

# VISION

## Shaping SMART LOGISTICS

.....  
**AUTONOMOUS VAN**

Mastering the last mile with innovative ZF technology

.....  
**FORMULA E EVERYWHERE**

How ZF is bringing electric drives to all vehicles



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Freight transport is rapidly increasing worldwide. More and more freight and delivery vehicles are clogging up city streets. The logistics system as we know it is threatening to collapse. Improved interconnectedness could be the answer to significantly improving efficiency.

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Logistics service providers deliver billions of shipments annually. An autonomous concept vehicle developed by ZF is revolutionizing the “last mile” to the benefit of both drivers and customers.

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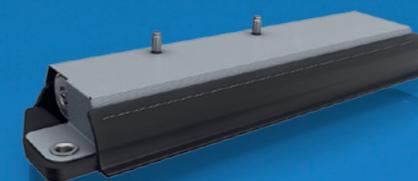
# ZF HIGHLIGHT

# Innovatively Lightweight

**A KNEE AIRBAG IN A FABRIC HOUSING? INDUSTRY EXPERTS SAID IT COULDN'T BE DONE. BUT THAT'S PRECISELY WHAT ZF WILL BE BRINGING TO VOLUME PRODUCTION IN 2019.**

The heavier a vehicle is, the higher its emissions under combustion and the lower its range under electric power. All the more reason to minimize the weight of individual components. ZF's new knee airbag is much more than just a standard improvement in this respect. At just 700 grams, the module weighs some 30% less than comparable products. So how did we do it? A world first: the airbag housing is made of fabric instead of metal. The concept can be adapted to the needs of any market or vehicle model. Yet another advantage is that it requires around 20% less installation space. So it's not just the lightest in the industry, but also the most compact. In early 2019, a major European manufacturer will be starting volume production of our fabric airbag module.

*The ZF knee airbag is the lightest and smallest the industry has ever seen.*





# Smart logistics is the way forward for mobility

**ZF IS WORKING RESOLUTELY TO ENSURE THAT ITS SYSTEM SOLUTIONS ARE FULLY NETWORKED, AND TO PLAY A MAJOR ROLE IN SHAPING THE FUTURE OF MOBILITY THROUGH DIGITALIZATION.**

Am I the only one who gets riled by double-parked delivery vehicles blocking the street and causing jams? I see it all the time. And the couriers are just as stressed out. Time is short, and parking space is a rare commodity, so it's no wonder they resign themselves to annoying other road users and just pulling up wherever they can. And last but not least, logistics companies themselves are battling to solve this issue of the last mile. Looking for parking spaces and constantly getting in and out of the van slows down deliveries and consequently drives up costs.

Fortunately, I can promise you that next-generation mobility will make this scenario a thing of the past. So what is ZF doing about it? We're applying our unique system expertise to deliver high-precision smart logistics solutions so that, for example, a delivery vehicle can look for its own parking space, or can follow couriers as if on a virtual leash while they make deliveries on foot.

It's no coincidence that we're making great strides in autonomous driving features specifically for commercial vehicles. My view is that we'll see early adoption of these in manageable areas like depots or specially designated downtown zones.

We'll be exhibiting many more exciting innovations at this year's International Motor Show. But these are not just a vague promise: we're already delivering next-generation mobility products. Read on for a taste of what is, and what's to come!

**Wolf-Henning Scheider**  
Chief executive officer  
ZF Friedrichshafen AG



ZF MOMENT

# Heavyweights on the water

Towboats and barges are a common sight on US inland waterways. According to the American Waterways Operators industry association, 60 percent of US grain destined for export is transported this way. A typical "tow," which consists of 15 interconnected cargo barges, transports the same volume of cargo as 1,050 large semi-trailer trucks. Our photo shows the 23-meter long, 11-meter wide American Power on the Ohio River. Two 360°-steerable azimuth thrusters (series 5000) from ZF propel this American Commercial Barge Line tugboat, providing maximum maneuverability. Not only do thrusters boost safety on the winding river, their efficient design also ensures lower emissions, providing the same thrust as conventional shaftlines, but with a smaller engine size.

facts and figures



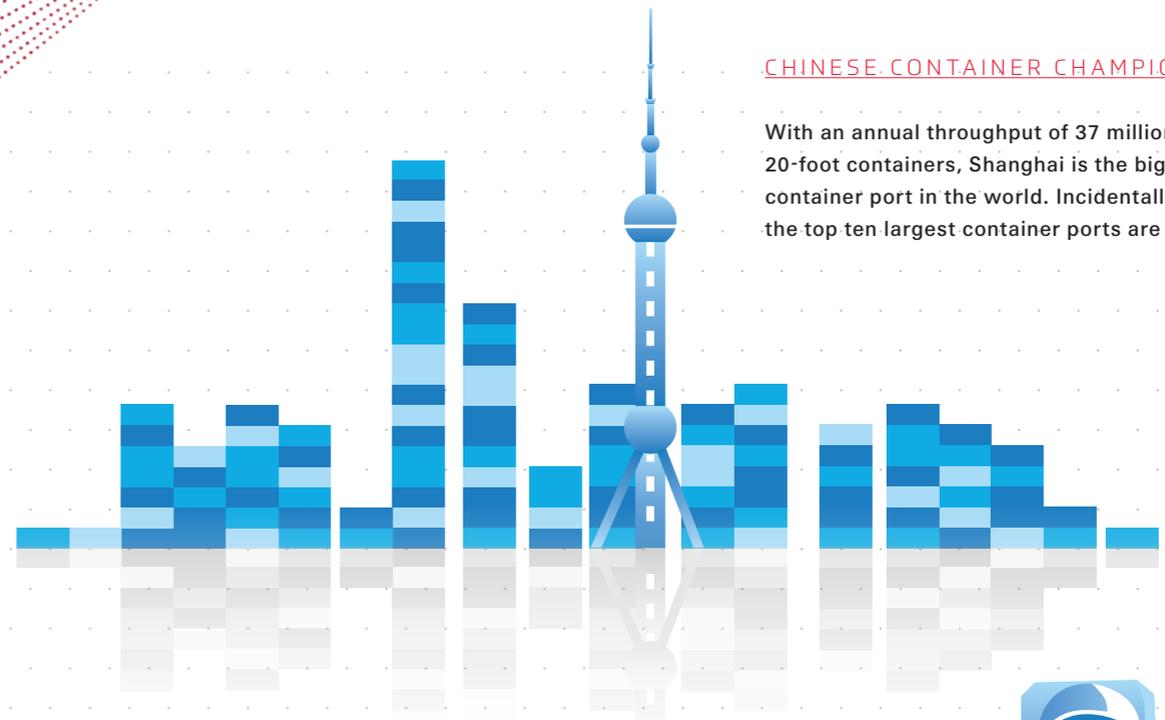
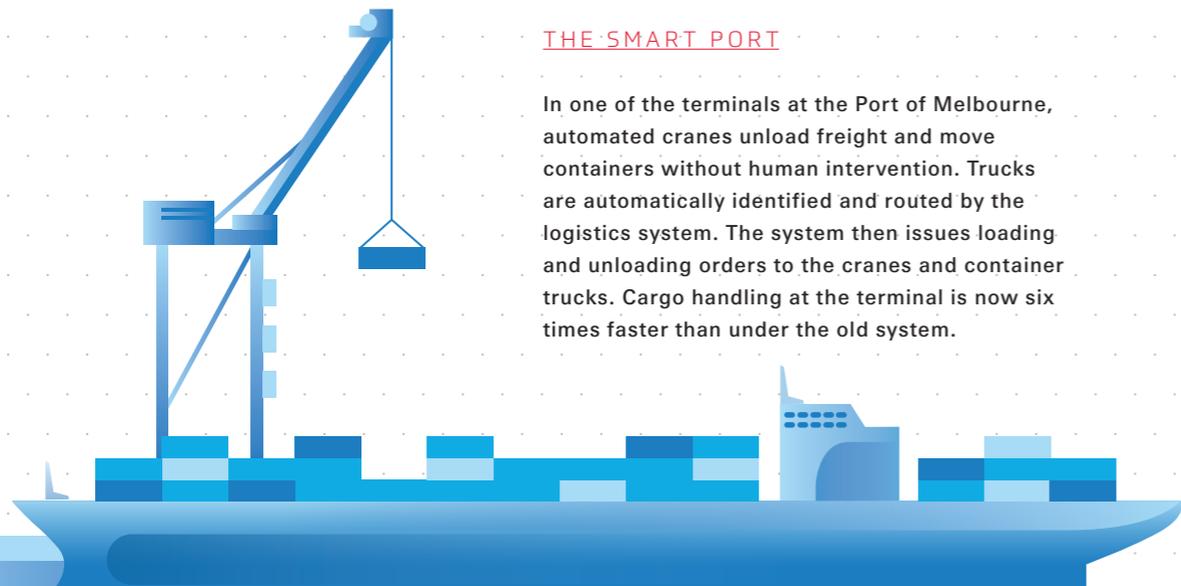
# Logistics

## Right place, right time

BEHIND EVERY TIMELY DELIVERY OF GOODS LIES A SOPHISTICATED SUPPLY CHAIN. READ ON FOR SOME INTERESTING AND CURIOUS FACTS ABOUT LOGISTICS.

### THE SMART PORT

In one of the terminals at the Port of Melbourne, automated cranes unload freight and move containers without human intervention. Trucks are automatically identified and routed by the logistics system. The system then issues loading and unloading orders to the cranes and container trucks. Cargo handling at the terminal is now six times faster than under the old system.

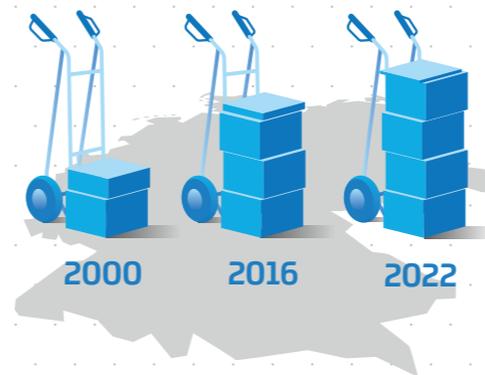


### CHINESE CONTAINER CHAMPION

With an annual throughput of 37 million standard 20-foot containers, Shanghai is the biggest container port in the world. Incidentally, six of the top ten largest container ports are in China.

### PARCEL BOOM

In 2016, Germany's courier, express and parcel (CEP) services delivered around 3.16 billion shipments; that's over 10 million per delivery day. Volumes have doubled since 2000. The German Association for Mail and Express Logistics (BIEK) estimates that annual volumes will reach approximately 4.15 billion by 2021.



### ASTRONOMICAL PRICES

Supplying another celestial object is a very particular kind of logistical challenge. First, it requires enough fuel on board for the whole journey; and second, there's no "roadside assistance" in space if something breaks down. As you'd expect, the prices are equally astronomical: sending a kilo of freight to the moon currently costs in the region of \$41,000.

