engineering solutions

Welcome to the Next Level of Future Mobility

"In navigating the volatile, uncertain, complex and ambiguous landscape of the automotive and motorsport industry, our commitment to transformation is unwavering. Embracing change, we are strategically evolving our product and service portfolios and organization to not just meet, but exceed, the dynamic demands of the future.

By aligning our portfolio with the diverse needs of our customers, we not only enhance satisfaction but also fortify our position as industry leaders, ensuring sustained growth and relevance in an ever-evolving market.

- Dirk Adamczyk, Managing Director

Contents

03
Test & Validation

04
Cybersecurity

05
Engineering Services

00

ZF Engineering Solutions

The Best for the Best!

Driving Innovation Beyond the Track: ZF Engineering Solutions (ZES), a pioneering force in automotive, motorbike and motorsport technology. More than developers and distributors, we seamlessly transfer cutting-edge technologies from motorsport to road applications.

Catering to Formula 1, Formula E, WRC, DTM and beyond, we offer a complete spectrum of engineering services, from product development and testing to special applications, small volume production and motorbike components.

Globally trusted, ZF sets the standard with innovative technology, unwavering reliability and top-tier service - because excellence is our constant claim.

Check our website for more insights

Performance counts, Passion wins. ZF Engineering Solutions

Since the foundation of ZF, transmissions, shock absorbers and clutches have been used in standard and motorsport vehicles. These areas have been and will stay inseparably connected – with success. This holds true for the legendary Mercedes Silver Arrows of the 1930s as well as for the Formula 1 and Formula E cars of today, for national and international long distance and circuit racing events as well as for rally championships.

Winning championships and building reliable and safe, performance road legal vehicles is not possible without ZF Engineering Solutions.

Flexibility and Experts

There is more to it than having new materials, technology and expertise – you also have to know how to apply them. Especially when top performance is required. For this purpose, experts are needed. Experienced employees who cooperate in agile teams, find solutions and implement them. This requires a flexible company. The logical consequence was to establish ZF Engineering Solutions (ZES). Operating on an international level, we develop, design, produce and distribute ZF products and services to our customers.

Customer Centric

About 550 employees are working at ZES on 14 sites around the globe. Their mission is to provide individual support with focus on the customers' wishes. Experts from different departments work together in agile teams with tailored processes to meet the customer requirements in the best way from the initial talks to delivering the project and the supply of parts or services to satisfied customers.

From Race to Road

ZF is an innovation driven company that develops volume production-ready products based on its own R&D efforts and thus invests in the next generation of mobility - which applies for ZES, too. Our development objectives for chassis and powertrain products encompass package optimization, weight reduction and performance enhancement. ZES distinguishes itself from its competitors thanks to OE standards, FMEA, project and process management and the expertise from ZF's volume production business.

As a premier subsidiary of ZF Group, our commitment is to pioneer innovative, sustainable and intelligent mobility solutions, propelling the industry forward.

From race to road, we aim to redefine the future, where our expertise in automotive excellence meets the demands of a rapidly evolving world, ushering in an era of intelligent and connected mobility for new automotive customers and established niche markets across the industry as well transferring the automotive knowledge to other non-automotive industries.

To best suit the varying demands of our customers we divided into three areas:

special applications

engineering consulting & services

motorsport & tradition

For more insights on ZES and to stay updated follow us on LinkedIn

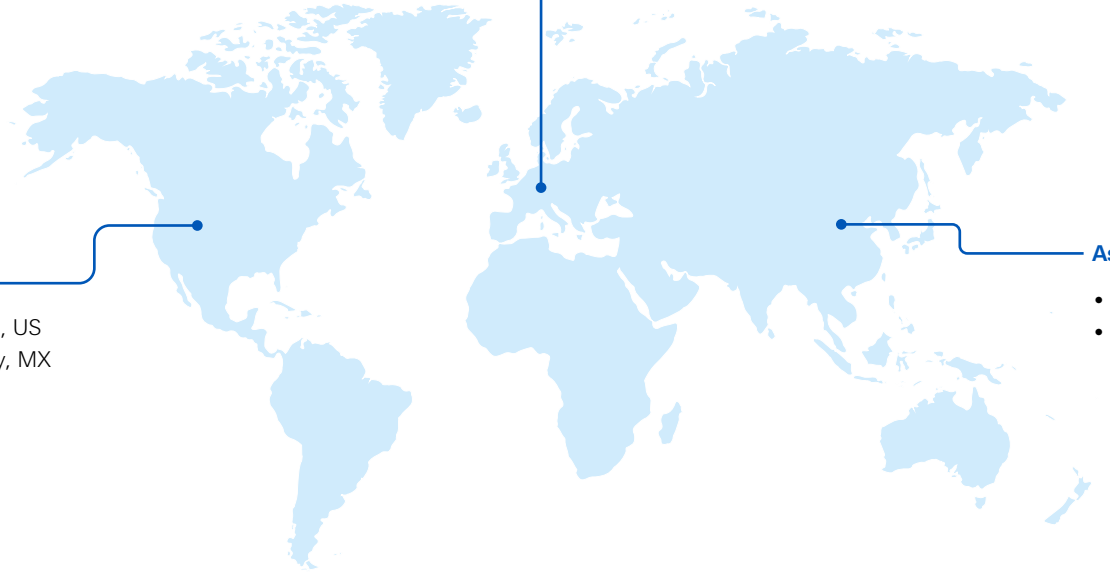
Three Areas.
One Company.
ZF Engineering Solutions

Our Locations Around the Globe

Our global presence spans 14 strategically located sites across three continents - from the United States through Europe to Asia - ensuring we are always close to our customers and the markets they serve. With dedicated hubs in each region, our “local for local” approach enables us to deliver tailored solutions with the speed and precision that today’s dynamic automotive and non-automotive industries demand. Whether it’s collaborating on cutting-edge projects or providing on-the-ground support, our hubs are committed to being where our customers need us most, driving innovation and performance in every corner of the world.

Europe

- **Schweinfurt, DE (headquarter)**
- Plzen, CZ
- Coblenz, DE
- Friedrichshafen, DE
- Munich, DE
- Saarbrücken, DE
- Shirley GB
- Candiolo, IT
- Czestochowa, PL
- Timisoara, RO



Americas

- Northville, US
- Monterrey, MX

Asia

- Shanghai, CN
- Hyderabad, IN

The Markets we serve

At ZES, we serve a diverse range of market segments with our unique setup built around three distinct product lines. From high-performance motorsport to intelligent mobility, our expertise extends beyond the automotive world into non-automotive sectors including healthcare, medical, infrastructure and aerospace. We are redefining the future of transportation and technology, offering innovative, sustainable and intelligent solutions across industries. Whether on the race track, smart streets or advanced aerospace applications, we deliver cutting-edge products and services that meet the evolving demands of both established and niche markets.

Aerospace

All manufacturer or supplier in the aerospace market.

Aftermarket

Focus on chassis and powertrain tuning for road legal cars.

Automotive

With focus on sports cars and hypercars and new automotive customer.

Infrastructure

Cities or towns with digitalized infrastructure.

Motorbike

Covers all two- and three-wheelers plus the ATV and UTV segment.

Off-highway

Other applications that are not designed for road use.

Other

All segments excluded from the nammed groupings.

Race bikes

All bikes designed to be in competition on track and off-road.

Race cars

All kinds of racing from formula over prototypes to touring or rally cars.

Race trucks

Trucks used to compete on race tracks or off-road.

Rail

Focus on rail related manufacturers and suppliers.

Tradition

Any classic or vintage vehicle with ZF components.

"At our core, we champion the seamless transition of chassis and powertrain products and technologies from concept to road to serve new automotive customers, sports cars, hypercars, motorbikes and off-highway applications. Our commitment to excellence is realized through tailored processes and an efficient operational backbone swiftly deploying groundbreaking solutions, supported by global hub structured sales organization - fulfilling our mission to redefine the world of mobility.

- Adrian Mitcham
Head of Special Applications

special applications

Get customized: Special Applications

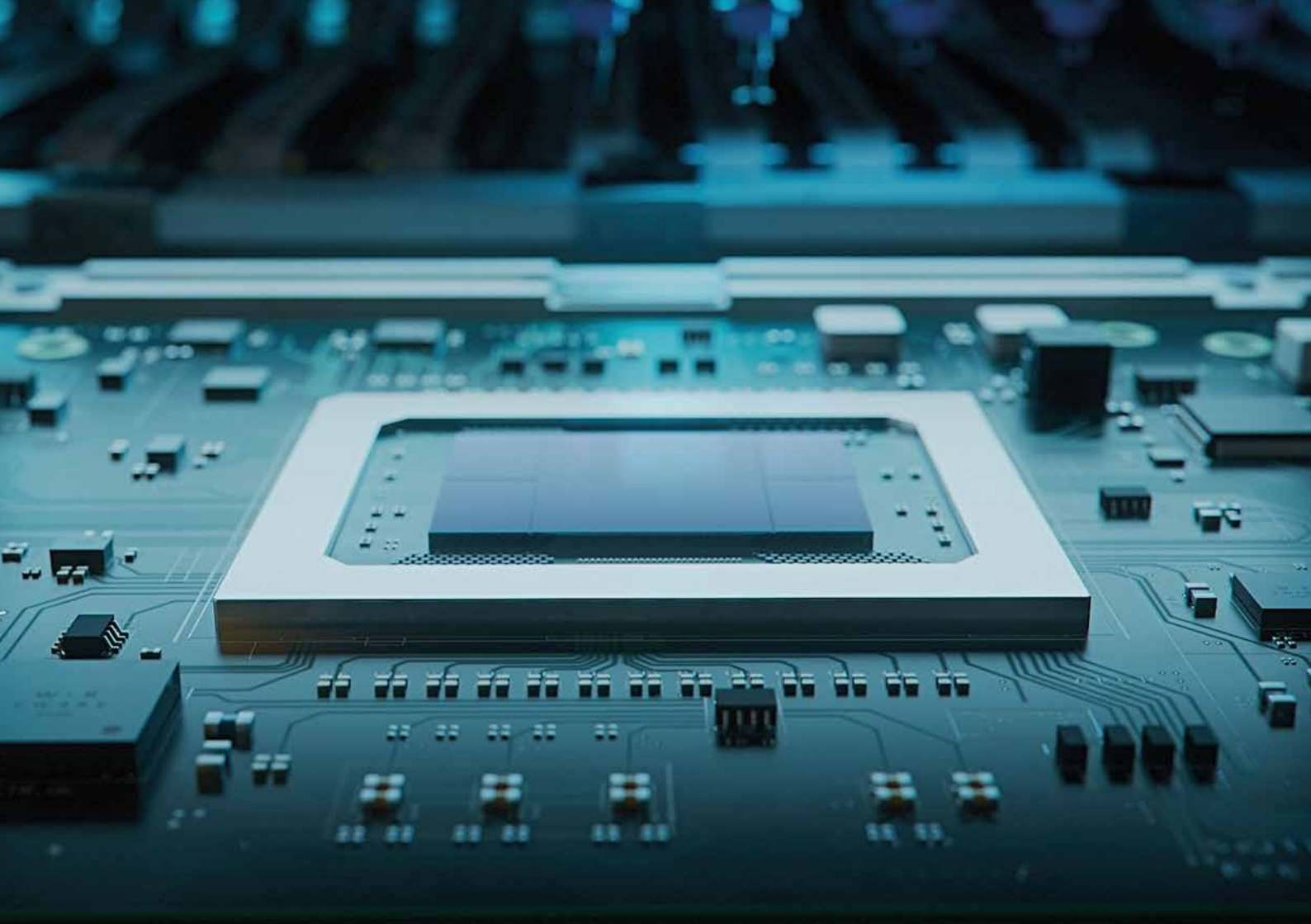
Our customers trust in ZF products for more than 120 years. As a wholly owned subsidiary of ZF Friedrichshafen AG, we have access to the products and innovations of the entire ZF Group. We are cross-linked with more than 16.000 developers of the ZF central research and advance development departments and countless colleagues from ZF's business units and production plants.

Our Goal: Automotive Technology with tailor-made Services for Special OE Projects

The success of companies in the automotive industry will largely depend on their innovative strength in the coming years. Autonomous driving, e-mobility and lightweight body construction are no longer a dream of the future, but are already a key influence on profit and loss. ZES knows the strengths of the automotive industry and sets the decisive parameters for its future viability.

We develop the feasibility study for your alternative powertrain, take over the quality management of your new product features or completely plan a project tailored to your individual requirement profile. Test engineers, software developers and production planners consistently pursue their goals. We adapt to your processes and at the same time support you in optimizing them. Design the mobility of the future with us.

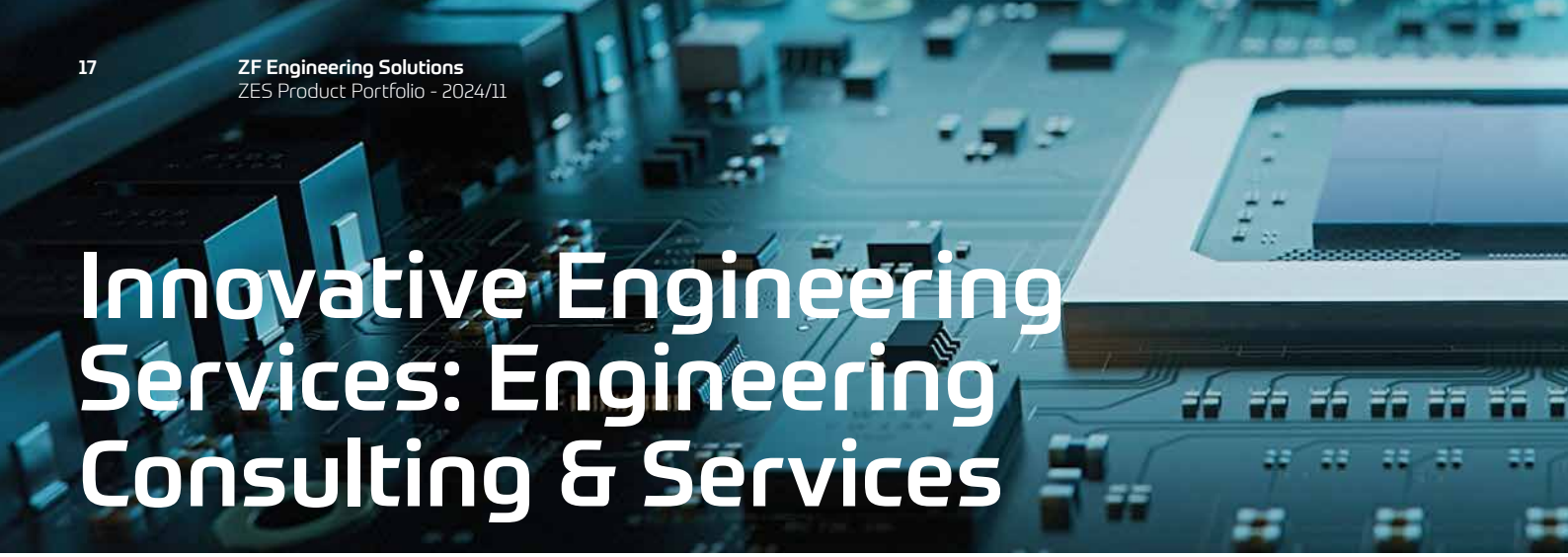
Our quality management system is certified to DIN EN ISO 9001:2015 and DIN EN ISO 14001 ensuring the highest level of process, planning and legal certainty across all contractual models of cooperation. Regular internal audits form the basis to get even better – and always deliver the highest quality.



"We specialize in delivering tailored consulting and engineering projects focused on Cybersecurity and system integration for divisional and external clients. Adding our wide range of Test & validation services for various industries, especially in the aerospace segment. Our passion for excellence drives us to advance technological frontiers in this critical field, reflecting a dedication to unparalleled services to make the world safer.

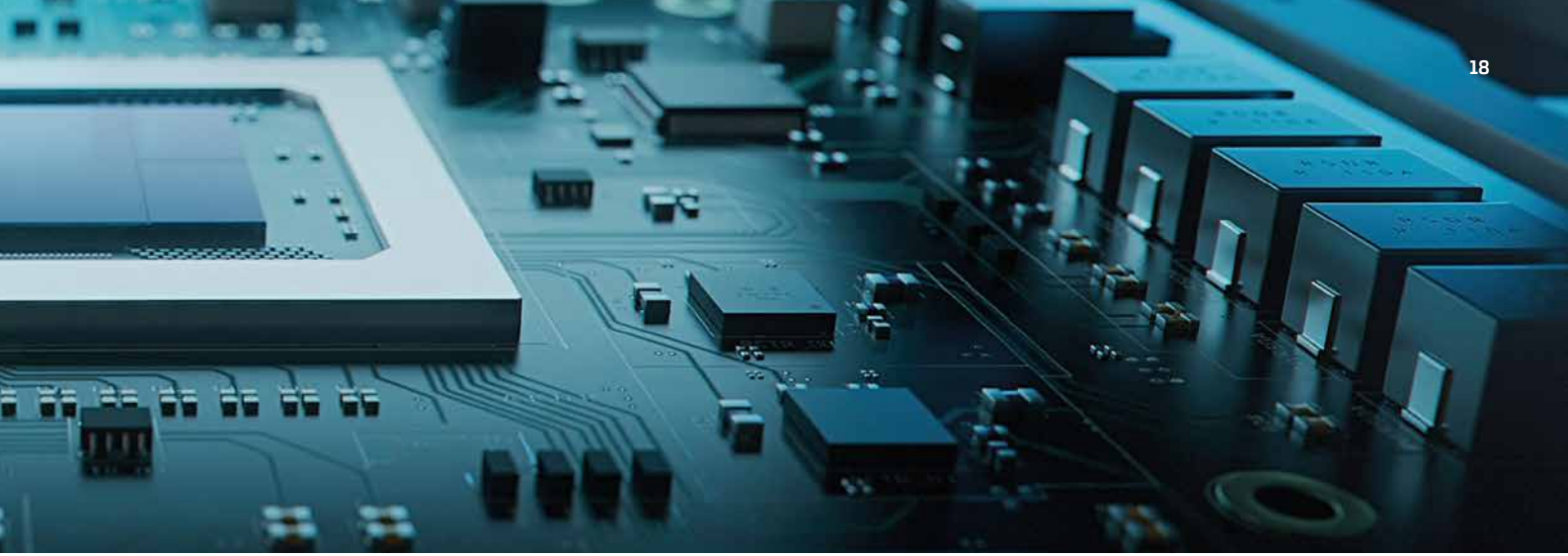
- Michael Eisenbarth
Head of Engineering
Consulting & Services

engineering consulting & services



Innovative Engineering Services: Engineering Consulting & Services

Our Engineering consulting & services division delivers UKAS-accredited Test & validation, full-service Cybersecurity, advanced virtual engineering, system integration and comprehensive vehicle testing. With a focus on quality and performance, we ensure secure, optimized and compliant solutions for today's demanding automotive landscape, driving innovation with precision and reliability.



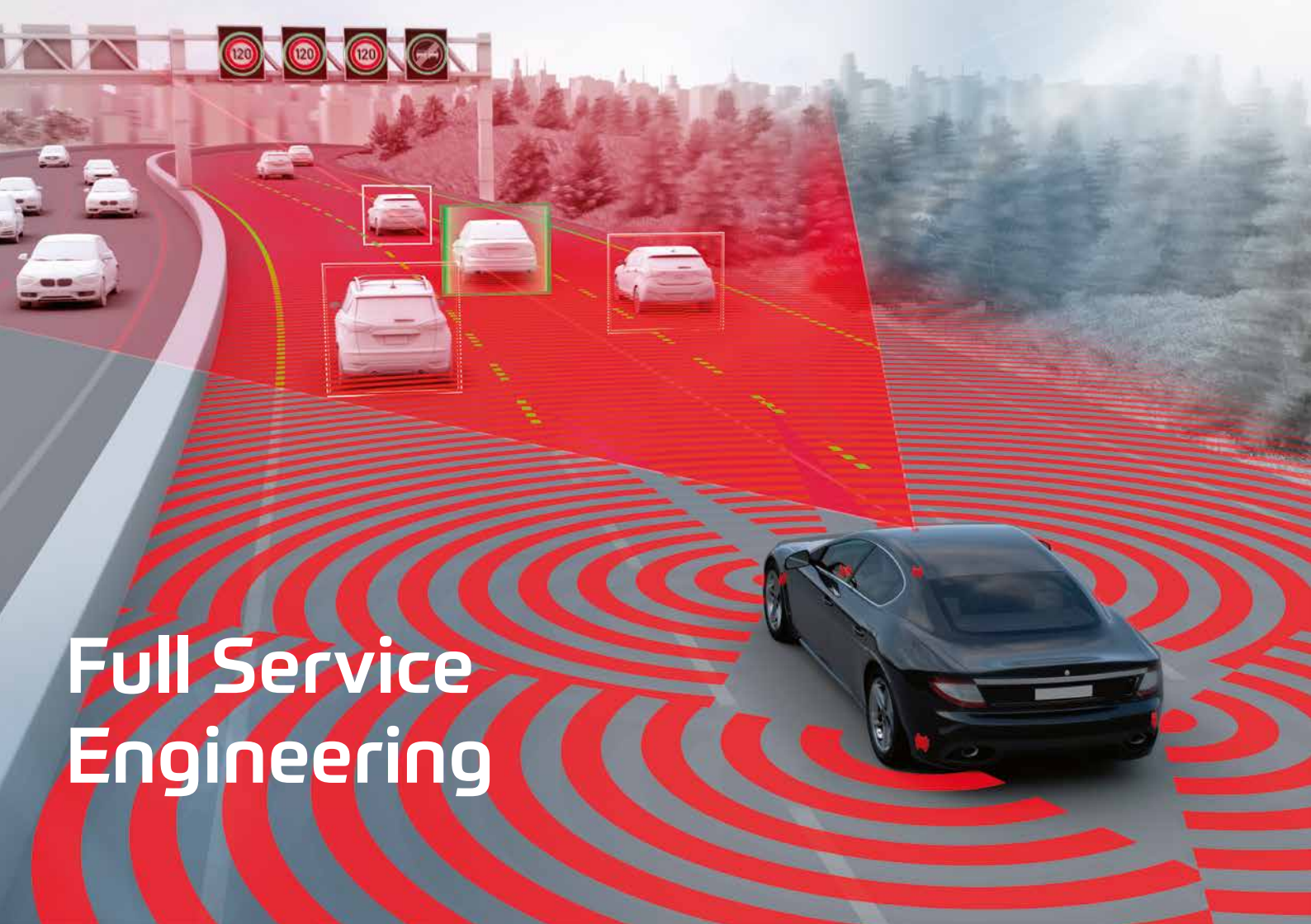
Our Engineering consulting & services team is dedicated to meeting the highest standards in automotive excellence through a holistic approach across three core pillars: Cybersecurity, Engineering services and Test & validation. These pillars empower clients to navigate complex regulatory demands, enhance vehicle and component security, and push the boundaries of automotive performance.

Our Cybersecurity services provide a full-spectrum defense strategy, securing automotive and non-automotive systems against evolving cyber threats through vulnerability assessments, secure software integration and life cycle monitoring solutions.

Engineering services focus on virtual prototyping, system integration, and optimization, enabling cost-effective and precise development cycles.

Lastly, our UKAS-accredited Test & validation services ensure components and systems meet rigorous performance and safety standards through reliable, certified assessments.

Discover how each of these pillars can enhance your projects on the next pages and the services in chapters 03 to 05: Cybersecurity, Engineering, and Test & validation. Together, they form the foundation of our commitment to quality, innovation, and excellence in automotive engineering.



Full Service Engineering

Cybersecurity

In an age where connectivity and data security are paramount, our full-service Cybersecurity offerings are designed to safeguard critical automotive and non-automotive systems against evolving threats. Covering everything from threat assessments and vulnerability testing to secure software integration and ongoing monitoring, our Cybersecurity services protect both data integrity and passenger safety.

Engineering

By leveraging cutting-edge simulation and modeling tools, our virtual engineering team enables cost-effective, rapid prototyping and optimization of automotive components and systems. This approach accelerates development cycles, reduces physical testing needs, and supports precise tuning of performance characteristics, especially important for high-performance and motorsport applications.

With a deep understanding of complex automotive systems, our engineers integrate advanced technologies into cohesive, optimized platforms, ready for real-world deployment. Whether handling powertrain, suspension or electrical integration, our services ensure that each subsystem operates harmoniously within the vehicle's overall architecture.

Test & Validation

Our technical centre's expertise in new product development and applications engineering is supported by its state-of-the-art product validation facilities in Solihull, UK. With external ISO 17025 accreditation by UKAS, we are highly experienced in the areas of environmental, material and EMC testing.

In addition to our certifications - UKAS accredited testing laboratory No. 0332 - we also provide a range of testing support services like instrumentation and prototyping. Our experienced test equipment design engineers are available to support all testing performed on- or off-site.

„Our commitment to technological leadership extends beyond the racetrack as we bring the pinnacle of products and technologies from race to road. Developing products on the track and transfering these technologies into products for high-performance sport cars and hypercars for everyday use is our DNA since decades. Keeping this heritage and writing new chapters to it is our passion and key driver.

- Rainer Kirchner
Head of Motorsport & Tradition

motorsport & tradition


RedBull
RAVENOL
27
DEKRA

Success is our Sport: Winning is the Goal

Whether is it Formula 1, Formula E, 24 Hours of Le Mans, DTM or European Truck Racing Championship and further international racing series like Super GT or V8 Supercars, ZF's dampers, clutches, transmissions and electric powertrains contribute to achieving the decisive head start.

Formula Series

In Formula 1, the royal league of motorsport, it's a tradition that championships have been won with ZF technology for decades.

Even in the youngest Formula racing series - Formula E - winning without ZF products is not possible.

Prototype Series

In the last 25 years, all prototype cars used in IMSA and WEC are equipped with ZF products. Teams and manufacturers relying on ZF technology have secured the overall win more than 20 times.

GT Series

As ZF motorsport is supplying components like dampers, clutches or transmission as well as EPHS to the well-known manufacturer in the GT2, GT3 and GT4 segment and to several TCR manufacturers, winning is part of our business. Being used around the globe in sprint and endurance races, the components supplied prove their performance and reliability and are the first choice of our customers when the target is to win races and championships.

Rally

The long lasting history of ZF and Rally goes back to the factory racing of VW Motorsport in Rally Dakar and WRC. Winning four consecutive times the WRC drivers, manufacturer and teams championship is proof of the quality and performance of our products. Transferring the knowledge gained in the WRC to the other Rally classes brought lots of trophies back from the rallies won with ZF technology.

Off-road

Knowledge gained and technologies tested in WRC offered us the chance to win championships from the very beginning when entering the off-road market in World RX and Rally Dakar. Three consecutive World RX team and driver championship titles is a proof of outstanding performance of our products.

Motorbike

Being the first with a new technology in a racing series is always a risk. But as we take risks to be at the forefront of competition, we proved that with our technologies, races are won. Especially with the legendary carbon fibre fork TF2 in FIM EWC with BMW Motorrad Motorsport. In addition to the FIM EWC championships also in national superbike racing series like the german IDM races and titles are also won with our damping products.

Learn more about ZF motorsport

The Team is the Star: ZF as Technology Partner

ZES is the technology partner of many famous motorsport teams, from Formula E and DTM to different brand cups and the most important premium vehicle manufacturers. ZF maintains a particularly close cooperation with some racing teams or manufacturers in order to develop new and improve existing products for the race tracks and the street.

BHA Hyundai US

ZF is technology partnership of BHA by supplying and developing the latest generation of TD2 TCR dampers and TS2 struts on the Hyundai Elantra N TCR.

BMW Motorrad Motorsport

The technological partnership with BMW Motorrad Motorsport in the FIM EWC has the target to showcase the technological leadership of ZF motorsport with the TF2 carbon fibre fork and the TD2 shock in the high-end superbike segment.

Christian Engelhart

Since 2012 Christian Engelhart is brand ambassador of ZF. Christian is one of the most successful GT drivers in the world with many victories on prestigious sprint and endurance races and championships.

Joachim Waagaard

Being one of the best drifters on the planet the partnership with Joachim aims to pave the way for the RCS184 clutches in the drift environment.

Kristoffersson Motorsport

We started together to win championships and we proved it. Three consecutive titles for KMS and Johan Kristoffersson with our innovative OS3 Rally Struts is the result.

KTM X-Bow

Using our dampers for both street and race cars - we made the slogan from Race to Road reality. The innovative PD0 and the TD3 as well as the EPBn10 make the difference in winning races at the top end.

Ring Racing

The technological partnership with Ring Racing offers us the best development platform on the Nurburgring for our latest TD4 damper innovation.

Schwabentruck and Hahn Racing

Since many years we're partnering and winning championships with both Schwabentruck and Hahn Racing with our SACHS clutches and dampers and the ZF Eco Split transmission.

SSR Performance

Collaborating on the street legal performance segment of SSR with our latest TD5 dampers is a perfect match for both parties with the goal to revolutionise the performance tuning segment.

