

Together, we engineer the
Mobility of tomorrow.



FKFS

FKFS is both a development partner of the international automotive industry and an independent research institute. As an innovative partner, we benefit from our numerous test benches. With the help of our simulation procedures – including the application of AI – we are able to offer specialized services and consulting. Our skilled employees contribute their outstanding expertise to each project and consistently place customer benefit at the forefront of their work.



Competencies & Consulting



Overall vehicle & components



- Aerodynamics
- Driving dynamics & chassis control
- Acoustics & NVH
- Comfort
- Thermal management

Powertrain systems & -energies



- Powertrain technologies
- Battery technologies
- Renewable energy carriers
- Operating strategies

E/E & Software



- Software & AI
- Electrical system
- Charging technology
- Function development & application
- Functional safety

Smart mobility



- Automated driving
- Car2x
- Traffic modeling
- Mobility Concepts

Validation & Verification



- Environmental influences
- Quality & Reliability
- Certifications

Services



Vehicle test benches



Handling Roadway

Servo-hydraulic
4-post test stand

Accoustic test chamber

Roller Dynamometer Test
Facility

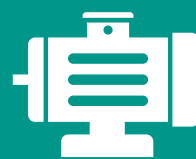
Tire-Road Noise Test Bench
& Noise Measurement Trailer

Stuttgart Driving Simulator

Climate Road-to-Rig

Climatic Chamber

Powertrain
Test Benches



Powertrain test benches
for drive systems

Hybrid Engine Test Bench

Development Test Bench
for High-Speed Drives

NVH Single-Axis
Test Bench

NVH Powertrain Test Bench

High-Performance Electrical
Powertrain Test Bench

Multi-Configuration
Powertrain Test Bench

Vehicle-Related
Powertrain Superstructures

Wind Tunnels



Vehicle Aeroacoustic
Wind Tunnel

Model Wind Tunnel

Thermal Wind Tunnel

Climatic Wind Tunnel

Instrumentation &
Analytic Technology



Driving Dynamics
Instrumentation

Acoustic Measurement
Equipment

Special Measurement
Systems

Aerodynamic
Measurement Systems

Thermal Comfort Manikin

Simulation



0D/1D-Simulation
incl. longitudinal dynamics

3D/CFD-Simulation-
QuickSim

Life Cycle / Total Cost
Analysis

Digital Competence
Development

Artificial Intelligence &
Data Science

Virtual Driving Characteris-
tics Development

Simulative E/E Architecture
Optimizations

Virtual Development



Handling Roadway

The Handling Roadway is a new, innovative test bench concept enabling combined lateral, longitudinal and vertical dynamic operating states to be investigated under laboratory conditions. All four steel belt units can be steered and actuated vertically with high bandwidths. The vehicle is attached to the test bench in such a way that the heave, pitching and rolling motion can occur freely, according to the acting tire forces. The remaining degrees of freedom are calculated in the simulation, so that almost any maneuver can be driven.

Longitudinal	Lateral	Vertical
Belt speed		0,5 – 220 km/h
Peak power/continuous power		220/140 kW
Max. longitudinal force		6 kN

Application Examples

- ✓ Driving dynamics standard maneuvers
- ✓ Investigating axles and steering systems
- ✓ Vertical dynamics under simultaneous longitudinal and/or lateral excitation
- ✓ Designing control systems
- ✓ Powertrain investigations



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Longitudinal

Lateral

Vertical

Max. belt steering angle	±20°
Belt steering bandwidth	15 Hz
Max. lateral force	10 kN

Application Examples

- ✓ Driving dynamics standard maneuvers
- ✓ Investigating axles and steering systems
- ✓ Vertical dynamics under simultaneous longitudinal and/or lateral excitation
- ✓ Designing control systems
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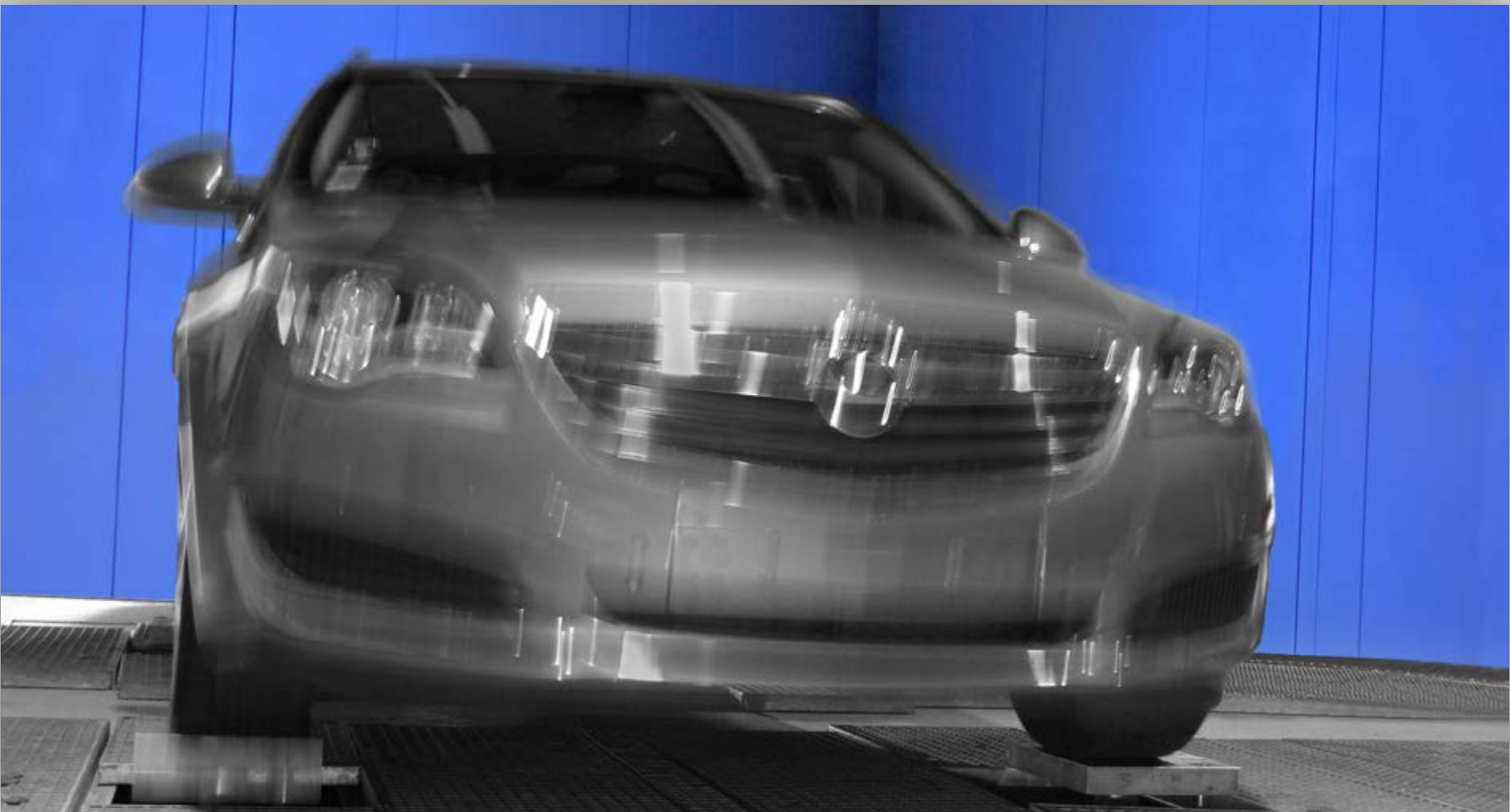
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Longitudinal	Lateral	Vertical
Max. vertical displacement		±75 mm
Max. vertical acceleration		7 g
Max. vertical force		15 kN
Vertical excitation bandwidth		15 Hz

Application Examples

- ✓ Driving dynamics standard maneuvers
- ✓ Investigating axles and steering systems
- ✓ Vertical dynamics under simultaneous longitudinal and/or lateral excitation
- ✓ Designing control systems
- ✓ Powertrain investigations



Servo-Hydraulic 4-Post Test Bench

The servo-hydraulic 4-post test bench at FKFS enables vertical excitation at all four wheels of a vehicle. The posts can be equipped with linear guides in order to avoid lateral force components acting on the wheels.

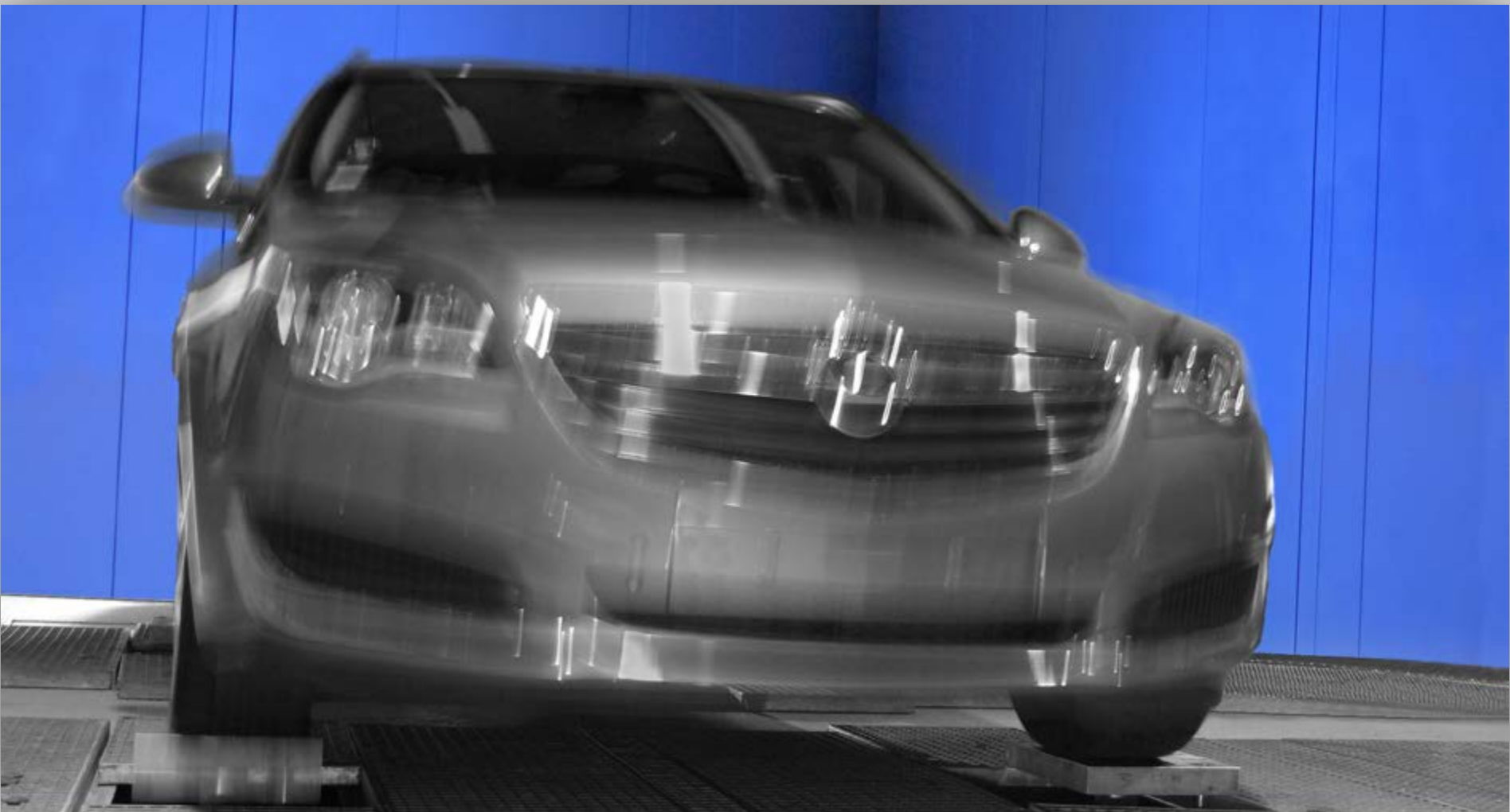
Technical Data 1

Technical Data 2

Maximum force	$\pm 63 \text{ kN}$
Maximum stroke	$\pm 125 \text{ mm}$
Frequency range	0 – 200 Hz