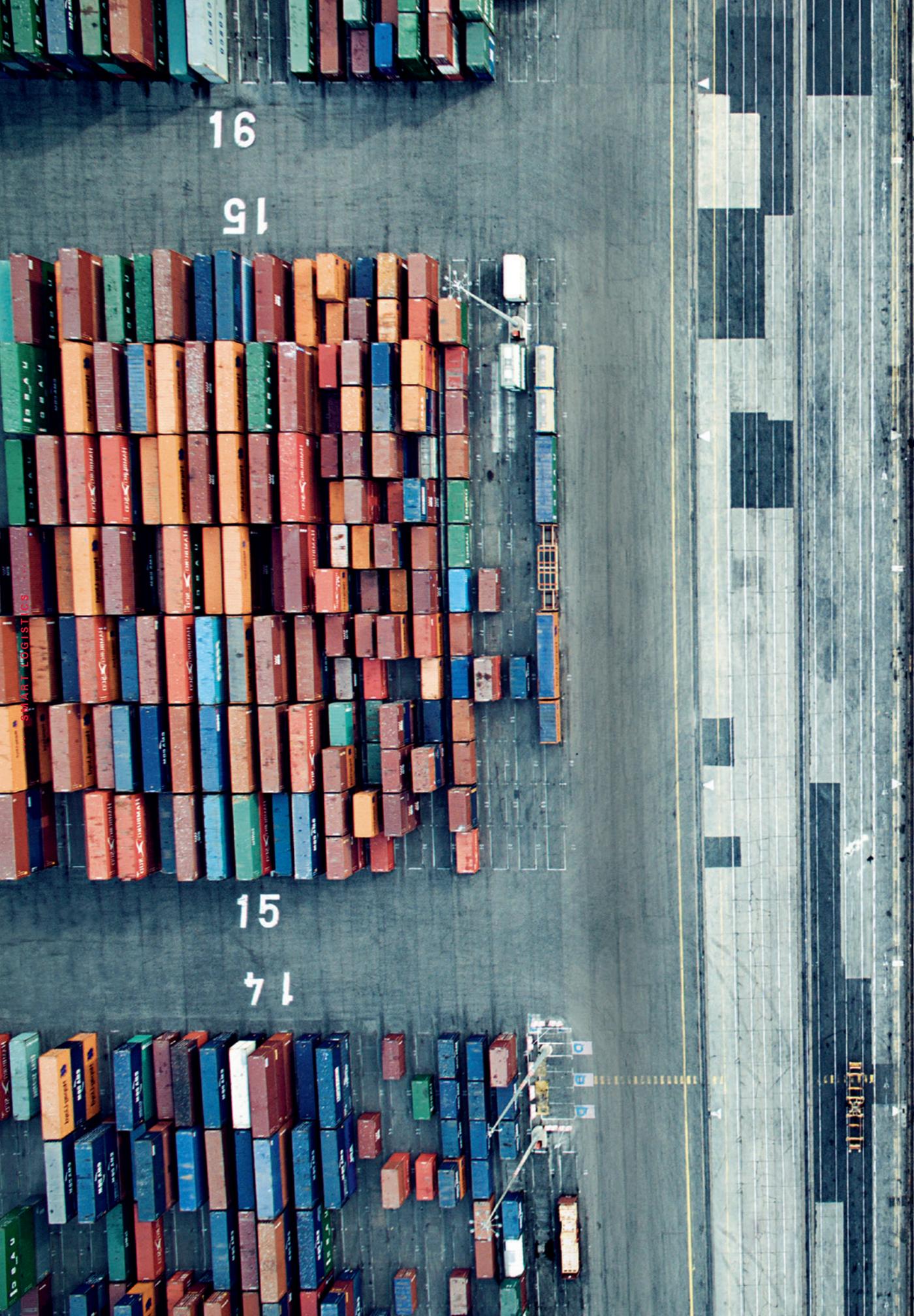


### LOSSES WITH A HEAVY PRICE

Around a third of all foodstuffs produced in the world never actually reach consumers; they perish during storage, transport or processing. Modern technologies like condition monitoring are critical in reducing these losses, for example by promptly flagging up breaks in the cold chain.



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# Time for a reboot



FREIGHT TRANSPORT BY LAND, SEA AND AIR IS RAPIDLY INCREASING WORLDWIDE. MORE AND MORE GOODS VEHICLES ARE CLOGGING UP CITY STREETS. THE LOGISTICS SYSTEM AS WE KNOW IT IS THREATENING TO COLLAPSE. BUT EXPERTS ARE OPTIMISTIC THAT BETTER INTEGRATION COULD BE THE ANSWER TO IMPROVING EFFICIENCY SIGNIFICANTLY.

*Text: Martin Westerhoff*

The roar of a Boeing 747 cargo freighter briefly shattered the surreal silence that had reigned over the ports of Los Angeles and Long Beach for days. The pilots were headed for Japan. Below them, tens of thousands of sea containers were stacking up on the ground. And the plane's cargo? Ton upon ton of frozen French fries.

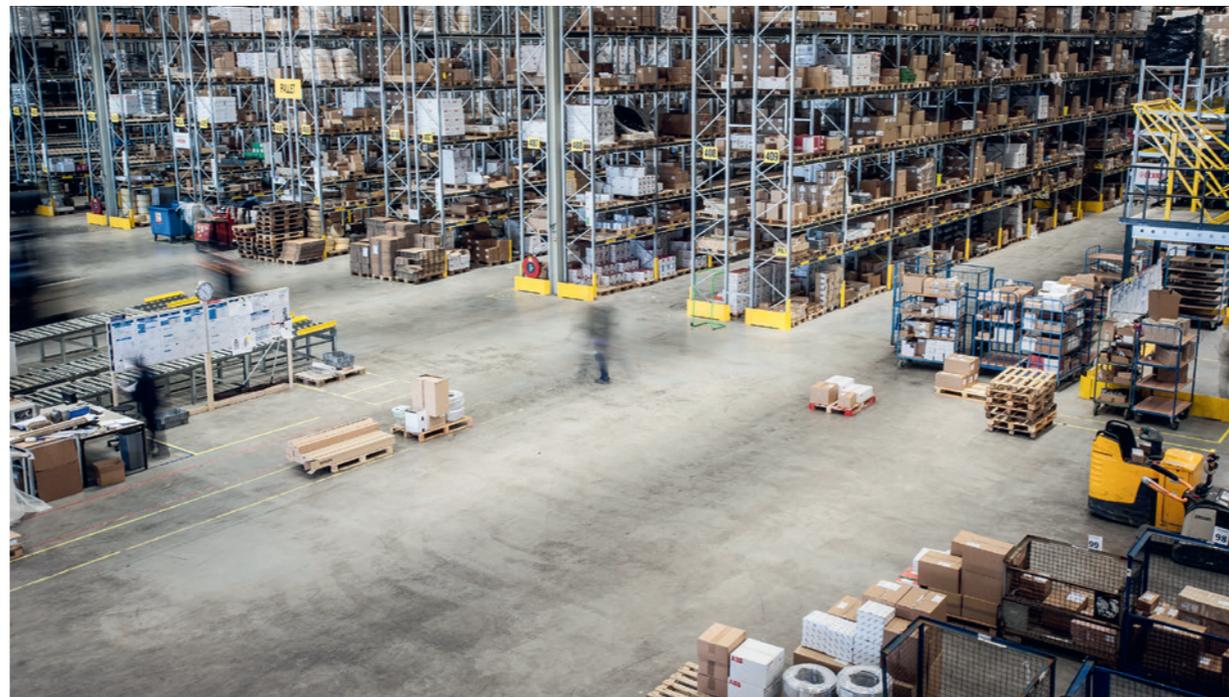
Seriously? Flying fries to Japan? It may sound downright unbelievable, but in December 2014 it became a very costly reality for one US fast food chain. At the time, the two West Coast ports were notoriously overburdened. The dockworkers went on strike, leaving restaurant managers to deal with the chaos caused by a serious shortage of the one thing a hamburger is simply not complete without. It was not just the wrath of Japanese customers – who were having their fries rationed – that was at stake. Sales had already dropped by 21 percent, and the strike threatened a further slump as well as considerable reputational damage for the fast-food chain with its 3,000-plus restaurants in Japan. Ultimately, over 1,000 tons of “flying fries” were sent to the Land of the Rising Sun as a result of the strike.

### IMPROVING LOGISTICAL EFFICIENCY THROUGH BETTER CONNECTIVITY

This anecdote shows what a tightly woven web global trade really is, and the far-reaching consequences of an interruption, let alone a break, in the logistics chain. According to forecasts by the EU Commission, road, rail and maritime freight traffic is set to increase by 25 percent between 2010 and 2030. In light of this, logistics specialists are calling for urgent action. “The logistics

system and traffic as a whole can only work efficiently if it's sufficiently well connected,” says Majid Sarvi, a professor of transport engineering at Melbourne University.

Boosting communication between the means of transportation, the goods and the infrastructure is among the core tasks of a new discipline dubbed “smart logistics.” Smart logistics aims to help meet the challenges posed by a growing number of unknowns and an increasingly complex transportation chain. The transportation chain is made up of the collection



Logistics centers and warehouses have a long way to go in terms of efficiency. Intelligent solutions are the answer.

## STREETS IN DIRE STRAITS

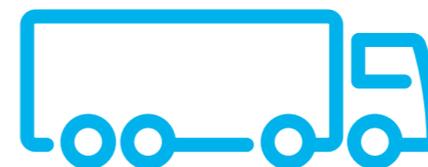
According to an OECD survey, international road freight transportation grew by 96.12 percent between 2001 and 2015. Across the 47 countries in the sample, haulage capacity rose from roughly 7 trillion ton-kilometers (tkm) to over 14 trillion. A ton-kilometer is a unit of measurement obtained by multiplying the volume transported by the distance traveled to deliver it.

2001



7.165 TRILLION TKM

2015



14.050 TRILLION TKM

chain (the “first mile”), the transit chain and the delivery chain (the “last mile”). The Department of Industrial Engineering and Innovation Sciences at Eindhoven University of Technology has defined the intricacy of this challenge in no uncertain terms. According to the Dutch researchers, smart logistics implies synchronizing four domains: a logistics system only works efficiently if scheduling, ICT, personnel and legislation are well aligned.

### INTO THE UNKNOWN

This system can very easily get out of step, requiring rapid intervention. A case in point is the scenario playing out since late May 2018 in Hamburg, the first German city to ban non-Euro 6 diesel vehicles from two of its streets. “Bans inevitably drive change. This shows just what a hot topic the last mile is,” warned Professor Uwe Clausen of the Fraunhofer Institute for Material Flow and Logistics (IML), speaking at the first courier, express and parcel services industry conference (CEP), which was staged last year by German publisher EuroTransportMedia (ETM) with ZF's support.

### UNDER THE SPOTLIGHT: THE LAST MILE

A host of current logistics developments and innovations are focused on the last mile along with upstream transfer from the transit chain – so not just on shipping, but also on depots and warehouses. The reasons are twofold. First, the rapidly accelerating pace of the mail-order business; and second, the ongoing trend toward global urbanization. The net result is spiraling demand for deliveries to city-dwellers. According to United Nations (UN) estimates, 55 percent of the world's 7.62 billion

inhabitants are urbanites today; by 2050, that proportion will have risen to 68 percent.

