

GAST Automotive Industry & Technology Research Report

No. 903_June 14, 2023

Subject: Smart Vehicle Development Strategies for Better User Experience

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□ User Experience Becomes the Key Competitiveness of Smart Vehicles

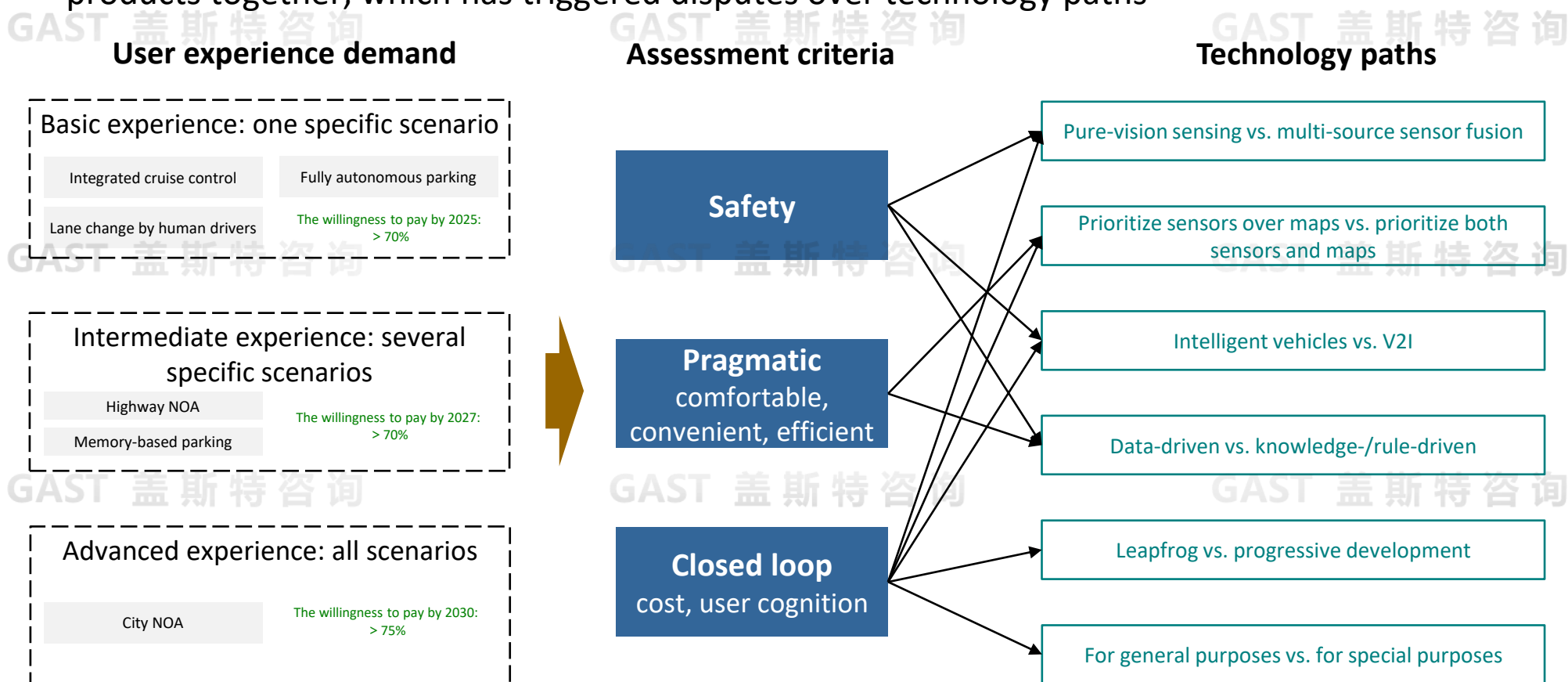
➤ Intelligent Driving-Oriented Products Improve User Experience

□ SOA Enables Users to Flexibly Experience Functions in Specific Scenarios

□ Data-Driven Product Development Precisely Meet User Experience Needs

Multiple Technology Paths for Intelligent Driving Based on User Experience

- A series of factors, including intensifying competition, more sophisticated technologies, lower system costs, and higher user cognition, drive the development of intelligent driving-oriented products together, which has triggered disputes over technology paths



User Experience Becomes a Key Indicator to Gauge Intelligent Driving

- Allowing users to experience expected intelligent driving functions would face a series of challenges

Expected intelligent driving user experience

Better user understanding and faster response

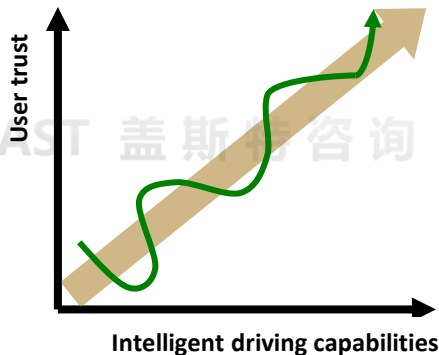
- Functions: fast diagnosis; update & improvement; continuous evolution
- Commercialize massive compliant data; share additional revenues with users from data analysis services
- Explore new applications and scenarios via big data, enabling “user-specific offerings”

More intelligent and safer

- Use V2I to complement information: realize 360-degree “NLOS sensing”
- Leverage V2I to read the driver’s intention: make driving behaviors more predictable
- Utilize V2I to sense scenarios: enable reliable hierarchic safety warnings

First challenge:

unbalance between intelligent driving capabilities and user trust



- Too much trust: insufficient supervision
- Inadequate trust: influence the utilization of systems
- Good user experience is designed as a key approach to remove the gap between user trust and intelligent driving capabilities

Second challenge:

No unified standards for gauging user experience

Multi-dimension evaluation system

User experience feedback

Objective quantitative indexes of companies

...

- User experience evaluations vary greatly in the industry
- Forge an industry-wide consensus, make a deep dive into user research, and develop a unified system in line with user needs

Dimensions of Evaluating User Experience in Autonomous Driving

- For autonomous driving: users concern about the availability of AD to help people and free them from the driving task to the maximum extent in real-world driving scenarios, rather than AD levels

Dimension		User needs and evaluations	Principle of AD system design for user experience
Safety	Functions	➤ Safety is the priority for users to consider the adoption of autonomous driving	✓ AD functions entail corresponding safety measures → more advanced functions require a higher level of safety
	Take-over authority	➤ Users expect a more user-friendly process of taking over the driving task, avoiding causing surprise, anxiety, worry, etc.	✓ The AD system should send clear instructions to take over the control of vehicles and prepare enough redundancy → avoid causing surprise, anxiety, worry, etc.
Feeling	Driving & riding comfort	➤ Users pay great attention to the feeling of driving and riding with an AD system. With the same functions, vehicles that can provide a high level of comfort would be more popular among users	✓ The principle of algorithm design policies: an AD system should have the same driving habits as human drivers → e.g., more experienced in handling edge cases
Scenario	Scenario coverage	<ul style="list-style-type: none"> ➤ Users expect AD to address problems in daily life ➤ Functions suitable for specific scenarios: if one function could adapt to more specific scenarios, the user experience would be better 	✓ Available frequent scenarios in daily life → pragmatic
	Smooth scenario switch	➤ Users focus on experience brought the shift of functions during the switch between scenarios	<ul style="list-style-type: none"> ✓ Smooth switch between scenarios and functions + clear reminders ✓ Precise route planning: avoid traffic congestion; make rapid decisions

