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# AUTOMOTIVE BRAKING SYSTEMS EUROPE 2023

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# A DEEP DIVE INTO BRAKE-BY-WIRE SYSTEMS


INTERVIEW WITH:

## TONI FRENZEL, PROJECT DIRECTOR NEW BRAKING SYSTEMS

BOSCH

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**Toni Frenzel**

Part of:

AUTOMOTIVE CHASSIS SYSTEMS 2023

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**In this exclusive interview, Automotive IQ learns more on brake-by-wire technology from Toni Frenzel, the Project Director for New Braking Systems at Bosch. As we navigate the shifting landscape of automotive innovation, Toni provides valuable insights into the adoption curve, benefits, challenges, and safety considerations surrounding brake-by-wire systems. With a wealth of expertise in this field, Toni sheds light on the technical intricacies and regulatory aspects that are shaping the future of braking technology.**

**This Interview Focuses on:**

- What's driving the transition to brake-by-wire
- Brake-by-wire safety
- Developments in brake-by-wire system architecture

**Toni will be at the Automotive Braking Systems Europe 2023 conference, taking part in a panel discussion, as well as presenting.**

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AGENDA

**MULTI-STAKEHOLDER PANEL: EXPLORE WHAT'S DRIVING THE TRANSITION TO BRAKE-BY-WIRE**

**PRESENTATION - EXPLORE DEVELOPMENTS IN BRAKE-BY-WIRE SYSTEM ARCHITECTURE**

## Explore What's Driving the Transition to Brake-By-Wire

**Q: Could you provide insights into the current state of the adoption curve for brake-by-wire systems within the braking industry? How far along are we in this transition?**

**Toni**
The introduction of brake-by-wire as well as steer-by-wire is intensively discussed within the automotive industry. We perceive an increasing market interest and expect the introduction of first systems in this decade.

In brake-by-wire systems, there is no mechanic or hydraulic connection between the brake pedal and the brake actuation. This means that only electrical connection is available, even in the event of a failure. The technical challenge for by-wire systems is to provide state-of-the-art performance and functional safety, even in the event of a system failure. Therefore, an alignment on legislation and homologation as well as the technical requirements is needed.

**Q: What, in your view, is the primary added value that brake-by-wire systems bring to customers compared to traditional braking systems?**

**Toni**
Brake-by-wire offers strong advantages to the OEM. As there is no mechanical interface between the brake pedal and the brake actuation, the actuation can be placed freely and the OEM gains interior and exterior design flexibility. Variants (e.g., LHD, RHD) are reduced and the vehicle production is simplified. Furthermore, crash safety is improved.

For the end-customer, brake-by-wire offers completely new possibilities in HMI (human-machine interface) design beyond a classical brake pedal. Furthermore, by-wire systems support automated driving.

We need to distinguish between wet and dry brake-by-wire systems. Wet systems use hydraulic fluid for the transmission of the brake force from the brake actuationto the wheel brakes. All mentioned brake-by-wire benefits can be realised with this technology. The Bosch approach for wet brake-by-wire is based on well-known technology: a by-wire-actuator (BWA) is combined with a conventional ESP®.

In contrast, dry brake-by-wire systems, such as the electromechanical brake (EMB), introduce new technology: one actuator per wheel directly builds and transmits mechanical brake force.

The EMB provides the additional benefit of not requiring brake fluid, which simplifies both vehicle production and service: no brake pipes need to be mounted, the brake fluid filling process is avoided, and the vehicle owner saves the service cost of brake fluid exchange.

**Q: As we explore the advantages and disadvantages of brake-by-wire technology, could you highlight a few key benefits that stand out, as well as potential challenges that manufacturers need to address?**

**Toni**
As mentioned before, the key benefits of brake-by-wire for the OEM are cost savings by complexity reduction in production. This outweighs the higher price of by-wire technology.

A key challenge of brake-by-wire (as well as of steer-by-wire) for the OEM is the required invest into a highly reliable power net: a robust back-up must be ensured in case of a power net failures, and the complete system needs to be validated and homologated.

Additional challenges lie in the backup performance which needs to be acceptable for the end user. Bosch's view is that the availability must be comparable to today's hydraulic brake systems, and a minimum deceleration of 6.43 m/s² must be achieved in case of a single failure event.

**Q: Given the evolving landscape of automotive legislation, are there any potential regulatory changes or mandates that could significantly impact the rollout of brake-by-wire systems? How is the industry preparing for such possibilities?**

**Toni**
The regulatory organisations are currently aligning legislation of steering (ECE R79) and braking systems (ECE R13 H) towards future by-wire systems. The automotive industry and the homologation organisations are involved in this process.

## Brake-by-Wire Safety

**Q: When it comes to ensuring safety in brake-by-wire systems, what level of redundancy is being deemed necessary to meet safety requirements effectively? How are these redundancy levels being achieved in practice?**

**Toni**
Firstly, the system must be robust against common cause failures. Bosch's approach in a hydraulic brake-by-wire system is the combination of two independent actuators (BWA and ESP®) with a redundant power supply. For EMB systems, also the central control unit needs to be redundant.

Secondly, a functional backup is required for each single electrical failure, which ensures a deceleration of at least 6.43 m/s². A hydraulic brake-by-wire system with two independent actuators, both acting on all 4 wheels, fulfils this requirement. In EMB systems, at least 3 wheels are needed for this deceleration, which results in additional effort on the power net.

## Explore Developments in Brake-By-Wire System Architecture

**Q: Different brake-by-wire architectures come with their own set of advantages and disadvantages. From your perspective, how do these architectural choices impact functionality, performance, efficiency, and overall cost?**

**Toni**
Bosch distinguishes between centralised and decentralised brake-by-wire architectures. Centralised means brake force is built centrally in one actuator unit for all four wheels, decentralised means brake force is built by one actuator per wheel.

For centralised brake-by-wire, Bosch sees clear advantages in a 2-actuator system based on proven technology (BWA + ESP®). We believe it to be the best brake-by-wire concept with regards to robustness and cost/benefit-ratio.

A dry EMB system as a decentralised brake-by-wire architecture with four electromechanical wheel actuators provides additional benefits in vehicle production and service, but at a significantly higher cost.

A bridge technology based on a hydraulic actuator (with mechanical backup) on the front axle and EMB on the rear axle doesn´t realise all by-wire benefits, but adds complexity and cost to the brake system, making it questionable if this wet/dry approach will gain a sustainable market presence.

**Q: As autonomy levels in vehicles continue to increase, how is the actuation system architecture within brake-by-wire evolving to accommodate these higher levels of vehicle autonomy? Are there any notable trends in this area?**

**Toni**
As brake-by-wire systems need to be redundant and common cause-failure free, they already fulfil the main requirements of automated driving level 3 and higher. Both use cases require the same system components as enablers, e.g., a redundant power net or new by-wire HMI, so there are technical and commercial synergies. An increasing take rate of automated driving functions supports by-wire introduction and vice-versa.

**Q: Can you outline the pros and cons of both 48-volt and a 12-volt power supply for brake-by-wire systems and explain how these choices are being navigated within the industry?**

**Toni**
There is a growing interest to be ready for 48V, but brake-by-wire itself doesn't need 48V as enabler. The advantage of lower currents with 48V comes with higher component cost. The total cost of ownership must be considered on vehicle level.