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Autonomous Driving Domain Controller and Central Control Unit (CCU) Industry Report, 2024-2025

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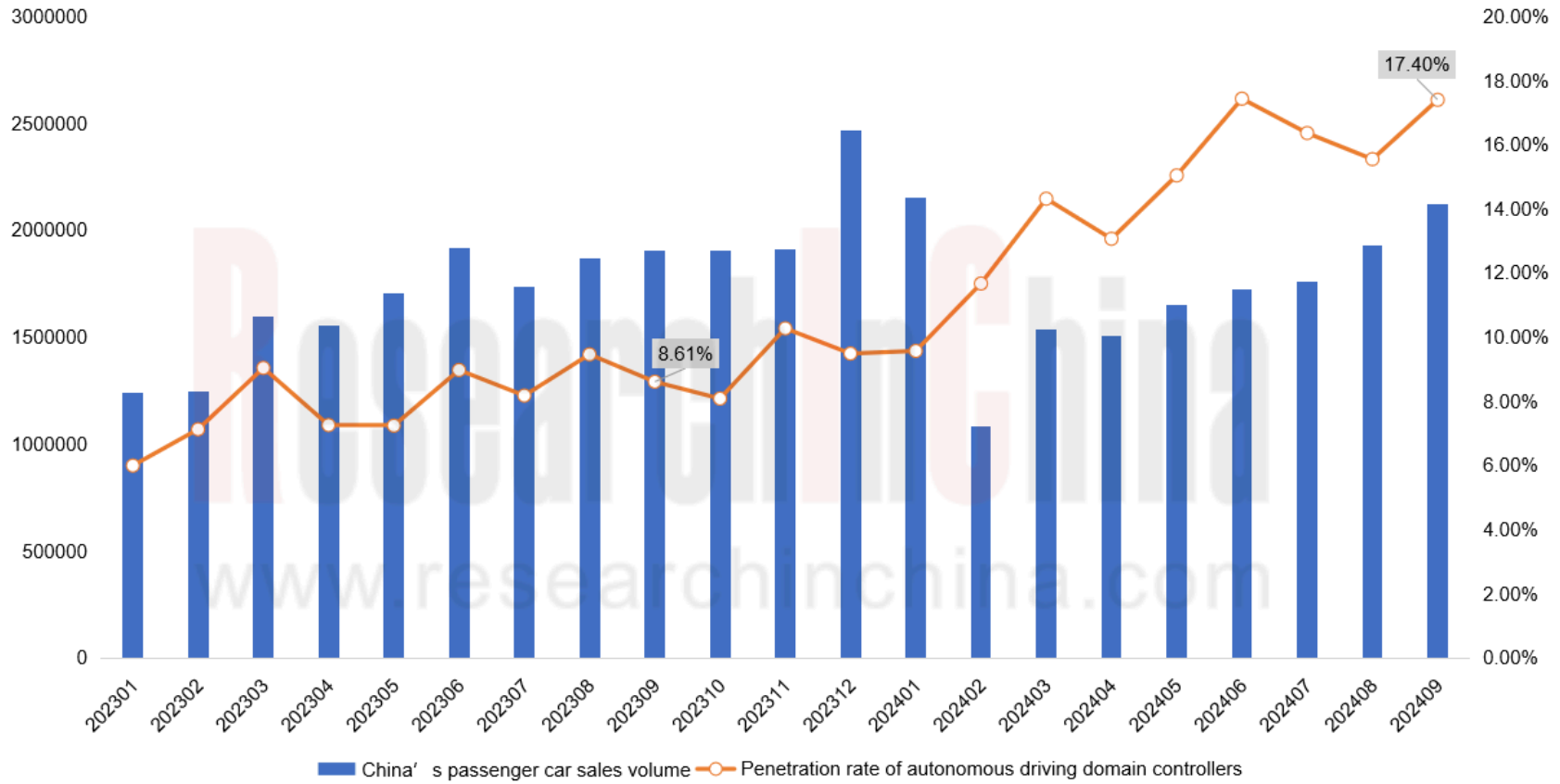
Autonomous Driving Domain Controller Research: One Board/One Chip Solution Will Have Profound Impacts on the Automotive Supply Chain

As per ResearchInChina, passenger cars (excluding imports and exports) in the Chinese market were installed with 2.254 million sets of OEM intelligent driving domain controllers as standard from January to September 2024. Since 2023, the penetration rate of autonomous driving domain controllers has surged month by month, hitting 17.4% in September 2024, compared with only 8.61% in the same period last year.

