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“With 1000 parameters for steering feel, we can really make the difference”

The steering system is one of the chassis components that will play a key role in making highly automated driving a reality. But how can a redundant design be implemented in the same amount of space and with the same package? In the ATZ interview, Alexander Gaedke, Head of System and Advance Development at Bosch Automotive Steering, answers this question and also discusses whether a brake system can replace the steering and why the concept of steer-by-wire has always failed in the past.

ATZ _ Alexander Gaedke, the electromechanical steering gear is one of the key elements on the route towards fully autonomous driving. Has the same amount of progress been made with other control functions?

GAEDKE _ At Bosch we have extensive expertise in the field of autonomous driving. Many of the components required for the introduction of highly

automated driving are to a large extent already available, for example the steering and braking systems.

Was the steering the last of these components?

No, everything has been developed to the same level. In the case of brakes, we have an in-house solution. We can com-

bine iBooster, our electromechanical braking power booster, with our ESP system to provide the necessary redundancy. In the unlikely event that one of the two components fails, the other can bring the car to a standstill without the driver having to intervene. The steering is a very special case, but we are developing a redundant system.

Alexander Gaedke (born in 1978) has been Head of the System and Advance Development division at Robert Bosch Automotive Steering GmbH since 2015. In this role, he is responsible for the system and advance development, CAE development, development data management and patent departments based in the town of Schwäbisch Gmünd in southern Germany. Gaedke has a degree in electrical engineering from Fulda University of Applied Sciences. He began his career in 2001 at ThyssenKrupp Automotive Mechatronics GmbH in Munich as a Developer and Project Leader for Chassis Control Systems in the Hardware and Software Development department. In 2006 he moved to ZF Lenksysteme GmbH, which was then a fifty-fifty joint venture (now Robert Bosch Automotive Steering GmbH), as Head of Advance Development in Schwäbisch Gmünd. He was promoted in 2011 to the position of Head of Corporate Research and Development.



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At the North American International Auto Show in Detroit in January 2017, you presented a redundant steering system of this kind for cars which is fail-safe. Doesn't 100 % safe mean having a second steering system in the car?

At Bosch, the correct wording is not fail-safe, but fail-operational. This means that the system can still function in the event of a first failure. But you are right that we will never be able to fit two steering systems into one car. The situation is different in aircraft because they have several ailerons and one rudder that allow them to fly in a curve. If one of the ailerons is faulty, the pilot can compensate for the failure by using a different one. That's not possible in a car. This is why we have developed a concept that enables cars to have just one steering system. We have looked very closely at the functional safety requirements of ISO 26262 and developed a redundant steering system on this basis that has the same package and takes up the same amount of space. This electromechanical steering gear, known as electric power steering or EPS, has largely been made possible by the high integration density of the electronics.

How does this new steering system from Bosch provide redundancy?

In contrast to previous systems, it is now essential that the interfaces to the steering system are clearly defined from a safety perspective. In the past, the

safety requirements in this area were very limited. This situation will change significantly in future, because we need a redundant energy supply and also redundant communications. We worked closely with our customers to coordinate a standard for those interfaces. It was important for us to understand what the steering system must be able to do when a first failure occurs. How much of the steering function is really still needed? Vehicle tests have been carried out to determine how much power is required

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from the steering system to enable the driver or the autopilot to control the vehicle. It became clear that roughly 50 % of the maximum steering power is more than adequate on the motorway. The higher the speed, the smaller the steering forces that are needed. In order to provide the necessary power in the case of a first failure, we have developed new redundancy concepts for the motor and the control electronics, but the software also plays a key role in the creation of a redundant system.

You mentioned working with manufacturers to put a standard in place. Is it a formal

standard or a guideline issued by the German Association of the Automotive Industry (VDA)?

No, it's not either of those things. With regard to the work with the manufacturers, it is important to say that of course they also had an interest in standardising things as much as possible and not developing individual solutions, ultimately because the interfaces to the steering system are not the car's unique selling point. Safety is the essential issue and the models can be differentiated from one another by means of the software functionality.

What emergency strategies do you have for situations when the driver does not take back responsibility for driving?

