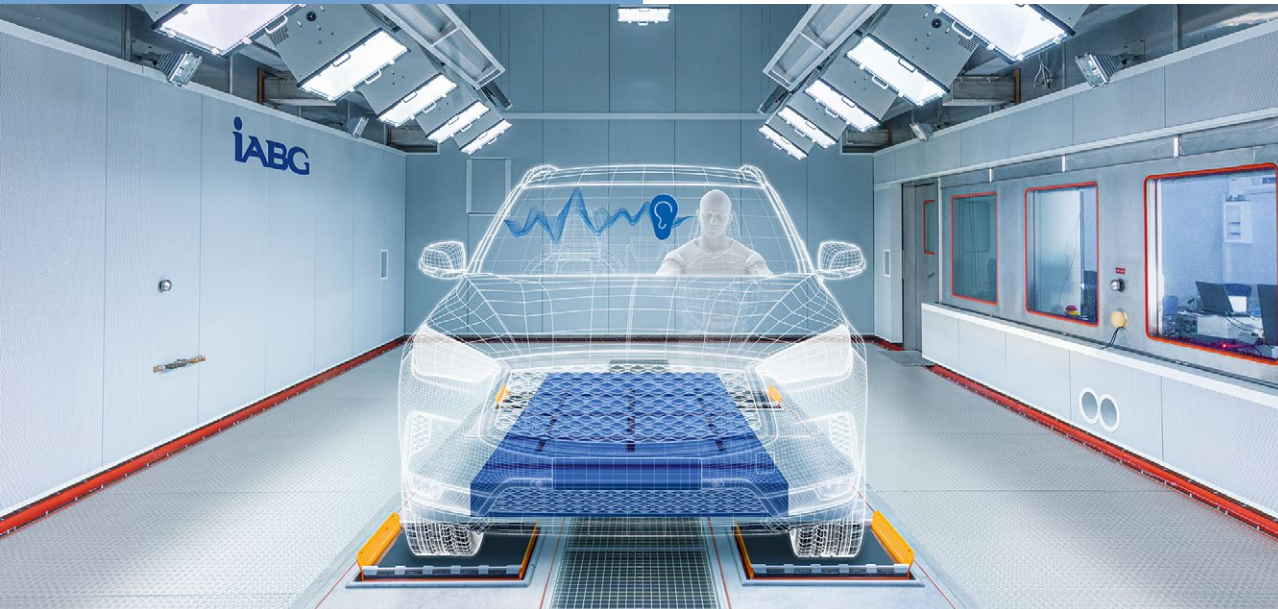


IABG. The Future.



**Vertical Dynamic Structural
Test Bench (VESPA)**

iABG

Vertical Dynamic Structural Test Bench (VESPA) and Aggregate Services

Reliability and safety are decisive for vehicles which are getting more and more complex with ever more functions. In our facilities over the last 50 years, we have tested and qualified complete vehicles and their components in compliance with current standards and customer specifications.

Modern mobility concepts make the requirements for vehicle design ever more demanding. The Vertical Dynamic Structural Test Bench (VESPA) provides the testing technology for conventional as well as electric drives to meet these requirements. It combines fatigue strength, fatigue and vibration tests. In addition, it also permits noise and vibration analysis.

We provide our customers with a wide range of services, which can be individually customised:

Test Bench Services

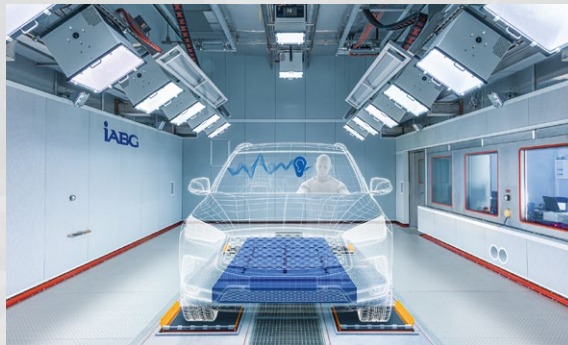
- Fatigue strength tests on vehicle bodies and motorcycles
- Tests on electric vehicles possible
- Determination of interference noise under climate stress
- Simulation of ageing processes for vehicle components through climate simulation and solar simulation in combination with vertical road excitation
- Human-rated mode (person in the vehicle during specific test modes)