Penetration Rate of Autonomous Driving Domain Controllers in Passenger Cars in China,2023-2024



Source: ResearchInChina

Three development stages of autonomous driving domain controller: Multi-Board, One Board, One Chip

For major OEMs, the development and application of autonomous driving domain controllers have become widespread, and they will evolve towards central control units (CCUs) in the next stage. This report divides the development of autonomous driving domain controllers into three stages:

Stage 1: Multi/One Box, Multi-Board, Multi-Chip

In a Multi-Box solution, each domain controller has a separate circuit board, and data is transmitted between domains via Ethernet. This reflects the current popular domain-centralized EEA with mature technology and controllable cost but limited Ethernet transmission rate (mostly 100-1000Mb/s).

Stage 2: One Box, One Board, Multi-Chip

Encoding and decoding are no longer needed between different domains in the vehicle, so that the chips, power supplies, heat dissipation and wiring harnesses for encoding and decoding can be saved, which reduces costs. Chips transmit data through the PCIe interface. Currently, PCIe Gen 4 is widely used in automotive systems, with 16 GT/s, and a transfer rate of 1.97 Gb/s per lane. Through multi-lane aggregation, the transfer rate of PCIe Gen 4 is generally 10Gb/s+, much higher than that of Ethernet.

At this stage, body domain and gateway functions are integrated and equipped with central gateway chips such as NXP S32G, SemiDrive G9H, and Renesas RH850.

Stage 3: One Box, One Chip

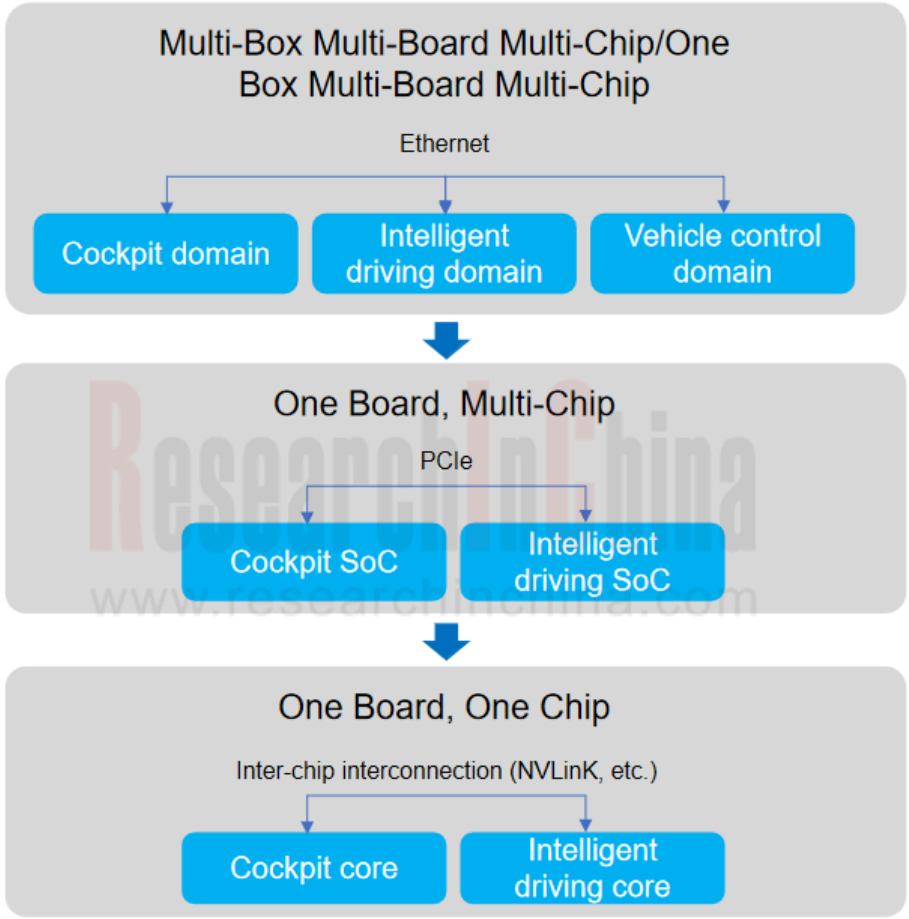
A domain controller SoC has multiple IP cores which are interconnected by inter-chip communication. Many high-performance electric vehicles in the future will pack DRIVE Thor, NVIDIA's next-generation autonomous vehicle (AV) processor based on the NVIDIA Blackwell architecture which is designed for Transformer, Large Language Models (LLM) and generative AI workloads. NVIDIA has equipped the next-generation Thor with NVLink 5 interconnect technology. The chip memory bandwidth can reach over 100 Gb/s.

