

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

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Data-Driven Product Development Precisely Meet User Experience Needs

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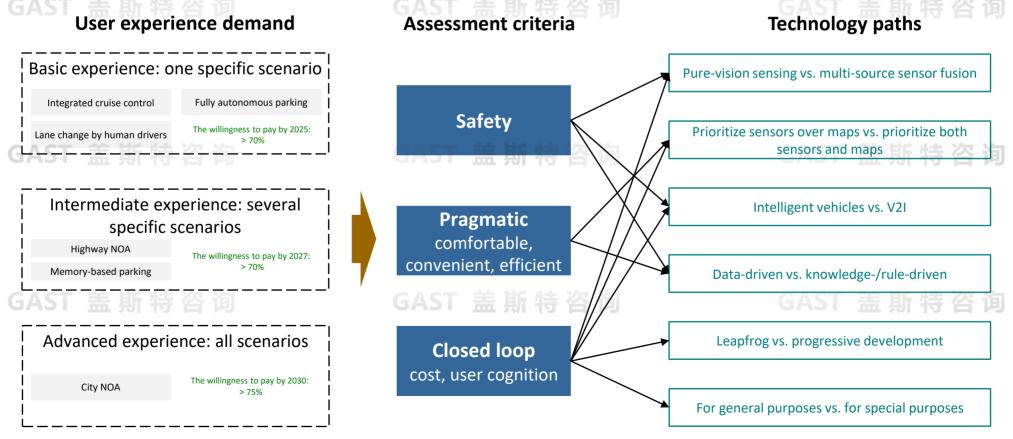
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Multiple Technology Paths for Intelligent Driving Based on User Experience

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 "userspecific 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 User trust supervision

Intelligent driving capabilities

- 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

User needs and evaluations **Dimension** Principle of AD system design for user experience Safety is the priority for users to consider the adoption ✓ AD functions entail corresponding safety measures → more advanced **Functions** of autonomous driving functions require a higher level of safety Safety > Users expect a more user-friendly process of taking ✓ The AD system should send clear instructions to take over the control of Take-over over the driving task, avoiding causing surprise, anxiety vehicles and prepare enough redundancy → avoid causing surprise, authority anxiety, worry, etc. worry, etc. Users pay great attention to the feeling of driving and ✓ The principle of algorithm design policies: an AD system should have Driving & riding riding with an AD system. With the same functions, **Feeling** the same driving habits as human drivers \rightarrow e.g., more experienced in vehicles that can provide a high level of comfort would comfort handling edge cases be more popular among users > Users expect AD to address problems in daily life > Functions suitable for specific scenarios: if one function ✓ Available frequent scenarios in daily life → pragmatic Scenario coverage could adapt to more specific scenarios, the user experience would be better Scenario Smooth scenario ✓ Smooth switch between scenarios and functions + clear reminders > Users focus on experience brought the shift of ✓ Precise route planning: avoid traffic congestion; make rapid decisions functions during the switch between scenarios switch

☐ 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

- Chips feature a higher level of integration, saving materials → lower cost than multichip solutions
- Some underlying software can be shared, saving the cost of developing and outsourcing software
- Adopt shared memory: shorter communication latency than the previous modes of bus-based transmission and "switch between two plates"
- 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

Application experience

Redundant intelligent driving solutions

Simulation of assisted driving environment

Convenient access to intelligent driving functions

Immersive feedback on driving status

- 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
- 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
- Activate Highway/City NOA, parking, and other functions via voice, gesture, etc. → enable "hands-free" driving
- 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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warning before the function exits \rightarrow the user regains

