SMART TECHNOLOGY
FOR A MORE MOBILE TOMORROW

Agile, efficient, interconnected: ZF's Advanced Urban Vehicle concept car demonstrates the enormous potential of smart interaction between chassis, driveline and driver assistance systems.
Regenerative braking

The electric motors in hybrid and all-electric drivelines are also capable of braking. Because this puts them into generator mode, they even produce electricity, which is fed back into the battery. For more vigorous braking maneuvers, foundation brakes are also needed. This complex interaction requires optimized “brake blending” – now available from a single source: ZF.

8-SPEED PLUG-IN HYBRID TRANSMISSION

The basic 8HP transmission is fitted with a powerful electric motor with a peak output of 90 kilowatts. Depending on the battery system installed, ZF’s 8-speed plug-in hybrid transmission enables cars to drive at around 75 mph for distances of up to 30 miles, powered entirely by electricity.

9HP

Small gear steps with a broad spread of ratios: the 9-speed automatic transmission significantly improves the fuel consumption of vehicles with front transverse engines by ensuring that their engines always run in the most economical speed range.

LIGHTWEIGHT DESIGN

The less a car weighs, the better for all kinds of things, including fuel consumption, range and handling. ZF’s lightweight design strategy combines all the most promising lightweight engineering approaches.

TOURQUE CONVERTERS

ZF’s next-generation torque converters are true all-rounders, capable of transferring tractive force very efficiently while simultaneously smoothing out all kinds of rotational irregularities from the engine. Consequently even modern, downsized 2-cylinder and 3-cylinder engines run very quietly.

ELECTRIC AXLE DRIVE

The electric drive module is positioned in the center of the axle. The electric motor, single-speed transmission plus differential, housing and cooling system, as well as the power electronics and control software, form a single, compact, tightly integrated unit. Due to the high-speed design – the drive is capable of running at up to 21,000 revolutions per minute – the unit is capable of producing up to 115 kilowatts.

INTEGRATED BRAKE CONTROL

Unlike existing systems, the fully Integrated Brake Control (IBC) system is vacuum-independent, reducing the complexity of hybrid and all-electric cars in particular. At the same time, IBC is more effective, more compact, lighter and more powerful than conventional braking systems – and even has its own built-in electronic stability control.

ELECTRIC TWIST BEAM

Axle and drive combined: two electric motors built into the rear axle next to the wheels, each capable of producing 40 kilowatts, deliver plenty of power for driving all-electric subcompacts.

POWER ELECTRONICS

The performance of an electric driveline can only be fully optimized if the hardware is supported by precision-tuned power electronics. ZF inverters help ensure that not a single ampere is wasted.

Predictive damping

Active systems make cars safer. ZF offers such systems – and takes them a step further. When networked together and supplied with information on the vehicle’s surroundings, they become even more powerful. Because then the vehicle’s active damping, steering and roll stabilization systems are capable of anticipating the challenging test of driving skills waiting just around the next bend...

ACTIVE SEATBELTS

The second-generation Active Control Retractor 2 (ACR2) is often used together with the Active Buckle Lifter (ABL). The two systems enhance occupant safety by pretensioning seatbelts in anticipation of potentially hazardous situations or prior to automatically triggered braking maneuvers – but also during dynamic driving maneuvers, or if there is too much slack in the seating position.

CENTER AIRBAG

Almost 30 percent of severe injuries in side-impact collisions happen to occupants on the far side of the vehicle. In order to provide significant protection potential for this challenging crash mode, ZF TRW developed the center airbag that positions itself between driver and passenger during side-impact collisions.

Following the integration of TRW, ZF has the broadest product portfolio of any automotive supplier in the world. Now the company can offer these technologies and solutions as a full-spectrum response to the three major mobility megatrends.
“The integration of TRW into the ZF Group is guided by a clear vision: as one of the world’s leading technology companies, we want to supply the global automotive industry with complete system solutions for the megatrends of the future.”

Dr. Stefan Sommer, ZF CEO*

* You can read the full interview with Dr. Stefan Sommer starting on page 38.
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Race fever in Friedrichshafen! In June, 500 Formula Student competitors gathered at the Friedrichshafen Exhibition Center. ZF sponsors a total of 36 student teams around the world. At ZF Race Camp, students taking part in the race series work together with ZF engineers and alumni. It’s a fantastic opportunity to discuss, for example, the specific challenges involved in racing electric vehicles – more than half of the student-built racing cars are e-racers. For ZF, these committed students are ideal candidates for recruitment, and Race Camp is the perfect platform for meeting them in person.

**Tomorrow’s engineers**

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IN RALLIES AND CITY TRAFFIC

From racing trucks and coaches to racing bikes and plug-in hybrids as efficient as they are dynamic: These vehicles with ZF technology are new on the market.

MAN Lion’s Intercity

6-speed manual transmission or EcoLife automatic transmission with TopoDyn Life Damper technology
Camera and radar system

The new MAN Lion’s Intercity is equipped with the latest drive technology. The fine-staged 6-speed EcoLife automatic transmission is thus able to provide its user with better performance and high cost-effectiveness. The topography-dependent TopoDyn transmission control unit ensures clear saving effects particularly on routes with varied profiles.

Mercedes AMG GT

CDC adaptive damping system
Lightweight vibration dampers
Chassis components

The CDC adaptive damping system adapts the chassis damping continuously and in real time to the current driving situation – smoothly, precisely, and for each individual wheel. Thus, the CDC resolves the conflict of aims between comfortable-soft and dynamic-firm chassis tuning.

Honda CR-V

9-speed automatic transmission
Vibration dampers
Electronic safety systems

Thanks to the high spacing of the 9-speed automatic transmission, the engine always operates in the ideal speed range. The nine drive positions ensure small gear steps and a high level of driving comfort. The 9HP thus guarantees high energy efficiency, cuts fuel consumption, and thereby also CO2 emissions.

BMW X5 xDrive40e

8-speed plug-in hybrid transmission
CDC adaptive damping system
Chassis components
Electronic components
Braking
Airbags

ZF’s plug-in hybrid transmission is based on the advanced 8-speed automatic transmission (8HP) which replaces the torque converter in its housing with an electric motor – and virtually without taking up any additional installation space. The motor’s 83-kilowatt output and 250 newton meters of torque are sufficient to achieve electrically powered speeds of up to 76 mph.

Kamaz Master Truck

VG 2000 transfer case
16-speed ZF Ecosplit manual transmission
ZF clutch system

The VG 2000 transfer case is characterized by high reliability and optimal power distribution. The unit gave an impressive demonstration of its strengths at this year’s Dakar Rally, with Kamaz Master Trucks claiming first, second and third positions in the overall rankings.

MV Agusta Turismo Veloce Lusso

CDC adaptive damping system on the front fork/telescopic fork as well as on the rear fork

The CDC adaptive damping system ensures better road contact for motorcycles. This increases safety particularly when braking, accelerating and banking. The damping system also adapts to varying weight conditions, for example, when riding pillion.
ZF Completes Acquisition of TRW

With the purchase, the company further strengthens its expertise in safety and automated driving.

U.S. supplier TRW Automotive is now part of the ZF Group. As ZF’s new Active & Passive Safety Technology division, the specialist manufacturer of driver-assist and occupant safety systems has expanded ZF’s portfolio to cover some exceptionally promising areas of business. “We’re combining the strengths of ZF and TRW to form a world-leading supplier of system solutions to the automotive industry,” explained ZF CEO Dr. Stefan Sommer as the transaction was closed on May 15, 2015. “The combined company is a powerhouse in the fields of automotive technology, driver assistance and occupant safety systems, powertrain and chassis technology, and braking and steering systems,” underlined John C. Plant, the current CEO of ZF TRW. The acquisition has created one of the world’s largest automotive suppliers, with a workforce currently numbering 134,000 employees and combined sales in excess of 30 billion euros.

Engineering Center expanded

Following a 12-month construction project, ZF has opened the extended Engineering Center in Pilsen in the Czech Republic (photo). The facility covers nearly 76,000 square feet and houses a prototype unit and a unit for manufacturing jigs and fixtures, as well as laboratories and test benches. The main focus of the new Center’s work will be on software development and testing, and on developing and qualifying mechatronic components. Due to Pilsen’s strong rapid prototyping capabilities, ZF has installed the company’s first 3-D metal printer in the Engineering Center. Among other things, it will be used to produce functional prototypes.

Software team reinforces expertise

In July, ZF acquired a team of around 50 developers from HDLE GmbH in Amtzell, Baden-Württemberg (Germany). With the acquisition, ZF is bringing additional technical expertise in driver-assist systems on board, further strengthening the company’s ability to produce semi-automated driving applications in the future. The HDLE software development team will be integrated into the Corporate Research & Development Center at ZF’s head office in Friedrichshafen. Together with the developers, the technology company also acquired several test vehicles, as well as the results of development work to date. At ZF, the new team will focus, among other things, on surround-view technology that uses cameras to transfer a 360-degree view of the vehicle’s surroundings to a dashboard display.