On the whole, the Multi-Board solution in Stage 1 has been basically realized. Leading emerging OEMs, such as NIO and Xpeng, have entered Stage 2, and have mass-produced and delivered the One Board solution. Some OEMs may directly jump to Stage 3 - the One Chip solution. It is expected that 2025 will be the first year for the One Chip solution to be spawned. In this process, generally the chassis and power domains will not be integrated with the One Chip solution, mainly because suppliers offer relatively closed solutions and it is unlikely that they will grant OEMs permissions.

AI foundation models are the focus of competition among OEMs. The One Chip solution with high bandwidth capabilities allows all software to share data and computing power, and supports the implementation of end-to-end foundation models, LLMs, etc.

In addition, the One Chip solution makes the free combination of IP cores a possibility, and chips designed based on the Chiplet architecture will become one of the important directions for the development of automotive chips in the next decade.

Autonomous Driving Domain Controllers Keep Evolving with EEA



Source: ResearchInChina

Autonomous driving domain controller development strategy - the industry is rapidly deploying One Board and One Chip solutions

In 2024, the industry is rapidly deploying One Board and One Chip intelligent driving domain controller solutions under the pressure to further reduce costs.

Autonomous Driving and Central Control Unit (CCU) Domain Controller Solutions of Tier1 Suppliers

Tier1	IVI Solution	Type	SOP	Master SOC	Compute	Cross-domain	Features of Functional Integration
ECARX	Skyland Pro	One Board	2023	Black sesame A1000 *2	116T	✓ Driving-parking integration	✓ It has been mass-produced for Lynk & Co 08 EM-P and Lynk & Co 07 EM-P, with highway NOA available on most highways & elevated sections across China. ✓ It supports the development of high-level ADAS functions such as urban NOA and cross-floor HPA.
	Super Brain®	One Board	/	SiEngine SE1000 *1 Black Sesame A1000 *1	132K 900G 66T	✓ Cockpit-driving-parking integration	✓ One Board Dual Chip cockpit-driving-parking integration solution
	Super Brain® Antora1000 Pro	One Board	/	SiEngine SE1000 *2	200K 1800G 16T	✓ Cockpit-driving-parking integration	✓ One Board Dual Chip cockpit-driving-parking integration solution: high-level cockpit, L2 ADAS, parking ✓ ASIL-B functional safety ✓ 58Gb/s BW
	Super Brain® Antora1000	One Chip	2025	SiEngine SE1000*1	100K 900G 8T	✓ Cockpit-driving-parking integration	✓ One Chip cockpit-driving-parking integration solution: cockpit, L2 ADAS, parking ✓ ASIL-B functional safety ✓ 51Gb/s BW ✓ Extreme cost reduction
				SiEngine SE1000 Pro*1	150K 900G 56T	✓ Cockpit-driving-parking integration	✓ One Chip cockpit-driving-parking integration solution: cockpit, highway NOA, HPA ✓ ASIL-B functional safety ✓ 150Gb/s BW
	Skyland Pro	One Chip	2025	Black Sesame A1000*1	58T	✓ Driving-parking integration	✓ 1R7V ✓ Map-free highway NOA, commuting NOA, and HPA ✓ ASIL-B functional safety
	AD1000 domain controller solution	One Chip	2025	SiEngine AD1000*1	256T	✓ Driving-parking integration	✓ End-to-end foundation model based intelligent driving, map-free, and Occupancy Network ✓ Taped out successfully, joint development started ✓ 200Gb/s BW
Desay SV	IPU14	One Chip	2025	NVIDIA DRIVE Thor	2000T	✓ Integrated cockpit control	✓ Implement L4 functions ✓ A single chip can run Linux, QNX and Android at the same time
	ICPS01E	One Chip	2025	Qualcomm SA8775	Up to 72T	✓ Cockpit-driving-parking integration	✓ Desay SV and Chery cooperated to develop the "8775 cockpit-driving integrated central computing platform". Chery provides vehicle resources and Desay SV undertakes specific product development.
Lenovo Vehicle Computing	AD1 domain controllers	One Chip	2025	NVIDIA DRIVE Thor X*2	2000T	✓ Cockpit-driving-parking integration	✓ Planned and designed for L4 autonomous driving commercial application scenarios ✓ The inference of the Transformer model is 5 times faster. ✓ Lenovo's self-developed AI middleware - Ultra Boost is also adapted on AD1 to further improve the platform's computing efficiency in terms of model acceleration, operator enhancement and task scheduling to meet the demand for high computing power.
	AH1 domain controllers	One Chip	2025	NVIDIA Drive Thor U	730T	✓ Cockpit-driving-parking integration	✓ Designed specifically for L2++ ADAS ✓ AH1 has a MIG system, and its fault isolation mechanism can ensure the safe application of intelligent driving. ✓ The newly designed Transformer engine architecture supports foundation models on the edge, incorporating FP8 and FP4 data types, greatly improving performance while ensuring inference accuracy. ✓ It can realize driving-parking integration functions in all scenarios, e.g., urban NOA, highway NOA, and VPA.
Z-One	Z-One Galaxy® cockpit-driving integrated computing platform - ZXD2	One Board	2025	Horizon J6 + Qualcomm's latest chip	Up to 560T	✓ Cockpit-driving integration	✓ It adopts the One Box software and hardware integrated design, which reduces the weight of the computing platform by 40%, downsizes the volume by 30%, improves computing power and storage efficiency by 30%, increases data communication bandwidth by 30 times, and shortens the vehicle OTA updates to 30 minutes ✓ SOA software platform based on cross-domain integration and atomized service capabilities for intelligent cockpit, intelligent driving and intelligent vehicle control ✓ Cockpit-driving integration experience covering all scenarios, such as highway NOA, urban NOA, and smart parking.

