GAST Automotive Industry & Technology Research Report
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Subject: Recent Developments of Intelligent Connected Vehicles (Nov. 2022)

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Digest of the Latest Policies: *Notice on Promoting the Development of ICVs and Maintaining the Security of Surveying, Mapping and Geo-Information*

■ The *Notice* clearly defines surveying & mapping activities and subjects of HD maps, and regularizes the behavior of surveying & mapping subjects

Tighten supervision over HD maps

Surveying and mapping activities	The act of collecting, storing, transmitting and processing geographic information of vehicles and surrounding road facilities by ICVs after the installation or integration of sensors such as satellite navigation and positioning receiving modules	Surveying and mapping subjects	**Three categories:** automakers, service providers (map vendors) and some intelligent driving software providers (autonomous driving companies)
Behavior of surveying and mapping subjects	• Domestic enterprises can carry out surveying and mapping activities by obtaining surveying and mapping qualifications or entrusting qualified units • **Foreign-funded enterprises are prohibited from ground mobile mapping and navigation electronic map compilation**		A surveying and mapping qualification (Class A) is required for surveying and mapping. Otherwise, it is illegal

Notifying related supporting behavior

Tightening approval of Class A qualification	Impact on autonomous driving	Ways for AD players to gain access to HD maps
Among the original 31 units with Class A qualification, only 19 have passed the qualification review so far	① Slow down the application of urban NOX systems	✓ **Continue to apply for Class A qualification:** great uncertainty ✓ **Apply for Class B qualification:** collection activities are only allowed within the autonomous driving zone designated by the relevant government department ✓ **Cooperate with map vendors:** the collection and maintenance efficiency of map vendors cannot meet the needs of some enterprises → professional + crowdsourcing collection. Six pilot cities have launched pilot application of HD maps for ICVs
• Characteristics of enterprises failing to pass the approval: have served a large number of users, have certain convenient conditions for collecting data via crowdsourcing, or have foreign capital background	② Hit the gray area of HD map data collection (self-collection and self-use in the past) → affect the algorithm iteration speed	

□ **The *Notice* adds the provision that foreign-funded enterprises are prohibited from navigation electronic map compilation → foreign automakers must seek cooperation with local map suppliers when they need to operate autonomous vehicles with HD maps**

Digest of the Latest Policies: Impact of Stricter Supervision on HD Maps

■ China is tightening the audit of HD map drawing qualifications, which has had a certain impact on foreign/domestic enterprises

Impact of qualification restrictions

① Foreign enterprises: cannot carry out mapping in China, or acquire mapping qualification through the acquisition of local mapping companies

② Domestic enterprises: if the original surveying and mapping qualification fails to pass the review, it will affect the implementation of the ADAS

- For example, Zhitu Technology acquired by XPeng Motors failed to pass the review → impede the application of navigation guided pilot (NGP) function to production vehicles + defer the large-scale implementation plan

Options for foreign-owned enterprises

➢ Only cooperate with local map vendors that have passed the review

- The enterprises that have passed the review (Baidu, AutoNavi, NavInfo and Tencent, etc.) will become important targets for multiple automakers to seek cooperation

Options for domestic enterprises

① Continue to apply for Class A qualification review (difficult to pass)
② Apply for Class B qualification (small area, limited development)
③ Shift to the solution of "paying more attention to sensors than maps" (a transitional solution)
- XPeng released XNGP to break away from reliance on HD maps

④ Cooperate with third-party map vendors
- NIO + Tencent, Li Auto + AutoNavi, XPeng + AutoNavi (implemented in Guangzhou)

- **In a short term, enterprises with technical capabilities will shift to the solution of "paying more attention to sensors than maps" or cooperate with other map vendors to achieve NOX function. In the long run, the NOX function will be available at a fast pace after the policy is released**
- **The strict examination of qualifications propels Chinese and foreign enterprises to stand at the same starting line: by jointly adopting maps from third-party professional map vendors to cut their map collection costs, enterprises can focus more on developing vehicle-side algorithm technologies**

Digest of the Latest Policies: Review and Renewal Status of HD Map Class A Qualifications

- By the end of 2021, only 19 of the 31 qualified enterprises have passed the review

Units that have passed the review	AutoNavi	Shenzhen Careland Technology	SpeedChina	SFMAP Technology (Shenzhen)
	MXNavi	Tencent Dadi Tongtu (Beijing) Technology	Beijing Baidu Zhitu Technology	PIESAT Information Technology
	Beijing Huawei Digital Technology	Beijing Lingtu Software Technology	Liaoning Maptech	Provincial Geomatics Center of Jiangsu
	NavInfo	Beijing Meituan Map Technology	ECARX	Zhejiang Province Surveying and Mapping Science and Technology Institute of Hangzhou
	Jiangsu Province Surveying & Mapping Engineering Institute	Guizhou Kuandeng Intelligent Cloud Technology	Hebei Quandao Science and Technology	
Units that have failed the review	EMG	Momenta		
Units whose information is not publicly available	National Geomatics Center of China (NGCC)	Beijing Intercity High-Tech Information Technology	Beijing Jingdong	Ditu Technology (Beijing)
	Wuhan KOTEI Informatics	Heading Data Intelligence	Leador Spatial Information Technology	China Trans Geomatics
	Jiangsu Jingzhong Information Technology	Jiangsu Zhitu Technology		

Industry Developments: The First Batch of Pilot Projects for the Application of Smart Transportation

- Recently, the Ministry of Transport announced the first batch of pilot projects for the application of smart transportation in 14 autonomous driving directions

City / Pilot scenario	Beijing	Shanghai (2)	Shenzhen	Guangzhou	Suzhou	Chongqing	Tianjin (2)	Zhengzhou	Hefei	Changchun	Jinan	Xiamen
Robotaxi	38	50		210	430							
Robobus	5	7		50	47	10		40	5	8		
Port scenario		120	38				76					18
Autonomous sanitation		5			25	4			3			
Main-line logistics							6			2	3-6	
End-user delivery	65	30										
Self-service vending	80	20			49				3			
Results (technical guidelines/standards)	3	5+5	/	2	12	2	0+5	3	/	2	1	3

- **The regional distribution of pilot projects reflects to some extent the development of the city's auto industry and autonomous driving industry. The projects cover relatively comprehensive scenarios, which helps explore problems in the practical application and operation of AVs, and provides better service and operational patterns for future smart transportation**

*Note: figures indicate the expected number of vehicles or results

Industry Developments: MIIT Will Guide More Localities to Accelerate the Industrialization of ICVs

- On October 17, the Ministry of Industry and Information Technology (MIIT) replied to the proposal on speeding up the formulation of innovative policies related to unmanned driving

Proposal	➢ Forge ahead with pilot demonstrations → create policy pilot zones for passenger-carrying operation of fully autonomous vehicles	➢ Improve policy environment → accelerate the revision, release and implementation of the *Road Traffic Safety Law*	➢ Promote infrastructure construction → build intelligent transport infrastructure in a moderately advanced manner and give full play to the advantage of 5G in remote control
MIIT's reply	**Adhere to the principle of "intelligent vehicles + connectivity technologies"**		
	✓ Join hands with the Ministry of Public Security, Ministry of Transport, and Ministry of Housing and Urban-Rural Development to guide more localities to launch pilot projects ✓ Support to build 17 national ICV demonstration areas, promote 26 provinces (cities) to release detailed management rules, open test roads spanning more than 3,200km and issue more than 700 test license plates	✓ Initiate the revision of the *Road Traffic Safety Law*, which is undergoing the review process ✓ Clarify the management requirements on automotive data security, network security, functional security, Safety of The Intended Functionality (SOTIF) and OTA updates, etc.	✓ Continue to deploy key projects related to IoV and promote the construction of national IoV pilot zones ✓ Well organize the pilots for the collaborative development of smart city infrastructure and ICVs ✓ Step up efforts in building intelligent infrastructure and promote the upgrading of road infrastructure