Aggregate Services

- Optical measuring systems
- NDT procedures
- Noise and vibration analyses
- Validation of sensor systems
- Damage-equivalent test spectra - FatiResponse®
- System/multibody system simulation
- VDI 3822-compliant systematic failure analysis



*Our seal stands for the quality of
our accredited and certified test house.*



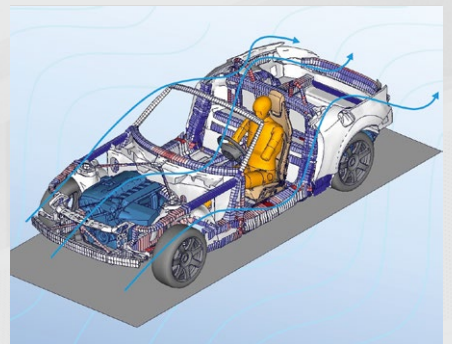
Vertical Dynamic Structural Test Bench (VESPA)



Optical measuring systems



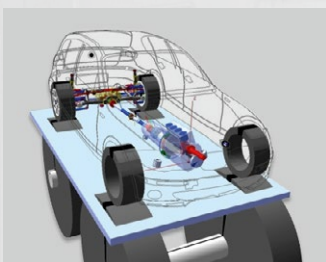
NDT procedures



Noise and vibration analysis



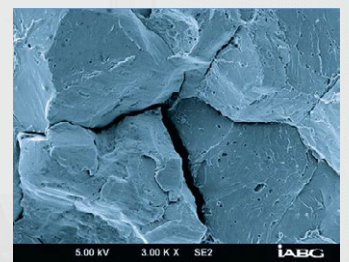
Validation of sensor systems



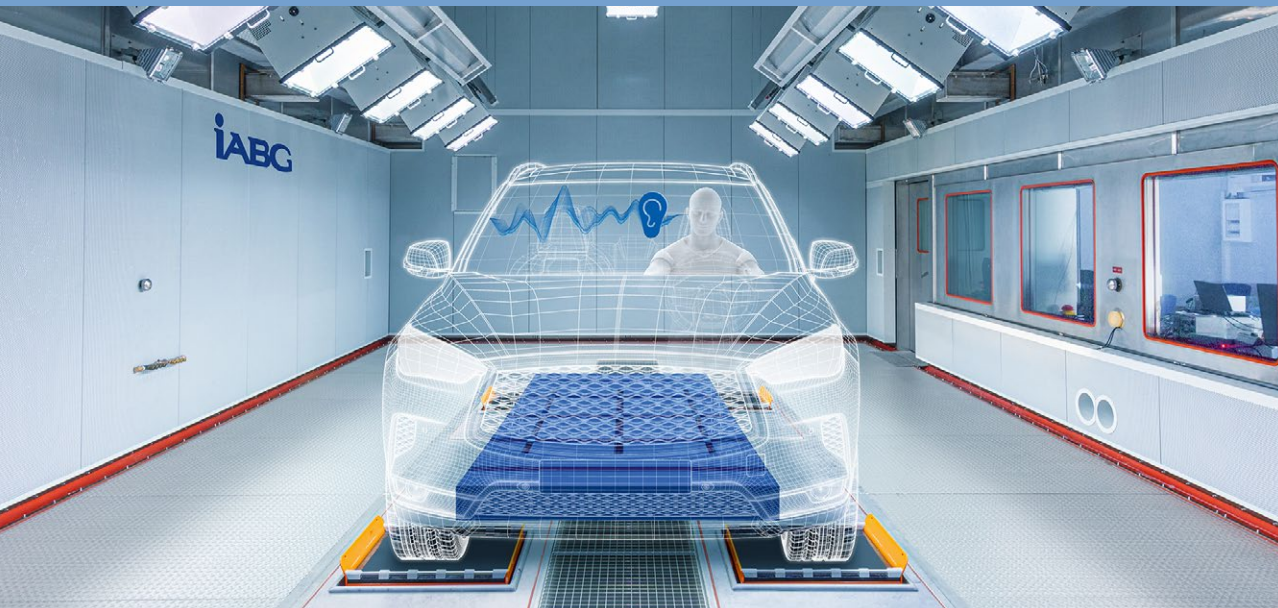
System/multibody system simulation



Damage-equivalent test spectra



VDI 3822-compliant failure analyses



Vertical Dynamic Structural Test Bench (VESPA)

Within the context of modified mobility concepts, the Vertical Dynamic Structural Test Bench (VESPA) provides the testing technology to meet the new requirements for vehicles.

For example, we conduct fatigue strength tests on the structure of electric vehicles as well as noise analyses according to the customers' specifications.

Our Services

- Fatigue strength tests on car bodies and motorcycles along with operating load simulation tests, derived from vehicle measurements
- Determination of interference noise under various climate conditions
- Simulation of ageing processes for vehicle components through climate simulation and solar simulation in combination with vertical road excitation
- Human-rated mode (person in the vehicle during specific test modes)

Additional Services in Environmental Simulation Facilities

- Preconditioning
- Ageing of components or complete vehicles
- Environmental and functional tests on components or complete vehicles

Technical Data

System performance:

- Four electrodynamic vertical actuators with 41kN
- Continuous operation possible (24/7)
- Maximum velocity: 4 m/s
- Frequency range: 0 to 150 Hz
- Dynamic stroke: ± 125 mm

Suitable for vehicles:

- Up to 4,000 kg
- Wheel base: 1,800 mm – 4,200 mm