Source: ResearchInChina

ECARX's Layout of "One Board" and "One Chip"

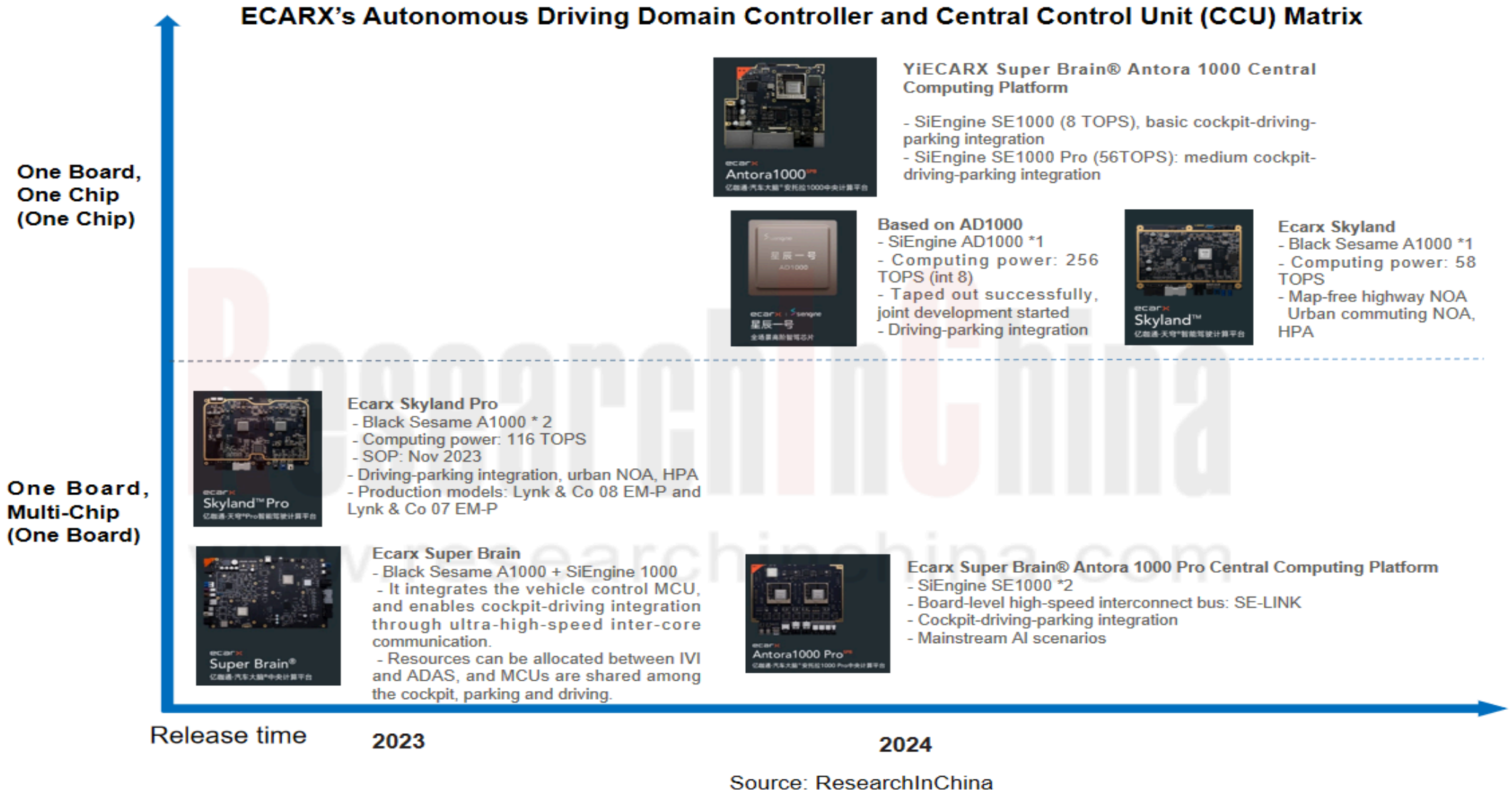
"One board": In the design of the "One Board" solution, ECARX focuses on the domestic production-ready chip strategy. In terms of hardware, it adopts the "one board and dual chip" architecture design, and uses the domestic mature 7nm automotive-grade chip (Longying No.1) and intelligent driving SoC (Huashan A1000) as two master SoCs for high-speed interconnect via PCIe. As for software, the highly standardized and modular "Cloudpeak" cross-domain software platform enables the interconnection and interoperability of functional domains, thereby realizing the mass production of "One Board and Multi-Chip" domain controller/central computing platforms.

