COMPONENTS AND SYSTEMS FOR CARS
The demands placed on suppliers in the automotive sector are changing dramatically. Increasingly, suppliers are being called upon to integrate components into complex systems—a development task that can only succeed on the basis of close partnerships with vehicle manufacturers. The future will bring continued demands for reduced fuel consumption, emissions, weight and installation space, along with enhanced comfort, safety, and driving dynamics. To meet these goals, innovative products are essential. ZF has taken on this responsibility, demonstrating expertise in generating multifunctional solutions with its intelligent suspension systems.
Car Chassis Technology from a Single Supplier

ZF is a global leader in driveline and chassis technology. The Car Chassis Technology division pools the group’s expertise in chassis technology for passenger cars and light commercial vehicles.

The chassis is one of the most complex – and most important – systems in a car. It determines the driving dynamics of the car. Steering, wheel control, bearing, damping, spring, stabilizer and brake system all determine a vehicle’s character. In addition, the vehicle’s NVH (noise, vibration, harshness) behavior, ensuring that vibrations and noise are not felt or heard in the vehicle while driving, is improved. This ensures that passenger comfort increases. It is very important how the individual systems and components harmonize with one another. This is precisely where ZF comes in. Thanks to the Car Chassis Technology division’s comprehensive know-how, the group is able to offer customers complete chassis expertise from a single source.

With 7 development locations and over 50 production sites throughout the world, ZF’s Car Chassis Technology division is always within easy reach of its customers.

This is necessary, not least because the complete axles for automobile manufacturers produced by ZF, are delivered to the manufacturers’ assembly lines just-in-sequence. Close cooperation also brings the best results when it comes to developing chassis.

Around the world, ZF enjoys excellent reputation as outstanding development partner. To ensure that this remains the case for car chassis technology, the division invested about 165 million euros in research and development in 2012. There are a lot of challenges: mechatronics, for example, is making its way into vehicle chassis and makes it possible to link the chassis with other active systems. This improves consumption figures and also boosts safety and driving dynamics. Furthermore, new lightweight designs in the chassis are already making a significant contribution to an individual mobility that saves resources.
Lightweight Construction, Ideal Form

With each new model generation, cars become safer, more comfortable, and more dynamic — but they also tend to get heavier. The goal in the future will be to reverse this spiraling weight. Working with new materials and innovative designs, ZF makes car chassis lighter.

Less weight means lower fuel consumption. And a reduced proportion of unsprung mass — for instance in the chassis — also improves driving dynamics. Increasingly, alternative materials such as aluminum or fiber-plastic composites are being used in vehicle chassis to achieve these double goals. But it’s not a simple matter because these lighter materials demand new chassis designs.

A study of a car rear axle with a wheel-guiding transverse spring made of glass-fiber-reinforced plastic shows that ZF already has the expertise to manufacture complete axle systems from lightweight materials. However, a weight reduction of twelve to fifteen percent compared with a conventional steel rear axle is not the only advantage. Also significant is the reduced complexity of the axle due to the component integration, making installation by the vehicle manufacturer much easier.

What’s more, when it comes to individual chassis components, ZF lets the extra weight melt away:

A lightweight suspension strut wheel carrier module only weighs half as much as a conventional steel-aluminum module. It is made of a mix of GRP, high-strength steel, and aluminum. To compensate for high bending stress, ZF engineers used an upside-down design for the aluminum cylinder tube.

ZF is already active in lightweight construction. ZF applies this material mix and combination of all lightweight construction options in volume production, for instance, for pedals or lightweight dampers. While the pedals made of fiber reinforced composite score in terms of plastics, the lightweight dampers feature tubes made of aluminum whose wall thickness is dimensioned differently depending on the load. This makes production challenging because, after all, 17 process stages have to be coordinated. Another mature lightweight construction solution ready for series production is the SMiCA (Sheet Metal integrated Control Arm). The control arm requires no rivets or screw connections. This makes it lighter than conventional sheet metal control arms. Moreover, it requires less installation space and provides more freedom in designing the chassis.

![Impact of vehicle weight on fuel consumption](image)

- New European Driving Cycle (NEDC)
- Real customer driving cycle (AUTO MOTOR UND SPORT lap)

<table>
<thead>
<tr>
<th>Consumption</th>
<th>100%</th>
<th>99%</th>
<th>98%</th>
<th>97%</th>
<th>96%</th>
<th>95%</th>
<th>94%</th>
<th>93%</th>
<th>92%</th>
<th>91%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in vehicle mass</td>
<td>0%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>25%</td>
<td>30%</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

In compact vehicles with innovative, economical engines, it is possible to save 4% fuel by reducing the vehicle mass by 10%.