Application Examples

- ✓ Testing of the durability of individual components
- ✓ Investigation of e.g. squeak and rattle noise
- ✓ Simulation of rolling noise excitation in the vehicle (up to approx. 150 Hz)
- ✓ Comfort testing (e.g. engine vibration or micro-jitter in convertibles)



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Technical Data 1

Technical Data 2

Max. wheelbase	4100 mm
Min. wheelbase	1500 mm
Max. track width	2000 mm
Min. track width	900 mm

Application Examples

- ✓ Testing of the durability of individual components
- ✓ Investigation of e.g. squeak and rattle noise
- ✓ Simulation of rolling noise excitation in the vehicle (up to approx. 150 Hz)
- ✓ Comfort testing (e.g. engine vibration or micro-jitter in convertibles)



Acoustic Test Chamber

An anechoic test chamber equipped with broad-band compact absorbers (semi-anechoic chamber) is available for noise measurement and noise optimization of vehicles, vehicle subsystems and other devices. The chamber is completely decoupled from the surrounding building and features an exhaust extraction system.

Technical Data 1

Acoustic Test Chamber internal dimensions (l x w x h)	9 m x 5 m x 4 m
lower frequency limit	125 Hz

Application Examples

- ✓ Acoustic Development on cars and vans with and without engine operation
- ✓ Localization of sound sources (e.g. with microphone arrays)
- ✓ Measurement and optimization of functional and operating noise
- ✓ Investigation of acoustic transfer paths



Roller Dynamometer Test Facility: Performance role

At test speeds of up to 300 km/h, it is used for dynamic and static power measurement. In addition, the test bench guarantees maximum measurement accuracy and reproducibility thanks to its active measurement of drag performance. The rolling behavior of the tire is similar to that on the road. Operating modes such as load simulation including optional modules for recording external measurement data, driving cycles etc. are possible. The test track is equipped with an airstream fan and conditioned air to simulate road driving under realistic conditions.

General

Type	2-axle parting roll
Speed	300 km/h
Power	260 kW each
Max. axle load	2500 kg

Application Examples

- ✓ Performance measurement
- ✓ Exhaust-gas measurement
- ✓ Constant drive
- ✓ Use of non-vehicle-integrable measurement technology on a moving vehicle
- ✓ Various driving cycles for vehicle application under reproducible conditions



Tire-Road Noise Test Bench & Noise Measurement Trailer

FKFS investigates tire-road noise of vehicles not only by far field measurements using microphones at the side of the road. FKFS investigates tire-road noise also by means of a specially developed trailer. In this, the noise can be recorded with several microphones around the tire in the close range. Background noise from outside the trailer is suppressed to the greatest possible extent. Based on these tire-road noise measurements and by using the tire-road noise test bench developed at FKFS, it is possible to determine the contribution of the air-borne tire-road noise to the interior noise of a vehicle in an isolated way.

Application Examples

- ✓ Recording the tire road noise directly at the point of origin
- ✓ Investigation of the radiation behavior of the tire-road noise
- ✓ Determination of the tire road noise contribution to the interior noise



Stuttgart Driving Simulator

With its 9-axis motion system, which is unique in the European research landscape, the Stuttgart driving simulator enables the realistic representation of interactive and autonomous driving scenarios in the city, on highways, country roads and PGs. In addition to expert and test person studies for development and research, we offer a wide range of consulting services, e.g. the use case-based design of driving simulators and simulator centers for customers, motion cueing algorithms, scenario design, radar/lidar sensor simulation and software integration.

Technical Data 1

Technical Data 2

Longitudinal and lateral movements up to 8 m/s^2

Yawing movements $\pm 160^\circ$

360° visualisation

Spatial sound- and NVH-system

Steering wheel and brake pedal force simulation

Application Examples

- | | |
|---|--|
| ✓ Chassis development, active chassis systems | ✓ Functional safety (brakes, steering, chassis) |
| ✓ Interactive optimization of driving characteristics | ✓ User Experience, HMI, Driving Comfort, Motion Sickness |
| ✓ Driver assistance systems and autonomous driving | ✓ Perception and accident research |



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Technical Data 1

Technical Data 2

Full vehicle mockups (cars and trucks)

HMI- and Autonom- Mockup (ID Buzz)

Customized scenario and traffic simulation

Eye- and Bodytracking, EEG, EMG, heart rate etc.

Application Examples

- ✓ Chassis development, active chassis systems
- ✓ Interactive optimization of driving characteristics
- ✓ Driver assistance systems and autonomous driving

- ✓ Functional safety (brakes, steering, chassis)
- ✓ User Experience, HMI, Driving Comfort, Motion Sickness
- ✓ Perception and accident research



Climate Road-to-Rig

This test bench enables environmental simulations on battery-powered electric vehicles (BEV) in the temperature range from -30°C to +50°C. It enables research and testing of electric powertrains in the vehicle. GPS spoofing and the CarMaker route simulation program make it possible to simulate any route. A battery simulation offers the possibility of simulating charging processes under a wide range of environmental conditions and to investigate the reactions of the vehicle systems. A fan simulates the airstream up to a speed of 210 km/h.

Technical Data 1

Environmental simulation	-30 °C bis +50°C
Battery simulation	822 kW (1000 V, 1200A)
4 highly dynamic wheel machines	4 x 650 kW , 10kHz
Fan	210 km/h

Application Examples

- ✓ Module testing during operation
- ✓ Performance measurement (-30°C – 50°C)
- ✓ Battery test during extreme requirements of load & temperature
- ✓ Method development for integration and development of components



Climatic Chamber

Our climate chamber enables environmental tests under extreme conditions. Whether heat, cold, humidity or solar exposure – with flexible control of all climate parameters, realistic scenarios can be reproduced for the development and validation of modern vehicles. The combination of precise climate simulation and high-performance testing technology offers ideal conditions for reliable and reproducible test results – regardless of the type of powertrain.

Dimensions & conditions

1-axe-dynamometer

Test section (l x w x h)	12 m x 5 m x 5 m
Driveway (w x h)	4 m x 4 m
Temperature range between –35 °C and 55 °C	
Rel. Humidity	10 – 90 %
Solar load range	500 – 1100 W/m²

Application Examples

- | | |
|------------------------------------|----------------------------------|
| ✓ Thermal Management | ✓ Thermal Validation |
| ✓ Driving Performance (stationary) | ✓ Windshield de-icing/Defogging |
| ✓ Climate Comfort | ✓ Investigations at extreme cold |



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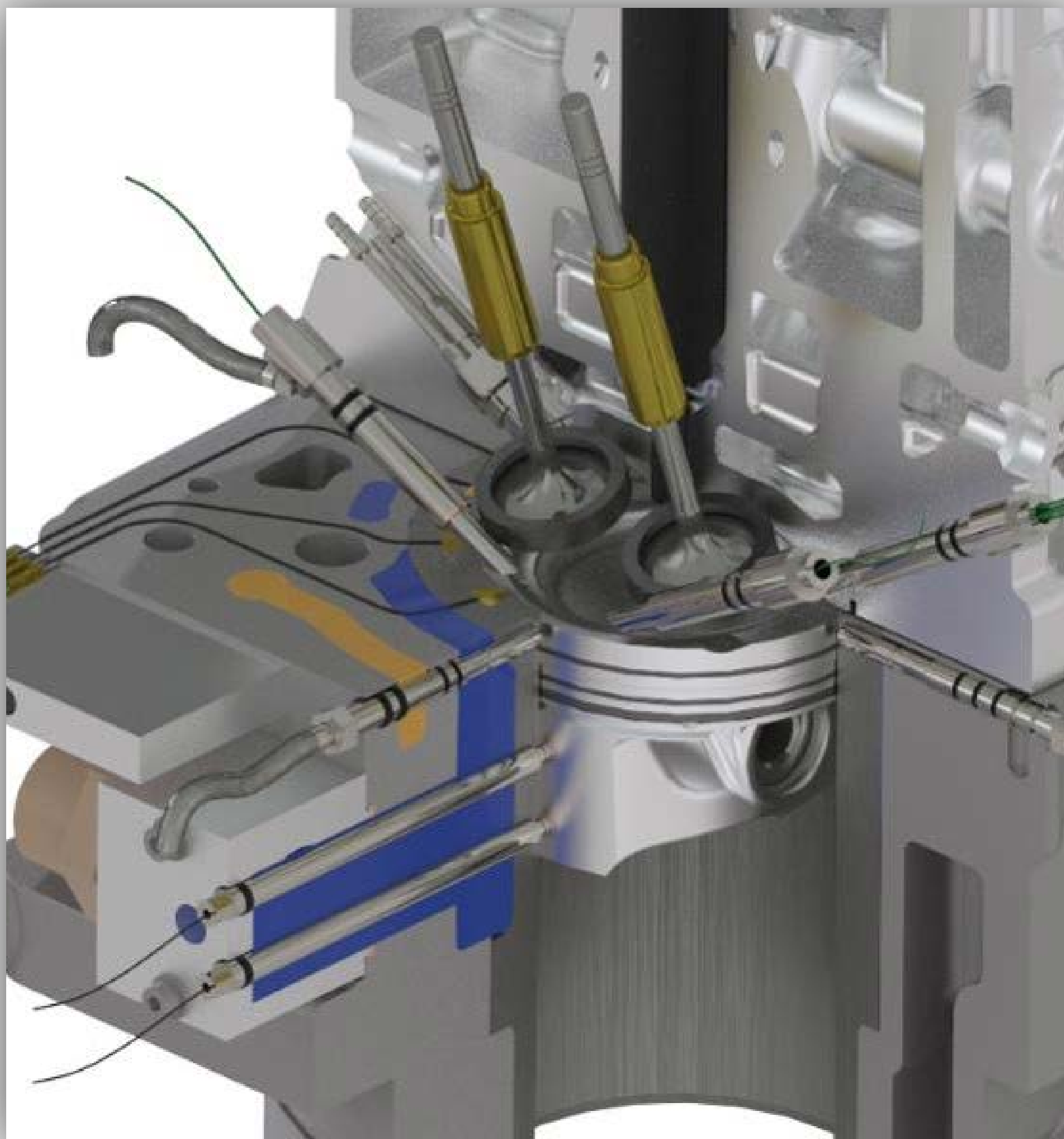
Dimensions & conditions

1-axle-dynamometer

Max. continuous power	260 kW
Max. traction force roller	6 kN
Max. roller speed	200 km/h
Max. wind speed	120 km/h
Nozzle area	0,48 m² (0,8 x 0,6)

Application Examples

- | | |
|------------------------------------|----------------------------------|
| ✓ Thermal Management | ✓ Thermal Validation |
| ✓ Driving Performance (stationary) | ✓ Windshield de-icing/Defogging |
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Engine test benches for powertrain systems (hydrogen engines)

The development of hydrogen-powered internal combustion engines places high demands on infrastructure and measurement technology. FKFS has various test benches for single-cylinder units and full engines that run on hydrogen. These enable both the development of new combustion processes on externally charged, highly instrumented research engines, the operation of near-series full engines and the optimization of special exhaust gas aftertreatment systems adapted to the requirements of hydrogen combustion.