Ideal opportunities

“ZF offers ideal opportunities for engineering and science students,” confirmed Renate Luftmann, Managing Director of FEMTEC. The career platform supports aspiring women engineers and scientists specializing in MINT subjects (mathematics, informatics, natural sciences and technology). This is why ZF and FEMTEC have entered into a cooperation agreement. “Supporting talented young women is really important to ZF,” confirmed Jürgen Holeksa, ZF’s Corporate HR Director.

22.8 percent energy savings were achieved by ZF between 2012 and the end of 2014. In a project lasting several years, the company took a good, hard look at all offices and production facilities, searching for ways to enhance energy efficiency. The final result actually exceeded the target of 20 percent.

New acquisition

Building big transmissions

ZF is acquiring the industrial transmission business of Bosch Rexroth AG, together with more than 1,200 employees. This represents the company’s first step into the market for industrial transmissions as used in, for example, oil-drilling platforms, mining vehicles, tunnel boring machines (photo) and cable-car systems. “Strengthening the non-automotive segment is one of the key objectives of our long-term corporate strategy,” emphasized ZF CEO Dr. Stefan Sommer.

S-Cam4 by ZF TRW

First production order

A major European automotive manufacturer has placed the first order for ZF TRW’s latest generation of cameras, the S-Cam4 family. The camera family comprises two systems, the S-Cam4 and the Tri-Cam4. The S-Cam4 mono-camera system was developed especially for pedestrian-triggered automatic emergency braking (AEB) applications. The premium Tri-Cam4 also features a telephoto lens and a fisheye lens for long and short-range applications respectively, the combination is ideal for semi-automated driving functions. The two cameras’ respective fields of vision are illustrated above: the Tri-Cam4 on the left, the S-Cam4 on the right.
TOTTALLY RELAXED AT 75 MPH

ZF’s Highway Driving Assist system supports semi-automated driving. A novel driving experience on the autobahn near Düsseldorf in Germany.

By Joachim Becker
Photos: Mareike Foecking

B lack paintwork gleams in the sunlight: a sporty-looking station wagon is parked in the yard of ZF’s Düsseldorf plant. From the outside, the car looks identical to a standard production model. But hidden beneath the skin are sophisticated systems representing an extra 2,500 hours of work. Only when you flip open the tailgate and lift the floor of the trunk does the car reveal its secret. It’s an experimental vehicle. The space normally reserved for the spare tire holds a neatly wired computer network with enough processing power to teach a computer on wheels how to recognize its surroundings.
In the open-plan office above the ZF TRW workshops in Düsseldorf, robotics experts rub shoulders with physicists and IT wizards. All of these team members were recruited with the aim of gathering together the broadest possible range of IT expertise – supplemented by an ability to think outside the box.

The car in front of me is among the most complex pieces of equipment that customers can buy. However, you need to build up some experience with this system before you can safely relinquish control and allow it to brake and steer on its own. “Our development team in Düsseldorf can draw on ZF resources from across the entire company,” enthuses Dr. Marco Wegener. We’ve left Düsseldorf’s city center far behind us and now we’re cruising along the A3 autobahn, heading toward Cologne. That’s when the 30-year-old Wegener tells me to press two buttons – and let go of the steering wheel.

Centering automatically
There’s no computer display to tell me what the experimental vehicle is about to do. But I can clearly feel the action of the electric motor on the steering gear, automatically keeping the car in the center of our lane. It works like a lane-keeping assistant, using cameras to monitor the lane ahead. A radar-assisted Adaptive Cruise Control (ACC) system is responsible for keeping us at the correct safe distance from the vehicle in front. ZF TRW has been producing driver-assist systems like this for a long time – increasingly, they’re becoming standard equipment in the automotive industry. Starting in 2017, for example, all Peugeot, Citroën and DS models will be equipped with the latest camera and radar technology from ZF TRW. The systems supplier will also be responsible for function development and systems integration – for both the individual sensors, and for data fusion across the sensor network as a whole.

What does the camera behind the windshield see? What’s the radar system picking up? I keep asking myself these questions during the test drive. As we travel along at 75 mph, cars regularly overtake us on the left and right. As we approach an on-ramp, a green station wagon cuts in front of us so sharply that the Highway Driving Assist system slams on the brakes. From the viewpoint of a machine whose job it is to maintain the statutory safe distance, the incident must be just as stressful as the absence of lane markings on a freshly asphalted section of road. The system must respond to events within fractions of a second, and then return the car to the middle of the lane. By flicking a directional indicator, I can also make the car change lanes automatically. That means it not only has to monitor its own lane, but the neighboring lane as well. The computer can only be sure the maneuver is safe to execute once all the different types of sensors have reached a consensual “world view”.

Detect – anticipate – act
At present, driver assistance – or as they are known in the industry, “driver assist” – systems are only capable of perceiving a very limited segment of the vehicle’s surroundings. In particular, they lack the experience required to classify objects and judge their movements. For example, emergency braking assistants attempt to recognize pedestrians crossing the road. So far, however, this only really works in cities. By contrast, seasoned drivers develop a sixth sense. If the vehicle in front of us starts to move toward the median strip, we can tell it’s about to move out and overtake – whether or not it is signaling.

A self-driving vehicle must constantly observe, analyze, anticipate and plan for everything around it. In order to make the right decisions in real time, it needs a sophisticated model of its surroundings. “Teaching a car what it’s supposed to do is an absolutely fascinating job,” explains Dr. Marco Wegener.

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In actual fact, I’m able to take my hands off the steering wheel for long stretches of the A3 freeway. But I’m not allowed to pick up my notepad and take notes while driving at high speed. The ZF experts who would normally be sitting behind the wheel are specially trained as test drivers. They keep a close eye on the traffic at all times and can override the system whenever they want to. Let’s be clear: fully automated – i.e. driverless – cars are still a media-tillating myth. Reporters love to tell us about self-driving research vehicles fitted out with laser scanners that cost as much as a luxury sedan. But such research vehicles are only tangentially relevant to production cars. If clever onboard assistants are to become truly affordable, they’ll have to do without all the expensive extras and use advanced versions of standard components instead.

The ZF TRW team in Düsseldorf always keeps this democratization of innovations firmly in mind. “We’re working on automated driving functions based on our next-gen camera and radar systems,” explains project head Dr. Carsten Hass. The high priority ZF is giving to this key area of future activity is reflected by the company’s latest acquisition: this summer, ZF purchased HDL6 GmbH. The German company’s 50-strong development team specializes in driver-assist systems and “surround view” technology. The cameras they use are capable of monitoring cross-traffic movements superbly, even at highway on-ramps, whereas conventional cameras and radar systems only patchily detect pedestrians and cyclists, even when they’re directly alongside the car.

After my test drive, it has become clear to me just how crucial this 360° surround-view technology is for automated driving. Admittedly, even if the car had been fitted with this technology, I still wouldn’t have been able to take notes during the drive – but it would have been another big step in that direction.

“Teaching a car what it’s supposed to do is an absolutely fascinating job.”

Dr. Marco Wegener, Development Engineer
Agile, intelligent, urban: a concept vehicle from ZF shows what the future of urban mobility could look like.

By Andreas Neemann

A compact city car stops in the middle of the street, a few yards from a very tight parking space. Both driver and passenger get out, much to the surprise of passersby. Are they really going to leave the car parked like that? No, they aren’t. The driver taps his smartwatch, and the empty car starts moving by itself, automatically reversing back into the tight parking space. In a single, smooth motion – making for quite a show. In particular, what it demonstrates is the very tight turning angle of the front wheels which, for a few moments, looked as if they were turned at a 90-degree angle to their wheel housings. By now it is quite clear that there is something different about this car.

And the answer to this puzzle is called the "Advanced Urban Vehicle," a concept vehicle from ZF that is an extremely agile, locally emission-free, all-electric car. It is also equipped with many smart assistance functions designed to relieve the driver of irritating drive operations – like cranking the steering wheel when parallel parking, to name but one.

"With this concept, we are exploring solutions for the compact and subcompact vehicle segment, which will be required for meeting the future demands of individual urban mobility," explains Dr. Harald Naunheimer, Head of Corporate Research & Development at ZF.

The "Smart Parking Assist" feature described above is one of these solutions. Ultrasound and in-
A display on the steering wheel reminds the driver which mode the car is currently being operated in.

“The concept car shows which mobility solutions can be achieved today if existing systems and technologies are networked with one another.”