WS Racing

The only all female racing around the globe is trusting on our products. The 8HP, TS2 struts and TD2 dampers are tested under hardest conditions on the legendary Nurburgring Endurance Series and in the 24hrs race - where performance and reliability matter.

Close to the Scene: On-Site Service

Excellent support - the claim of ZF motorsport. However, it is not limited to technological developments. Thanks to the extensive support system, ZF motorsport technicians are available around the globe for motorsport applications and small volume production development.

Comprehensive Service at the Race Track

We are using service trucks with modern test benches for all products we supply to motorsport and road vehicle customers. With a fully equipped workshop area we can tune or service our products close to and with our customers on any race track or proving ground around the globe.

Quality Assurance at every Race

During the race season, we support our customers at motorsport events around the globe, in 24 countries on four continents. This extensive service significantly contributes to the many worldwide victories supported by ZF.

Warranty and Guarantee

If you have questions, complaints, warranty or guarantee issues, the service and consultancy team will gladly support you anytime.

Learn more about our service partner network

Our global Service Partner Network

To complement our dedicated motorsport factory service centers in the US and Germany, we have established a comprehensive service partner network, strategically positioned to serve our customers with minimal distance and downtime. This network ensures that wherever our customers are located, they can rely on rapid, expert support to keep their vehicles performing at their best. With service partners across key regions, we are committed to providing the highest level of service, reducing turnaround times and keeping our customers on track - both on the road and on the race track.

Europe

- **Factory Service (Schweinfurt, DE)**
- Baumschlager Rally & Racing, AT
- Dullinger Fahrwerktechnik, AT
- R.Tec, BE
- Kresta Racing, CZ
- René's race Engineering, DE
- Nadal Technologies, ES
- Printsport OY, FI
- R.Tec, FR
- Damper Tek, GB
- N.T.P., IT
- Orioli Suspension, IT
- Suspension Racing Technologies, LV
- Wevers Sport, NL

Americas

- **Factory Service (Northville, US)**
- GT3 Cup Challenge, BR
- Agiservo, PY
- JK Motorsport, PE

Asia

- Triple Eight Race Engineering, AU
- Guogui Yitron Racing Technology, CN
- Enable, JP

Historical Milestones

2023 New partnership with ABT Motorsport in Formula E. First ever pole position of Gen3 with Mahindra Racing in Formula E. Dakar Rally winning team (truck category) with ZF technology.

2022 First victory for BMW Motorrad Motorsport in the FIM Endurance World Championship (FIM EWC) with ZF suspension. The winner as well as 14 of the Top 20 cars at the 24-Hour Nurburgring are equipped with products from ZF Race Engineering.

2021 First Formula E victory for Mahindra Racing "powered by ZF" at the London ePrix with a ZF electric powertrain (e-motor, transmission, inverter) The overall winner as well as seven cars from the Top 10 at the legendary 24-Hour race at the Nurburgring are equipped with products from ZF Race Engineering.

2020 ZF brand ambassador Christian Engelhart wins the driver's championship title in ADAC GT Masters.

2019 ZF becomes "Official Powertrain Partner" of Mahindra Racing in Formula E. First victory for the ZF all-electric powertrain in Formula E at the Hong Kong E-Prix.

2018 Dakar hat trick for Peugeot with shock absorbers and clutches from ZF. 20 year anniversary ZF Race Engineering.

2017 Porsche wins the 24 Hours of Le Mans with a ZF clutch for the third consecutive time.

2016 Integration of Conekt in Solihull UK into ZF Race Engineering.

2016 ZF is an official technology partner of the Venturi Formula E Team.

2015 ZF celebrates the 100 year anniversary after founding the company in the year 1915. Merger and integration of the company TRW into the ZF Group.

2014 - 2016 The FIA World Championships in WEC & WRC are won by ZF equipped vehicles once again.

2013 All FIA World Championships (WEC, WTCC, F1, WRC) are obtained with products from ZF.

2012 ZF provides the Audi R18 at the 24h race of Le Mans with a clutch and a special steering system. All three DTM teams are equipped with ZF clutches. ZF partner BMW wins the manufacturer ranking of the DTM.

2011 Volkswagen wins the Rally Dakar for the third time in a row with shock absorbers and clutches from ZF.

2009 The newly founded Team Brawn GP is equipped with rotational dampers from ZF; Brawn wins the world championship.

2007 „Official Supplier" relationship with the BMW Sauber F1 Team (rotational dampers).

2001 Conekt brand established

1999 - 2004 Ferrari and Michael Schumacher win a total of six consecutive constructors' championships with ZF shock absorbers.

1998 Foundation of Sachs Race Engineering GmbH.

1993 Debut of Sachs in the Formula 1 with Mercedes and Sauber.

1985 - 1986 The Porsche-Team of Joest Racing wins the 24h race of Le Mans with Sachs products and defends the title in the following year.

1966 Opening of the motodrome and the new Sachs curve at the Hockenheimring.

1965 Lucas Technical Centre opened in Shirley, UK

1964 Jim Clark wins the Grand Prix in the Formula 1 with the Lotus 33 R9, provided with ZF transmissions.

1937 The first Mercedes „Silver Arrows" are equipped with Sachs shock absorbers and clutches.

1915 Foundation of ZF Friedrichshafen AG.

1895 Foundation of „Schweinfurter Präzisions-Kugellagerwerke Fichtel & Sachs" by Ernst Sachs and Karl Fichtel. WTCC, F1, WRC) are obtained with products from ZF.

Tuning fueled by Passion

SACHS Performance products are the first choice for demanding car drivers. Their extraordinary resilience guarantees an unforgettable driving experience with maximum dynamics. ZES develops these high-performance tuning products of top quality combined with profound motorsport know-how.

When only the best is enough – SACHS Performance Coilover Suspensions (CSS) and reinforced Clutches (PCS) are the first choice.

Learn more about our Brand Sachs Performance and the products.

As prime features of SACHS tuning products, quality and high-performance are a result of the company's years of involvement in the motorsport industry.
It has been an equipment supplier for numerous race teams for Formula 1 to customer racing that have won hundreds of races and (world) championships.
The comprehensive expertise gained on the toughest race tracks in the world has been directly applied to the development of SACHS Performance products, which means that even the most ambitious drivers are perfectly equipped with SACHS Performance tuning products.


EXTREME PERFORMANCE

ZF Tradition gets you back on the Road

Whatever is necessary - we offer you the right Solution

Reconditioning

We work with specialized staff, high-precision tools and test benches to carry out reconditioning or repairs for all our historic products.

Repairs

Based on recalculations and the use of the latest manufacturing technologies, we produce high-quality original spare parts and products for you.

Re-manufacturing

Thanks to our extensive drawing archive, we are able to reproduce any of our spare parts according to the original parts list, original drawings and the ZF quality of the time.

Original spare Parts for classic Cars

ZF Tradition has original spare parts for all historical ZF products ready for you. Should a spare part not be in stock, we can always offer you a one-off production for your required spare part.

Fore more information on ZF Tradition see
zf.com/tradition

01

Chassis

Introducing our cutting-edge chassis product portfolio, where advanced engineering meets unmatched performance for both road-legal and motorsport applications. Designed to elevate vehicle dynamics, our portfolio includes high-performance damping, braking and steering solutions, all crafted to deliver an unparalleled driving experience. Emphasizing lightweight construction, every component is engineered for superior agility and handling. With a focus on individualization, our engineering kits provide bespoke solutions, tailored for everything from one-off builds to small series production.

Additionally, we offer selected products from the ZF range, now made available for niche markets and small series, ensuring that even specialized needs are met with precision and quality.

Check our website for more insights

Braking

Our braking portfolio is at the heart of vehicle dynamics, playing a critical role in the performance and safety of every street and race car. Precision-engineered for maximum stopping power and control, our braking solutions ensure optimal handling and stability in all driving conditions. Whether navigating tight corners on the track or ensuring safety on the road, our products are designed to deliver consistent, reliable performance.

Check our website for more insights

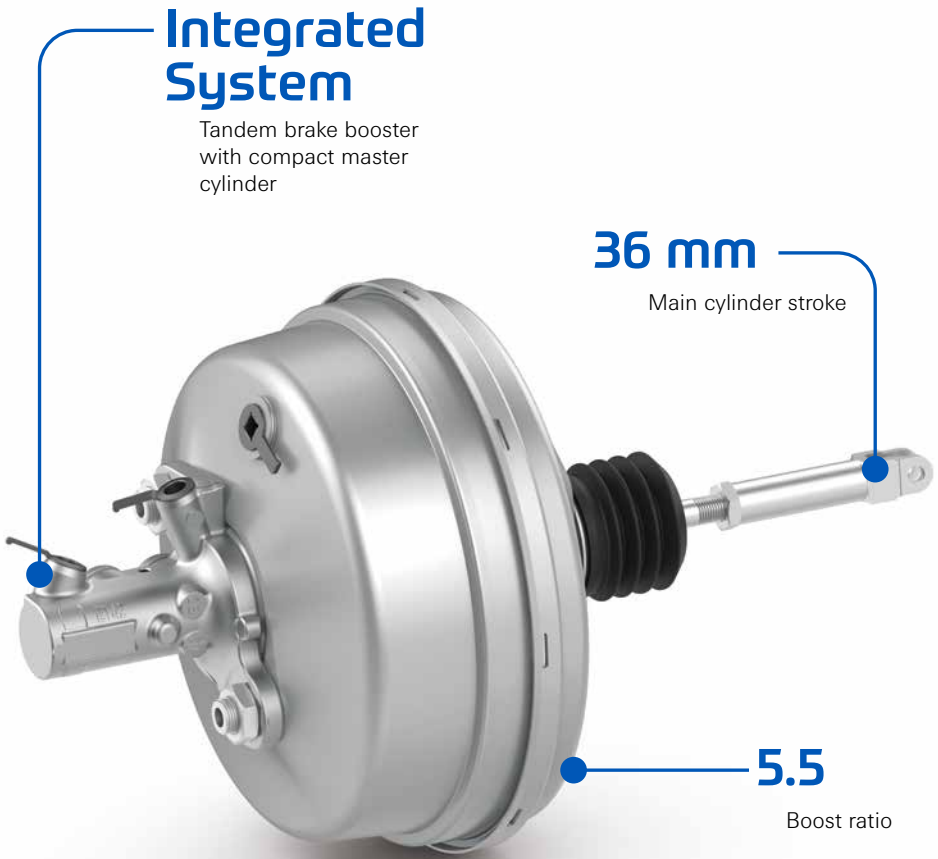
Brake Booster

The ZF Brake Booster (BB) combines a tandem brake booster with compact master cylinder and a remote reservoir, providing an easily integrated system that can be tailored to meet the requirements of high-performance vehicles.

Designed and developed for:

Key Dimensions

- **Outer diameter:** 246.5 mm
- **Adjustable rod length:** 156 – 172 mm
- **Shell length:** 141.8 mm
- **Master cylinder**
  - Bore: 25.4 mm
  - Stroke: 36 mm (18/18)
  - Port pitch: 38 mm
- **Reservoir**
  - Capacity to maximum: 395 cc
  - Compensating volume: 52 cc
  - Switching volume: 230 cc



Watch the video to learn more about the product

Electric Parking Brake

Focused on developing the most lightweight product, the Electric Parking Brake niche (EPBn) eliminates the need for mechanical cables. With the EPBn solution compact actuators apply the park brake offering improvements in packaging, performance and driver convenience for the niche vehicle segment.

Designed and developed for:

Discover the versatility of our Electric parking brake (EPBn) system, available in four distinct variants to meet the diverse needs of modern vehicles. Engineered for precision and reliability, our EPBn offers clamping forces of 10 kN, 17 kN and 22 kN, providing tailored braking performance for a wide range of applications. Whether for niche applications, high-performance vehciles or heavy-duty applications, our EPBn variants ensure optimal safety and stability.

	EPBn10	EPBn17	EPBn22	EPBnTL
Nominal clamp force	10 kN	17 kN	22 kN	
Residual drag		< 1 Nm		
Disc thickness		12 - 38 mm		
Disc diameter		< 400 mm		
Apply time		< 1.0 s		
Release time		< 0.5 s		
Weight	2.2 kg	2.4 kg	3.4 kg	
ECU	●	●	●	
Software	●	●	●	
Disc compatibility		Steel and ceramic		

● available ○ not available

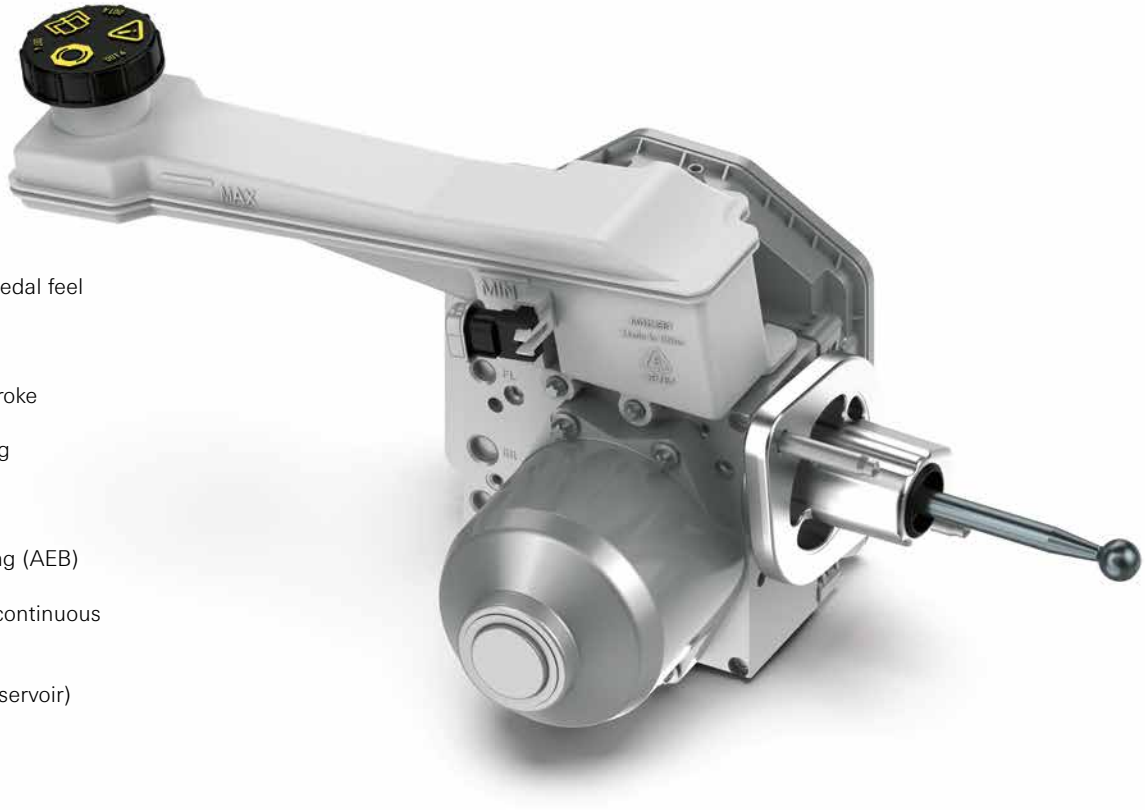
Integrated Brake Control

Integrated Brake Control (IBC) is a non-vacuum, fully integrated electro-hydraulic system providing premium brake performance for automatic emergency braking, full energy recuperation and redundant fall-back options up to full automated driving for passenger car and light truck segments.

Designed and developed for:

Key Facts:

- Vacuum independent
- Seamless regenerative braking
- Brake hardware independent pedal feel
- Brake pedal travel max. 80 mm
- Master cylinder with 42 mm stroke
- Weight saving of approx. 2-3 kg
- Crash length of 120 mm
- Autonomous emergency braking (AEB)
- Dual acting plunger (DAP) for continuous on-demand pressure capability
- Weight: approx. 5.3 kg (w/o reservoir)



Damping

Our damping portfolio delivers unmatched performance and reliability across a wide range of applications, including dampers, struts and forks designed for road, track and off-road use. Focused on lightweight construction and high-performance hydraulics, these products are packed with features rigorously tested in motorsport environments.

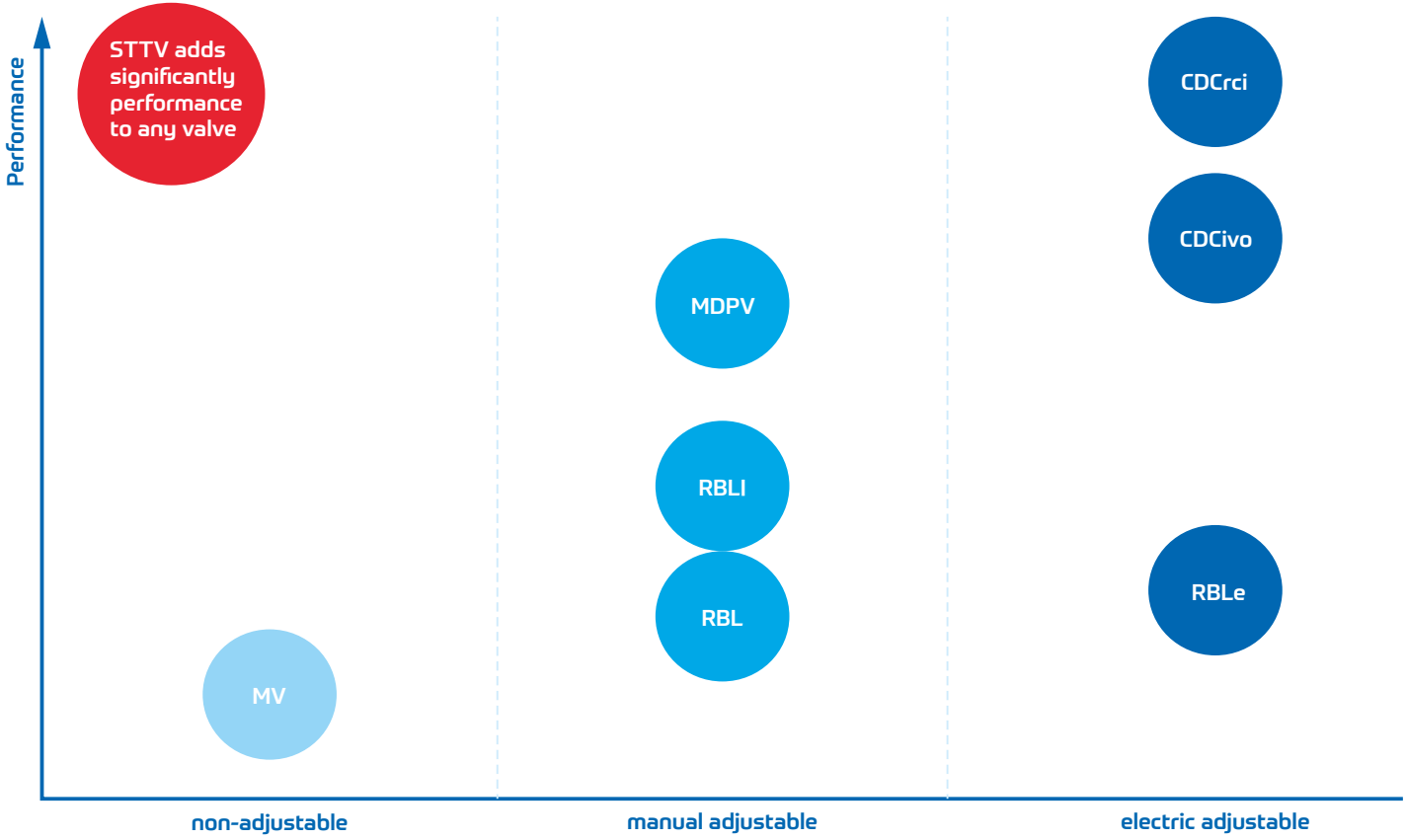
Now, this race-proven technology is available for road-legal cars and bikes, as well as for the most demanding off-highway conditions. Whether you're navigating city streets, tearing up the track or conquering rugged terrain, our damping solutions provide the precision, durability and adaptability you need for every journey.

Check our website for more insights

Valves and Adjustment

ZF's innovative valve systems, evolved from the renowned SACHS and Boge technologies, carry a legacy of technical leadership built through decades of motorsport and road legal developments. From non-adjustable dampers to mechanical and electrically adjustable systems, ZF has consistently pushed the boundaries of performance and precision. Our latest breakthroughs feature continuously adjustable electric valves, independently tuned for bump and rebound, offering unparalleled control and adaptability. Proven on the racetrack and engineered for road applications, ZF's damping systems set the standard for reliability, comfort and dynamic vehicle performance.

Designed and developed for:


Performance
STTV adds significantly performance to any valve
MV
MDPV
RBLI
RBL
CDCrci
CDCivo
RBLe
non-adjustable
manual adjustable
electric adjustable

MV

Our innovative non-adjustable Modular valve (MV) kit offers a wide range of tunablility with different damping characteristics.

The ZES Modular valve (MV) is a high-performance solution designed for motorsport and special applications, offering extensive tuning flexibility. With the ability to provide linear, semi-digressive, or digressive damping characteristics, the valve is designed to meet all requirements an application might need and offers independent tuning in both bump and rebound. The innovative PDO (pressure dependent bleed control) technology enables independent bleed adjustment independent for bump and rebound in monotube dampers for precise control, while the banded piston enhances sealing efficiency. For applications requiring higher bump forces or lower gas pressures, the piston valve can be supported by a base valve (STTV technology).

Available in multiple piston diameters (30, 36 and 45 mm), the MV is fine-tunable during ride work sessions to meet specific performance demands. Its durability has been rigorously tested and approved for series applications, meeting all customer specifications for reliability and performance.

STTV

One tube - two valves. The Single tube twin valve (STTV) technology followed our race to road approach as it was developed for the race tracks and now transferred to our road legal Performance dampers and struts.

Introducing the STTV (Single tube twin valve) technology - a breakthrough in damper performance and customization. Designed to deliver higher damping forces through an additional base valve, this innovative system ensures unmatched response and adaptability for a superior ride.

Whether enhancing passenger comfort or pushing the limits in motorsport, STTV technology offers unparalleled flexibility and reliability, redefining damper performance.

Key benefits:

- Reduced gas pressure provides better initial damping and performance.
- Eliminates the risk of cavitation
- Extends the options for tuning the damping force characteristics to new levels.
- Available as an inline cartridge or external reservoir
- Compatible with all damper types.

RBL

now also available with electric adjustment (RBLe)

Keeping the tunability of our MV and adding the option for external adjustment when the damper or strut is mounted in the vehicle.

Our RBL (Rebound bump low-speed) adds an adjustable bypass valve on the piston rod to the damping force characteristics of the MV, which offers enhanced control and tuning flexibility for motorsport and special applications. This configuration allows for precise, common low-speed damping adjustment in both bump and rebound, adding an extra layer of customization to the system. The valve provides linear, semi-digressive, or digressive damping characteristics, with independent tuning for bump and rebound.

The bypass valve improves low-speed handling with almost not affecting high-speed damping, resulting in smoother performance and increased driver control and can be adjusted when the dampers or struts are mounted on the car with its external adjuster. With the banded piston for enhanced sealing and optional base valve (STTV) support for higher bump forces and/or lower gas pressure, this system delivers maximum flexibility.

Available in piston diameters of 36 and 45 mm, it is fine-tunable during ride work sessions by the manufacturer and in the car by the end-consumer.

RBLI

The next level of performance and adjustability by the use of an independent low-speed adjustment in bump and rebound via two separate adjusters.

The RBLI (Rebound bump low-speed independent) offers advanced tuning capabilities for performance-oriented customers on both road and track, with its adjustment based on two external adjusters for independent adjustment of bump and rebound low-speed damping. This next evolution, from the RBL to the RBLI, allows drivers to fine-tune their suspension for precise control and optimal handling while having the dampers and struts installed in the vehicle.

The external adjusters enable easy, on-the-go adjustment of low-speed damping in both bump and rebound seperate, providing smoother cornering, improved traction and enhanced vehicle stability.

Ideal for enthusiasts who demand the best performance, this system ensures that suspension settings can be tailored for both everyday road comfort and track-level precision, delivering a truly personalized driving experience.

The durable and reliable design - available in 36 and 45 mm piston diameter - meets all series application requirements.

MSPV

More flexibility and more tuning possibilities with our latest solid piston valve system MSPV.

The MSPV (Modular solid piston valve) offers comprehensive adjustability for high-performance damping in motorsport and for sport cars and hypercars for street legal use. It features independent low-speed bump and rebound adjustments via a needle adjuster, allowing precise control over low-speed dynamics. For high-speed bump and rebound, it utilizes a shimmed piston, providing optimal damping control at higher velocities. Additionally, the drop-off can be fine-tuned with a separate shimmed piston.

The system is easy to adjust with to different tools all the adjusters can set fine control of high-speed settings, low-speed adjustments and if installed the drop-off activation and timing. This ensures quick and intuitive tuning.

The click-feeling is optimized for precision and the design minimizes unwanted parallel flow resistance.

What sets the MSPV apart is its modular adjustability - it can be upgraded or downgraded during service.

From the beginning of its development we focused on optimizing long-term running costs for our customers.

High-performance and cost efficiency come together in our track dampers with MSPV.

CDC

CDC adapts damping in real-time, providing a perfect balance between comfort and performance for any driving condition.

ZF's Continuous damping control (CDC) is an advanced semi-active suspension system designed to provide a wide range of damping settings, from high comfort to extreme driving performance. By continuously adjusting damping forces in real-time based on road conditions, vehicle speed and driving dynamics, CDC optimizes both ride comfort and handling. Each damper adjusts independently, ensuring the perfect balance between safety and performance.

To further enhance customization, ZF uses an valve part engineering kit that provides the highest hydraulic tuning flexibility during ride work sessions with customers. The CDC is mainly used as internal valve (CDCivo) in our monotube dampers but can also be designed as external single (CDCevo) or twin valve (CDCrci) with rebound and bump independent valve. The valve is developed for precise adjustments to the damping characteristics, enabling engineers to fine-tune the suspension to meet specific performance and comfort requirements.

This flexibility allows the system to deliver maximum comfort during everyday driving and shift seamlessly to performance-oriented damping for dynamic or extreme driving conditions. Whether cruising in comfort or pushing the limits on the track, CDC - with its advanced tuning capabilities - enhances stability, reduces body roll and improves traction for an unparalleled driving experience for safe and performance-orientated driving.

Watch the video to learn more about the PD0

Performance Dampers

Our comprehensive road-legal Performance Damper (PD) portfolio is designed to cater to a wide spectrum of driving needs. From robust non-adjustable dampers to precision mechanical adjustable options and all the way to advanced electrically controlled dampers, our portfolio offers unparalleled flexibility. Each damper features a high-performance monotube design, available in both steel and aluminium, ensuring durability and optimal vehicle dynamics. With extensive individualization options, these dampers can be tailored to specific driving preferences. Our ready-to-install damper modules make upgrading your vehicle's suspension system seamless, delivering exceptional control, comfort and handling for your every journey.

Designed and developed for:

PD0

PD1

PD1e

PD2

PDi

Max. rebound force	Ø36: 5,500 N / Ø45: 8,500 N				
Max. bump force	Ø36: 2,500 N / Ø45: 3,500 N				
Damping adjustment	None	Bump/rebound low speed	Bump/rebound low speed (electric)	Bump/rebound low speed independent	CDC (electric)
Piston diameter	36 or 45 mm				
Piston rod diameter	13 or 15 mm				
Height adjustment	●	●	●	●	●
Lift/drop actuator	● / ●	● / ●	● / ●	● / ●	● / ●
Damper body	Aluminium or steel				
Damper module	●	●	●	●	●
External reservoir	●	●	●	●	●
For McPherson	○	○	○	○	○

● available ○ not available

PD0

The PD0 offers outstanding temperature performance and perfect wheel load adjustment for different ride heights on the road and race track.

Designed to meet the demands on performance and weight the damper is available in steel or aluminium in different sizes.

The non-adjustable version is designed for pure light weight.

Features and Options

- STTV
- External reservoir
- Linear or progressive spring system
- Lift or drop function
- Ready to install modules

Lift/Drop

Lift or drop actuator can be equipped to the damper module

STTV

Each monotube damper can be equipped with an traditional base valve either in-line or with external reservoir

-35 to 120 °C

Temperature range of the monotube dampers

2 kg

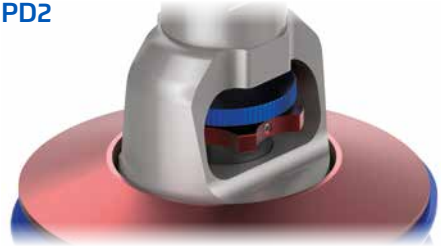
Total weight of a damper module depending on length and spring

160 bar

Maximum inner pressure of the monotube dampers

PD1

PD2



PD1 - PD2

The characteristics of the PD0 are combined with manually adjustable damping in the PD1 and PD2.

Combining the damping force adjustment (RBL or RBLI) with the light weight approach of the PD enables the driver to optimize the setup on its needs. No matter if it is changing conditions on the race track or just more comfort on your daily ride, the one- or two-way adjustable versions make it happen.

