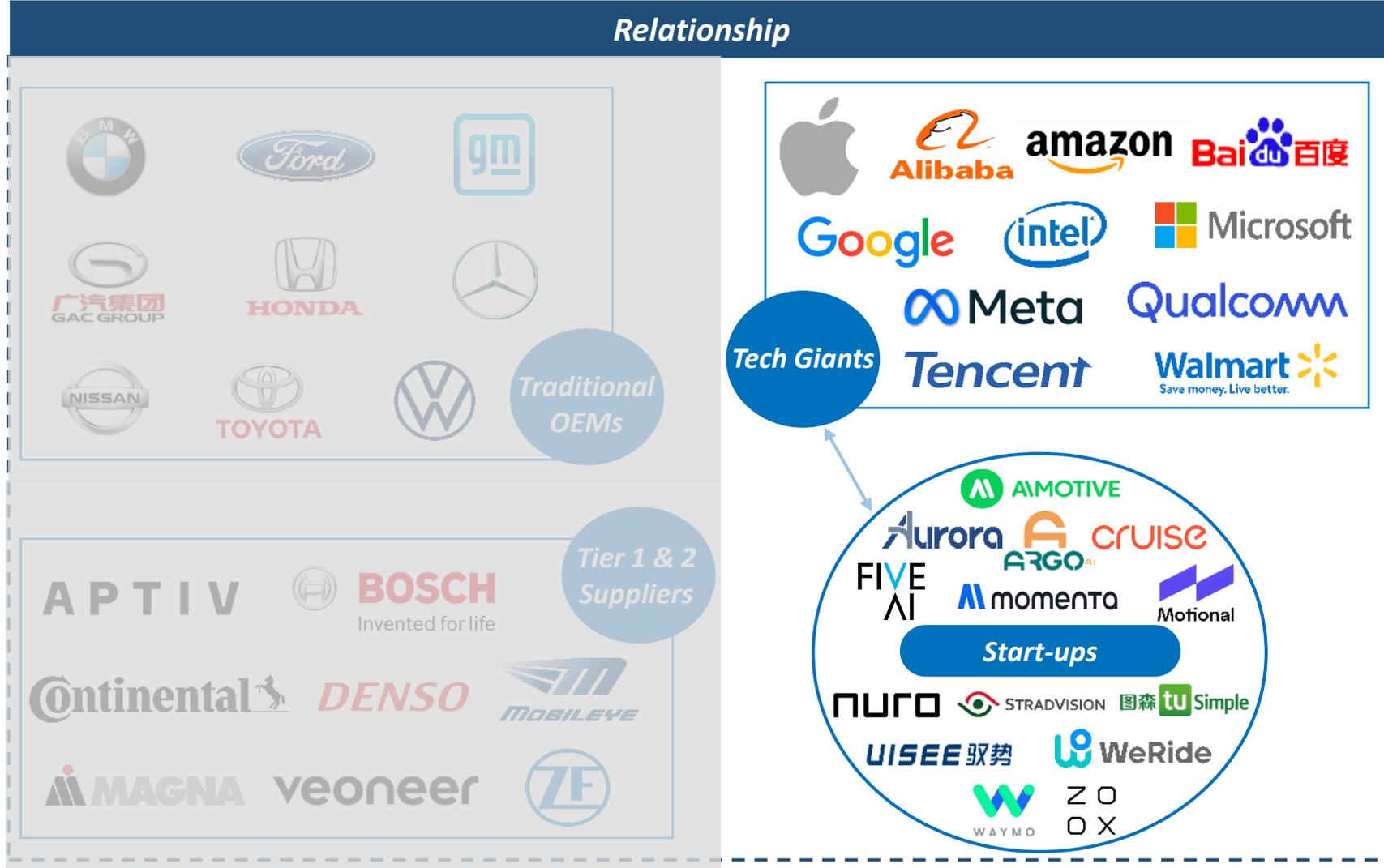
Motional plans to launch its L4 Robo-taxi service in Las Vegas in 2023

Current platform meets the demands of ADAS but faces challenges to achieve higher level autonomous driving. Bosch will launch scalable solutions through cooperation with investees and other partners

IMPACTS

Aptiv has built up a more integrated capability through acquisition to provide a comprehensive solution for OEMs in the intelligence defined era of automobile

There have been several approaches and attempts to engage in the autonomous driving field from Tier 1 and 2 Suppliers. Some like Bosch are building a more open ecosystem through minority and strategic investment with project collaborations. Delphi adopts a more integrated approach through M&A, spin-offs and JVs.