Dr. Harald Naunheimer, Head of Corporate Research & Development

The infrared sensors mounted around the car scan the car’s surroundings and keep an eye out for parking places. If the car finds one, the driver receives a message on the display. All the driver has to do now is sit tight and let the car do the parking. The parking assist steers the car and controls the maneuver by means of the sensors and an additional camera in the rear. The system-capable electric power steering system moves the steering wheel as if by magic. It detects whether the driver has his or her hands on the wheel or not thanks to its “hands-on detection” feature.

Dr. Harald Naunheimer explains the benefits of the Advanced Urban Vehicle to Peter Lake, who will take charge of ZF’s Corporate Market activities starting in October 2015.

Or the occupants can first step out of the vehicle and then start the parking maneuver from the outside using an app on a smart device. It is extremely practical in view of the increasing lack of parking places in the city. With the system developed by ZF, tight parking places that are close to parking obstacles such as walls or pillars can be used that would otherwise remain empty.

Dr. Harald Naunheimer

**Drive, steering, and axles working as a team**

The basic idea of the smart parker is to achieve the perfect interaction between driveline and chassis, combined with an intelligent system network. The turning angle of the front wheels is extreme at 75 degrees—and verges on a right angle of 90 degrees. A specially designed front axle combined with a customized electric power steering system and other design changes to the wheel housing made this tight turning angle possible.

Conventionally powered vehicles would be unable to handle such a tight turning angle—they could not use it from a standstill and would literally “trip over” their turned-out front wheels. Not so with the Advanced Urban Vehicle. The two electric motors integrated in the rear axle mounted near the wheels power the vehicle with a total of 80 kilowatts of output, delivering a top speed of 93 mph.

The torque vectoring system distributes the torque individually to each wheel. If the left wheel stops moving while the right wheel moves forward, the car, including its rear end, moves to the left—and in doing so supports the left-hand drive of the tightly turned front wheels. This interaction between hardware and software, chassis and steering, drive and system network makes it possible for the 12-foot Advanced Urban Vehicle to slip into a parking space just over 14 feet long in a single move. It also has an exceptionally tight turning circle of 21.33 feet, which means that a quick U-turn on a two-lane road is no problem at all.

Collective intelligence thanks to connectivity

This prototype car is also highly efficient when it comes to getting around outside the city in the suburbs. An additional feature called “PreVision Cloud Assist” gathers information on types of road, such as an oncoming curve, from the cloud well in advance, compares it with the vehicle data, and calculates the optimal speed for driving through it. If the car goes too fast, PreVision Cloud Assist cuts the torque in time—an action typically called “taking the foot off the pedal.” This feature reduces the loss of drive energy compared to normal cases in which the driver would step on the brake. The system functions in both directions with the Advanced Urban Vehicle also storing data in the cloud. If such a concept goes into volume production, all cars that are equipped with such a system will accumulate a wealth of information that they or others will later have access to.

PreVision Cloud Assist does not intervene without the driver knowing. A small OLED display in the steering wheel keeps the driver informed at all times. A mode switch allows the driver to activate sporty or normal control. “The assistance systems in our concept study can already be implemented because existing technologies in the car can be networked with one another,” explains Dr. Harald Naunheimer.

“Driver commands and driver behavior interact with the environment of the car, which also accesses very general data such as maps or weather information.” The Advanced Urban Vehicle is an example of potential innovation from the merged ZF and TRW companies. The electric power steering system, steering wheel, sensors, and rear camera were developed by the American safety systems specialist.

Developed by ZF, the mobility app uFlip is the perfect complement to the Advanced Urban Vehicle. It uses real-time data to calculate the fastest, most favorable route based on carpooling and public-transit options, and can also carry out smart parking space searches. Rural areas in particular can be connected to cities more efficiently, relieving traffic congestion. uFlip will be available to download free of charge from Google Play and the Apple App Store in the fall.
ALL YOU NEED IS TWO

SUVs, compact cars, sedans, sportscars: the latest generation of ZF automatic transmissions has taken the automotive world by storm. They’re Top of the Pops in all vehicle segments.

By Achim Neuwirth

Okay, so it’s hard to believe that the Maserati Ghibli has anything in common with the Iveco Daily Hi-Matic van, but it does: the same ZF automatic transmission. The 8-speed box in the Ghibli enables the 434-hp sports sedan to sprint from 0 to 60 mph in just 5.5 seconds. In the Hi-Matic, it provides driving programs that make it easier for delivery drivers to overtake or perform other tricky maneuvers. Of course the transmissions in the two vehicles aren’t absolutely identical; in each case, ZF engineers customized the basic unit to meet the special requirements associated with each application.

“Modular” is the magic word that explains the 8HP’s success in the marketplace: ZF uses the basic transmission unit as a platform for a very wide range of applications. The 8HP is currently installed in over 600 different vehicle models and drivelines. The ZF production plant in Saarbrücken outputs around 10,000 customized units every day.

With the 9HP, ZF has taken a different approach. The transmission is designed for vehicles with front transverse engines – that is, for the world’s fastest growing passenger-car segment. In fact, some 75 percent of all cars produced are fitted with front transverse power plants. The 9HP has made a big splash. Although it’s been on the market for less than two years, it’s already installed in nine model ranges built by seven different carmakers. And that’s just the start.

This wild success is primarily due to fuel efficiency. One special feature of ZF automatic transmissions is that they keep engines running at low engine speeds, which helps reduce fuel consumption. At a time when vehicle emissions around the world are subject to strict CO₂ limits, this is a very attractive quality. Long may their triumph continue!

Achim Neuwirth

ZF automatic transmissions for cars: the story started 50 years ago. Read all about it on page 48!
TRW technologies are the ideal companion to the ZF portfolio for passenger cars. The supplier can now combine existing products to offer powerful, active systems from one single source in the future.

By Andreas Neemann

The company combining ZF and TRW is committed to supplying complete system solutions, explained ZF CEO Dr. Stefan Sommer on the occasion of the acquisition. But what does that mean exactly? And to what extent can the competencies of these former separate enterprises be bundled together to leverage new product developments with added value for the customer? Three concrete examples demonstrate just how well this can succeed.

Brake plus driveline

Regenerative braking is the energy recovery mechanism used to generate electric energy by braking. Hybrid and all-electric vehicles have featured such regenerative brakes since the very beginning. The vehicle is not slowed down by the service brakes on the wheel but by the electric motor instead, which can switch from motor to generator mode within seconds. The disadvantage: the braking effect produced – triggered by the generator’s drag torque – can only handle gentle braking maneuvers. When the driver steps harder on the brake pedal, the service brakes still have to engage. This division is often seamless in everyday driving situations. Jerky deceleration disturbs driving comfort every time the braking effect is “switched” from the electric motor to the service brake. What is needed is a seamless transition from one braking system to the other, known as “brake blending” – and in the future, ZF will be able to meet this demand by integrating...
Safety megatrend

Sensors, high-resolution cameras, as well as software algorithms and on-board computing power make it possible: In the future, intelligent systems in the vehicle will be able to identify and interpret hazardous situations independently of the driver, and react rapidly and correctly by performing autonomous braking or evasive maneuvers. This will raise the safety standard in vehicles to a new level.

Efficiency megatrend

Vehicles with very low fuel consumption and emissions are already on the road today. Increasing electrification will boost efficiency still further. Even more potential can be tapped if the networking between consumption-relevant systems in the vehicle is further improved and vehicles use information on their surroundings, i.e. the course of the road and the route.

Automated driving megatrend

The technology already exists: Sensors precisely record what happens around the vehicle, cameras monitor the lane and even "head" traffic signs, a control unit in the car uses the information to calculate ideal driving maneuvers and autonomously actuates the steering system, brakes, and drive. This is the core element of automated driving that will characterize future road traffic.

Brakes and driveline. However, this is not simply a comfort feature. "We can optimize the entire energy management system when both the brakes and the electric motor come from the same source," explains Dr. Harald Naunheimer, Head of Corporate Research and Development at ZF. As a result, hybrid and electric vehicles will also become more efficient. Another positive side effect which automotive manufacturers and end customers can look forward to: service brake wear is also reduced.

Steering plus brake plus chassis

Today, stability programs are a widespread standard in the industry. They prevent a vehicle from reaching its handling limits or even skidding by applying braking to wheels individually. By interlinking the steering system, brake, and active chassis system, ZF could even exceed these limits. A glance at the extended product portfolio reveals the possibilities available. Firstly, a combination of steering system, brake, and rear axle steering AKC (Active Kinematics Control) can stabilize driving through systematic steering and braking interventions and prevent lateral slippage of the vehicle. Secondly, the interconnection of steering system, active CDC (Continuous Damping Control), and ARS (Active Roll Stabilization system) is a valuable asset. This prevents the vehicle body from rolling and pitching and ensures enhanced contact of the tires with the road while increasing safety reserves.