The valve system is derived from our motorsport technology used in GT and touring car racing series to meet the requirements of different race tracks or changing conditions over the weekend. The PD1 offers a low speed adjuster for both bump and rebound (RBL). With the advanced adjustment in the PD2 you're able to adjust low speed damping in bump and rebound independently (RBLI) without interference.

PD1e

The PD1e offers outstanding temperature performance and perfect wheel load adjustment for different conditions on the road and race track. Designed to meet the demands on performance and weight the damper is available in steel or aluminium in different sizes.
The electric one-way adjustable damper version is based on the PD1 with an upgrade due to an electric stepper motor instead of the manual adjuster.

Features and Options

- Base valve
- External reservoir
- Linear or progressive spring system
- Lift or drop function
- Ready to install modules

50 ms

Time to change low speed rebound and bump damping

STTV

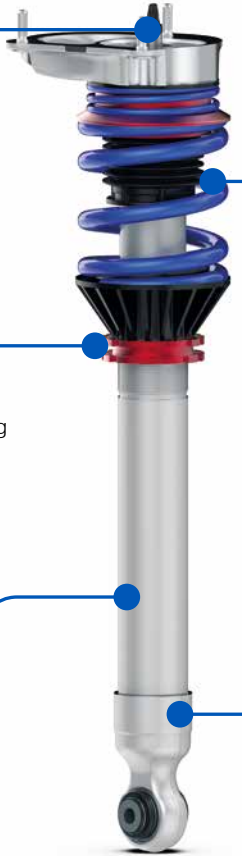
Each monotube damper can be equipped with an base valve either in-line or with external reservoir

Connectors

Our electric adjustable dampers and struts offer flexible connector options to meet the customer demands. They can be equipped with either a pigtail connector or the ZF integrated connector. The pigtail connector is designed to meet specific customer connectors, ensuring seamless integration into the vehicle.
The ZF integrated connector, on the other hand, is directly connected to the female interface located in the piston rod, eliminating the need for additional wiring harness modifications. The male connector is part of the car's wiring harness, ensuring a clean, secure and efficient connection within the vehicle's electrical system. This provides flexibility and saves time during vehicle assembly in the customer plant.

Pigtail

Integrated connector



Connector

Pigtail cable or ZF piston rod integrated connector available

0 - 1.9 A

Current range which can be used depending on fail-mode

2 fail-modes

Fail-safe or fail-soft option with different range of current

<30 ms

Time to change the current independent of stroke position and piston speed

Continuous

Damping force can be adjusted in any position and speed during the stroke

PDi

The PDi is the high-end damping solution of our road legal Performance damper program. Equipped with an electric adjustable valve called CDC (Continuous damping control), it offers the best damping performance you can get. With its wide spread the CDC can be used for softest comfort demands as well as the highest performance requirements your facing with sports cars and hypercars on the track without changing dampers. Combing the CDC with lightweight aluminium designed and structural optimized components it's a perfect match for hardest conditions.

The damper design prioritizes lightweight construction, optimizing friction for smooth, responsive performance. Customizable to meet specific vehicle and driver needs, each damper is engineered for durability and robustness, ensuring long-lasting reliability.

Performance Struts

Introducing our advanced road-legal Performance strut (PS) portfolio, specifically designed for vehicles with McPherson axle configurations. Built to cater to a wide spectrum of driving needs, our struts range from robust non-adjustable options to precision mechanical and electrically adjustable variants. Each strut features a high-performance monotube design, available in steel and aluminium, ensuring durability, highest bending stiffness and optimal vehicle dynamics. With extensive individualization options, these struts can be tailored to specific driving preferences.

Designed and developed for:





	PS0	PS1	PS1e	PS2	PSi
Max. rebound force			Ø36: 5,500 N		
Max. bump force			Ø36: 2,500 N		
Damping adjustment	None	Bump/rebound low speed	Bump/rebound low speed (electric)	Bump/rebound low speed independent	CDC (electric)
Piston diameter			36 mm		
Piston rod diameter			15 mm		
Height adjustment	●	●	●	●	●
Lift/drop actuator	○ / ○	○ / ○	○ ○	○ / ○	○/ ○
Damper body			Steel and aluminium		
Damper module	●	●	●	●	●
External reservoir	○	○	○	○	○
For McPherson	●	●	●	●	●

● available ○ not available

Spring System

Linear or progressive spring system can be designed with one or multiple springs

Environmental Protection

The bearings and the running surfaces are available in sealed or protected versions for long reliability on the roads

STTV

Each monotube damper can be equipped with a base valve either in-line or with external reservoir

Height adjustable

Customer specific adjustment range

Damping Force

Can be adjusted with tool less adjusters or with electric controlled valves

One basic Design - different Options

The PS, is a modular suspension solution featuring a steel or aluminium outer tube and upside-down mounted monotube damper with a chrome-coated surface for durability, performance and higher bending stiffness on a McPherson strut compared to a similar twin tube strut.

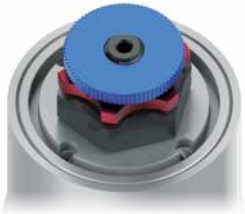
The PS design allows flexibility with a range of valve systems, from non-adjustable (MV) to various levels of adjustability one way (RBL) or two-way (RBLI). For advanced needs, we offer electronically adjustable (RBLe) and continuously adjustable (CDC) options.

The entire system is modular, enabling customization of not only the damping but also the upper mounting, spring system and more to fit different vehicle requirements and preferences, providing both performance and comfort in any driving condition.

PS0

PS1

PS1e



PS2

PSi

Track Dampers

The all new Track Dampers (TD) product family is engineered for ultimate performance on the track. Designed with a focus on lightweight construction, high stiffness and unmatched robustness, these dampers deliver the high quality and low friction required for competitive racing we are offer since more than 100 years. Featuring a precision-engineered monotube design, the TD family comes either with a piston valve or a solid piston combined with a valve block, ensuring optimal performance across various racing disciplines. Available in different sizes, our Track dampers are perfect for touring cars, GT cars, formula cars and prototype vehicles.

Designed and developed for:

	TD0	TD1	TD2 - TD5
Max. rebound force	8,500 N		10,000 N
Max. bump force	3,500 N		12,000 N
Valve type	Piston valve		Solid piston with valve block
Damping adjustment	None	Bump/rebound low speed	Bump low/high rebound low/high drop-off
Piston diameter	27 / 30 / 36 / 45 mm	36 / 45 mm	30 / 32 / 36 mm
Piston rod diameter	11 / 13 / 15 mm	13 / 15 mm	13 / 15 mm
Height adjustment	●	●	●
Pre-load adjustment	●	●	●
Damper body	Aluminium		
Damper module	●	●	●
External reservoir	●	●	●
For McPherson	○	○	○

● available ○ not available

TD0

The TD0 non-adjustable Track Damper combines the precision of monotube technology with a broad range of sizes and diameters, tailored to meet diverse customer needs. Its monotube design offers superior heat dissipation, reduced weight and consistent performance under extreme conditions. Whether in sprint or endurance racing, this robust damper ensures reliable performance on every track, making it an ideal choice for those seeking lightweight, durable and high-performing damping solutions.

Damper Design

The TD0 damper design is highly versatile, built on proven monotube damper technology. It features both internal and external gas reservoirs with a separating piston, providing enhanced performance and flexibility. Available in a range of piston sizes (25, 28, 30, 36 and 45 mm) and rod sizes (8, 10, 11, 13 and 15 mm), the TD0 damper ensures optimal customization. Additionally, customers can choose between a one-piece or screwed body construction, offering flexibility in terms of durability, ease of maintenance and weight optimization. This adaptability makes it ideal for high-performance motorsport applications requiring precise damping control.

Valve System

The Modular valve (MV) features a shimmed piston valve offering linear, semi-digressive and digressive damping characteristics in both bump and rebound. It provides extensive tuning flexibility, allowing precise adjustments during ride work sessions to optimize vehicle performance and handling.

Titanium

Piston rod can be made from titanium as optional feature instead of standard steel

160 g

Total weight of a damper depending on length and diameter

8 - 15 mm

Different piston rod diameter can be selected

Individualization

Highly customizable and individual solutions can be offered

TD1

The TD1 is designed as one-way adjustable damper for one make series or entry level motorsport with focus on good performance and low running costs. Its damper design principle as a monotube damper offers outstanding damping force stability under any condition due to the perfect heat transfer of the aluminium outer tube. The threaded outer tube enables precise wheel load adjustment for different tracks and track conditions.

Damper Design

The damper design prioritizes lightweight construction, optimizing friction for smooth, responsive performance. Customizable to meet specific vehicle and driver needs, each damper is engineered for durability and robustness, ensuring long-lasting reliability.

Valve System

The Modular valve (MV) features a shimmed piston valve offering linear, semi-digressive and digressive damping characteristics in both bump and rebound. Enhanced with a piston rod adjustment and needle bypass valve, it provides extensive tuning flexibility, allowing precise adjustments to optimize vehicle performance and handling on the track.

Features and Options

- Base valve
- External reservoir
- Linear or progressive spring system
- Ready to install modules

Spring System

Linear or progressive spring system can be designed with one or multiple springs

Up to 120°C

Maximum operating temperature

20 Clicks

Tool-les low speed adjuster with 20 clicks

Height adjustable

Customer specific adjustment range

STTV

Each monotube damper can be equipped with a base valve either in-line or with external reservoir

TD2 - TD5

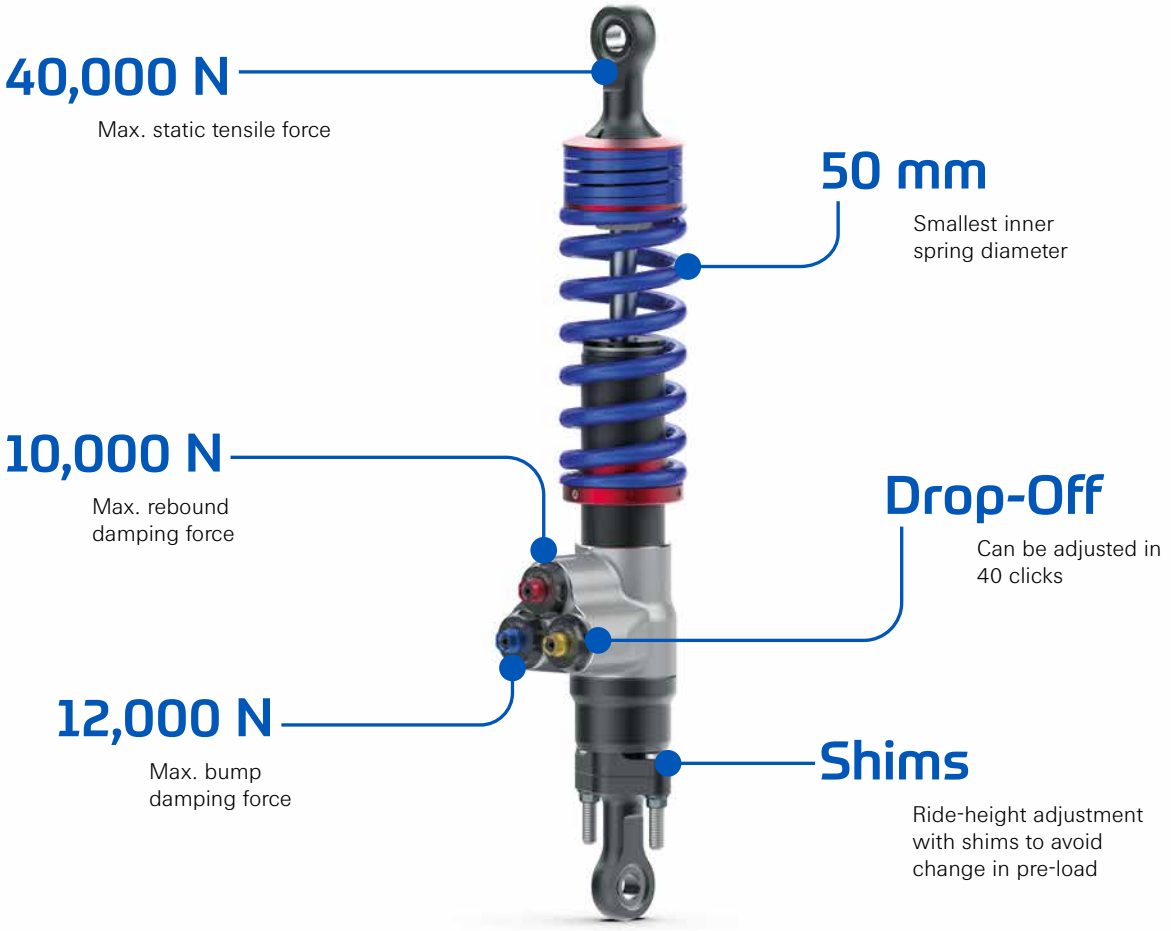
Introducing the all-new TD2 to TD5 multi-adjustable Track Damper engineering kit, designed for maximum flexibility and performance. This innovative system is built around solid piston technology and offers modular adjustability from 2-way up to 5-way damping adjustment, catering to a wide range of racing and performance needs. The TD2 to TD5 can be upgraded or downgraded during service, providing the adaptability required for various motorsport applications. With precision engineering, this damper kit ensures optimal control, durability and customization for professional and enthusiast drivers alike.

Damper Design

The modular damper design with different diameters features a forged valve block and a standard gas reservoir in two dimensions, enabling it to handle strokes up to 150 mm. The valve block is engineered to be package-optimized, making it suitable for compact or restricted installation spaces. For vehicles where packaging space is critical, an external reservoir solution can be implemented, providing flexibility in damper configuration without compromising performance.

Its easy-to-service design ensures quick access for maintenance or tuning adjustments, further improving its adaptability for various applications.

Thanks to the monotube principle, the damper can be installed in any orientation, offering significant flexibility in vehicle setup and design.


40,000 N
Max. static tensile force
50 mm
Smallest inner spring diameter
10,000 N
Max. rebound damping force
Drop-Off
Can be adjusted in 40 clicks
12,000 N
Max. bump damping force
Shims
Ride-height adjustment with shims to avoid change in pre-load

What's new and special?

Pre-load independent Ride Height adjustment

The ride height adjustment system utilizes shims clamped by two bolts and nuts at the ring eye, allowing for precise and independent spring pre-load and ride height adjustments. This setup offers flexibility in weight balancing, as adjustments can be made without altering the spring pre-load. The shims come in various defined heights, simplifying the process of achieving the perfect balance. This system is designed for quick and easy changes, providing a streamlined solution for fine-tuning suspension geometry for optimal performance and reproducibility on any track.

Damping Adjustment in one place

The TD series offers a highly configurable system with a selectable amount of adjusters (2 to 5) that are all conveniently located in one direction and at one access point. This design ensures easy reach and time efficiency, making it ideal for the race tracks. The adjusters are manually adjustable with only two tools for all adjusters, making quick adjustments on the go simple and intuitive.

Why we call it Drop-Off and not blow-off?

A blow-off valve allows an immediate reduction of damping force when a certain pressure threshold is exceeded. The valve opens when the damper encounters a sudden, sharp force - such as hitting a curb - allowing the oil to bypass the main flow path, by limiting pressure. This ensures that the vehicle remains stable and controlled under extreme conditions, preventing excessive force build up that could otherwise upset the vehicle's balance and to maintain grip. The pressure limiting design of the blow-off results in a flat damping force curve which stays at the maximum even if piston speed is increased. Unfortunately the pressure needs to decrease again before the function is usable again. Getting a second harder impact can result in loss of body control.

Despite that we decided to develop and implement in our high-performance dampers the best technology our customers can get to make a difference where tens of a second can put you in second place and **we call it Drop-Off**. If you're hitting a curb with our drop-off technology, you'll ask if there was one. Allowing the wheel to travel free in bump stroke, the car is keeping is balance and calmness under any condition. As soon as the impact is over the wheel is smoothly decreasing speed due an increase of damping force to the regular setup. Getting another or even harder impact directly after the first one, the valve is designed to increase damping force with piston speed and the wheel to keep road contact.

Modular Solid Piston Valve

Our MSPV (Modular Solid Piston Valve) offers comprehensive adjustability for high-performance damping in motorsport. It features independent low-speed bump and rebound adjustments via a needle adjuster, allowing precise control over low-speed dynamics. For high-speed bump and rebound, it utilizes a shimmed piston, providing optimal damping control at higher velocities. Additionally, the drop-off can be fine-tuned with a separate shimmed piston.

The system is easy to adjust: a nut allows fine control of high-speed settings, while a hex key manages low-speed adjustments, ensuring quick and intuitive tuning. The click-feeling is optimized for precision and the design minimizes unwanted parallel flow resistance.

What sets the MSPV apart is its modular adjustability - it can be upgraded or downgraded during service. From the beginning of its development we focused on cost-efficiency and therefore we had a clear goal to optimize long-term running costs for our customers. High-performance and cost efficiency come together in our track dampers with MSPV.

Adjuster	TD2	TD3	TD4	TD5
Bump - low speed	●	●	●	●
Bump - high speed	○	●	●	●
Rebound - low speed	●	●	●	●
Rebound - high speed	○	○	●	●
Drop-off	○	○	○	●

TDXevo

Introducing the TDXevo Track Damper series, our most customizable solution for motorsport applications, no matter it is automotive or motorbike. Designed for maximum versatility, the TDXevo solutions can be built as a non-adjustable unit or scaled up to a 6-way or more adjustable configurations - whatever the customer wishes and what is needed to win championships. Options include either a piston valve, solid piston with valve block or rotation damping, allowing for precise control over damping characteristics.

This damper is engineered for prototype and formula racing cars as well as superbike or prototype motorbikes, from entry-level to high-end applications. It can also be tailored for specialized set-ups like linked dampers, heave and roll systems or even steering dampers for motorbikes, making it the perfect solution for factory racing teams seeking ultimate flexibility in performance tuning.

TDXevo linked Damper

The TDXevo linked damper system combines the advantages of interconnected dampers with the ability for independent bump and rebound, high- and low-speed adjustment. The dampers can be connected with different set-ups (axle-, side- or cross-link) to manage both vertical and lateral movements - specifically heave and roll. The dampers work together to distribute loads across multiple wheels, optimizing performance during cornering, braking and acceleration.

The addition of independent high- and low-speed adjusters for both bump and rebound further enhances the system's tunability. The low-speed adjusters control the car's body motion in slower movements, such as cornering and weight transfer, while the high-speed adjusters manage the car's behaviour over bumps and curbs. This independent control allows for precise tuning of the damper settings to suit different track conditions and driver preferences.
This setup helps maintain optimal aerodynamic stability, gives the flexibility to optimize grip, balance and stability, making the car more predictable and responsive in different racing conditions, particularly in prototype and formula racing. It also ensures that the tires maintain optimal contact with the road, improving overall performance and lap times, as well as tire wear.

Through-rod damper (TRD) technology

The TRD damper uses a piston rod passing right through the damping chamber and out of the other end of the damper body. This means that the chamber maintains a constant volume of damping fluid - there is no displacement of the working fluid caused by piston rod travel. Consequently, in the bump direction the damper does not have to work in opposition to the gas pressurisation of the fluid.

In a damper the gas charge causes high friction and high internal pressure. The key factor of the TRD is running the minimum gas pressure. A low internal pressure improves responsiveness and friction behaviour. Even with big temperature changes friction remains at

constant levels. However, the damper system needs a minimum gas pressure for the following reasons: avoiding cavitation and compensating for the changes in oil volume due to temperature changes.

The piston is not pre-loaded by the gas pressure so there is no so-called initial friction, which the piston in an ordinary damper has to override as well. An advantage of the TRD is that raising the gas pressure does not influence the reaction time of the valve system in the damping piston. Thanks to the TRD technology there is no more need for a second progressive gas spring, which, in conventional dampers, negatively influences the aerodynamics of the racing vehicle.

TDXevo third Element

Elevate your race car's performance with the TDXevo third element. This advanced system features three dampers with independent low and high-speed bump and rebound adjustability, enhanced by cutting-edge TRD technology. Engineered specifically for high-performance motorsport, these dampers deliver ultra-low friction, precise adjustability, and symmetric damping curves, allowing you to fine-tune roll and heave motions independently. The result? Exceptional cornering stability, superior bump absorption, maximum grip, and a consistently stable aerodynamic platform.

The dampers are designed as solid piston dampers with low and high-speed bump and rebound damping adjustment as well as an optional drop-off. It's basic design features the TRD technology providing symmetric damping force characteristics in bump and rebound which results in a similar roll behaviour independent of the rolling direction. Furthermore the spring pre-load adjustment on the roll-dampers is separated from the ride height adjustment which offers a wide range of flexiblity on adapting the car for different tracks and changing track or weather conditions.
Using a three damper setup offers the flexibility to use different spring rates and bump and rebound stops for the rolling and heave motion. Even track specific asymmetric rolling characteristics can be designed.

TDXevo heave and roll

Upgrade your race car's performance with our TDXevo heave and roll system. Two dampers with low and high-speed adjustable bump and rebound combined with TRD technology. Tailored for high-performance and prototype motorsport applications our **heave and roll dampers** are designed as solid piston dampers with low and high-speed bump and rebound damping adjustment as well as an optional drop-off.

It's basic design features the TRD technology providing symmetric damping force characteristics in bump and rebound which results in a similar roll behaviour independent of the rolling direction.

Using a two damper setup offers the flexibility to use different spring rates and bump and rebound stops for the rolling and heave motion.

TDXevo rotation Damper

The TDXevo rotation damper is an advanced, compact solution for high-performance motorsport. Utilizing a rotary movement, the vane rotates inside the damper body, where valves operate similarly to traditional linear dampers.

The damper's body is not only responsible for damping but also replaces multiple suspension components, including the rocker, push rod- and anti-roll-bar-linkage and torsion spring, streamlining the entire setup. The friction-reducing coating on the vane and absence of oil displacement eliminate air spring effects, offering lighter weight, improved stiffness and a more direct suspension response.

Weighing just 950g, the TDXevo ensures exceptional high-frequency response and performance efficiency, outperforming conventional set-ups.

Track Struts

Introducing the Track Struts (TS) series, engineered with upside-down assembled monotube damper technology for superior performance, replacing conventional large volume twin-tube dampers. These struts come with steel or aluminium outer tubes, offering enhanced stiffness and durability.
Available in non-adjustable up to 2-way adjustable versions, all Track struts feature MV technology, ensuring precise damping control. For added tunability, optional needle adjusters are available, providing flexible low-speed damping adjustments, ideal for entry performance and one make motorsport series where both reliability and customization are key.

Designed and developed for:

	TS0	TS1	TS2
Max. rebound force		Ø36: 7,000 N	
Max. bump force		Ø36: 4,000 N	
Valve type		Piston valve	
Damping adjustment	None	Bump/rebound low speed	Bump/rebound low speed independent
Piston diameter		36 mm	
Piston rod diameter		15 mm	
Height adjustment	●	●	●
Damper body		Steel or aluminium	
Damper module	●	●	●
External reservoir	●	●	●
For McPherson	●	●	●

● available ○ not available

Spring System

Linear or progressive spring system can be designed with one or multiple springs

Up to 120°C

Maximum operating temperature

STTV

Each monotube damper can be equipped with an base valve either in-line or with external reservoir

Height adjustable

Customer specific adjustment range

Damping Force

Can be adjusted with tool-less adjusters in 20 clicks

Modular Valve (MV) - one valve many Options

Our **Modular Valve (MV)** is a high-performance solution designed for motorsport applications, offering extensive tuning flexibility. With the ability to provide linear, semi-digressive, or digressive damping characteristics, the valve allows for independent tuning in both bump and rebound. The innovative PDO technology enables independent bleed adjustment for precise control, while the banded piston enhances sealing efficiency. For applications requiring higher bump forces or lower gas pressures, the piston valve can be supported by a base valve.

The **RBL** (Rebound Bump Low-Speed) adds a bypass valve on the piston rod to the MV, which offers enhanced control and tuning flexibility. This configuration allows for precise low-speed damping adjustments in both bump and rebound, adding an extra layer of customization to the system. The damping characteristics can be adjusted in the same like the MV.

The **RBLI** (Rebound Bump Low-Speed Independent), feature independent low-speed bump and low-speed rebound adjustment with two external adjusters on the piston rod. This next evolution, from the RBL to the RBLI allows drivers to fine-tune their suspension for precise control and optimal handling.

All our piston rod external adjusters enable easy, on-the-go adjustment of low-speed damping in both bump and rebound without the need of any tool and even when the struts are mounted on the car.

In our track struts TS the piston diameter is 36 mm with two piston rod options - 13 mm or 15 mm.

Adjuster	TS0	TS1	TS2
Bump/rebound - LS*	○	●	○
Bump - low speed	○	○	●
Rebound - low speed	○	○	●

*LS = low speed

TS0

TS1

TS2


CHAMPION
LUBRICANTS
DUNLOP
MONSTER
ENERGY
alpha
MRP
Van Zon
HORECA
SHOEI
31

Watch the video to learn more about the product

Track Forks

Introducing the TF high-performance motorbike Track Forks, engineered specifically for circuit racing, including sprint and endurance events for superbikes. These cutting-edge forks are available in lightweight aluminium or carbon fibre, featuring hybrid AL-CFK inner tubes or steel and aluminium tubes. With a closed cartridge gas-pressurized design, they deliver exceptional stability, low friction and minimal hysteresis for superior responsiveness and control. The TF is built to withstand the intense demands of motorbike racing, offering precision handling and high-performance reliability in every lap, making them the ultimate choice for professional racers.

Designed and developed for:

What's special on our FIM EWC winning Setup?

Our Cartridge Design and Adjustment

The ZF motorbike cartridge delivers top-tier performance with its **closed cartridge** design. Featuring a 25 mm piston, 10 mm piston rod and 30 mm floating piston, it ensures precise and responsive damping. Riders can easily make **on-the-fly adjustments while the cartridge is mounted**, including **spring pre-load adjustment** up to 20 mm and 40-clicks bump or rebound damping adjustments. With low gas pressure, this system guarantees optimal performance in demanding conditions. The cartridge can seamlessly fit into existing outer tubes or be paired with ZF carbon fibre or aluminium outer tubes, offering maximum flexibility and high-end performance.

With Carbon Fibre - the Magic begins

The telescopic unit outer and inner tube design from ZF presents a highly customizable solution for high-performance motorbikes, integrating the multiple CFK UHD layers for the outer and inner tubes. This design offers the unique option to **tailor the bending stiffness** and **lateral and longitudinal bending behaviour** of the fork individually and independently, thanks to the versatility of carbon fibre. This allows precise adjustments to match the specific handling needs of each bike. The outer tube features bonded aluminium sleeves for easy mounting and a chrome-plated inner tube for enhanced durability. Aluminium versions are also available for a balance between performance and cost. Perfect for both racers and enthusiasts, these solutions deliver precision and adaptability.

The perfect Match - TD2

Combining the TF with the TD2 rear axle shock creates a next-level performance package. The TD2 features independent low-speed bump and rebound adjustments, utilizing a 40 mm shimmed solid piston and valve block for superior damping control. Its innovative design, including a spring pre-load-independent length adjustment and pneumatic release for spring pre-load adjustments, ensures precision tuning for any track. At just 1,600 g (without springs), the TD2 is engineered for agility, providing more grip, less pumping, reduced friction and better tire wear control, ultimately improving ride dynamics and stability.

Combined with the outperformance advantages of the carbon fibre TF2 fork, this setup significantly enhances cornering precision and rider confidence, offering unbeatable tire-to-road feedback for both high-speed circuits and demanding track conditions.

57 mm

Upper clamping diameter, 59 mm lower clamping diameter and 46 mm sliding tube diameter

Trail-braking

Perfect matching bending behaviour due to homogeneous bending behaviour results in optimized front wheel feedback

Carbon Fibre

Inner and outer tube can be manufactured from carbon fibre

57 %

Overall weight saving of a carbon fibre inner tube compared to a steel one

3,250 g

Overall weight of a single carbon fibre fork leg including cartridge with spring and oil


KMS
OMP
PIRELLI

Off-road Damper

Our Off-road Damper (OD) program delivers cutting-edge solutions designed for rally cars, buggies and trucks tackling the toughest terrains across the globe. Featuring eye-to-eye dampers, our products offer extensive adjustment possibilities for maximum performance. This includes independent low and high-speed bump and rebound damping, bump stop adjustments and patented travel-dependent damping, all designed to handle extreme off-road conditions. Whether you're competing in desert rallies or navigating rugged terrains, our dampers provide the durability, adjustability and performance needed to conquer the most demanding off-road environments with precision and control.

Designed and developed for:

OD - made for the toughest Races around the Dlobe

Introducing our OD Off-road eye-to-eye dampers, engineered for the toughest off-road races, including the legendary Rally Dakar. These gas-charged monotube aluminium dampers with external reservoirs are specifically designed to excel in rally raid and truck applications, ensuring that you can conquer even the roughest terrains.

Our dampers feature multi-adjustability, allowing for precise tuning of low and high-speed bump and rebound, along with a hydraulic bump stop for enhanced performance. Equipped with motorsport low-friction spherical bearings at the ring eyes and friction-optimized sealings, these dampers provide superior responsiveness and durability.