According to a UN report published in May, the pace of urbanization is particularly fast in developing and emerging countries. The latest figures from China's National Office for Statistics reveal that 58.52 percent of the nation lives in urban areas. Professor George Q. Huang, chair of industrial and manufacturing systems engineering at Hong Kong University, outlines the situation in the vast economic area that takes in China, Hong Kong and Taiwan: "E-commerce in Greater China has exploded in the last few years, which means that delivery logistics are increasingly becoming a bottleneck."

# "A networked traffic system is essential for more efficient logistics."

**MAJID SARVI**

Professor of transport engineering, Melbourne University

*Long-haul transport too will benefit from networked logistics concepts.*



Indeed, more and more warehouses on various scales are springing up across mainland China to accommodate online orders. "However, they're still using old-school logistics systems that don't stand up to present and future requirements," says Huang. For example, the time from receiving an incoming order to handing over the package to a logistics company is too long. Space utilization in these logistics parks also leaves much to be desired.

## PROCESS SYNCHRONIZATION AND IMPROVED COORDINATION

"But one of the most critical factors is a lack of synchronization between the three stages – goods manufacturer to logistics park, order compilation at the park, and customer delivery," Huang laments. The institute he heads up is currently working on cloud-based solutions for a project dubbed "iPark: Core Technologies of Intelligent Ecommerce



*An everyday scenario in downtown areas across the globe: delivery vehicles obstructing traffic.*

Logistics Parks." These solutions are intended to synchronize the complex processes involved and to coordinate them more effectively. Huang also predicts a paradigm shift in automation with autonomous robotics, but its progress is currently hampered by the excessive amortization periods involved.

Professor Majid Sarvi is equally convinced that the logistics sector cannot solve the last-mile issue alone. Rather, it's about looking at traffic as a whole. "Transportation is a multimodal system made up of all means of transport, plus the infrastructure," says Sarvi. Efficiency will only improve if we can network the entire system so as to coordinate and optimize it. "The same applies to autonomous cars: they only deliver advantages if they're linked with a central data platform that monitors the whole transport business – including traffic lights and pedestrians," he explains.

## TESTING TOMORROW'S TRAFFIC TODAY

Melbourne University is running trials in an inner city area of six square kilometers to examine how this kind of smart transportation system might work. With the help of over 40 partners including industrialists, policymakers and researchers, university engineers are developing and testing communication systems for vehicle-to-vehicle (V2V), Vehicle-to-vulnerable-road-users (V2P) and vehicle-to-infrastructure (V2I) use. Sensors record the flow of motor vehicles, cyclists, pedestrians and public transportation in real time. This connected system is called the Australian Integrated Multimodal EcoSystem (AIMES).

"A productive transport system is essential not just for urban quality of life, but also for an economy to compete globally," Sarvi reiterates. He sums it up perfectly, and that's why smart logistics solutions are such a high priority for tomorrow's society.

did **you** know?

# Milestones in modern logistics

GLOBAL TRADE AS WE KNOW IT TODAY WOULD BE UNTHINKABLE WITHOUT CERTAIN GROUNDBREAKING LOGISTICS INVENTIONS. HERE ARE SOME OF THOSE SEMINAL MOMENTS.

1830



The steam engine, invented by James Watt in 1769, and the development of the railroads took the transport of goods to a whole new level. The turn of the nineteenth century heralded the advent of the steam locomotive, and 1830 saw the inauguration of the first rail route for freight – the Liverpool and Manchester Railway. From then on, the use of freight cars has risen steadily, and benchmarks such as the 1,435 millimeter standard gage became the norm.

1907



In 1907, with \$100 of seed capital and two bicycles, Seattle-based US entrepreneur James E. Casey founded the world's first parcel delivery service – the American Messenger Company, which would later become the United Parcel Service (UPS). Today, UPS has a fleet of 237 aircraft and 108,210 delivery cars, vans, haulers and motorcycles dedicated to delivering packages. Over 8,100 of its vehicles are powered by alternative fuels and advanced technologies.

1953



In the early 1950s, Toyota engineer Taiichi Ohno was tasked with boosting the car company's productivity. While visiting a supermarket in the US, he had a eureka moment. Today we call it the "just-in-time" concept. Ohno realized that people only purchased what they needed then and there, and that in principle a supermarket was simply a well-run warehouse. He saw that if incoming goods matched outgoing goods as accurately as possible, no long-term storage space was required.

1956



On April 26, 1956, Malcom McLean launched the world's first container ship – the Ideal X. Prior to this, he had grown the McLean Trucking Company into the second-largest freight forwarder in the US in a just few short years. He then sold 75 percent of the company and invested in ships. After a few modifications, McLean equipped the Ideal X with 58 steel boxes that were built in-house and tailor-made to fit the chassis of his trucks. Containerization was born, and has since become the world's leading method of freight transportation. Then came an invention that revolutionized logistics: the barcode. At the time, the industry paid it scant attention.

1974



But many subsequent innovations, such as automatic tracking or modern warehousing, would have been inconceivable without it. Americans Norman Joseph Woodland, George Laurer and Bernard Silver are credited as its inventors. Incidentally, the very first barcoded product, scanned on June 26, 1974 by a cashier in Ohio, was a 10-pack of gum.



... SMART LOGISTICS ...

17

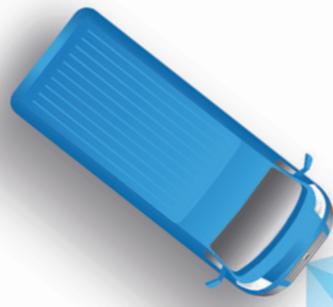
# Satisfaction included – right to your door

LOGISTICS SERVICE PROVIDERS DELIVER BILLIONS OF SHIPMENTS A YEAR. A NEW ZF CONCEPT VEHICLE HERALDS A BETTER WAY TO MEET THE CHALLENGES OF THE FINAL DELIVERY STAGE, KNOWN AS THE “LAST MILE.”

...  
*If necessary, the van drives on autonomously while the courier makes the delivery.*

Online retail is so practical. One click and your goods are on their way to your door. At least that's the theory. But in practice, the hassle often starts as soon as you get your order confirmation: the delivery deadline is etched in stone. The delivery window you're given forces you to take the day off or work from home. And far too often you still find a card in your mailbox telling you the package is waiting for collection at a package shop or has been left with a neighbor. Equally, you may find your package sitting on your doorstep, where anyone could simply walk away with it. However, it's not just those awaiting delivery who are feeling hassled. In downtown areas with a lack of parking space, delivery trucks blocking the road are a common sight. According to a study by auditing and consulting firm PwC, goods traffic is responsible for 80 percent of rush-hour jams in the city. The study's authors also found that one in three Germans is unhappy with their package deliveries.

*Text: Kathrin Wildemann*



You want to see the ZF Innovation Van in action? Just scan the QR code and enjoy the video.



Meanwhile, couriers are under extreme time pressure, often having to deal with 200 consignments a day. On average, they have barely three minutes to get to the next customer's address, park, find the right front door and hand over the package. And it's even more irritating if the recipient is out and they have to try again later. ZF has the technology to make life easier for both parties: a driverless van with an intelligent delivery system that networks the package, the courier and the recipient.

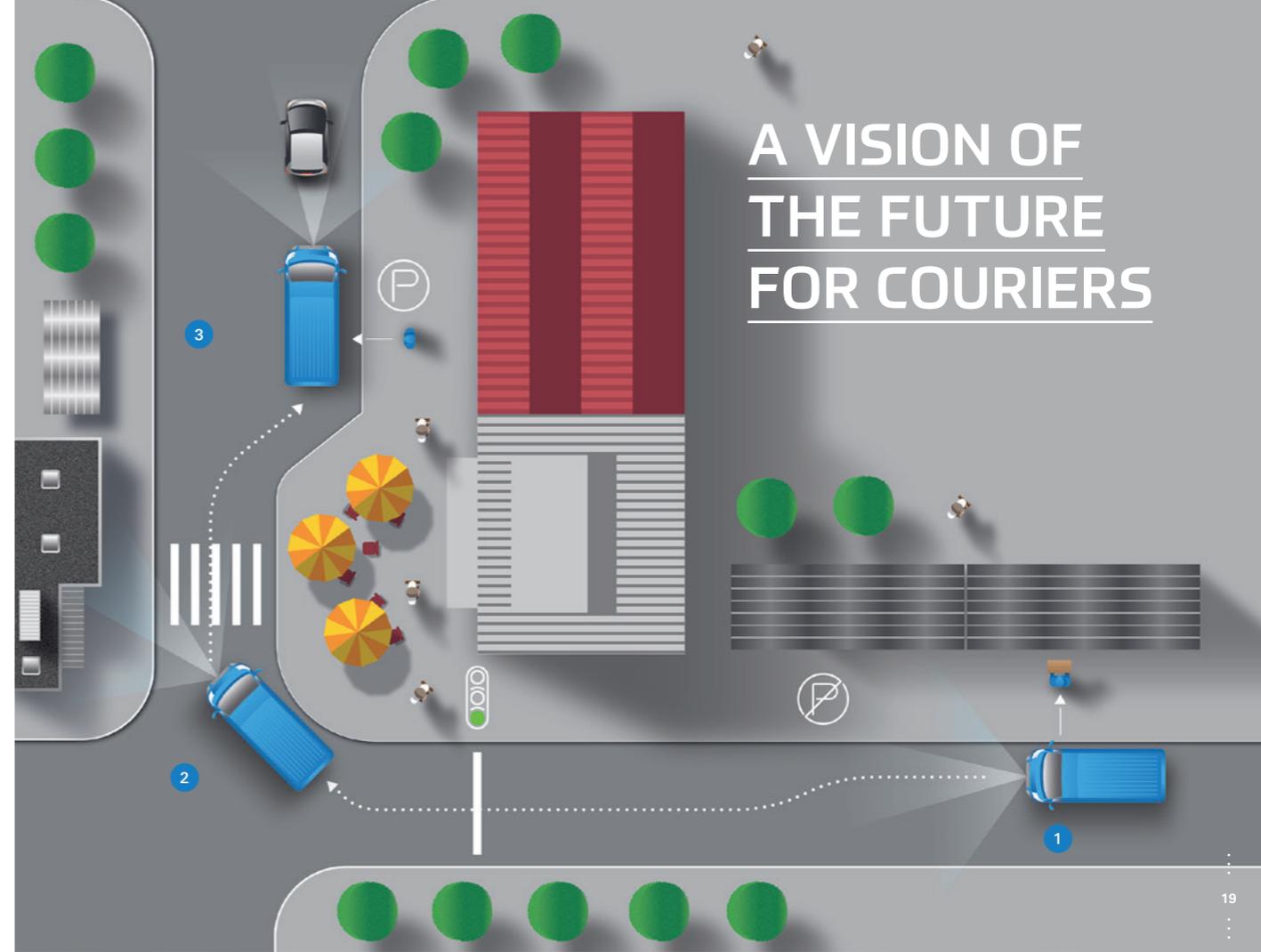
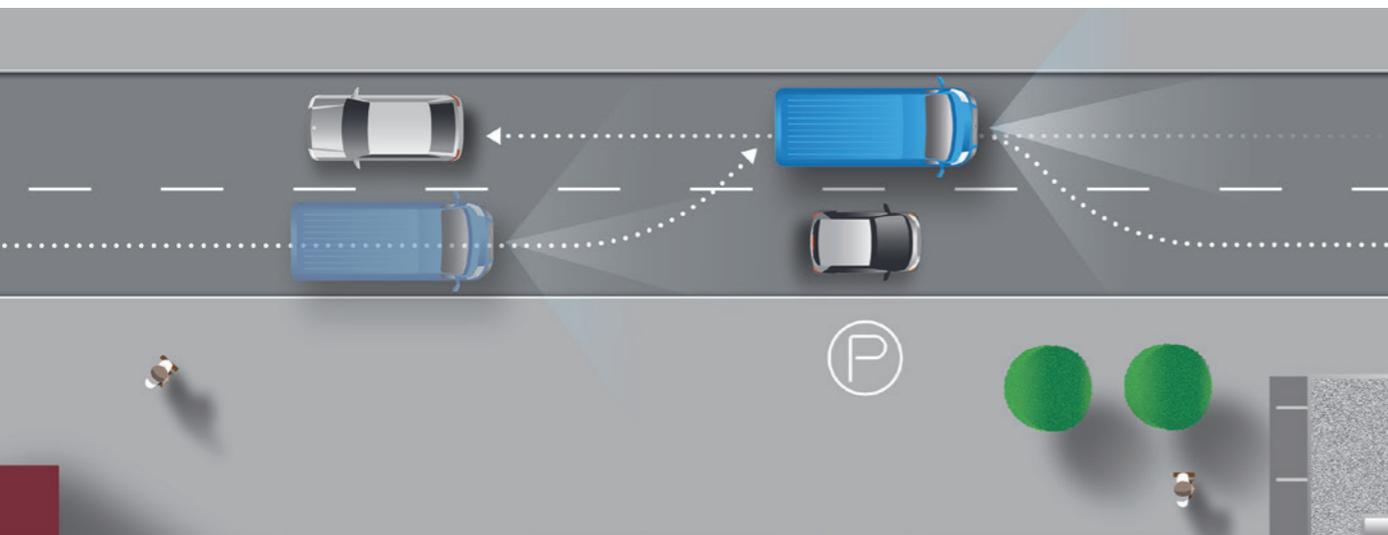
The ZF Innovation Van finds the most efficient delivery sequence at any given time, using a cloud-based support system that stores relevant data for each consignment, such as delivery location and preferred timeslot. "The package practically finds its own way there," Georg Mihatsch, the project manager who oversaw development of the ZF Innovation Van, explains.

