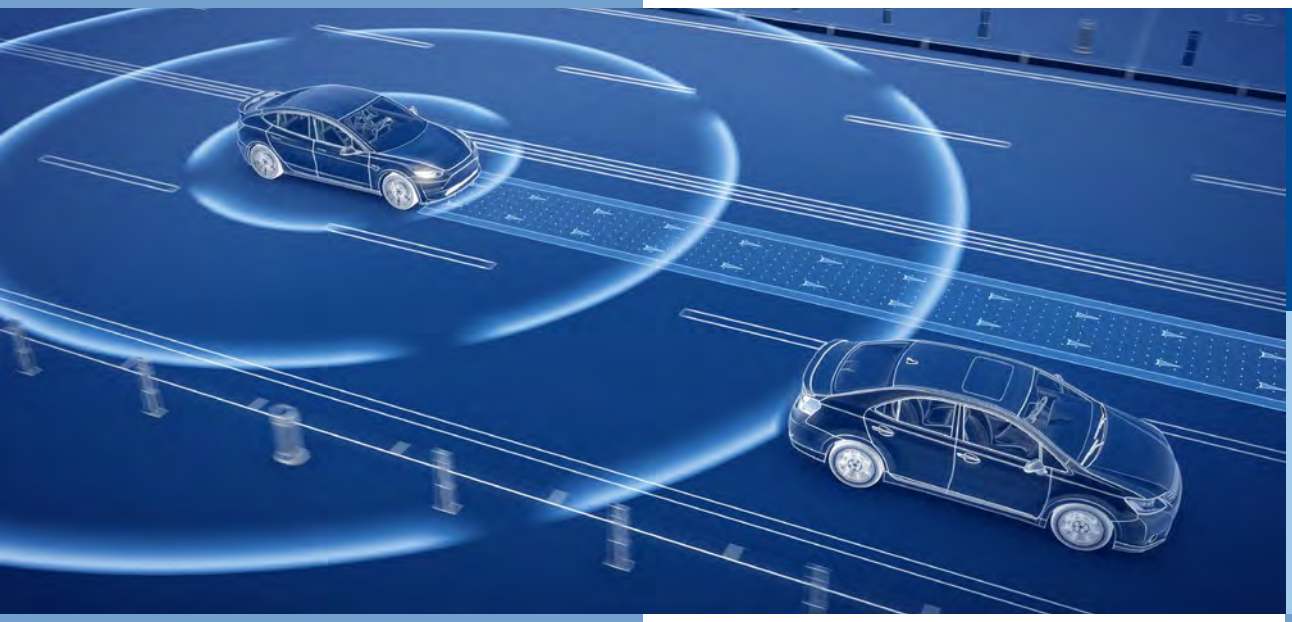
IABG. The Future.