Optimized for the maximum lightweight, the dampers utilize STTV technology for exceptional performance. The 20 mm hollow piston rod and piston diameter options of 45 mm (1.77 inch) or 55 mm (2.16 inch) ensure robust performance, while the 52 or 66 mm threaded outer tube allows for easy spring pre-load and ride height adjustments, contributing to optimal weight balancing.

Designed with efficiency in mind, the piggyback external reservoir features cooling ribs and the damper body is equipped with temperature-optimized cooling ribs to maintain performance under extreme conditions. Additionally, integrated temperature and pressure sensor threads allow for plug-and-play sensor installation, providing valuable data for fine-tuning your setup. For added versatility, a non-adjustable hydraulic rebound stop and position-sensitive fast rebound option are available.

Elevate your off-road experience and tackle the toughest terrains with confidence, knowing that our OD deliver the performance and reliability you need to push your limits.

Travel dependent Damping

Introducing our patented stroke dependent adjustable damping (patent DE 10 2008 044 081 B4), engineered specifically for the intense demands of rally raid and truck racing. This innovative damper system offers unmatched flexibility in tuning, featuring multiple clicks per adjuster for both bump and rebound, allowing for precision adjustments tailored to any terrain.

With piston diameters of 55 mm (2.16 inches) or 75 mm (3 inches), a 20 or 25 mm steel piston rod (hollow versions available) and the ability to integrate STTV technology, this damper provides the ideal balance between performance and durability. The aluminium damper body, equipped with heat-dissipating ribs, ensures optimal temperature stability, even under extreme conditions - being able to operate at an average temperature of 120 °C with short-term peaks up to 180 °C.

Designed to endure the toughest environments, including the Dakar Rally, this system delivers key benefits

- Improved crew comfort
- Enhanced chassis protection via progressive damping
- Superior temperature stability
- significantly better traction and chassis control.

With a weight range between 5 to 15 kg, depending on the dimensions and a maximum piston speed of 6 m/s, this damper system ensures peak performance in the most challenging off-road settings.

Watch the video with Johan to learn more about the products.

Off-road Struts

Introducing our Off-road Struts (OS), expertly engineered for rally cars utilizing McPherson strut technology. These gas-charged monotube struts are designed with FIA World Rally Championship-winning technology, proven in various championships to deliver unparalleled performance and reliability under the toughest conditions. Our struts are fully customizable, allowing you to tailor designs to meet your specific requirements. Whether you need adjustments for different terrains or preferences, our team collaborates closely with you to deliver a product that aligns with your racing goals. Experience the difference in handling, stability and overall performance on the track.

Designed and developed for:

"As a seven-time FIA Rallycross World Champion, I know that success is built on a solid foundation of innovation and tradition. The ZF Off-road struts OS3 have truly redefined what's possible in our sport. Their low friction design and easy adjustability provide outstanding performance, allowing me to tackle jumps, curbs and heavy impacts with confidence. With the experience and knowledge passed down through my father, Tommy and the legacy of former SACHS, our partnership is key to bringing the sport to the next level of performance. Together, we make the impossible possible, securing not just races but world championship titles. The perfect tunability of these struts is essential for our continued success on the track.

- Johan Kristoffersson

Off-road Strut (OS) Program: Performance for every Rally Class

The OS program is the ultimate suspension solution for McPherson axles, engineered to deliver exceptional performance across all rally classes - from Rally1, Rally2 and RX1 to entry-level classes like Rally4 and Rally5. With a focus on maximum customizability and high-performance adaptability, our struts are designed to meet the most demanding customer needs and conditions.

Key Features:

- **Maximum customizability:** Tailored to customer-specific requirements, from stroke length to damping characteristics, ensuring an exact fit for your vehicle's needs.
- **Multi-adjustable damping:** Precise tuning of bump and rebound for both low and high-speed performance, including external bump stop adjustment.
- **Stroke-dependent damping:** Provides optimal damping performance at every stage of suspension travel.
- **45mm large piston:** Maximizes damping force and stability for consistent performance.
- **Precise performance up to 20Hz:** Delivers ultra-responsive damping even under the most extreme conditions.
- **Hysteresis optimized damping:** Maintains consistent performance and smooth damping transitions for superior control.
- **200 bar inner pressure limit:** Ensures robust performance and durability under high-pressure situations.
- **Non-elastic bump stop options:** Choose between a non-adjustable but tunable bump stop or fully adjustable external bump stop based on your setup needs.
- **Hydraulic rebound stops:** Offers superior protection and control during heavy impacts.
- **Low gas pressure design:** Reduces friction for smoother operation and better handling response.

- **Chrome-tube super finish:** Unmatched low friction technology after years of development. This will give you the traction you are looking for.
- **FEA-optimized design:** Structurally optimized for weight and stiffness, ensuring the lightest possible strut without compromising durability.
- **Gravel and tarmac set-ups:** Available with different strokes tailored specifically for each surface, ensuring optimal handling and grip in every condition.
- **Friction-optimized seals and bushings:** Guarantee perfect initial damping response, with long service intervals to reduce running costs.
- **Advanced heat management:** Direct mounted external reservoirs with optional cooling ribs on the reservoir and damper body for improved heat dissipation.
- **High-performance off-road damper oil:** Ensures excellent temperature stability and resilience, even in extreme conditions.
- **World-wide service network:** Providing expert support wherever you compete, keeping your vehicle in peak condition.
- **Test benches up to 6 m/s**

The OS program is engineered for those who demand excellence, whether you're fighting for world championships in Rally1 or refining your setup in Rally5. With unparalleled customizability, durability and precision, these struts are key to maximizing your performance - on gravel, tarmac or any terrain in between.

Take control of the podium with ZF's industry-leading suspension solutions - designed to make the impossible, possible.

Adjuster	OS0	OS1	OS2	OS3	OS4
Bump/rebound - LS	○	●	○	○	○
Bump - low speed	○	○	●	●	●
Bump - high speed	○	○	●	●	●
Rebound - low speed	○	○	○	●	●
Rebound - high speed	○	○	○	○	●
Hydraulic bump stop	◔	◔	◔	◔	◔

◔ = Option

Steering

Our steering portfolio showcases the evolution of steering technology, from traditional hydraulic systems to advanced electric steering solutions. Designed with high reliability and customization in mind, our systems offer seamless integration and are easy to install. Each package includes a full suite of mechatronics, ECU and software, providing a complete, ready-to-use solution. Whether for road, track or specialized applications, our steering systems deliver precision control and adaptability, driving the future of vehicle dynamics.

Check our website for more insights

EPHS MPU

The ZF Electric Powered Hydraulic Steering Motor Pump Unit (EPHS MPU) is an innovative steering technology that allows a conventional hydraulic steering system to run without an engine driven pump. This can be used on conventional petrol and diesel vehicles as well as hybrid and electric vehicles. The level of assist provided by EPHS MPU can be varied depending on the vehicle speed and rate of steer, giving a tailored steering feel and substantial fuel savings over traditional hydraulic power steering. Without the need for a direct connection to the engine, an EPHS MPU can also ease packaging issues as it can be positioned virtually anywhere in the engine bay or in any other convenient location where it can be connected to the steering rack.

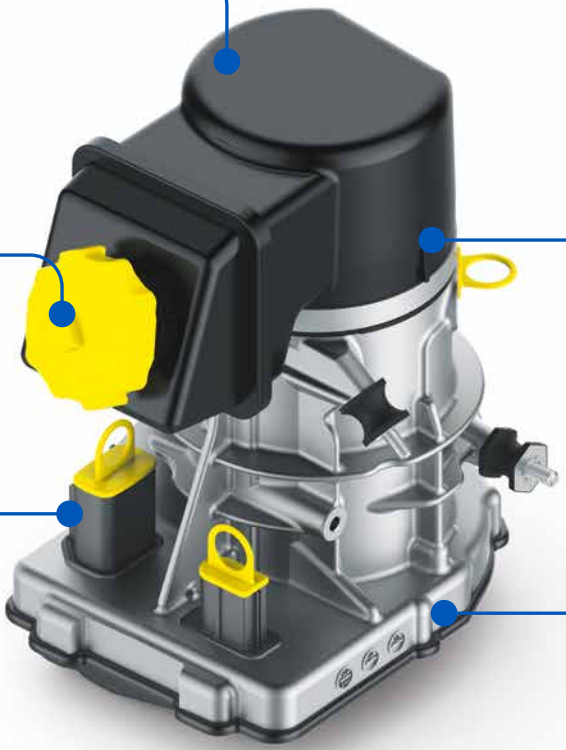
Designed and developed for:

89-C EVO 100-C

Electric motor	Brushless PMAC motor with inner rotor	
Pump	Outer gear pump with consistent disp. volume	
Max. volume flow	9.1 ... 10.6 l/m	12.0 l/m
Max. system pressure	113 ... 124.5 bar	120 bar
Control parameters	Vehicle speed and steering rate	
Hydraulic power	890 W	1,000 W
Max. current @ 13.5V	98 A	115 A
Stand-by current	< 2.5 A	
Operation temperature	-40 ... 105 °C	
Displacement volume	1.5 ... 1.75 cm^3	2.0 cm^3
Weight	4.5 kg	5.0 kg

89-C EVO

The 89-C EVO is a compact, high-performance Electric Powered Hydraulic Steering Motor Pump Unit (EPHS MPU) that brings innovation and flexibility to modern vehicles. This system provides variable assist based on vehicle speed and steering rate, ensuring a tailored and responsive steering feel while delivering substantial fuel savings. Additionally, its design allows for flexible installation, as the EPHS MPU can be positioned anywhere in the engine bay or other convenient locations, easing packaging constraints and enhancing overall vehicle integration.



124.5 bar
Maximum system pressure

-40 to 105°C
Operation Temperature

4.5 kg
Total weight

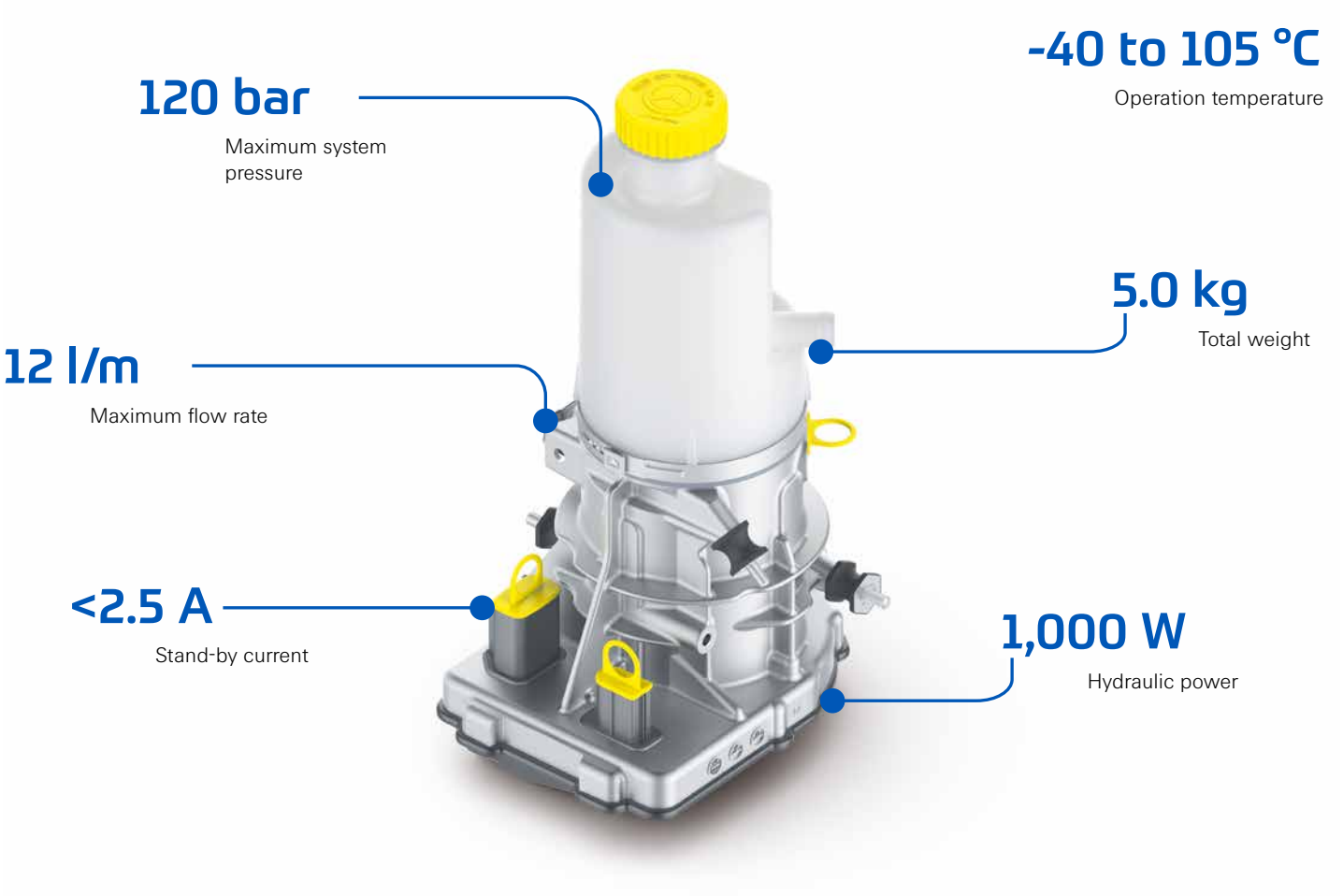
10.6 l/m
Maximum flow rate

<2.5 A
Stand-by current

890 W
Hydraulic power

100-C

Our motorsport only 100-C takes electric-powered hydraulic steering to the next level, offering greater power with higher displacement volume and flow rates compared to its smaller counterparts. Ideal for motorsport applications requiring increased steering force, the 100-C provides the same benefits of an engine-independent system, making it suitable for petrol, diesel, hybrid and electric vehicles. With its advanced design, it delivers variable assist based on speed and steering rate, ensuring precise control and a responsive steering feel. The 100-C also allows flexible installation, as the pump can be positioned virtually anywhere in the engine bay or beyond.


120 bar
Maximum system pressure
-40 to 105 °C
Operation temperature
5.0 kg
Total weight
12 l/m
Maximum flow rate
<2.5 A
Stand-by current
1,000 W
Hydraulic power

Systems

Our comprehensive chassis systems portfolio enhances performance and customization options, building on our advanced damper solutions to include innovative add-ons like lift actuators and other supporting systems. Engineered to elevate vehicle dynamics, these systems offer cutting-edge functionality for a range of applications, from everyday road use to high-performance settings. Our modular approach to chassis integration allows for seamless compatibility with existing setups, enabling precise control and adaptability across various platforms. Trust in our solutions to deliver refined, reliable performance, improving ride comfort, stability and handling with the highest standards of engineering excellence.

Check our website for more insights

Watch the video with to learn more about the push rod lift LP25.

Lift Actuator

Designed for high-performance road cars with low ground clearance and advanced aerodynamic concepts, the Lift actuator offers the perfect solution for protecting your vehicle's critical components, like the front splitter. With both on-damper (LD) and push-rod (LP) configurations available, this system ensures optimal lift performance without compromising the vehicle's handling or comfort. Whether it's navigating speed bumps, driving onto a trailer or getting in and out of a garage, with the ZF lift system the front axle can be raised quickly and easily, preserving your vehicle's aerodynamics while maintaining road performance. Designed to blend seamlessly with track-optimized set-ups, this system allows for precision driving on the road without any loss of comfort - making it the perfect solution for both everyday use and high-speed performance.

Designed and developed for:

	LD25	LP25
Stroke	25 mm	25 mm
Lift / descent time	<5 s / <5 s	
Static lift force	18,000 N	> 4,000 N
Static rebound force	0 N	< 3,000 N
Mounting position	On damper	Push-rod
Stand-alone / system	● / ○	● / ○
ECU	○	○
Software	○	○
Pump	○	●
Operation temperature	-35°C to +85°C	
Weight	700 g	1,200 g

● available ○ not available

02

Powertrain

Building on ZF's long-standing legacy in transmissiones and the renowned expertise of SACHS in clutches and clutch actuation, our powertrain products are now leading the charge into the next generation of mobility. The long heritage and knowledge gained in motorsport are key drivers for the features, innovations and advanced materials used in our clutch programs. As we transition to electrified powertrains, we bring forward our commitment to high quality, long lifetime and cutting-edge solutions. Our advanced powertrain components are designed to meet the demands of modern vehicles, ensuring seamless performance and reliability in a rapidly evolving automotive landscape. With decades of experience driving innovation, we continue to power the future of mobility.

Check our website for more insights


Clutch

Our clutch program, derived from a rich motorsport legacy, is engineered to deliver unmatched performance and reliability always at the top-end of performance and innovation. Built in three distinct layers - starting with the robust Performance clutch (PCS), advancing through the enhanced Racing clutch (RCS) and culminating in the high-performance top end Individual clutch (ICS) - this program offers tailored solutions for every application.

Our clutches are available in various sizes, with options for different friction materials, housing materials and disc configurations. Supported by reliable and flexible engineering kits with numerous add-ons, our clutch program ensures precise customization and superior performance for both street and track use.

Check our website for more insights


EXTREME PERFORMANCE

Watch the video to learn more about the product

PCS

Our Performance Clutches (PCS) are the first choice for demanding drivers who want to enhance their high-performance cars. Different products can be used depending on driver requirements. Every PCS is a product of the concentrated expertise obtained from years of working in the motorsport industry. Compared to volume-production pressure plates, PCS pressure plates have a higher transferable torque and are less sensitive to thrust loading. PCS pressure plates are used with different disks, depending on the vehicle's requirements.

Designed and developed for:

PCS

The Performance Clutch (PCS) range offers a wide selection of clutch diameters, friction materials and combinations with single mass flywheels to meet diverse performance requirements. Designed for flexibility, the range includes both single and twin-disc solutions with increased load capacity, ensuring optimal performance for various applications. Whether for high-torque demands or precise engagement, our clutches are engineered to provide superior durability and reliability, tailored to meet the specific needs of each vehicle and driving condition.

Designed for

- High-performance street cars
- Tuning
- Entry classes in motorsport

Features

- Flywheels
- Torsion damped discs
- Twin disc variants

Advantages

Catalogue program with already over 27,000 existing applications.

280 - 720 Nm

Transmittable torque

Pressure Plate

Mandatory to install with PCS discs

Clutch Disc

Available in 10 different sizes, friction material (sinter or organic) and rigid or torsional damped as one disc or twin-disc

Single Mass Flywheel

Available for different applications

180 - 430 mm

Available disc diameters

RCS

Watch the video with Christian Engelhart to learn more about RCS.

With our modular Racing Clutch System (RCS), we offer a high degree of variability for racing clutches. The system can be configured to provide individual solutions for specific vehicles and tracks. Their low weight and moment of inertia are among the most important parameters for racing. We guarantee rapid availability and unproblematic exchange of individual components. RCS clutches have not been developed for specific vehicles, but can be used in virtually all cars. However, adjustments have to be made, such as to the geometry of the flywheel, position of the releaser and the limitation of the clutch release travel.

For more insights have a look in our catalogue

Designed and developed for:

	RCS115	RCS140	RCS184	RCS200
Clutch disc diameter	115 mm	140 mm	184 mm	200 mm
Transmittable torque	1,450 ... 1,935 Nm	480 ... 1,920 Nm	260 ... 2,616 Nm	561 ... 2,497 Nm
Max. moment of inertia	0.008995 kgm²	0.011585 kgm²	0.027736 kgm²	0.03398 kgm²
Disc options	3 - 4	1 - 4	1 - 4	1 - 3
Sinter disc	●	●	●	●
Organic disc	○	○	●	●
Carbon disc	●	●	○	●
Pull / push type	● / ●	● / ●	● / ●	● / ●
Anti-stall solution	○	○	●	○
Forged housing	●	●	●	●
Flywheel	●	●	●	●
Weight	2.7 ... 3.56 kg	1.77 ... 3.68 kg	2.2 ... 4.94 kg	3.15 ... 5.28 kg

● available ○ not available

RCS115

This highly sophisticated clutch is the perfect blend of durability and performance. Designed for high-end applications it stands out with a remarkably low mass and an astonishingly favourable inertia. This makes it an excellent feature in your powertrain in regards to acceleration and elasticity. The well elaborated high strength steel housing is the ideal containment for the impressive friction stack. And by the way, size wise this is the closest you will get to a Formula 1 clutch.

Designed for

- Formula racing cars
- Circuit racing
- Prototype racing

Features

- Flywheels
- Slave cylinder
- Ring piston assy
- Pre-pressure valve
- Stud bolts and K-nuts
- Release rings
- Adapter plates

Advantages

Formula 1 style clutch with impressive torque capacity and incredibly low inertia

Housing

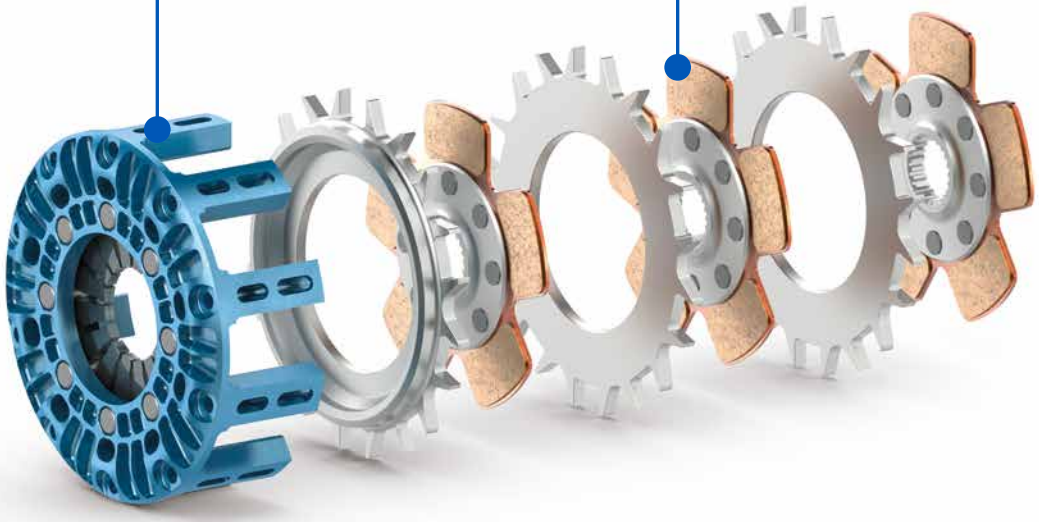
Forged in steel

Clutch Disc

Available as 3 or 4 sinter or carbon disc version

Inertia

Between 0.006578 and 0.008995 kgm^2



Weight

2.7 to 3.56 kg

RCS140

The forged high-strength aluminium housing is the result of brilliant engineering, delivering a motorsport clutch that efficiently fulfils all your performance requirements. The housing design integrates heat ventilation supporting the high-performance friction stack and thus ideal for a wide range of applications. The star in our clutch program is equipped with an extremely wear resistant state of the art patented aluminium coating, providing high mileage capabilities. At the same time it contributes significantly favourable to your race car, in terms of mass and inertia, making it an extremely competitive powertrain component.

Designed for

- Formula racing cars
- Circuit racing
- Touring cars
- Prototype racing

Features

- Flywheels
- Slave cylinder
- Ring piston assy
- Pre-pressure valve
- Stud bolts and K-Nuts
- Release rings
- Adapter plates

Advantages

A wide range of spring loads available. Proven and tested in all motorsport classes. Convertible to carbon/carbon and carbon/sinter.

Housing

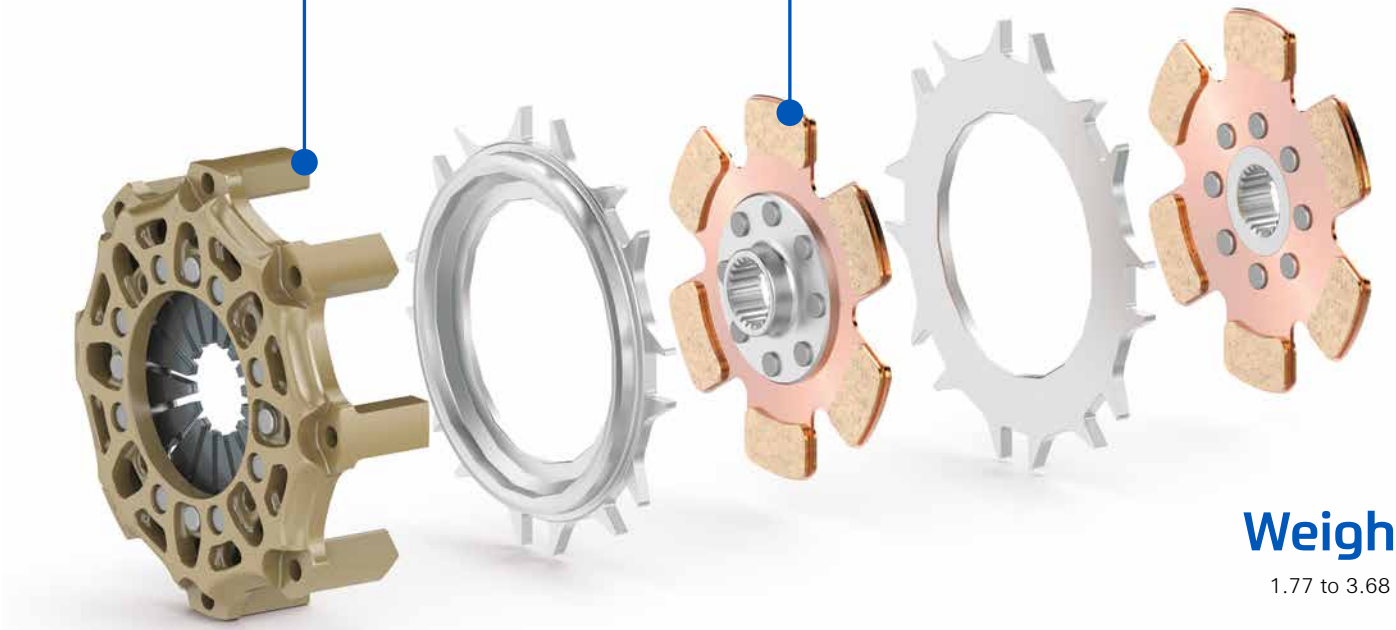
Forged in aluminium

Clutch Disc

Available as 1 to 4 sinter or carbon disc version

Inertia

Between 0.005711 and 0.011585 kgm^2



Weight

1.77 to 3.68 kg

RCS184

If you are looking for a clutch that can easily cope with the harsh demands of modern day motorsport, then you have found what you are looking for. This motorsport clutch is an excellent synthesis of robustness and reliability whilst maintaining its competitive character, due to its favourable mass and inertia properties. Keeping this in mind and knowing that it is used in race winning powertrains, it additionally provides high thermal stability making it fit for off-road race applications, absorbing the unexpected misuse events.

Designed for

- Rally racing
- Circuit racing
- Touring racing

Features

- Flywheels
- Slave cylinder
- Ring piston assy
- Pre-pressure valve
- Stud bolts and K-nuts
- Release rings
- Adapter plates
- Anti-stall-clutch

Advantages

Two spring loads available.
Two release diameters.

Housing

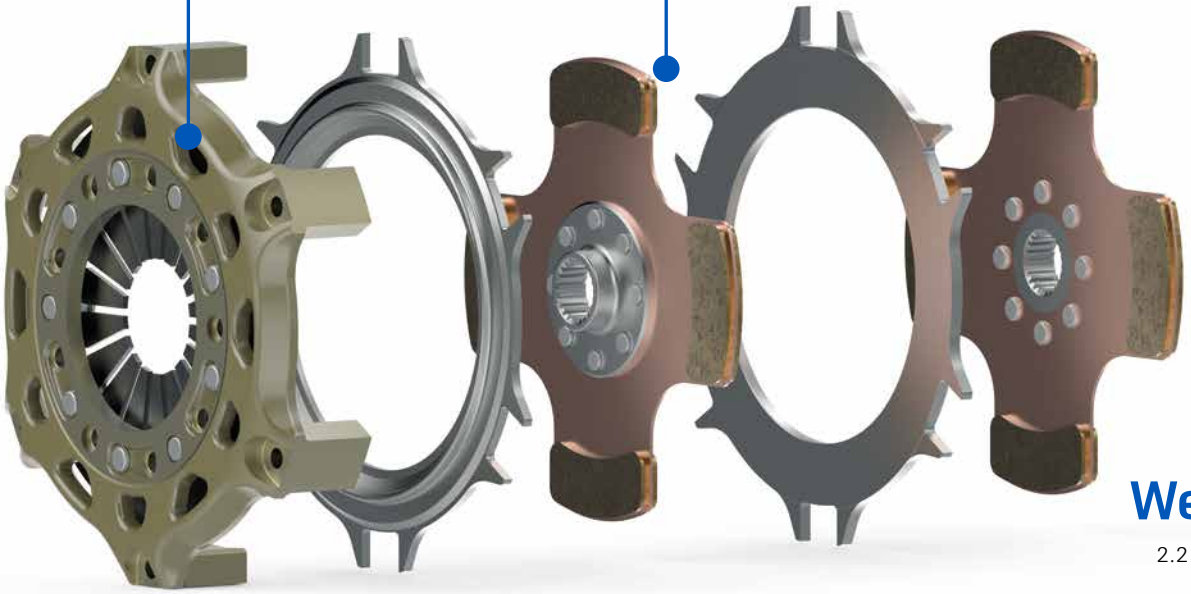
Forged in aluminium

Clutch Disc

Available as 1 to 4 organic, sinter or carbon disc version

Inertia

Between 0.012550 and 0.027736 kgm^2



Weight

2.2 to 4.94 kg

RCS200

You have found a perfect clutch to handle the hard demands of modern day motorsport. The specialised shot peened housing excellently fuses robustness and reliability into one, whilst maintaining the competitive character with its conducive mass and inertia properties. Keeping this in mind and knowing that it is used in race winning powertrains, it further provides high thermal stability making it fit for off-track races absorbing unexpected misuse events. On top of that the modulation comfort will leave you with all desires fulfilled.

