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Passenger Car Intelligent Steering Industry Research Report, 2022

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Research on intelligent steering of passenger cars: The development of intelligent steering is accelerating, and it will be put on vehicles in batches in 2023

In September 2022, Geely and Hella jointly developed a series production-ready steer-by-wire (SBW) system which will be spawned from 2026.

In October 2022, NIO signed a strategic cooperation agreement with ZF. They will work together in the development of SBW products.

Toyota bZ4X featuring JTEKT 's SBW technology was put into mass production and launched in October 2022.

Schaeffler Technologies AG & Co. KG and Arnold Verwaltungs GmbH signed a basic agreement under which Schaeffler Technologies AG & Co. KG will acquire the remaining 10% stake in the joint venture company Schaeffler Paravan Technologie GmbH & Co. KG (Schaeffler Paravan) from Arnold Verwaltungs GmbH. Schaeffler's objective is to accelerate the development of integrated SBW systems for large-series automotive production, and also to use the market access gained through Space Drive applications to market fully developed volume production solutions.
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From the perspective of supply and demand, the above-mentioned phenomena indicate that intelligent steering systems (including SBW systems) will gradually enter the consumer market. In 2023, the era of traditional mechanical connection will come to an end, while the SBW age may begin.

SBW systems will gradually replace electronic power steering systems

With the development of intelligence, automotive chassis is evolving from traditional chassis to chassis-by-wire. For the sake of more accurate actuation, faster response and higher safety, high-level intelligent driving or autonomous vehicles require chassis systems to cancel the mechanical connection between actuators as much as possible, and use electrical signals to transmit instructions instead. At the same time, the system reliability and security should be ensured by additional redundant electronic components.

At present, electronic power steering (EPS) systems are the most advanced steering system solution for mass production. The fundamental difference between SBW and EPS is that the former removes mechanical connection between steering wheel and steering rod, and completely decouples steering wheel and steering mechanism. After being widely used in high-level intelligent driving in the future, SBW can avoid interference with the driver's steering action and possible collision when the vehicle automatically turns in an emergency under control of ECU. Without a physical structure, SBW helps improve vehicle performance in terms of lightweight, responsiveness, and cockpit layout.

In chassis-by-wire, a SBW system is the core component that controls the lateral movement, and also one of important actuators of high-level intelligent driving. At present, SBW systems are still in the technical verification stage, let alone mass production. However, the absence of mechanical redundancy puts forward higher requirements for the reliability of electronic equipment and systems. Before high-level autonomous driving is popular, there are still many challenges for the development of SBW. At present, EPS is still the mainstream of market, but SBW with smaller size and higher security will embody the future trend.

With the development of high-level autonomous driving and the synchronization of "electrification, intelligence, software and sharing", the intelligent steering of passenger cars presents the following development trends:

Trend 1: Steering systems gradually evolve

As the core part of chassis, steering systems have gone through many mutations, such as mechanical steering systems, hydraulic power steering (HPS) systems, electric power steering (EPS) systems, redundant steering systems (RSS), steer-by-wire (SBW) systems, etc., gradually transforming from mechanization to electrification, then to intelligence. The operating performance of steering systems has been improved, with higher levels of integration, electrification and intelligence. As the penetration rate of autonomous driving increases, the evolution to SBW systems will accelerate, and the upgrade of steering systems will match the level of autonomous driving.