### TAKING THE STRAIN OFF DRIVERS

What's more, customers can use an app to track where their package is at any time as well as to enter or change their preferred delivery time and location at short notice. The system then calculates a new route in real time. Obviously, it takes account of the current traffic situation and predicts the delivery window reliably. All of this data converges in the ZF cloud, which in turn sends it to couriers via data glasses, allowing them to prepare en route for the next delivery while the smart van does the driving.

The vehicle's camera, radar and LIDAR systems map its surroundings in the form of a data cluster, and the AI-capable ZF ProAI central computer converts this to instructions for the chassis, steering system and drive actuators. As a result, the van steers itself safely and independently

While the courier delivers the package, the van drives on autonomously and finds itself a parking spot.



# A VISION OF THE FUTURE FOR COURIERS

1

The van stops in a no-parking zone. The courier hops out with the consignment.

2

While the courier is on the way to the customer's door, the van slips back into the flow of traffic and looks for a suitable place to stop.

3

The data glasses relay the location to the courier, who gets back in where the van is parked.



through even the most labyrinthine city traffic. But what about the blocked streets? We thought of that too. So if there's no parking space at the delivery address, the Innovation Van drops off the driver and looks for a suitable place to stop. This means that couriers can focus on their job – delivering packages to customers, who in

turn receive their goods right on time. It goes without saying that as a technology company working to shape the future of mobility, ZF always factors in environmental impact. Courtesy of a central electric axle drive, the ZF Innovation Van is not only pollution-free, but also quiet and therefore resident-friendly.



“Our smart, networked innovation vehicles optimize the logistics chain.”

**MARK MOHR**  
Head of ADAS Project Center

The systems-integration capable ReAX truck steering system and the TraXon automatic transmission system receive steering and acceleration commands direct from the control electronics.

The ZF Pro AI is the command box in charge of it all. This unit is so powerful that it evaluates the enormous amounts of information coming from the sensors in a fraction of a second and converts it to commands using intelligent algorithms. ZF is currently involved in a variety of platooning projects with truck manufacturers.

**NEW FREEDOMS – THE AUTONOMOUS DEPOT**

Once the truck drivers reach their destination, there’s more work to do: they have to hand over freight documents at the incoming goods department, park and wait. Break time? Forget it. At any moment they may have to get back in the truck, maneuver it to the loading ramp and decouple the trailer for unloading. It’s an intricate maneuver that requires the utmost concentration. After a long haul, no breaks and yet more taxing maneuvers, drivers are often completely exhausted. Last year in Germany alone, there were 16,500 notifiable commercial vehicle work accidents that did not occur on the road, with 28 of them ending with fatalities.

Stress, fatigue and distraction don’t factor into it: the Terminal Yard Tractor shunts autonomously, safely and precisely.



The ZF Innovation Truck: drivers could park this hybrid truck on arrival at the depot and take a break while automation takes care of the shunting.



Take a look behind the gates of the depot of the future – simply scan the QR code and watch the video.

ZF’s approach is to make depot processes easier, safer and more reliable through autonomous driving, which in turn would also make them more cost-effective. ZF is demonstrating this using a coherent concept centering on ZF’s Innovation Truck, with our Terminal Yard Tractor as a shunter. “Our concept incorporates the logistics infrastructure of the forwarding agent. So we have a large part of the logistics chain in the frame,” says Mark Mohr, head of ZF’s commercial vehicle ADAS project center.

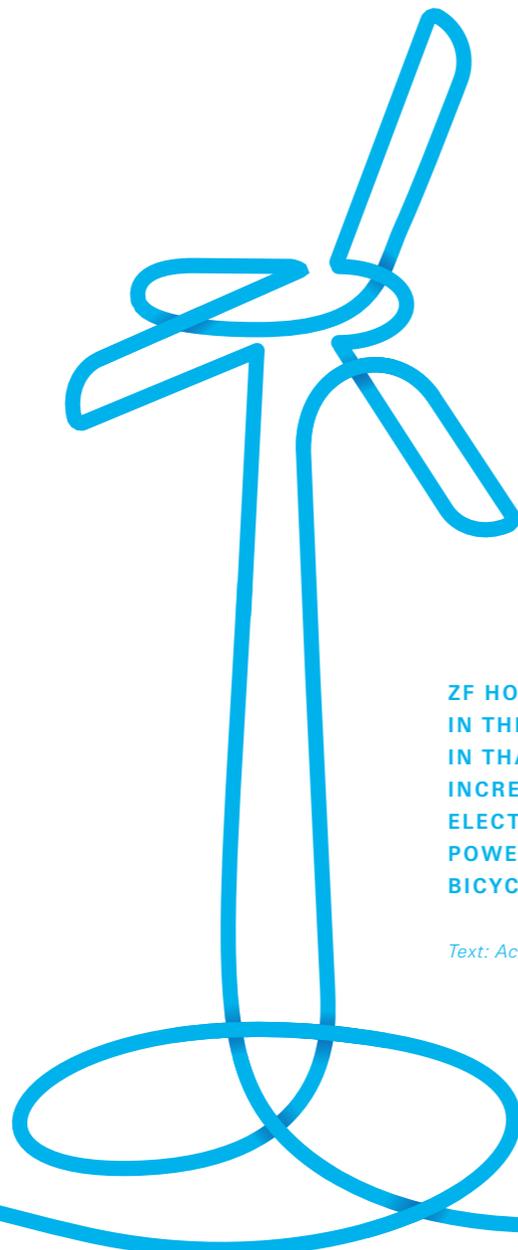
management system has the potential to make today’s standard freight documentation obsolete.

The ZF Innovation Truck can carry out lots of tasks without a driver. It finds its own way to its target position at the depot, puts down its loaded exchangeable container and picks up another container. Even experienced truckers need extensive practice and absolute concentration to inch the vehicle backwards into position under the container. More often than not, property gets damaged. But the ZF Innovation Truck consistently carries out this maneuver quickly, accurately and as safely as possible. The shunting is done by another ZF innovation vehicle, the Terminal Yard Tractor. It picks up the trailer and moves it reliably from place to place. And it can work all day, every day – even 24/7 if necessary – without any sign of fatigue.

Networked into the slipstream: platooned trucks.



# A company full of energy



**ZF HOLDS A UNIQUE POSITION IN THE MOBILITY SECTOR IN THAT WE SUPPLY AN INCREDIBLY DIVERSE RANGE OF ELECTRIC DRIVE SYSTEMS THAT POWER EVERYTHING FROM BICYCLES TO TRUCK TRAILERS.**

*Text: Achim Neuwirth*

No more panting and wheezing your way uphill, and no more hot and sticky morning commutes – pedelecs have arrived! In 2017, almost one in four new bicycles sold in Germany had an auxiliary electric motor. And thanks to ZF, sales are set to go on rising. The Group recently became one of three partners in the newly founded Sachs Micro Mobility Solutions GmbH. The kickoff for this joint venture is the production launch of drive and brake systems for pedelecs and e-bikes.

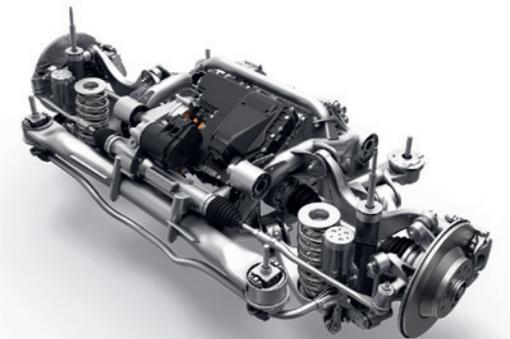
## **ELECTRONICS FOR PRIVATE TRANSPORT**

Hybrid passenger cars combine a combustion engine with an electric motor. The hybrid module used in ZF's 8-speed 8P automatic transmission supports a host of hybrid applications that make it the ideal solution. The mild version delivers up to 20 kW of extra electric power. That's not enough for purely electric driving, so we designed a plug-in hybrid version of the 8P that makes it feasible. Its electric module boasts a peak output of 90 kW and maximum torque of 250 Nm. This boost in speed makes zero-emission driving at up to 120 km/h possible over a good 50 km range, depending on the onboard battery. ZF's 7-speed dual clutch transmission was designed with a focus on combustion. But its 8-speed successor, co-developed with Porsche as a 100 kW hybrid drive right from the outset, is the opposite – a sure sign that electrically-assisted mobility is becoming the norm. A variant without an electric drive module is based on it.