Designed for

- Rally racing
- Circuit racing
- Touring racing

Features

- Flywheels
- Slave Cylinder
- Ring Piston Assembly
- Pre-Pressure Valve
- Stud Bolts and K-Nuts
- Release Rings
- Adapter Plates

Advantages

Lightweight design, low release force, low mass and inertia.

Clutch Disc

Available as 1, 2, or 3 organic, sinter or carbon disc version

Housing

Forged in aluminium

Inertia

Between 0.02089 and 0.03398 kgm^2

Weight

3.15 to 5.28 kg

ICS

The ZF Individual clutch (ICS) program is designed for those who demand maximum individualization, offering fully customizable solutions for every purpose - whether it's high-performance road cars, race cars, boats, helicopters, or any other form of mobility. With a wide array of configurations and features, this clutch system is engineered to meet the exact specifications of each customer, delivering exceptional performance, reliability and versatility.

Designed and developed for:

Examples of customization Options

Quick clutch change system:

- Designed for efficiency: The ICS clutch allows for rapid clutch module changes during maintenance or racing conditions, minimizing downtime.
- Dual clutch module: The second clutch module can be carried “piggyback,” allowing for immediate swapping during demanding performance scenarios.
- Integrated release bearing: For a seamless integration, the release mechanism is built into the clutch housing, simplifying installation and operation.
- Axial force-free design: The release force is supported within the closed clutch system, protecting both the input and output shafts from axial load.

Torque limiter:

- Designed for component protection, the torque limiter offers defined reduction or cutting off of torque spikes to safeguard critical powertrain components, such as the transmission and drive shafts, while reducing torsional vibrations.

Centrifugal clutch technology:

- Automatic engagement: For specific applications, the centrifugal clutch allows for automatic starting without manual clutch pedal operation - ideal for smooth, jerk-free launches with no risk of stalling the engine.
- Precise, consistent starts: Ensures ideal and repeatable starting performance, whether on the road or the racetrack. An external release bearing is not required if manual disengagement isn’t needed.

Enhanced cooling and durability:

- Forced cooling airflow: The clutch module features forced airflow to maintain optimal temperatures during heavy use, while cooling fins provide additional local cooling to prevent overheating in critical areas.

Why choose the ICS?

The ICS Clutch Program provides unmatched flexibility and innovation, with the ability to fully customize the clutch system to your precise requirements. By incorporating advanced torque management, axial force-free operation, quick-change features and centrifugal clutch technology, ZF delivers an industry-leading solution for superior performance and protection across a range of applications - street legal and motorsport applications.

ICS97

- Low weight (860g)
- Very low moment of inertia
- Consistent multi-start behaviour
- Extremely temperature resistant
- High durability
- No flywheel wear
- Designed for Formula race cars

ICS140

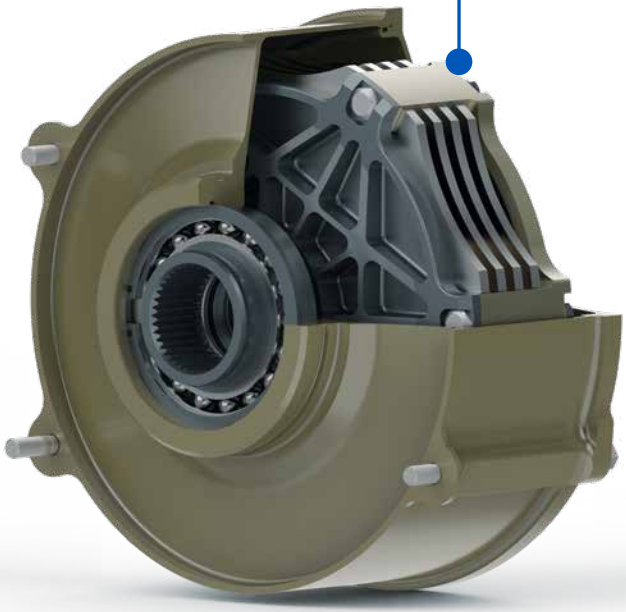
- Pull type clutch
- Concentric slave cylinder with 80 bar operating pressure and integrated travel sensor
- Street legal application for hypercars

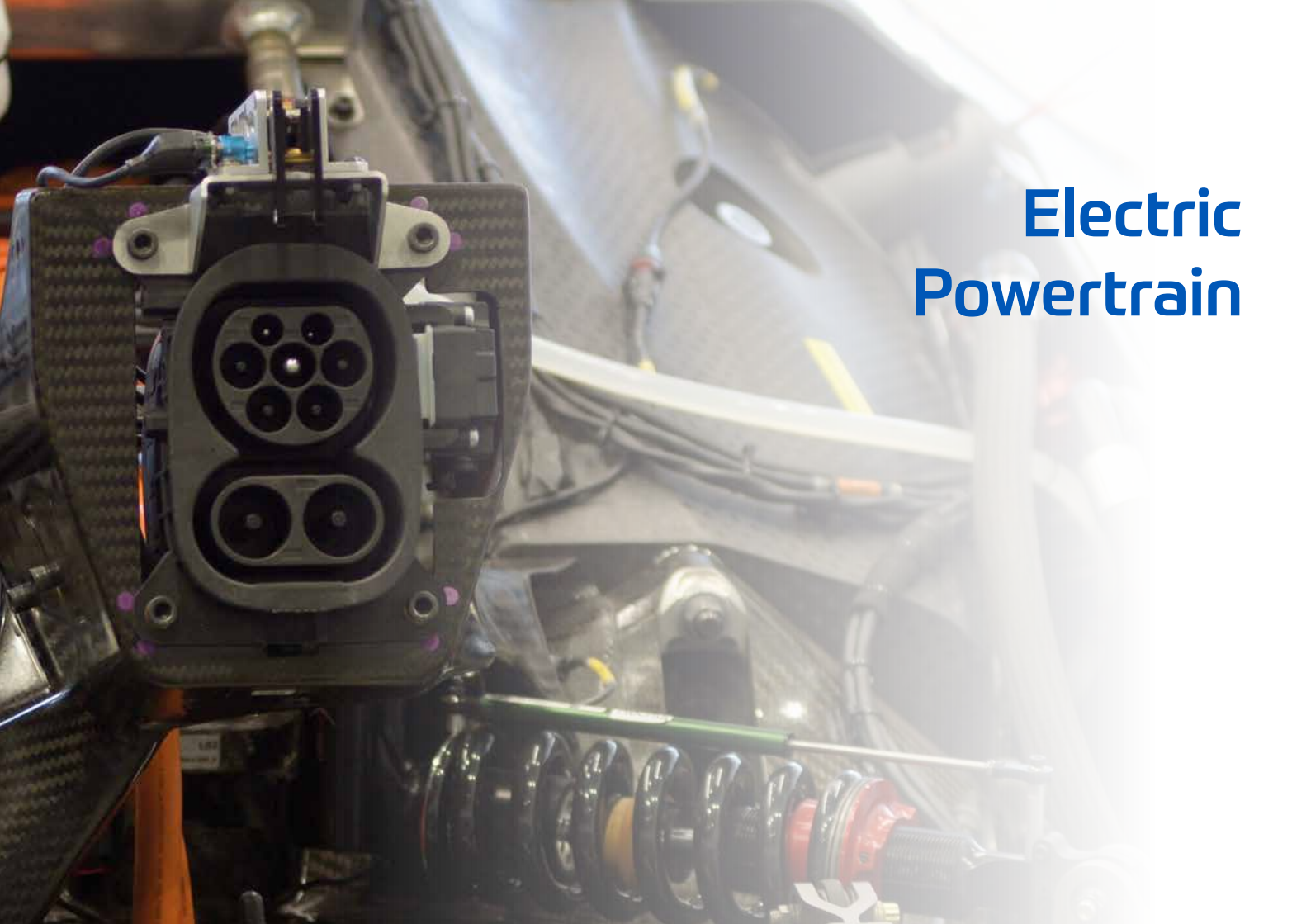
ICS184

- Weight and stiffness optimized housing
- Weight optimized sinter clutch discs
- Carbon intermediate discs
- Stress and stiffness optimized CSC (concentric slave cylinder) with 15 kN end stop force and position sensor

ICS200

- Closed clutch system with quick releaser
- Integrated clutch releaser
- Designed for Rally Dakar





Electric Powertrain

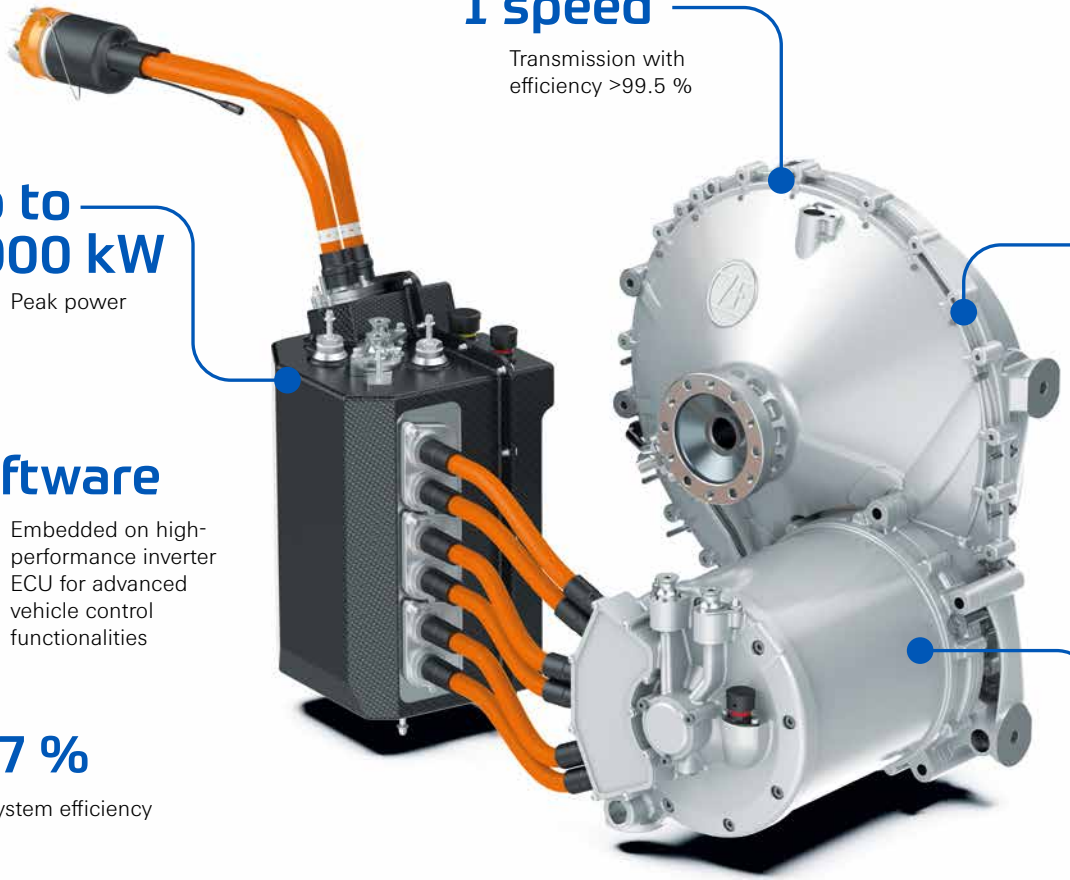
From race to road, ZF's electric powertrain product range delivers high-performance, efficient technologies tailored to meet individual requirements. Our comprehensive electric powertrain solutions include eDrive systems or single components such as E-machines, inverters, transmissions/reducers and software calibration. Designed for motorsport, niche markets and performance cars, our state-of-the-art eDrives prioritize key elements like high power density, lightweight construction, compact packaging, thermal efficiency and rapid torque response. Built on both proven and tested series technology as well as high-end motorsport technology, our product portfolio offers customizable powertrain systems or individual components for cars, motorbikes, off-highway and special purpose vehicles, ensuring cutting-edge performance for every application.

Watch the video to learn more about the product

Electric Powertrain

The evolution of ZF's Formula E powertrain has been instrumental in shaping the future of electric mobility. As the foundation for our groundbreaking 800V technology now used in series e-drives, the insights gained from the high-performance demands of Formula E have been key in developing cost and energy-efficient, powerful powertrains for both road and racing applications. This race-proven technology will be equipped with software and as an option with individual vehicle functionalities and produced in short-term in ZF facilities, ensuring high quality and exceptional performance. With every advancement in motorsport, ZF continues to push the boundaries of e-mobility, driving innovation from the race to road.

Designed and developed for:



1 speed

Transmission with efficiency >99.5 %

<50 kg

System weight

Up to 1,000 kW

Peak power

>7 kW/kg

Power density

Software

Embedded on high-performance inverter ECU for advanced vehicle control functionalities

>97 %

System efficiency

>4,000 Nm

Peak torque

Transmission

ZF's long-standing history in transmission technology has been a cornerstone of automotive innovation, driving success across both road and motorsport. From early manual transmissions to today's advanced automatic and electric transmissions, ZF has led the way in precision engineering. In motorsport, ZF's transmission technology continues to evolve, delivering faster gearshifts, lighter designs and higher torque capacity - key factors in winning championships. Teams across racing disciplines rely on ZF's cutting-edge solutions to gain a competitive edge, translating advanced technology into crucial milliseconds on the track. As motorsport technology advances, ZF remains at the forefront, helping to power champions to victory.

Check our website for more insights

Automatic Transmission

Introducing the 8HP transmission, a high-performance solution derived from motorsport applications. Engineered for both the street and track, the 8HP transmission boasts a lightweight design, exceptional durability and lightning-fast gear shifts. With its ability to handle high levels of transmittable torque, this transmission is built to deliver peak performance in demanding conditions. Whether you're pushing limits on the road or track, the 8HP offers the perfect blend of speed, strength and reliability for unparalleled driving dynamics.

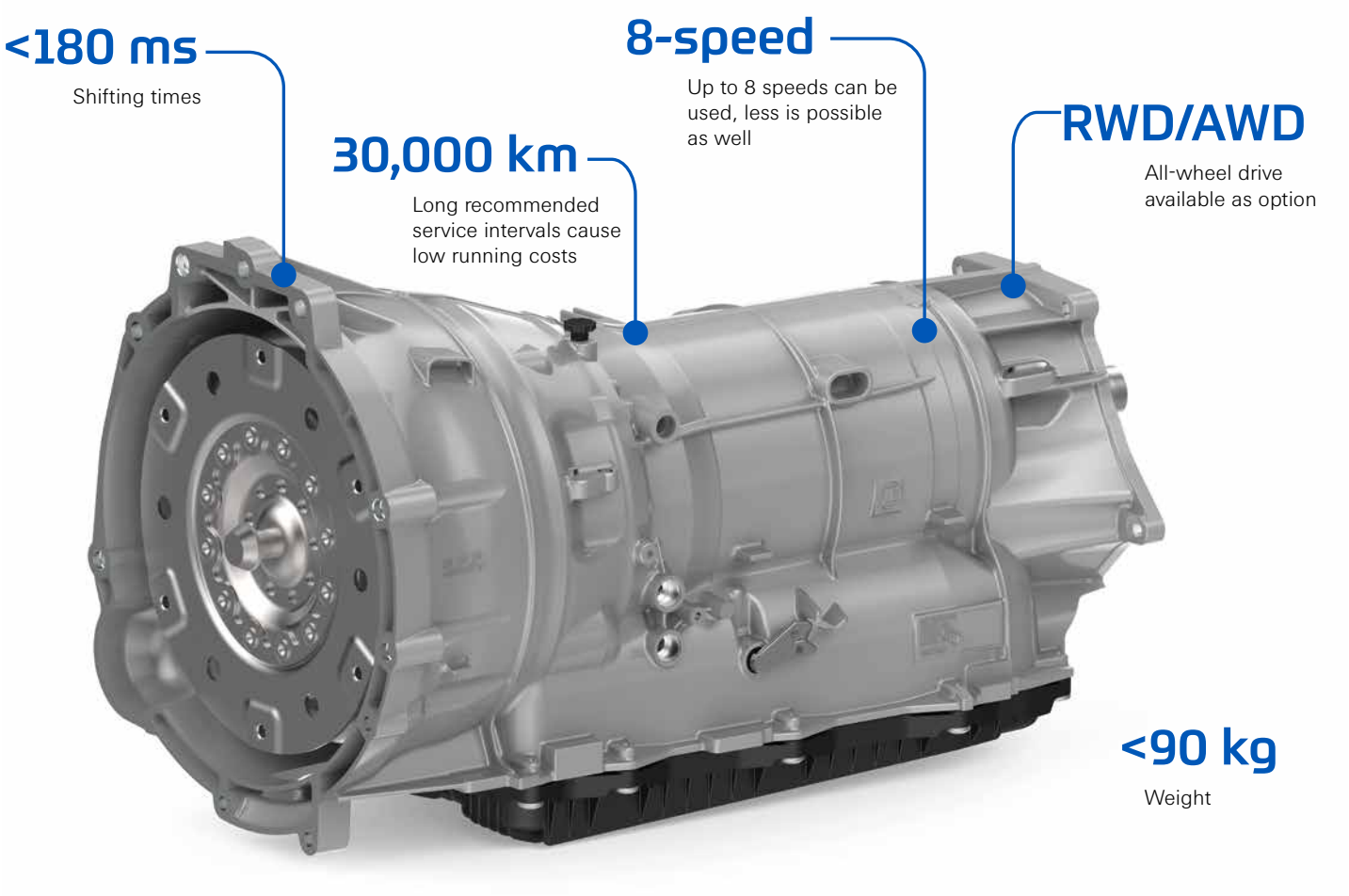
Designed and developed for:

	8HP75	8HP95	8HP76
Generation	Gen2	Gen2	Gen3
Speed	8	8	8
Transmittable torque	750 Nm	1,000 Nm	750 Nm
Max. input speed (1st-6th / 7th / 8th gear)	7,200 1/min^{-1} / 6,000 1/min^{-1} / 4,500 1/min^{-1}		
Ratio (1st / 8th gear)	5.00 / 0.64	4.71 / 0.67	5.50 / 0.64
Spread	7.81	7.07	8.59
Shifting times	<180 ms		
Service intervall	30,000 km (ZF recommendation)		
Hybrid	○	○	○
RWD / AWD	● / ●	● / ●	● / ●
ECU / software	● / ●	● / ●	● / ●
Dry weight	87 kg	89 kg	84 kg

● available ○ not available

8HP

The ZF 8HP transmission, a masterpiece of engineering, has seen four generations of refinement to cater to both road and motorsport applications. Its versatility shines through with a wide range of gear ratios, ensuring optimal performance across various driving conditions. Whether you're looking for rear-wheel drive or all-wheel drive configurations, the 8HP has you covered. Designed for rapid gear shifts and equipped with hybrid readiness, it provides a seamless driving experience while maintaining high reliability. With its long service intervals and low running costs, the 8HP stands out as a cost-effective solution for motorsport applications. The package includes an advanced ECU and software, enhancing its adaptability to different torque levels and driving needs. With up to eight speeds, the ZF 8HP is engineered to deliver exceptional performance on the track.


<180 ms
Shifting times
30,000 km
Long recommended service intervals cause low running costs
8-speed
Up to 8 speeds can be used, less is possible as well
RWD/AWD
All-wheel drive available as option
<90 kg
Weight

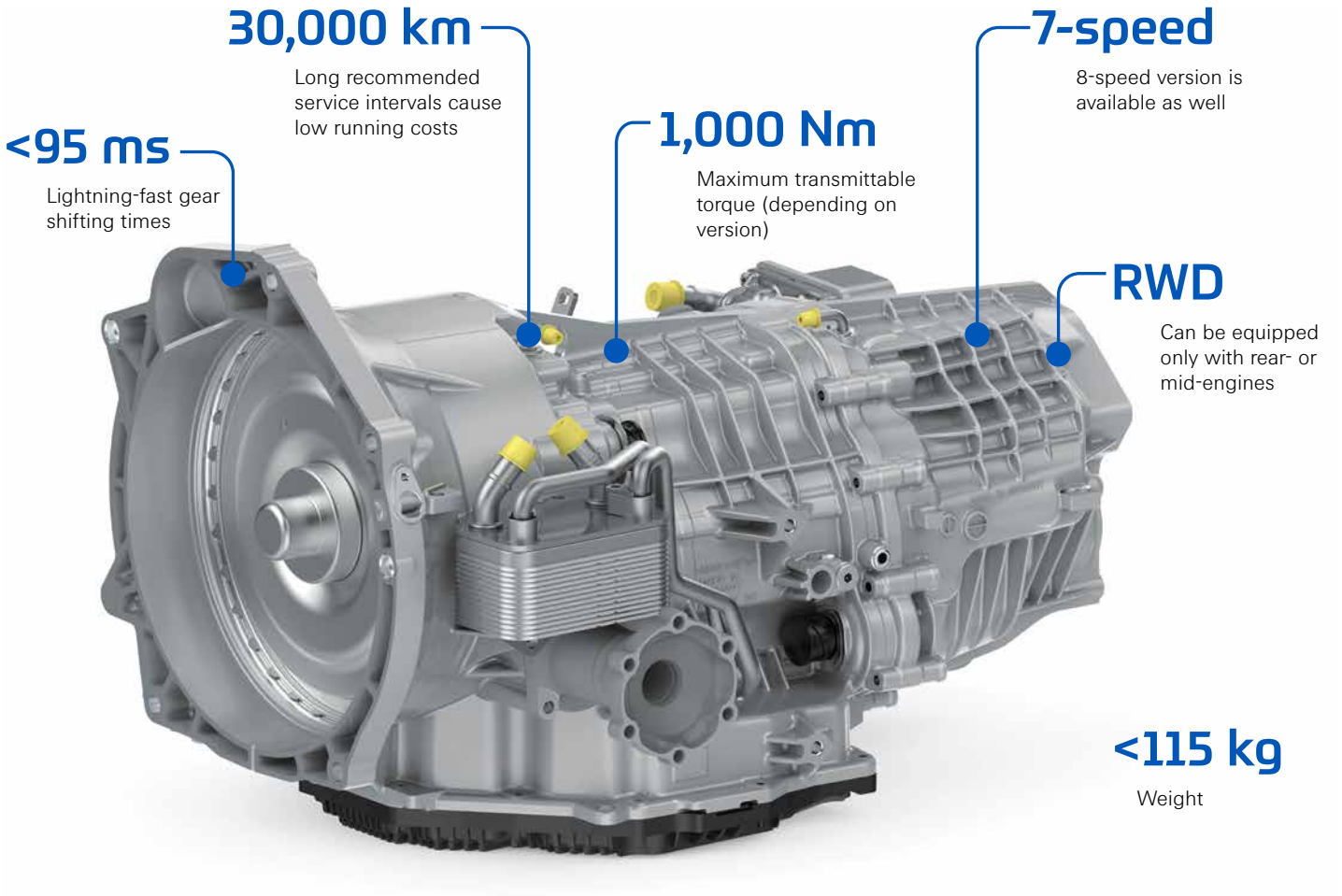
Dual-Clutch Transmission

The ZF Dual-Clutch Transmission (DCT), now in its third generation, is a cutting-edge solution developed for both road and motorsport applications. With its roots in high-performance road cars, the DCT delivers lightning-fast gear shifts thanks to its two-clutch design, ensuring seamless power delivery and precision on the track.

Offering a wide range of gear ratios and up to 7 speeds, it's optimized for both mid-engine and rear-engine layouts, providing flexibility for various vehicle architectures. Available in rear-wheel drive as standard, with an all-wheel drive option, the DCT is hybrid-ready, catering to the latest electrification trends in performance vehicles.

Engineered for high reliability, long service intervals and low running costs, this transmission is built to endure the demands of motorsport without sacrificing cost efficiency. Complete with an integrated ECU and software package, it handles various torque levels, making it a versatile choice for race machines.

Designed and developed for:


30,000 km
Long recommended service intervals cause low running costs
<95 ms
Lightning-fast gear shifting times
1,000 Nm
Maximum transmittable torque (depending on version)
7-speed
8-speed version is available as well
RWD
Can be equipped only with rear- or mid-engines
<115 kg
Weight

03

Test & Validation

Our test and validation area, enhanced by the expertise and facilities from the former TRW, offers a full range of modern, state-of-the-art chambers and transient test facilities to ensure product reliability and performance. With advanced capabilities in EMC, vibration, climatic testing, instrumentation and advanced prototyping, we provide cutting-edge solutions for testing automotive and other industry components. Our facilities, equipped with the latest technology, enable us to meet the highest standards in durability, precision and quality, ensuring robust validation at every stage of development.

Check our website for more insights

Why does UKAS matter for you?

Unmatched trust and compliance:

This accreditation, awarded by the United Kingdom Accreditation Service (UKAS), validates our technical expertise and confirms that our testing facilities operate to internationally recognized standards. Whether you are in the automotive, aerospace or any other industry, you can trust our results to meet and exceed global compliance requirements.

Accelerate your development process:

Our UKAS-accredited lab ensures that your products undergo testing with the highest degree of precision and accuracy. This speeds up your product development cycles, ensuring faster time-to-market without compromising on safety or performance.

Comprehensive testing capabilities:

As UKAS Test Laboratory No. 0332, ZF Automotive UK Limited - the ZES UK designation - provides comprehensive testing solutions, including mechanical, environmental, EMC and safety testing. This enables us to support you across the entire product life cycle, from concept through to final validation.

Tailored solutions for your industry:

Whether you are working on complex automotive engineering projects or aerospace advancements, our accredited testing services are tailored to your unique requirements, ensuring your products excel in real-world conditions.

UKAS Test Laboratory No. 0332

Our full schedule of accredited capabilities can be found by clicking UKAS logo or scanning the QR-code below.

EMC

A whole suite of Electromagnetic compatibility (EMC) tests can be performed on one site, including radiated EMC testing in semi-anechoic chambers, conducted EMC and transient testing in specially screened rooms. With our wealth of experience of EMC testing in various sectors including automotive, aerospace and more, our internationally accredited EMC laboratories in the UK allow us to test products ranging from the smallest component to large systems.

Designed for:

UKAS Test Laboratory No. 0332

Our full schedule of accredited capabilities can be found by clicking UKAS logo or scanning the QR-code below.

UKAS TESTING

Our Facilities and Capabilities

- Radiated emissions and immunity testing up to 18 GHz
- Radiated immunity testing in excess of 3,000 V/m
- Radiated emissions utilising FFT (fast fourier transformation) receivers
- Indirect lightning testing to RTCA/DO-160 (EUROCAE ED-14) level five
- Five semi-anechoic chambers, maximum size 8.4 m x 5.6 m x 6.0 m
- Semi-anechoic chamber linked to 250 Hp drive / dynamometer for EMC testing of large motors and generators e.g. EV drive systems, aircraft generators
- Mobile test-bench ground planes for complex EUT layouts
- Environmentally controlled electrical / transient test rooms
- ESD ±25 kV
- Exported spikes
- Compass safe distance

Type of Test	Range of Measurement
Conducted emissions	20 Hz to 400 MHz
Radiated emissions	20 Hz to 40 GHz
Conducted susceptibility	10 Hz to 400 MHz
Radiated susceptibility	• 20 Hz to 18 GHz • 14 kHz to 18 GHz - 200 V/m • 400 MHz to 1 GHz - 700 V/m CW • 1 GHz to 18 GHz - 3000 V/m PM • Magnetic immunity
Power surges and transients for damped sinusoids	7 kHz to 100 MHz, maximum levels - 1500 V / 75A
Automotive transients, noise and voltage tests	

Chambers	Size (W x L x H)	Door (W x H)	Specials
Screened semi-anechoic room			
G	8.4 x 5.6 x 4.8 m	4 x 3.5 m	
H	6 x 5.6 x 3.6 m	2.4 x 2.4 m	
I	8.4 x 5.6 x 6 m	4 x 3.5 m	
J	6 x 6 x 3.6 m	2.4 x 2.4 m	186 kVA variable drive
K	6 x 6 x 3.1 m	2.4 x 2.4 m	
ESD/transient room			
1	7 x 4 x 3 m		
2	7 x 3.8 x 3.3 m		

Environmental Testing

Our expertise in environmental testing allows us to simulate conditions that will provide detailed knowledge on how the product will operate and survive in its final environment. We test and validate the performance of components, assemblies and systems under a range of environmental conditions experienced by products from a range of industries including aerospace, automotive and others.