- ❑ Good design of AD systems should encompass ① active safety; ② “driving and riding” feelings like “veteran human drivers”; ③ clear and smooth switch between scenarios/functions; ④ clear and redundant authority switch; ⑤ daily life services

Integrate Cockpit and Driving Domains to Improve User Experience

- Truly integrate the cockpit and driving domains: fully integrate functions of the smart cockpit domain and the intelligent driving domain into one SoC

Product development	Lower cost	Shorter communication latency	Larger space for OTA updates
	<ul style="list-style-type: none"> Chips feature a higher level of integration, saving materials → lower cost than multi-chip solutions Some underlying software can be shared, saving the cost of developing and outsourcing software 	<ul style="list-style-type: none"> Adopt shared memory: shorter communication latency than the previous modes of bus-based transmission and “switch between two plates” 	<ul style="list-style-type: none"> Share data of the smart cockpit domain and the intelligent driving domain, creating larger space for upgrading software Fully and timely reuse sensor data: create more innovative functions
	Redundant intelligent driving solutions	<ul style="list-style-type: none"> If the intelligent driving domain fails to work, the smart cockpit domain could take over the control of the vehicle successfully and seamlessly as a redundant part 	
	Simulation of assisted driving environment	<ul style="list-style-type: none"> Intelligent driving systems can display data of pedestrians, vehicles, objects, etc. on 3D maps and AR-HUD, making driving in a virtual world extremely similar to driving in the real world 	
Application experience	Convenient access to intelligent driving functions	<ul style="list-style-type: none"> Activate Highway/City NOA, parking, and other functions via voice, gesture, etc. → enable “hands-free” driving 	
	Immersive feedback on driving status	<ul style="list-style-type: none"> If the intelligent driving system predicts a risk, the cockpit domain would send warnings in diverse manners: voice, vibrations of the steering wheel, seats, safety belts, etc. → enable immersive user experience 	

- The smart cockpit domain enables better HMI and the intelligent driving domain promises better V2E experience. Integrating the two domains would create people-vehicle-environment interaction ecosystems → as a key carrier, vehicles would provide better experience for drivers and passengers

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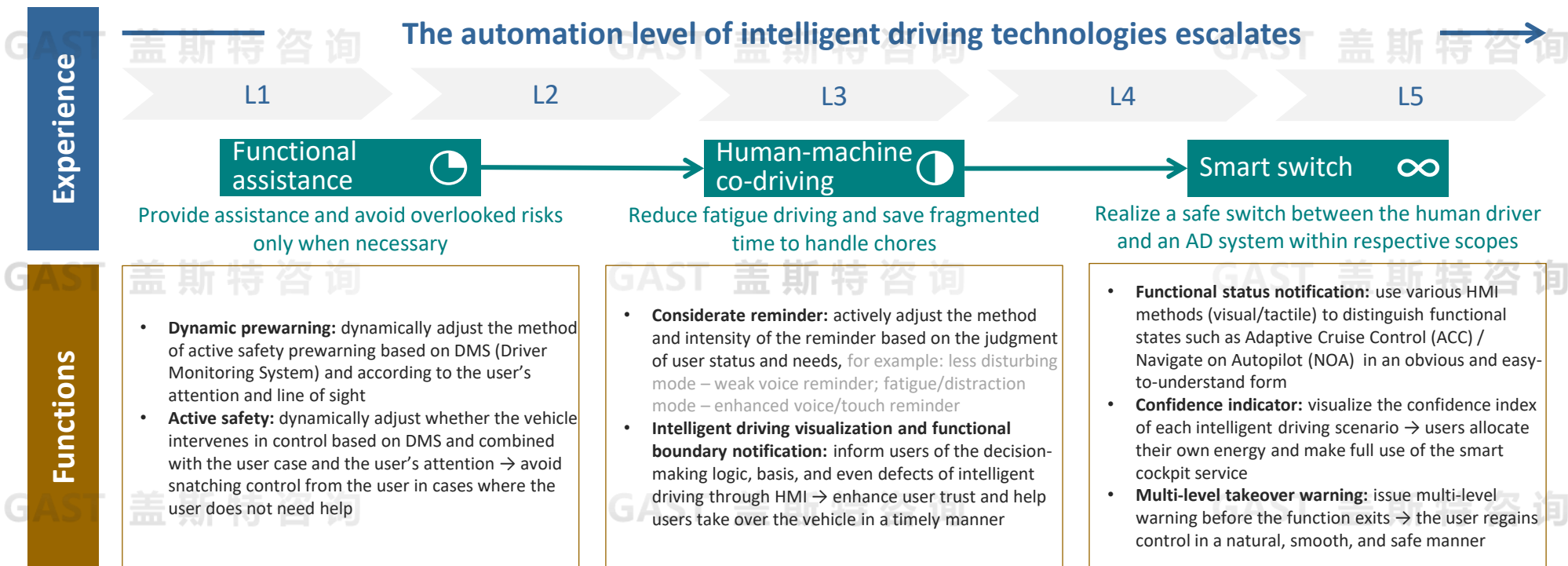
➤ Smart Cockpit-Oriented Products Improve User Experience

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Evolution Trends of User Demand for Smart Cockpit

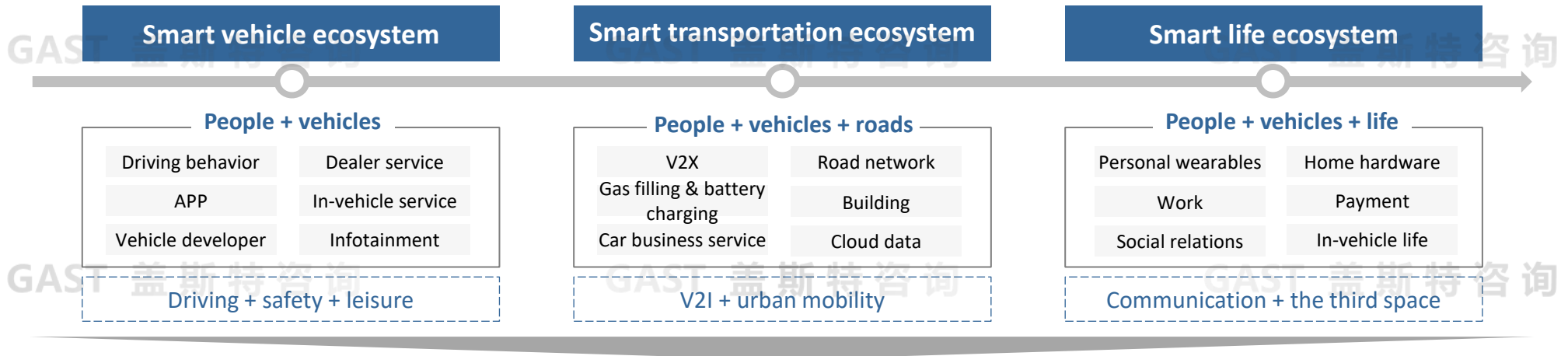
- As the automation level of intelligent driving technologies escalates, users continuously require better experience in smart cockpits