control in a natural, smooth, and safe manner

user does not need help

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

The automation level of intelligent driving technologies escalates Experience L1 L2 L3 L4 L5 **Functional** Smart switch 00 assistance co-driving Realize a safe switch between the human driver Provide assistance and avoid overlooked risks Reduce fatigue driving and save fragmented and an AD system within respective scopes only when necessary time to handle chores Functional status notification: use various HMI methods (visual/tactile) to distinguish functional Considerate reminder: actively adjust the method Dynamic prewarning: dynamically adjust the method states such as Adaptive Cruise Control (ACC) / and intensity of the reminder based on the judgment of active safety prewarning based on DMS (Driver Functions Navigate on Autopilot (NOA) in an obvious and easyof user status and needs, for example: less disturbing Monitoring System) and according to the user's mode – weak voice reminder: fatigue/distraction to-understand form attention and line of sight Confidence indicator: visualize the confidence index mode - enhanced voice/touch reminder Active safety: dynamically adjust whether the vehicle Intelligent driving visualization and functional of each intelligent driving scenario → users allocate intervenes in control based on DMS and combined their own energy and make full use of the smart boundary notification: inform users of the decisionwith the user case and the user's attention \rightarrow avoid cockpit service making logic, basis, and even defects of intelligent snatching control from the user in cases where the Multi-level takeover warning: issue multi-level driving through HMI → enhance user trust and help

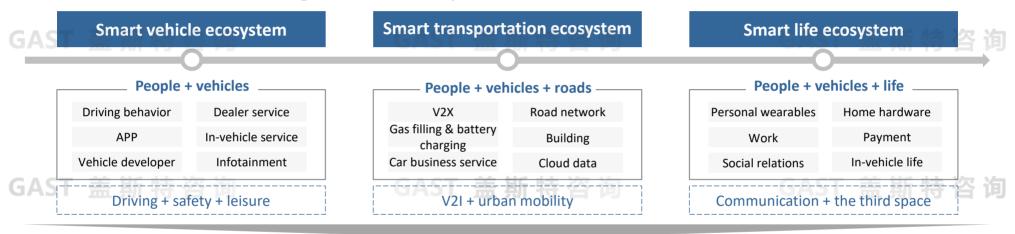
Integrated with each other, smart cockpits and intelligent driving technologies empower each other. When designing functions of smart cockpits, developers should precisely identify users' fluid pain points, which would change with driving tasks, thus meeting their demand for better experience

users take over the vehicle in a timely manner



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-driverpassenger 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

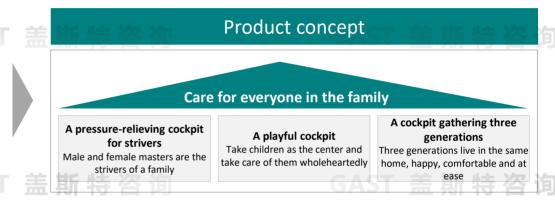


Dongfeng: Smart Cockpit Concept

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

User profile

- Basic information: 2+2+2 families in cities, including 2 children, 2 middle-aged people (33~38 years old), and 2 elderly people
- Values: the main values of this group are self-confidence, caring for the family, peace of mind and relaxation
- Core needs: family mobility. Since the car is a mobile home, it is necessary to develop a pleasant smart cockpit focusing on space, comfort, and interaction



Scenario combinations based on the user experience

- Confident driving: easy & convenient steering, 540degree surround view, Full Assisted Parking Aid (FAPA)...
- Relieve driving fatigue: a comfortable driver's seat with all necessary functions
- Zero-pressure lunch break at work: zero-pressure seats + flat seats in the third row
- Privacy space: sunshade in the second row, independent voice zones

- The vehicle accompanies your growth: a changeable digital man, unbounded ecosystem
- ➤ The seat helps you coax your baby: check the status of the baby at any time via custody mode, multi-screen interactive entertainment, seat side sliding, and OMS (Occupant Monitoring System) (camera, gesture recognition, cabin monitoring, etc.)
- Environmentally friendly cockpit: no odor, virus isolation, skin-friendly feeling
- > Space care: three rows of large space, which are adjustable, courtesy seats, armrests for getting on the car
- Close to nature: comfortable camping bag, light show, outdoor music, discharge
- ➤ Karaoke party: sing/talk if you want
- > Caring for the elderly: anti-motion sickness electric mode

☐ 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

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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

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

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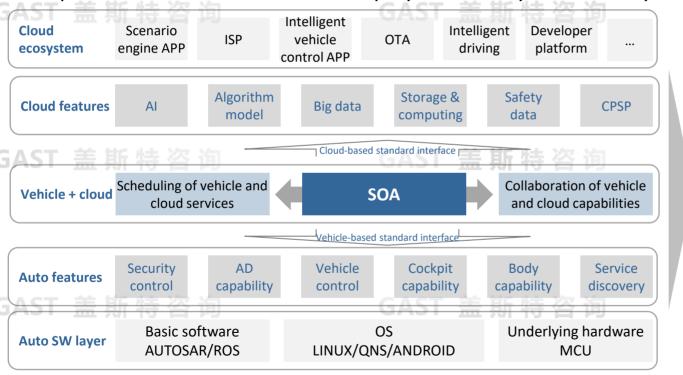
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SOA Empowers the Development of Upper-Layer Software