Designed for:

UKAS Test Laboratory No. 0332

Our full schedule of accredited capabilities can be found by clicking UKAS logo or scanning the QR-code below.

Climatics

Our Environmental testing facilities provide a rigorous range of climatic tests certified by UKAS Test Laboratory No. 0332, ensuring compliance with the highest industry standards. Specializing in automotive and high-resilience applications, our climatic testing suite is designed to validate product durability in the harshest environmental conditions.

Our services include splash water testing to ISO 16750-4 standards, replicating real-world exposure to moisture, condensation and dewing. Our temperature and humidity tests cover extreme conditions, including temperature cycling with rapid rate changes, hot and cold temperature storage and thermal shock testing for components that must endure abrupt thermal transitions. We also offer ice water shock testing for submersion and splash water resilience.

For materials prone to corrosion or chemical exposure, our facilities provide corrosion testing covering salt spray, cyclic salt and salt/SO_2 exposure, as well as chemical and fluid contamination tests at elevated temperatures. Icing and altitude testing ensure components are fit for high-altitude and freezing conditions.

Our UKAS-accredited laboratory offers precision testing that meets the exacting requirements of automotive and advanced resilience-focused industries, delivering reliable data and ensuring your products are prepared for even the most challenging environments.

Our capabilities and equipment

Have a closer look on our test services and chambers on the following pages

Extract of our Capabilities in Climatics

Type of Test	Parameters
Drip-proof / waterproof / rain	Drip tray: 1.00 x 0.75 m
Dry heat	• T: up to +180 °C • RH: min. 20%
Fluid contamination	• T: ambient to +150 °C
High humidity / low temperature	• T: -50 to +80 °C • RH: 20% to 98%
Humidity - cyclic	• T: +10 to +85 °C • RH: 20% to 98%
Humidity - steady state	• T: +10 to +85 °C • RH: 20% to 98%
Ice water shock - splash water method	• T: 0 to +125 °C
Icing	

Type of Test	Parameters
Ingress protection	• IP classes: IP3X to IP6X, IPX1 to IPX8 and IPX9K • Solid foreign objects • Dust protected and dust tight • Water (vertical dripping water, spraying water, splashing water, water jets, power jetting water, immersion, ingress) • And more
Low pressure/temperature and over pressure	• T: -70 to +180 °C • p: min. 1.0 kPa
Low temperature	• T: min. -70 °C
Salt mist - cyclic	• T: max. +70 °C • RH: max. 100%
Thermal cycling	• T: -70 to +180 °C • Max rate 15 °C/min
Thermal shock	• T: -70 to +200 °C in <30 s
Water immersion - air to liquid	Cylindrical submersion tank (diameter: 0.75 m / depth: 1.4 m)

Our Chambers

Take a closer look on our chambers and ovens on the following pages for the previously described test capabilities.

Chamber	Manufacturer	Model	Type						Internal Dimension (H x W x D) [mm]	Working Volume (H x W x D) [mm]
			Altitude	Dewing	Humidity	Salt	Tempr.	Thermal shock		
A/D	Weiss	WK1 600			●		●		950 x 800 x 770	750 x 600 x 570
Ascott A	Ascott	1000xp				●			1,320 x 1,300 x 980	
Ascitt BB	Ascott	CC450iP			●	●			1,140 x 1,010 x 640	
B	ACS	CST3202T						●	650 x 620 x 700	450 x 420 x 500
C	Weiss	WKS 3-1000/70/5		●	●		●		950 x 1,100 x 950	650 x 800 x 650
E	Votsch	VCV 7100-5/S			●		●		1,000 x 980 x 980	700 x 680 x 680
F	ACS	UD1000 C	●		●		●		1,020 x 1,010 x 1,010	720 x 710 x 710
G	Fiscons						●			
H	Weiss	ShockEvent 300						●	610 x 770 x 650	410 x 570 x 450
I	Votsch	VT³ 7030 S2						●	610 x 770 x 650	410 x 570 x 450
J	Votsch	VCS 7090			●		●		880 x 960 x 1,000	580 x 660 x 700
L	Votsch	VCS 7200-3/S			●		●		1,160 x 1,980 x 1,070	860 x 1,680 x 770
M/N	Weiss	WK11 1000/70/5			●		●		950 x 1,060 x 920	650 x 760 x 620
O	Weiss	WKS 3-1300/70/5			●		●		925 x 1,100 x 1,325	625 x 800 x 1,025
P	ACS	DM1200 CES			●		●		950 x 1,000 x 1,130	650 x 700 x 830
Q-Fog	Q-Fog	CCT 1100				●			500 x 1,470 x 860	
R	ACS	DM600 T					●		892 x 850 x 730	592 x 550 x 430
T	Weiss	TS130						●	430 x 460 x 590	230 x 260 x 390
V	Votsch	VCV 7100-5/S			●		●		1,000 x 890 x 1,000	700 x 680 x 700
W	CTS	TSS 70/130						●	410 x 470 x 660	210 x 270 x460

No. of Ports / Shelves	Port Dimension [mm]	Temperature	Max. Ramp Rates [°C/min]	Max. Loading Shelf / Floor
3 / 2	50 / 120	-70 to +180 °C	4	40 / - kg
1 / -		+50 °C		
1 / -		+70 °C		
2 / 2	70	-80 to +220 °C	<30 s	50 / 50 kg
3 / 1	130 / 50	-70 to +180 °C	6	50 / - kg
4 / 2		-70 to +180 °C	5	
1 / 2	160	-70 to +180 °C	3	50 / - kg
2 / -	110	-70 to +120 °C	1	50 / - kg
2 / 2	80	-80 to +220 °C	<30 s	100 / 100 kg
2 / 2	80	-80 to +220 °C	<30 s	100 / 100 kg
4 / 2	150 / 100	-70 to +180 °C	5	
5 / -	150 / 100	-70 to +180 °C	5	- / 315 kg
3 / 2	120	-70 to +180 °C	6	50 / 150 kg
3 / 2	125	-72 to +180 °C	15	
4 / 2	180 / 90	-75 to +180 °C	5	50 / 100 kg
2 / -				
2 / 1	150 / 80	-70 to +180 °C	5	50 kg / 100 kg/m^2
1 / 2	30	-80 to +220 °C	<30 s	20 / 20 kg
- / -		-70 to +180 °C	5	
1 / 2	55	-80 to +200 °C	<30 s	20 / - kg

Oven	Manufacturer	Model	Type						Internal Dimension (H x W x D) [mm]	Working Volume (H x W x D) [mm]
			Altitude	Dewing	Humidity	Salt	Tempr.	Thermal shock		
2	LTE Scientific	Vulcan					●		600 x 370 x 370	450 x 220 x 220
3	Memmert	UF260Plus					●		780 x 610 x 470	580 x 410 x 270
4	Memmert	UF260Plus					●		780 x 610 x 470	580 x 410 x 270
5	LTE Scientific	OP60-UF					●		600 x 370 x 370	450 x 220 x 220
6	LTE Scientific	OP60-UF					●		600 x 370 x 370	450 x 220 x 220
7	Memmert	UF1060Plus					●		1,200 x 1,040 x 850	900 x 740 x 550
8	Gallenkamp						●			
9	Carbolite	PF 200					●		740 x 585 x 510	590 x 435 x 360
11	Carbolite	PF 200					●		740 x 585 x 510	590 x 435 x 360
12	LTE Scientific	OP250-MF					●		1,000 x 500 x 500	800 x 300 x 300
13	LTE Scientific	OP250-MF					●		1,000 x 500 x 500	800 x 300 x 300

No. of Ports / Shelves	Port Dimension [mm]	Temperature	Max. Ramp Rates [°C/min]	Max. Loading Shelf / Floor
- / 2		+200 °C		
2 / 3	57	+300 °C	5	30 / - kg
2 / 3	57	+300 °C	5	30 / - kg
- / 2		+250 °C		50 / - kg
- / 2		+250 °C		50 / - kg
1 / 3	120	+300 °C	5	
- / 2		+200 °C		
- / 2		+300 °C		
- / 2		+300 °C		
- / 3		+250 °C		120 / - kg
- / 3		+250 °C		120 / - kg

Vibration

Our Environmental testing segment offers a comprehensive range of Vibration testing services designed to push your products to their limits, ensuring durability and performance under extreme conditions. From Vibration measurement and frequency analysis to advanced test profiles such as sine, random, sine-on-random, gunfire, shock and bump, our facilities can simulate a variety of real-world conditions. Additionally, we provide drop and topple testing and resonance detection with dwell, ensuring that every frequency and force is evaluated for robust performance.

With multi-channel frequency analysis capabilities, our Vibration testing services capture critical data across complex structures, making it ideal for high-stakes applications in the automotive, aerospace and other industries. For comprehensive insights, we offer combined Temperature, Humidity and Vibration testing, delivering a holistic view of a component's resilience under combined environmental stressors.

In-house fixture design and manufacturing

Our in-house fixture design and manufacturing capabilities ensure secure and precise mounting, customized to your specific testing requirements. This means faster turnaround times, high adaptability and accurate test conditions. Whether you need standalone Vibration testing or a tailored combination of Environmental tests, our facilities are equipped to meet the toughest testing standards.

Shaker	LDS V8-56K		LDS V875-40K		LDS V870E-SPAK25		LDS V875-SPAK40		G&W V2664 / DSA5-25K	
Peak thrust (sine)	57.8 kN		35.5 kN		33.3 kN		35.5 kN		25 kN	
Peak thrust (random)	66 kN		31.1 kN		26.6 kN		31.1 kN		25 kN	
Max. payload	700 kg		600 kg		600 kg		600 kg		500 kg	
Slip-table size	750 x 750 mm		750 x 750 mm		500 x 500 mm		-		-	
Max. acceleration	vertical	slip-table	vertical	slip-table	vertical	slip-table	vertical	slip-table	vertical	slip-table
0 kg	140 G_n	44 G_n	50 G_n	28 G_n	100 G_n	41 G_n	50 G_n	-	50 G_n	-
100 kg	47 G_n	24 G_n	38 G_n	18 G_n	26 G_n	18 G_n	38 G_n	-	16 G_n	-
Max. velocity	2.0 m/s^2		1.5 m/s^2		1.4 m/s^2		1.4 m/s^2		1.27 m/s^2	
Max. displacement	63.5 mm		50 mm		50 mm (peak to peak)		50 mm		50 mm	
Frequency range	3 - 2,500 Hz		3 - 2,500 Hz		3 - 2,500 Hz		3 - 2,500 Hz		3 - 2,000 Hz	
Vibration profiles	• random • sinusoidal • shock • sine-on-random		• random • sinusoidal • shock • SRS • sine-on-random • random-on-random		• random • sinusoidal • shock • sine-on-random		• random • sinusoidal • shock • SRS • sine-on-random • random-on-random		• random • sinusoidal • shock • SRS • sine-on-random • random-on-random	
Environmental chamber	-						Votsch VCV 7100-5/S			
Temperature range			-70 to 180 °C		-60 to 150° C		-70 to 180 °C (4 °C/min)		-70 to 180 °C (4 °C/min)	
Humidity			up to 95% RH		-		-			
Size (W x H x L)			1.25 x 1.0 x 1.25 m				1.0 x 1.0 x 1.0 m			

Material Analysis

We provide reliability analysis services to enable our customers to improve the operating performance and integrity of electronic and electromechanical products. By combining a wide variety of skills in metallic and non-metallic systems and expert knowledge of materials processing and electronics manufacturing techniques with modern analytical methods, our teams are able to meet the most challenging customer requirements.

Designed for:

Failure Analysis and Investigation

We offer a range of failure analysis and material investigation services, ranging from standalone component tests to comprehensive forensic engineering projects. Our teams are able to determine root causes of failures by applying a suite of scientific tools and analytical techniques, enabling our customers to identify design and process improvement opportunities.

Our well-equipped laboratory includes facilities to undertake:

- SEM analysis
- X-ray radiography
- FT-IR organics analysis
- Strain gauging for electronic assemblies
- Mechanical testing
- Metallography
- Optical inspection and measurement (e.g. to IPC-A-610 standard)

Materials Testing

We offer both destructive and non destructive mechanical testing services including:

- Tensile strength
- Compression loads
- Cyclic loading
- Temperature controlled chamber for mechanical testing between -70 °C and +350 °C
- Strain measurement, on- or off-site
- Macro- and micro-hardness

With the aid of the on site prototyping facility, jigs and fixtures can be made to allow for the testing of even the most unusual shaped products.

Our non-destructive Analysis Services

Scanning Electron Microscopy (SEM) with Energy Dispersive X-Ray Analysis (EDX)

- Failure analysis
- Contamination analysis
- Materials characterisation
- Fracture analysis
- Inorganic (metallic) analysis (e.g. particle)

Optical Imagery (Micro)

- Stereo microscopes
- IPC analysis (IPC-A-600 & 610)
- Weld quality assessment (e.g. resistance welded components)
- Digital microscope (e.g. profilometry of surface features)

Optical Imagery (Macro)

- Optical cameras for sample identification and external analysis
- IPC analysis (IPC-A-600 & 610) for end product acceptance criteria for electronic assemblies and PCBs

CT - X-Ray

- 2D X-ray imaging
  (e.g. PCB layout within housings, through hole voiding etc.)
- 3D laminography imaging
  (e.g. Internal chip architecture, PCB layout etc.)

FT-IR
(Fourier Transform Infra Red)

- Contamination analysis
- Materials characterisation
- Organic (polymer) analysis

Our destructive Analysis Services

Sample Preparation

- Epoxy impregnation of samples to prevent processing damage
- Precision cutting of devices (e.g. diamond saw)
- Cold/hot mounting of samples
- Manual/automatic grinding and polishing

Chemical Treatment

- De-capsulation to reveal chip/wafer
- Chemical removal of coatings, foam for optical inspection
- Sulphur corrosion – bespoke testing of PCBs

Optical Inspection (of mounted Samples)

- Optical microscopes
  (e.g. solder quality, micro structure etc.)
- SEM
  (e.g. solder quality, inter-metallic thickness etc.)
- Digital microscope
  (e.g. solder quality)

Mechanical Testing

- Tensile/compression testing (e.g. connector testing)
- Flexural testing (e.g. PCB analysis)
- Dye and pull testing (e.g. BGA/chip analysis)
- Cyclic loading (e.g. BGA/chip analysis)

Strain Analysis

- Strain gauging of PCBS for stress/strain identification.

Heat Treatment

- Ash content analysis of polymers
- Pyrolysis

Prototyping & Instrumentation

At ZES, we understand that speed, precision and flexibility are key to staying ahead in any product development. That's why our in-house prototyping capabilities are at the core of our Test & validation services, as well as being available as a stand-alone offering.

Designed for:

Prototyping

Our workshops are fully equipped with state-of-the-art milling and turning machines with CNC capabilities, along with drilling, surface grinding, spark eroding and vehicle fitment facilities. This infrastructure enables us to make precise modifications, all done under one roof to ensure a streamlined, efficient process.

Whether working with common metallic or non-metallic materials, our stocked inventory allows us to deliver rapid part production without long lead times. This is especially critical when fast turnarounds are needed to adapt to design changes or unexpected test results.

Whether you're looking for a partner to support your R&D efforts or simply need high-quality, bespoke components, our prototyping service is tailored to meet the demands of the various industries. From concept to fitment, we ensure your parts are validated for peak performance.

With us, you're not just getting a part; you're getting the support of a complete workshop that brings your vision to reality - fast.

Instrumentation

We don't just stop at prototyping - we take it a step further with our instrumentation services, offered as a stand-alone solution or integrated with our Test & validation packages.

Our in-house capabilities allow us to fit advanced instrumentation to your prototype or production parts, ensuring precise data collection for performance analysis. No matter what kind of sensor you wish, we have the expertise to seamlessly integrate the instrumentation that fits your specific testing needs. Our extensive workshop facilities ensure that any modifications needed for sensor placement or wiring are handled with precision.

This service is perfect for customers needing real-time, accurate performance data during testing, product development or other applications. Whether you require stand-alone instrumentation to augment your in-house testing or as part of our full test and validation services, we've got you covered.

By choosing our instrumentation services, you're ensuring that your prototypes aren't just built quickly - they're built with the data-driven insights needed to optimize performance and reliability.

04

Cybersecurity

In a connected world, Cybersecurity is vital for protecting critical systems. We offer comprehensive services for product and software development companies and critical infrastructure providers, including R&D support with technology scouting, feasibility studies and proof-of-concept development. Our engineering support ensures smooth project execution through project management, compliance assurance, system/software engineering and supplier management. To ensure robust defense, we provide Testing and Product Evaluation with penetration/fuzz testing, code reviews and vulnerability scanning. Additionally, our long-term support offers continuous protection and monitoring to safeguard against evolving threats.

Check our website for more insights

Coaching & Consultancy Services

Our Cybersecurity Coaching and consultancy services are designed to seamlessly integrate into agile development environments, ensuring that security is embedded at every stage of the development life-cycle.

Integration with agile Practices

We integrate security into your agile development practices. In collaboration with your team we ensure that security becomes a core part of every sprint, helping to address potential vulnerabilities early in the process. Through active participation in daily stand-up meetings, we ensure that security updates, concerns and tasks are consistently communicated, fostering collaboration between all team members. Our approach ensures real-time identification and resolution of security issues, keeping your development process secure and efficient from start to finish.

Automation and Tools

Our Automated testing services implement advanced tools like Static application security testing (SAST) and Dynamic application security testing (DAST). These tools automatically identify vulnerabilities early in the development cycle, enabling fast, efficient re-mediation. Additionally, we integrate security checks directly into your CI/CD pipeline, ensuring that vulnerabilities are detected and addressed before they reach production, resulting in a secure and seamless release process.

All our Cybersecurity services offered comply with the latest automotive security standards: ISO/SAE 21434 and UNECE R 155. These standards ensure that Cybersecurity practices are aligned with industry best practices for risk management and Cybersecurity in road vehicles. ISO/SAE 21434 focuses on the entire vehicle life-cycle, while UNECE R 155 mandates Cybersecurity management systems for vehicle manufacturers.

For more information, you can refer to **ISO/SAE 21434** and **UNECE R 155**.

Collaboration and Training

Collaboration between developers, security experts and operations teams is crucial. This ensures that security becomes a shared responsibility throughout the organization. Additionally, we provide continuous training to keep your team informed about secure coding practices and the latest security threats. This ongoing education helps maintain vigilance and adaptability in an ever-evolving threat landscape.

Risk Management

To safeguard your systems we provide expert coaching on proactive Risk management. Through regular threat modelling, we identify potential vulnerabilities and attack vectors early, allowing for timely mitigation before risks escalate. Additionally, we conduct detailed risk assessments that prioritize vulnerabilities based on their likelihood and potential impact, ensuring that your team addresses the most critical security threats first.

Best Practices

Our “shifting left” approach ensures that security is built into the development process from the earliest stages, reducing cost and impact of fixing security issues post-release. Additionally we help you to identify and train security champions within your teams, ensuring that security best practices are advocated and continuously implemented throughout the development life-cycle.

For fast progress and clear process we developed best practice templates which are one of the key elements of our coaching:

- **Risk assessment templates** (e.g. NIST risk management framework template, network risk assessment template)
- **Incident response templates** (e.g. incident response plan template, post-incident analysis template)
- **Vulnerability management templates** (e.g. vulnerability assessment template, vulnerability management policy template)
- **Compliance and audit templates** (e.g. security compliance checklist, audit report template)
- **Training and awareness templates** (e.g. employee training plan template, phishing simulation template)
- **Security policy templates** (e.g. information security policy template, access control policy template)

Life Cycle Monitoring

Our service ensures continuous protection throughout your system's life-cycle, from initial design to deployment and beyond. We pro actively monitor, detect and respond to threats, maintaining robust security and minimizing risks at every stage.

SOC Development

We specialize in creating and maintaining Security operations centers (SOCs) to enhance your organization's threat detection, response and prevention capabilities. Our SOCs provide centralized monitoring and management of security incidents in real-time.

Planning and design
We begin with a comprehensive assessment of your current security posture to identify gaps and define the scope of the SOC, including the assets and systems it will monitor. We then develop the SOC architecture, including network design, data flow and integration with existing systems.

Technology and tools
Our implementation includes Security information and event management (SIEM) systems for collecting and analysing security data, along with monitoring tools like Intrusion detection systems (IDS) and Endpoint detection and response (EDR) solutions. We also utilize automation tools to streamline incident response and reduce manual workload.

Staffing and training
We define key roles within the SOC, such as Tier 1 analysts, incident responders and threat hunters. We provide ongoing training programs to ensure staff is up-to-date with the latest threats and technologies.

Processes and procedures
We develop and document incident response plans that outline steps for detection, containment, eradication and recovery. Additionally, we establish Standard operating procedures (SOP) for routine tasks and incident handling.

Security updates and patches
We implement a robust patch management process to ensure all systems and applications are up-to-date with the latest security patches. This includes regular scanning for patches, prioritizing based on severity, timely deployment and verification of successful application.

Continuous improvement
We conduct regular audits and assessments to identify areas for improvement, integrate threat intelligence to stay informed about emerging threats and implement a feedback loop to learn from past incidents and enhance future responses.

Compliance and reporting
We ensure the SOC complies with relevant regulations and standards, such as GDPR, HIPAA or PCI DSS. We also develop reporting mechanisms to keep stakeholders informed about the SOC's activities and performance.

Our SOC development services are designed to provide robust and continuous security coverage, adapting to new threats and ensuring comprehensive protection for your organization.

Incident Management

Our Incident management service ensures effective identification, management and resolution of security incidents.

We assist with establishing policies and procedures for incident response, detecting and analysing potential security issues, containing incidents to prevent further damage, eradicating the root cause and recovering affected systems.

Additionally, we conduct post-incident analyses to improve future response strategies.

Vulnerability Management

The Vulnerability management service provides a continuous approach to identifying, assessing and mitigating security vulnerabilities.

We scan systems and applications to discover vulnerabilities, assess their severity and potential impact and apply necessary patches or fixes.

We also verify that vulnerabilities have been effectively addressed and continuously monitor for new vulnerabilities while improving the management process.

Software Development

Cybersecurity Software development focuses on creating software designed to protect systems, networks and data from digital threats. It involves implementing robust security measures throughout the software life-cycle, from initial design and coding to deployment and maintenance. This practice ensures that software is resilient against attacks, vulnerabilities are addressed and compliance with industry regulations is maintained, safeguarding critical information and infrastructure from evolving cyber threats.

Requirements

Our Software development requirements ensure your software is secure, resilient and free from vulnerabilities throughout its life-cycle. We provide comprehensive guidelines and specifications from planning through maintenance, ensuring adherence to the highest security standards.

We focus on integrating security by design, including early threat modelling and secure architecture with encryption and authentication. Our approach involves adhering to secure coding practices, using updated libraries and applying least privilege principles. We implement strong authentication and role-based access control, encrypt sensitive data and ensure compliance with regulations like GDPR and HIPAA.

Our services include static and dynamic vulnerability testing, penetration testing and incorporating security into CI/CD pipelines along with peer code reviews.

We also ensure rapid vulnerability patching and effective dependency management. Compliance with industry standards such as PCI-DSS, SOC 2 and NIST is maintained, alongside real-time monitoring and clear incident management processes.

Additionally, we offer training on Cybersecurity best practices for developers and end-users to enhance overall security awareness.

DevSecOps Tooling

Our DevSecOps practice integrates security into every phase of the software development lifecycle, combining Development (Dev), Security (Sec) and Operations (Ops). This approach ensures that security is a continuous, integral part of the development process, not just an afterthought.

We provide a comprehensive suite of tools to enhance your security posture. Continuous integration/Continuous deployment (CI/CD) tools like Jenkins and GitLab CI/CD automate build, test and deployment processes with integrated security checks. Static application security testing (SAST) tools, such as Checkmarx and SonarQube, analyze source code for vulnerabilities without executing it. Dynamic application security testing (DAST) tools, including OWASP ZAP and Burp Suite, test running applications for vulnerabilities by simulating attacks. Container security tools like Aqua Security and Twistlock ensure the security of containerized applications. Infrastructure as Code (IaC) security tools, such as Terraform and AWS CloudFormation, scan infrastructure code for security issues. Compliance monitoring tools, including Chef InSpec and OpenSCAP, ensure adherence to industry standards and regulations.

By adopting our DevSecOps approach, you ensure a robust, security-focused development life-cycle, protecting your applications and infrastructure from potential threats while meeting industry standards and regulations.

Cybersecurity Software development focuses on creating software to protect systems and networks from digital attacks and unauthorized access.

Key areas include **SecOC (Secure onboard communication)**, which ensures secure vehicle network communication through authentication and encryption; **Bootloader,** which verifies digital signatures to start the OS in a trusted environment; and **Flashing**, which updates firmware to secure versions. Additionally, **diagnosis tools** help identify and address security breaches or vulnerabilities. These elements are essential for maintaining system integrity and security, especially in critical environments like control systems.

Reach out to us to get your individual software solution from our offerings.

System Design & Analysis

System design & analysis involves crafting and evaluating secure architectures to protect against cyber threats. This process ensures robust defences by integrating security measures and analysing potential vulnerabilities, aiming for resilient infrastructures that effectively prevent and respond to security incidents.

System Analysis

Starting with a thorough examination of your system or network to identify, evaluate and mitigate potential security risks and vulnerabilities. We conduct in-depth threat modelling to pinpoint weaknesses and attack vectors, assess risks to prioritize critical issues and perform vulnerability assessments through detailed scans and penetration testing. The findings are translated into clear security requirements, implementing measures like encryption, access controls and intrusion detection systems. Ensuring compliance with industry standards and regulations, such as GDPR and ISO 27001, enables us to develop effective mitigation strategies to address and reduce risks.

Concept Development

Translating the findings from previous analysis into a strategic and technical framework for robust protection against cyber threats is crucial. We design a high-level approach to Cybersecurity by defining clear security goals, identifying potential threats and determining the policies, technologies and processes necessary to safeguard your assets and data. The detailed system analysis helps us prioritize protection efforts where they are most needed. We then define security objectives and requirements, focusing on confidentiality, integrity, availability and resilience to ensure business continuity and regulatory compliance.

Our service includes designing a secure system architecture with integrated measures such as network segmentation, firewalls, intrusion detection systems (IDS), encryption and secure authentication mechanisms. We develop comprehensive security policies and protocols for data access, handling, incident response and guidelines for employees and third parties. Assistance in selecting the right technologies, including anti-virus software, firewalls, encryption tools and monitoring systems, tailored to your specific needs and risks is part of our service as well as providing detailed implementation plan outlining time lines, resource allocation and responsibilities to ensure a structured approach.

System Requirements

Leverage insights from detailed system analysis and concept development, we guide the design, development and implementation of secure systems to safeguard data, processes and communications from unauthorized access and breaches. Therefore defining the specifications and criteria your system must meet to ensure robust protection against cyber threats and compliance with relevant security standards is the next step.

We focus on ensuring confidentiality by making sensitive data accessible only to authorized entities through encryption and access controls. Integrity is maintained by protecting data from unauthorized modifications using techniques like hashing and digital signatures. To guarantee availability, we implement measures to keep systems functional and protected against attacks, including redundancy mechanisms. Our approach includes defining robust authentication and authorization processes, such as multi-factor authentication and role-based access control, to ensure secure user and system identification. We also emphasize comprehensive auditing and logging of system activity to facilitate forensic analysis if breaches occur. Compliance with industry standards and regulations, such as GDPR, HIPAA, NIST and ISO/IEC 27001, is a key aspect, achieved through rigorous documentation and regular audits.

We establish requirements for incident detection and response, including the use of intrusion detection systems and regular vulnerability scans, to ensure prompt and effective management of security incidents. Data encryption is implemented to protect information both in transit and at rest. Physical security measures are also considered, including securing server rooms and controlling access to sensitive areas. Finally, we ensure system resilience and recovery capabilities with backup systems, data recovery plans and strategies to minimize disruptions during incidents.

This comprehensive approach ensures your system is secure, resilient, compliant and well-equipped to handle and recover from security incidents.

Manufacturing

Cybersecurity in manufacturing involves protecting manufacturing systems and processes from cyber threats through various strategies, technologies and practices. This includes securing industrial control systems (ICS), Internet of Things (IoT) devices, production software and the supply chain. With the rise of Industry 4.0 and smart factories, Cybersecurity is crucial for safeguarding intellectual property, ensuring operational continuity and preventing disruptions from cyber attacks.

Key focus areas include system and network protection to prevent hacking and malware, data security to protect sensitive production and customer information and operational technology (OT) security to secure ICS like PLCs and SCADA systems. Supply chain security is essential to protect against risks from third-party vendors and compliance with standards such as ISO 27001, NIST, or TISAX is necessary. Risk management and monitoring involve regular assessments, vulnerability scanning and real-time system monitoring to address potential Cybersecurity risks.

Testing

Cybersecurity Testing evaluates the security of systems, applications and networks to identify vulnerabilities. It includes methods like penetration testing and vulnerability scanning to simulate attacks and uncover weaknesses. This process helps organizations strengthen defences, ensure compliance and protect sensitive data from potential cyber threats.