"An advanced driver assistance system from one single source – in other words from us –, allows us to perfectly match and coordinate all components."

Dr. Alois Seewald, Technical Director Automated Driving at ZF TRW

Ideal for assistance systems

Both of these viable driver-controlled systems not only increase vehicle safety, they also provide the ideal basis for emergency braking and collision avoidance assistance systems in which sensors and cameras from the ZF TRW product portfolio identify hazardous situations, and control electronics calculate driving maneuvers based on this information. "An advanced driver assistance system from one single source – in other words from us – allows us to perfectly match and coordinate all components," according to Dr. Alois Seewald, Technical Director Automated Driving at ZF TRW.

Efficiency megatrend

Vehicles with very low fuel consumption and emissions are already on the road today. Increasing electrification will boost efficiency still further. Even more potential can be tapped if the networking between consumption-relevant systems in the vehicle is further improved and vehicles use information on their surroundings, i.e. the course of the road and the route.

Automated driving megatrend

The technology already exists: Sensors precisely record what happens around the vehicle, cameras monitor the lane and even "head" traffic signs, a control unit in the car uses the information to calculate ideal driving maneuvers and autonomously actuates the steering system, brakes, and drive. This is the core element of automated driving that will characterize future road traffic.

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London in 2025, and the British capital is proud of its new high-rise skyline along the banks of the Thames. The new cityscape is based on farsighted plans laid more than a decade ago. Even before that, it was clear that the city’s population would soon swell to over ten million – with a concomitant impact on the streetscape. For many years, London has been levying congestion charges on vehicles traveling anywhere in the city center. In 2025, most people think twice about paying out nearly 50 euros a day to drive into the city in their own cars – and that’s before they add on the exorbitant parking charges.

Even so, few people miss driving in the crowded metropolitan center. Thanks to the recent introduction of fully automated taxis, personal automobility is faster and more convenient than ever before. City hopping using a smartphone app has rapidly become a popular tourist pastime. Just tap the on-screen “hail” button, and a white car promptly pulls up to the curb. It’s not long since driverless, electrically powered “White Cabs” replaced London’s old Black Cabs, with their human drivers and polluting diesel engines. The new e-cab’s doors swing open as if by magic, and as passengers climb aboard, they’re greeted by name on the display inside the passenger compartment.

**Driving without steering wheel or pedals**

Back to the present day: it took an IT company to catapult automated driving from the research laboratory into the news headlines. After driving more than 600,000 test miles using heavily modified conventional cars, Google dropped a bombshell in 2014: their two-seater driverless car – without steering wheel or pedals – became an overnight sensation and a trending social media topic worldwide. “We imagine a Google car as a small pod that’s always on the move,” explained Jens Redmer, in charge of New Products and Solutions at Google Germany. “It’s not the ‘emotional’ car you use at weekends to take a drive through a beautiful stretch of countryside. But it is the kind of car you use to run errands in the city center, because it doesn’t need a parking space and immediately drives off to pick up the next fare.”

By Joachim Becker
Speed and urbanization have always been key characteristics of the modern era. But in many parts of the world, the hustle and bustle of life in the big city is reaching its limits. By 2050, the planet will be home to ten billion people – and 70 percent of them will live in conurbations. Increasingly, city dwellers are calling for measures to mitigate the traffic and accident hotspots associated with metropolitan areas. The requisite technology already exists: advanced driver-assist systems such as Adaptive Cruise Control (ACC), traffic-jam assistance and automatic emergency braking systems have already proved their mettle in everyday use. Studies show that driver-assist systems using radar and cameras significantly reduce accident figures. What’s more, the defensive, rules-based driving style characteristic of those assistants helps dense traffic flow more smoothly. Many experts have set their sights on Vision Zero (“zero traffic fatalities”). Self-driving cars of the future will be able to move through heavy traffic like a synchronized swarm. Because these computers on wheels will be networked with traffic lights, the highway infrastructure and each other, they’ll be capable of relaying traffic reports and alerts from vehicle to vehicle in real time. Over large parts of the road network, this won’t just make them faster but also – and most importantly – safer than other modes of transport.

Legal framework

A recently published study entitled “Urban Mobility System Upgrade” illustrates just how advantageous such autopilots could be for inner-city traffic. In the study, the International Transport Forum at the OECD assesses the capabilities of self-driving taxis, concluding that an automated chauffeur service could replace half of the cars in inner cities without any loss of convenience. At the same time, such a service would halve the number of parking spaces needed.

But before that can happen, a suitable legal framework must be developed. The internationally agreed 1968 Vienna Convention on Road Traffic still stipulates that “every driver shall at all times be able to control his vehicle or to guide his animals”, a formulation dating from a time when horse-drawn carriages were still a common sight on roads. True, the Vienna Convention was updated in 2014 with an important provision: automated systems enabling cars to drive themselves are permissible so long as they “can be overridden or switched off by the driver” at any time. This clause does legitimate driver assistance systems, which had previously operated in a gray zone. Nevertheless, the driver remains liable at all times. Before drivers can turn to other, non-driving-related pursuits a clean conscience, both the technology and the legal framework have to evolve. With this in mind, Germany’s Federal Minister of Transport set up an Automated Driving roundtable at the end of 2013. A recently published study entitled “Urban Mobility System Upgrade” illustrates just how advantageous such autopilots could be for inner-city traffic. In the study, the International Transport Forum at the OECD assesses the capabilities of self-driving taxis, concluding that an automated chauffeur service could replace half of the cars in inner cities without any loss of convenience. At the same time, such a service would halve the number of parking spaces needed.

Interpreting their surroundings

In order to react to their surroundings, onboard driver-assist systems must first be able to perceive them. Redundant systems are consequently imperative.

Beam-based systems

Distances from and to other objects are measured by:

1. Infrared laser sensors
   
   Suitable for short distances and at low speeds. An ideal solution for urban emergency braking assistants, for example.

2. Radar sensors
   
   Suitable for highway speeds and capable of “seeing” up to 200 yards ahead. They provide the input for adaptive cruise control systems and traffic-jam assistants, which can automatically maintain a safe distance from the car in front, brake to a stop and – in the case of semi-autonomous vehicles – automatically drive off again.

Vehicle-to-X communication

Communication between all relevant “smart” objects:

1. Other vehicles
   
   Capable of relaying warnings of traffic jams or hazardous hotspots that cannot be anticipated in advance. Also able to provide information on available parking spaces or alternative routes.

2. Traffic infrastructure
   
   Traffic lights or traffic management systems tell the onboard system what speed to travel at in order to take full advantage of a “green wave”.

3. Traffic radio and navigation or telematics services
   
   Provide traffic information.

4. Traffic-infrastructure
   
   Traffic-infrastructure vehicles or traffic management systems tell the onboard system what speed to travel at in order to take full advantage of a “green wave”.

5. Charging stations report on availability.

6. Traffic radio and navigation or telematics services
   
   Provide traffic information.

7. Charging stations report on availability.

8. Traffic radio and navigation or telematics services
   
   Provide traffic information.

9. Traffic radio and navigation or telematics services
   
   Provide traffic information.

10. Infrared or thermal imaging cameras
   
   Provide accurate night-vision functionality.

Imaging systems

Surrounding objects are detected by:

1. Mono-camera systems
   
   Providing information for lane departure and rear-end collision warning systems, active lane-keeping assistants and traffic sign recognition systems.

2. Stereo-camera systems
   
   Capable of three-dimensional vision for supporting driver-assist systems such as pedestrian detection.

3. Other road users such as pedestrians or cyclists
   
   Capable of three-dimensional vision for supporting driver-assist systems such as pedestrian detection.

4. Traffic infrastructure
   
   Traffic lights or traffic management systems tell the onboard system what speed to travel at in order to take full advantage of a “green wave”.

5. Other vehicles
   
   Capable of relaying warnings of traffic jams or hazardous hotspots that cannot be anticipated in advance. Also able to provide information on available parking spaces or alternative routes.

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   Provide traffic information.

10. Infrared or thermal imaging cameras
   
   Provide accurate night-vision functionality.
control of the wheel or automatically adjust the car’s speed at up to 40 mph. In the fall of 2015, the "driver-assist systems will make driving more comfortable and safer, especially on highways and freeways."

Head of Corporate Research & Development
Dr. Harald Naunheimer

Highly automated driver-assist systems will make driving more comfortable and safer, especially on highways and freeways.

Rules for man and machine

Self-driving vehicles still face daunting legal obstacles. For example: confronted by an unavoidable accident, how does an autopilot decide whether to place other people in danger by taking evasion action? Such ethical questions need to be clarified, as do issues of data transparency and data sovereignty, not to mention a host of other legal and political details that require open debate across all sectors of society.