■ 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

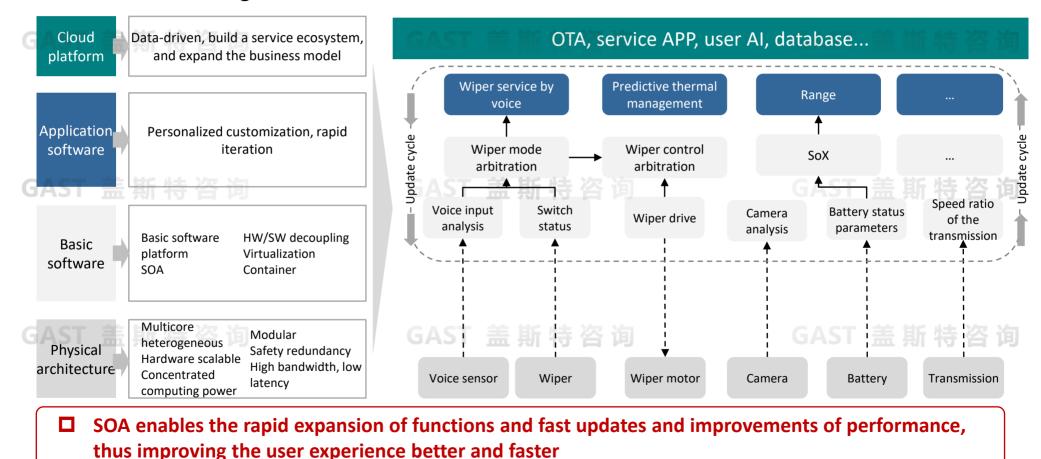


- Services are invoked by more users via standardized interfaces -> compatibility
- Standalone services can be combined on demand for more complex and flexible scenarios
- Standalone services ensure separate upgrades of services
- With small changes, software can adapt to fickle user needs → realize rapid iteration and upgrade of services
- ☐ 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

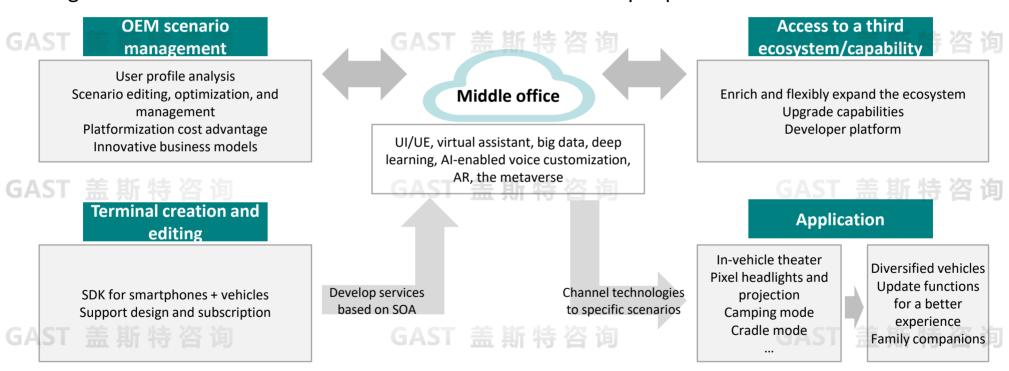
■ SOA extracts the common parts of software into services layer by layer, enabling rapid iteration with minimal changes in software





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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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

Key factors

Good functions and applications

Require massive data of real-world scenarios for the training of algorithms, software-in-loop tests, and the verification of functions

System design

Component design

Data labeling

Simulation test

Data mining

Satisfactory user experience

Satisfy different and user-specific needs based on data of behavior preference
 Behavior analysis
 OTA update
 Behavior prediction
 Community