Application Examples

- ✓ Combustion process development, e.g. H₂-HD-DI
- ✓ Wall heat flow measurement possible
- ✓ Basic consulting ECU
- ✓ Controller parameterization in transient operating conditions
- ✓ Optimization of exhaust gas after treatment, e.g. H₂-SCR, H₂ mass spectroscopy/ Quantum cascade laser available
- ✓ Optimization of the overall system of hybrid topologies in real driving cycles (RDE)



Hybrid Engine Test Bench

The Hybrid Engine Test Bench The hybrid engine test bench enables the investigation of combined powertrains consisting of thermal energy converters and electric motors. The vehicle and driver simulation xMot from FEV GmbH allows the representation of any vehicle models and driving routes on the test bench. A CVS system enables the summary emission measurement as prescribed in certification measurements.

General

Loading system

Battery simulation

Type	ECODyn 470 H (Fa. DASYM)
Automation	Morphee 2 (Fa. FEV)
Measurement technology for electrical components	Yokogawa WT1804E Power Analyzer
Measurement technology for emissions	Horiba Mexa One (Rohabgas) + Horiba Mexa One (CVS)

Application Examples

-  Measurement of powertrains with simulation of the vehicle environment
-  Development of serial hybridized powertrains



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General

Loading system

Battery simulation

Max. output	470 kW
Max. speed	9000 min ⁻¹
Max. torque	990 Nm
Execution	Asynchronous machine

Application Examples

-  Measurement of powertrains with simulation of the vehicle environment
-  Development of serial hybridized powertrains



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General

Loading system

Battery simulation

Max. output	300 kW
Voltage range	0-1000 V DC
Max. power	±1200 A DC

Application Examples



Measurement of powertrains with simulation of the vehicle environment



Development of serial hybridized powertrains



Development Test Bench for High-Speed Drives

The test bench enables the testing of eDrives in very early stage of development. For this it provides high speed up to 24.000 rpm but low torque. Typical applications are highly precise drag torque measurements and thermal examinations under the influence of rotational speed. In order to achieve the maximum possible flexibility during testing, the test bench has a modular and flexible design. A comprehensive range of test bench equipment is available for operating and analysing modern drivetrains.

Input eDrive 1

Input eDrive 2

Battery simulator

Power, max.	157 kW
Torque, max.	300 Nm
Speed, max.	13.000 1/min

Application examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical) and highly precise drag torque measurements
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
- ✓ Investigation of dynamic behavior as well as thermal and vibrational effects
- ✓ Testing of durability, application and function



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Input eDrive 1

Input eDrive 2

Battery simulator

Power, max.	35 kW
Torque, max.	14 Nm
Speed, max.	24.000 1/min

Application examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical) and highly precise drag torque measurements
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
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Input eDrive 1

Input eDrive 2

Battery simulator

Power, max.	1.160 kW
Voltage range	0...1.000 V
Current, max.	1.600 A
Dynamic	2.000 V/ms

Application examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical) and highly precise drag torque measurements
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
- ✓ Investigation of dynamic behavior as well as thermal and vibrational effects
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NVH Single-Axis Test Bench

Drive noises are an essential part of the perception of a vehicle. On the full low-reflection NVH axle test bench, all drive units from inverter e-motor transmissions to combustion engines with transmissions and hybrid components can be tested. Vibrations and radiated airborne noise are measured and analyzed to ensure the desired noise perception.

Technical Data 1

Technical Data 2

Type	A2-NVH-Axis Test Bench
Speed	400 km/h
Power per axle	1100 kW (10 sec.)
Wheel torque max.	5500 Nm (10 sec.)
Battery simulation performance	540 kW (10 sec.)

Application Examples

- | | |
|---|--------------------------------------|
| ✓ Sound pressure level measurements | ✓ Rotational uniformity measurements |
| ✓ Acceleration measurements | ✓ Standard FFT analysis |
| ✓ Laser vibrometric measurements | ✓ Wavelet analysis |
| ✓ Beamforming-/ Holography measurements | ✓ Digital order analysis |



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Tehcnical Data 1

Technical Data 2

Voltage battery simulation	up to 1000V
Maximum current	1600 A
Fuel supply	Gasoline, diesel and liquid special fuels
Measurement technology	10 channels airborne sound, 100 channels structural sound, 2xCAN-FD

Application Examples

- | | |
|---|--------------------------------------|
| ✓ Sound pressure level measurements | ✓ Rotational uniformity measurements |
| ✓ Acceleration measurements | ✓ Standard FFT analysis |
| ✓ Laser vibrometric measurements | ✓ Wavelet analysis |
| ✓ Beamforming-/ Holography measurements | ✓ Digital order analysis |



NVH Engine Test Bench

A fully low-reflection test bench is available for acoustic tests on combustion engines. Standard powertrains and front-transverse configurations are possible. In addition to airborne and structure-borne noise, torsional vibrations or combustion excitation can also be investigated.

Technical Data 1

Type	NVH Engine Test Bench
Speed	530 kW
Torque, max.	1500 Nm
Speed, max.	7000 min ⁻¹
Fuel supply	Gasoline, diesel, liquid special fuels

Application Examples

- ✓ Sound pressure level measurements
- ✓ Acceleration measurements
- ✓ Beamforming-/ Holography measurements
- ✓ Rotational uniformity measurements
- ✓ Standard FFT analysis
- ✓ Work leeway resolved analysis
- ✓ Digital order analysis



High-Performance Electric Powertrain Test Bench

The test bench enables the testing of complete powertrains or individual components (e.g. eDrives or gearboxes) from electric vehicles. The driving resistances are simulated by two highly dynamic eDrives. The input is provided either by the drive of the device under test (DUT) or a dynamic eDrive of the test bench. A highly dynamic high-voltage battery simulator is used to supply the DUT with electrical energy. A comprehensive range of test bench equipment is available for operating and analysing modern drivetrains.

Input eDrive	Output	Battery
Power, max.	700 kW	
Torque, max.	1.000 Nm	
Speed, max.	20.000 1/min	
Dynamic	69.000 1/min/s	

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurement (mechanical and electrical)
- ✓ Testing of durability, application and function
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
- ✓ Investigation of dynamic behaviour as well as thermal and vibration effects



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Input	Output eDrives (2x)	Battery
Power, max.	720 kW	
Torque, max.	6.000 Nm	
Speed, max.	3.000 1/min	
Dynamic	37.000 1/min/s	

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurement (mechanical and electrical)
- ✓ Testing of durability, application and function
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
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Input	Output	Battery simulator
Power, max.	1.160 kW	
Voltage range	0...1.000 V	
Current, max.	1.600 A	
Dynamic	2.000 V/ms	

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurement (mechanical and electrical)
- ✓ Testing of durability, application and function
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
- ✓ Investigation of dynamic behaviour as well as thermal and vibration effects



Multi-Configuration Powertrain Test Bench

The test bench enables testing of complete powertrains up to 4WD configurations or individual components (e.g. eDrives or gearboxes) from conventional, hybrid and electric vehicles. The driving resistances are simulated by four dynamic eDrives. The input is carried out either by the device under test (DUT) or a dynamic eDrive of the test bench. Highly dynamic high-voltage battery simulators are used to supply the DUT with electrical energy. A comprehensive range of test bench equipment is available for operating and analysing modern drivetrains.

Input eDrive 1	Input 2	Output	Battery
Power, max.	600 kW		
Torque, max.	1.300 Nm		
Speed, max.	8.000 1/min		
Dynamic	113.000 1/min/s		

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical)
- ✓ Testing of durability, application and function
- ✓ Hardware-in-the-Loop testing
- ✓ Wide range of special tests
- ✓ Investigation of dynamic behavior as well as thermal and vibrational effects



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Input 1	Alternative input eDrive	Output	Battery
Power, max.	600 kW		
Torque, max.	520 Nm		
Speed, max.	20.000 1/min		

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical)
- ✓ Testing of durability, application and function
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Input 1	Input 2	Output eDrives (4x)	Battery
Power, max.		450 kW	
Torque, max.		4.500 Nm	
Speed, max.		3.000 1/min	
Dynamic		40.000 1/min/s	

Application Examples

- ✓ Initial commissioning
- ✓ Efficiency measurements (mechanical and electrical)
- ✓ Testing of durability, application and function
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- ✓ Wide range of special tests
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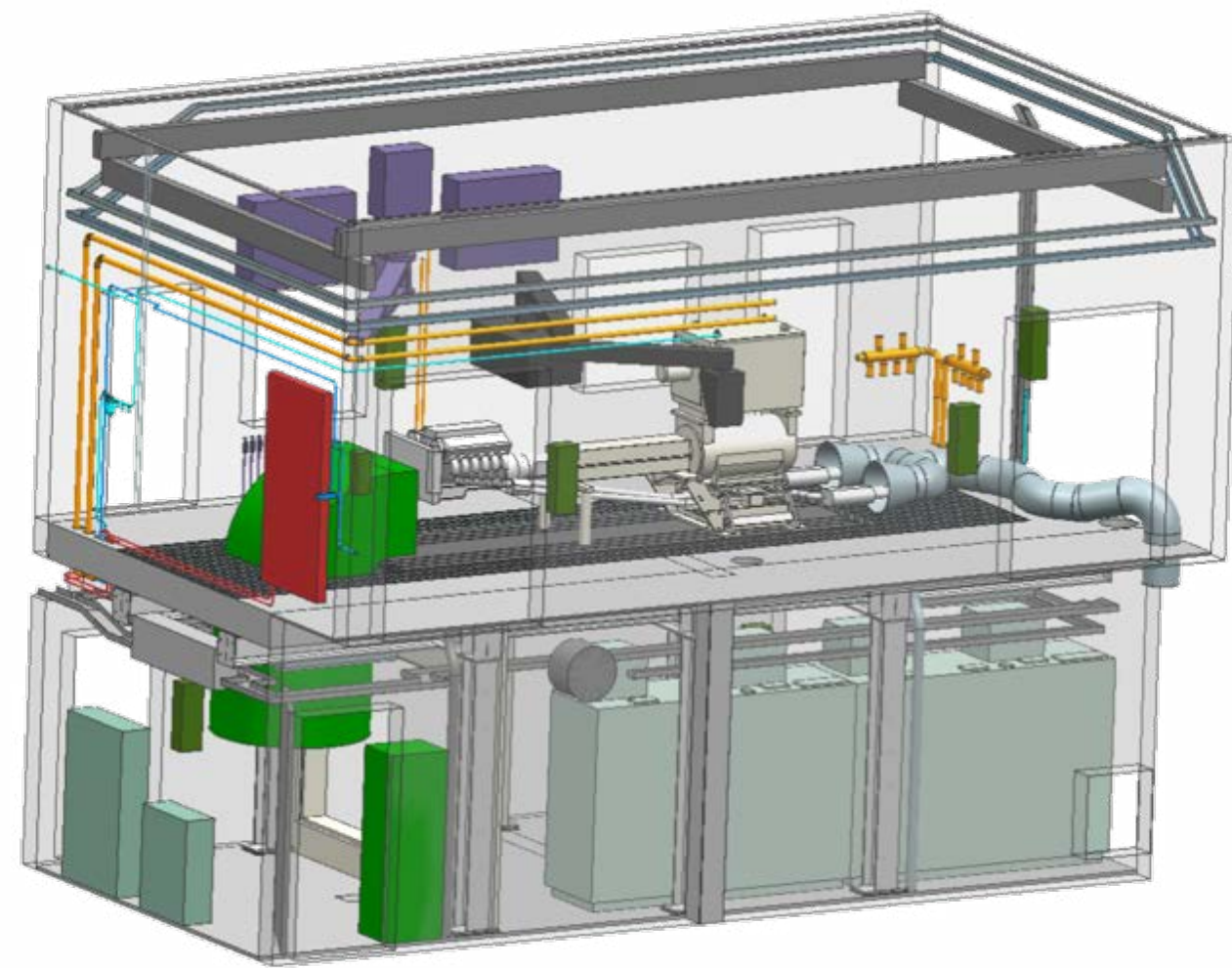
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Similar to the vehicle Drive train superstructures

