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“We soon found that we had a lot in common from a technical perspective”

The steering system is one of the most important safety components of the chassis. The ability to steer the front and rear wheels at the same time can make cars safer and also improve the ride. ATZ spoke to Dr. Christoph Elbers and Dr. Dirk Kesselgruber from ZF and ZF TRW about the benefits of their all-wheel steering system, working together after TRW became part of ZF and why it should now be possible to achieve market penetration.

Dr.-Ing. Christoph Elbers (born in 1968) has been Head of Preliminary Development and Driving Dynamics in the ZF Car Chassis division since October 2009. In this role he is responsible for axle systems, chassis components, damping modules, mechatronic systems and lightweight plastic structures. Alongside his existing position, he was also appointed interim Head of Development in the Car Chassis division in May 2015. Elbers has a degree in mechanical engineering and manufacturing from RWTH Aachen University. The subject of his doctoral thesis was the mathematical representation of kinematics and elastokinematics from test bench measurements for the simulation of driving dynamics.

Dr.-Ing. Dirk Kesselgruber (born in 1973) is Senior Vice President Global Steering Engineering at ZF TRW since June 2013. His responsibilities include global product and application development in the field of steering systems. Before moving to his current post, he held various management positions in production development, programme management and quality assurance, in particular in the product sectors of steering, suspension and braking systems. Kesselgruber completed a graduate diploma in mechanical engineering at the Technical University of Duisburg, specialising in control system technology, and completed his doctoral dissertation on control systems for passenger cars brake systems.

ATZ _ Christoph Elbers, Dirk Kesselgruber, you have installed a prototype all-wheel steering system in a compact car. The system consists of electric power-assisted steering at the front of the car and active rear axle kinematics. Which was the bigger challenge when it came to linking the two functions? The technical implementation or getting ZF and ZF TRW to work together?

KESSELGRUBER _ During the project to develop this test vehicle, we didn't encounter any problems caused by the fact that we were formerly competitors. We soon found that we had a lot in common from a technical perspective. There were operational issues involving the sites in Düsseldorf and Dielingen, such as who would be given the steering prototype first and who would be allowed to fine-tune the car and when. We had also had practice with the ZF Advanced Urban Vehicle which we worked on together for the Frankfurt Motor Show (IAA) in 2015.

ELBERS _ Engineers generally get on well with one another. The pilot project for the IAA brought us together on the mechanical side and most importantly in relation to the functional and software integration aspects. This meant that we were able to pick the right teams for these prototypes.

"Improving functions for the end customers is the key issue for us"

KESSELGRUBER _ We are also running this project in other parts of the world. Similar activities are taking place on the other side of the Atlantic where the Washington site is working closely with the Northville site.

How do the two axles interact in the prototype in technical terms?

KESSELGRUBER _ As things currently stand, the basic architecture involves one control unit for each axle. A joint driving dynamics algorithm is used to operate my front axle and Christoph Elbers' rear axle as required. In the test vehicle in the USA, they are already using integrated control units with shared electronics. On the one hand, the units can control the topology centrally when they need more processing power or set up a master and slave system. On the other hand, they can take the form of an operating system at a vehicle level, where the control unit no longer knows which hardware it is running on. That is a question of how the mainstream in electronics will develop.

ELBERS _ We have been successful in terms of both comfort and stability. If the rear axle steers in the opposite direction to the front axle, this reduces the car's turning circle by more than 1 m, depending on the axle architecture. This makes the car more agile and manoeuvrable. At speeds above 60 km/h, the two axles steer together into corners, which gives the car greater stability. This means that at higher speeds the wheelbase is made longer in virtual terms as a result of the rear axle kinematics, which has a positive effect on active safety. Improving functions for the end customers and doing things that they would really notice were the key issues for us, in terms of comfort, safety and dynamics.

KESSELGRUBER _ Using a touch screen the driver of the prototype can set the parameters and get to know the bandwidth available for a car of this kind. Depending on the driving situation, the objectives are quite different. So the interaction between the front and rear steering systems will always vary in relation to the car's situation.

A lot of companies have produced all-wheel steering systems in recent decades. Some of them appeared on the market and disappeared again very quickly. Why do you think that your system will achieve long-term market penetration?