- Track width: 1,200 mm – 2,000 mm
- Max. vehicle height: 2,200 mm

Climate conditioning

- Temperature range: -40°C to $+85^{\circ}\text{C}$
- Rel. humidity: up to 98 %
- Solar simulation facility: 1050 W/m^2

Measuring technology:

- Iteration capacity of the test bench for strain gauges, acceleration and displacement transducers
- Additional data acquisition of temperature, strain, acceleration and displacement



Measuring Technology and Optical Measuring Systems

Measuring Technology

- Sensor application (force, torque, pressure, temperature, path, speed, acceleration, strains, etc.)
- Telemetry applications
- Road tests
- Optical deformation measurement, photogrammetry, 3D scans
- Measurement data acquisition and evaluation
- Analysis of operational vibrations and alignment with design criteria, preparation of test signals and operational loads for test bench trials
- Calibrations

Equipment

- HBM measuring amplifier systems, scalable in the range of 1 to 10,000 measuring channels
- Central and distributed systems (data link via field bus)
- 42-channel PAK system (Müller-BBM)
- Extensive range of sensors for many physical measurements
- and much more

Optical Measuring Systems • Applications

- Behaviour analyses for structures subjected to loads ranging from static to highly dynamic
- Point-based and full-field measurements in 3D of
 - elongations
 - displacements

- Component positioning and measuring of test benches
- Component sizes scalable from a few millimetres to several hundred metres

ARAMIS • Image Correlation

- Stereo-optical measurements by means of digital image correlation (DIC)
- Static and dynamic point-based and full-field measurements to determine
 - 3D coordinates
 - 3D displacements, velocities and accelerations
 - surface strains
 - evaluations of six degrees of freedom (6DoF)
 - deformation characteristics

ARAMIS • High-Speed Measurements

- For highly dynamic procedures, IABG has HS cameras that can generate tens of thousands of images per second
- Applications included: drop tests, ballistic tests, blast tests, crash tests, etc.