The targeted dissipation of thermal energy is of great importance for conventional drives powered by renewable fuels, as well as for hydrogen fuel cell systems and battery electric drives. The FKFS therefore has test benches that allow the vehicle-related construction of drives (H2ICE, BEV, FCV). These are characterized by a blowing of the drive unit proportional to the vehicle speed and thus allow the experimental representation of realistic component temperatures.

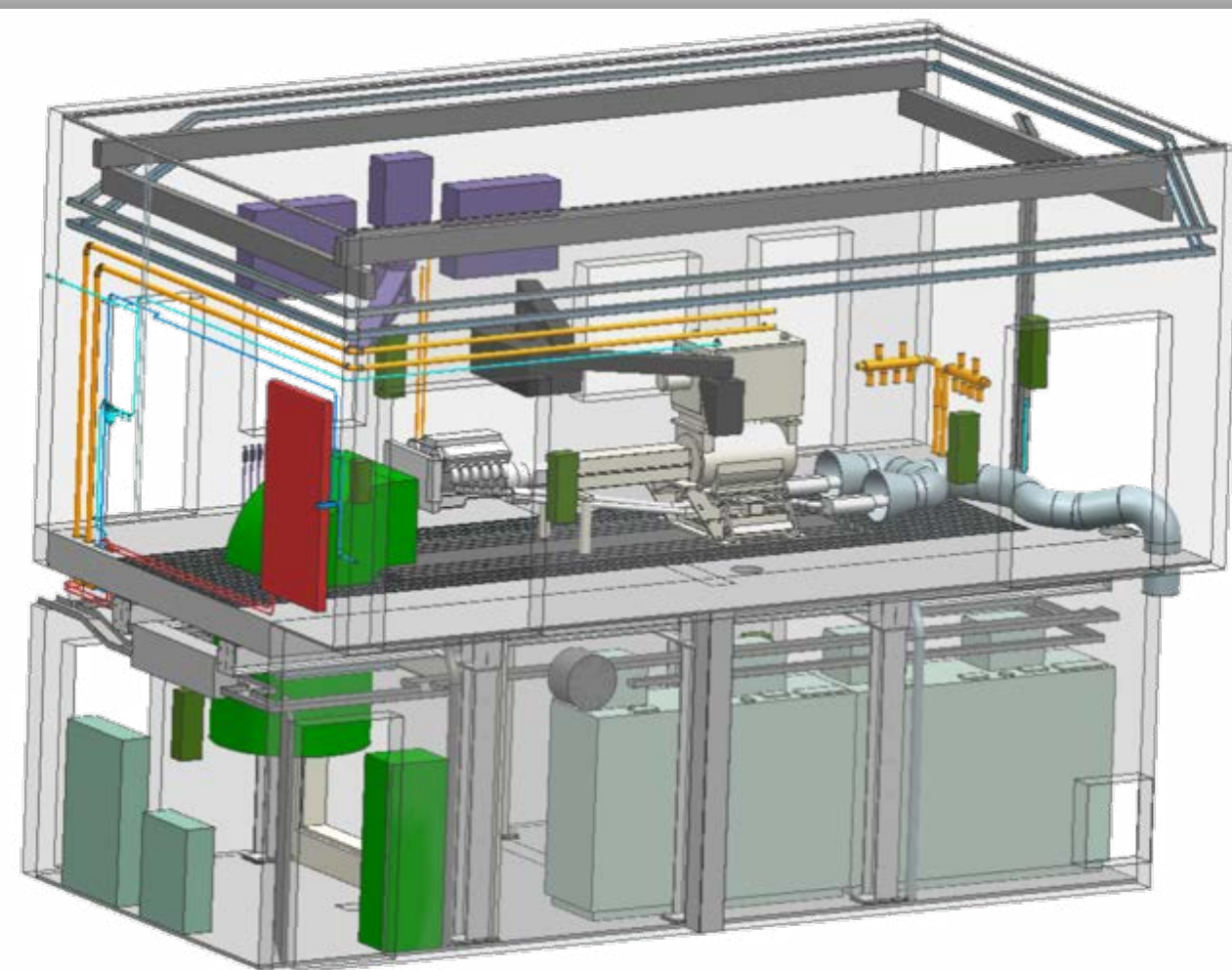
Technical Data 1

Technical Data 2

Type	A1 test stand with blow-in
Wind speed up to	180 km/h
Max. volume flow	187.000 m ³ /h
Blower Power	160 kW

Application Examples

- ✓ Validation/optimization of thermal management
- ✓ Investigation of degradation FC during simulated uphill travel
- ✓ Operating strategy for exhaust gas aftertreatment in RDE cycles
- ✓ Emission-optimized operating strategy for hybrid concepts
- ✓ Pre-emission EU7 legislation



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Technical Data 1

Technical Data 2

Max. power	470 kW
Max. torque	990 Nm
Max. speed	9.000 min ⁻¹

Application Examples

- ✓ Validation/optimization of thermal management
- ✓ Investigation of degradation FC during simulated uphill travel
- ✓ Operating strategy for exhaust gas aftertreatment in RDE cycles
- ✓ Emission-optimized operating strategy for hybrid concepts
- ✓ Pre-emission EU7 legislation



Vehicle Aeroacoustics Wind Tunnel

The FKFS aeroacoustic vehicle wind tunnel (Göttingen-type wind tunnel) is one of the most modern of its kind in Europe for aerodynamic testing of cars, vans and racing vehicles. In addition to acoustic methods, other extensive test facilities are available for measuring forces, pressures and speeds as well as for flow visualization. The standard use of a 5-belt system is to simulate road travel with rotating wheels and moving ground in the vehicle wind tunnel.

Dimensions 1

Dimensions 2

Sound-pressure level

Dimensions of nozzle (w x h)	5,8 m x 3,87 m
Exit area of nozzle	22,45 m ²
Contraction ratio	4,41
Length of open jet test section	9,95 m

Application Examples

- ✓ Measurement of aerodynamic coefficients (stationary & transient)
- ✓ Flow field and surface pressure measurement
- ✓ Aeroacoustic measurements at the car's surface and in its interior
- ✓ Surface vibration measurements with laser vibrometers
- ✓ Noise source localization with microphone arrays and an acoustic mirror



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Dimensions 1

Dimensions 2

Sound-pressure level

Diameter of axial fan	7,1 m
Operating output	3,3 MW (335 1/m)
Max. flow velocity	260 km/h

Application Examples

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Dimensions 1

Dimensions 2

Sound-pressure level

Sound-pressure level of empty test section at 140 km/h

- Out-of-Flow

64,7 dB(A)

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Dimensions 1

Dimensions 2

Dimensions of nozzle (w x h)	1,575 m x 1,05 m
Exit area of nozzle	1,654 m ²
Length of open-nozzle test section	2,585 m
Max. flow velocity	288 km/h
Turn table diameter	2080 mm

Model Wind Tunnel

For the aerodynamic investigation of vehicle models, the FKFS a 1:4/1:5 model wind tunnel (Göttingen-type wind tunnel) with a 5-belt system for simulating the road surface and rotating wheels. Flow field measurements with Particle Image Velocimetry (PIV) or single and multi-hole probes can be carried out with the traversing device. Facilities for model preparation and modelling, as well as the possibility of model digitization using 3D surface scans are also part of the system.

Application Examples

- ✓ Aerodynamic force measurements on passenger car models in quarter scale and 20% scale
- ✓ Aerodynamic shape optimization
- ✓ Surface pressure measurements
- ✓ Flow field measurements with PIV or multi-hole probes
- ✓ Calibration of flow measurement devices (e.g. anemometers)
- ✓ Frontal area measurements
- ✓ 3D surface scans



Dimensions 1

Dimensions 2

Center belt length	1700 mm
Available center belt widths	225 mm / 250 mm / 312 mm
Available wheel drive unit belts widths	69 mm / 85 mm / 115 mm
Maximum wheel base	800 mm

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Thermal Wind Tunnel

The FKFS thermal wind tunnel is a high-performance 2-axis roller test bench with closed air flow. A large number of different complete vehicle tests can be carried out here regardless of the season and weather conditions and driving tests can be realistically simulated. Typical areas of application include performance and thermal management tests, pollution experiments and brake and component function tests. Various options for irrigation, including visualization, enable many special uses.

Dimensions 2-axle-dynamometer	2-axl-d.	Air.
-------------------------------	----------	------

Test section (l x w x h)	15,8 m x 6,8 m x 5,5 m
Entrance (w x h)	2,9 m x 4,0 m
Dynamometer diameter	1,6 m
Dynamometer speed	max. 300 km/h
Driving/braking power	respectively max. 300 kW front and 500 kW rear.

Application Examples

- ✓ Thermal Management
- ✓ Driving performance test (stationary and cyclical)
- ✓ Pollution investigation
- ✓ Break performance (dry and wet)
- ✓ Wiper function test, wiper motor design
- ✓ Air intake, water separation
- ✓ Sensor function test (e.g. in wet conditions)



Dim. 2-axle dyn.

2-axle-dynamometer

Air.

Traction force when
under braking 20 kN

The test bench has two identical sets of rollers (for the front and rear axles).

The rollers can be moved in the longitudinal direction.

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Dim. 2-axle-dyn.	2-axle-dyn.	Air path
------------------	-------------	----------

	large nozzle	small nozzle
Air flow velocity	max. 210 km/h	max. 240 km/h
Nozzle cross section	6 m² (2,45 x 2,45)	4 m² (2,45 x 1,60)
Air temperature regulation between 20 °C and 50 °C.		
Deviating operating conditions on request.		

Application Examples

- | | |
|--|---|
| ✓ Thermal Management | ✓ Wiper function test, wiper motor design |
| ✓ Driving performance test (stationary and cyclical) | ✓ Air intake, water separation |
| ✓ Pollution investigation | ✓ Sensor function test (e.g. in wet conditions) |
| ✓ Break performance (dry and wet) | |



Dimensions 2-axle-dynamometer

2-axl-d.