Emergency takeover Online store

Huge business value

 Provide value-added services by integrating data of vehicles and users

Business analysis

Mobility services

Auto financing

V2X

Maintenance & repair

Car accessories

Current hallenges

- Data of smart vehicles: wide coverage, massive scale, long life cycle, and high safety risk
- OEMs were less competitive in data storage and short of professional data talents
 - Increasingly higher requirements on information security, making it hard to secure data compliance



OEMs and other stakeholders hesitate to collect and use data, which is not utilized efficiently

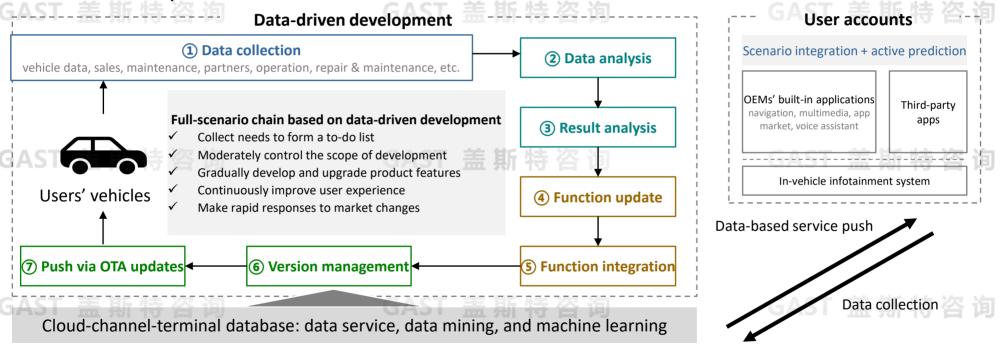
It is hard to build a closed-loop framework

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

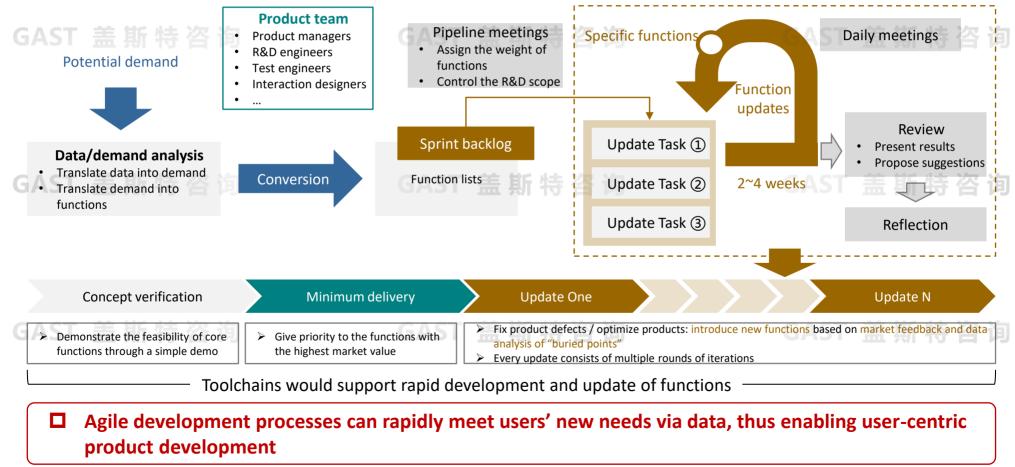


■ Building a shared, open platform based on user data and the unified database is the key to connecting the data of users, vehicles, clouds, and services → make a deep dive into user data to enable datadriven product development



Data-Driven Agile Product Development Processes

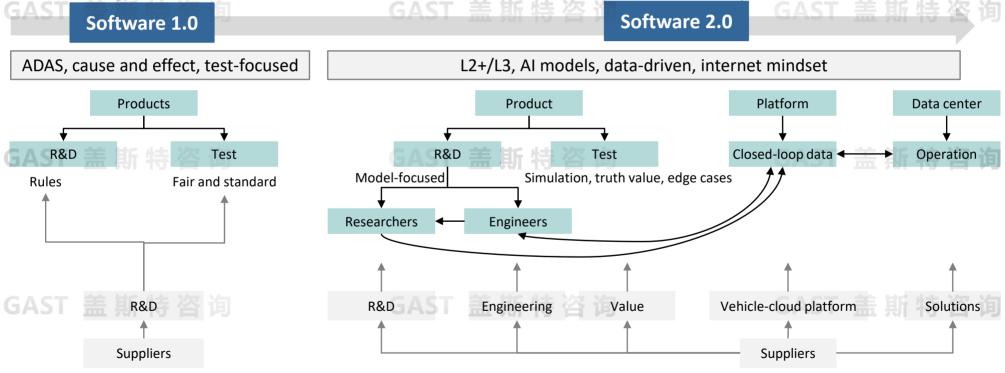
Changing the product development mode requires OEMs to adopt agile development processes,
 thus enabling fast development and updates of functions





