

How the software-defined vehicle trend is driving innovation in chassis features

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Steer-by-wire technology eliminates mechanical steering connection, offering benefits for manufacturers and drivers.

Steer-by-wire technology (SbW) eliminates the mechanical connection between the steering wheel and steering rack, relying solely on electronic communication. It offers numerous benefits for manufacturers and drivers, including the ability to produce a “dry” chassis without hydraulic fluid. It also

opens possibilities for semi-autonomous safety systems and alternative steering controls. The systems are fully redundant, ensuring backup functionality in case of hardware or software failures. SbW is a crucial component for autonomous vehicles, and we can expect to see more examples of it in the coming years. Its adoption in mainstream vehicles, such as the Toyota bZ4X and Lexus RZ 450e, is a sign of things to come.



Source: Getty Images/ Bim

To learn more, we spoke to Peter Holdmann, member of the board of management and head of Division Chassis Solutions, ZF.



Source: ZF

Key takeaways:

- **The automotive industry is undergoing a transformative shift with the rise of electrification, automation and software control. This has sparked the software-defined vehicle trend, embraced by industry leaders such as ZF. This trend unlocks exciting opportunities for innovative chassis features and cutting-edge vehicle motion control functions.**
- **ZF believes it is well-positioned to gain significant market share in the expanding x-by-wire chassis systems field by 2030. Initially, innovative products will be integrated into premium vehicles. However, as standardization, regulatory advancements, technological developments and the necessary vehicle infrastructure for x-by-wire systems continue to progress, ZF expects wider adoption beyond premium segments.**
- **SbW systems have the potential for various future applications. One example is the elimination of extreme driver inputs or providing support in unexpected driving situations. Semi-autonomous vehicles can use road-safety data and driver behavior to predict potentially dangerous situations and take proactive measures, such as applying optimal steering inputs to prevent loss of control.**

The following is an edited transcript of the conversation.

S&P Global Mobility: What advantages does the scalability and modularity of the SbW system offer for integration into existing and future vehicle architectures?

Peter Holdmann: ZF has developed SbW technology as a scalable and modular system, making it easy for vehicle manufacturers to adopt and take advantage of its benefits. The system meets the requirements of different markets and customers, ensuring effective integration into existing and future vehicle architectures.

In the future, a single, central high-performance computer could control the SbW system alongside other driving dynamics functions. ZF is already showcasing this concept with its cubiX software platform and the Chassis 2.0 concept. With SbW, engineers can precisely define steering characteristics using software, while the mechanical elements remain unchanged. For right-hand drive variants, only the steering wheel actuator needs to be installed on the opposite side of the cockpit.

SbW also offers advantages in terms of passive safety. By eliminating some mechanical steering components, there are fewer potential hazards for occupants in the event of an accident. This also opens up new possibilities for the installation position of the driver airbag. ZF prioritizes compliance with automotive standards and cybersecurity, ensuring that their steer-by-wire system incorporates all necessary redundancy and safety elements.

As a system that is electric, intelligent, software-based and interconnected, steer-by-wire is seen as a groundbreaking component for tomorrow's mobility. It is ready to transform the industry in multiple ways, seizing the opportunities of the future.

What are the main drivers behind the adoption of SbW systems by [original equipment manufacturers], and how does it align with the growing demand for autonomous driving capabilities?

Vehicles have undergone significant changes, becoming increasingly electrified, automated and software-controlled. This shift has led to the emergence of the software-defined vehicle trend, which is being embraced by the entire industry, including ZF. This trend opens up new possibilities for chassis features and vehicle motion control functions.

ZF's by-wire technology plays a crucial role in enabling these advancements. It allows for the integration of new safety and comfort features, as well as the realization of fully autonomous vehicle control. In the case of passenger vehicles, steer-by-wire offers unique capabilities such as retractable steering wheels for fully automated driving modes. It also enhances intelligence by providing a fully adaptable steering ratio, reducing the handwheel angle during parking or low-speed maneuvers. Furthermore, the removal of the steering column improves crash safety.

Overall, ZF believes that "by-wire" technology is the perfect fit for future electric and automated vehicles, offering enhanced capabilities and contributing to the ongoing transformation of the automotive industry.

How fast do you expect this technology to be adopted in the market?