Air.

Test section (l x w x h)	15,8 m x 11,6 m x 7,5 m
Entrance (w x h)	4 m x 4 m
Dynamometer diameter	2 m
Dynamometer speed	max. 280 km/h
Driving/braking power	front 300 kW rear 450 kW

Climatic Wind Tunnel

The Climatic Wind Tunnel is a closed wind tunnel of Göttingen design with a powerful 2-axis roller test rig. A large number of different vehicle tests can be carried out regardless of the season and weather conditions and driving tests can be realistically simulated. The climatic wind tunnel is primarily used for thermal tests in the temperature range between 10 and 55 °C.

Application Examples

- | | |
|--|---|
| ✓ Thermal Management | ✓ Thermal Validation |
| ✓ Driving performance test (stationary and cyclical) | ✓ Braking performance in the driving cycle test |
| ✓ Climate Comfort | ✓ HV charging tests |



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Dim. 2-axle dyn.

2-axle-dynamometer

Air.

Traction in breaking front 13 kN rear 26 kN

The test bench has two identical sets of rollers (for the front and rear axles).

Wheel base 2,3 – 6,9 m

HPC charger 280 kW@800 V

Application Examples

- | | |
|--|---|
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Dim. 2-axle-dyn.	2-axle-dyn.	Air path
------------------	-------------	----------

	truck nozzle	car nozzle
Air flow velocity	max. 135 km/h	max. 265 km/h
Nozzle cross section	12 m² (3 x 4)	4,7 m² (2,3 x 3,05)
Air temperature regulation between 10 °C and 55 °C		
rel. humidity	10 – 90 %	

Application Examples

- | | |
|--|---|
| ✓ Thermal Management | ✓ Thermal Validation |
| ✓ Driving performance test (stationary and cyclical) | ✓ Braking performance in the driving cycle test |
| ✓ Climate Comfort | ✓ HV charging tests |



Driving Dynamics Instrumentation

FKFS has a comprehensive, mobile and up-to-date selection of instrumentation for extensive driving dynamics and vehicle testing. The equipment is constantly being expanded and modernized so that it always remains up-to-date and efficient. A selection of different systems is available for data acquisition, including compact, modular and particularly high-scanning systems. The customer benefits from FKFS's many years of experience in the targeted, flexible and efficient use and operation of the technology and evaluation of the data.

Movement sizes

Forces & Moments

Inertial measurement systems
(gyro-stabilized platforms)

Laser distance sensors

Contactless
speed measurement

Acceleration sensors

differential GPS (dGPS)

Cable-actuated travel sensors

Application Examples



Objektive measurement of
driving dynamics parameters



Driving resistance
measurements



Driving comfort tests



Tire characterization



Determination of load spectra
in customer-oriented
driving profiles



Movement sizes

Forces & Moments

Measuring rims

Measuring steering wheel

Component application with strain gages

Wheel load scales

Pressure instrumentation (wind excitation)

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Application Examples

- ✓ Objektive measurement of driving dynamics parameters
- ✓ Driving comfort tests
- ✓ Determination of load spectra in customer-oriented driving profiles

- ✓ Driving resistance measurements
- ✓ Tire characterization



Acoustic Measurement Equipment

FKFS has a wide range of standard and special acoustic measurement equipment, as well as the software tools needed to perform signal and modal analysis.

Applicaton Examples

- ✓ artificial heads to record binaural sound signals and the possibility of aurally accurate reproduction
- ✓ Laser vibrometers and laser scanning vibrometers for determining, among other things of operating vibration modes of sound-emitting surfaces
- ✓ Microphone array systems for localizing sound sources in the vehicle interior and for investigating exterior noise
- ✓ Microphones (including surface microphones) and acceleration sensors (uni- and triaxial) for targeted sound and vibration measurements
- ✓ Torsional uniformity analysis (torsional vibrations)



Special Measurement Technology

FKFS special measurement technology is both within the drive train and far beyond. FKFS offers „everything from a single source“ - from design, layout and production to the application of your measurement technology, including sensor or component-specific calibration. From the idea to the measurement result, you will find a competent contact at FKFS who will support you in the implementation of your development task or take it over completely for you.

Application Examples

- | | |
|--|-------------------------------------|
| ✓ Distance measurement | ✓ Component temperature measurement |
| ✓ Strain measurement | ✓ Signal transmission systems |
| ✓ Fast surface temperature measurement | ✓ Digital application |



Aerodynamic Measurement Systems

In the field of aerodynamics, FKFS has extensive measurement equipment for analyzing the flow around and through the vehicle.

In addition, we also offer the possibility of visualizing and quantifying flow situations in the vehicle cabin and components.

Application Examples

- ✓ Mobile systems for simultaneous pressure measurement at over 500 measuring points
- ✓ Multi-hole probes for the temporally high-resolution spatial determination of flow velocity and angle
- ✓ Specially developed radiator probes for cooling air volume flow measurements (see below) on the installed vehicle radiator
- ✓ 3D PIV system
- ✓ Evaluating the air flow rates on vehicle comfort seats with seat ventilation
- ✓ Recording the volume flow at air vents for conditioning the interior of the vehicle cabin

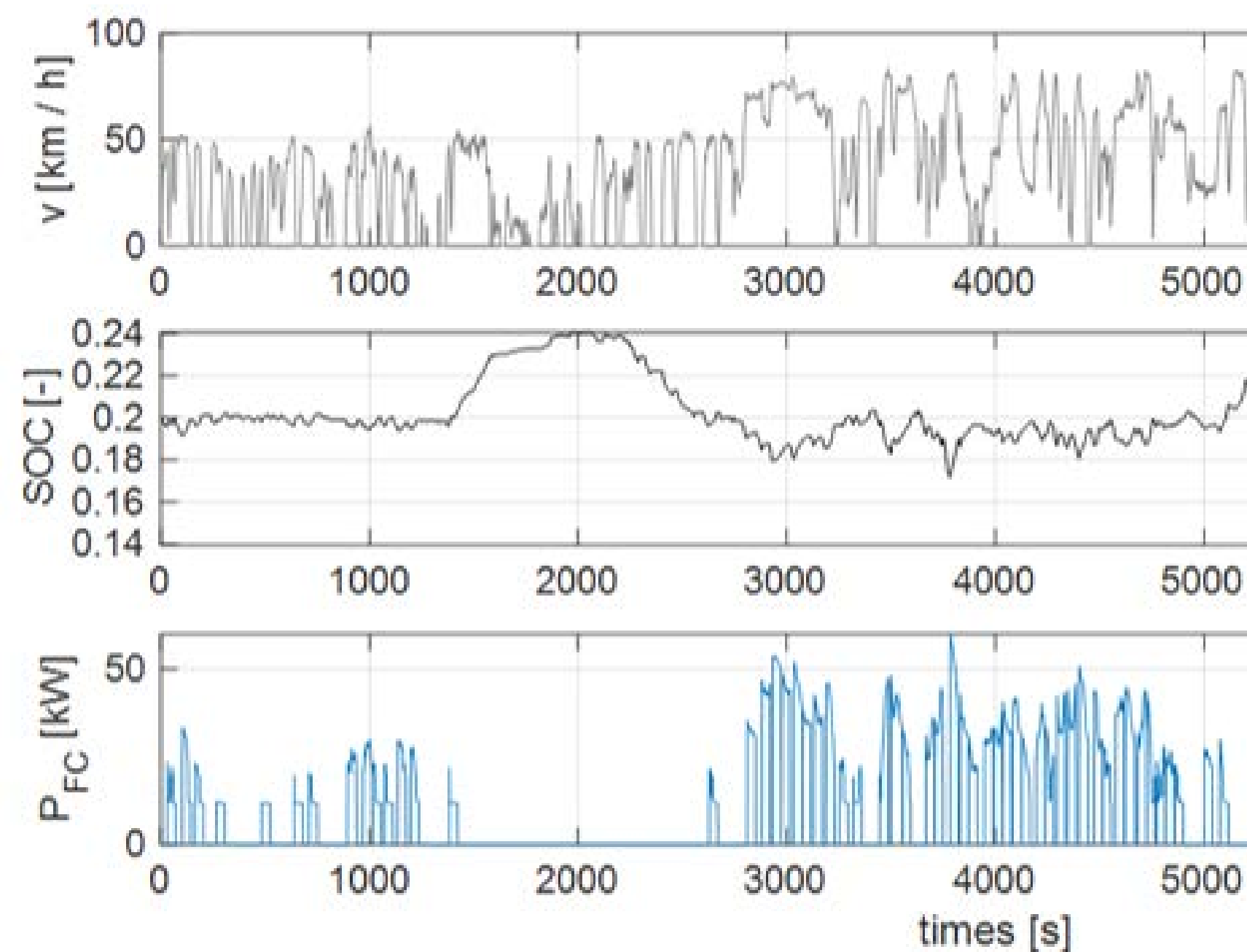


Thermal Comfort Manikin

The FKFS Thermal Comfort Manikin can be used together with its digital twin at all stages of development to objectively assess passenger comfort. The direct measurement of air velocities at selected parts of the body records the flow field in the vehicle cabin and enables isothermal investigations into draught-free conditions in convertibles.

Application Examples

- ✓ Thermal comfort rating
- ✓ Measuring the temperature distribution
- ✓ Coordination of the HVAC control strategy
- ✓ Draught assessment of Ventilation concepts
- ✓ Draught control Cabrio

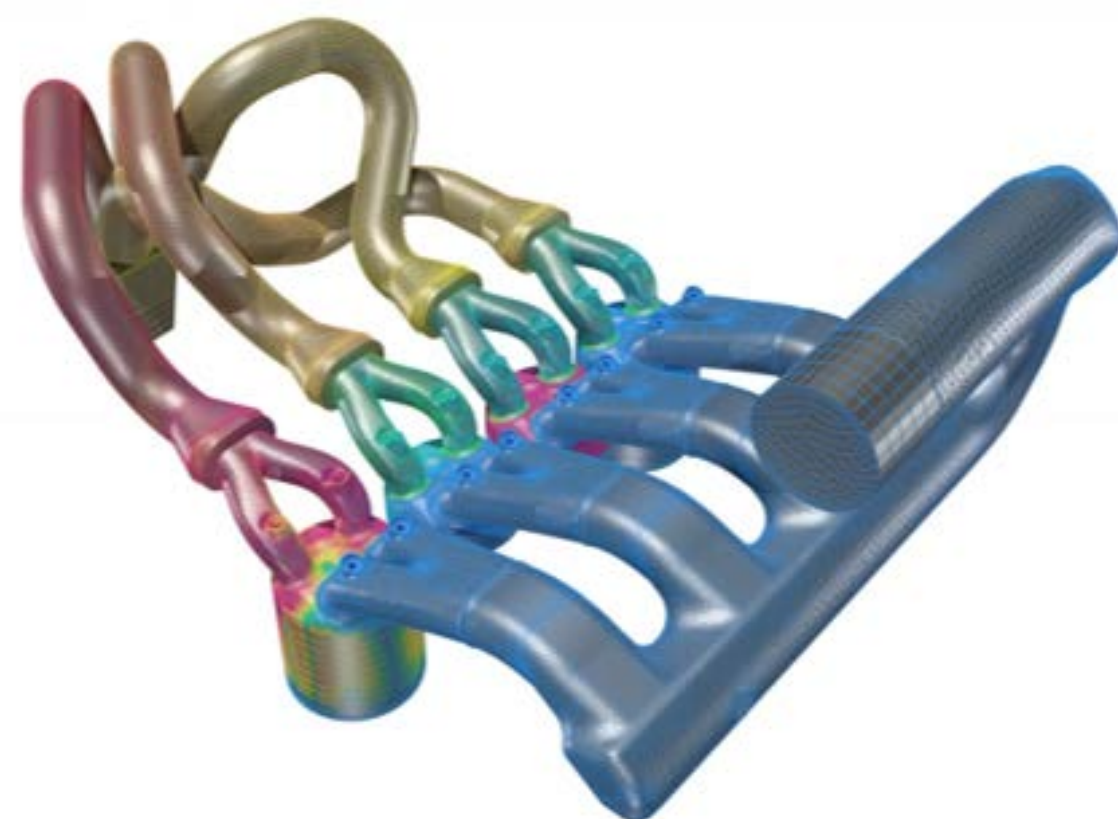


OD/1D-Simulation incl. longitudinal dynamics

The selection and design of drive concepts for vehicles requires knowledge of the performance requirements and the dynamic requirements in different driving situations, the heat flows to be dissipated and the energy to be expended in each case and the associated emissions. For this purpose, longitudinal dynamics simulations are being developed at the FKFS on the basis of a modular simulation kit, which enables the rapid dimensioning and optimization of a wide variety of drives and topologies for a wide range of vehicle classes.