Software functional Testing

Software functional testing ensures applications perform their intended functions securely. It involves verifying that all features work correctly, including user interfaces, APIs and databases. The process includes security testing to identify vulnerabilities through methods like penetration testing and code reviews. Authentication and authorization are checked to confirm proper access controls. Data protection is assessed to ensure sensitive information is encrypted and secure. Compliance testing verifies adherence to standards such as GDPR and HIPAA. Performance testing evaluates how well the software handles various conditions, including high traffic, while maintaining security.

Fuzz Testing

Fuzz testing is a critical Cybersecurity technique used to uncover coding errors and security vulnerabilities in software, operating systems or networks. This method involves injecting a large volume of random, unexpected, or malformed inputs into a system to observe its responses and identify potential weaknesses.

- **Automated testing:** Utilizes tools known as fuzzers to generate and inject various inputs automatically.
- **Types of fuzzing:** Includes application fuzzing to test user interfaces and APIs, protocol fuzzing for network protocols and file format fuzzing.
- **Detection of vulnerabilities:** Effective at discovering issues such as buffer overflows, denial of service (DoS) attacks, cross-site scripting (XSS) and code injection.
- **Monitoring and analysis:** Involves monitoring the system for crashes or errors and analysing the root causes of any vulnerabilities detected.
- **Cost-effective:** Provides a straightforward and affordable way to enhance security by identifying and addressing potential vulnerabilities.

Penetration Testing

Penetration testing simulates cyber attacks to identify vulnerabilities in your system that could be exploited by malicious hackers The primary goal is to uncover weaknesses before they can be exploited.

Our process includes:

- **Planning:** Defining the test's scope and objectives.
- **Reconnaissance:** Gathering information to identify potential entry points.
- **Exploitation:** Attempting to exploit identified vulnerabilities to gain unauthorized access.
- **Post-exploitation:** Assessing the impact of the exploited vulnerabilities.
- **Reporting:** Documenting findings, including discovered vulnerabilities, methods used and re-mediation recommendations.

We offer various types of pen tests:

- **External testing:** Targets external assets such as web applications and network infrastructure.
- **Internal testing:** Simulates attacks from within the organization's network to find insider vulnerabilities.
- **Blind testing:** Conducted without prior knowledge of the target system, simulating a real-world attack.
- **Double-blind testing:** Both the tester and the organization's security team are unaware of the test, providing a realistic evaluation of detection and response capabilities.

Code Reviews

Our Code review service meticulously examines the source code of an application to identify vulnerabilities and ensure adherence to security best practices. We utilize both manual and automated methods for thorough analysis. Manual reviews involve security experts inspecting the code for vulnerabilities like logic errors and insecure practices, providing a detailed, though time-consuming, assessment. Automated tools, such as SonarQube, Checkmarx and Fortify, quickly scan for known vulnerabilities and insecure coding patterns, delivering broad reports.

We focus on common vulnerabilities like SQL injection, Cross-site scripting (XSS) and buffer overflows. Our review also ensures adherence to best practices, including input validation, secure error handling and proper access controls. Additionally, we verify compliance with relevant security standards and regulations, such as OWASP guidelines, to enhance your software's security posture.

05

Engineering Services

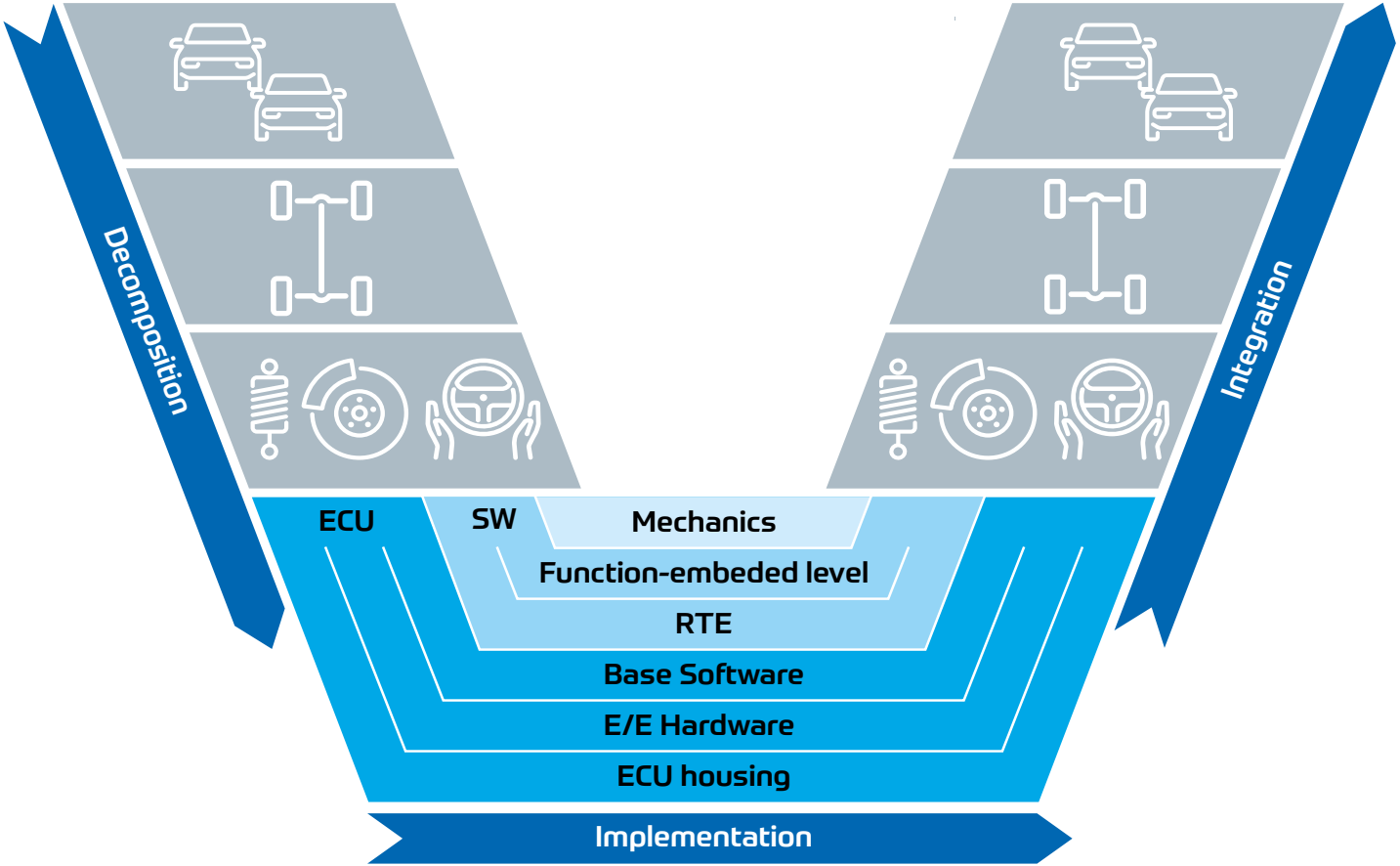
Our engineering consulting services leverage decades of expertise across the automotive and other industries, delivering specialized solutions tailored to your needs. With a focus on digitalized product development, our experts bring deep knowledge in areas ranging from motorsport to everyday automotive and all non-automotive applications. Whether you need assistance with concept development, product optimization or navigating complex regulatory environments, our team is equipped to provide cutting-edge consulting. We work closely with your team, using our industry insights and advanced tools to ensure your projects meet the highest standards of performance, efficiency and innovation and is delivered in time.

Check our website for more insights

System Integration

Our System integration service offers expert integration of mechatronic components into vehicle sub-systems and the seamless integration of these sub-systems into the overall vehicle architecture. Utilizing ZF middleware and advanced vehicle dynamics systems such as Cubix, we ensure precise and efficient integration, enhancing system performance and vehicle control. Whether it's optimizing communication between components or ensuring full compatibility with the vehicle's infrastructure, our solutions are tailored to provide reliable, high-performance integration, allowing for smoother operations and enhanced vehicle functionality across diverse platforms. This service is ideal for manufacturers aiming for cutting-edge vehicle dynamics and system efficiency.

Designed for:


Decomposition
Integration
ECU
SW
Mechanics
Function-embeded level
RTE
Base Software
E/E Hardware
ECU housing
Implementation


ZF
cubiX
GOODYEAR

Test Services

At ZES, we offer comprehensive test services, specializing in all aspects of proving ground management, planning and physical vehicle testing. From prototype vehicle builds to the strategic design of test tracks, Our services are focused on bringing real-world conditions into controlled environments. Our advanced facilities and expertise allow us to support every phase of vehicle development, ensuring that all aspects of performance, safety and durability are rigorously tested. Whether you're refining a prototype or optimizing a test strategy, we deliver precision and reliability in proving ground and real-world testing for automotive innovation.

Designed for:

Vehicle Testing

Proving Ground Management

We offer expert Proving ground management and planning services tailored to the unique demands of automotive, truck and motorbike customers. Our approach ensures that every test facility is optimized for your specific requirements - whether you're developing performance cars, heavy-duty trucks or high-performance motorcycles.

We handle all aspects of proving ground planning, from site layout and infrastructure design to advanced safety systems and test track configurations. Our management services ensure seamless operations with real-time support, maintenance and upgrades for sustained, reliable testing. Whether you're testing durability, dynamics or safety, ZES provides world-class solutions to accelerate your vehicle development journey.

Test Track Strategy

Our Test track strategy service is designed to help automotive customers maximize the efficiency and effectiveness of their proving ground testing. Whether you're validating new technologies, enhancing vehicle dynamics, or ensuring compliance with safety standards, our team develops custom strategies to align with your development goals.

We offer tailored test track layouts and usage plans that meet specific testing needs, from high-speed performance runs to low-speed durability assessments. Our strategic approach ensures that every element of your proving ground is utilized optimally to accelerate time-to-market, reduce testing costs and improve vehicle performance.

Physical Testing

We offer broad physical testing services across on-road environments, proving grounds and test benches, delivering a complete solution for validating vehicle performance, durability and safety. We rigorously assess components and systems under real-world conditions, from challenging road scenarios to controlled proving grounds. Our state-of-the-art test benches allow precise, repeatable testing of specific vehicle subsystems, ensuring validation before on-road trials.

This holistic approach ensures that all mechanical and electrical systems meet the highest standards for performance, reliability and safety. With ZES, you gain the insights to fine-tune your designs, achieve faster development cycles and deliver superior products to market.

Vehicle Prototype Built up

We provide prototype build-up services tailored to automotive, truck and motorbike applications, showcasing cutting-edge ZF products, sub-systems and complete systems. Whether you're developing demonstration vehicles for technology showcases, product validation or client presentations, we deliver precision-built prototypes that fully integrate ZF's advanced mechatronics and systems.

From individual components like suspension and damper systems to fully integrated solutions, our expert teams ensure seamless system integration. This service enables manufacturers to highlight the advantages of ZF technology in real-world conditions, accelerating development and delivering impressive, market-ready demonstrations.

Ride Work and Track Support

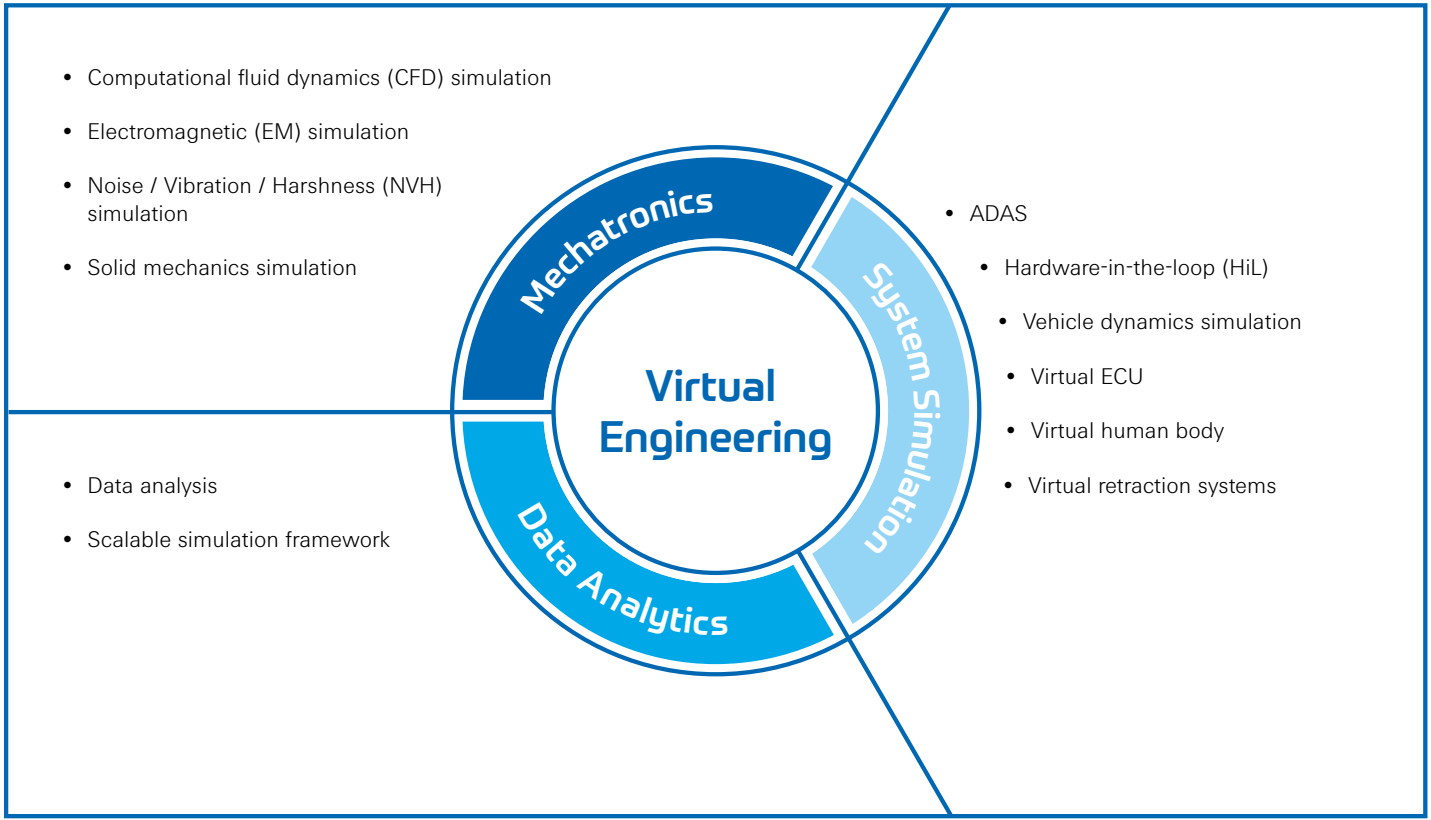
Our global ride work service offers motorsport and special applications customers unparalleled support with road-legal vehicles and track side assistance, ensuring peak performance for your racing endeavours or road-legal testing. We provide fully equipped support trucks, complete with on-site workshops and testing machines for components such as dampers and clutches.

Our mobile setup allows for real-time adjustments and precision testing during your race events, enabling immediate diagnostics and optimizations to keep your vehicle at the top of its game. Whether you need fine-tuning, repairs or performance evaluations, we ensure your motorsport team has everything it needs, wherever you race.

Virtual Engineering

Virtual engineering plays a critical role in the product development process, enhancing both base and application development phases for our customers. It allows for early-stage performance testing, virtual prototyping and validation before physical prototypes are built, saving time and reducing costs. We offer simulation as an integral part of our development services or as a stand-alone solution to address specific customer needs. Our advanced virtual engineering tools and methodologies enable us to analyse everything from system dynamics to material behaviour under real-world conditions, ensuring that every product meets its performance, safety and reliability goals before it hits the road or track.

Designed for:


Computational fluid dynamics (CFD) simulation
Electromagnetic (EM) simulation
Noise / Vibration / Harshness (NVH) simulation
Solid mechanics simulation
Mechatronics
ADAS
Hardware-in-the-loop (HiL)
Vehicle dynamics simulation
Virtual ECU
Virtual human body
Virtual retraction systems
System Simulation
Virtual Engineering
Data analysis
Scalable simulation framework
Data Analytics

Data Analytics

Data analytics is a transformative tool in today's business landscape, unlocking valuable insights from raw data to drive smarter decisions and innovation. By collecting, analysing and interpreting large volumes of data, we enable you to gain a deeper understanding of customer behaviours, market trends and operational efficiency. This data-driven approach enables you to make precise adjustments to your strategies, enhancing product development, marketing and customer satisfaction.

Data Analytics

Unlock the full potential of data-driven insights with our advanced Data analytics services, specifically tailored for automotive and industrial applications.

Our comprehensive solutions cover Road load data (RLD) evaluation, Condition monitoring (CoMo) and End-of-line (EOL) data analysis, providing crucial insights to optimize product performance and reliability.

RLD evaluation:

Through CARLOS driving, we gather extensive raw data from road tests or test circuits, which are then processed to deliver actionable insights. This includes channel correction, peak removal and custom classifications, creating a clean dataset ready for simulations, damage calculations and component design.

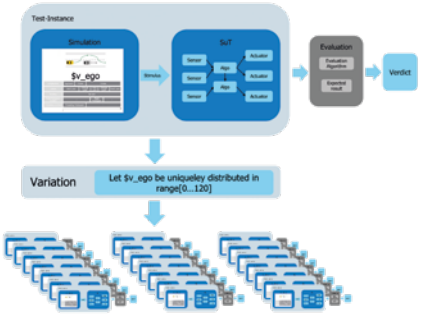
Condition monitoring:

By evaluating vibration data from test bench measurements on transmissions or eVDs, we identify potential sources of unwanted vibrations. Our order analysis and spectrum tracking help diagnose and prevent operational issues early, enhancing durability.

EOL data analysis:

Using stochastic methods to analyse End-of-line NVH data, we ensure consistency with simulation models. This alignment improves simulation reliability and predictive accuracy, reducing unplanned testing and accelerating development cycles.

Scalable Simulation Frameworks



Experience unparalleled efficiency and scalability in testing with our Data analytics Scalable simulation framework. Designed for modern development needs, this cloud-based framework allows you to execute and manage massive volumes of parallel scenario simulations, enabling a new level of testing throughput and quality assurance.

With our Scalable simulation framework, you can test more scenarios, reduce execution efforts and improve product reliability - all while accelerating development and reducing costs. Perfect for organizations seeking to maximize quality through data-driven, automated testing solutions.

Key Benefits:

- **Scalability:** Run high volumes of parallel simulations, meeting the demands of statistical testing that require extensive scenario sampling for robust results.
- **Statistical testing:** Generate insights from statistically sampled scenarios, ensuring comprehensive coverage without the traditional time and resource constraints.
- **Process automation**: Streamline and automate testing work flows, reducing manual effort and enhancing efficiency while managing all relevant test assets in one place.
- **Enhanced efficiency:** Automated test execution management, made easier with parallelization, accelerates development cycles and ensures that even complex simulations are handled within realistic time frames.
- **Process safety and compliance:** Our framework ensures complete traceability and auditability, which is essential for quality assurance and regulatory compliance.
- **Continuous improvement:** Integrate this framework with CI/CD pipelines, allowing automated testing to consistently enhance product quality with every development iteration.

Mechatronics

Our comprehensive mechatronics simulation services are designed to ensure optimal performance, reliability and efficiency across a wide range of applications, from cooling systems to electromagnetic and fatigue analysis. By leverage advanced Computational fluid dynamics (CFD) and Efficiency simulations, we enable early design evaluations, ensuring robust thermal management and streamlined energy use across the entire operational range.

Our portfolio also includes Electromagnetic (EM) simulation, Environmental simulation and Noise/Vibration/Harshness (NVH) analysis, each aimed at improving product reliability and robustness while minimizing the need for costly physical prototypes, starting at a very early stage of the product development design and concept stage.

With decades of expertise and strong partnerships with industry leaders, we accelerate development timeliness and deepen product understanding through virtual optimization, allowing products to meet stringent requirements and exceed performance expectations. Using state of the art simulation tools from ANSYS enables us to streamline our process and optimization loops.

By reducing the need for time-intensive physical tests, our simulations facilitate faster, cost-effective development while generating insights that drive superior design and functionality.

Overview of our Services

- Computational fluid dynamics (CFD) simulation
- Efficiency simulation
- Electro-magnetic (EM) simulation
- Environmental simulation
- Fatigue simulation
- Noise / Vibration / Harshness (NVH) simulation

For advanced simulation and further insights we couple single methods to multi-methods simulation models.

CFD Simulation

Our advanced CFD (Computational fluid dynamics) simulation solutions provide unparalleled insights across a full range of chassis and powertrain components - from dampers to eDrives, transmissions and clutches. With our state-of-the-art modelling, we precisely analyse fluid flow dynamics within each component, enabling us to optimize designs for performance, durability and efficiency.

By simulating complex fluid interactions, our CFD tools help reduce fluid resistance, minimize energy loss and enhance cooling efficiency under real-world conditions. This comprehensive approach applies not only to damper performance but also extends to lubrication and thermal management across critical systems, improving reliability and extending product lifespan.

Integrated into every development phase, CFD allows for rapid, iterative improvements while also being available as a standalone service. With expertise in heat transfer and thermal management, we support you in creating systems that excel in even the most demanding applications, ensuring your products stand out in both performance and endurance.

Our Services:

Fluid structure interaction

- Fluid flow analysis
- Fluid structure interaction
- Heat transfer
- Aerodynamics

EM Simulation

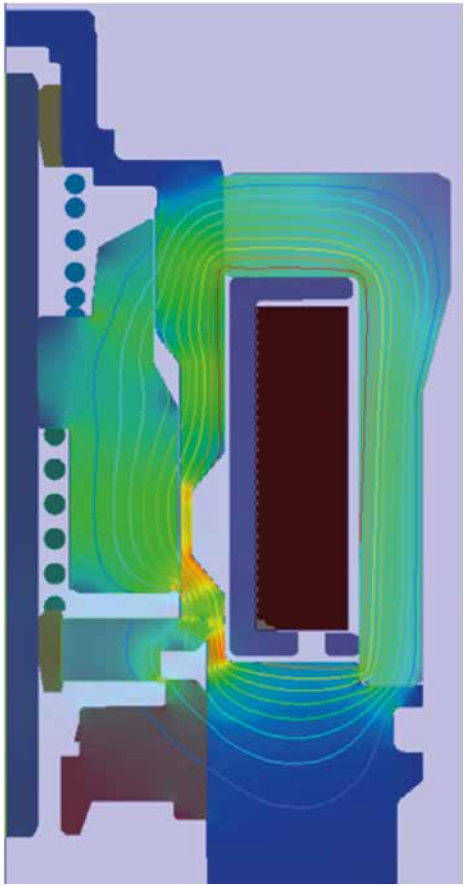
Our Electromagnetic (EM) simulation services offer cutting-edge insights into power loss, force and torque characteristics for mechatronic products in powertrain and chassis systems. With precision modelling, we enable detailed analysis of electromagnetic fields and their impact on performance, ensuring that designs are optimized for maximum efficiency and durability.

By assessing power loss, we help to minimize energy wastage, improve thermal management and boost system efficiency. Force and torque simulations provide valuable data on load handling and response times, essential for enhancing driveability and reliability in both powertrain and chassis applications.

Partnering with us for EM simulations means leverage advanced virtual testing to refine product design early in development, reduce costly physical prototypes and bring optimized products to market faster. With our expertise, you can achieve a smoother, more powerful and energy-efficient performance, meeting the demands of high-performance applications in a competitive landscape.

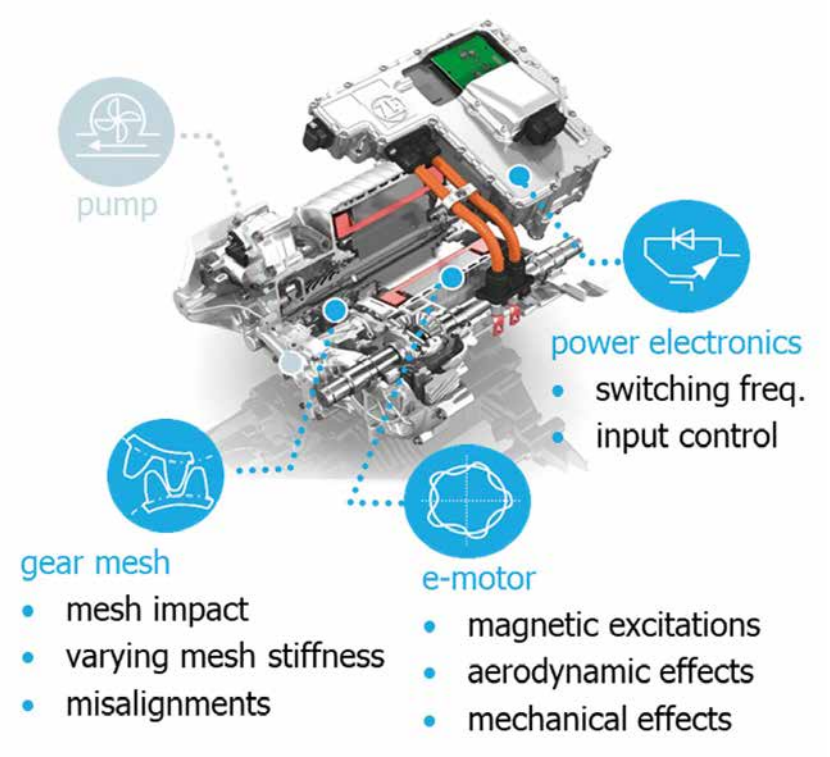
Key Benefits:

- **Increased forces and torques:** Achieve stronger, more responsive systems through targeted design optimization, enhancing both powertrain and chassis performance.
- **Robust initial design:** Early-stage optimization minimizes design iterations, resulting in faster, more efficient development.
- **Reduced power loss and increased component lifespan:** Optimized power efficiency reduces thermal stress, extending product longevity.



NVH Simulation

Our NVH (Noise, vibration and harshness) simulation services deliver deep insights into the vibrational and acoustic behaviour of structures, allowing for precise optimization for robust and reliable design. By analysing modal properties and understanding critical eigenfrequencies and -modes, we can pre-emptively identify and address potential NVH issues.



Key Features:

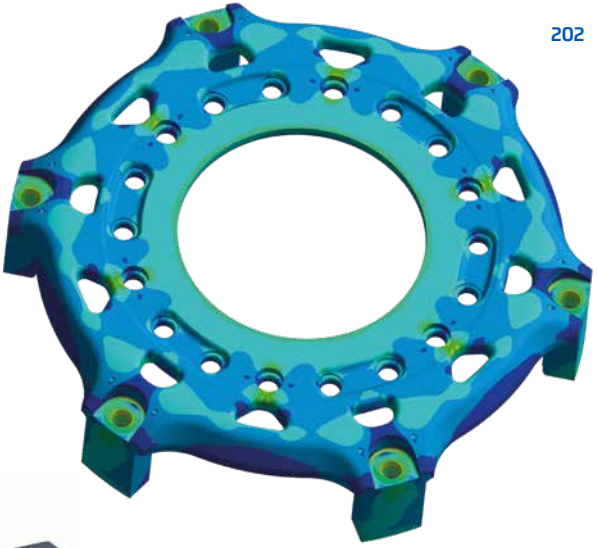
- **Industry-leading eDrive simulation:** Our NVH methodology provides a precise view of eDrive behaviour, utilizing time and spatial electromagnetic force density spectra to accurately predict excitation patterns and noise.
- **Advanced stochastic approach:** With cutting-edge stochastic methods and acoustic synthesis, we provide a comprehensive, system-wide picture, covering all potential NVH scenarios.
- **Root-cause analysis and optimization:** We identify frequency-dependent behaviours early in the design process, optimizing for customer-specific conditions to ensure design feasibility and reduce costly revisions.
- **Virtual release for rapid development:** By leverage virtual simulation, we skip unnecessary design loops, saving time and costs and ensure hardware testing results align closely with predictions.

Solid Mechanics

Our Solid mechanics services offer deep insights into the structural and performance characteristics of mechanical products, helping ensure optimal strength, displacement and weight distribution. We simulate real-world forces and environmental conditions, including temperature effects, to assess how components will perform under stress.

Beyond basic strength evaluation, we focus on bending and stiffness optimization, crucial for improving performance and durability, especially in automotive and motorsport applications. We also work with advanced materials like carbon fibre, offering lightweight yet robust solutions. With topology optimization, we create designs that reduce material use while maximizing strength and efficiency.

Our simulation services are integrated into every phase of our product development process and also available as a standalone service, supporting your engineering projects with precise, data-driven design optimization.