Wherein, ECARX Skyland Pro, an intelligent driving computing platform equipped with two "Huashan A1000" chips and the ECARX Antora? 1000 Pro computing platform fitted with two "Longying No.1" chips, have been spawned and delivered for Lynk & Co. 08 EM-P and Lynk & Co 07 EM-P.

"One Chip": ECARX has created two "cockpit-parking integration" One Chip products based on China's first 7nm automotive-grade SoC "Longying No.1" (8 TOPS): "ECARX Antora? 1000 Computing Platform (AI Enhanced Version)" and "ECARX Super Brain" ? Antora 1000 Plus Computing Platform". The two products have been mass-produced and installed in Geely Galaxy E5 and Lynk & Co Z20 respectively. Galaxy E5 enjoys good reputation in terms of intelligence and performs well in the market, and it has received good market feedback at the mass production level.

The more integrated "cockpit-driving-parking integration" version can support the development of cockpit-driving-parking integration functions including L2 ADAS, automated parking, and mainstream cockpit functions. It is extremely cost-effective and is expected to be available to vehicles in 2025. It is reported that ECARX may develop a cockpit-driving-parking integration solution based on the upgraded "Longying No.1 Pro" (56 TOPS) to support higher-level cockpit-driving-parking integration functions.

ECARX's Autonomous Driving Domain Controller and Central Control Unit (CCU) Matrix