Application Examples

- ✓ A wide variety of vehicles (motorcycles, cars, commercial vehicles, construction machinery, ships)
- ✓ Hybrid topologies: parallel, serial, power-split
- ✓ Energy source: battery, H₂, e-Fuel (Methanol, FT, NH₃, etc.)
- ✓ Various powertrains: BEV, (P)HEV, FCV, H₂/eF-ICE
- ✓ Basis for LCA



3D/CFD-Simulation-QuickSim

With our powerful simulation tool QuickSim, a 3D CFD software developed in-house, we carry out precise virtual investigations that encompass the entire engine system.

Thanks to QuickSim's modular structure, you can respond flexibly to your specific requirements, while our in-house development resources – supported by our synergies between the OD department and our testbench capacities – enable you to implement your projects comprehensively, efficiently and quickly.

Motors

Fuel

Motorsport

Special motors

Development of all engine types (cars, trucks, ships, airplanes, etc.)

Flow dynamics, combustion, cooling, injection, Multiphase flow etc.

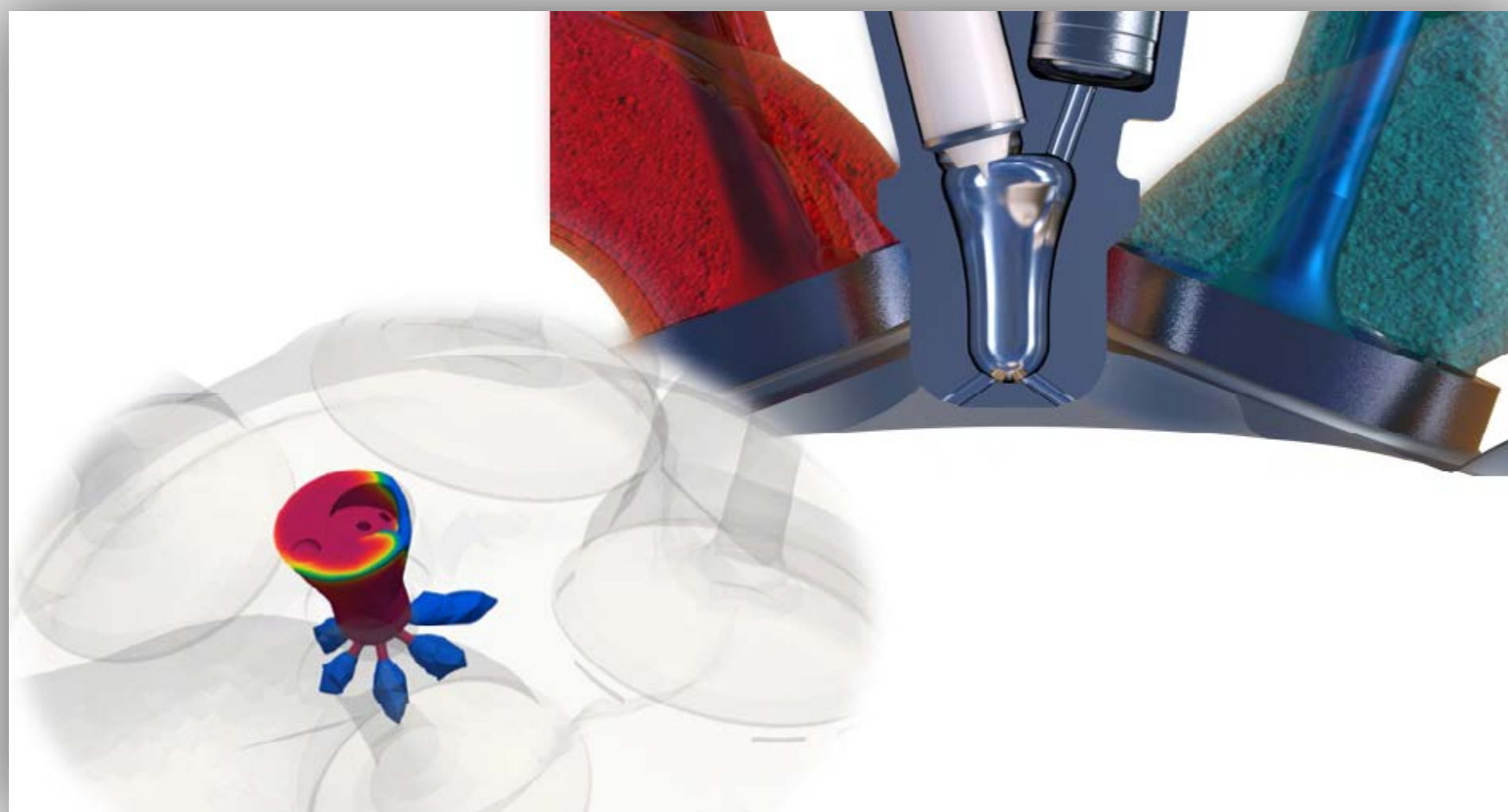
Flexible network generation and motion simulation (cylinders, valves, turbocharger, etc.)

Optimization of motor efficiency through calibration up to 50 %

Application Examples

- ✓ Full engine and multicylinder simulation
- ✓ Pre-chamber and cylinder head optimization
- ✓ CFD + CHT + FEM Simulation coupling

- ✓ Every fuel displayable
- ✓ Injection simulation and PDA measurement
- ✓ Complete construction incl. component design



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Motors

Fuel

Motorsport

Special motors

Analysis and application of different fuels
(liquid and gaseous)

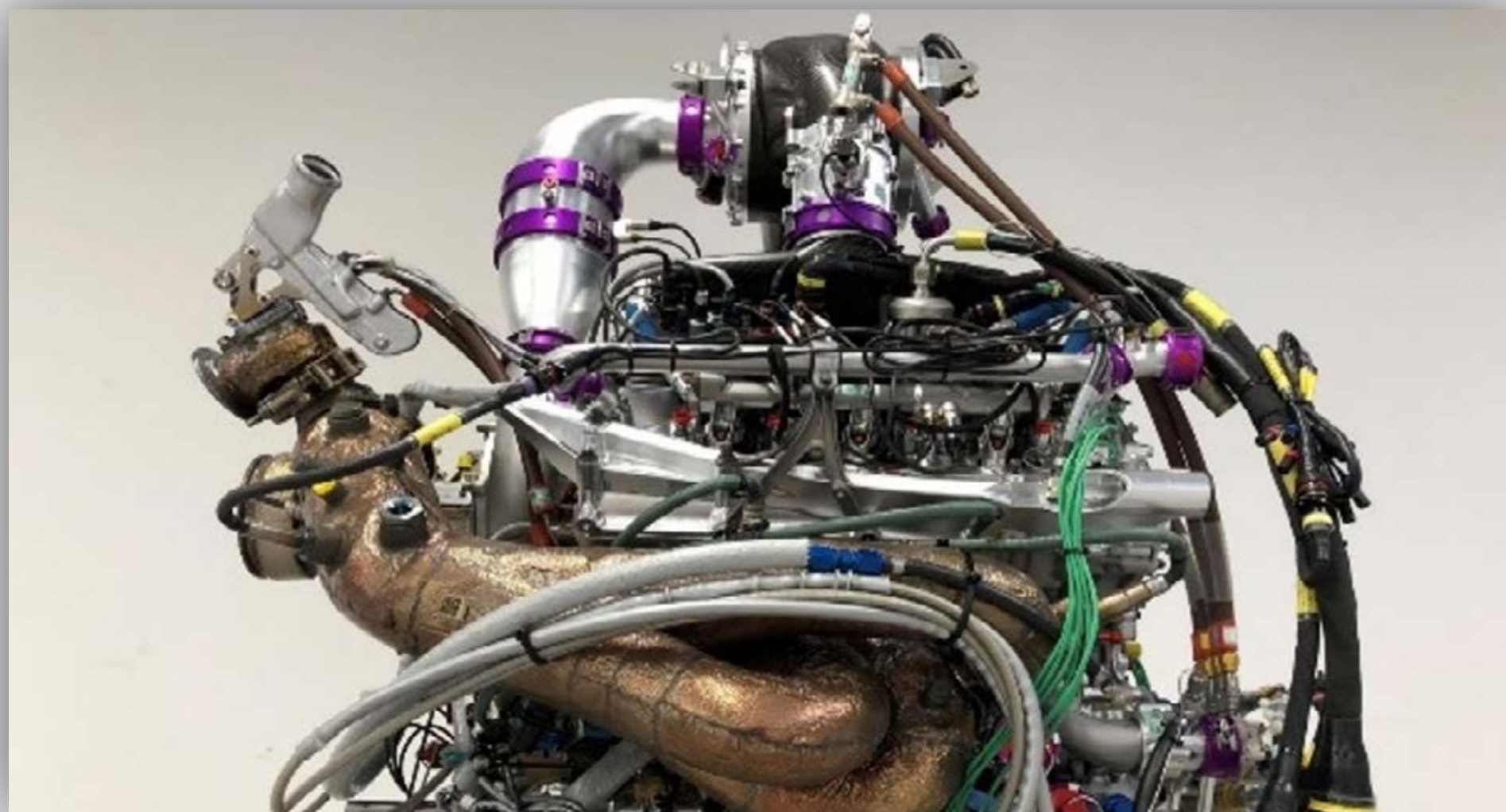
Analysis of SMD, droplet distribution and spray development

Calibration of the injection by adjusting the measurements
at the PDA laboratory

Optimization of the composition of different fuels

Application Examples

- | | |
|--|--|
| ✓ Full engine and multicylinder simulation | ✓ Every fuel displayable |
| ✓ Pre-chamber and cylinder head optimization | ✓ Injection simulation and PDA measurement |
| ✓ CFD + CHT + FEM Simulation coupling | ✓ Complete construction incl. component design |



Motors

Fuel

Motorsport

Special motors

Active in MotoGP, F1, WRC, & high performance models from leading OEMs.