Psychological issues
Surveys show that many people are afraid of automated driving:
- They are anxious about feeling at the mercy of a machine.
- Because many people regard driving as the epitome of self-determination, they are afraid of losing control and becoming purely passive passengers.
- Many fear being spied upon, because sensors such as interior cameras are there to ensure that drivers don’t fall asleep or become overly distracted.
- On the other hand, anybody who has experienced at first hand a situation in which an automatic braking system has successfully prevented an accident has faith in driver assistance systems.

Legal issues
- The 1968 Vienna Convention on Road Traffic still stipulates that "every driver shall at all times be able to control his vehicle". In 2015, an amendment is likely to be ratified that permits the installation of systems enabling a car to drive itself as long as the system "can be overridden or switched off by the drive" at any time.
- Amendments to licensing laws are also required. According to EU legislation, self-driving cars are not permitted to exceed 60 mph (100 km/h).
- The issue of liability for accidents must be clarified. Who is liable if a self-driving car is involved in an accident? At present, the burden of proof lies with the driver or if he or she wishes to claim a technical fault. In the case of highly automated vehicles, drivers must have an opportunity to exonerate themselves if, contrary to expectations, the technology fails.

Redundant systems required
So it’s clear that developers need a great deal of expertise if they’re not to lose themselves in the complexity of it all. Self-driving cars can only respond rapidly and reliably if at least two different types of...
The six levels of automated driving

<table>
<thead>
<tr>
<th>Level</th>
<th>Driver</th>
<th>System</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEVEL 0</strong> DRIVER ONLY</td>
<td>Totally in control</td>
<td>-</td>
<td>Yesterday</td>
</tr>
<tr>
<td><strong>LEVEL 1</strong> ASSISTED</td>
<td>Longitudinal and lateral control at all times</td>
<td>-</td>
<td>Today</td>
</tr>
<tr>
<td><strong>LEVEL 2</strong> PARTIAL AUTOMATION</td>
<td>Must monitor the system at all times</td>
<td>-</td>
<td>Starting in 2016</td>
</tr>
<tr>
<td><strong>LEVEL 3</strong> CONDITIONAL AUTOMATION</td>
<td>May pursue non-driving-related activities</td>
<td>-</td>
<td>Starting in approx. 2020</td>
</tr>
<tr>
<td><strong>LEVEL 4</strong> HIGH AUTOMATION</td>
<td>No longer needs to monitor the system</td>
<td>-</td>
<td>Starting in approx. 2025</td>
</tr>
<tr>
<td><strong>LEVEL 5</strong> FULL AUTOMATION</td>
<td>Not required</td>
<td>-</td>
<td>?</td>
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Fully automated driving will evolve in a series of stages from one level to another. Many of the necessary driver-assist systems are already in operation today.

sensors identify the same object at the same moment. The level of processing power required to achieve this is threatening to spiral right out of control, however, because imaging systems such as cameras and laser scanners (LiDAR) produce vast quantities of raw data. So the art of improving driving automation lies in data fusion: intelligently and efficiently combining data from all sensor systems at the same time.

“To provide the necessary system resilience, automated driving requires redundant systems,” confirms Dr. Harald Naunheimer, Head of Corporate Research & Development at ZF. “But instead of installing individual components twice over, you can network together the braking, steering and drive-line systems – components that are all packed full of sensors.”

**Competitors from the IT industry**

Automated driving is accelerating the paradigm shift from mechanical engineering to onboard computer-based systems in cars. At the same time, the digital revolution is shortening innovation cycles and attracting new competitors from the IT industry, who are very interested in the data generated by these four-wheel sensor platforms. The automotive industry, and its leading suppliers in particular, are reorganizing themselves so they can handle the entire spectrum of vehicle development activities at new and higher levels. ZF, for example, has just acquired TRW, one of the largest and most successful U.S. automotive suppliers. The two companies’ product portfolios are a perfect fit; the new, combined organization now has all the technologies required to build self-driving systems under one roof.

“Together, we cover the entire gamut of competencies and components required to build complete, turn-key driving systems, from all-electric and hybrid drive-lines through electronic control systems and power electronics to chassis components and systems, steering and braking systems, sensors such as camera and radar systems, as well as safety systems – all of which can be controlled by state-of-the-art driver-assist systems,” explains ZF CEO Dr. Stefan Sommer. ZF’s acquisition of TRW has happened at a decisive stage in the move to highly automated driving. “If you analyze the development of electronic wiring systems in cars from their earliest beginnings to the present day, you are struck by the similarity with the long-term evolution of biological nervous systems,” wrote Professor Klaus Mainzer back in 2004. “But unlike living systems, conventional electronic systems are rigid and inflexible,” added the Munich-based expert in artificial intelligence. And that’s why, starting in 2016, the supercomputers in cars will be remotely connected to back-end servers capable of processing vehicle data in near-real time. This will transform cars into learning systems that are able to evolve continuously, independently of the actual hardware.

**Constant updates via mobile communications**

Until that time finally arrives, one ironclad rule will continue to apply: self-driving cars really don’t like surprises that conflict with the rules they have been programmed to follow. Situations that pose dilemmas – such as unavoidable accidents, for example – cannot yet be solved by algorithms alone. “Only human beings are capable of making sensible decisions in uncertain conditions,” confirms Professor Thomas Stieglitz from the University of Freiburg’s Institute of Microsystem Technology (IMTEK). “Only human beings excel at doing this, clearly demonstrating the limits of technology.” With the help of a permanent link to back-end processing power, vehicles will be able to learn to cope with ethical conundrums. Automated driving as a networked function can follow closely in the footsteps of the public debate. Thanks to continuous updates over a mobile telecommunications interface, the car may thus evolve to transcend itself.

It is highly probable that most of the obstacles to autonomous driving will have been eliminated in ten years or so. London could become the first major European city to create priority lanes for fully autonomous cars. Dedicated lanes would mean that our imaginary White Cabs would no longer need drivers. The system will have learned to automatically return to a minimal-risk state at any time. It will also become commonplace for passengers to chat with their “invisible chauffeurs” – to discuss alternative routes for avoiding traffic jams, for example (yes, traffic jams will almost certainly still occur). And there’s one sentence from the early days of man-machine dialog you definitely won’t hear any more: “Turn around when possible.”
“WE’RE COMBINING THE STRENGTHS OF TWO CHAMPIONS”

Why the acquisition of TRW fits perfectly with ZF’s strategy for the future, and how customers – as well as the newly merged company – are already seeing benefits. CEO Dr. Stefan Sommer explains everything in his interview with drive.

Dr. Sommer, the purchase of TRW was ZF’s largest acquisition ever. What was the reasoning behind this decision?

I’m happy this complex corporate transaction has worked out – for the most part smoothly, and in an amazingly short time. The acquisition was important and the right thing to do. It’s a milestone on our way into a shared future that’s more secure. The entire automotive industry, including suppliers like us, is currently going through a period of profound change. We’ve identified three megatrends to which our new setup will enable us to respond very effectively. Over the next few years, the key industry priorities will be: more efficiency, more safety, plus automated driving.

What strengths is TRW contributing to the company that will help ZF respond to these priorities?

As far as efficiency is concerned, ZF was already very well-positioned with our hybrid and all-electric drivelines. What TRW has contributed to the expanded company is enormous braking expertise – in the recovery of braking energy, for example. As for the second megatrend, safety, we’re now in a position to network together steering systems with active chassis damping solutions.

And what about automated driving – what solutions is TRW bringing to the table?

The ones I would mention immediately are TRW’s valuable expertise in sensor and radar technology, onboard information processing and actuator systems. In fact, we’re now able to deliver a single-source response to the automated driving trend – from automatic transmissions and axle drives to active chassis systems right through to driver-assist systems that include camera and radar systems, steering systems, electronic management systems and software, and vehicle control systems. In short, our integration was and is guided by a clear vision: we want to be a world-leading supplier to the automotive industry by offering complete system solutions for the megatrends of the future. And now we’ve brought together all the technologies relevant to these three megatrends – efficiency, safety and fully automated driving – under one roof.
That all sounds great, but what makes you so sure that this “marriage” will succeed?
To put it in a nutshell: because we’re a very good fit, and because this is about two champions joining forces. The integration is taking place from a position of strength – in products, technologies, market coverage and financial independence. The end result is a group that, with total combined sales of more than 30 billion euros and 134,000 employees, is now ranked among the world’s top three automotive suppliers.

What does this mean for any customers the two companies have in common?
We’re making huge efforts to provide our customers with top-quality service and ensure our day-to-day business continues to run as it did before. That’s why our first step was to incorporate TRW into ZF as a fifth division called “Active & Passive Safety Technology”. Now we’re in the process of bundling key activities so our customers will enjoy further benefits. Initially, this means focusing on, for example, new product development, the sales network and our aftermarket business. We’re expecting the entire integration process to last between three and five years.