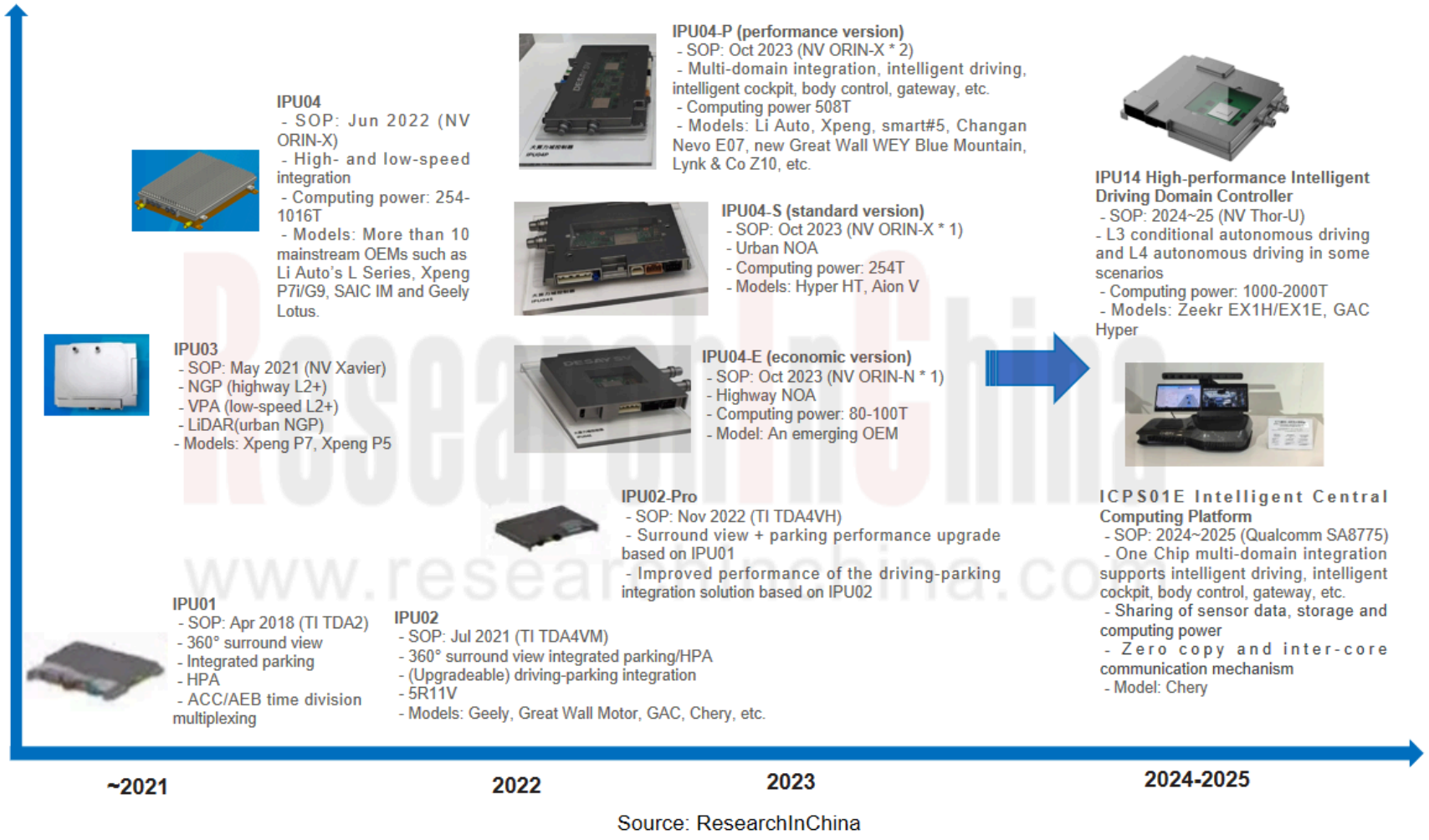
Source: ResearchInChina

Desay SV's Layout of "One Chip" - IPU14 & ICPS01E

IPU14: In October 2024, Desay SV publicly exhibited IPU14, its next-generation high-performance intelligent driving domain controller, for the first time. Equipped with NVIDIA's most powerful intelligent driving chip - Thor-U, IPU14 supports one-chip cockpit-driving integration, L3 conditional autonomous driving, and L4 autonomous driving in some scenarios;

ICPS01E: In October 2024, the "8775 cockpit-driving integrated central computing platform" co-developed by Desay SV and Chery made a debut. In the joint development process, Chery provided vehicle resources, and Desay SV undertook specific product development.

Desay SV's Autonomous Driving Domain Controller and Central Control Unit (CCU) Matrix



Source: ResearchInChina

Z-One's "One Board" Product - ZXD2

In September 2024, Z-One officially announced that the prototype of ZXD2 (Z-ONE X Device), Z-One's second-generation central brain based on Horizon Journey? 6 and Qualcomm's latest cockpit SoC, was lighted up. ZXD2 realizes the cross-domain integration of intelligent driving, intelligent cockpit, intelligent computing and other systems.

ZXD2 also adopts the One Box software and hardware integrated design, which reduces the weight of the computing platform by 40%, downsizes the volume by 30%, improves computing power and storage efficiency by 30%, increases data communication bandwidth by 30 times, and shortens the vehicle OTA update time to 30 minutes.