Optimized workflow for fast prototyping & fast simulations

Automated optimization of injector and injection

Advanced analysis: knock detection, mixture formation, engine dynamics, etc.

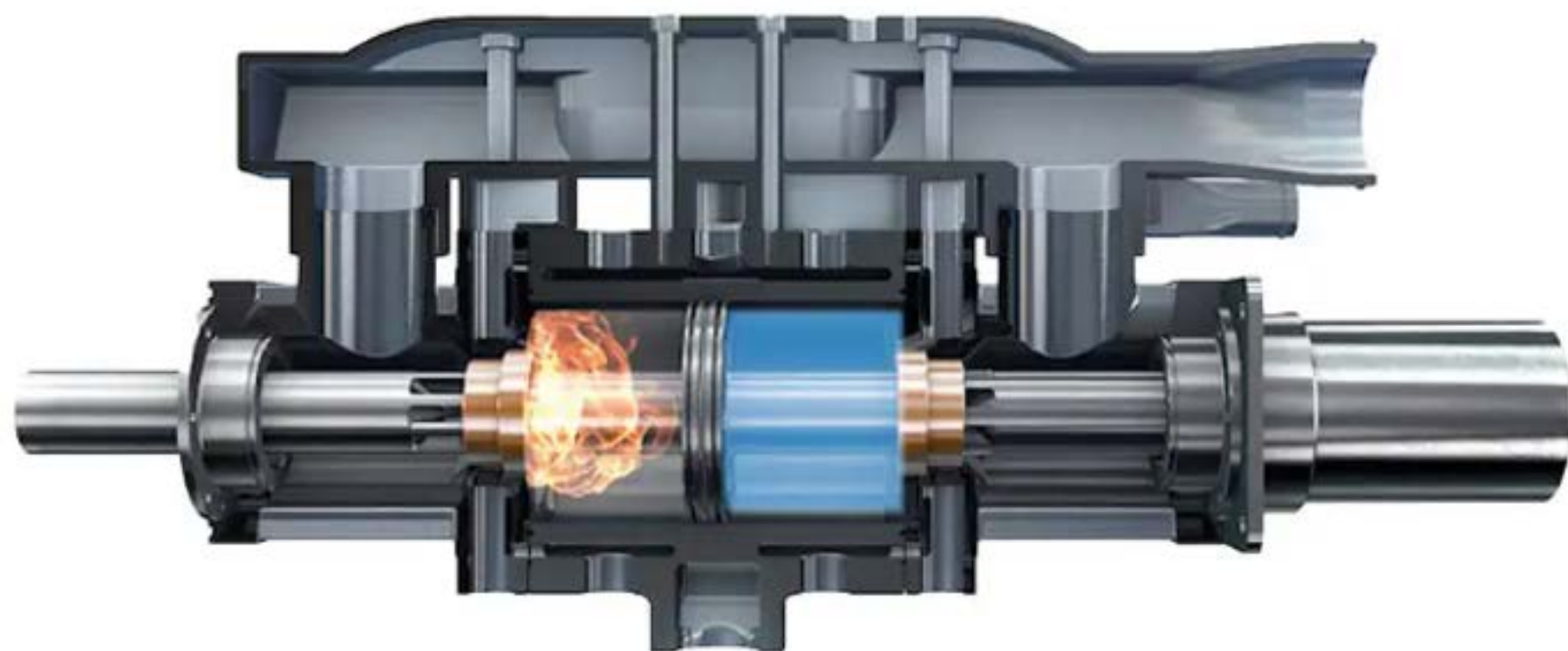
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Motors

Fuel

Motorsport

Special motors

We are not limited to reciprocating engines:
Wankel, Linear, Rotary, etc.

Experience in various disciplines: road transportation,
energy, and aviation.

Application Examples

- | | |
|--|--|
| ✓ Full engine and multicylinder simulation | ✓ Every fuel displayable |
| ✓ Pre-chamber and cylinder head optimization | ✓ Injection simulation and PDA measurement |
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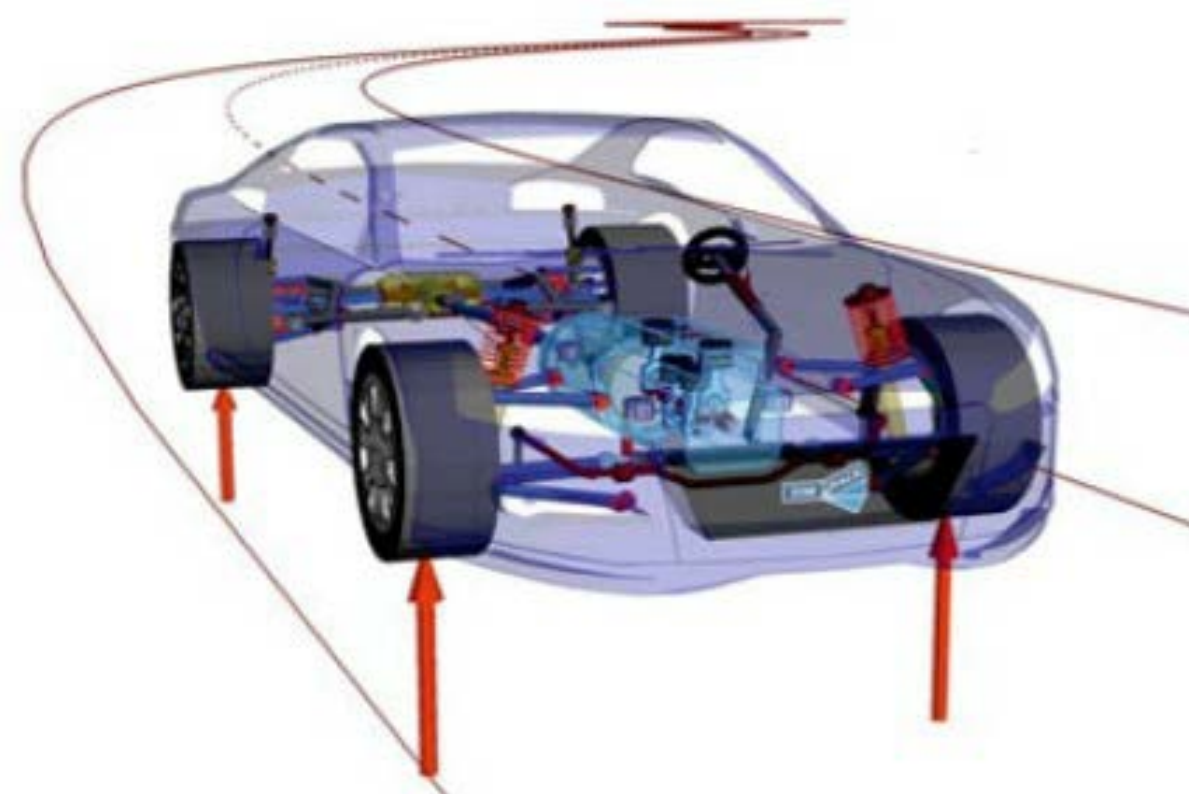


Life Cycle Assessment/ Total Cost of Ownership

Especially in the development of new vehicle powertrain systems, the ecological consideration over the entire life cycle of the product is a central tool. Together with a consideration of the total costs for the user, important criteria are available for the comparative evaluation of vehicle concepts. FKFS offers detailed analyses (Life Cycle Assessment & Total Cost of Ownership) for this purpose, which are generated using tools that have been specially adapted to the balancing of vehicle powertrains.

Application Examples

- ✓ LCA according to DIN ISO 14040 and 14044
- ✓ Quantification of the costs for Production and use (TCO)
- ✓ Balancing the production paths of energy sources
- ✓ Emission-optimized design of drive topologies
- ✓ Forecasting energy consumption during the utilization phase using longitudinal dynamics simulation
- ✓ Comparative evaluation of powertrain concepts



Digital Skills Development

The use of suitable models is of crucial importance for theoretical and simulative investigations. Application-specific modelling is necessary in order to achieve an optimum balance between mapping quality and parameterization effort. FKFS uses established simulation tools from the automotive industry and develops individual solutions as required.

Modeling

Complete vehicle models

Component models

Environment models

Models of active chassis systems

Application Examples



Driving dynamics and
driving comfort examinations



Chassis parameterization,
K&C



Virtual Driving Characteristics Development

By integrating the driving characteristics into the virtual development process, vehicle concepts can be designed much more efficiently. This makes it possible to analyze and optimize the vehicle with respect to all customer- and brand-specific characteristics before a physical model exists. Virtual development processes allow the integration of innovative methods such as AI-based modeling and optimization processes, sensitivity analyses, and solution space methods. They support systematic and systems engineering-oriented vehicle development in all development phases - from early characteristics oriented chassis design to virtual application and homologation methods, as well as many digital twin-based analyses.