Will the expanded ZF Group be making an appearance at upcoming international motor shows?
ZF will be showing off the company’s new, expanded portfolio at the Frankfurt Motor Show (IAA) in September, the Tokyo Motor Show in November and NAIAS in Detroit in January 2016. At all of these events we’ll be demonstrating – with our Advanced Urban Vehicle innovation prototype, for example – just how well ZF and TRW products already work together. Also in January 2016, we’ll be jointly presenting our combined technologies at the Consumer Electronics Show (CES) in Las Vegas for the very first time.

Automated driving will certainly be a major focus of CES, as it was this year. What progress has the company made in developing this technology?
Semi-automated driving – that is, vehicles capable of taking longitudinal and lateral control while, of course, under the driver’s constant supervision – is already available today. In fact, we’ll be presenting a driver-assist system of this kind at this year’s Frankfurt Motor Show, in the form of our Highway Driving Assist function. Safety technologies like emergency braking systems are also already in use. Automated driving will evolve in stages until we finally produce fully autonomous vehicles, as we continue to develop sensor and actuator technologies and integrate driver-assist functions to create a sophisticated functional system. But that’s just the technical aspect...

... not forgetting the legal and ethical aspects, which are already being hotly debated.
Quite right: the two aspects you mention, coupled with social acceptance, are vitaly important for the further development of these technologies. Who’s liable for accidents involving automated systems? What criteria should assistance systems apply when making decisions in tricky situations? These are just a couple of the key issues involved. But also, let’s not forget that we shouldn’t allow the sheer enjoyment of driving to fall by the wayside. This is another area with a lot of potential.

Interest in automated driving is prompting major IT companies like Google and Apple to push into the automotive sector. What will this mean for ZF?
Both companies are making waves in the automotive industry. They want to make cars part of the world of the Internet, satisfying the needs of customers, including new entrants to the marketplace. Their biggest selling point is efficiency. However, to make autonomous cars really work, you need to be able to control them remotely, which means integrating software, sensors, actuators, computer memory and networking in a single, robust and reliable way.

In view of the omnipresent debate about automated driving, has the issue of efficiency lost some of its significance?
Certainly not. We’re still working to ensure that our products support energy-efficient mobility using as few resources as possible. At a time when growing volumes of traffic are driving up global pollution levels, efficiency is more important than ever – in fact, we’re already seeing major paradigm shifts.

You’ll have to explain that.
Well, a good example is the automatic transmission. We’ve had automatic transmissions in our portfolio for 50 years. For much of that time, comfort was the main priority, but over the last few years, fuel efficiency has become steadily more important. Compared to its predecessor, our 8-speed automatic transmission uses as much as 11 percent less fuel; the hybrid version uses up to 22 percent less. By combining them with driver-assist systems, we can unlock further potential savings.

Their own. I anticipate some fruitful collaborative models here; we can certainly imagine working with them. In principle, we’re happy to offer our products and our development expertise to all customers, including new entrants to the marketplace.
SERIAL LIFESAVERS

In the town of Alfdorf near Stuttgart in Germany, ZF TRW develops passive safety systems such as airbags and seatbelts. Taking a look behind the scenes at the Airbag Test Laboratory.

By Britta Höller
Photos: Dominik Gigler

A crash test dummy is fitted with about 100 sensors. They transmit important information on the quality of the airbags as well as all safety systems.

Using the hydraulic crash simulation unit, collisions are simulated at speeds of up to 47 mph.

An ear-piercing horn sounds. With an output of more than 100,000 watts, 48 spotlights bathe the testing facility in a glistening light to ensure ideal photo conditions for the high-speed cameras.

The test sled – equipped with a complete restraint system made up of seatbelts and airbags as well as a crash test dummy – sits in front of the hydraulic sled installation. In an instant, a diagonal frontal collision at more than 30 mph is simulated. With a bang, the seatbelts tighten and the airbags fill with a whoosh while the test sled, along with the dummy, is thrown backwards from the power of the impact. This is a daily occurrence at ZF TRW’s crash simulation facility in Alfdorf, the headquarters of the Occupant Safety Systems (OSS) unit. Aside from seatbelts, airbags are the most important element when it comes to passive safety. Both are developed by ZF’s new corporate Active & Passive Safety Technology division in Alfdorf near Stuttgart.
In Alfdorf, airbag prototypes like the one shown here by Rolf Hörsch, Prototype Mechanic at ZF TRW, are produced manually in many work steps. In volume production, this would be done by machines.

The success story of the airbag began in 1951 when Munich inventor Walter Linderer filed a patent for an airbag prototype. The first airbags were launched on the U.S. market in 1974, but did not arrive in Germany until six years later.

The basic principle of the airbag system has barely changed since it was first put into volume production. Pressure and acceleration sensors around the vehicle are analyzed by a control unit. The crash algorithm in the control unit identifies the beginning of a crash and triggers the gas generator via an electrical signal. In a matter of seconds, the stream of gas fills the airbag which then absorbs the kinetic energy of the passengers.

From idea to production
Depending on whether it is an enhancement to an existing product or an entirely new development, it can take months or even years before an airbag is installed in a production vehicle on the factory floor. This development process has two stages: the core development stage covers the early phases from the initial idea and various concepts to the design of the basic airbag. Near the end of this first stage, enough detailed information is available to present the new product to the customer. The beginning of the second development stage is the volume production order. During application development, the airbag is adapted precisely to the customer’s vehicle specifications.

While innovation management, product planning, and airbag core development are handled centrally by ZF TRW in Alfdorf, application development is done at the locations closest to each customer. “This allows us to provide optimal customer care,” explains Dr. Swen Schaub, Senior Manager of Engineering Strategy & Communication at ZF TRW in Alfdorf. “For our German customers, we also manage application development here in Alfdorf.”

About 1,600 employees work at the Alfdorf facility, with more than 680 involved in the development of seatbelt and airbag systems. They ensure that innovations in the field of occupant safety make daily progress. The airbag portfolio is continuously modified and expanded because engineers are confronted not only with challenges such as new vehicle designs, but also changes to regulations by institutions such as Euro NCAP, the European consumer protection organization. That’s why proven technologies, such as “classic” frontal airbags (airbags for drivers),
Mr. Schultz, airbags are now an established technology. How much potential is there for further development?

While traffic safety in Germany has risen considerably, the approximately 3,000 traffic fatalities that occur annually on German roads are still too high. Moreover, Germany, or Europe, is only one part of the global market. Today, technologies must become lighter and smaller, and we must also offer greater flexibility in terms of styling.

What airbag innovations is ZF TRW currently working on?

First of all, we’re constantly improving our proven technologies. Weight reduction and better use of space are the drivers behind these efforts. Lighter gas inflators are helping us achieve this. In addition, design engineers are thinking about replacing plastic housings with housings made of industrial textiles. Adaptive systems that adjust to the environment and the occupants are playing an important role in the development of new concepts. Finally, occupant safety in the rear is also becoming increasingly important.

What trends will drive airbag development over the long term?

On the one hand, conventional airbags will continue to penetrate deeper into the market, primarily in developing countries. On the other hand, the question arises of what the automobile of the future will look like. Will we even have steering wheels at all? Where will we put the driver airbag then? The airbag will certainly establish itself to an even greater degree as an inherent component of the car, and along with new features and new technologies, it will be possible to offer even greater improvements to occupant safety.

passengers and knees) and side airbags (including thorax airbags for torso protection and curtain airbags for protecting the head in side-impact collisions) must be constantly modified and enhanced.

At the same time, entirely new airbag concepts are also developed in Alfdorf and prepared for volume production, such as the world’s first roof airbag on the passenger side of the Citroen C4 Cactus. This airbag module is not placed in the dashboard, as usual, but rather on or below the roof liner above the windshield. This protects the passenger and provides more cabin space, creating new options for redesigning the vehicle interior.

Innovations such as the center airbag

ZF TRW in Alfdorf is also working on numerous other innovations, such as the center airbag, which deploys between the two front seats and better stabilizes the driver in the event of a side impact, while also ensuring that the driver and the passenger do not collide with one another.

"Another major priority are airbags that can be deployed before a crash based on sensor data from radar and camera systems," adds Dirk Schultz, Director of Engineering for Inflatable Restraint Systems and Inflators at ZF TRW in Alfdorf. "This will help us gain valuable milliseconds. Such pre-crash systems are particularly interesting in the case of side collisions, because there is only a narrow crumple zone between the occupants and the vehicle crashing into them."

The Alfdorf facility is ideally equipped for the tests required during the development process. In addition to its prototype manufacturing workshop, it has an airbag lab for performing static tests relating to components. "About 1,500 times a month, we test airbags to their limits," explains test coordinator Armin Abele. "To do this, we install the airbag module in its usual position or an appropriate substitute and store it for several hours in a cold or heat chamber." Within ten seconds of leaving the chamber, the airbag is deployed so that all parts are still at the desired temperature. To analyze the results, a high-speed camera is used to record all details of the deployment and positioning of the airbag.