TRITOP • Photogrammetry

- Precise determination of the 3D coordinates of object points under static conditions
- Comparison with CAD data / software supported:
 - false colour rendering
 - deviation of individual points as labels
 - sections, angles and dimensions
- Customised reports according to your requirements
- Determination of three-dimensional displacements and deformations of objects and components exposed to loads in stages
- A team of experts is available for further analyses, e.g. FE modelling, on request

ATOS • 3D Scanner

- High-precision, full-field 3D digitisation of component geometries
- Comparison of actual 3D coordinates with CAD data
- Comparison of component geometries before and after a test (mechanical, thermal, etc.)
- Optional reverse engineering of the scan data into a CAD model

Customer Benefits

- Significantly less effort for measurements that would normally require a large number of conventional position sensors and/or strain sensors.
- 3D information is obtained for each measuring point.
- Measurement data is immediately visualised and correlated with CAD and FE models.
- IABG operates in close collaboration with GOM (Gesellschaft für optische Messtechnik) and can therefore deliver innovative, customer-specific solutions for any new measurement task.
- IABG has more than 50 years of experience in the mechanical testing of parts, components and large assemblies. Customers benefit from the comprehensive know-how of an interdisciplinary team of experts.
- IABG offers a unique combination of optical and electrical measurement technology, test setup and execution with the respective infrastructure as well as advanced technical services, all from a single source.

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Non-destructive testing • NDT Procedures

Securing structural integrity requires specific structural analyses and adapted structural inspections.

IABG provides expert advice concerning suitable measures for sustaining structural integrity and qualified technical personnel to undertake structural inspections according to customer specifications and in compliance with official requirements. Our range of services includes:

Structural Inspection

Either in our test laboratories or in mobile on-site facilities, we perform inspection tests according to customer-specific requirements and with flexible implementation of the latest technological equipment.

Our experienced specialists possess the required qualifications up to stage III according to EN ISO 9712 or EN 4179 (NAS410) for eddy current testing (ET), ultrasonic testing (UT), dye penetrant testing (PT), magnetic particle testing (MT), visual testing (VT) and x-ray testing.

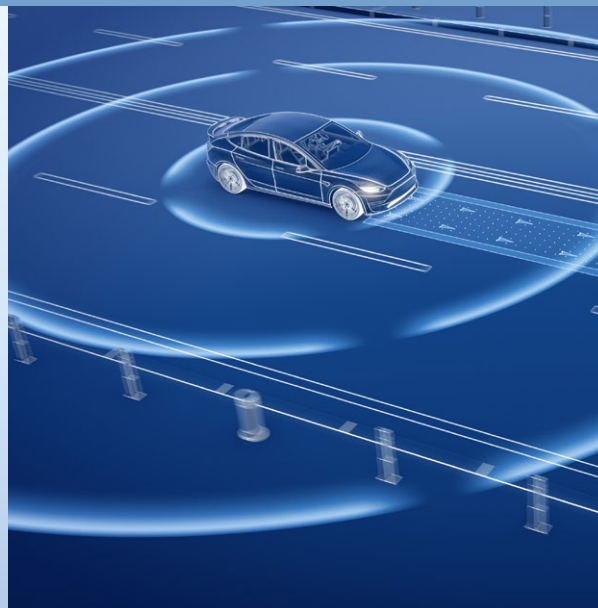
Technical and Scientific Consulting

- Selection of inspection procedures and drafting of test regulations
- Development and validation of NDT procedures
- Optimisation of structural inspections with non-destructive tests
- Performance of non-destructive tests
- Consulting and quality assurance in the development and manufacture of structures

Inspection and Damage Documentation

- Drafting of inspection manuals (non-destructive testing manuals)
- Design and implementation of calibration standards as part of the inspection manuals
- Documentation of inspection results according to customer requirements or in the IABG format

The damage documentation and damage management can be recorded in the IABG software DamDoc, a server-based database. The experience gained from innumerable fatigue tests on aircraft is a solid base that permits reliable and rapid communication and coordination with our customers.