- Integrated with each other, smart cockpits and intelligent driving technologies empower each other. When designing functions of smart cockpits, developers should precisely identify users' fluid pain points, which would change with driving tasks, thus meeting their demand for better experience

Trends of Users to Experience Smart Cockpit Functions in Scenarios

- With the smart vehicle ecosystem as the core, smart cockpit functions are continuously available in more scenarios, creating a new user experience



Build an open architecture for smart vehicles, smart transportation, and smart life to enable a collaborative auto ecosystem

IoV ecosystem + internet ecosystem + IoT ecosystem

- Connect the IoV, the IoT, and the internet
- As new and independent mobile terminals, vehicles are connected to different ecosystems

A community of vehicles, roads, and cities

- Build a new intelligent urban infrastructure system on all fronts
- Deeply integrate smart vehicles into smart transportation and smart city initiatives

- Directly connecting smart vehicles, new scenarios, new business models, and new ecosystems, smart cockpits should be designed with a focus on people, vehicles, roads, and life, and be integrated with other industries**

Diversified Interactions in the Smart Cockpit Meet User Needs

- A smart cockpit features diversified HMI methods, with multimodal interaction and voice assistants as the current two major directions

Multimodal interaction

- Multi-modal crossing and integration → constantly create new functional experiences and product forms

- Conduct input and output between people and the vehicle from multiple angles of vision, hearing, smell, and touch, which is in line with the user's experience value in all aspects
- Multi-modal interactions effectively complement each other to improve expression accuracy and efficiency

Voice assistant

- Voice communication tends to be a natural dialogue between humans → realize in-depth human-machine collaboration

- Visualize the virtual assistant, so that the interactive medium begins to have clear human settings and emotions, can better understand the needs and give personalized feedback
- A trust relationship is gradually built between human and machine, and the machine is no longer just an instruction executor

Multi-screen interaction

- Multi-device display & linkage in the vehicle → bring rich and convenient sensory interaction to occupants

- The cockpit system is equipped with more and larger display screens, visualized VR devices, AR-HUD and other 3D HMI designs for the front and rear rows

Virtual touch

- Simplify the hardware structure and facilitate personalized configuration

- Realize virtual touch through display, holography and other technologies, reduce physical buttons, and allow freedom configuration according to user habits to achieve a touch experience within reach

Multi-player interaction

- Interact with occupants in the vehicle individually or collectively to enhance the overall experience of the cockpit

- No longer only interact with the driver, break the traditional barriers of OS-driver-passenger interaction, and create a sense of integrated interaction inside the cockpit

Active interaction

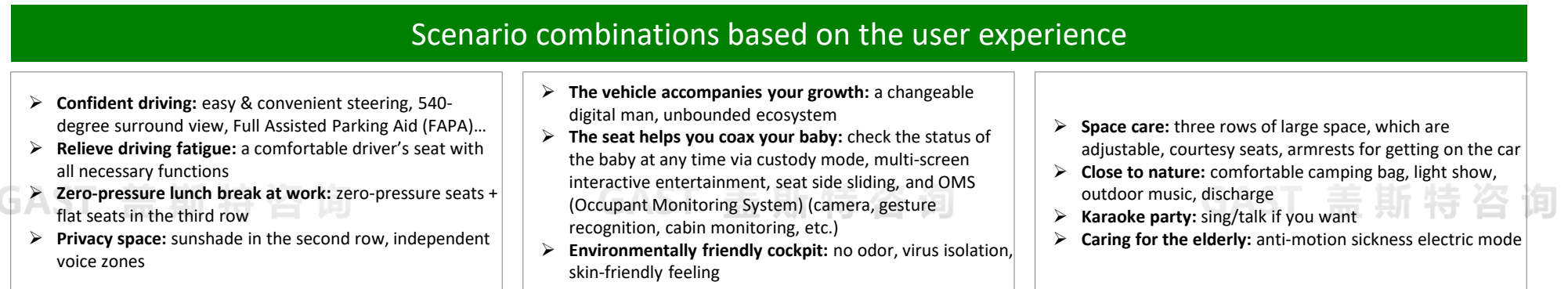
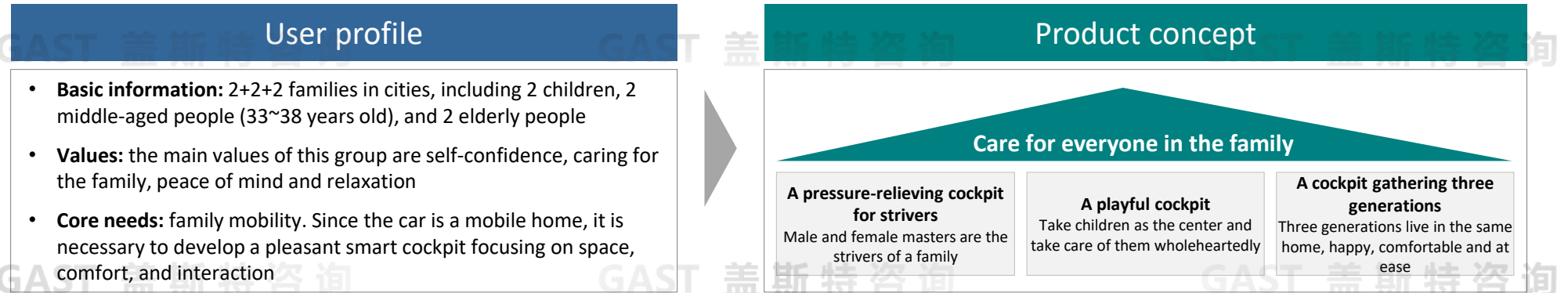
- The interactive medium shifts from passive receptive interaction to active perceptual interaction

- Give users proactive suggestions and recommendations for safety, emotion, environment, etc. based on biometric recognition, scenario perception and other technologies according to different scenarios and driving & riding conditions

- The core concept of designing smart cockpit-based interactions: leverage relevant industrial technologies and design expressions to improve the driving and riding experience for users – safer driving, more considerate services, and smarter recommendations

Dongfeng: Smart Cockpit Concept

- Focus on meeting the needs of two-child family users: strengthen the attribute of family use and emphasize comfort, entertainment, and interaction



- ❑ Focusing on the affection need and other higher-level needs of target users would be the priority for players to design and develop smart cockpits

Changan: Interaction Design System Based on Human Factors Engineering

- Design safe (moderately credible), efficient (comprehensible), human-like (emotional), and comfortable interaction solutions based on the use of vehicles, user needs, and human factors engineering to continuously improve the product experience