ZF is also an expert in axle-based passenger car electrification. Our mSTARS (modular Semi-Trailing Arm Rear Suspension) axle system is even suitable as a replacement for conventional rear axles in existing vehicle platforms and is also equipped for the ZF eVD (Electric Vehicle Drive) axle drive module. With a peak output of 150 kW, this module lays the foundations for all-electric compact cars. Combined with a front-axle ICE drive, our electric axle drive transforms vehicles into axle-hybrids and 4x4s. In our recently unveiled concept vehicle equipped

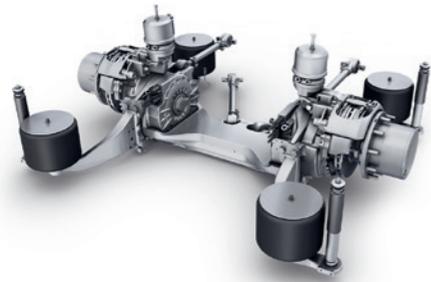


*The 8P hybrid drive combines combustion power with electric driving.*



*An electric drive integrated into ZF's versatile mSTARS rear axle system.*





with eAMT (electrified Automated Manual Transmission) it also compensates for the momentary loss of propulsion when the automated transmission shifts, providing continuous thrust.

**(ALMOST) UNLIMITED  
E-MOBILITY**

Our electric axle drive is also used as the sole drive for minibuses. For example, it provides the acceleration for the e.GO Mover people and cargo mover, which is designed for automated driving. e.GO Moove GmbH starts volume production of the vehicle in 2019. e.GO Moove is a joint venture between ZF and e.GO Mobile AG. For much larger low-floor buses, we supply the AxTrax AVE electric portal axle, formerly the ZF AVE 130. It features two 125 kW electric motors and a torque of 485 Nm. In articulated buses, it's even possible to install two AxTRAX AVEs. The drive is already operational in parts of the urban public transport fleets in Stuttgart, Mannheim and Bonn.

CeTrax is yet another system from ZF allowing all-electric driving for heavy commercial vehicles. This electric central drive boasts an output of 300 kW and a torque of 4,400 Nm. Its little brother, CeTrax lite, features a 150 kW, 380 Nm module for delivery vans and other light commercial vehicles weighing up to 7.5 tons. CeTrax mid is a dual package with two 150 kW modules for medium-duty commercial vehicles up to 19 tons.



The ZF CeTrax – our electric central drive for commercial vehicles.

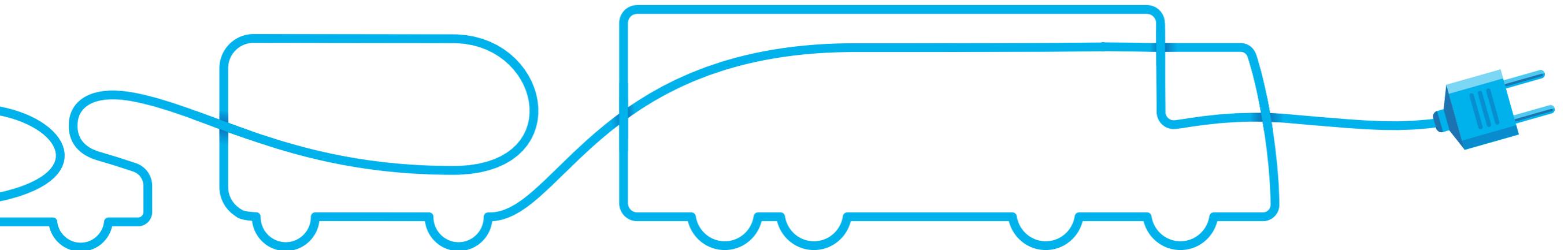
TraXon, our automatic transmission for heavy trucks and buses, is also suitable for commercial vehicle hybridization. It's powerful enough to move a 40-ton truck at the depot solely with electric drive. Equally, industrial trucks such as forklifts can be powered by ZF electric drives in the 4.5 to 10 kW performance range. Take our Innovation Forklift, for example: ZF engineers taught it to drive not just electrically, but also autonomously.

In off-road machinery, ZF's eTRAC drives are the basis for all-electric tractor concepts as well as for unusual hybrid solutions: our electric Front Axle Drive (eFAD) combines torsion-free 4x4 drive with low consumption, while the eTRAC-GPE 50 electric wheel head on our Innovation Tractor features an electric motor on both the left and right wheels of one of the trailer axles. The electric drive provides up to 80 kW when the tractor is on loose or muddy ground or when driving up or on steep inclines. This trailer traction management system can often alleviate the need to buy a bigger tractor. A plough electrified by ZF offers similar advantages.

“The driveline electrification can no longer be contained. To this end, we develop and deliver core components as well as entire systems for all vehicle types.”

**JÖRG GROTENDORST**

Head of e-mobility



# The dynamic sedan

ZF'S NEW ACTIVE DAMPING SYSTEM, SMOTION, TAKES DRIVING COMFORT, DYNAMICS AND SAFETY TO A WHOLE NEW LEVEL. THAT'S A HUGE PLUS WHEN IT COMES TO HIGHLY AUTOMATED DRIVING.

Text: Martin Westerhoff



Long plastic ridges are stuck to the asphalt like oversized Band-Aids. They are there for one reason and one reason only: to wreak as much havoc as possible on any car that crosses them. Unperturbed, the driver steers his blue compact MPV onto this special shake and vibration track. One of the passengers in the back clutches the handle above the window as the minivan crosses the bumps at full speed. But from inside the car, they're barely noticeable. "Impressive!" he gasps, releasing his grip.

## ACTIVE EQUALS SAFER AND MORE COMFORTABLE

Sven Greger, the man behind the wheel, chuckles with satisfaction. He's a ZF research engineer who works on the basic development of our semi-active and active

chassis components. Greger is used to passengers – many of them buyers or other research engineers from international automotive manufacturers – reacting this way on the proving ground. "Our sMOTION fully active chassis system introduces new degrees of freedom to counteract vehicle body movement," he says. "We can give each wheel its own active countermovement to prevent driving situations from exciting the car body." But along with greater comfort, sMOTION significantly improves dynamics and safety compared to current systems. Used in conjunction with cameras, the chassis system can identify the road condition, for example by anticipating bumps or potholes, and change its settings accordingly.

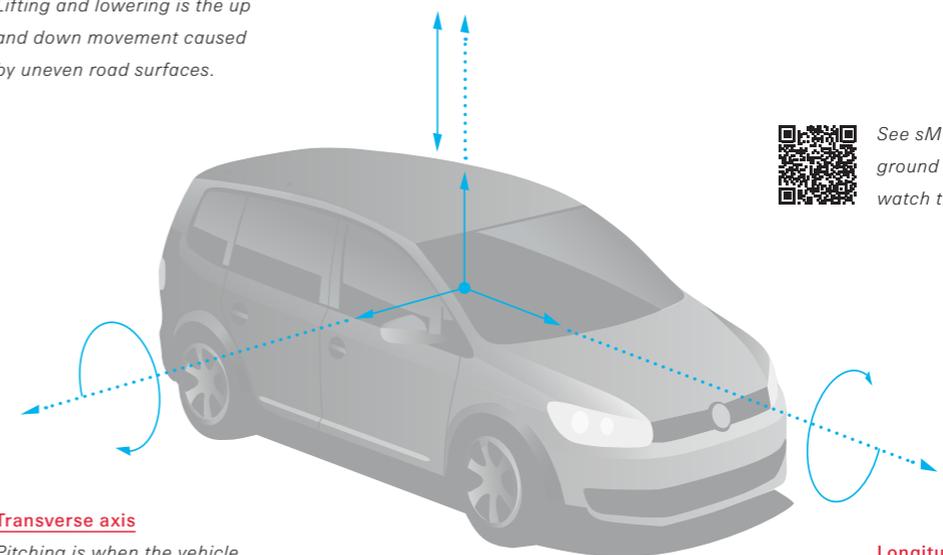
A damping system has to deal with a lot of situations. Uneven tracks inevitably lead to direct impact, which is cushioned by the

suspension. If a wheel rolls over an obstacle, it lifts, compressing a spring between the steering knuckle and the car body. Then the spring decompresses. The shock absorber's job is to attenuate the resulting vibration as quickly as possible. Aside from direct impact, vehicles have to contend with motive forces, braking forces and centrifugal forces. These forces associated with driving dynamics can prompt the car body to move in the direction of three spatial axes (see diagram below). The challenge lies in the fact that different driving situations each demand a specific damping force. Minimizing body movement on curves requires high damping force. Driving over slightly uneven surfaces only requires a little. And safe contact between the tires and the ground requires moderate damping force. "A conventional shock absorber can only ever reach a compromise between sporty and comfortable, albeit a good compromise," says Dr. Christoph Elbers, vice president car chassis technology development at ZF.

## WHEN VEHICLE DYNAMICS TRIGGER MOVEMENT, SMOTION KICKS IN

### Vertical axis

Lifting and lowering is the up and down movement caused by uneven road surfaces.



### Transverse axis

Pitching is when the vehicle dips (when decelerating) or rears up (when accelerating).

### Longitudinal axis

Rolling refers to the side tilt caused by cornering.



See sMOTION on the proving ground – scan the QR code to watch the video.

## THE EVOLUTION OF THE CDC DAMPING SYSTEM

ZF's semi-active Continuous Damping Control (CDC) system solved the problem of these conflicting objectives decades ago. Our semi-active damping system went into volume production for passenger cars in 1997. Using the signals from two wheel and body sensors for each spatial axis, plus additional information such as vehicle speed, lateral acceleration and steering angle stored in a control unit, the system continuously monitors driving conditions and calculates the optimum damping force for each wheel. The shock absorber has either one or two electronically controlled solenoid valves that can change the oil flow in milliseconds to adjust the damping hardness. ZF chassis expert Dr. Elbers explains: "sMOTION takes things a step further. Using the basic design of our tried-and-tested CDC, we developed a damper that can actively pull up or push down the wheel."

Until now, vehicle body excitation was tolerated or even desirable to a certain degree so as to give drivers perceptible feedback

on conditions. But in highly automated or autonomous vehicles, all the occupants become passengers. "And in that scenario, every vibration, impact, roll or pitch simply stops people from reading or working. This causes dispositions known as motion sickness, making these activities impossible," says Dr. Elbers. "This effect is amplified by innovative seat arrangements in which driver and passengers may no longer have a view in the direction of travel." A remedy can only be found in an active chassis. sMOTION is a ZF solution for the future that is already improving driving comfort today. Practically undisturbed by the driving process, passengers can spend their travel time working or relaxing.

"sMOTION can actively pull up or push down the wheels."

## DR. CHRISTOPH ELBERS

Vice president car chassis technology development

## POWERFUL ACTUATORS FOR A SMOOTH RIDE

sMOTION can actively adjust movements occurring at a frequency of up to 5 Hertz – the equivalent of 0.2 seconds of vibration. In our test vehicle, these adjustments are made by a 2.5 kW actuator on each wheel. It's an electric pump that increases the oil pressure either above or below the shock absorber piston and therefore actively moves it. For high-frequency excitations – such as manhole covers, cross joints, rough asphalt or gravel – the sMOTION shock absorber has a bypass that reverts to the CDC solenoid valves.