Validation of Sensors for Advanced Driver Assistance Systems and for Highly Automated and Autonomous Driving Functions

The IABG supports its customers in the early design stage with analytical methods (safety assessment). The chosen safety architecture is examined using modelling, simulation and subsequent validation in compliance with the relevant standards.

Test facilities, simulators and hardware-in-the-loop (HiL) tests provide support from the prototype phase through to product qualification.

The vertical dynamic structural test bench (VESPA) meets all the requirements for inspecting sensors and sensor systems on complete vehicles.

Services

- Function and performance analyses under the influence of mechanical and climatic loads
- Endurance tests
- Calibration and alignment of sensors in different vehicle poses
- Optional integration of target generators

Technical Data

Dynamic Tests

- Simulation of the vibration effects of different road surfaces
- Simulation of pitch and roll manoeuvres

Static Tests

- Reproducible setup of static vehicle poses
- Pitch and roll positions, adjustable individually and in combination

IABG. The Future.



Damage-Equivalent Test Spectra • FatiResponse®

IABG offers customer-specific method development, services and test setting software for the efficient and reliable design of structures and components.

IABG Software FatiResponse®

- Description of damage content via Fatigue Response Spectra (FRS)
- Derivation of damage-equivalent test spectra and test time signals
- Combination of user profiles to create individual mission profiles
- Examination of the actual response amplitudes in the case of accelerated tests

Acquisition and Preparation of Load Data

- Installation of sensors and metrological instrumentation on test vehicles
- Execution of measurement campaigns to capture operational loads
- Processing and analysis of measurement results

Qualification

- Performance of vibration tests up to 2,500 Hz on electro-mechanical or servo-hydraulic shakers under different climate and environmental conditions
- FEM simulation and computational fatigue strength analyses of components under vibration-type loads

Development Support

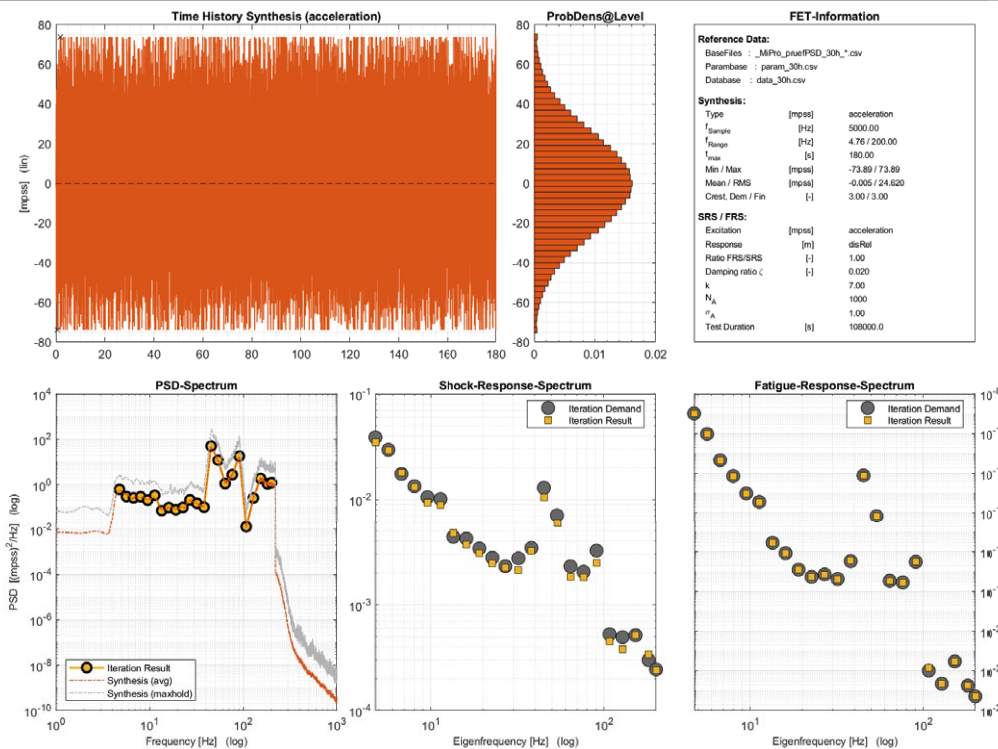
- Optimisation of components and systems exposed to vibration loads (dynamic behaviour and service life)
- Characterisation of material behaviour in the IABG fatigue strength testing laboratory
- Material and failure analyses to identify potential issues and optimise components