Lastly, airbags are tested in dynamic tests in the vehicle environment together with other technologies. The Alfdorf test facilities include two bungee units on which the test sled drives into an obstacle as well as a hydraulic unit in which the test sled is thrown backwards using a hydraulic cylinder. The crash test dummy has come through all of those collisions completely unscathed - thanks to the airbags.
They represent one of the company’s great success stories: ZF has been manufacturing automatic transmissions for half a century. A four-wheel journey back through time.

By Andreas Neemann
Photos: Detlef Majer

The car reeks of old upholstery, auto work-shops and worn rubber, with a sweet-sour hint of gasoline. Climbing into the 1967 BMW 2000 C and starting up the engine is like stepping back into an earlier age. You won’t find any power-assisted steering or braking in this old timer, and you can forget about air conditioning. But one thing still works surprisingly well – the action of the three-speed automatic transmission.

Inside the 2000 C you’ll find the 3HP, the first multi-ratio automatic transmission for cars, brought to market by ZF exactly 50 years ago. To smooth the company’s entry into the automatic car transmission business, ZF sought out a partner, striking a deal with Borg-Warner – then one of the largest U.S. car transmission manufacturers – in 1970. But the American company abandoned the joint venture after just two years. ZF soldiered on, making further investments in the Saarbrücken production facility and Kressbronn R&D unit all on its own.

It was a courageous decision that ultimately ended in success. Today, automatic car transmissions are one of ZF’s main revenue generators and one of the company’s most popular product groups, as confirmed by a quick glance at the figures. The entire annual production of 3HP transmissions in 1975 – a total of 43,000 units – could now be manufactured by ZF’s Saarbrücken plant in less than a week. Around 10,000 complete 8HP units leave the production plant every day. This means the facility is producing more than 2.5 million finished transmissions every year.

This long-term success is also due to the many innovations introduced by ZF since 1965. Conceptually, modern transmissions are still comparable to those earlier units, as indicated by the ZF nomenclature, which has remained consistent from the 3HP to the 9HP. Engine power is transferred to the transmission by a hydrodynamic torque converter (signified by the letter H). Within the transmission, the necessary gear
“In 1978, electronic components were regarded as too vulnerable to use in hardworking transmissions. Nowadays, they’re indispensable.”

Georg Gierer, former Head of Development for Passenger Car Transmission Electronics

“With the 8HP, for the first time we succeeded in putting all planned sizes into production simultaneously.”

Dr. Albert Dick, Head of the Passenger Car Transmission Standard Model Series

To watch an online video showing the cars on these pages in action, visit: www.zf.com/50yearsATvideo

Scan this code to view the video.

Faster gearshifts: since the second-generation 6HP, ZF automatic transmissions have been more agile than manual transmissions – attractive in sportier vehicles like the BMW Alpina B3 GT3.

Extraordinary variety of applications: thanks to its modular design, the 8HP transmission is even used in high-powered sedans like the Maserati Quattroporte (top right) and supercars like the Jaguar P-Type R (right).

Around 10,000 8-speed automatic transmissions a day in 400 different variants.

In 2013, ZF further expanded its range of transmissions by adding the 9HP, designed for cars with front transverse engines like the Range Rover Evoque.

With the 8HP, for the first time we succeeded in putting all planned sizes into production simultaneously.

Dr. Albert Dick, Head of the Passenger Car Transmission Standard Model Series

Extraordinary variety of applications: thanks to its modular design, the 8HP transmission is even used in high-powered sedans like the Maserati Quattroporte (top right) and supercars like the Jaguar P-Type R (right).

5HP

6HP

9HP

steps are produced by planetary gearsets (represented by the letter P). But with each new generation, the company has made its automatic transmissions more fuel-efficient, more responsive, more versatile in terms of functionality, and more individual in terms of shifting behavior. To do so, the company has taken many different approaches – starting with the torque converter, that was first paired with a lock-up clutch in the 4HP. Since then, ZF has steadily reduced the time required to transfer engine power using fuel-intensive hydraulic methods. The 4HP also saw the first appearance of electronics: software was used to define the transmission’s shifting points more precisely, improving shift quality. This improved even more as onboard networking was introduced. The 5HP unit was capable of adjusting its shifting behavior in response to driving resistance – modern transmissions also adapt to match individual driving styles.

Shift programs and certain components vary from one customer to another. So today, each 8-speed automatic transmission is a little different, depending on which carmaker is using it, which engine it’s combined with, and whether it’s driving a sedan, an all-wheel-drive SUV, a sports car or a hybrid. ZF designed this versatility into the 8HP from the start. The modular concept – fruit of early-stage collaboration between development engineers and production specialists – is the reason why ZF in Saarbrücken can now produce around 10,000 transmissions a day in 400 different variants.

Fifty years ago, North America was regarded as the pioneer of automatic transmissions for cars, ZF as a latecomer. Today, ZF is setting the technical benchmarks. U.S. demand for ZF transmissions has risen so rapidly that in 2013, the company built a transmission plant in Gray Court, South Carolina. The plant now produces the latest ZF automatic transmission, the 9HP, developed for vehicles with front transverse engines – the world’s fastest-growing market segment. Opening yet another chapter in the success story.
Fun for all the family — around the world, Family Days give employees an opportunity to show their families where they work.

Socially engaged employees are traveling to other ZF locations so they can compare notes with colleagues there. Outside working hours, their personal missions range from developing the infrastructure of a group of South Pacific islands to building schools in the Caribbean, or giving foster children a stable home.

To celebrate ZF’s centennial, the company has organized a variety of hands-on activities. The aim is to thank employees while also encouraging more mingling, sharing and networking around the world.

An interactive portal connects employees around the world, acting as a platform for news, information and dialog, and for sharing photos and other content.

"My photo with the Big 100!" Employees have been taking photos of each other in front of ZF’s man-high "Big 100" sculpture. The result: a collection of witty, creative images from around the world, reflecting loyalty and solidarity.

ZF memories: a ZF game, a commemorative plate awarded for years of service and a belt buckle with the ZF logo were among the finds made and photographed by employees.

"One global ZF" is the slogan for the many celebrations of the company’s 100th Anniversary taking place throughout 2015 — celebrations focused on encouraging global exchanges between ZF employees. A number of employees with unusual life stories are touring ZF locations around the world, making contact with a wide range of colleagues. Participants in various hands-on activities such as "My photo with the Big 100!" and "ZF memories" are also winning trips to other ZF locations. The company aims to give as many employees as possible the opportunity to experience "one global ZF" for themselves — at first hand, in person.

Family Days are a well-established ZF tradition, enabling ZF employees to show off their workplaces to their families. This year, they all share a common theme: the ZF centennial, offering ZF sites yet another opportunity to compare notes. And a dedicated intranet set up especially for the Anniversary is acting as a platform for virtual dialog between employees. "This is our way of saying thank you to our employees for making the company what it is today. By organizing these activities, we also hope to encourage cross-border exchanges between all parts of ZF, promoting international knowledge transfer and ultimately benefiting our customers," explains Corporate HR Director Jürgen Holeksa.

Alongside these activities, the company is also using the Anniversary year to write up its history. Two books (History in Motion and Technology in Motion: 100 Years of ZF) tell the story of the company and its technologies. Both titles can be purchased in bookstores or online.

For more on the history of ZF, visit: www.zf.com/100years
Shanghai is choking in traffic. The Chinese megacity needs a smart transport mix and a better infrastructure – and in the near future, so will many other metropolitan areas.

Jieson Zhang’s greatest joy in life is currently his red Mercedes. Every evening, he leaves his office in Shanghai’s Lujiazui financial district at around 6:00 p.m., climbs into his new car and sets off on his homeward journey. He has been a proud car owner for the last three months. So far, the fact that he spends a large part of his journey stuck in traffic jams hasn’t bothered him much. The first stage of his journey is the worst – it takes Zhang a good 20 minutes to reach the tunnel that connects the Pudong district with Puxi, the historic center of Shanghai. His actual office is located about half a mile from the entrance to the underpass. Zhang is 27 years old and has a good job with one of China’s largest financial services providers. He’s also studying at Fudan University in Shanghai. He doesn’t use his car to travel anywhere else. “I drive to work, and at weekends I drive to university,” he says.

Zhang has finally left the tunnel and is turning onto one of Shanghai’s famous skyways. In some parts of the city, up to five of these eight-lane urban expressways are stacked one above the other. The skyways are spectacular at night, when they’re all lit up in blue. Now, however, it’s early evening, and they’re weighed down by what looks like an endless, slow-moving metal caterpillar. The expressways were originally built as a guarantee of mobility. Today, the city elders prefer to rely on developing the subway system.