Investment: Nuro
Spin-off: Waymo

Investment: Aurora
M&A: Zoox

Google spun off Waymo as an independent division and invested in Nuro to transform local commerce

ACTIONS

Amazon invested in Aurora and made its first acquisition in self-driving by acquiring Zoox for \$1.2Bn to empower its last-mile delivery service

Nuro also signed a five-year strategic partnership with Google Cloud on large-scale self-driving simulations, machine learning services and data storage from its fleet of vehicles

STATUS

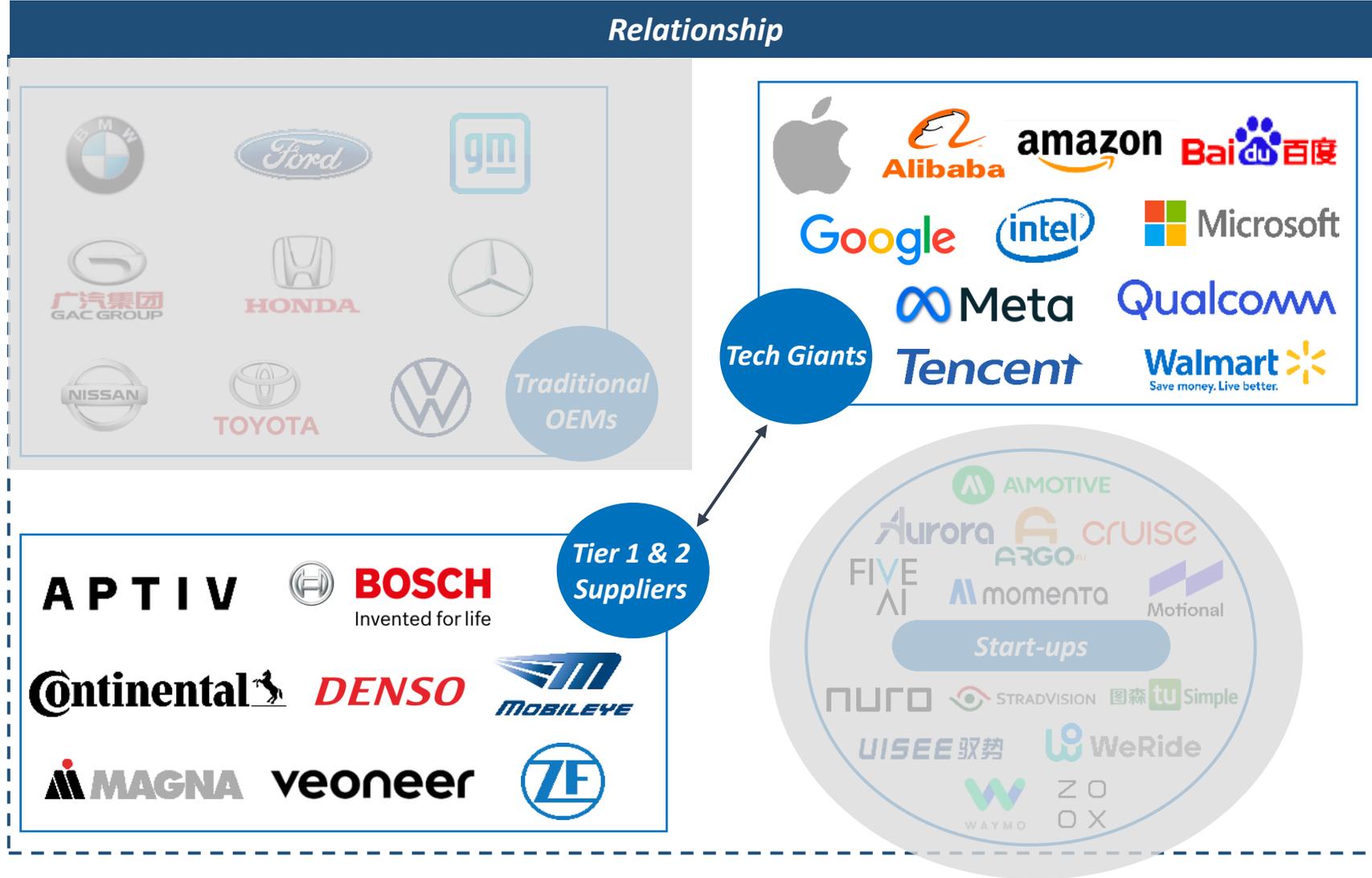
Zoox is now certified to meet the highest U.S. crash safety standards from June 2022, but has not provided any commercial services