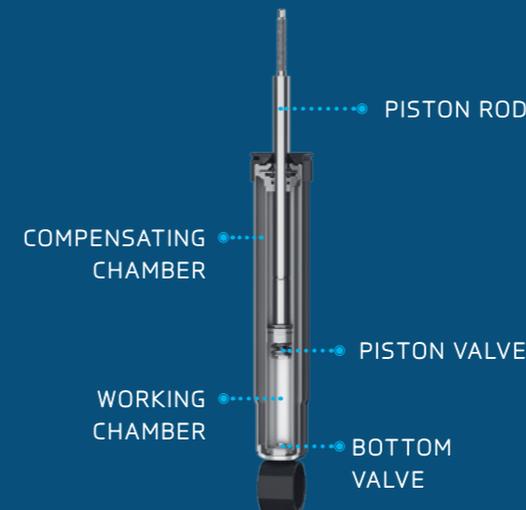
Dr. Achim Thomä, technical project manager for sMOTION, found himself and his team confronted with an unusual challenge. How could they convey the system's effectiveness if it stopped excitation so unobtrusively that passengers could barely feel a thing? The solution was simple. For demonstration purposes, Sven Greger now uses a tablet to control the shock absorbers on a stationary vehicle: individually, in pairs, or all four at once. As he taps the screen, the van lifts and lowers, pitches, rolls and shakes like a rodeo horse, at which point the engineers in the seats have every reason to cling to the handles despite the fact the car is not going anywhere!

sMOTION actively counteracts side tilt when cornering. The key to autonomous driving is a beautifully undisturbed vehicle body.



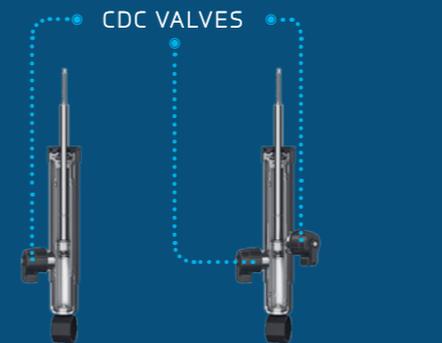
## sMOTION

No longer passive, but fully active – our shock absorber technology



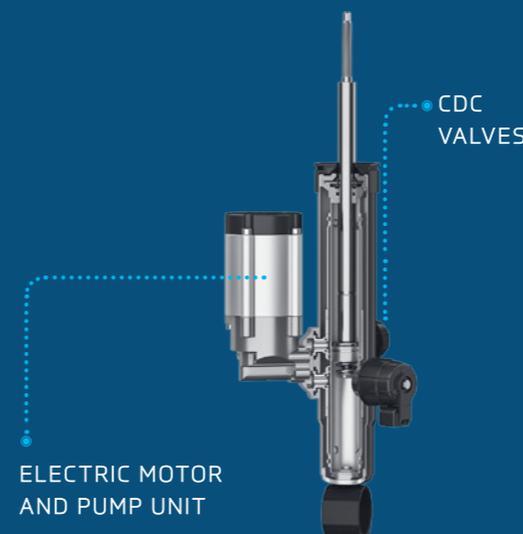
## STANDARD TWIN-TUBE SHOCK ABSORBER

The piston rod of the twin-tube shock absorber is attached to the car body, and its casing is attached to the steering knuckle. In the casing is a second pipe completely full of oil, which is the working chamber. The piston moves inside this cylinder. The distance between the inner pipe and the casing serves as a compensating chamber. This is not completely full of oil, since it has to be able to accommodate the oil displaced from the working chamber when the piston rod goes down. The bottom of the working chamber and the piston contain valves that restrict the oil flow more on the rebound direction (when the piston comes up) than in the compression direction (when the piston goes down). When the piston rises, it sucks oil out of the compensation chamber back into the working chamber.



## TWIN-TUBE SHOCK ABSORBER WITH CDC

A shock absorber with Continuous Damping Control (CDC) uses either one or two electrically controlled solenoid valves. The CDC valves are used to vary the hydraulic resistance continuously. Low resistance produces soft damping; high resistance produces hard damping.



## TWIN-TUBE SHOCK ABSORBER WITH sMOTION

The sMOTION shock absorber has an electric pump that pumps the oil from the upper working chamber to the lower chamber or vice versa. This produces active force. A bypass upstream of the pump makes it possible to activate two CDC valves to deal with frequencies above 5 Hertz.



Fascinated by shock absorbers?  
Simply scan this QR code for more information.

# CLEAN AIR AND EFFICIENCY GO



**ELECTRIFIED, AUTONOMOUS COMMERCIAL VEHICLES HOLD OUT THE PROMISE OF SAFE, ZERO-EMISSION DRIVING. WITH EXISTING STEERING SYSTEMS, HOWEVER, THIS IS MORE OF A FANTASY. SO WE'RE DELIGHTED TO INTRODUCE ZF'S PROTOTYPE FOR AN ELECTROMECHANICAL STEERING SYSTEM. A WORLD FIRST.**

*Text: Achim Neuwirth*

## **A BIG WIN FOR EFFICIENCY**

But the environmental compatibility of this steering system goes beyond driving features alone; even the technology itself is eco-friendly.

"Based on its first test drives in trucks, ReAX EPS operates up to 15 percent more efficiently than our most advanced electro-hydraulic system to date," says Schulz. What's more, it's much lighter. This weight reduction, as well as its compact design, is due to dispensing with the pump system, which means that it has no need for a fossil fuel drive. Since a diesel engine always has to be running for servo-assisted electro-hydraulic steering systems, they are unsuited for full hybrids and purely electric drives. ReAX EPS, on the other hand, has two advantages in this respect. First, its actuator is designed for an electric vehicle drive. Second, the steering system itself requires so little installation space that it allows greater design freedom for the components electrifying the vehicle's driveline. The first vehicles to benefit from ZF's steering innovation will no doubt be delivery trucks, since those with combustion engines are likely to soon be banned from certain city centers.

The electric drive purrs quietly until the vehicle comes to a standstill. The only sound that follows is rubber on asphalt as the front wheels turn while parking. As if by magic, the steering wheel turns all by itself. This is a familiar scenario to drivers of hybrid and electric passenger cars equipped with ZF technology.

This, however, is different: the vehicle is a truck. ZF has transferred its system expertise in passenger car steering technology to commercial vehicles. The outcome – at the same time a world first – is ReAX EPS, an electromechanical steering system for trucks and buses. "ReAX EPS is the first all-electric steering system for commercial vehicles to hit the market," says Mitja Schulz, head of ZF's CV Steering Systems Business Unit. Currently a prototype,

our Electrically Powered Steering (EPS) makes the electrification and automation of commercial vehicles a whole lot easier. "ReAX EPS even has the potential to allow autonomous vehicles to maneuver without a mechanical link between the steering wheel and steered wheels," says Schulz.

## **INTELLIGENTLY NETWORKED WITH THE FUTURE**

Steering a 40-ton truck without a direct mechanical link or a hydraulic pump system? Unthinkable. Until now. But ReAX EPS has an electric motor with a maximum torque of 70 Nm to transfer the required force to the steering mechanisms. ZF has combined this motor, its control unit, the steering gear and the sensor system in a highly compact actuator unit. So the steering can be electronically controlled and

adjusted. "In line with ZF's guiding principle, See – Think – Act, ReAX EPS is a critical system component for enabling trucks and buses to act," says Schulz, who goes on to explain in more detail. "Networked with cutting-edge control electronics such as the ZF ProAI central computer and with environmental sensors and other vehicle systems, the intelligent steering system can handle many tasks, ranging from lateral control to SAE Level 4 automated driving." This means that a truck can steer itself on certain sections of the highway or in loading areas so the driver can work on other activities or rest. ReAX EPS is also perfect for platooning, where trucks are electronically coupled while driving, with minimal safety distances between them thanks to the autopilot. In addition, it can be used in Park Assist or Lane Keeping Assist features.



*Lower energy consumption, lower weight and less space: dispensing with the hydraulic pump makes ReAX EPS a highly efficient, flexible-use system.*

# NEW HEIGHTS

**MAJOR CHINESE CORPORATIONS ARE WORKING INTENSELY ON THE TECHNOLOGIES OF TOMORROW. ONE OF THEIR KEY FOCUSES IS ARTIFICIAL INTELLIGENCE (AI). ZF AND CHINESE TECHNOLOGY COMPANY BAIDU ARE WORKING TOGETHER TO ACCELERATE THE DEVELOPMENT OF AUTONOMOUS DRIVING CONCEPTS.**

*Text: Friederike Pater*

Slowly but surely, the taxi carves its way through the maze of cars, mopeds and buses in stop-and-go traffic. The taxi passes miles of factory buildings and giant warehouses, and it's hard to believe that just 40 years ago the city of Shenzhen was still a sleepy fishing village just outside Hong Kong. Today, the cityscape is dominated by glass skyscrapers nosing up through a layer of smog. The buildings bear the names of Chinese technology giants: Huawei, Tencent, ZTE, Dingoo.

## **DIGITALIZATION, MADE IN SHENZHEN**

No other city demonstrates China's digital evolution as well as Shenzhen. It has become the heart of China's nationwide digitalization overnight and is churning out technological innovations at a breathtaking pace. ZF is already a part of this unique ecosystem. "Here in China, we march to the beat of a different drum; everything has to be faster, higher, more advanced," says Qi Ping, head of development at ZF China. "It is fascinating to see how quickly ideas can turn into series products." The spirit of innovation, the fast pace and an unquenchable thirst for progress makes Chinese companies valuable partners.

"By working with technology leaders such as Baidu or automotive manufacturers like Chery, we gain deep insights into the market that is set to determine the future of the global economy. China could soon be our most important market, and we're well prepared for that," says Qi.

## **STRONG GROWTH IN ARTIFICIAL INTELLIGENCE**

One particular technology is drawing the attention of developers in Shenzhen and all over China. It is so important that it has even been given a major role in the national five-year plan: artificial intelligence (AI). The Chinese government is sure that AI will shape the future.

A study by market research company Gartner backs this up. Gartner analysts place the global business value of artificial intelligence in 2018 at \$1.2 trillion, an increase of 70 percent compared to 2017. According to forecasts, the figure will rise to \$3.9 trillion within the next four years.

## **BIG DATA IS BOOSTING AI**

While it's true that the US is the birthplace of artificial intelligence, China too has become an AI epicenter. By 2025, it will be closing in on North America and within another five years will be market leader. A study by auditing and consulting firm PwC estimates that China's GDP will rise to the equivalent of \$7 trillion by 2030 purely on the back of AI. As a comparison, for North America PwC predicts a GDP increase of about 15 percent, to \$3.7 trillion.

But state subsidies and regulations are not the only factors behind the AI explosion. Given its large population, China also has a huge volume of data at its disposal, providing artificial intelligence with the information it needs in order to advance. On top of this, the country draws on its concentrated knowledge of digitalization.