- **MIIT's reply shows that China will unswervingly follow the path of industrializing ICVs, but the timeline for taking corresponding measures remains to be determined by the results of the demonstration areas. Enterprises should actively participate in the argumentation of regulations and demonstration pilots**

Industry Developments: Shanghai Actively Promotes the Development of ICV Industry

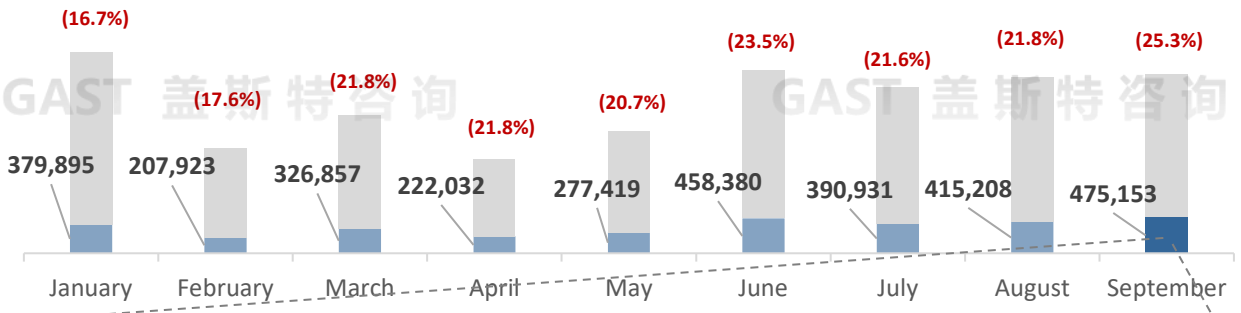
- Recently, Shanghai issued *the Plan for Accelerating Innovative Development of ICVs in Shanghai,* opened up Shanghai Intelligent Vehicle Software Park in Jiading District and established Shanghai Integrated Innovation Center of Smart Cities and Intelligent Vehicles

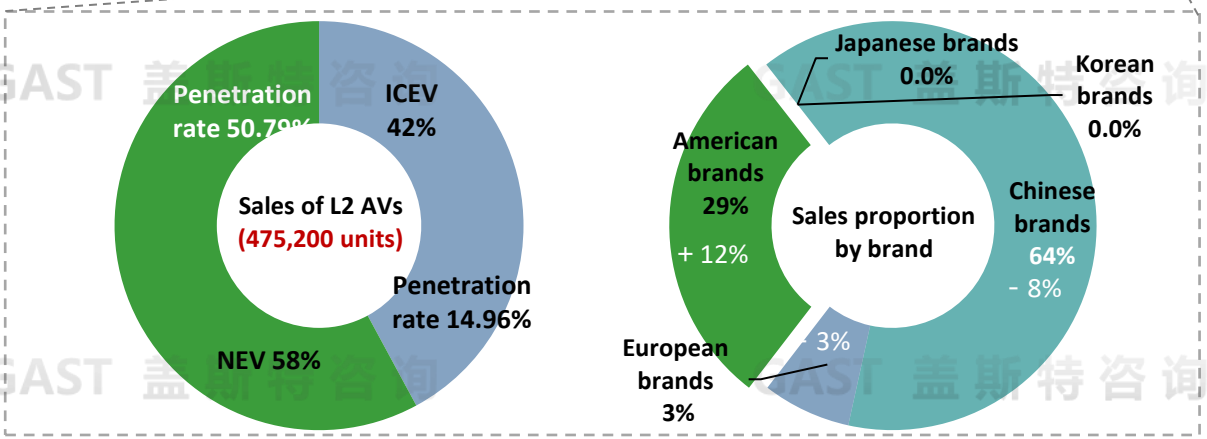
Goals for 2025	① Industry scale: up to 500 billion CNY	② Proportion of L2~L3 AVs produced: more than 70%	③ L4+: realize commercial applications in limited regions and specific use cases
Key tasks	**Breakthroughs in new technologies** ✓ Automotive-grade chips, AI algorithms, LiDAR, automotive OS, intelligent computing platforms and X-by-wire execution systems ✓ Virtual simulation, HIL simulation and vehicle road testing technologies	**Layout of new terminals** ✓ Intelligent driving terminals, smart cockpit terminals, intelligent communications terminals and large ICV terminals	**Cultivation of new ecosystems** ✓ Enhance the core cometitiveness of OEMs ✓ Build a multi-level key component industry system for ICVs ✓ Promote the cross-domain integration of various market players
	New spatial pattern ✓ Lin-gang High-Level AD Demonstration Area ✓ Pudong New Area: accelerate the deployment of automotive-grade chips and AI algorithms ✓ Fengxian District: Full-chain Smart Driving Innovation Pilot Zone	**New applications** ✓ Establish a mechanism for recognizing non-local test and evaluation results ✓ Move faster to build application scenarios such as smart taxis, smart buses and unmanned sanitation vehicles	**New supporting infrastructure** ✓ Promote the upgrade of intelligent traffic lights ✓ Launch pilot projects for the application of HD maps for autonomous driving ✓ Explore a new mechanism for the investment and operation of infrastructure
Industrial park planning	➢ It is dominated by intelligent vehicle software, autonomous driving, IOV, smart cockpit and intelligent traffic information services (ITIS)		

Shanghai has made ICV industry as one of the key industries that can boost its economic growth → relevant supporting policies are introduced in succession; the quantifiable and specific targets in the implementation plan will further drive the commercialization of autonomous driving

Market Developments: Intelligent Passenger Vehicle Sales Trend

Sales and penetration rate (%) of intelligent passenger vehicles from January to September 2022





Cumulative monthly penetration rate in 2022

- In September 2022, due to small impact of chip crunch, the sales of intelligent vehicles showed a continuous growth compared with July to August
- In September 2022, both the sales and proportion of intelligent vehicles hit a new record this year, and the penetration rate rose by nearly 4 percentage points month-on-month
- From late September to mid-October, a total of 13 NEVs with L2 intelligent driving functions were launched/added, all coming standard with OTA updates

Sales in September 2022

- Among L2 intelligent vehicles, intelligent ICEVs occupy a lion's share due to high sales, but scored a penetration rate of only 14.96%, a significant gap with that of NEVs (50.79%)
- Among NEVs, BEV models occupied a major share and posted sales increase, and the sales gap between PHEVs and BEVs has widen
- The proportion of American brands increased because Tesla delivered its vehicles in a centralized manner in September and saw sales pick up. Chinese brands continued to occupy a dominant share

*Definition of intelligent passenger vehicles: L2 AD capabilities (ACC + LKA) + OTA updates