FatiResponse® Software Packet

Flexible configuration and running of the separate modules like

| | |
|--------|---|
| FET | The Fatigue Equivalence Testing module generates a power density spectrum (PSD) from the specified fatigue response spectra for the vibration test. |
| MIPRO | The Mission Profiling module permits the combination of any number of user profiles for generating a characteristic fatigue response spectrum. |
| PSD2TH | From the given power density spectra, the module generates corresponding noise signals in the time range. |

FATIRESPONSE

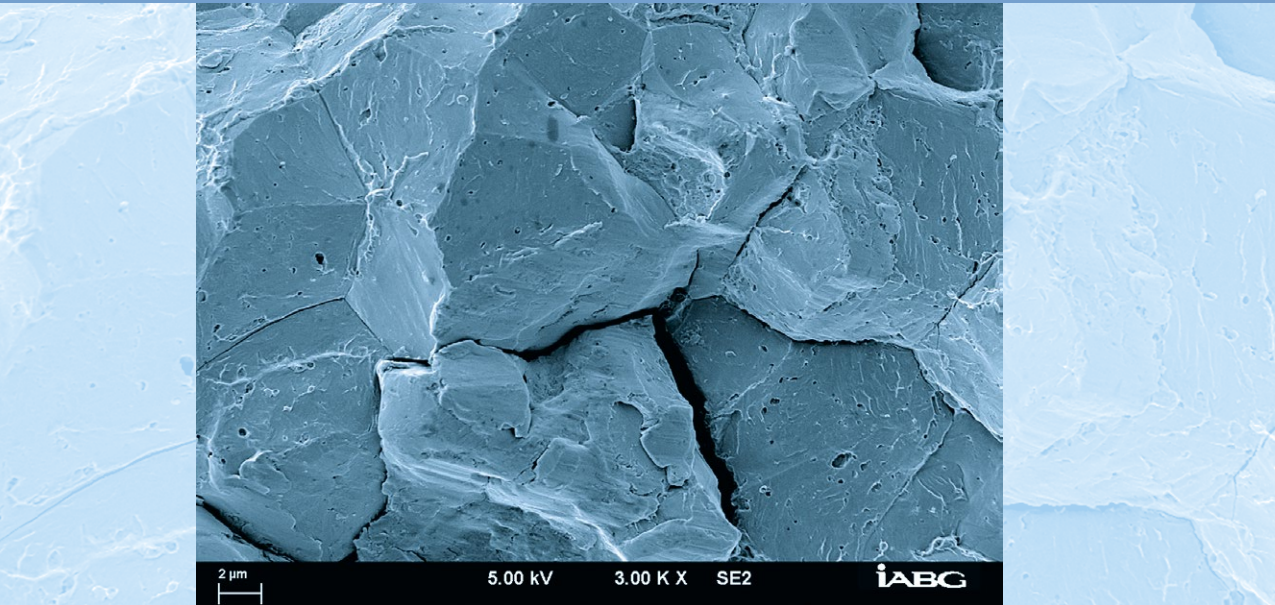


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Systematic Failure Analysis

Tests and Analyses in an Accredited Materials Testing Laboratory

Failure Analysis acc. to VDI 3822

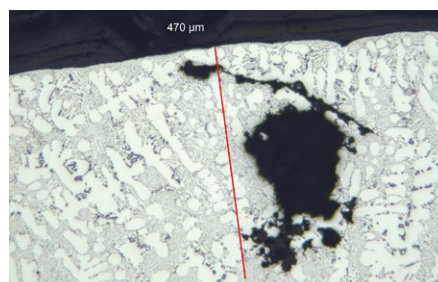
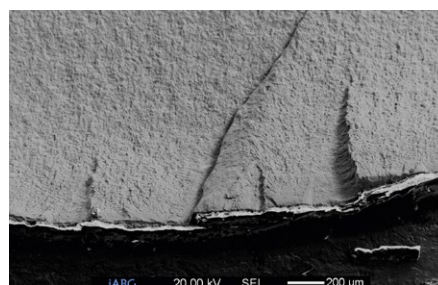
- Determination of the failure mechanisms
- Deduction of possible failure causes
- Creation of evaluative failure reports
- Failure reconstruction by simulation tests
- Recommendation/Definition of failure corrective actions
- Consulting on failure prevention and on the design, construction and testing of components
- Component testing on-site and in the laboratory

Cross-Industry Activities