"Artificial intelligence is intriguing to me as it can be used in so many areas of life and can even improve it. Last but not least, it also offers solutions for the mobility of the future," explains Dr. Xing Yuan, general manager of series production and commercialization at Baidu. "Our goal is to promote AI technology and make it practical for everyday life."

## **RESEARCH IN HOMEGROWN AI LABORATORIES**

Baidu has been working in partnership with ZF since 2017. Along with Alibaba and Tencent, it forms part of the corporate triumvirate known as "BAT," which represents a kind of digital parallel universe in China. Baidu, once a search engine developer and operator, has become the Chinese equivalent of Google and Wikipedia. Today, it's also the leading provider of high-resolution maps. Online retailer Alibaba started out as a kind of Chinese eBay and has developed into an Amazon-like e-commerce giant in no time. Tencent dominates instant messaging

“Here in China, we march to the beat of a different drum; everything has to be faster, higher, more advanced.”

## QI PING

Head of development, ZF China

services with its WeChat platform and is also a leader in the gaming sector. All three companies now have their own “AI Labs” in which they explore the universe of artificial intelligence.

China has become a pioneer in alternative concepts of mobility. The government’s next goal is to set the global standard for the autonomous cars of the future. It intends to network intelligent vehicles with a view to reducing accidents and emissions by 30 percent and 20 percent respectively by 2025.

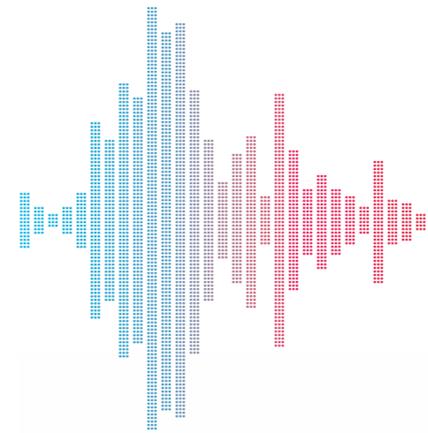
### COMBINED STRENGTHS

“AI is a game changer, and autonomous driving is the future of mobility. And we want to be part of that from the outset,” says Xing Yuan, explaining Baidu’s transformation into an AI specialist. “Autonomous driving presents the perfect challenge when it comes to the use of artificial intelligence. And we are focusing on use of the technology in the automotive sector. Our goal is to commercialize AI for volume production.”

Baidu’s high-resolution maps are making a major contribution to autonomous driving. Modern sensor technology in special vehicles records the global road networks and provides the data for high-definition (HD) maps. However, updating the entire traffic infrastructure on a daily basis is near-impossible. To remain in the game, Baidu had to find the right partner. “Cooperation between a digitization company such as Baidu and an established automotive supplier like ZF allows the strengths of each company to come to the fore, to the customers’ benefit,” comments Dr. Xing Yuan, and adds: “ZF is the perfect partner for us, and its super-computer ZF ProAI is an excellent product.” ZF ProAI is an AI-capable vehicle computer with a wide range of configuration options.

### ON A COMMON MISSION

Chinese car-sharing operator Pand’s electric vehicles are already being tested with the ZF-Baidu technology, and some Chinese cities will soon allow autonomous vehicles to be tested on public roads. :



## SPEAKER’S CORNER

Erik Figenbaum is a researcher at the Norwegian Institute of Transport Economics (TØI) in Oslo, an independent and privately owned research institute based on a foundation.



# Electrified Nation

**FOR YEARS NOW, NORWAY HAS BEEN GATHERING EXPERIENCE WITH ELECTRIC VEHICLES ON A LARGE SCALE. HOW DOES E-MOBILITY WORK IN THIS NORDIC COUNTRY, AND HOW CAN THIS BE TRANSFERRED TO OTHER COUNTRIES? AN ASSESSMENT.**

Norway is the global leader in electric vehicle adoption per capita. More than eight percent of the cars in the national fleet are rechargeable. Two-thirds are battery electric vehicles (BEVs); the rest are plug-in hybrids (PHEVs). Since the 1990s, Norway has been supporting the BEV market through exemptions in purchase tax, road toll, parking charges, and by bus lane access. PHEVs have fewer incentives, but are more attractive than diesel vehicles. Together, they facilitate a gradual shift to e-mobility.

The substantial tax exemptions have made BEVs the cheapest vehicles to buy, and this advantage becomes directly visible in the sales price. Multi-vehicle families, the main adopters, find BEVs economical to use and face only few barriers. They park and recharge their BEV on their own land, and can use their other vehicle for driving long distances. If other countries are able to reach the same group with suitable incentives, a market pull will be created, leading to a steep increase in BEV adoption.

But Norway has other favorable conditions. Diesel is expensive, and electricity is cheap with 98 percent based on emission-free hydropower, so the emission benefit is huge. This benefit has also been realized at EU level, as electricity production is part of the EU greenhouse gas emission trading system, whereas transportation is not. Low superhighway speed limits in Norway reduce energy consumption and preserve the range, whereas cold winters reduce the range by 25 percent compared to summer driving. The Norwegian grid is robust enough to handle charging, as we use electricity for space heating. Countries with less robust grids will need policies that are capable of cushioning electricity peaks resulting

from charging loads. 94 percent of Norwegian BEV owners charge at home in their own parking space, and many only drive locally, hence getting by with home charging.

On long-distance trips, users will of course need to recharge – unlike diesel car owners, who can fill up for the entire trip. It will be expensive to operate a fast-charging infrastructure meeting all needs for long-distance driving on peak travel days. On-street charging is another big challenge inhibiting BEV ownership in densely populated cities. The municipality of Oslo has installed chargers in parking lots and on streets, but struggles to keep up with the demand. Other mobility services could act as supportive measures preserving mobility in crowded city centers. Battery life is not yet an issue in Norway – maybe, because our summers are not that hot. Heat, however, is the main factor in degrading battery life. When the battery capacity decreases, BEVs will most likely continue to be used by less-demanding users until the end of the vehicle life. Then the batteries are handed in for recycling, organized by the vehicle importers, and subsidized by a 300 -euro scrappage bonus.

Norway has proven that BEVs can sell well in a mass market, and that the vehicles can easily be integrated into the overall vehicle fleet by multi-car households. The Norwegian e-mobility incentives have created a powerful bottom-up market pull, whereas governments in countries like Germany focus more on policies creating a top-down market push. The bonus to German BEV buyers introduced last year seems less effective than originally expected and may therefore need to be increased in order to have a real impact on their purchasing behavior. :

## THE THREE CHINESE AI GIANTS: DID YOU KNOW?



### Baidu

The Beijing-based group operates the eponymous search engine Baidu. In the first quarter of 2018, the company generated revenue of approximately \$3.33 billion. Baidu is not afraid to experiment, and is constantly expanding into new business areas – from meal delivery services, to online payment providers, to tomorrow’s autonomous driving.



### Alibaba

Chinese internet conglomerate Alibaba Group is home to 12 brands. One of the most successful is the mobile payment service Alipay, run by group subsidiary Ant Financial, currently the most valuable fintech company in the world. Its main sources of sales are B2C and B2B e-commerce platforms Alibaba.com and AliExpress.



### Tencent

With brand equity of \$178 billion, Tencent currently ranks fourth among the world’s most valuable brands. The group operates in a diverse range of business areas from instant messaging to social media and online gaming. WeChat is the most popular messaging service in China, with a billion users.

# Miraculous transformation

*Text: Frank Thoma*

**REMANUFACTURING IS A SUSTAINABLE ALTERNATIVE TO NEW PRODUCTION. A VISIT TO THE CZECH LOCATION IN FRÝDLANT EXEMPLIFIES HOW ZF IS GIVING A SECOND LIFE TO DIFFERENT SAFETY TECHNOLOGY PRODUCTS THROUGH REMANUFACTURING OF USED PRODUCTS.**



*Brake caliper before and after remanufacturing.*

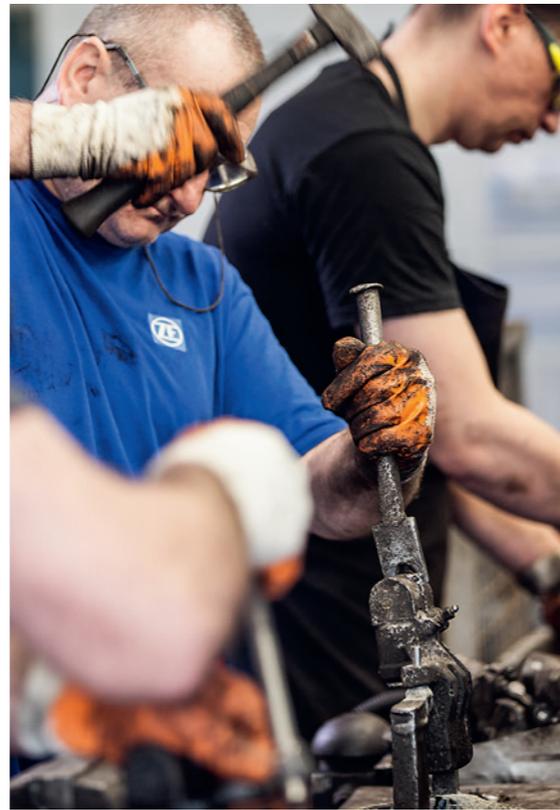
Frýdlant is a tranquil town of 8,000 inhabitants in the northern Czech Republic, just a few forests and fields away from the Polish border. ZF has a special factory here in Frýdlant. First, the navigation system guides visitors uphill to the extreme western edge of the town. On top of the hill, a two-story, half-round building stands on stilts. To its side, two floors lower, are four elongated workshops nestled against the slope. The large logo on the facade and the blue ZF flags fluttering in the wind in front make the announcement of the navigation system superfluous: "You have reached your destination."

The destination is a remanufacturing plant. Since 1999, its employees have been reworking a wide variety of automotive safety technology products on 20,000 square meters. In contrast to conventional repair of individual products in workshops, remanufacturing is reconditioning of high-quality components on an industrial scale. It may differ from a new part in terms of price but not in quality. The ecological footprint is also good: compared to newly manufactured products, remanufacturing requires between 50 and 90 percent less raw materials and only about one-tenth of the energy. Helmut Ernst, senior vice president of the ZF Aftermarket Division, says: "We enable our customers' mobility in line with nature, because of the perfect complement of economy and ecology in remanufacturing. Our innovational strength relates to technology and the corresponding service offers."

The remanufacturing portfolio in Frýdlant includes brake calipers for passenger as well as commercial vehicles, mechanical, hydraulic and electric passenger



Delivery of brake calipers to the sorting hall.