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More Driving Dynamics and Comfort

Driving a car is supposed to be fun, but few things are as subjective as the enjoyment of driving. Depending on the type of person the driver is, and the mood he or she is in, either high speed or gentle cruising may be fun. Driving dynamics and driving comfort are two sides of the same coin. ZF products in the chassis release a vehicle’s potential.

The chassis has many tasks: it bears loads, suspends, dampens, steers, stabilizes and transfers the drive power to the wheels, and thus to the road. It also prevents undesired noises and vibrations from the road from entering the passenger compartment via the bodywork. A system supplier such as ZF must be able to do everything concerning the chassis. We need to work in partnership with manufacturers during development, offer them comprehensive solutions for production and supply logistics and also retain sight of drivers’ expectations. ZF can satisfy all these needs as a supplier of complete axle systems, chassis components and active systems.

Linking active chassis systems together offers new levels of freedom with regard to driving safety, dynamics and comfort, without making compromises. An example of this is the active damping system CDC® (Continuous Damping Control). Even as a single system, it increases comfort, driving dynamics and safety considerably. This effect is enhanced further when it works together with ARS® roll stabilization and the active kinematic adjustment system AKC®. Switchable engine mounts also improve driving comfort and dynamics by providing maximum isolation from structure-borne noise when the engine is at idle and by damping vibrations when the vehicle is moving.

With or without electronic assistance, sound knowledge of axle and elastokinematics is needed to design the optimum chassis. This knowledge can determine the motion and distortion to the chassis that can occur while driving and, if applied correctly, can contribute to stable driving. ZF has mastered the entire process chain of chassis development and takes comfort and driving dynamics into account from an early stage, from design and calculation for prototype construction, first tests, coordination to validation and production. At the end of the day, the intensive research and development work can be noticeably felt by drivers and passengers who still feel relaxed and comfortable when they get out of the car after a long journey.
Cars are becoming safer all the time. And that is good. With slippery roads, bumps, and obstacles challenging drivers daily. With its wide product range, ZF makes an important contribution to ensure safe driving everyday.

“Always stay grounded” is the motto for safety in road traffic. Drivers with optimum road contact can cope better even with tricky situations such as swerving at high speed. The chassis is decisive here because the front and rear axes determine the road-holding and therefore the safety of a car.

Safety for all classes
From individual dampers to complete axles, ZF supplies chassis components and systems for all classes worldwide. The automotive supplier group’s core competence is know-how in the fine-tuning of all chassis parts. One highlight is the CDC electronic damping system: Using data from sensors, it seamlessly and precisely adjusts the chassis damping to each driving situation – individually for each wheel and in fractions of a second. This not only prevents pitching or rolling in threshold areas, but is also very comfortable for passengers. The CDC4 is available for all four wheels, while the CDC 1XL (“one axle”) is for the rear axle alone and is an economical alternative above all for small cars.

A common problem with a fully loaded trunk is a “sensitive” rear-end due to the one-sided weight distribution.

Components without electronics
The Nivomat® leveling system works entirely without electronics: it ensures that loaded passenger cars always maintain the correct height and that there is no sinking above the rear axle. This prevents sluggish handling or, indeed, damper perforation. Car/trailer combinations are also much more stable – which is a plus when changing lanes, overtaking or when driving in bad road conditions.

Corner modules ensure outstanding off-road mobility with large spring travel for maximum traction and safety in tricky situations. Ball joints and rubber mounts are specifically designed to make off-road driving as safe as possible.

Nowadays, airbags are an integral part of the passive safety systems in modern vehicles. The focus at ZF is on contributing to these safety requirements by developing airbag housings made of plastic which are fitted at key points in the vehicle. Moreover, thanks to their lightweight construction they help to save fuel, thus protecting the environment.
Fields of Expertise in Car Chassis Technology

**Selected production volumes**

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axle systems</td>
<td>&gt; 3,000,000</td>
</tr>
<tr>
<td>Shock absorbers</td>
<td>&gt; 56,000,000</td>
</tr>
<tr>
<td>NVH components</td>
<td>&gt; 230,000,000</td>
</tr>
<tr>
<td>Ball joints</td>
<td>&gt; 210,000,000</td>
</tr>
<tr>
<td>Precision plastic parts</td>
<td>&gt; 216,000,000</td>
</tr>
</tbody>
</table>