Classification of Passenger Car Steering Systems

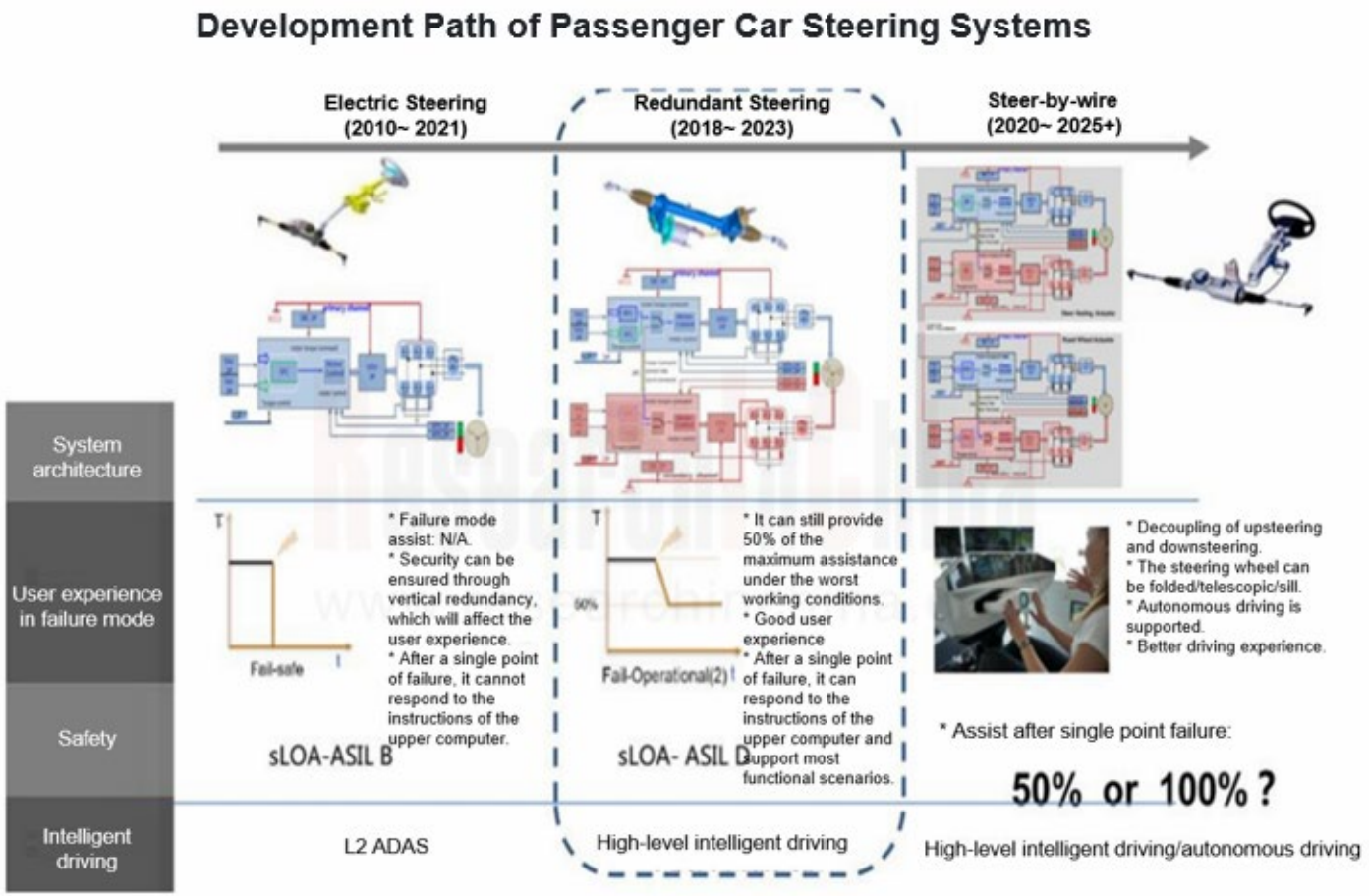
No.	Type	Composition	Main Features	Advantages / Disadvantages
1	Steer-by-wire system (SBW)	Steering wheel module Front wheel steering module Main controller Fail-safe system	No steering wheel	Small footprint, high safety. A high-power feedback motor and a steering motor are required
2	Electronic power steering system (EPS)	Torque sensor Speed sensor Electric motor Reducer Electronic control unit	An electronically controlled motor generates auxiliary power for steering	Simple structure, low weight and small footprint. Limited auxiliary power and high cost.
3	Electronic hydraulic power steering system (EHPS)	Oil tank Power steering control unit Electric pump Steering gear Power steering sensor	The steering oil pump is driven by a motor and equipped with an electronic control system.	Low energy consumption, sensitive response. Not as stable as HPS. High maintenance cost.
4	Mechanical steering system (MS)	Steering control mechanism Steering gear Steering gear transmission mechanism	Purely driven by human power. Tires are steered by amplifying and changing the direction of human power.	Simple structure and low cost. Laborious operation, unstable stability and accuracy
5	Mechanical hydraulic power steering system (HPS)	Hydraulic pump Oil pipe Pressure & flow control valve V-shaped drive belt Oil tank	The driver's physical strength and engine power are combined as steering energy, amplifying the force transmitted by the driver	High safety, low cost and sufficient steering power. High energy consumption and high maintenance cost.