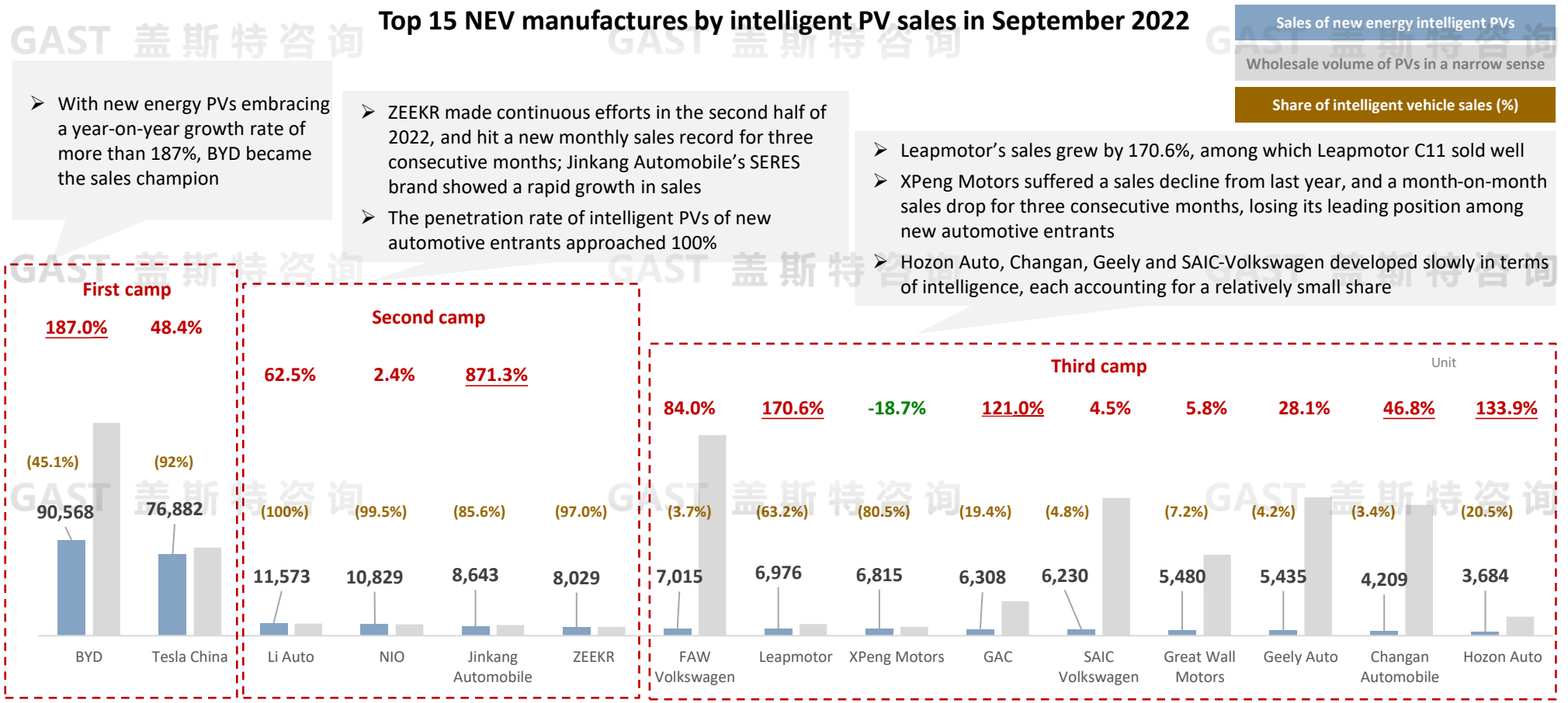
- **Intelligent vehicle sales grew against the trend of overall declining sales of passenger vehicles because: ① a number of new vehicles hit the market in September; ② Chinese users prefer intelligent functions → prompt automakers to accelerate the intelligent layout in China's market**

*Data source: China Banking and Insurance Regulatory Commission (CBIRC)

Market Developments: Top 15 NEV Manufacturers by Intelligent PV Sales

- In September, the most notable changes from the previous month were: SAIC Volkswagen drop six places to No.11; Jinkang Automobile climbed two places to No.5

Top 15 NEV manufactures by intelligent PV sales in September 2022



- With new energy PVs embracing a year-on-year growth rate of more than 187%, BYD became the sales champion
- ZEEKR made continuous efforts in the second half of 2022, and hit a new monthly sales record for three consecutive months; Jinkang Automobile's SERES brand showed a rapid growth in sales
- The penetration rate of intelligent PVs of new automotive entrants approached 100%
- Leapmotor's sales grew by 170.6%, among which Leapmotor C11 sold well
- XPeng Motors suffered a sales decline from last year, and a month-on-month sales drop for three consecutive months, losing its leading position among new automotive entrants
- Hozon Auto, Changan, Geely and SAIC-Volkswagen developed slowly in terms of intelligence, each accounting for a relatively small share

*Data source: CPCA

Market Developments: Sales of Top 15 Intelligent New Energy Passenger Vehicle Models

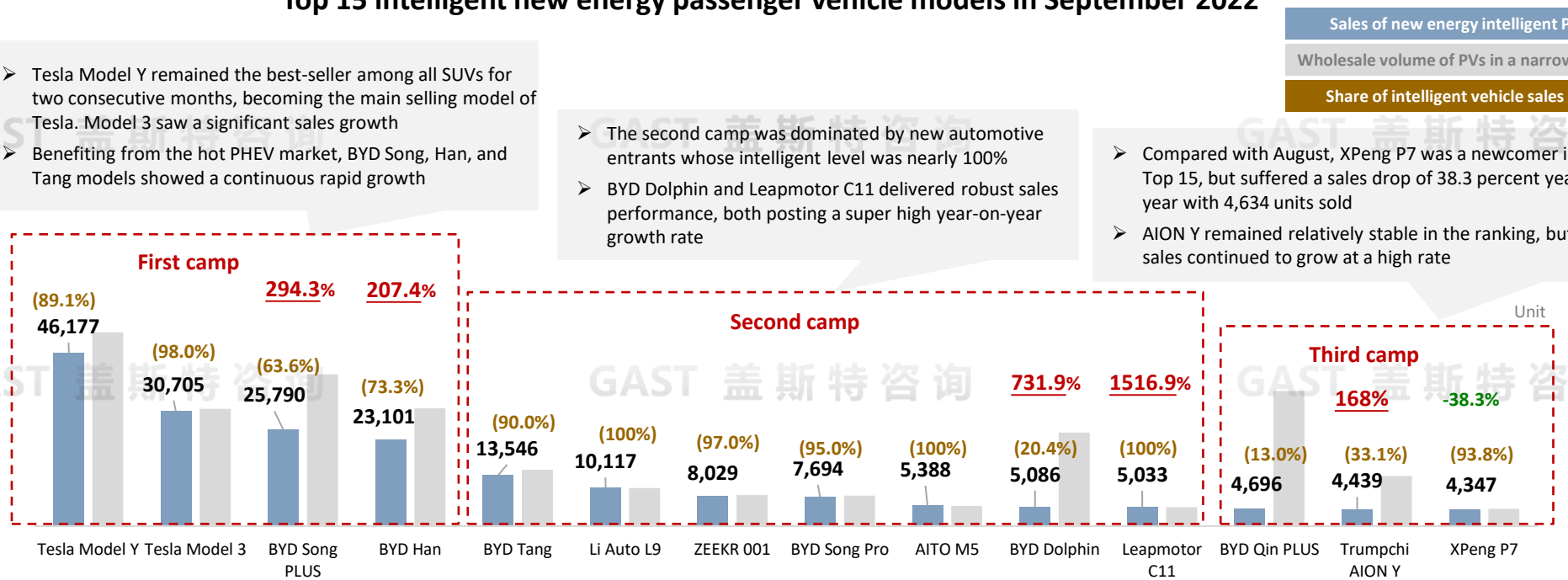
- Compared with August, Model 3 saw a notable change in the ranking in September (up by 14 places). As a new model, Li Auto L9 was ranked the 6th place. BYD (Song, Han, Dolphin), Leapmotor C11, and AION Y showed a rapid growth