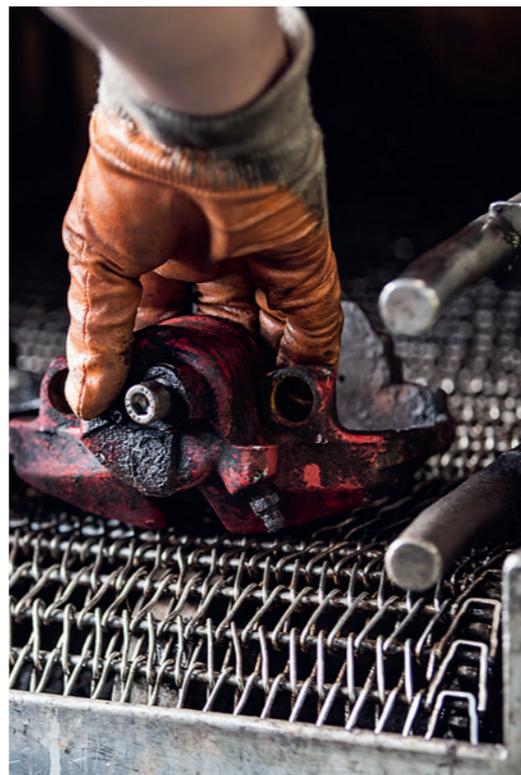
Removal of all attachment parts from the caliper.



Brake calipers leave the blasting unit and are reworked.



Finally, the assembly of the now-plated calipers takes place.



Afterwards, brake calipers are transported through an industrial washing machine.



Watch the Frýdlant remanufacturing processes at work – the QR code takes you directly to the video.

car steering systems, commercial vehicle steering systems, vane pumps, electrohydraulic steering system pumps, and mechatronic and electronic components. New products are added almost every year. “It’s absolutely fascinating to make something new out of something used with clever solutions in detail – and to be able to do such a thing in an environmentally friendly and sustainable manner,” Jirka Horvath says enthusiastically. The director operations remanufacturing has been in Frýdlant for 16 years. During this time, he has shaped the process of the plant becoming specialized in remanufacturing, along with its growth from 120 employees to currently around 370.

### BEST GLOBAL GROWTH PROSPECTS

Horvath is not the only one convinced that the business in remanufacturing will continue to grow. Analysts from market research firm Frost & Sullivan concluded in their 2016 survey that worldwide remanufacturing sales relating to passenger cars and light commercial vehicles alone will reach nearly \$50 billion by 2022 (2015 sales estimated at \$31.7 billion). For the period from 2015 to 2022, they expect an annual growth rate of

6.6 percent. Although the United States is considered the largest remanufacturing market, the prospects for strong growth are still bright for Europe and particularly for China. Aging vehicle fleets as well as the required CO<sub>2</sub> reduction are boosting the remanufacturing business. For example, surveys show that in Europe half of all vehicles are already older than eight years. This ensures a steady stream of used parts – referred to as “cores” – from the market to remanufacturing plants like the one in Frýdlant.

How does remanufacturing work? Horvath takes his visitors on a tour of the factory halls, using the example of his main product, the brake caliper, to show the individual steps of remanufacturing.

### TRANSFORMING A USED PART INTO A NEW PRODUCT

Individually packaged in large boxes or unpackaged in wire-frame baskets, forklift trucks bring the brake calipers, which have become oily-black and corroded over the years, into the sorting hall. There, an employee records each individual brake caliper by entering its part number into a PC. In the process, he also subjects the part to a visual inspection. “For the safety of the remanufactured product, it is extremely important that only undamaged parts enter the remanufacturing process,” Horvath explains. The brake calipers, now recorded in the system, continue to another hall for disassembly. The visitors are greeted by loud banging there. Three men with gloves and safety goggles use heavy tools to remove the piston from the brake cylinder and all attachments made of rubber, metal and plastic from the brake caliper. They are placed in waste containers. :)

**50**  
BILLION US DOLLARS

is the expected global annual turnover from remanufacturing for passenger cars and light commercial vehicles by 2022 (currently \$31.7 billion).

Special screws protect the sensitive threads on the brake caliper from the next processing steps. The brake caliper is transported through an industrial washing machine on a wire mesh conveyor. A neutral cleaner degreases the surfaces there. Now the brake caliper is ready for what is referred to as the continuous shot blast machine. Depending on the brake caliper material, it is blasted with small plastic or steel particles for up to 15 minutes. At the end of this process, a formerly black component with a rough surface has become a smooth, matt-shimmering brake caliper that already looks like new. A ZF service provider then plates the component.

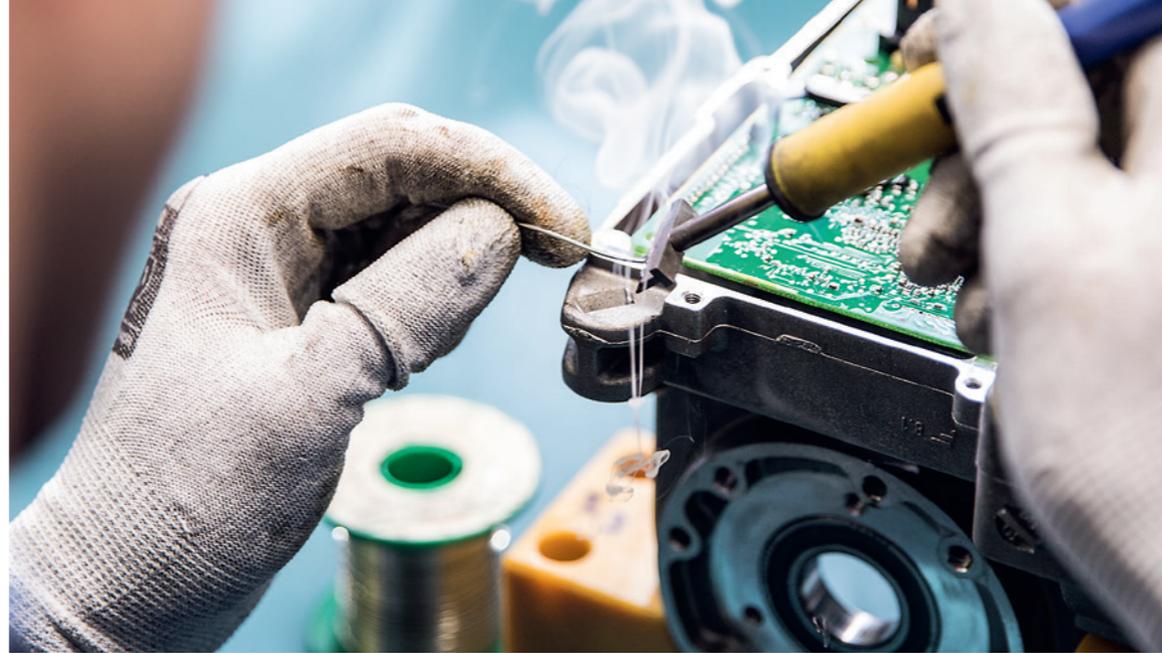
“It is absolutely fascinating to make something new out of something used – and to be able to do such a thing in an environmentally friendly and sustainable manner.”

**JIRKA HORVATH**  
Director operations remanufacturing

### SAFETY WITHOUT COMPROMISE

After the component returns to the plant, assembly takes place. Employees provide each brake caliper with up to 20 new parts necessary for its function. In addition, the housing receives a special engraving, as brake calipers are only allowed to be remanufactured once. On the adjacent test bench, the pressure test is carried out for tightness of the hydraulically actuated piston and for the strength of the entire brake caliper structure. “Braking and steering systems are safety-relevant car parts that can save lives. That’s why safety comes first with the remanufacturing process; we would never compromise on quality,” says Horvath. For this reason, every product is tested – without exception – before it is packaged and returned to the market.

Cannot be distinguished from a new part: a remanufactured brake caliper.



An in-house mechatronic laboratory opens many interesting possibilities in remanufacturing.



### NEW REMANUFACTURING APPLICATIONS

One area that is becoming increasingly important is the remanufacturing of mechatronics and electronics. The experts in Frýdlant are already reconditioning mechatronic modules of steering pumps, replacing electronic components on circuit boards and updating software. Because remanufacturing incorporates the advancement of technology into

the used product, it complies with the state of the series production. In cases where there are no spare parts for refurbishing electrical steering systems, for example, engineers look for alternatives and even develop control electronics tailored to what is needed. For this purpose, ZF operates its own mechatronic laboratory in Frýdlant.

As more and more electronics are making mechanical components in the car intelligent, it is only a

matter of time before the need for remanufacturing also increases for these products. Examples for this include products such as hybrid transmissions or electric axle drives. Horvath is aware of this and preparing for it: “In remanufacturing, we are currently experiencing a movement towards mechatronics and electronics. In order to live up to our maxim of ‘safety first’ completely, we will be investing more in the future – in our capabilities as well as in our equipment.”

Each electrical steering with remanufactured electronics and mechanics is put on a test bench at the end of the process.





# Not just for mountaineering fans

Mid-size cars, luxury vehicles, SUVs – ZF’s 8-speed 8HP automatic transmission shifts them all! Produced according to the modular design principle, it can accommodate each and every application. And with a 300 to 1,000 Nm torque range, it’s also ideal for use in all-wheel drive vehicles – like the Stelvio, Alfa Romeo’s first SUV, named after the highest pass

in Italy’s Dolomite Mountains. Alfa Romeo equips all Stelvio engines with the 8HP as standard. Why? Because it’s efficient and dynamic. With the top-of-the-line engine in “Race” mode, the transmission can shift in just 150 milliseconds and, under ideal conditions, the Stelvio can go from 0 to 100 km/h in 3.8 seconds.

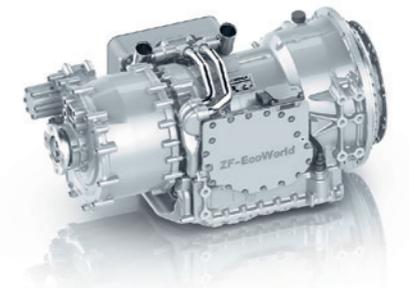


“ZF’s effort to shepherd electric and autonomous technology into commercial vehicles highlights the role that automotive suppliers hope to play in a changing industry.”

TRUCKS.COM  
USA

# Clean and green on the Emerald Isle

Reducing fuel consumption and emissions – and therefore also costs – is now the order of the day for train operators just as it is for everyone else. ZF’s 6-speed EcoWorld automatic transmission fits the bill perfectly, saving almost 20 percent more fuel compared to hydrodynamic transmissions, with a corresponding drop in CO<sub>2</sub> emissions. At just 496 kilograms, the ZF



EcoWorld is one of the lightest among powershift transmissions. Integrated in its compact housing is a primary retarder with high braking performance. Irish Rail, Ireland’s national railroad operator, was quick to see these benefits. They recently signed a deal with MTU to retrofit three compact drive systems for the ZF EcoWorld transmission system.



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in a  
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60

**YEARS**

*ZF in Brazil: The 60th anniversary of the first company location outside Germany will be celebrated with many scheduled events in the fall.*

# Emission-free through the city

Demand for city buses with hybrid or all-electric drives is increasing across the globe. The AxTrax AVE (formerly the AVE 130) electric portal axle with integrated wheel hub drive is suitable for all electric buses, hybrid buses and low-floor trolleybuses. Since the installation space required is no bigger than for a conventional portal axle, ZF's drive axle can be integrated into existing chassis platforms. Mercedes-Benz has opted for the AxTrax AVE in its new all-electric eCitaro. Each of the axle's two electric motors has an output of 125 kW, powered by lithium-ion batteries on the roof and in the rear. Volume production of the eCitaro is due to start at the end of the year.



## Masthead

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