Source: ResearchInChina

Trend 2: From electric control steering, redundant steering to SBW

Amid the electrification of vehicles, intelligence has become a new driving force for the development of steering technology. In response to the requirements of autonomous driving, steering systems should feature higher safety and reliability to ensure that vehicles can enter a safe state or even continue to run safely when electrical systems fail. Therefore, the industry is studying new technologies such as redundant EPS and SBW to guarantee system safety. Compared with redundant EPS, the most notable feature of SBW lies in zero mechanical connection between the steering wheel and the actuator, which brings about obvious advantages in cost control, design flexibility, functional richness and space layout.

As the core role of intelligent chassis, steering systems have high technical barriers. At present, German, American, Japanese and Korean steering giants still dominate the steering system market, especially redundant EPS and SBW segments. China is catching up with them. With the gradual maturity of China's intelligent automotive industry chain, some enterprises have mastered the core technology of steering systems and even SBW. They are expected to break the technical barriers and quickly seize the market share in the future.



Source: Intelligent Electric Chassis Technology Roadmap

Trend 3: SBW has not seen mass production, but domestic and foreign automakers and suppliers are deploying SBW vigorously

Toyota bZ4X has once again introduced the SBW technology to automotive market, providing the first experience for the mass production and application of SBW. It may make a major breakthrough in the development of SBW technology. Tesla aims to start mass production of its eagerly anticipated all-electric pickup truck “Cybertruck” in late 2023. Great Wall Motor's next-generation smart chassis also adopts SBW technology and it plans to start mass production in 2023. SBW will be verified by the market extensively.

At present, neither international nor local vendors have realized mass production of SBW technology. Amid high R&D investment by local enterprises, the vendors with leading positions in EPS and technology accumulation will perform better in SBW technology, and may surpass international counterparts soon.

SBW Products and Layout of Some Automakers and Tier1 Suppliers

No.	Automakers and Tier1 suppliers	SBW products and layout	Mass production time
1	Great Wall Motor	Great Wall Smart Chassis-by-Wire (including SBW)	2023
2	Toyota	The BZ4X with SBW technology will be mass-produced.	2022
3	Geely	Geely and Hella jointly develop an all-electric SBW system	
4	NIO	NIO signed a strategic cooperation agreement with ZF to work together in the development of SBW products.	
5	Hongqi	It independently develops redundant EPS and combines domestic supporting resources to complete a round of verification	
6	Tesla	The first model equipped with this technology will be Cybertruck, a battery-electric pickup truck owned by Tesla.	
7	Bosch (including Bosch Huayu)	In 2018, Bosch Huayu’s SBW products were displayed on Demo cars.	2024
8	Schaeffler	The Space Drive 3 steer-by-wire system debuted	2021
9	ZF	SBW&AKC2.0 rear axle steering module was released	Not in mass production yet
10	Nexteer Automotive	Announced the expansion of its advanced steering technology suite, including Steer-by-Wire, Steering on Demand™ System, Quiet Wheel™ Steering	Unknown
11	JTEKT	It has received many orders from OEMs	2022-2023
12	Lianchuang Electronic Technology	SBW, ongoing research and available prototypes	
13	KYB	DAS is supplied to Infiniti	2013
14	Mando	Mando released its SBW technology at CES 2021, which is expected to serve Canoo	
15	Bethel Automotive Safety Systems	It acquired Zhejiang Wanda, and is developing SBW. It has a prototype.	
16	Ningbo Tuopu	SBW under development.	
17	Zhejiang Shibao	SBW under development.	
18	NASN	NASN’s fully redundant pinion SBW system has been introduced in two versions for passenger cars and small buses respectively.	