**Suspension Technology**
- Monotube damper
- Twin-tube damper
- Suspension struts
- Suspension strut modules
- Pre-loaded valve technology
- Varo® – Stroke-dependent damping
- Sensitive Damping Control
- Nivomat® – Leveling system
- CDC® – Continuous Damping Control
- ARS® rol stabilization

**Chassis Components**
- Suspension ball joints
- Cross-axle joints
- Tie rods
- Stabilizer links
- Control arms
- Knuckles and Hubs

**Rubber & Plastics**
- Suspension strut mounts
- Subframe mounts
- Conventional/hydraulic suspension link mounts
- Stabilizer bar bushings
- Powertrain suspension systems
- Switchable and active engine mounts
- Differential mounts
- Plastic pedal modules
- Plastic oil pans
- Plastic airbag housings
- Plastic gearshift components

**Chassis Systems**
- Front axles
- Rear axles
- Corner modules
- Active Kinematics Control (AKC®)
Research and Development
to Secure Mobility

Innovations are not a purpose in themselves for ZF; they must pay off, for manufacturers, fleet owners, and drivers, but also for the environment and society. Each new development must prove itself among the conflicting priorities of these criteria.

The ZF Group benefits from an international network of development centers: The main development locations are Friedrichshafen, Diebling, Passau, Schweinfurt, Schwäbisch Gmünd, Northville near Detroit (USA), Pilsen (Czech Republic), and Shanghai (China). Worldwide, more than 7,100 employees work in Research and Development. Every year, ZF invests approximately five percent of its sales in Research and Development. With success, because innovative products from ZF set the standards for state-of-the-art technology – again and again. Development work at ZF is organized according to decentralized and central functions.

The divisions and business units focus on markets and product expertise, ensuring customer-centered, competitive technological product development. Corporate R&D works with a strong emphasis on basic research and theory and supports the functional development areas in the divisions.

Customer focus as the key to our success
The development work of ZF’s Car Chassis Technology division consistently follows customer demand. The most modern development tools guarantee an optimum time-to-market solution: From simulation, testing and coordination to series production, ZF’s decades of expertise have helped to build up its know-how for efficient chassis development in accordance with customer specifications. ZF’s global presence provides perfect conditions to work cheek-to-jowl with vehicle manufacturers.

Starting with an idea and finishing with an innovative product, ZF develops sophisticated mobility concepts for today and tomorrow. As a reliable partner of the automobile industry, the Car Chassis Technology division has a holistic approach to the development process, from the choice of materials to the maintenance-friendliness of the final products.

In the end, everyone from the manufacturer to the end customer benefits from this approach.

Whether it’s a suspension strut or a complete axle system, ZF always has its eye on all the details and how they interact. This expertise in integration turns optimally designed individual components into comprehensively tested chassis systems with great functionality and a long service life.
The ZF Group

Shaping the future responsibly

Our enthusiasm for innovative products and processes and our uncompromising pursuit of quality have made us a global leader in driveline and chassis technology. We are contributing towards a sustainable future by producing advanced technology solutions with the goal of improving mobility, increasing the efficiency of our products and systems, and conserving resources.

Our customers in the automotive and industrial sectors welcome our determined focus on products and services, which provide great customer value. Improvements in energy efficiency, cost-effectiveness, dynamics, safety, and comfort are key to our work. Simultaneously, we are aiming for continuous improvement in our business processes and the services we provide. As a globally active company, we react quickly and flexibly to changing regional market demands with the goal of always providing a competitive price/performance ratio.

Our independence and financial security form the basis of our long-term business success. Our profitability allows us to make the necessary investments in new products, technologies, and markets, thus securing the future of our company on behalf of our customers, market affiliates, employees, and the owners of ZF.

Our tradition and values strengthen our managerial decisions. Together, they are both an obligation and an incentive to maintain a reliable and respectful relationship with customers, market affiliates, and employees. Our worldwide compliance organization ensures that locally applicable laws and regulations are adhered to. We accept our responsibility towards society and will protect the environment at all of our locations.

Our employees worldwide recognize us as a fair employer, focusing on the future and offering attractive career prospects. We value the varied cultural backgrounds of our employees, their competencies, and their diligence and motivation. Their goal-oriented dedication to ZF, beyond the borders of their own field of work and location, shapes our company culture and is the key to our success.