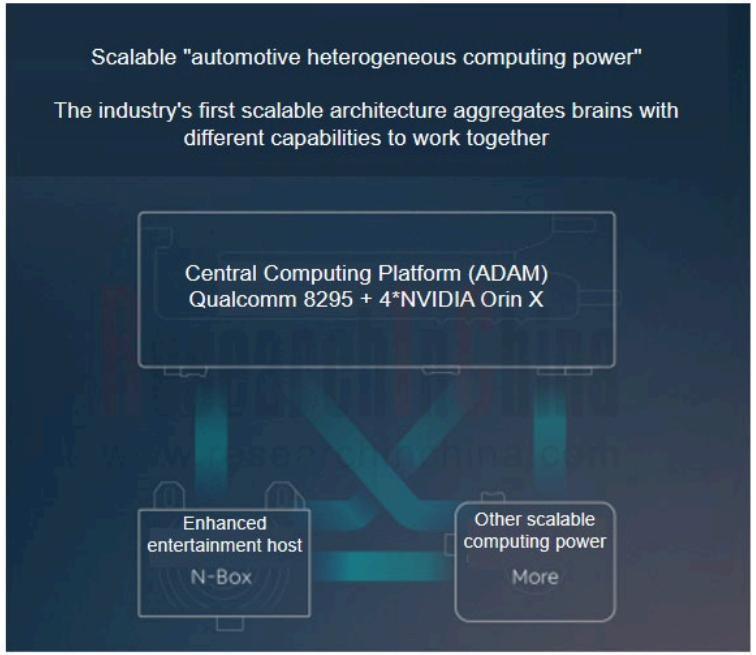
Source: Z-One

Xpeng and NIO "One Board and Multi-Chip" domain controller computing platforms

Some OEMs like Xpeng and NIO have implemented mass production of "One Board and Multi-Chip" domain controller computing platforms.

Xpeng's "One Board" Product – XCCP

It combines C-DCU and XPU, and enables integration of such functions as intelligent driving, cockpit, cluster, gateway, IMU, and power amplifier. Compared with the previous central computing architecture, XCCP saves costs by 40% and improves performance by 50%.
Xpeng X9 has achieved cockpit-driving integration. The communication between the two chips on the same circuit board lies in PCIe, with the rate up to 10 Gb/s;



Source: NIO

NIO's "One Board" Product – ADAM

The cockpit-driving integration solution involves a Qualcomm Snapdragon 8295 intelligent cockpit chip and 4 NVIDIA Orin X intelligent driving chips. The new central computing platform integrates more than 12,000 devices, solving technical challenges such as PI/SI, EMC and Thermal posed by high integration. It is 40% smaller and 20% lighter than a cockpit-driving separation domain controller.

The central computing platform ADAM can eliminate the need for encoding and decoding between different domains in the vehicle, saving the chips, power supplies, heat dissipation and wiring harnesses for encoding and decoding. The etched circuit on the circuit board directly replaces Gigabit Ethernet, and the data bandwidth between the intelligent driving domain and the cockpit domain is greatly increased from Gigabit to 16Gbps, realizing a more than 10-fold increase in transfer rate.

Cross-domain computing power sharing can call up to 256TOPS computing power for intelligent driving, intelligent cockpit and vehicle control. Cross-domain computing power sharing also allows for more reasonable allocation of computing power, rather than completely limits it to either of the intelligent driving domain or the intelligent cockpit domain.

The One Chip solution will have profound impacts on the automotive domain controller and chip supply chain

The One Chip solution may be the ultimate form of “cockpit-driving integration”, and its advantages lie in:

1) Lower system cost: the one SoC solution is more integrated, and enables material sharing, with lower BOM costs.

2) Quicker system response: compared with inter-board Switch communication or inter-chip PCIe communication, intra-chip communication features shorter delay, higher bandwidth, and quicker system response.

3) Software shares data and computing power: a unified vehicle operating system supports end-to-end foundation models, language large models, etc.

Under the One Chip solution, typical multi-domain fusion SoCs include NVIDIA Drive Thor, Qualcomm Snapdragon Ride Flex SA8775 and SA8795, Black Sesame "Wudang" C1200 and the latest Renesas R- Car X5.