Top 15 intelligent new energy passenger vehicle models in September 2022

- Tesla Model Y remained the best-seller among all SUVs for two consecutive months, becoming the main selling model of Tesla. Model 3 saw a significant sales growth
- Benefiting from the hot PHEV market, BYD Song, Han, and Tang models showed a continuous rapid growth

- The second camp was dominated by new automotive entrants whose intelligent level was nearly 100%
- BYD Dolphin and Leapmotor C11 delivered robust sales performance, both posting a super high year-on-year growth rate

- Compared with August, XPeng P7 was a newcomer in the Top 15, but suffered a sales drop of 38.3 percent year-on-year with 4,634 units sold
- AION Y remained relatively stable in the ranking, but its sales continued to grow at a high rate



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Corporate Strategies of Tech Companies: Tencent's "Vehicle-Cloud Integration" Strategy

- Tencent Intelligent Mobility has recently unveiled its newly upgraded "Vehicle-Cloud Integration" strategy, which breaks down its business layout into three levels: vehicle side, smartphone side and cloud side

Closed-loop management of data for higher efficiency

Vehicle side	• Intelligent cockpit TAI, intelligent driving map, HD map, intelligent scenario engine, in-vehicle mini programs, etc.	Boost intelligent evolution of vehicles
Smartphone side	• Leverage its social media tools WeChat and Enterprise WeChat, and a new "Tencent Mobility Service" mini program to form a seamless connection between smartphones and vehicles	Connect smartphone and vehicle scenarios
Cloud side	• Cloud services covering R&D, manufacturing, marketing, operation and after-sales services	Provides full-chain solutions

Automotive business layout

Intelligent in-vehicle systems	Autonomous driving tool chain
• Based on Tencent's rich application ecosystem: intelligent driving map, WeChat for vehicles, in-vehicle mini programs, Tencent Meeting, QQ Music, Tencent Video, etc.	• Development and operation cloud platform + simulation platform + HD map platform + L2.5/L4 modular technology solution + system security

Positioned as a digital assistant for OEMs and mobility enterprises in the auto race, Tencent has certain competitiveness in the IoV business segment based on application ecosystem

Corporate Strategies of Tech Companies: Tencent Focuses on Deploying Tencent Intelligent Automobile Cloud

- Tencent Cloud has built a complete cloud service solution, which can provide IaaS (Infrastructure as a Service) at the bottom layer, PaaS (Platform as a Service) at the middle layer, and SaaS (Software as a Service) at the upper layer

Development opportunities

- Autonomous driving tool chain becomes the key to competition, and building an intelligent computing center will be the focus of competition in the next stage
- Algorithm models of various autonomous driving companies converge → the core competitiveness of autonomous driving track in the next stage: an efficient autonomous driving data closed-loop system, which processes data in an efficient and low-cost way to improve algorithm training

Tencent Intelligent Automobile Cloud

- Connect all links of autonomous driving R&D, including data acquisition, storage, labelling, algorithm training, simulation evaluation, mass production data backhaul, data operation, etc.

Industry eco-markets Data/algorithm/application/ service	Industry data ecosystem Scenario library/ evaluation library	Industry algorithm ecosystem Perception/prediction/ planning	Industry application ecosystem Simulation software/ plug-in	Industry service ecosystem Data acquisition/labeling	Development workbench Autonomous driving tool chain Data acquisition Data management service (DMS) Data labeling Data training …
Aggregation of industry capabilities	Data storage	Data processing	Efficient computing	Intelligent cockpit	Intelligent driving map
Special cloud for intelligent vehicles	Storage, computing, network, middleware, big data, DevOps, distributed databases …				

Combined with industrial development opportunities and Tencent's technical advantages in maps, big data, AI and computing power layout, Tencent Intelligent Automobile Cloud is expected to become Tencent's most competitive product in the auto race

Corporate Strategies of AD Players: Haomo.AI's "Data-Driven" Development Model

- The autonomous driving industry has basically passed the hardware-driven (piling-up of hardware) and software-driven (focus on algorithms) eras. With the scale and diversity of data becoming more important, Haomo.AI is moving fast into a data-driven 3.0 era

Data driven	Scale Over 100 million km	+ Perception Joint output of results from multi-modal sensors	+ Cognition Explainable scenario-based driving knowledge	+ Model Large model + big data
Competitive advantage	Scenario-based user experience design Technology engineering ability Effective synergy	AI technology	• Transformer, a large model based on Attention mechanism • High computing demand, high training cost, high implementation difficulty	New requirements for data size → • Data self-training as the mainstay, data channels + computing centers • Efficient accumulation of data and conversion of data into knowledge
Technology path	Apply technology to products Use data to improve technology Closed loop	Products generate data	• Urban L2 driver assistance as the entry point + low cost + low difficulty in large-scale application in vehicles + high frequency of use → rapidly obtain massive and effective real-world use data	
Specific measures	• Based on data of assisted driving for 17+ million km, the data intelligence system MANA has a learning time of 310,000 + hours and a virtual driving age of 40,000 years • MANA supercomputing center: aim to support a large model with 100 billion parameters, achieve the training data scale of 1 million clips, and reduce the total training cost by 200 times			

In the battle of vying for data intelligence technology, Haomo.AI achieves the rapid product iteration based on data-driven real-world scenarios

Corporate Strategies of AD Players: Haomo.AI Adopts a Progressive Way to Turn Autonomous Driving into Reality

- To obtain high-quality mass production data from users' real scenarios on a large scale has become a core element to make autonomous driving become mature → boasting advanced autonomous driving technologies and capabilities, Haomo.AI takes low-level driver assistance products as the carrier to turn autonomous driving into reality

Data advantage in quantity

- Progressive route: earlier application in in production vehicles + earlier scale-up → easier to obtain sufficient data than the leapfrog route

Data advantage in quality

- Compared with the leapfrog targeted data collection method, the data collection from users' real-world use cases features lower cost and higher quality

Bring scale effect by virtue of the market + drive rapid product iteration → build a two-way cycle of user experience and data acquisition of intelligent driving products

Production situation	Haomo.AI's HPilot	• Haomo.AI's HPilot has been applied to more than 10 production vehicle models. After six OTA updates in two years, HPilot is at the forefront of domestic autonomous driving systems applied to production vehicles
	Haomo.AI's NOH	• Haomo.AI's urban NOH (Navigation on HPilot) will be available in 10 cities by the end of this year and will be expanded to 100 cities next year

- Data accumulation to expand the leading edge
- Asynchronous parallel development of multiple projects to speed up the application in production vehicles
- Provide users with intelligent assisted driving experience in all scenarios