ELBERS _ In the past, these systems were hydraulic and were adjusted to give a fixed ratio between sportiness and comfort. That was not a constructive solution and was not successful on the market. The systems were not able to react together to individual actions. Now the use of electronics allows us to control the systems in relation to the situation. Our system is also modular, which means that it can be adapted relatively easily to different types and classes of car. By making changes to the software we can design individual systems which will give the car a digital fingerprint.

KESSELGRUBER _ Back then the obstacles involved in introducing a new control system into a car were much greater. Only small numbers of systems were produced, in particular from the perspective of electronics, but a huge amount of development work was involved. But nowadays cars in Europe and in the USA have many standard electronic systems such as electric steering, which we can build on. This leads to a rapid reduction in costs. We are already developing concept cars with identical electronic systems for the front

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"Our all-wheel steering system can reduce a car's turning circle by more than a metre." – Christoph Elbers (left) and Dirk Kesselgruber (right) in conversation with Michael Reichenbach

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Elbers explains that the systems are modular and networked together, which means that less work is involved for OEMs in defining the interface

and rear axles, particularly now that ZF and ZF TRW are working together with the same modules.

ELBERS _ Our systems are modular and networked together. This means that less work is involved for car manufacturers in defining the interface. Our aim is to have no restrictions. Some OEMs won't want to buy a complete chassis from us and they don't have to. But all our products always fit together. As well as managing the systems engineering, we are always in a position to take a detailed approach to each subsystem and to integrate them in order to create a complete system.

How do you ensure that the system functions safely and reliably?

ELBERS _ We can divide the chassis very neatly into safety and comfort systems on the basis of the Asil classification. The brakes and our two steering systems, Servotronic and EPAS, are in the Asil D category because they have a high level of safety relevance, while the (semi-) active damper chassis is a comfort feature belonging in the Asil B or even the QM category. Both play an equally important role in the driving experience, but the development objectives are different.

What happened to the steer-by-wire systems that we heard a lot about at the start of the millennium?

KESSELGRUBER _ The reliability requirements placed on our products by autonomous driving are currently the main focus of development activities. I think that by 2023, in other words in seven years, every steering system for premium cars that comes off the production line will be steer-by-wire compatible. Regardless of what the OEMs do with this capability, whether or not they dispense with the steering wheel, and regardless of what the law allows, the steering systems of the future will be able to steer by wire. If steering actuators can no longer fail, we can take a more creative approach to designing the interior of cars. We have developed a number of new ideas in this area, such as folding steering wheels, new human-machine interfaces and the cockpit of the future, which we presented at the Consumer Electronics Show (CES) in January 2016. Whatever happens, we're prepared for it.

The focus of many of the presentations at chassis.tech on 14 and 15 June will be on fully autonomous driving. Is your all-wheel steering system ready for this?

ELBERS _ We need to network the individual functions of our system and enable them to act together, so that we can control them in terms of longitudinal, lateral and vertical dynamics and even ensure that they reach the optimum operating point. By networking the Active Kinematics Control (AKC) system with control systems such as ABS and EBC, we

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We are already developing concept cars with identical electronic systems for the front and rear axles, says Kesselgruber

can improve safety and have a stabilising effect on the car, for example in µ-split braking manoeuvres. By linking the two steering systems, we can improve safety on slippery surfaces, to prevent the car from skidding during lane changes or overtaking. Networking the systems for future partially or fully autonomous vehicles gives our prototype the potential to perform automated steering manoeuvres.

"The interaction between the front and rear axle will always vary in relation to the car's situation"

Which things are necessary and important for this?
The ongoing development of the radar, camera and/or lidar systems used to recognise the car's environment is important in this respect, because it will allow an environment model to be created that we urgently need in order to develop preview functions for our assistance systems and also for highly autonomous driving. Communication between vehicles, in other words car-to-car and car-to-infrastructure functions, also offers further potential. The virtual preview is generated from information provided by the vehicle ahead and the result is a sort of swarm intelligence among the communicating vehicles.

Christoph Elbers, Dirk Kesselgruber, thank you very much for this interesting interview.

Read more of the interview, in German language, it is available at www.springerprofessional.de, the online portal of ATZ.

INTERVIEW: Michael Reichenbach