OEMs' Organizational Reforms to Adopt Data-Driven Product Development

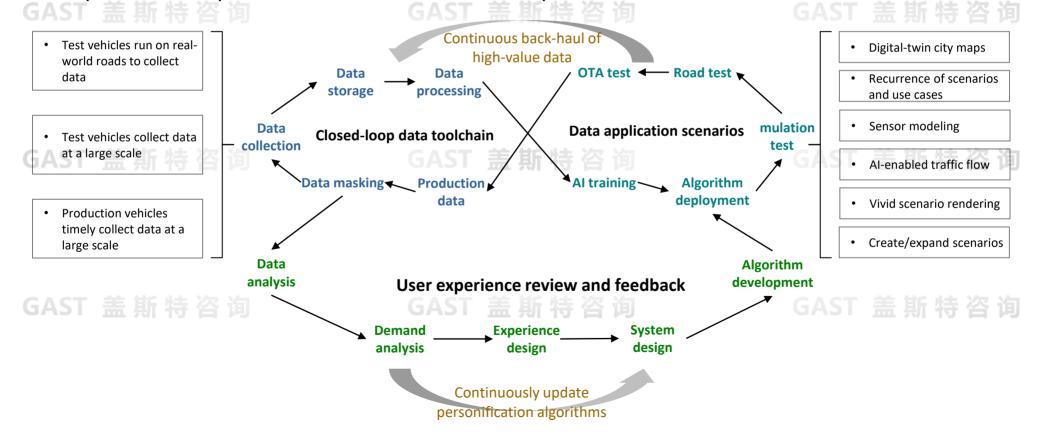
Data-driven products should allow for interactions between various services, with overall solutions. Therefore, the mindset of R&D shifts from the cause-and-effect relationship to a data-driven one, enabling full interactions between the software team and the data analysis team





Changan: Efficiently Improve User Experience with Closed-Loop Data

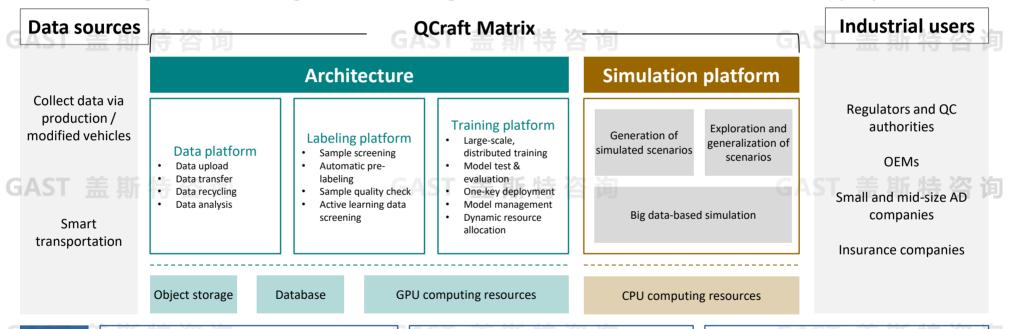
■ Generate "data" from large-scale applications and drive "intelligence" with "data": collect more than 1,000 use cases per day; drive the evolution of 12 types of intelligent driving algorithms; improve user experience in more than 100 items per month





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



Advantage

Safety

- > Address long-tail issues by modeling road tests and developing virtual scenarios in more corner cases
- Verify the completeness of scenarios and improve the safety of AD systems

- > Check the working flow via automatic/semiautomatic labeling, with continuous improvement of performance and increase in efficiency:
 - Data labeling efficiency of images: increased by 15%
 - Data labeling efficiency of 3D point clouds: increased by 60%

Efficiency

- Provide tailor-made solutions for customers as the core technologies, enabling long-term use and updates
- > Long test mileage in the virtual world: 100 times longer than the real-world test mileage → increase the test efficiency



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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