Haomo.AI's important resources lie in the data container endorsement provided by GWM. Considering the cost, user acceptance and other factors, it is a reasonable choice to leverage driver assistance technology to gradually morph into progressive development

Corporate Strategies of AD Players: Pony.ai Accelerates the Operation of Autonomous Driving Technologies

- Pony.ai's medium- to long-term goal is to scale up and commercialize AD technologies, and open operation is the key in the process of autonomous driving commercialization

Pony.ai
Autonomous driving SW and HW technologies

+

Caocao Mobility
Suitable for modified AVs + shared mobility platforms

+

Geely's Intelligent Driving Center
System software development + vehicle underlying platform construction

- Content of the cooperation: **enable the synergy between technology end, application end and data end**, jointly build an open operating platform for intelligent driving, and make robotaxi service available in Suzhou within this year
- Strategic significance of **"1+1+1" cooperation model**
  - AD player—Pony.ai: saves a lot of money compared with building its own fleet, and leverage OEMs' resources to rapidly amass data, improve R&D capabilities, and cut the cost to fall within the mass production range
  - Mobility platform—Caocao Mobility: connect the ride-hailing platform to the Robotaxi service, gather user traffic and accelerate the transformation into a mobility service provider
  - OEM—Geely Auto: rely on OEMs' big data systems, harness the commercial operation of Robotaxi to collect data and verify technologies → form a data-driven closed loop to continuously transfer accumulated technologies to the ecosystem

Pony.ai + **SAIC AI Lab**

- They have jointly built a fully autonomous driving concept vehicle based on SAIC Marvel-R, and carried out pilot operation of autonomous shuttle service
- They will jointly build an autonomous vehicle fleet suitable for large-scale commercial operation and expand it in a steady way

- **To commercialize autonomous driving technologies, the industry is changing from fighting alone to cooperation (the major trend): AD players, mobility platforms and OEMs complement each other's advantages to create a closed loop from technology R&D to commercial operation**

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Product Developments of OEMs: XPeng Opens City NGP to All Eligible P5 Vehicles in Guangzhou

- On October 22, XPeng P5 received its third major OTA update, which adds City NGP function to the vehicle. Covering nearly 90% of daily mobility scenarios, the function will be fully available to users in Guangzhou first

Function highlights

Wide coverage of scenarios	➢ Basic driving functions: cruising & car following in the lane, navigation/overtaking for lane change, merging into/out of the road, traffic light recognition & start/stop, intersection/roundabout/tunnel passage, avoiding other traffic participants (pedestrians, cyclists), etc. ➢ Tackle challenges in difficult urban scenarios: complex roads, irregular traffic behavior, frequent rerouting & construction, etc.
Intelligent driving safety system	➢ "Pre-use education" access test: ensures users understand safety boundaries before using City NGP function ➢ Combine user driving behavior data with "Smart Driving Score": provide customized usage guidelines
"Beginner Mode"	➢ Users can use City NGP on eligible roads, and after driving for more than 100 km and after 7 days from the first activation of the function, can activate all available roads

Upgrade of supporting functions

LCC enhanced version (for cities where City NGP is not available)

- ➢ Based on the same technology platform as City NGP, not limited by advanced driver assistance maps
- ➢ Capability enhancement: passing intersections, detouring and crossing curves, avoiding close cut-in targets
- ➢ Add self-recovery function. After the function is withdrawn, if the system recognizes that the environment meets the working conditions within a short period of time, it will automatically recover the LCC enhanced version and issue voice prompts
- ➢ Add traffic light recognition and traffic light status display on the instrument interface

Highway NGP

- ➢ Add an instrument SR interface for intelligent assisted driving environment simulation display, showing the perceived target objects and environmental information around the vehicle
  - Turn signal of nearby vehicles, guidance surface of the driveable area of the vehicle, guidance line of the vehicle's path planning, turning point reminder, identification and notification of risk scenarios, hierarchical takeover reminder, etc.

XPeng plans to remove roadblocks for highway, urban open road and parking scenarios by 2024. It still needs to adopt the transitional solution of paying more attention to sensors than maps, and reduce the dependence of technical solutions on HD maps

*NGP: Navigation Guided Pilot

Product Developments of OEMs: Rising Auto R7's RISING PILOT (1/2)

- Rising Auto R7, powered by RISING PILOT (a fully integrated high-level intelligent driving system), has completed the highway NOA test. It hit the market in late September, started delivery in late October, and will have highway NOA function upon delivery

Core software and hardware configuration	**Premium 4D imaging radar**	➢ **Layout solution:** 1 Premium 4D imaging radar in the front and rear of the vehicle respectively + 4 enhanced long-range angular radars around the vehicle ➢ **Advantages:** multiple transmitting and receiving channels to generate "point clouds" and directly form images → for AI models to resolve the contour and category of the target (will replace the role of LiDAR to some extent), and longer detection distance (200m → 350m) ➢ Serve as the debut of ZF's Premium 4D imaging radar in China
	Luminar 1,550nm LiDAR	➢ **Advantages:** due to the long wavelength, the laser light is far from the visible spectrum absorbed by the human eye → extend detection distance by increasing power; the detection distance of objects with 10% reflectivity reaches 250m; an angular resolution of 0.06°×0.06° (identify objects with a length/width/height of 30cm at 150m away)
	"Full fusion" algorithm (pre-fusion + post-fusion)	➢ **Pre-fusion:** retain the original data of each sensor (texture features, 3D data, RGB information, etc.), and use a set of complex AI algorithms consisting of multi-tasking neural networks to derive perceptual results through complex operations (high-performance processors & high-bandwidth communication & massive data-driven neural network learning); high potential for development and high accuracy of information ➢ **Post-fusion:** comparison and verification, weighting, arbitration of independent results from different sensors before adoption or abandonment; simple logic, fast computing, small communication bandwidth, but high loss and low accuracy of information □ **Computation & communication support:** 2 Nvidia Orin X chips + 4-channel Gigabit Ethernet + 9-channel 100M Ethernet

□ **Based on high-performance perception hardware, RISING PILOT collects sensor data for cross-validation, and can complete the whole process of perception, computation, decision-making and execution within milliseconds**

Product Developments of OEMs: Rising Auto R7's RISING PILOT (2/2)

- Rising Auto's intelligent driving team has optimized the algorithm to improve difficult scenarios in a targeted manner, and has achieved avoidance, courteous lane change, and maintenance of a flexible range of lateral safety distance, etc.