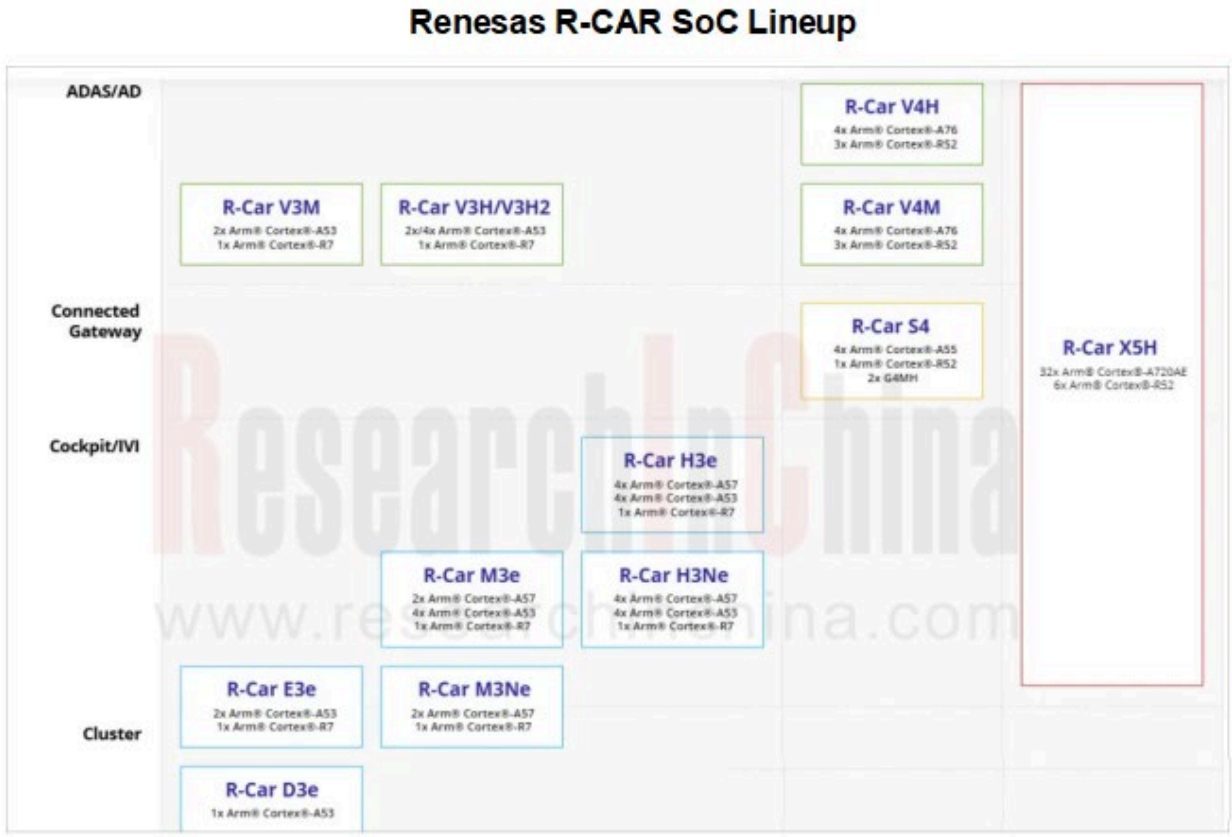
It is foreseeable that the One Chip solution will have profound influence on automotive domain controller hardware, vehicle operating systems, and automotive SoC design and manufacturing. OEMs, Tier1 suppliers and chip vendors will compete fiercely around new technology fields such as multi-domain fusion, chiplets, and inter-chip interconnect (PCIe, NVLink, etc.).

Renesas R-CAR SoC Lineup

In November 2024, Renesas was the first in the industry to launch a multi-domain fusion SoC family using an automotive-grade 3nm process - the R-Car X5 Series. A single chip can support multiple vehicle functional domains at the same time, including ADAS, IVI and gateway applications. The SoC offers the option to expand AI and graphics processing performance using chiplet technology. The R-Car X5 Series is scheduled to be mass-produced in 2027.

Key features of the R-Car X5 Series include:

- TSMC's most advanced 3nm process consumes 30-35% less power than the 5nm process under the same performance.
- 400TOPS AI compute supports expansion through chiplets, and can improve AI processing performance by 3-4 times or more.
- A total of 32 Arm? Cortex?-A720AE CPU cores have 1,000K DMIPS CPU compute.
- 6 Arm Cortex-R52 dual lockstep CPU cores achieve over 60K DMIPS and support ASIL D without external MCUs.
- 4TFLOPS GPU processing power
- Chiplet technology offers the standard UCIe (Universal Chiplet Interconnect Express) die-to-die interconnect and APIs.
- It supports virtual ECU development and allows for use of the Renesas RoX SDV platform to shorten the time to market for the automotive industry.



Source: Renesas

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Contact

Beijing Headquarters

TEL: 13718845418
Email: report@researchinchina.com

Website: ResearchInChina

WeChat: Zuosiqiche

Chengdu Branch

TEL: 028-68738514
FAX: 028-86930659

zuosiqiche