Virtual chassis design

Application

Homologation

Modular toolkit

Integration into customer-specific development environment

Target Cascading

Target Evaluation

Solution-Space-Method

Application Examples



Design in early concept phase



Virtual Validation



Efficient vehicle and controller parameterization



Subjective-objective correlation



Virtual chassis design

Application

Homologation

Subjective application of driving comfort functions

Objective application in simulation

Integration of modern test benches

Highly efficient optimization algorithms

Black-Box-Approaches

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Application Examples



Design in early concept phase



Virtual Validation



Efficient vehicle and controller parameterization



Subjective-objective correlation



Virtual Driving Characteristics Development

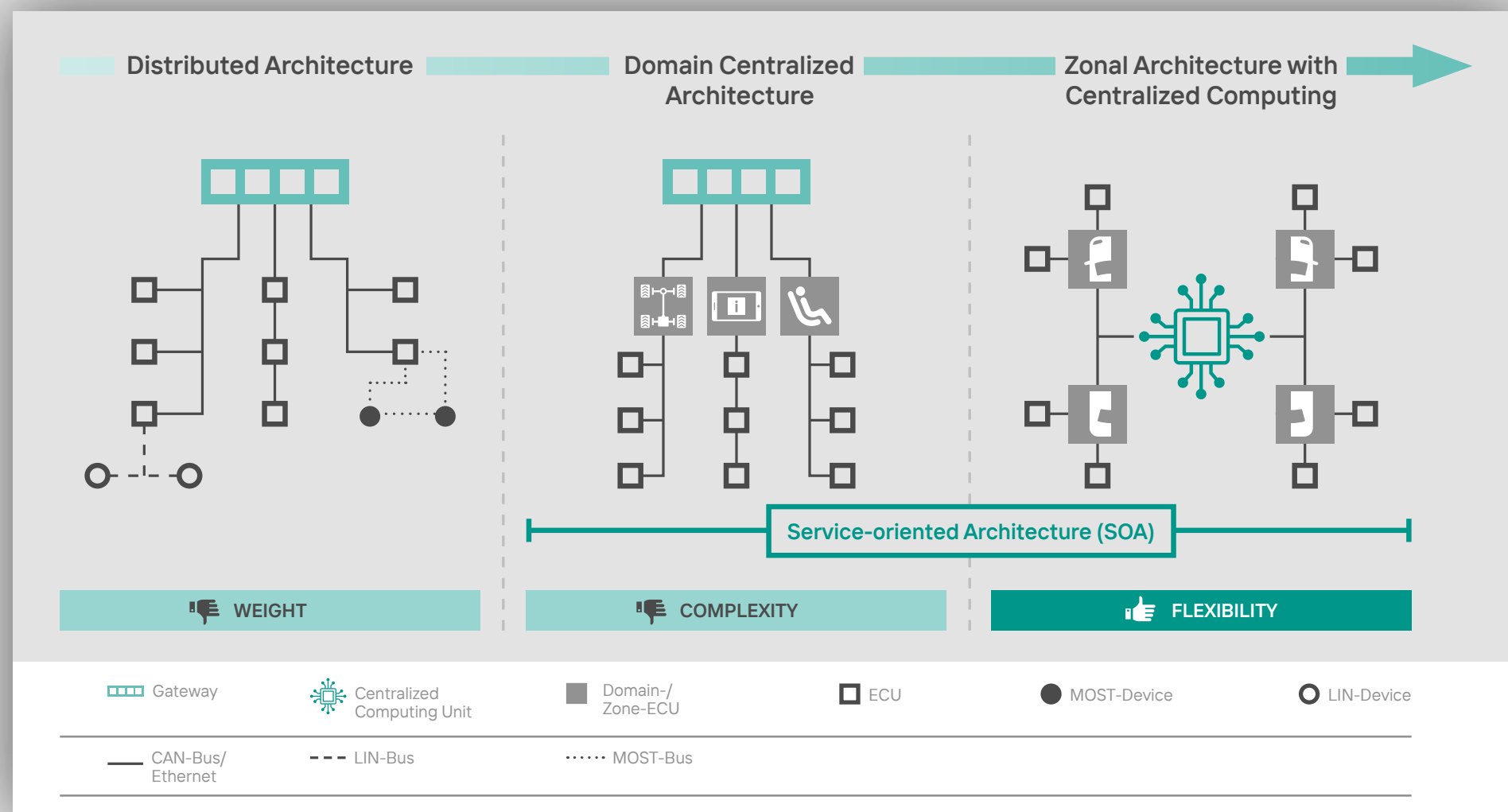
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- Virtual chassis design
- Application
- Homologation

- Virtual development and virtual testing of environmental sensors for ADAS
- Approval of software updates
- Increased accuracy and reliability

Application Examples

- ✓ Design in early concept phase
- ✓ Virtual Validation
- ✓ Efficient vehicle and controller parameterization
- ✓ Subjective-objective correlation



Simulative E/E Architecture Optimization

FKFS offers solutions for the design of optimized architectures that save costs, development and maintenance effort, reduce weight and resources and take into account the requirements for maintainability, flexibility and security.

Methods

Aspects

Complete vehicle simulation

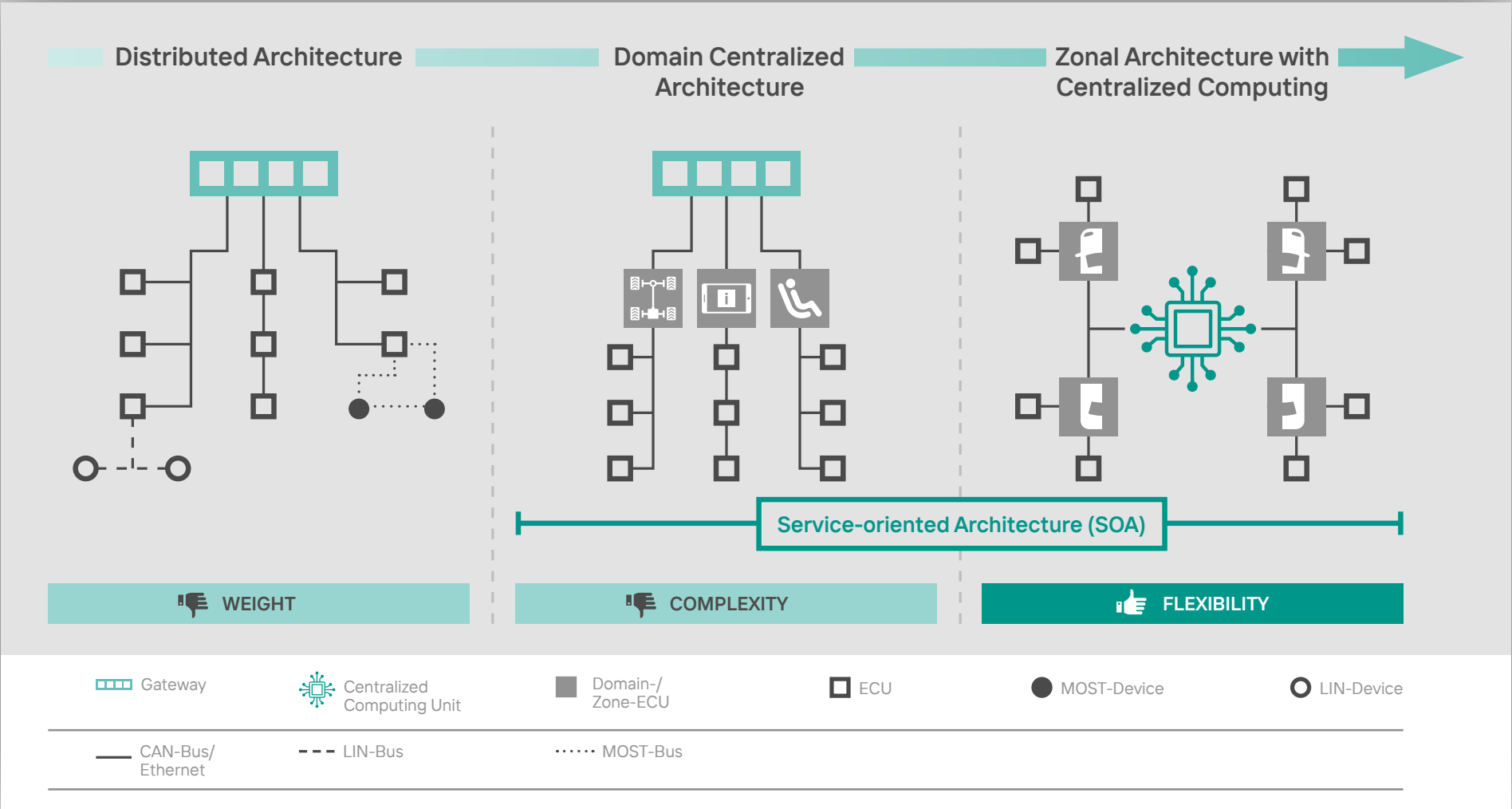
Virtual control units

Model-based optimization

Environment simulation

Application Examples

- ✓ Variant comparisons
- ✓ ASIL decomposition variations
- ✓ Cable harness optimizations
- ✓ HW/SW mapping optimizations
- ✓ Virtual testing
- ✓ ... answering your questions

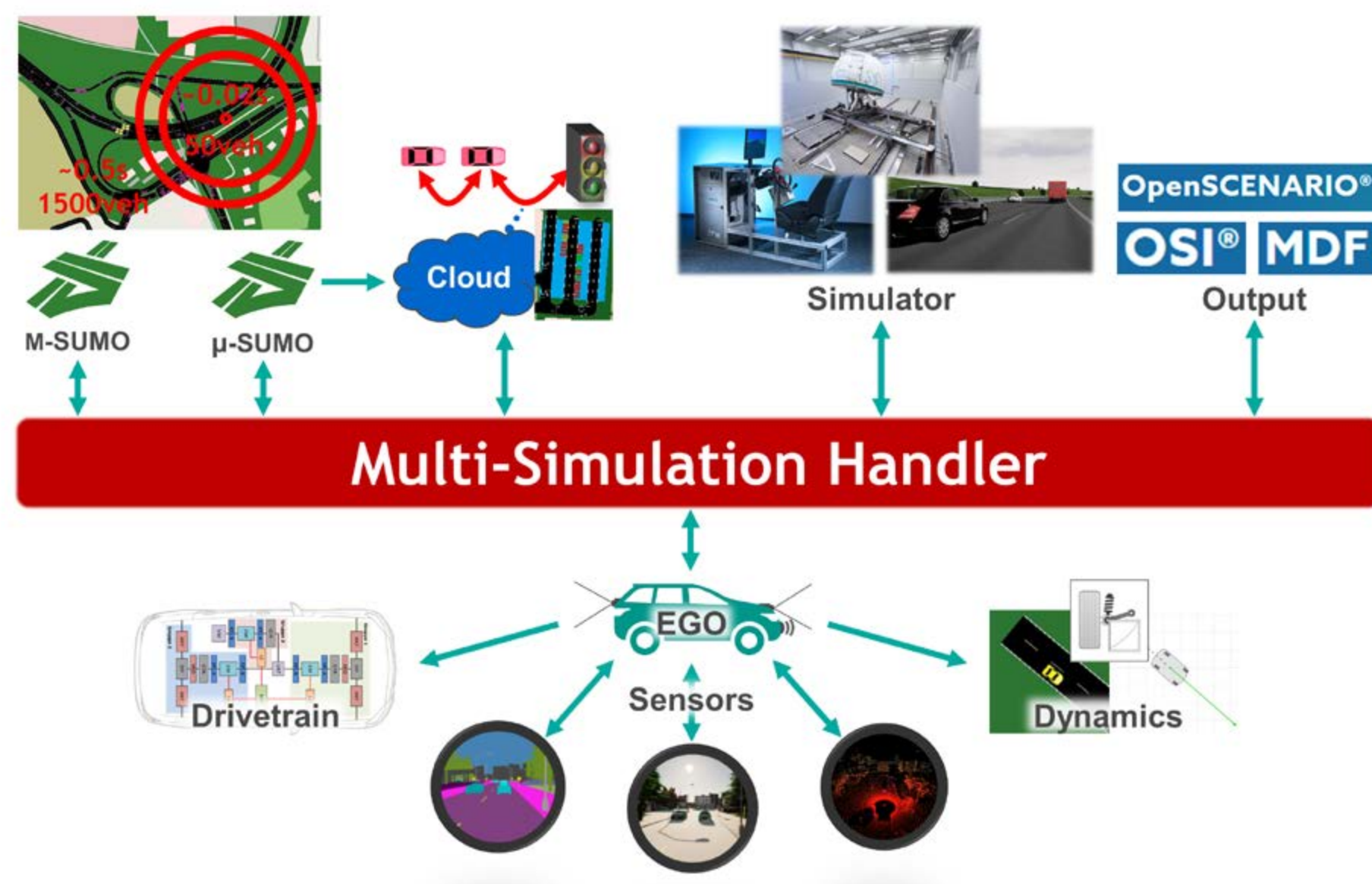


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Methods	Aspects
ISO 26262	
Hardware costs	
Reliability	
Energy consumption	

Application Examples	
✓ Variant comparisons	✓ HW/SW mapping optimizations
✓ ASIL decomposition variations	✓ Virtual testing
✓ Cable harness optimizations	✓ ... answering your questions



Virtual Development

The interaction between the vehicle and its environment requires a comprehensive simulation of the overall system of vehicle and environment for the virtual development of vehicle functions. This can only be achieved through the combination and integration of a wide range of tools.

Application Examples

- ✓ Generation of training data
- ✓ Scenario generation
- ✓ Experience of ADAS functions
- ✓ FuSa/SOTIF-investigations
- ✓ HIL applications
- ✓ Virtual application