Intelligent driving functions	**Highway NOA** ➢ Automatic lane change for overtaking ➢ Automatic driving on/off ramp	Driving and riding experience	➢ Automatic lane change for overtaking: real-time monitoring of the speed of vehicles on its own lane and lanes on both sides + accurate judgment + decisive execution ➢ Automatic driving on/off ramp: properly handle the situation of extra-wide lanes (no exit, lane departure, etc.), drive at an appropriate speed in the ramp with a large curvature, and in the case of large traffic flow, can also find the right time to merge into the lane
	Respond to construction signage	Driving and riding experience	➢ Recognize obstacles ahead and brake in advance to actively change lanes to bypass ➢ When there is a vehicle in the next lane, first slow down to let it overtake, and then change lanes

MY PILOT, a self-adjustable intelligent driving mode	**Support different driving styles → meet different user needs** • "Comfort" mode (for smoothness and comfort), "Sport" mode (for efficiency), "Standard" mode (balance between comfort and efficiency): the three driving modes vary greatly in style and decision-making strategies, and are the industry's first self-adjustable intelligent driving mode
"Scenario reconstruction" by the intelligent driving interaction system	• Whether the intelligent driving functions are activated or not, users can see the perceptual elements and detection effects of the algorithm on the center console screen and the dashboard, understand the logic of decision-making on vehicle driving, and gradually understand the system's capability boundary, so that users can stay curious about, know, try, trust, love and rely on the intelligent driving functions

- **With the full-stack self-development capability system, after the R7 is delivered, the intelligent driving functions, including highway NOA, will be continuously iterated through OTA updates, helping Rising Auto gain technological leadership in the longer life cycle of the product**

Product Developments of Tech Companies: Huawei Pushes Urban NCA Function in Shenzhen

- Recently, the "HI (Huawei Inside)" version of ArcFox αS powered by Huawei's urban NCA went into mass production; Shenzhen became the first city to open this function since it was the first to be approved to release urban HD maps

Technical capabilities

Hardware	• Sensors: Huawei has achieved in-house R&D and production of the main sensors required for autonomous driving, and Huawei LiDAR is expected to reach 5% of the global market share in 2022, ranking fourth in the world
	• Computing platform: MDC, an intelligent driving computing platform based on Ascend chips, with a computing power range of 48~400 TOPS, can support L2-L5 autonomous driving
Software	• There are about 2,000 people in the autonomous driving department, including about 1,200 people in the algorithm team, and related research investment reaches 1 billion USD/year
HD map	• Grade A surveying and mapping qualification for HD map production + map collecting and mapping capabilities
Upgrade channels	• Car owners in Shenzhen can directly upgrade their vehicles to the latest intelligent driving version through offline updates, OTA updates and other forms, and users in cities around Guangzhou and Shenzhen will receive OTA update push in batches

Self-development of full-stack technologies

Available functions

Autonomous cruising in urban areas
Unprotected passage at intersections
Cutting in line at close range
Active overtaking & lane change
Active merging & splitting
Tunnel passage
Creeping in blind zones
…

- **To open its function to users in more available cities faster, Huawei will gradually reduce its reliance on HD maps at this stage, and embark on the route of "paying more attention to sensors than maps"**

*NCA: Navigation Cruise Assist

Comparison of Recently Released Advanced Driver Assistance Systems

Dimension		GWM's Haomo.ai NOH	SAIC's Rising Auto R7	XPeng NGP	αS (HI version)
AD level		L2+	L2	L2+	L2+
AD system		HPilot 3.0 (city)	RISING PILOT (highway)	XPilot 3.5 (city)	Huawei ADS (city)
Hardware configurations	Sensor	2 LiDARs + 12 cameras + 5 MMW radars + 12 ultrasonic radars	1 LiDAR (optional) + 12 cameras + 2 4D MMW radars + 12 ultrasonic radars + 4 angular radars	2 LiDARs + 5 MMW radars + 13 cameras (P5)/12 cameras (G9) + 12 ultrasonic radars	3 LiDARs + 6 MMW radars + 13 cameras + 12 ultrasonic radars
	Chip	Qualcomm Snapdragon 8540 + Snapdragon 9000	2 NVIDIA Orin-X chips	2 NVIDIA Orin-X chips	Huawei MDC 810
	Computing power	360 TOPS	508 TOPS	508 TOPS	400 TOPS
HD map		/	Baidu	AutoNavi	Huawei
Voice interaction system		Self-developed	iFlytek	Self-developed + AISPEECH (underlying)	Huawei
Intelligent driving functions	Highway pilot	√	√ Automatic lane change + automatic driving on/off ramp	√ Automatic switching of highways, etc.	√
	Automatic parking	√	√	√	√ Vehicle summoning, etc.
	City pilot	√ Recognition of traffic lights, lane lines, etc.	×	√	√
Time for mass production		Q4 2022	October 2022	October 2022 (Guangzhou)	September 2022 (Shenzhen)
Actual user experience		Optimized for diverse and complex urban road conditions + faster and more timely perception and response capabilities → easier and safer driving	Stable performance in highway pilot + good performance in automatic driving on/off ramp; support for customizing intelligent driving modes according to the actual driving environment and user preferences	Basically no need of takeover during autonomous driving + road condition recognition + conservative in corner cases + close to human drivers in terms of start-stop and overtaking	Precise and decisive operation of the AD system + good overall performance on complex urban roads + merge into the crowded traffic in the form of human-machine co-driving

- **ADAS has gradually become the main battlefield for Chinese homegrown brands to compete. In the context of highway pilot gaining traction and city pilot applied to vehicles faster, the focus of competition in intelligent vehicles is switching from functions to user experience (comprehensive)**

Product Developments of Tech Companies: NVIDIA Unveils a Chip with a Supercomputing Power of 2,000 TOPS

- Recently, NVIDIA announced that Thor (2,000 TOPS) will replace the planned Atlan to be the follow-on to DRIVE Orin™, and will start production in 2025

DRIVE Thor SoC — adopt 4nm process with 77 billion transistors integrated inside

Grace — the industry's most powerful CPU (central processing unit) for single-threaded performance

- Based on ARM's all-new Poseidon architecture
- A highly specialized CPU for large-scale data-intensive high-performance computing and AI applications

Ada Lovelace — multi-instance GPU (graphics processing unit)

- Allow the transition from 32-bit to 8-bit data without sacrificing accuracy → **improve computational efficiency**
- Grace allows GPU's parallel computing capability to no longer be limited by CPU's scheduling capability → **highlight NVIDIA's advantages**

Hopper — inference converter (Transformer model) engine

- Accelerate inference performance of Transformer deep neural networks by up to 9x → **effectively support the complex AI workloads associated with autonomous driving**

The three core modules provide a total of 2,000 TOPS of AI computing power / 2,000 TFLOPS of floating point computing power, and the computing power resources can be flexibly configured

- With multidomain computing, the SoC allows concurrent time-critical processes to run without interruption, and vehicles to run Linux, QNX and Android simultaneously
- Support configuration for multiple modes: use all computing power for autonomous driving workflows; or use a portion for cockpit AI and infotainment, and a portion for assisted driving

- **The release of Thor represents a shift from the distributed computing solution to a fully centralized, functionally convergent single-chip solution in the automotive sector → speed up the move to a vehicle E/E architecture to a centralized one**

Product Developments of Tech Companies: Jika Intelligent Robot Mass Produce a Cost-effective Integrated Driving and Parking Solution

- Jika Intelligent Robot, a joint venture between Geely Auto Group and ECARX, launched a highly integrated intelligent driving platform for driving and parking application scenarios, which will be put into mass production and delivered by 2023

Features of the solution

① China-made core hardware with a high computing power	➢ Based on Black Sesame Technologies' A1000 chip, a China-made automotive-grade chip with a high computing power of up to 100+TOPS
② Highly flexible configuration	➢ Consider the cost during system architecture selection and design definition, reasonably cut the sensor configuration and computing power according to different definitions and requirements of autonomous driving levels in different brands and models, and plan different configurations
③ Data closed-loop → R&D closed-loop	➢ By opening main chips, middleware and underlying software applications, partners can obtain the data deep into the original perception level → after being desensitized, vehicle driving data is used for algorithm training to achieve efficient algorithm optimization and software iteration

Facilitate the mass production of products

Application scenarios

- ➢ Fully meet the driving and parking function requirements of different autonomous driving levels such as L2, L2+ and L3
- ➢ Available functions include: navigate on autopilot (NOA), highway assist (HWA), homezone parking pilot (HPP), etc.