Thanks to its comprehensive portfolio, ZF is well-positioned to gain a significant market share in the expanding x-by-wire chassis systems field. The company anticipates holding a substantial portion of the market by 2030. Initially, innovative products will be integrated into premium vehicles. However,

as standardization, regulatory advancements, technological developments and the necessary vehicle infrastructure for x-by-wire systems continue to progress, ZF expects wider adoption beyond the premium segments.

ZF has already secured significant high-volume orders for steer-by-wire systems from major original equipment manufacturers (OEMs) across global markets. Notably, one prominent global car manufacturer has successfully implemented ZF's technology on a large scale since 2023.

How does [ZF's] cubiX software technology enable the “intelligent chassis” to work with other components such as braking and SbW?

With its cubiX software, ZF is showcasing its system competence in delivering vehicle dynamics control for software-defined vehicles. The coordination of longitudinal, lateral and vertical dynamics is crucial for a pleasant driving experience, particularly in automated driving scenarios where comfort takes precedence over active driving. ZF's cubiX software plays a vital role in achieving this coordination by controlling the vehicle's dynamics through the interaction of various components such as brakes, driveline, steering, suspension and other actuators. Notably, cubiX is ZF's first software-only product and offers a significant advantage: Compatibility with multiple actuators regardless of their manufacturer or specific design. This flexibility allows OEMs to implement different models across a range without additional integration efforts, opening up interesting possibilities for new business concepts.

CubiX represents a decisive step towards the software-defined vehicle, moving away from multiple controllers for hardware components towards a centralized control unit and zoned architectures. This development takes into account the increasing complexity of automotive control software. Previously, components like dampers, brakes and rear-axle steering had their own control units that needed integration into the overall vehicle architecture. The new electrical and electronic vehicle architectures consolidate software for specific functional areas, known as domains, into a central control unit. With cubiX, ZF offers software that seamlessly integrates into the future vehicle's new electrical/electronic (E/E) architectures. CubiX is already being used in the Lotus Eletre, demonstrating its practical implementation.

What is the difference between true SbW and previous versions that had a mechanical redundancy?

In true SbW systems, there is no mechanical link between the steering wheel and the road wheels. Instead, the steering command is transmitted purely electrically. The requirements for redundancy in terms of electronics and power supply are higher to ensure continued operation in case of a subsystem failure.

What possibilities does SbW open up for semi-autonomous safety systems like accident avoidance?

Various future application examples are conceivable. For example: SbW-systems could eliminate a driver's extreme inputs or support when faced with unexpected driving situations. In addition, semi-autonomous vehicles will be able to predict potentially dangerous driving situations based on road-safety data and driver biological behaviors, and prepare accordingly, such as applying the best possible steering inputs to reduce the chance of a loss of control.

How does the tuning of an SbW system allow for different driving modes and adaptability to different driving conditions?

SbW is positioned as the steering system of the future, enabling higher levels of automation. In autopilot mode, it allows the driver to be completely hands-off. SbW enhances the driving experience for both manual and assisted driving, making it more enjoyable and engaging. Additionally, it provides OEMs with the ability to offer a range of comfortable and safer steering feel options. With SbW, it is now possible to customize the steering experience, from sporty and direct to comfortable and relaxed, all within the same vehicle.

The system can adapt the steering wheel movement based on the driving situation. For example, during parking or at low city speeds, the wheels' angle will change significantly for a change of direction, while at higher speeds such as on a highway, the angle will be slight. SbW also enhances driving safety in conjunction with other assistance systems. It effectively stabilizes the vehicle in emergency situations and compensates for excessive steering inputs by the driver. For instance, when the rear of the car loses traction, drivers tend to oversteer. SbW directly compensates for this at the wheels, independent of the actual movement of the steering wheel. This allows for greater customization of the interventions felt through the steering wheel from assistance systems.

In summary, SbW presents opportunities for designers and engineers to create a safer, more engaging and tailored dynamic experience that can be fine-tuned to align with any brand's characteristics.

S&P Global Mobility's "[The new strengths of steer-by-wire](#)" report examines the benefits and advancements of this technology in the automotive industry. It emphasizes scalability and integration into modern vehicles, outlining advantages and challenges. Reliable suppliers play a crucial role in successful implementation, and a comprehensive supplier analysis uncovers potential opportunities and obstacles during SbW adoption.

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