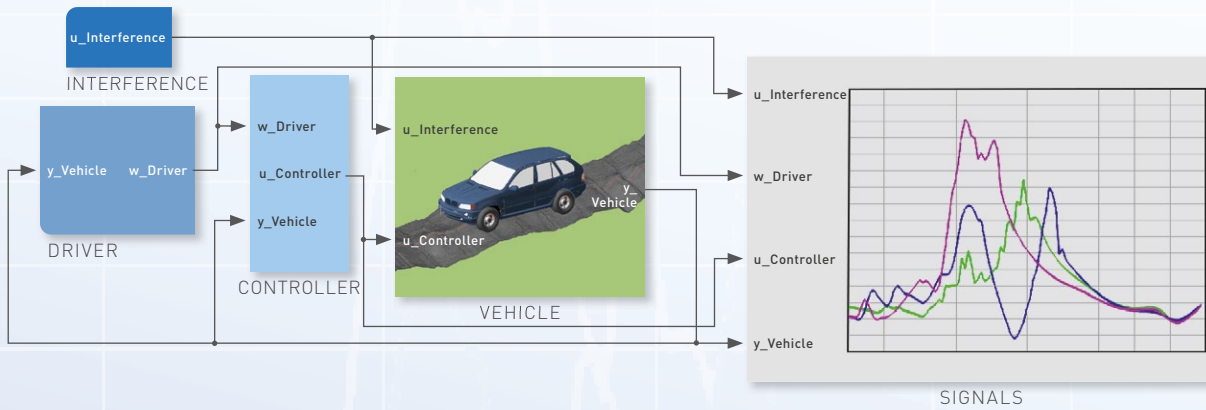
- Examination methods
- Macroscopy
- Light microscopy
- Hardness measurement
- Scanning electron microscopy
- Chemical analysis of materials
- X-ray inspection (2D/ μ CT)
- Residual stress measurements by x-ray
- On-site examinations

Your Advantages

- Short reaction times
- Immediate processing
- Failure analysis hotline:
schadensanalyse@iabg.de



Single-source Simulation and Testing



System / Multibody System Simulation

Long development times and high cost pressure in product development can be reduced significantly through fundamental and early system awareness. System simulation is essential in the product development process and in the imaging of existing technical systems as a digital twin.

Scope of Performance

- Setup and analysis of multiphysics systems (digital twin)
- Integration control and regulating systems
- Computer support for tests
- Model validation and optimisation
- Co-simulation of complex systems
- MBS simulation

Applications

- Simulation of driving dynamics, mileage and consumption
- Virtualisation of the fatigue test benches for large-scale aircraft structural tests
- Vibration comfort and structure-borne noise
- Simulation of operating loads
- Development of control, regulating and driver assistance functions