Application scenario targeted optimization case — HWA

- ➢ Focus on strengthening the ability to cope with such scenarios as irregular lane lines, vehicles with abnormal behavior, wide-body vehicles, high-density traffic, etc.
- ➢ Significantly reduce the number of driver take-overs and interventions → experience of continuity

Jika Intelligent Robot enters into the intelligent driving solution market with its platform products that balance cost and performance. Relying on Geely's large vehicle size, its products have an advantage in large-scale application, but still need to iterate based on actual user experience and user feedback

Contents

Characteristics of Super-Heterogeneous Universal Computing Platforms for Intelligent Vehicles

- Intelligent vehicles are complex computing systems that require comprehensive computing power → super-heterogenous universal computing platforms with high performance and integrated functions are a feasible way and the major solution to meet the rapidly growing demand for computing power

Super-heterogeneous universal computing platforms

Technical features

- Focus on designing universal computing units with higher computing power, such as CPUs, GPUs, etc.

Representative enterprises and products

- NIVIDIA DRIVE Thor, Qualcomm Snapdragon Ride, etc.

Advantages

- Better compatibility (suitable for different suppliers, OEMs and models) → more potential customers (higher market share currently)
- When there is enough computing power, companies do not need to pour a lot money or energy in algorithms to seek efficiency, but only need to focus on accuracy
- Universal architectures are usually adopted in the cloud while universal chips are more suitable for terminal-cloud collaboration

Disadvantages

- <30% utlization rate of computing power + advanced process → high cost
- Super-high computing power will cause ultra-high power consumption and difficulty in heat dissipation

VS

Customized computing platforms with HW/SW synergy

Technical features

- Focus on developing dedicated computing units, such as NPUs and BPUs based on ASIC (Application-specific integrated circuit), which put forward higher requirements on the collaboration of HW and SW

Representative enterprises and products

- Mobileye EyeQ series and Horizon Robotics Journey series

Advantages

- Over 70% or even 80% utilization rate of computing power + relatively lower requirements on process → obvious cost advantage
- Higher upper limit of real computing power potential under the design of HW and SW collaboration

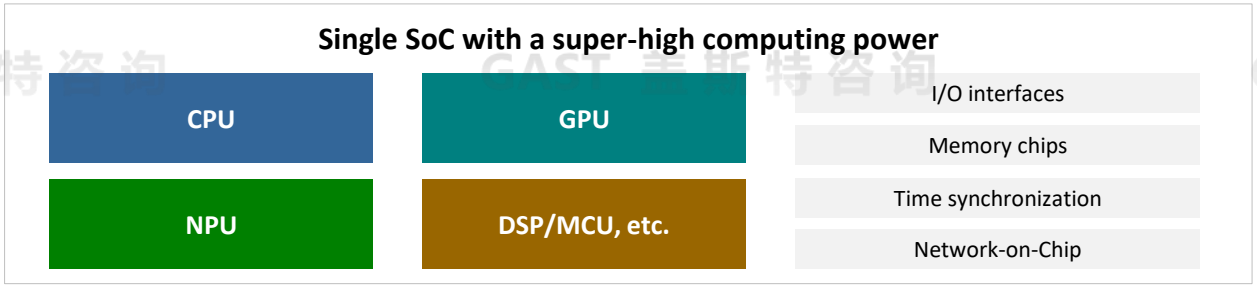
Disadvantages

- HW/SW collaboration design: higher complexity + higher requirements on forward-looking design
- AI algorithms iterate so fast that chips can not keep up with them
- Chip makers either self-produce HW and SW, or deeply cooperate with customers → hard to establish a product ecosystem

Solutions to Build a Super-Heterogeneous Universal Computing Platform

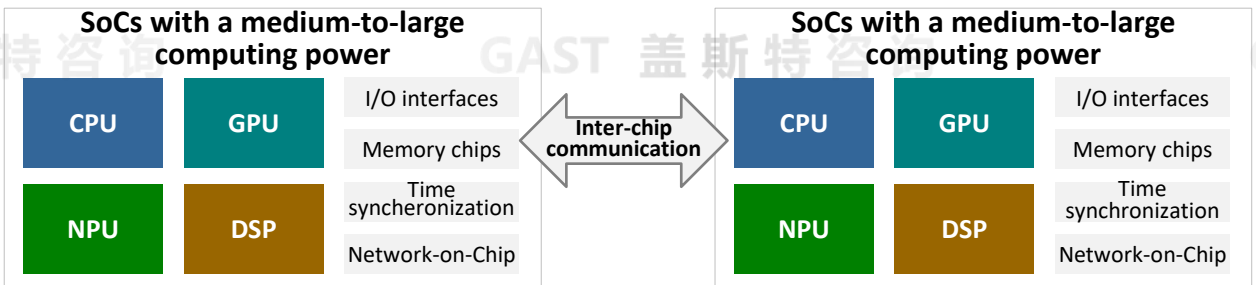
- There are three major solutions to establish a super-heterogeneous universal computing platform of intelligent vehicles

Single SoC as the core



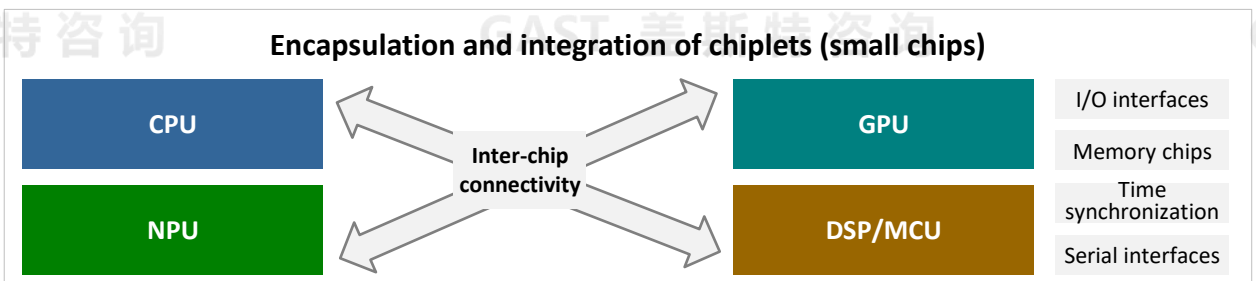
CPUs, GPUs, NPUs and other IPs are directly integrated during design and manufacturing, and different IPs communicate with each other through Networks-on-Chip

Multi-SoC cascade



Typically multiple SoCs of the same architecture are cascaded through inter-chip communication technology, and the computing power requirements of a single SoC can be relatively lowered

Chiplet technology



CPUs, GPUs, NPUs and other IPs are designed separately and manufactured into small chips and are integrated only at the time of encapsulation

Comparison of the Three Solutions (1) : Technology

- From the perspective of technology, all three solutions have their respective advantages and disadvantages, and currently face their own sticking points