Google's Transfer Appliance with its new online transfer capability helps Nuro speed up data delivery from the edge environment to Google's Cloud Storage

IMPACTS

With the acquisition of Zoox, Amazon aims to provide more automated last-mile delivery solutions, reducing human labor cost

Autonomous driving Start-ups not only need significant financial backing but data analytics infrastructure support, both of which Tech Giants can provide. Investment in this industry helps Tech-Giants on two fronts: firstly, these solutions reduce the need for human labor, secondly the market demand for their cloud services grow in the long term





M&A: 2017, Intel acquired Mobileye for \$15.3B
Relisting: 2022, Intel relisted Mobileye at \$16.7B

M&A: 2021, Qualcomm and SSW Partners acquired Veoneer for \$4.5B

With the acquisition of Mobileye, Intel aimed to forge a “CPU+FPGA+EyeQ+5G” platform, with the capability to provide a comprehensive solution for automotive clients

Upon completion of the acquisition, Qualcomm acquired the Arriver software business of Veoneer to enhance Qualcomm's software R&D capabilities in the autonomous driving

Due to its closed system, Mobileye was defined occasionally as Tier 1 and a Tier 2 player. Mobileye is facing the same challenge of its peers – customers are shifting to players with open systems

Qualcomm integrates Arriver's computer vision, decision-making and assisted driving assets into its autonomous driving platform - Snapdragon Ride

Mobileye relists to gain external capital for growth but more importantly to reshape the relationship between Intel and Mobileye, especially in terms of independence

Qualcomm + Veoneer to deliver scalable ADAS and collaborative AD solutions (L2-L4), configured on mass-production vehicles by 2024