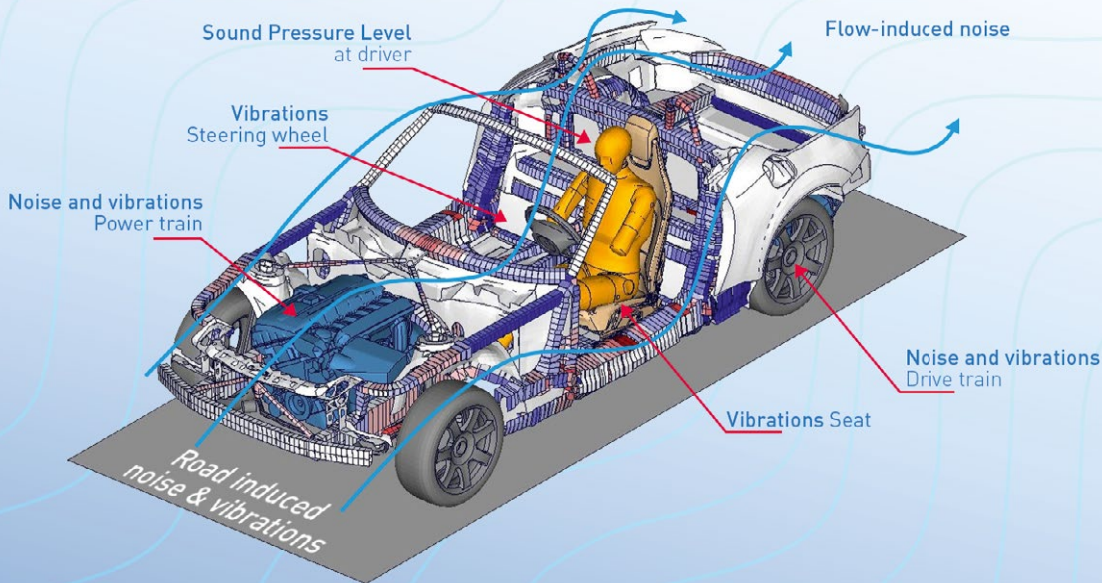
Software

- MATLAB/Simulink (Simscape) • RecurDyn
- SIMPACK • SimulationX • MSC/ADAMS

COMPLETE SYSTEM

SUBSYSTEM

COMPONENTS in the example of modelling of bearings



Acoustics Simulation and Data Analytics

Alongside test bench measurements, simulation methods deliver significant findings with regard to noise generation and the source of vibrations. The interaction of tests and simulation permits in-depth analysis and generation of a solid and validated basic model for elaborating and verifying major optimisation proposals.

Our detailed analyses based on simulations and measurement data enable a better understanding of the transmission of vibrations in the structure and the propagation of air-borne noise in the passenger compartment. We readily support our customers in the elaboration and implementation of improvements. The focus here is on how passengers subjectively perceive noise.

Furthermore, we propose the visualisation and evaluation of noise sources generated by the external flows around the vehicle at different driving speeds. Here we implement the latest calculation methods in the domain of aero-acoustics.

Services

Vibro-acoustics

- Determination of dominant transmission paths for structure-borne noise
- Visualisation of response spectra with varying excitation profiles
- Visualisation of relevant structure vibrations with respect to noise development
- Evaluation of bearing elements for optimum noise reduction

Psycho-acoustics

- Assessment of measured signals according to psycho-acoustic findings with regard to the subjective perception of noise

Aero-acoustics

- Determination of the Sound Pressure Level (SPL) distribution in the passenger compartment
- Visualisation of vehicle flows and sources of noise at different speeds
- Elaboration of improvement proposals concerning noise development in the passenger compartment and outside



AUTOMOTIVE



INFOCOM



MOBILITY, ENERGY & ENVIRONMENT



AERONAUTICS



SPACE



DEFENCE & SECURITY

IABG. The Future.

IABG offers integrated, ground-breaking solutions in the sectors Automotive • InfoCom • Mobility, Energy & Environment • Aeronautics • Space • Defence & Security. We provide independent and competent consulting. We implement with future viability and target orientation. We operate reliably and sustainably. Our success is based on an understanding of market trends and requirements, on our staff's technological excellence and a fair relationship with our customers and business partners.

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