Ideas		Topics		Projects	
Safe	Driving performance	Function definition		• Design of a solution for a moderate sense of trust in intelligent driving	• Research on the necessity of speech in different scenarios
	Driving load			• Research on the comprehensibility of intelligent driving	• Definition of an anthropomorphic companion/assistant
	User trust	User definition		• Research on the influence of driving style on driver acceptance of intelligent vehicles in multiple contexts	• Intelligent driving solutions for different driving styles
	...				• Personification of the logic of car following, lane changing, etc.
Efficient	Comprehensible	HMI	Visual mode	• Research on the availability of off-vehicle interactions	
	Accurate				• Definition of scenario reconstruction in the context of user load
	User-friendly		Auditory mode	• Comparison of intelligent driving alert solutions	• Selection of auditory modal types in different scenarios
	...			• Research on the comprehensibility of parking speech semantics	• Impact of volume on user driving performance
Pleasant	Coordinated	Multimodal fusion			• Impact of different modal information on user load
	Aesthetic				• Priority of modal fusion of interactive information
	Affective	Experience evaluation		• Partial evaluation	• Satisfaction of user demand list
	...			• Overall evaluation	• Display materials (video, copywriting, etc.)
					• Competitive product benchmarking
					• Mobility service

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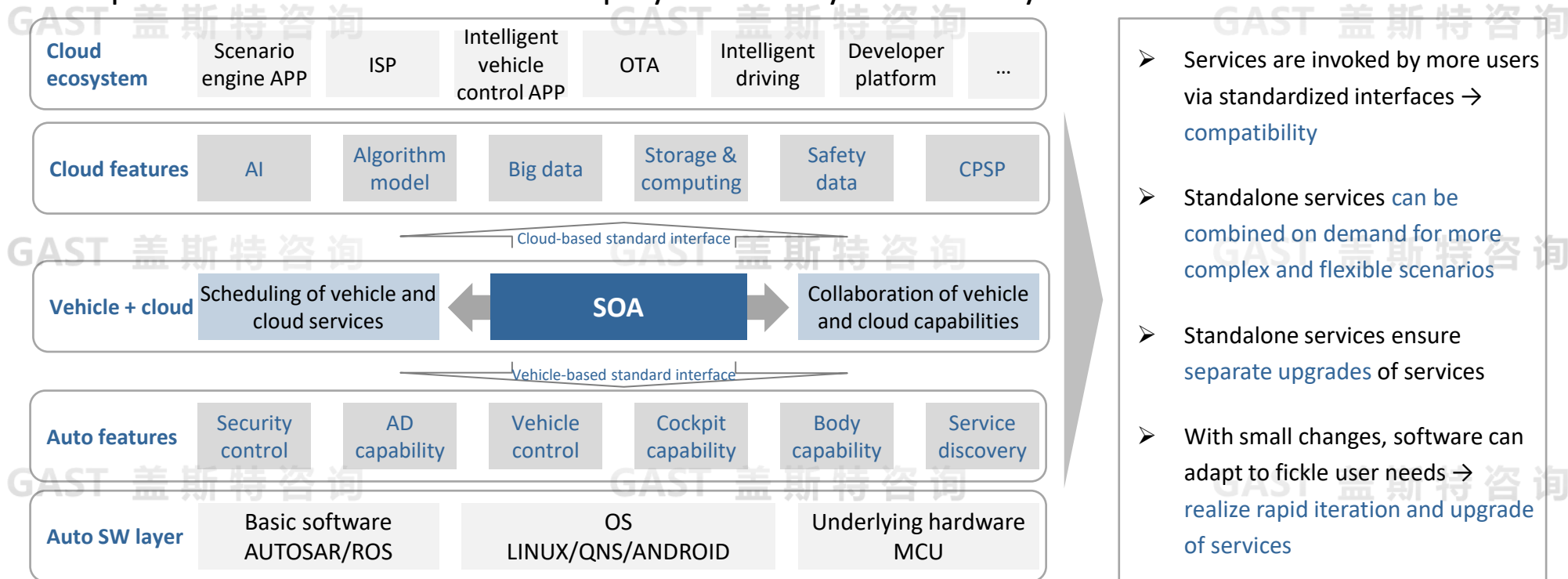
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SOA Empowers the Development of Upper-Layer Software

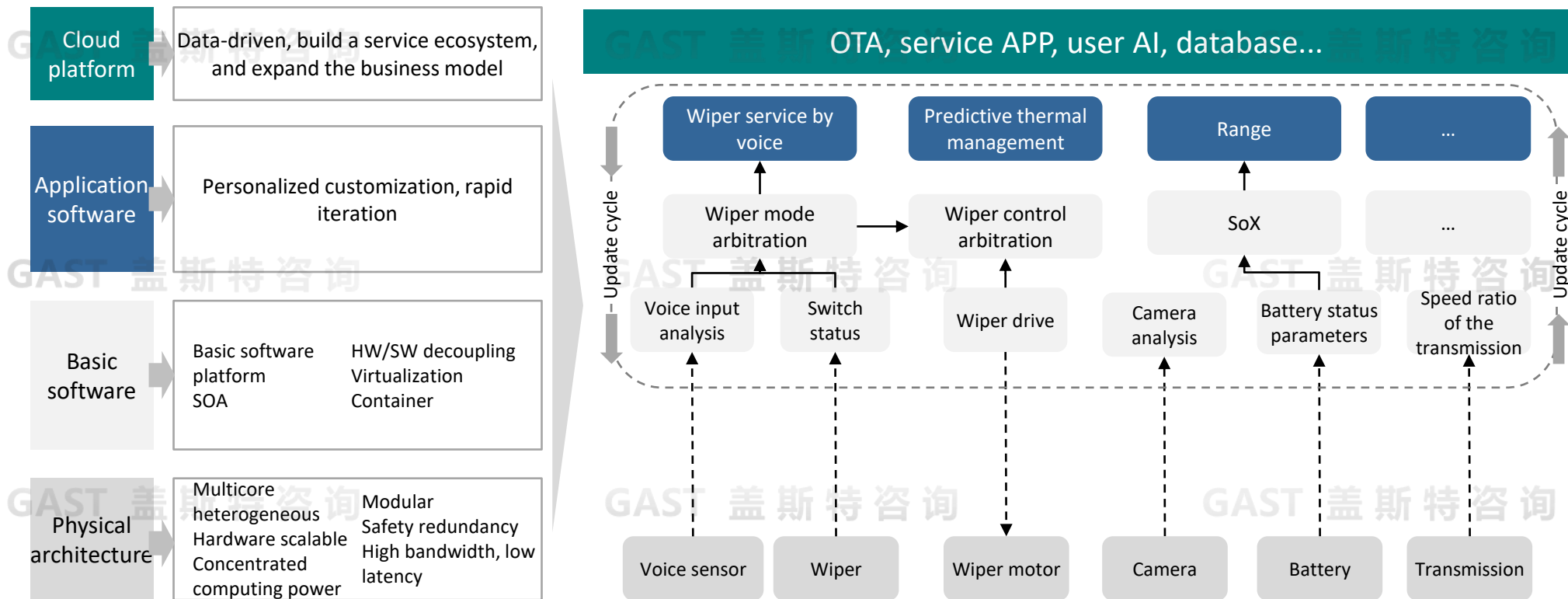
- After basic software shields differences between operating systems and hardware, SOA (Service-Oriented Architecture) can be applied to automotive and cloud software platforms with different chip architectures → define and deploy services by software layer