Our highly automated test vehicles ask the driver in reasonable time to take over at the steering wheel. If the driver does not respond to the request, for whatever reason, the car must automatically put itself in a safe situation. This means that the car is simply brought to a standstill safely in its lane. However, no one would want this to happen in the fast lane of the motorway at 130 km/h. In this case the car must move automatically and independently onto the hard shoulder and park there. It is use cases of precisely this kind that led us to decide that we needed a redundant steering system.

Instead of using a traditional steering manoeuvre, you could rely on the brake system to apply different braking forces to the wheels on each side of the car.



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If an aileron or a rudder is faulty, the pilot can compensate for the failure by using a different one. That's not possible in a car. This is why Bosch has developed a concept that enables cars to have just one steering system, as Alexander Gaedke (left) explains in conversation with Michael Reichenbach, Deputy Editor in Chief of ATZ

Initially we did consider doing this. We thought about how we could ensure the lateral guidance of the vehicle in a different way, but the brake system will not be able to guide the car across the motorway. Unfortunately, the brakes do not function as dynamically or as precisely as the steering in this situation, which means that we can't use this method for all use cases.

The chassis.tech plus conference in June will look in detail at the subject of modelling car steering systems. How do you achieve the right balance between computers, test rigs and test tracks?

The main consideration for end customers is the steering feel, which is a key part of the DNA of our customers, who are the manufacturers. This is a highly subjective issue and it has been the subject of many PhD dissertations and technical presentations. Of course at Bosch we are also working on objectifying the steering feel. We can use up to 1000 parameters to generate the steering feel

when we set up a steering system. Around 200 to 300 of these have an important influence on the end result. But when it comes to fine-tuning, we can really make the difference by using all 1000 parameters. In future the development process will need to be speeded up even more and this will only be possible with the help of virtualisation. Simulations will allow us to achieve the steering feel that the manufacturer wants more quickly. It is good that virtualisation can also be used for the safety approval process.

The homologation process for the ESP also takes place in virtual form. Is that the case with steering systems?

Not yet. The final approval always takes place in the car on the test track. However, in future this will become increasingly difficult because platforms will be more widely used and there will be larger numbers of variants. It will no longer be possible to test all the steering functions manually in the vehicle.

What future trends have you identified in the world of steering?

As I've already mentioned, one important trend that affects us is highly automated driving. When cars can drive themselves, we will be able to watch the steering wheel moving independently, because there will still be a rigid mechanical connection between the steering wheel and the steering gear. The steering gear down below will do the work and the steering wheel at the top will react as a spring mass system. As a result, the movements of the wheel may look very jerky. On the motorway that will be acceptable, because the steering angles are very small. But when the car is driving in urban situations, the wheel will make abrupt and dramatic movements. For this reason, we believe that the steering system needs to be separated from the steering wheel. This is where steer-by-wire comes in. This type of system has been permitted since 2005 under the terms of ECE Regulation No 79.

What form does your steer-by-wire solution take?

We are working towards completely removing the mechanical connection between the feedback unit at the top, in other words, the steering wheel unit, which includes an independent actuator to generate steering feel, and the steering gear at the bottom. The necessary technology is already available in the context of highly automated driving. In the past, steer-by-wire systems have always failed, because the cost of the redundant electrical systems needed for steering and communication was too high. However, with the introduction of highly automated driving, these electrical systems will now be available. Our fail-operational steering already meets the functional safety requirements to a large extent and can be considered to be a steer-by-wire system. This technology is highly interesting and will become more widespread over the next decade.

“Steer-by-wire will become more widespread in the next decade”

Does this mean that Bosch will be making steering wheels in future?

No. At Bosch Automotive Steering, our work takes place between the steering wheel and the vehicle’s wheels. We focus on the steering column and the intermediate steering shaft and steering gear. Nevertheless we are already working on alternatives to the steering wheel. It may be that we won’t need steering wheels at all in future. When driverless cars are introduced (SAE level 5), the vehicle occupants may want to use the space that can be freed up for a tablet or a similar device.

Alexander Gaedke, thank you for this interesting discussion.

You can read more of the interview in German on the ATZ online portal at www.springerprofessional.de.

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