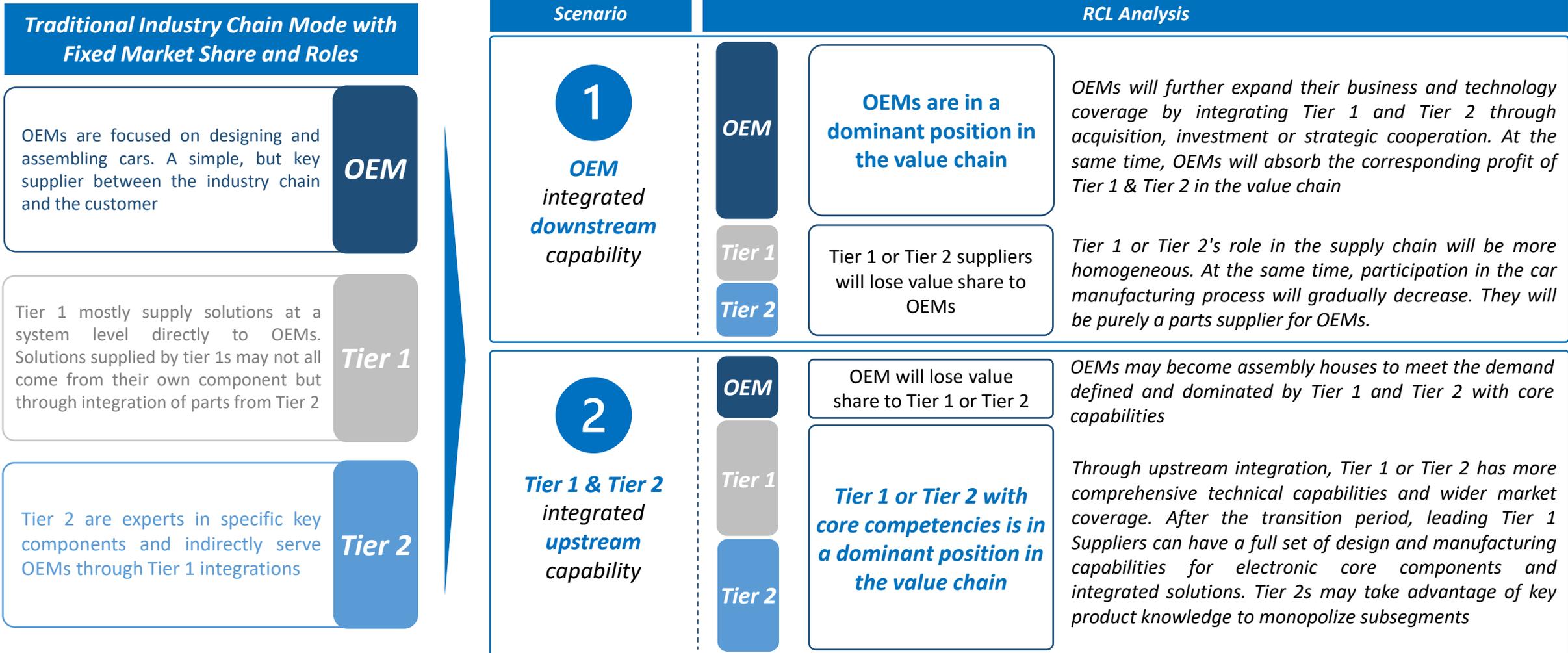
ACTIONS

STATUS

IMPACTS

Semiconductor giants are trying to build up more penetration and influence in the automobile industry through M&A of automobile suppliers. However, it needs to be careful to position itself, because such integration may threaten other peers of acquirers and encourage these companies to adopt other semiconductor solutions

- Dynamics among OEM, Tier 1/Tier 2 suppliers, cross-industry tech giants and autonomous driving start-ups are reshaping the automobile industry chain
- The traditional boundary among players may be redefined in the future
- The parties with more integrated capability would dominate the automobile industry chain
- M&A would become a critical approach for exogenous growth and key strategy for automotive industries players





RCL Insights

Industrial Perspectives

- The system architecture of today's vehicles is blocking to L3+ autonomous driving. Centralized E/E architecture (*electrical engine + electronic decision-making*) is critical for autonomous driving as it solves the problem of inefficient feedback through independent processes of the vehicle's subfunctions. E/E is essential to allow the vehicle to process a large amount of data and responses systematically
- "Software-defined vehicles (SDV)" has gradually become a consensus which is responsible for roughly 90% of the innovation in the industry
- The current landscape is reshaping the automotive industry to a flattened supply chain structure
- Start-ups are facing challenges in the short-term, and traditional automotive players are facing the challenge of competing start-ups, but their expertise of mechanical design and manufacture, human safety protection and quality control should not be underestimated



Commercial Perspectives

- EV's in the electric light vehicle market globally accounted for to 12.3% in 2022H1 (defined as SUVs, Vans, and Generic Cars)
- Alongside the increasing deployments of centralized E/E, it provides a solid ground for the accelerating commercialization of higher-level autonomous driving systems
- US tech giants, large automotive manufacturers and start-ups all underestimated the challenges and timeline for reaching commercialization
- In this context, more players are adopting a pragmatic approach: work with OEMs to deliver L2 solutions and generate cash first, aim for disruptive L4 autonomous driving solutions later



Financial Perspectives

- \$48bn has been invested in autonomous driving innovation as of today, the number of start-ups founded peaked in 2017 with the annual financing amount climbing until 2021
- The industry is still in a development phase, characterized by significant fundraising. Increased M&A may occur in the next few years, driven by the desire to vertically integrate different disciplines of technologies and fold in companies struggling with solvency.
- Under the current monetary environment, investors are more cautious to invest in companies with ambitious goals and a limited commercial roadmap. Companies with a more pragmatic approach, generating profits sooner will be preferred
- Such attitudes and preference of investors will impact the development strategy of autonomous driving companies, at least in the short-term. The long-term implication of how to move beyond L2 is less clear





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**Credit to Mike Powell, Ashley Smith (RCL London)*



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