- ❑ **After the adoption of SOA, software development would allow for separate service updates and upgrades on specific layers and enable the application layer to create new service portfolios**

Software Development that Conforms to SOA

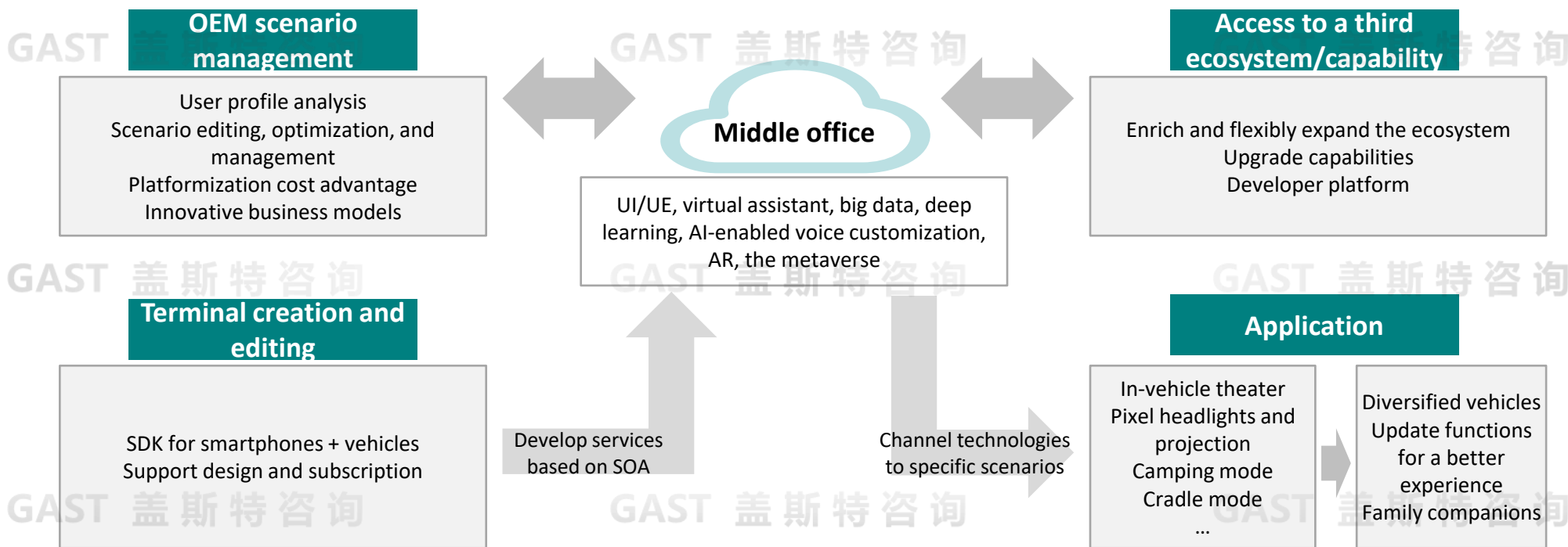
- SOA extracts the common parts of software into services layer by layer, enabling rapid iteration with minimal changes in software



- SOA enables the rapid expansion of functions and fast updates and improvements of performance, thus improving the user experience better and faster

Neusoft: SOA-Based Intelligent Scenario Engine

- Neusoft has formed a flexible software architecture based on SOA → build an intelligent scenario engine to realize scenario-driven close interaction between people and vehicles



- Based on AI algorithms, Neusoft integrates ecosystems of the cloud, vehicles, and other sectors to continuously meet users' demand for personalized mobility services and OEMs' requirement for refined operation via standardized services and a flexible middle office

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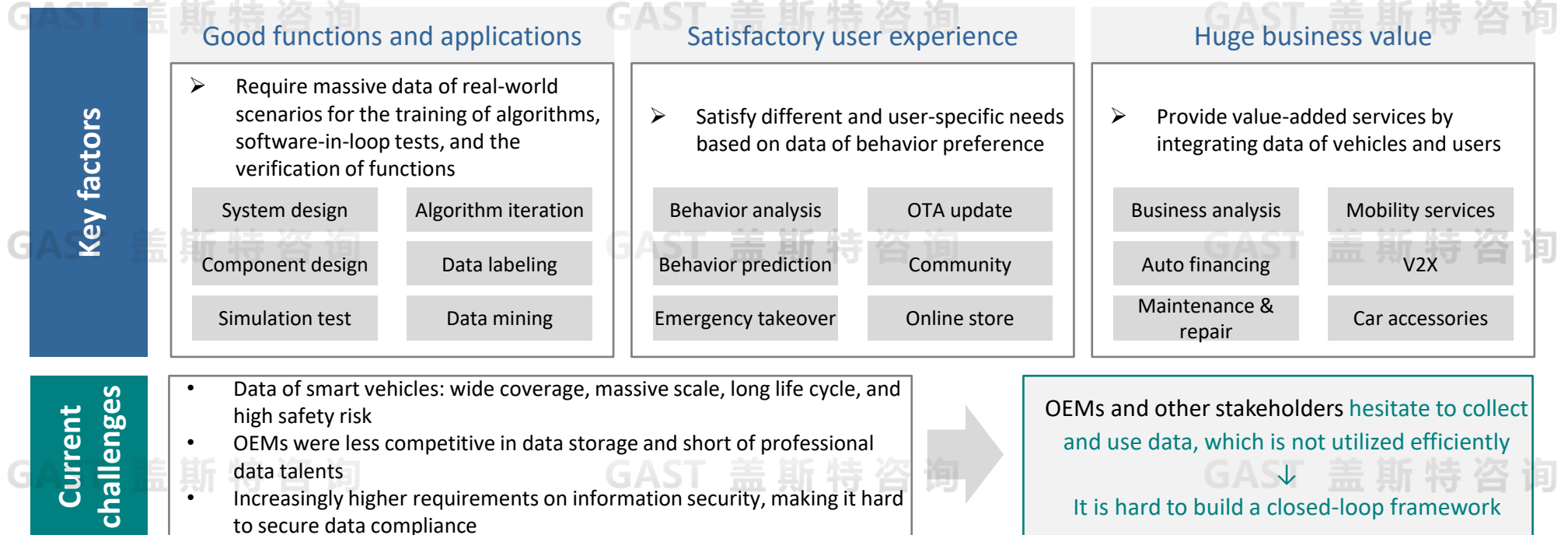
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Importance of Data in the Development of Smart Vehicles