Our Services:

- Strength and lifetime simulation
- Composites
- (dynamic) Fatigue simulation
- Topology optimization
- Thermal distribution
- Explicit dynamics


CANAL STREET
CANAL STATION
BROADWAY
42 km/h
73%
TRANSPORTER NOT MOVING
TRANSPORTER NOT MOVING
PASSENGER CAR PARKING
ZF
Autonomous Driving

System Simulation

At ZF, we are at the forefront of innovation, pushing the boundaries of Autonomous driving (AD) and Advanced driver assistance systems (ADAS) through cutting-edge virtual engineering. Our team leverages state-of-the-art simulation and modelling tools to accelerate the development of intelligent vehicle technologies. By creating highly accurate virtual environments, we can rigorously test and validate complex algorithms, sensor fusion and control systems in real-world conditions, all before physical prototypes are built. This approach not only enhances efficiency and safety but also significantly reduces time-to-market, ensuring that we deliver the most advanced, reliable and scalable solutions for the future of mobility. At ZF, virtual engineering is the key to unlocking the next generation of autonomous driving.

ADAS

Our ADAS simulation solutions deliver an unparalleled approach to developing and testing Advanced driver-assistance systems, leverage ZF's decades of simulation expertise. By virtualizing entire domains - environment, sensors and vehicles - we provide a fully integrated platform for software development and testing that accelerates innovation while ensuring quality and reliability.

Key Features:

- **Comprehensive domain virtualization:** We simulate entire systems, not just components, by creating digital twins of environments, sensor sets and vehicle models. This holistic approach enables rapid development and in-depth testing of complex ADAS systems.
- **Tailored solutions for every need:** Our team customizes solutions based on your unique requirements, utilizing our vast knowledge and experience to provide relevant, effective virtual prototypes.
- **Accelerated development:** With increasing demands for speed, engineers can front load tasks and virtualize ADAS systems, enabling early combination of virtual components for faster maturity and higher-quality outputs.
- **Global collaboration:** Digital twins and virtual prototypes are accessible worldwide, ensuring consistent development across global teams.

ZF Annotate

ZF Annotate is an advanced AI-powered tool designed to revolutionize ADAS/AD perception validation. Offering exceptional detection accuracy and rapid AI post-processing, it enables efficient testing, training and validation of Level 2+ to Level 5 ADAS/AD systems, reducing manual labelling errors and associated costs. Its highly scalable, cloud-based 360° annotation service seamlessly integrates with customer validation tool-chains, handling diverse multi-modal sensor data with impressive precision.

Launched in October 2022, ZF Annotate has processed over 250,000 km of data, allowing users to leverage extensive global datasets to refine perception models. The platform supports flexible setup options, utilizing either customer-owned or ZF-supplied systems and eliminates the need for costly retraining.

- **Advanced testing methodologies:**
  Shift development “left” with Model- (MiL), Software- (SiL) and Hardware-in-the-Loop (HiL) for early software and ECU validation. Realistic, scenario-based tests drawn from real-world data, smart sampling and robust accident datasets ensure comprehensive system evaluation.

- **Sensor model ecosystem:**
  We provide a broad range of sensor models - including ideal, stochastic and physics-based options - tailored to your testing needs.

ZF Visuals

ZF Visual is a versatile, real-time visualization tool for ADAS/AD systems, providing an interactive view of sensor and reference data across multiple use cases like in-car analysis, playback and post-assessment. With intuitive, customized layouts and flexible data views, ZF Visual enhances product development efficiency by delivering immersive visualizations that streamline root-cause analysis and reduce project communication needs.

This tool supports comparisons of Hardware- and Software-in-the-loop (HiL/SiL) data, as well as between product versions, helping engineers visually validate system performance across sensors (e.g. camera, radar, lidar). By allowing for configuration according to specific project requirements, ZF Visual facilitates a user-friendly experience, reducing learning curves and expediting development. Covering every phase of the product life-cycle, ZF Visual ensures effective, holistic visualization for all project stakeholders, driving faster, cost-effective insights and decision-making throughout the ADAS/AD development process.

Key Benefits:

- **Early system insight:**
  Virtual prototypes allow you to understand system performance before physical testing, identifying issues early in the development cycle.

- **Standardized testing and consistent results:**
  Test different sensor configurations against deterministic test cases for accurate, reproducible insights that enhance quality and safety.

- **Scalable virtual prototypes:**
  Our cloud-enabled scalability supports high-volume parallel simulations, reducing development time and increasing testing efficiency.

Hardware-in-the-Loop (HiL) Solutions

Elevate your development process with our HiL solutions designed for the automotive, motorbike, truck, marine and aerospace industries.

Designed for:

Our HiL Lab

- Our state-of-the-art HiL laboratory ensures comprehensive coverage of testing challenges, delivering faster results and deeper insights
- Flexible, scalable hardware solutions based on industry-proven dSPACE components, including customizable processing units and interface cards
- GNSS simulation ensures precise positioning and navigation under various conditions, vital for any vehicle.
- V2X simulation to test vehicle-to-everything communication scenarios, which is crucial for improving safety and efficiency
- Advanced camera simulations using GMSL and FPD-Link technologies, simulating camera behaviour in various lighting and environmental conditions to optimize your vision systems.
- 3D simulated environment based on Unreal Engine allows real-time raytracing for multiple sensors and creates immersive testing conditions
- Comprehensive rest bus simulations that include CAN, LIN, FlexRay, Ethernet and other protocols. This ensures seamless integration of all vehicle components, maintaining communication integrity throughout your system.

Your Advantages

- Access to a cutting-edge HiL Lab supported by a team of technical specialists
- Avoid high upfront costs on equipment and software with our monthly subscription model, offering continuous, predictable expenses for better budget management.
- Full remote & local control
- Enable parallel development of controllers and systems through rapid control prototyping, reducing time-to-market
- Quickly identify hard- and software-related issues before they become critical, ensuring higher system reliability.
- Extensive fault simulation and automated testing capabilities
- Benefit from expert consulting and project support, ensuring your project runs smoothly from start to finish

Chassis and Vehicle Dynamics HiL Solutions

Experience the benefits of faster iterations, reduced costs and superior performance - all while ensuring your vehicle exceeds industry standards.

With our cutting-edge simulation technology you can combine simulated test drives and real loads on powertrains. Our highly dynamic test benches allow comprehensive analysis and optimization of vehicle behaviour in a virtual environment, significantly reducing the time and costs associated with physical testing.

With our elasto-kinematic models, you can evaluate suspension dynamics, powertrain behaviour and vehicle performance accurately, allowing for better design decisions and enhanced product quality. Our vehicle dynamics simulations provide invaluable insights into handling characteristics, stability and overall ride quality.

By leverage our simulation capabilities, you can evaluate and fine-tune various parameters - such as suspension geometry, weight distribution, tire dynamics and custom interfaces simulating the physical camera, lidar and radar outputs - without the logistical challenges and expenses of real-world tests.

This not only accelerates the development cycle but also enhances precision in predicting how vehicles will perform under different conditions.

Aerospace HiL Solutions

- Dynamics and environment simulation across MiL, SiL, PiL and HiL
- Benefit from advanced sensor and actuator modelling with runtime error injection
- High-fidelity multi-body dynamics simulation for complex scenarios like rendezvous, docking including fluid dynamics (sloshing)
- Accelerate time-to-market with expert support during the commissioning of control units and mechatronic components
- Tailored test scenario development and advanced controller validation
- Rapid condition reproduction to thoroughly investigate, analyse and optimize your guidance and navigation systems
- Benefit from a wide range of additional interfaces - SpaceWire, MIL-STD-1553 and more - for seamless integration with your systems

Virtual ECU

At ZF, we offer cutting-edge Virtual ECU (V-ECU) development that streamlines your entire development process, from early software bring-up to full system validation. Our comprehensive solution ensures faster, more efficient software development, while enhancing quality and reducing costs.

Speed up software development
Get a head start on software development by simulating ECU functionality before physical units are available. This early software bring-up drastically shortens development life-cycles, enabling you to advance at an accelerated pace while reducing time-to-market.

Enhanced software quality
Our V-ECU approach ensures deterministic reproduction of system behaviour, allowing for early detection and resolution of software bugs before they escalate. Early issue identification in the development cycle minimizes the risk of late-stage fixes, leading to a more robust and reliable final product.

Accelerated software/system testing
Take advantage of the scalability and flexibility of our virtual testing environments. Run multiple tests simultaneously with varying scenarios and slashing validation times. The virtual environment allows for continuous validation, ensuring that all changes are tested instantly.

Early validation across all levels (L1-L4)

- Levels 1 & 2: Start testing early with rapid validation in the early stages of development.
- Levels 3 & 4: Test the complete application software and entire system in a full virtual environment, simulating real-world interactions and complex systems.

Scalable & flexible testing
Our solution enables parallel testing of numerous scenarios with maximum scalability, speeding up the validation process. Hybrid HiL set-ups enhance flexibility by combining physical ECUs with virtual ECUs, providing deeper insights and expanded testing capabilities.

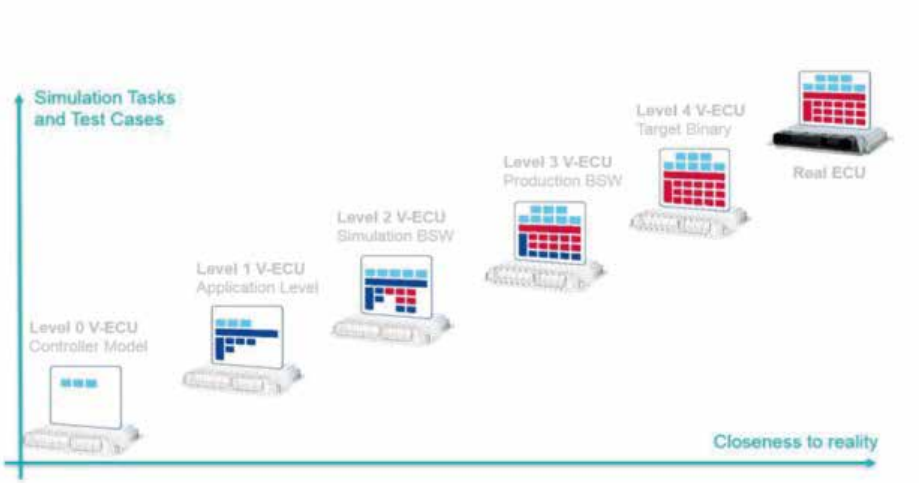
Unified development environment
Benefit from an integrated and consistent tool-chain that includes industry-leading software:

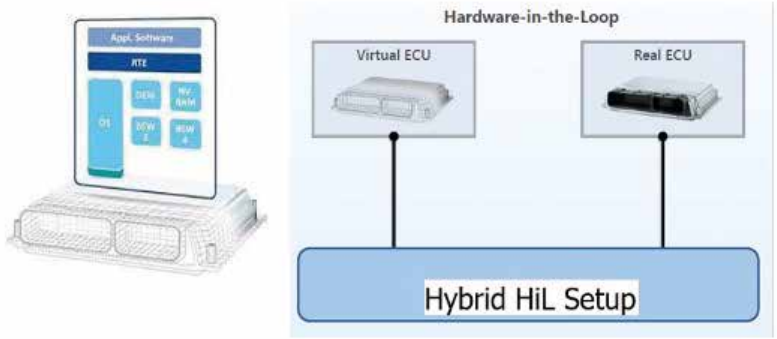
- MATLAB/Simulink for model-based design and simulation.
- dSPACE VEOS with SCALEXIO and Vector CANoe with VT System for robust hardware-in-the-loop (HiL) testing.
- Synopsys Virtualizer for L4 testing.

DevOps practices & cloud integration
Utilizing Continuous integration (CI) and Continuous testing (CT) practices, we ensure that every software change is validated automatically. Our cloud-based solutions offer a pay-as-you-go model that reduces maintenance costs, scales to your needs and integrates seamlessly into your work flow.

Key Benefits:

- **Enhanced software development & quality:** Shift-left testing and early issue detection lead to improved software reliability.
- **Faster time-to-market:** Speed up development cycles and reduce the time to market for your products.
- **Cost efficiency:** By reducing software development and testing costs and leverage the cloud, you ensure that your resources are used efficiently.



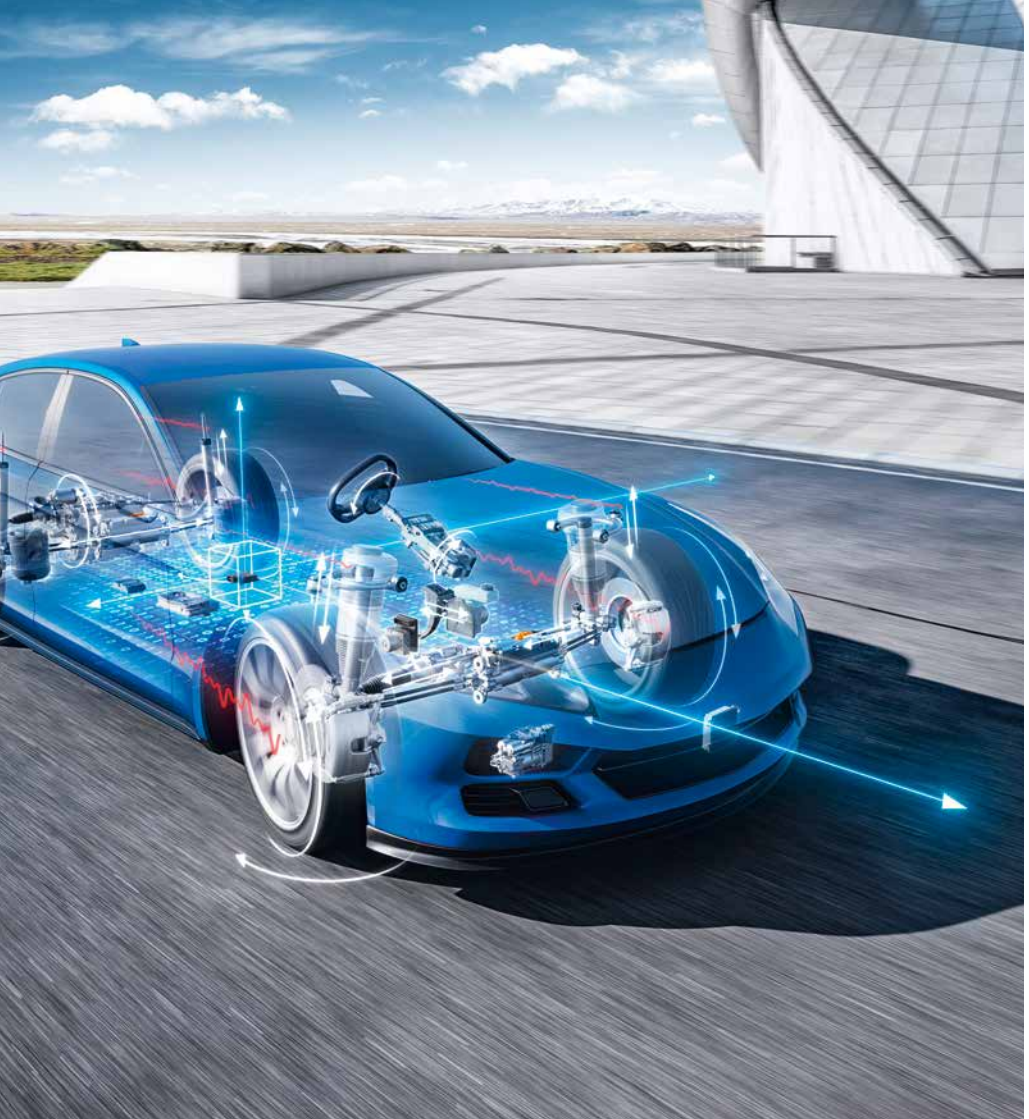


Vehicle Dynamics

Our Vehicle dynamics simulation service empowers automotive engineers with advanced virtual tools to streamline and accelerate the development process. By virtualizing a vehicle's dynamics, we enable rapid prototyping, testing and refinement - eliminating the need for constant physical trials and unlocking faster iteration cycles.

Key Features:

- **Comprehensive virtual models:** Our 3D-motion dynamics models include detailed component representations, allowing for precise simulations.
- **Flexible detail levels:** Create models with the exact level of detail required for various simulation tasks, from component-level analysis to full vehicle behaviour.
- **Seamless integration:** With compatibility through the FMI standard, our modular simulation approach integrates seamlessly with control design environments, supporting ADAS and AD algorithm development.
- **Scenario-based testing:** Enable rapid testing across a vast range of scenarios or complete manoeuvre catalogues, with automated KPI evaluations for quick insights.
- **Scalable cloud-based simulation:** Scale your simulations using cloud resources, facilitating parallel testing of vehicle variants and configurations.



Key benefits:

- **Efficient engineering:** Our simulations support end-to-end engineering, allowing you to test, iterate and optimize designs without the time and cost of physical prototypes.
- **Enhanced scenario testing:** Run exhaustive scenario-based tests that ensure robust vehicle performance across varied conditions.
- **Proven expertise:** Leverage our extensive experience as a Tier 1 supplier in vehicle component and system modelling for reliable, high-quality virtual results.

Virtual Human Body and Behaviour Simulation

At ZF, we offer cutting-edge virtual human body and behaviour simulation solutions that provide a comprehensive approach to safety and comfort in mobility engineering. Our tailored human body models and behaviour simulations are designed to predict, assess and enhance the safety and comfort of both vehicle occupants and Vulnerable road users (VRU), enabling the efficient development of AD and ADAS systems.

Predicting VRU injuries in crash scenarios
Our virtual simulation models allow you to predict injuries to Vulnerable road users (VRU) in real-world crash scenarios. By simulating pedestrians and cyclists in various traffic situations, we can evaluate injury risks with precision, improving safety measures for both occupants and VRU. This enables the development of more reliable safety systems that minimize harm in the event of a collision.

Realistic traffic scenario simulation
We create highly realistic traffic scenarios that integrate pedestrian and driver cognitive behaviour models. This includes simulating the behaviour of pedestrians, cyclists and drivers and how they interact within traffic environments. These scenarios allow for a deeper understanding of human decision-making and how various road users react in unpredictable situations, ensuring that your AD and ADAS algorithms are both robust and adaptive.

Efficient AD/ADAS algorithm development & safety assessment
Our simulation platform streamlines the development of AD and ADAS algorithms. Through the generation of synthetic traffic scenarios, we enable rigorous testing of safety functions, ensuring they perform in real-world environments. Automated evaluation with KPIs, including injury risk estimation, ensures you can continuously improve system performance and achieve optimal safety outcomes.

Injury assessment & risk estimation
We provide in-depth injury assessments for VRU through advanced in-crash simulations and surrogate models. Our injury risk functions offer insights into how different

crash scenarios affect VRUs, helping you design systems that mitigate injury risks. This process also includes the assessment of integrated safety systems, ensuring comprehensive safety performance from active to passive systems.

Scope and tool-chain
With our advanced models, comprehensive results and a unified tool-chain, you can accurately simulate and evaluate a wide range of safety and comfort scenarios. Our approach provides end-to-end testing, from pedestrian injury prediction to full system safety assessments.

Key Benefits:

- **Early evaluation & improvement of safety functions:** Quickly assess safety systems, ensuring they meet high standards from the beginning of development.
- **Holistic safety approach:** Our solution covers everything from active safety systems (e.g. collision avoidance) to passive safety systems (e.g. airbags, crumple zones), providing a well-rounded safety strategy.
- **EuroNCAP & car assessment programs:** Test and evaluate safety functions against globally recognized safety protocols, ensuring compliance with standards like EuroNCAP.
- **Years of expertise:** Leverage ZF's deep industry experience and partnerships with leading product manufacturers to ensure your systems are designed and tested with precision.

Virtual Restraint System and Crash Simulation

Our Virtual Restraint System and Crash Simulation solutions set a new standard for automotive safety, offering a comprehensive suite of simulations that protect occupants and vulnerable road users (VRUs) alike. By leverage state-of-the-art crash and restraint system simulations, we can accurately predict crash impulses, assess restraint system efficacy and model the impact of accidents on both vehicle occupants and unprotected pedestrians.

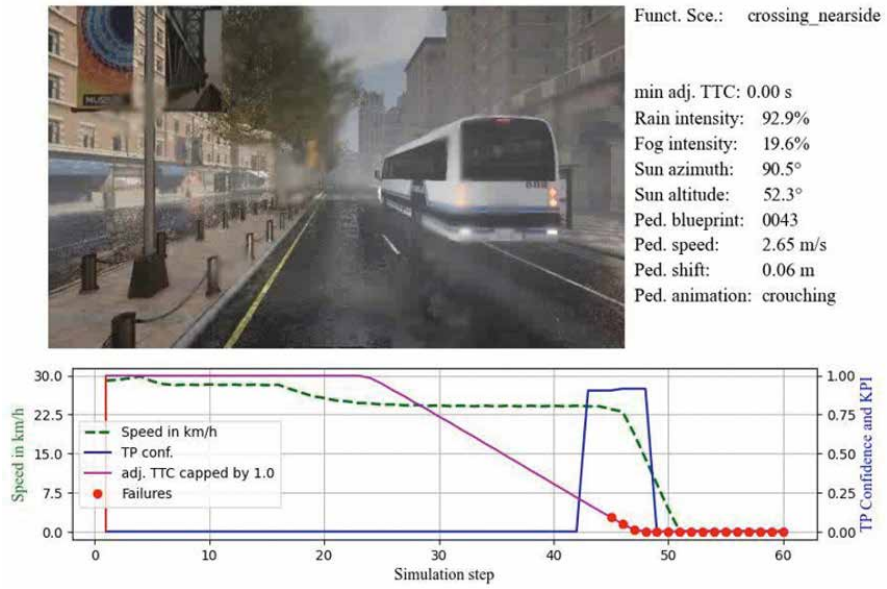
Comprehensive crash simulation & occupant safety
Our advanced crash simulation capabilities allow you to predict crash impulses, guiding passive safety development from the earliest stages. By simulating various crash scenarios, we identify the limitations and strengths of components, from sensors to restraint systems, ensuring robust performance across all scenarios. This approach delivers faster, data-driven development, reducing real-world testing requirements and ensuring occupant safety is front and center.

Restraint system simulation with unmatched precision
Our virtual restraint system simulation uses advanced computational models to predict occupant behaviour during collisions, enabling us to design systems that enhance occupant protection. From airbags to seatbelts, we evaluate the performance and limitations of restraint components, optimizing them for maximum safety and minimizing injury risks in diverse crash scenarios.

Evaluating VRU safety in crash scenarios
We go beyond the vehicle to protect pedestrians, cyclists and other VRU. Our simulations include crashes involving VRU, helping you design systems that consider and mitigate the impact on these unprotected road users. This approach ensures the vehicle provides safety for everyone on the road.

Realistic traffic scenarios with synthetic data
By generating realistic crash scenarios through traffic simulation, including VRU and environmental effects, we achieve a complete view of potential real-world impacts. Using synthetic image data from simulations, we overcome the limitations of real-world data collection, accelerating model testing and validation for safety technologies and integrated perception systems.

Detailed computational sled tests for restraint systems
Our computational sled test models provide valuable insights into restraint system performance in various crash situations. This virtual testing approach enables detailed evaluations of restraint components, meeting future regulatory requirements while reducing reliance on physical testing.



Scenario-based integrated safety performance assessment

Our virtual approach allows a scenario-based assessment of integrated safety, encompassing both active and passive systems. Our PDC airbag assessments evaluate airbag deployment strategies under different crash conditions, providing a complete safety performance view.

Key Benefits:

- **Accelerated development:** Virtual testing enables faster, more efficient restraint system development.
- **Holistic safety:** Combining active and passive safety measures provides a comprehensive safety assessment.
- **Synthetic data:** Generate synthetic images and data to overcome real-world testing limitations and improve model accuracy.
- **Reliability and compliance:** Rigorous virtual testing ensures the system meets future regulatory standards.

Image Copyrights

p. III - ©ZF Friedrichshafen AG

p. 1 - ©Limex Images

p. 3 (top) - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 8 - ©mas0380 – stock.adobe.com (110257004)

p. 11 (left) - ©ZF Automotive UK Ltd

p. 12 - ©KTM Sportscar GmbH, Kernasenko J.

p. 13-14 (top) - ©KTM Sportscar GmbH, Kernasenko J.

p. 15 - ©Shutterstock, Inc., IM Imagery, Photo ID 2122988936

p. 16 (left) - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 17-18 (top) - ©Shutterstock, Inc., IM Imagery, Photo ID 2122988936

p. 19 - ©ZF Friedrichshafen AG

p. 21 (left) - ©Foto Fay

p. 22 - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 23-24 (middle) - ©Limex Images

p. 25 (bottom left) - ©WS Racing, Swoosh Communication

p. 26 (top right) - ©Christian Engelhart, Axel Weichert

p. 27 - ©ZF Friedrichshafen AG

p. 30 - ©mas0380 – stock.adobe.com (110257004)

p. 34 - ©ZF Aftermarket

p. 36 - ©ZF Friedrichshafen AG

p. 37 - ©KMS, Bierre Photo Sport - Bolognese Fotografo

p. 39 - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 42 - ©ZF Race Engineering GmbH

p. 44 (all) - ©ZF Race Engineering GmbH

p. 46 - ©ZF Race Engineering GmbH

p. 47 - ©Limex Images

p. 51 - ©ZF Race Engineering GmbH

p. 53-56 - ©ZF Race Engineering GmbH

p. 58-62 (all) - ©ZF Race Engineering GmbH

p. 59-62 (all) - ©ZF Race Engineering GmbH

p. 64-66 (all) - ©ZF Race Engineering GmbH

p. 68 (all) - ©ZF Race Engineering GmbH

p. 70 (all) - ©ZF Race Engineering GmbH

p. 72 (all) - ©ZF Race Engineering GmbH

p. 74-76 (all) - ©ZF Race Engineering GmbH

p. 77 - ©Christian Engelhart, Michele Scudiero

p. 79-81 - ©ZF Race Engineering GmbH

p. 84-86 (all) - ©ZF Race Engineering GmbH

p. 87 - ©BMW Motorrad Motorsport

p. 89-90 (all) - ©ZF Race Engineering GmbH

p. 91 - ©KMS, Bierre Photo Sport - Bolognese Fotografo

p. 93-94 (all) - ©ZF Race Engineering GmbH

p. 96 - ©Limex Images

p. 97-98 (all) - ©ZF Race Engineering GmbH

p. 99 - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 102 (all) - ©ZF Race Engineering GmbH

p. 104 - ©ZF Race Engineering GmbH

p. 106 - ©ZF Race Engineering GmbH

p. 107 - ©ZF Friedrichshafen AG

p. 110 (all) - ©ZF Race Engineering GmbH

p. 111 - ©KTM Sportscar GmbH, Kernasenko J.

p. 113 - ©ZF Race Engineering GmbH, Markus Neugebauer

p. 115 - ©ZF Aftermarket

p. 118 - ©ZF Race Engineering GmbH

p. 120 (all) - ©ZF Race Engineering GmbH

p. 122 - ©ZF Race Engineering GmbH

p. 124 - ©ZF Race Engineering GmbH

p. 126 - ©ZF Race Engineering GmbH

p. 128 - ©ZF Race Engineering GmbH

p. 131-132 (all) - ©ZF Race Engineering GmbH

p. 133 - ©ZF Race Engineering GmbH, Markus Höckelmann

p. 136 - ©ZF Race Engineering GmbH

p. 137 - ©ZF Friedrichshafen AG

p. 140 - ©ZF Race Engineering GmbH

p. 142 - ©ZF Race Engineering GmbH

p. 144 - ©ZF Race Engineering GmbH

p. 145 - ©ZF Automotive UK Ltd

p. 148 - ©ZF Automotive UK Ltd

p. 152 - ©ZF Automotive UK Ltd

p. 154 - ©ZF Automotive UK Ltd

p. 156 - ©ZF Automotive UK Ltd

p. 161 - ©ZF Automotive UK Ltd

p. 165 - ©ZF Automotive UK Ltd

p. 166 - ©ZF Automotive UK Ltd

p. 168 - ©ZF Automotive UK Ltd

p. 170 - ©ZF Automotive UK Ltd

p. 171 - ©ZF Race Engineering GmbH, AI generated

p. 183 - ©ZF Race Engineering GmbH, AI generated

p. 187 - ©ZF Friedrichshafen AG

p. 189 - ©ZF Friedrichshafen AG

p. 190 - ©ZF Race Engineering GmbH

p. 193 - ©keetazalay – stock.adobe.com (926907178)

p. 195 - ©NicoElNino – stock.adobe.com (603253191)

p. 196 - ©ZF Friedrichshafen AG

p. 197 - ©ZF Race Engineering GmbH, AI generated

p. 199-202 (all) - ©ZF Race Engineering GmbH

p. 205-207 (all) - ©ZF Friedrichshafen AG

p. 209 - ©ZF Friedrichshafen AG

p. 210 - ©dimazel – stock.adobe.com (302537769)

p. 212 - ©ZF Friedrichshafen AG

p. 213-214 - ©ZF Friedrichshafen AG

p. 215-216 - ©ZF Friedrichshafen AG

p. 218 - ©ZF Friedrichshafen AG

ZF Engineering Solutions
ZF Race Engineering GmbH
Ernst-Sachs-Straße 62
97424 Schweinfurt
Germany

T +49 (0)9721 98-4300
service.zre@zf.com
www.zf-race-engineering.com

instagram.com/zf.motorsport
linkedin.com/company/zfraceengineering
youtube.com/zffriedrichshafenag
facebook.com/zfmotorsport