Solution	Advantages	Disadvantages	Sticking points
Single SoC	• **Highly shared internal storage resources**: the computing modules inside the SoC share the same storage area • **Deeply reused sensor data**: all data is transimitted into the same SoC, leading to faster speed, lower latency, and a shorter repsonse time of the system	• **Functional safety**: once the single SoC fails, it will be hard to guarantee safety • **Heat dissipation**: super-high computing power is concentrated on a single chip, making heat dissipation more difficult	• **System integration**: multiple high-performance computing modules are integrated into a single chip, which increases the complexity and computing power geometrically
Multi-SoC cascade	• **Higher computing efficiency in specific scenarios**: different SoCs can have specific application scenarios so that the design of related hardware and software can be adjusted according to specific requirements • **System redundancy**: different SoCs adopt the same architecture so that they can form redundancy to ensure functional safety	• **Duplication of storage resources:** some data needs to be copied across different SoCs' internal memory chips • **Loss of computing performance:** computing tasks might be split into many, operating across multiple SoCs, and there will be operations like data synchronization and aggregation, reducing centralized processing capacity	• **Time synchronization**: different data might be input to different SoCs, and there is latency in inter-chip communication, which makes the time synchronization design more complicated • **System isolation**: it is necessary to consider the isolation inside a single SoC and that among SoCs, which makes the system isolation design more complex
Chiplet	• **Platform-based development:** universal architectures + standardized interfaces + continuous iteration of Chiplet's design • **Chip yield**: the larger the chip area, the lower the yield and the higher the cost. Chiplet effectively controls the cost by making the chip smaller	• **Performance stability:** the communication efficiency among different chips is definitely lower than that within a single chip. When the computing task is too complex, it may be hard to maintain stable computing performance	• **C-Bus (Chip Bus):** require higher bandwidth and lower latency than the network-on-chip communication, but the technology is not yet mature enough

Comparison of the Three Solutions (2) : Application

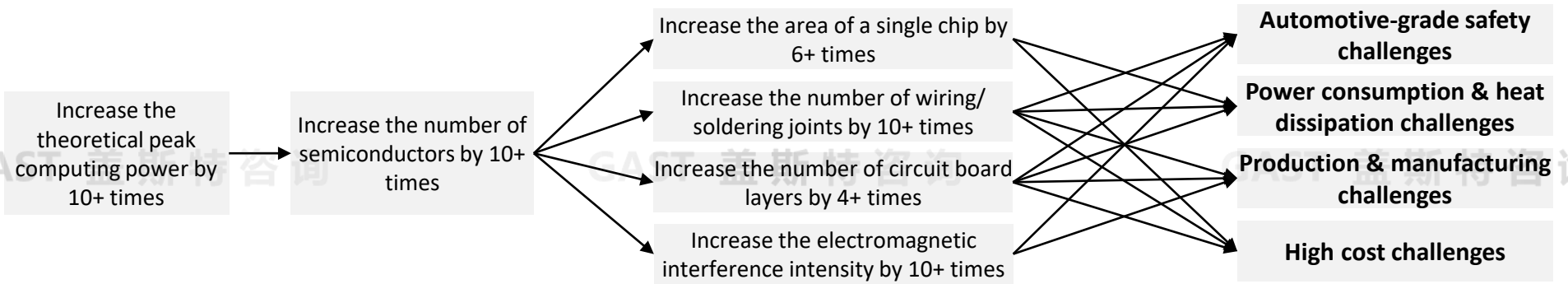
- From the perspective of application, multi-SoC cascade is a better solution at present. Single-SoC solution is suitable for future high-end models, and Chiplet solution may be more suitable for future mainstream models

Solution	Advantages	Disadvantages
Single SoC	• **The highest degree of generalization**: software developers can focus on algorithm optimization and business innovation without caring about the details of underlying hardware, which is favorable to form a software ecosystem, while in the other two solutions, software personnel still need to deal with hardware more or less • **Computing power reservation**: one single chip can solve all the computing power anxiety	• **Scope of application**: single SoCs have a fixed scope of application. They can only be applied to premium vehicles in the preliminary stage due to high cost, which makes it hard to lower the cost through amortization and making them difficult to spread to low- and mid-range models • **Product planning**: the development cycle of single SoCs with a super-high computing power is relatively longer, during which newer and more powerful technologies may emerge
Multi-SoC cascade	• **Flexible system configuration (cost control)**: for example, Horizon Robotics can use 128TOPS chips to enable computing platforms to achieve a computing power of 128~1024TOPS and customerize different configuration (cost control) solutions for different vehicle models • **Faster time-to-market:** can expand to higher computing power based on currently mature SOCs, without the need to redevelop	• **Overall cost of system materials**: each single SoC needs to accommodate its own infrastructure such as storage modules and power models, which results in related supporting costs and more complex stocking of supporting suppliers • **Computing power expansion**: the performance of inter-chip communication and data synchronization technology determines that multiple SoCs cannot be cascaded indefinitely, and there is an upper limit of computing power expansion
Chiplet	• **Product differentiation**: customize IP solutions for specific Chiplets based on OEMs' requirements • **Supply security**: the specific design and manufacturing process of a specific Chiplet can be flexibly adjusted to reduce the risk of supply disruption/technology blockage to a certain extent • **Product scalability:** theoretically, IP performance can be continuously optimized using standardized interfaces as long as the inter-chip connectivity capability is sufficient	• **Toolchain**: since Chiplet needs to accommodate more chip IPs and adapt to the requirements of various customers, its toolchain development will be more complex and the development, learning and usage costs will be higher than the other two solutions

Common Challenges of Super-Heterogeneous Universal Computing Platforms

- Without hardware and software optimization, future super-heterogeneous universal computing platforms may face bottlenecks in increasing computing power → long-term competitiveness remains to be further verified

Hardware: physical limits of semiconductors + process limits → face multiple challenges in order to increase the theoretical peak computing power



Software: with the continuous improvement of computing power, virtualization and management scheduling of hardware resources will become increasingly difficult

- The more heterogeneous chip architectures there are, the more difficult it will be to virtualize the hardware resources → the higher requirements for the performance of virtualization software
- The upper layer of the computing platform needs to run multiple independent operating systems and applications with different needs, which requires the underlying software to reasonably divide, isolate, manage and schedule the hardware resources → the efficiency of this part of software directly affects the normal operation of vehicle functions

Future Trends of Super-Heterogeneous Universal Computing Platforms

- To constantly increase computing power in the post-Moore era, super-heterogeneous universal computing platforms entail technological development and innovation from various aspects

① Innovate chip architectures	• Strive to make the computing platforms universal enough, and at the same time constantly pursue excellent performance, lower energy consumption and smaller footprints
② Accommodate different IPs	• Enable integration of chip IPs from different companies in computing platforms/SoCs to support platform-based and ecosystem-oriented design, thereby facilitating amortization of chip design costs
③ Collaborative design of cloud, edge and terminals	• Computing devices on the vehicle/road/cloud sides adopt the same architecture, allowing computing tasks to run adaptively at the most appropriate location in the cloud/edge/terminal sides, thus extending the computing power boundary
④ Optimize underlying software capabilities	• Continuously improve the ability of basic software to run across different processor architectures, different chips and different computing platforms, thus supporting flexible configuration and upgrade of computing platforms
⑤ Improve the toolchain ecosystem	• Integrate the underlying software and toolchain so that customers do not need to change their development environment when adopting different configurations of computing platforms, thus simplifying system integration and facilitating application innovation

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- The company provides nearly 1,000 research reports in Chinese, English and Japanese at present

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