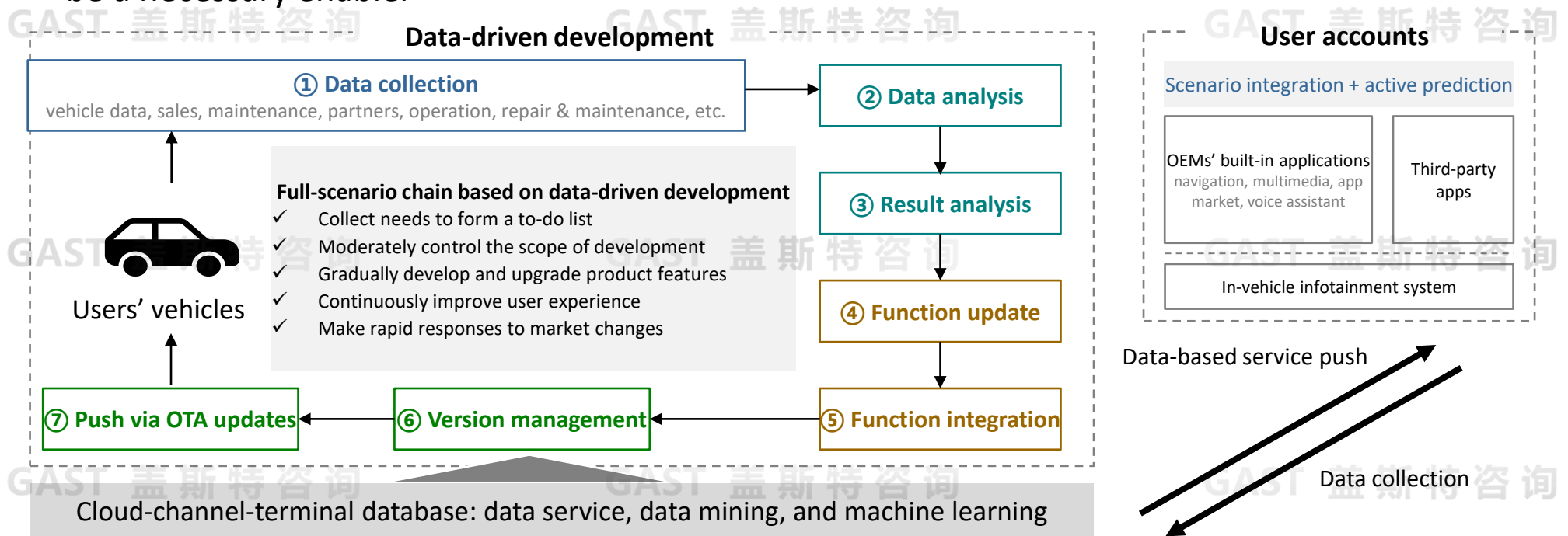
- The core competitiveness of smart vehicles lies in staying on top of the relationship between users and products, to which data is the core → the logic of developing smart vehicles has changed from engineering-driven approaches to data-driven playbooks



- **Building a closed loop of data can guide the improvement of intelligent technologies, the optimization of user experience, and the creation of value-added services, which is an important capability for OEMs to develop in the era of smart vehicles**

Data-Driven Development Mode of Smart Vehicles

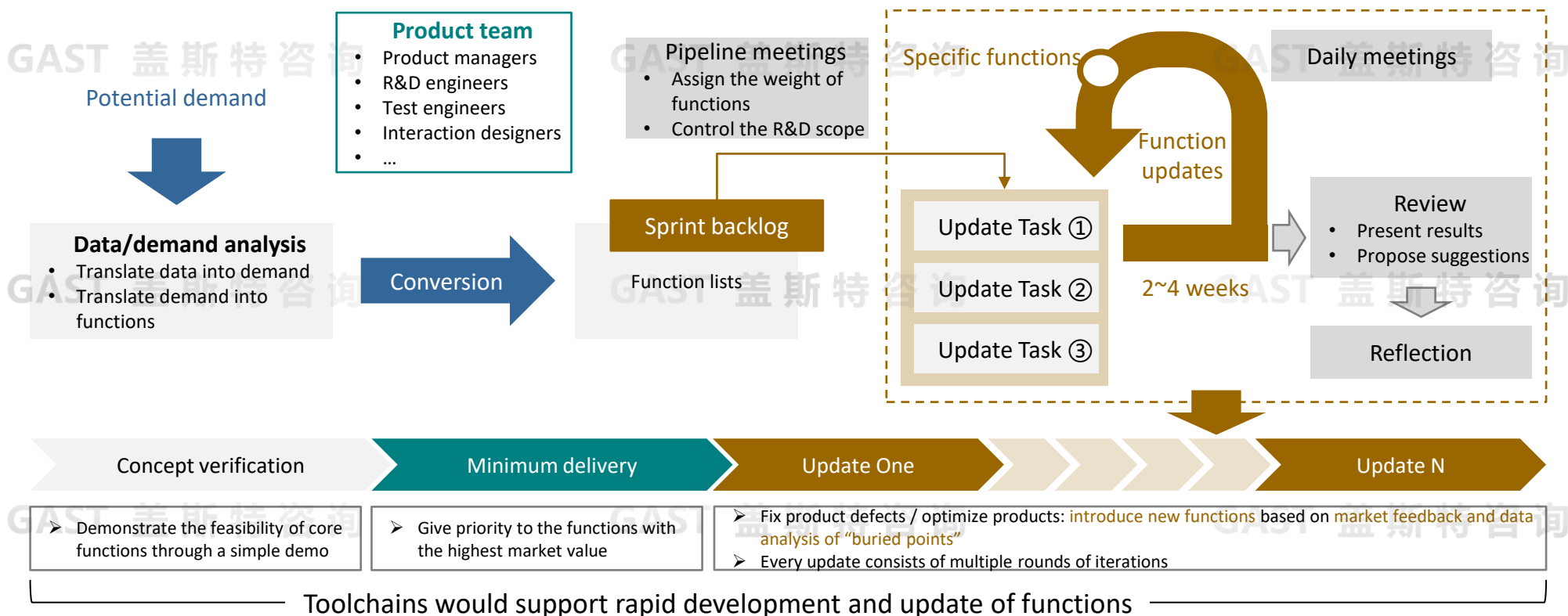
- To enable user experience via updates and upgrades of smart vehicles, OEMs should take real-time actions to improve products during the R&D process → the data-driven development mode would be a necessary enabler



- **Building a shared, open platform based on user data and the unified database is the key to connecting the data of users, vehicles, clouds, and services → make a deep dive into user data to enable data-driven product development**