It takes Zhang about 40 minutes to reach his destination. A security guard waves him into the parking lot while pedestrians and motorcyclists squeeze past his car. When Zhang was still a schoolboy, there were practically no cars in the city. “The only vehicles in the streets were bicycles and taxis,” he remembers. “And a taxi ride was extremely expensive.” Nowadays, Shanghai is positively overflowing with new cars. Over the last 20 years, China has grown into the world’s second largest economy. A good thing for the hundreds of millions of Chinese who have become relatively prosperous. For the new middle classes, having your own car is the most visible proof of success. One of the big winners is Germany’s auto industry, which has set a string of annual sales records in the country. This year, car sales in China are expected to climb to nearly 20 million. German carmakers are especially popular. But there’s a downside: because the infrastructure can’t keep up with this explosive growth, China’s cities are starting to choke up with traffic. The problem is worst in Beijing, where residents spend on average nearly two hours every day sitting in stationary vehicles.

Escaping from urban gridlock
China is a country rich in superlatives, and in August 2010, Beijing was able to add yet another. Traffic in the northwest of the nation’s capital came to a standstill for nearly five hours between 5:00 p.m. and 10:00 p.m. A security guard waves Jieson Zhang into a parking lot. Text: “It’s extremely hard to get a license in Shanghai. You need a lot of money, plenty of luck and a high-speed internet connection.” Photos: Jan Siefke
High-speed urbanization is the main reason for this trend. By 2012, for the first time in the country’s history, more Chinese were living in cities than in the countryside. Shanghai and Beijing have doubled their populations in the last 20 years: 24 million people now live in Shanghai, 21 million in Beijing. This migration is politically desirable and for the most part, happening in an orderly manner. Even though many of the residents of Shanghai or Beijing live in cramped or impoverished conditions, China doesn’t have slums like those in Africa and Latin America. Today, more than 160 cities in the People’s Republic have populations in excess of one million. It’s the largest urbanization movement in human history – and it’s not yet over. Over the next 20 years, another 300 million Chinese farmers are expected to become new city dwellers. This will pose enormous infrastructural challenges to the cities in which they settle.

### Largest urbanization movement in history

By 2010, there were already 4.8 million cars on the streets of Beijing. In Shanghai, by contrast, there were only 3.1 million. Some 38 percent of all households in the capital owned a vehicle, whereas in the same year, the equivalent figure in Shanghai was just 18 percent. According to a study by Jinhua Zhao at the MIT Department of Urban Studies and Planning, the main reason was Shanghai’s early decision to impose limits on the number of new vehicle registrations. Beijing only started using this tactic for the 2008 Olympic Games. “Shanghai had less money available at a much earlier stage,” explains Haixiao Pan, Professor of Urban Planning at Tongji University. “This meant that the metropolitan area couldn’t expand as quickly, so people had to make better use of existing structures.”

Even today, the two cities still follow different transport policies. Although Jieson Zhang has owned a car for three months, he still doesn’t have a license plate. “It’s seriously difficult to get hold of one,” he complains. “They’re expensive, plus you need to be lucky, and you also need a fast Internet connection.” To win these online auctions, you need quick reactions – it’s almost impossible using a conventional web browser. So Zhang has commissioned an agency to bid for his license plate. Together with the agency service, the bid is costing him 80,000 yuan – over 11,000 euros. He’s allowed to drive without a license plate for another three months, but after six months he can expect to pay a fine if he’s noticed by the police.

In Shanghai, a combination of lottery and auction determines who gets a license plate; in Beijing, by contrast, it all comes down to the luck of the draw. Surveys suggest that most citizens think the Beijing system is fairer. But the Shanghai approach does make the city a lot of money, which is reinvested in the public transport system. In 2012, the total was 6.7 billion yuan – almost one billion euros. So Shanghai now has 340 miles of subway track – the world’s largest subway network, embracing 14 lines and 337 subway stations (at 327 miles, Beijing’s subway network is slightly shorter). The first station was opened in 1993, then the subway system was massively extended prior to Expo 2010. By 2020, the city is planning to add four new lines and extend the network to around 500 miles.

Youlu Liu is one of eight million passengers who travel on the Shanghai subway every day. The 25-year-old works as a copy editor on a fashion magazine in Shanghai’s old city center. Every day, Liu spends around 45 minutes traveling on the subway. Her homeward journey starts at the East Nanjing Road station in the historic city center, which serves subway lines 2 and 10. The next station is People’s Square, one of the city’s major transportation hubs. The crowds are just as dense as you might imagine. In other countries, you hear public announcements like “Please allow passengers to alight before entering the car”; in China, this custom doesn’t apply.

\[\text{GLOBALIZATION}\]
While Shanghai has the largest subway system in the world, subway cars are still overcrowded during the morning and evening rush hours. "Sometimes I smell of ten different men," complains the petite Liu. Because she doesn't have to start work until around 10.00 a.m., she tries to avoid peak hours – often in vain. After a 20-minute ride, Liu changes lines at Hongqiao Road and travels the last two stops back to her apartment. But she has no intention of buying her own car. "You just spend your whole time sitting in traffic jams," she explains.

Possible solution: car sharing?

For the last few years, China's cities have also been experimenting with public bicycles. These were pioneered by Hangzhou, a city located about 95 miles southwest of Shanghai, which introduced a cycle-sharing system in 2008. Beijing and Shanghai followed Hangzhou's lead. China was once famous as a country of cyclists. Despite this – or maybe precisely because of it – you very rarely see cyclists on the streets any more. Electric bikes and electrically powered motorcycles have replaced traditional bicycles. Around 200 million Chinese now use these silent two-wheelers for their journeys. But even that isn't an option for Liu. It's all about image: electric bikes are mainly used by migrant workers and poor people. In a society as sensitive to social distinctions as modern-day China, this is a definite turn-off for the young, upwardly mobile middle classes. Car-sharing projects are somewhat more promising. Since the start of this year, for example, a company called car2go has been hiring out Smart cars to drivers in the megalopolis of Chongqing in central China. A joint venture between Daimler and Europcar, car2go hopes to extend the project to cover other cities. And the city of Wuhan, on the Yangtze River, has launched carpooling projects, encouraging residents to share one car among multiple travelers.

Traffic jams: a costly indulgence

But there's no miracle cure. "To bring the traffic problem under control, China's cities must combine all of these methods," explains Professor Haixiao Pan. Even so, neither the restrictions nor the incentives imposed by the city were enough to dissuade young banker Zhang from buying his own car. He paid out 378,000 yuan for his red Mercedes – more than 50,000 euros. Then there are the daily parking charges. "I try to be in the office by 7.30 a.m. every day – that means I get a cheaper parking slot." But even the cheap slots cost four euros a day; he pays slightly less to park in front of his parents' house in the evenings. Like many young Chinese, the 27-year-old still lives with his parents. Having his very own car takes precedence over travel and other luxuries. For Zhang, the Mercedes is – above all else – the sign that he's made it. "Cars are the number one status symbol," confirms Professor Haixiao Pan. But if this status symbol is to become more rather than less meaningful in the future, cities will need to make some intelligent investments in transport infrastructure.
From the standard transmission to the modular TraXon transmission system: for 90 years, ZF has used various strategies to lead the field in commercial vehicle transmissions.

yesterday

The mass motoring trend of the 1920s confronted ZF with a new challenge: to produce transmissions for an explosive proliferation of different vehicle models. But instead of building a wide variety of transmissions, ZF focused on developing a single product that satisfied all the driveline performance and assembly requirements of the time, launching the standard transmission in 1925.

and today

The TraXon automatic transmission system is based on the modular design concept. The basic transmission can be combined with five different starting elements, making it suitable for a wide range of applications. The new system also features a predictive shifting strategy to further reduce fuel consumption.

Award-winning corporate communication
ZF’s media efforts were recently honored with another Best of Corporate Publishing award. At the awards ceremony in Munich this summer, the company’s multi-channel communication through customer magazines, drive employees newspaper ZFnews, the online magazine at we›move.zf.com and ZF’s social media channels won the “Best Crossmedia Solution” Gold Award in the Automotive category for the second year running.

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From the early days of Zeppelin transmissions and the first automatic transmission for cars through to state-of-the-art trucks that can be parked by remote control: *Technology in Motion* tells the full story of ZF technologies and developments. The companion volume, *History in Motion*, covers the company’s entire 100-year history in chronological order. Together, these two richly illustrated volumes, each with over 260 pages, bring the company’s greatest achievements and most challenging moments vividly back to life. Both books can be purchased through Amazon (*Technology in Motion* will appear on September 14). In Canada, Mexico and the U.S. the books will be available from the end of October.