Source: ResearchInChina

Trend 4: 2023 may become the first year of mass production of SBW

Toyota will launch bZ4X equipped with a SBW system in European market. This system has an additional standby power supply module, which improves the stability and diversity of system power supply with lithium batteries and capacitors based on a traditional generator and 12V power supply. In order to ensure reliability and safety of steering system, bZ4X has added electronic redundancy to power supply, communication bus, torque sensor, motor angle sensor, microprocessor, power drive and motor coil. Toyota bZ4X has once again introduced SBW technology to automotive market, providing the first experience for the mass production and application of SBW. It may make a major breakthrough in the development of SBW technology. The technical achievements of SBW have taken shape, and mass production may start in 2023.

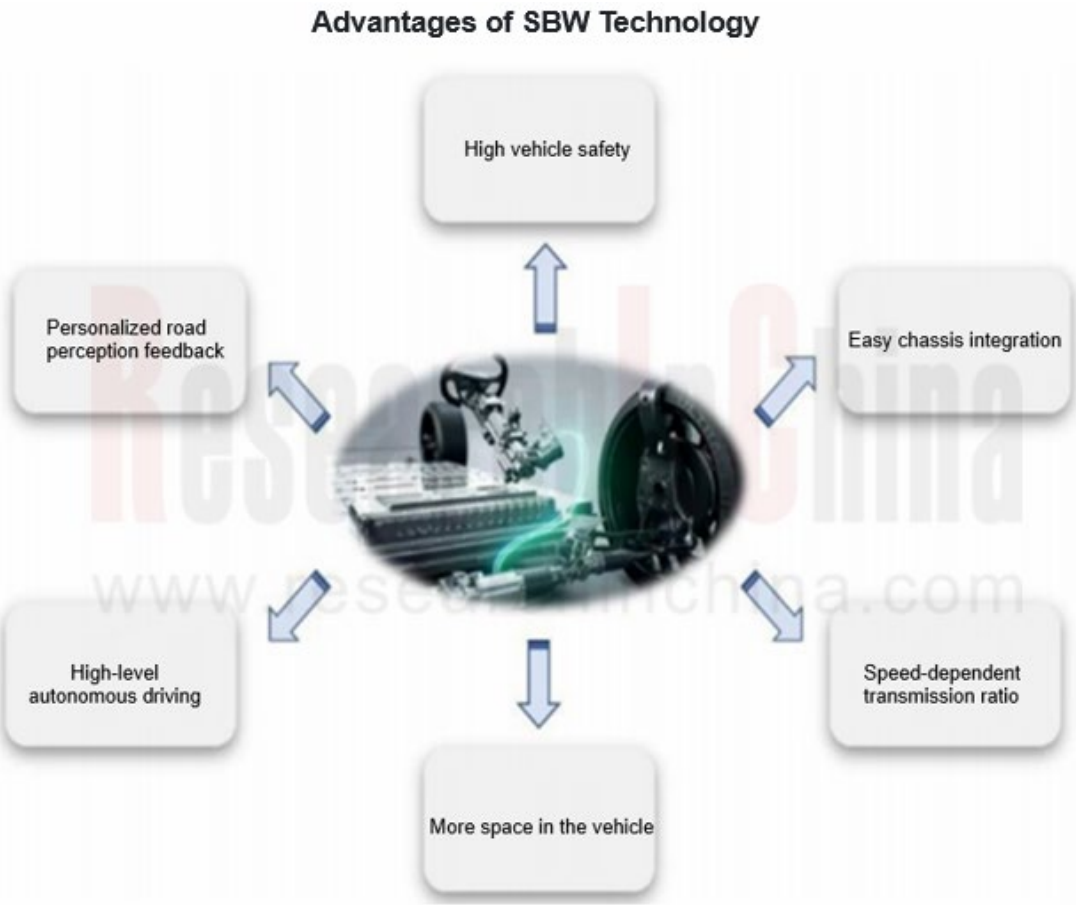
Source: Toyota

Trend 5: SBW highlights convenience

Without a steering column, SBW can prevent driver from being injured by steering column in an accident. When the driver is driving, SBW ECU can judge whether the driver's operation is reasonable according to the driving state, and make certain adjustments to improve driving stability and safety. At present, different models are equipped with different steering systems, which cannot fit all.

Due to mechanical decoupling and flexible space layout, SBW can be applied to different models, assisting the development of chassis integration and reducing the OEM production cost. The SBW system abolishes the intermediate mechanical shaft for connection in the traditional steering system, allows the ECU to handle steering actively, and keeps the steering wheel still during the steering process, which facilitates high-level intelligent driving and facilitates the driver to take over. The traditional steering system adopts mechanical connection with a fixed steering ratio, so that steering is determined by mechanical structures such as gears.

SBW has no mechanical connection, so the steering ratio can be adjusted at any time by software and the transmission ratio varies with the speed. After the steering column is removed, the space under the steering wheel becomes bigger, which makes the driver's legs have more room for movement with more freedom and convenience.



Source: GF Securities

Trend 6: The development goals and technology route of SBW systems

According to Intelligent Electric Chassis Technology Roadmap released by Wire Control Working Group of China Industry Technology Innovation Strategic Alliance for Electric Vehicle (CAEV) in 2022, the development goals of passenger car SBW are shown in the following figure:

Development Goals of SBW Technology

	2025	2030
Technology development goals	The SBW system that caters to L3+ autonomous driving should lead the world. The SBW system for autonomous driving in special scenarios should lead the world.	The SBW system that caters to L4+ autonomous driving should lead the world. The SBW system for autonomous driving in general scenarios should lead the world.
Key parts development goals	For L3+ core components (sensors, controllers, motors and reduction gears), independent design capabilities should be available and small trials should be conducted.	For L4+ core components (sensors, controllers, motors and reduction gears), independent design capabilities should be available and small trials should be conducted.
System feature goals	Autonomous driving follow-up should be equivalent to 100% traditional driving. For the manual driving mode, the user can rate the feel as 6 out of 10.	Full-speed-range autonomous driving scenario application. For the manual driving mode, the user can rate the feel as 8 out of 10.
Mass production goals	The SBW penetration rate should reach 5%. SBW system cost: less than RMB4,000.	SBW penetration rate should reach 30%.

Source: Intelligent Electric Chassis Technology Roadmap

Goals

Goals in 2025: The SBW system that caters to L3+ autonomous driving should lead the world. For L3+ core components, independent design capabilities should be available and small trials should be conducted. The SBW penetration rate should reach 5%.

Goals in 2030: The SBW system that caters to L4+ autonomous driving should lead the world. For L4+ core components, independent design capabilities should be available and small trials should be conducted. The SBW penetration rate should reach 30%.

The intelligent steering technology for passenger cars mainly follows the route:

- In 2022, SBW should vary with the speed with a variable transmission ratio.
- In 2023, functional safety should realize security network and safe development.
- In 2024, advanced functions should support highway assistance and traffic congestion assistance, and the mass production of rear wheel SBW should begin.
- In 2025, front wheel SBW should be mass-produced with dual redundant controllers (10fit) and the coordinated control of steering and braking.
- In 2028, autonomous driving should bolster self-learning, personalized software and FOTA updates.
- In 2030, intelligent chassis should feature SBW, brake-by-wire and suspension-by-wire to realize three-way coordinated control.

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