Data-Driven Agile Product Development Processes

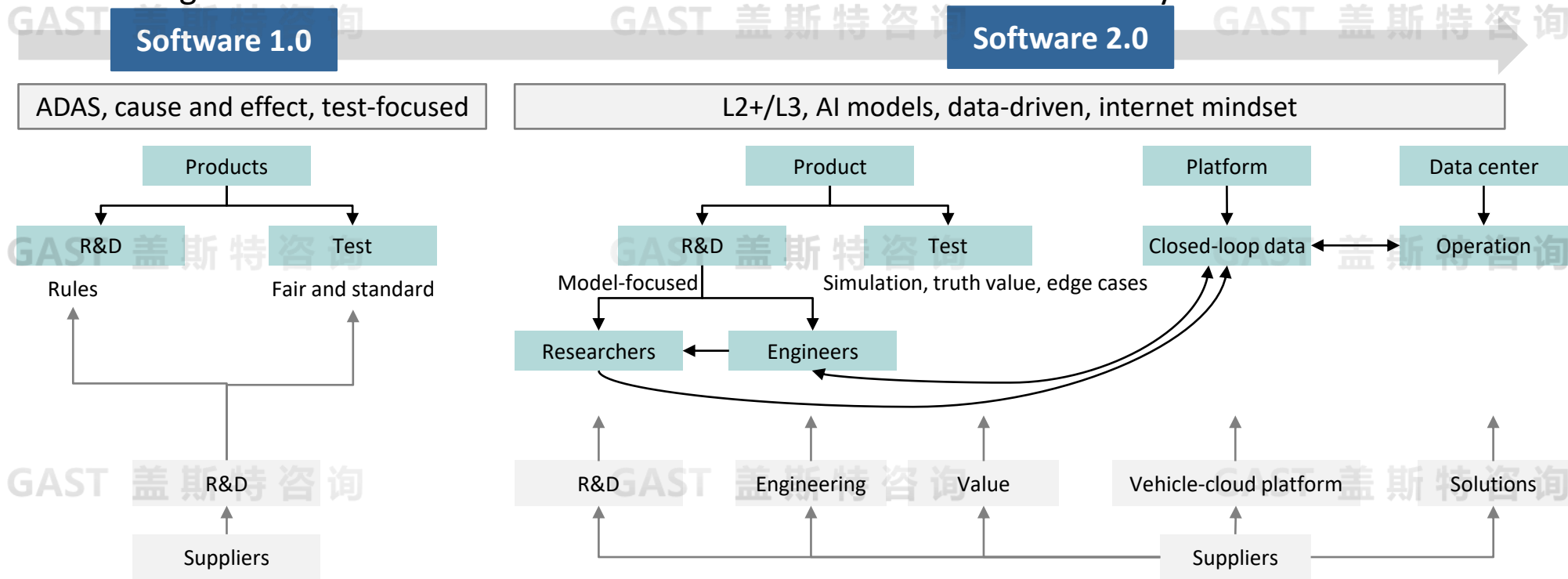
- Changing the product development mode requires OEMs to adopt agile development processes, thus enabling fast development and updates of functions



- Agile development processes can rapidly meet users' new needs via data, thus enabling user-centric product development**

OEMs' Organizational Reforms to Adopt Data-Driven Product Development

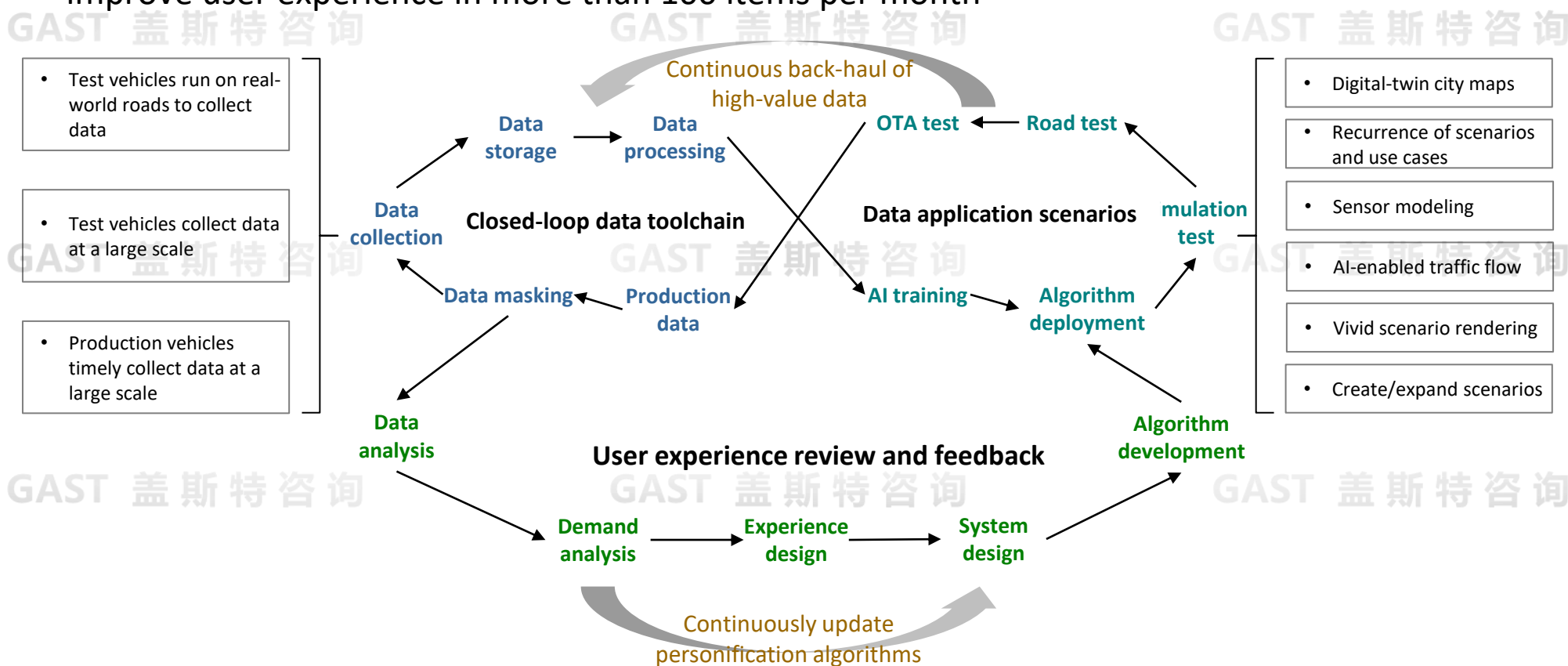
- Data-driven products should allow for interactions between various services, with overall solutions. Therefore, the mindset of R&D shifts from the cause-and-effect relationship to a data-driven one, enabling full interactions between the software team and the data analysis team



- ❑ Internally, OEMs should transform the organization. Externally, they should fully leverage suppliers' data solutions and data-based services

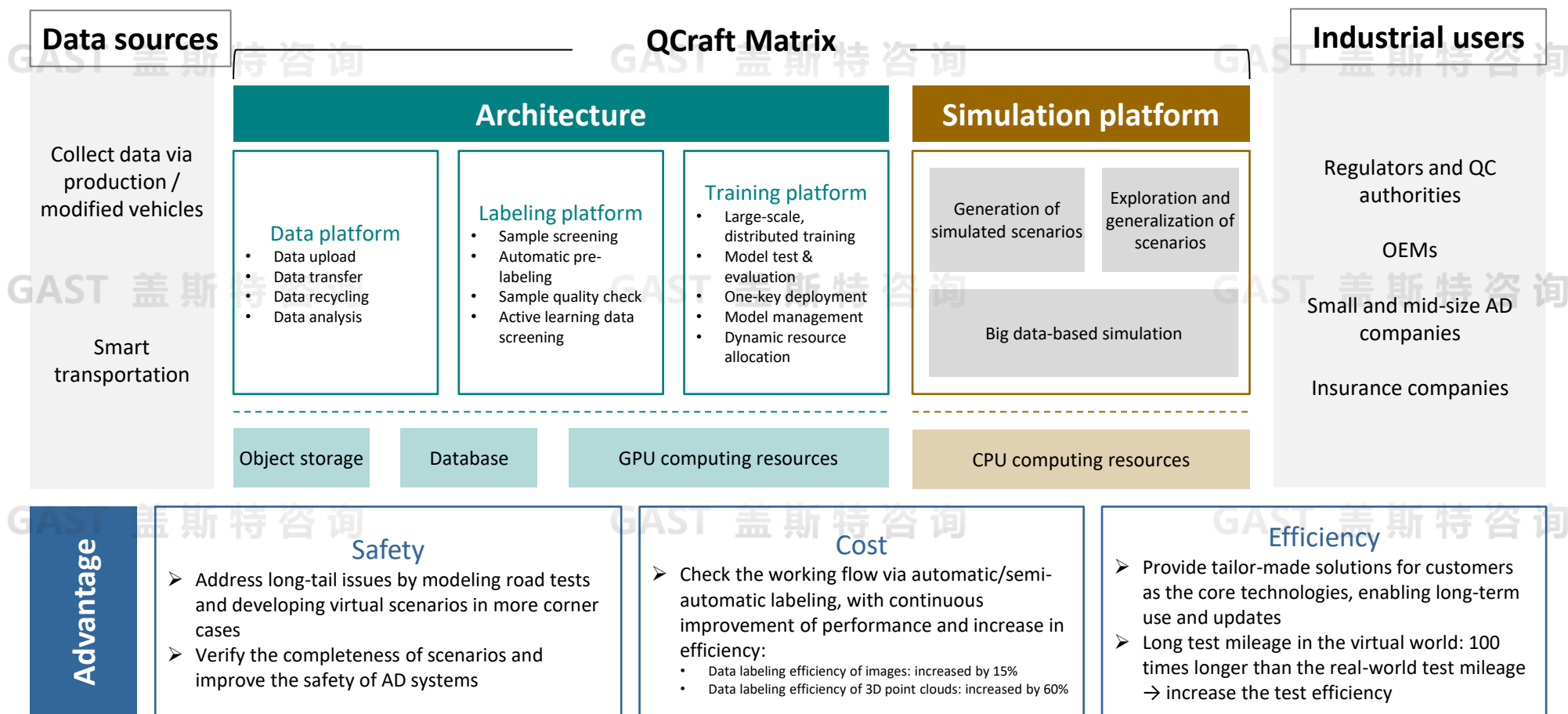
Changan: Efficiently Improve User Experience with Closed-Loop Data

- Generate “data” from large-scale applications and drive “intelligence” with “data”: collect more than 1,000 use cases per day; drive the evolution of 12 types of intelligent driving algorithms; improve user experience in more than 100 items per month



QCraft: Life-Cycle Solution for AD Data

- QCraft Matrix provides customers with closed-loop data services for AD, including data acquisition, data storage, data labeling, model training, simulation, verification, and model deployment



Summary

Smart Vehicle Development Strategies for Better User Experience

- ❑ **User experience is a key indicator to gauge the development of smart cockpit and intelligent driving domains**
 - ✓ With the improvement of intelligent driving functions, user experience demand and pain points change, requiring the development of specific functions
 - ✓ AD systems should focus on actual driving scenarios to help people and free people from the driving task to the maximum extent
 - ✓ Integrating smart cockpit and intelligent driving domains would create people-vehicle-environment interaction ecosystems → as a key carrier, vehicles would provide better experience for drivers and passengers
 - ✓ Diversified interactions become an important approach to improving user experience in smart cockpits. To be specific, multi-modal interaction and voice assistants are the priority, and the final purpose is to enable natural interactions between people and vehicles
 - ✓ Focusing on smart vehicle ecosystems, smart cockpits would continuously expand and integrate cross-industry ecosystems and technologies in transportation and daily life, thus combining and creating new scenarios for the application of functions
- ❑ **Software architectures of smart vehicles enable user-centric software development**
 - ✓ After the decoupling between software and hardware, the upgrade and evolution of smart vehicles would solely rely on software, to which the software update efficiency would become the key
 - ✓ Extract and translate every layer of the SOA into common service modules, enabling separate updates of services → rapidly adapt to fickle needs of the application layer (fickle user needs) with the minimum software changes and service portfolios
- ❑ **Develop smart vehicles based on data to precisely meet user needs**
 - ✓ Data becomes a key factor in developing smart vehicles, so OEMs should forge closed-loop data management capabilities to continuously satisfy user needs
 - ✓ Based on the connection of data from people, vehicles, clouds, and services, the data-driven development mode enables real-time improvement of products during the development process
 - ✓ The data-driven development mode requires the support of software development procedures and R&D architectures: agile development procedures + an R&D team that allows for full interaction between the software team and the data team



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Company Profile

Setting its foothold in China automotive industry, GAST Strategy Consulting, LLC is oriented to the globe to focus on the ecosystem of the whole automotive industry and starts from three dimensions (industry, enterprise and technology) to carry out in-depth study on strategy design, business positioning, management improvement, system building, business process reengineering, product planning, technology choices and business models. It is dedicated to providing governments at all levels with decision-making support and implementation advice and enterprises in the automotive industry chain and relevant industries with all-dimensional high-level professional consulting services in strategies, management and technologies. Since the establishment, GAST is dedicated to becoming a world top auto think tank as the vision and sharing wisdom as the mission. Adhering to creating value for clients and focusing on actual effects, GAST commits itself to forging long-term partnership and providing guidance service. It has fostered strategic partnership with and is providing services for nearly 100 domestic and international enterprises, organizations in the automotive industry and governments at all levels by virtue of comprehensive, systematic, advanced and pragmatic consulting methods.

Range of Service

Provide diversified and open services and flexible ways of cooperation for customers, including but not limited to:

- Executive-oriented strategy, management and technology consulting services
- All-round and customized special project research: covering macro strategy, industrial development, interpretation of policies and regulations, the internet, business models, corporate strategy and management, auto market, product research, product design methodology, research on auto shows, interpretation of forums, energy conservation and emission reduction, new energy vehicles, intelligent vehicles and comprehensive automotive technologies
- Serve as reliable resource that can win customers' long-term dependence and provide open cooperation that can meet customers' specific requirements at any time
- Provide a high-end sharing platform (CAIT) for industrial communication, exchange and in-depth research
- The company provides nearly 1,000 research reports in Chinese, English and Japanese at present

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