Highly Automated • Autonomous Driving

Range of Services

IABG

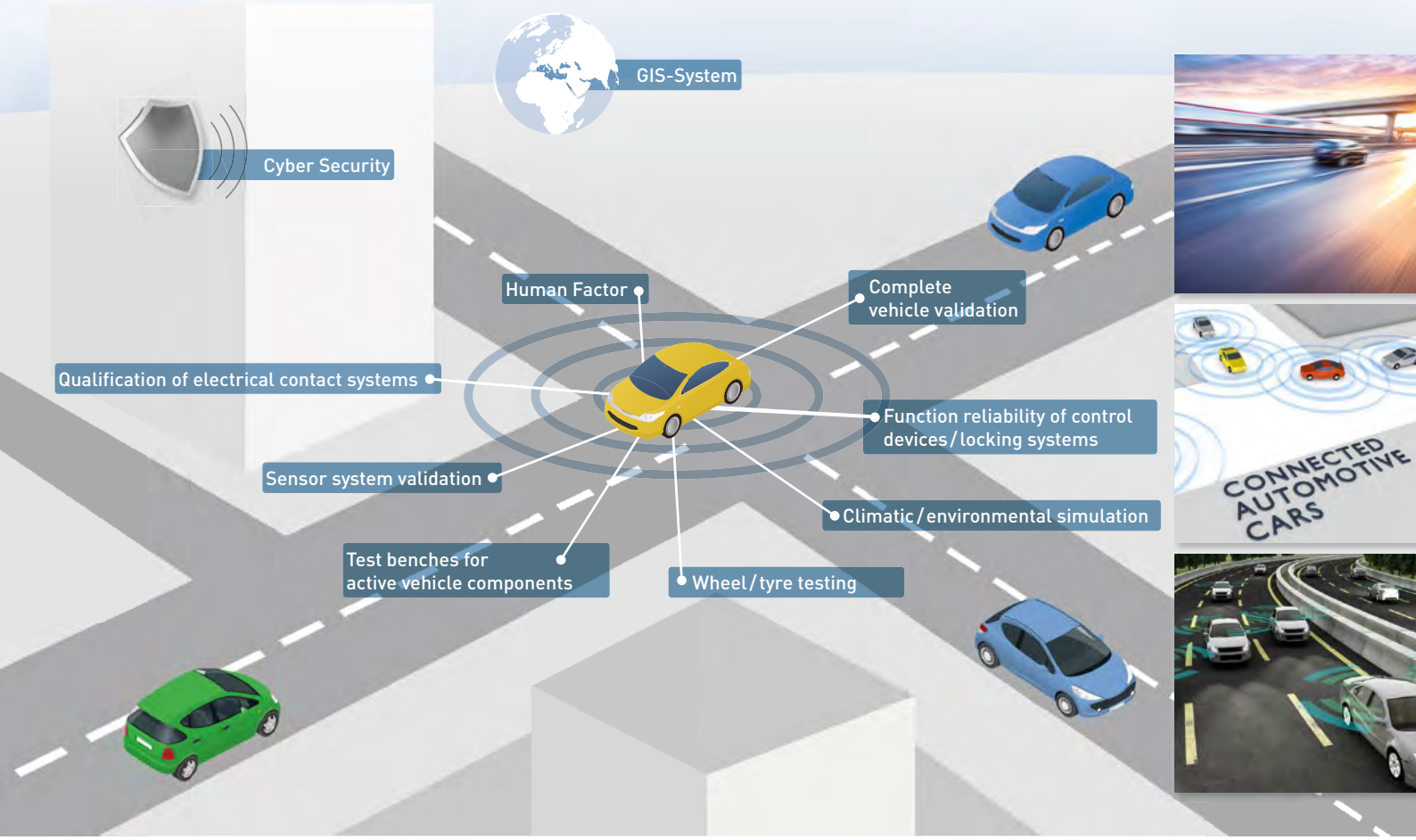
Range of Services for Highly Automated • Autonomous Driving

Safety and reliability are decisive in the development of driver assistance systems for automated and autonomous driving. We provide our customers with a wide range of services which can be individually customised. In the field of highly automated and autonomous driving the focus is on:

COMPLETE VEHICLE VALIDATION

COMPONENT VALIDATION

SENSOR SYSTEM VALIDATION



Complete vehicle validation

Sensor system validation

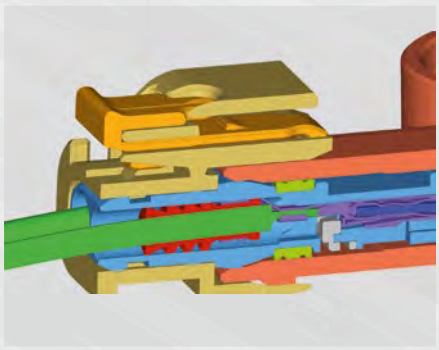
Functional reliability and human factors

Cyber security

Test benches for active vehicle components

Climatic / environmental simulation

Wheel / tyre testing



Qualification of connectors

safeHAD • SOTIF

Complete Vehicle Validation

Our Services

Vertical Dynamics Structural Test Bench

- Function and performance analyses under the influence of mechanical stress and various climatic conditions
- Endurance tests
- Optional integration of target generators
- 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

Acoustics Analyses

- Simulation of acoustic loads up to 156 dB (OASPL)
- Performance of acoustic fatigue tests making use of a progressive wave tube for up to 170 dB (OASPL)
- Measurement of sound pressure distribution, sound absorption and sound transmission
- Measurement of sound pressure and sound power in compliance with ISO 3740 ff or other standards

EMC Measurements

- Measurement of emitted interference/testing of immunity to interference up to 40 GHz with fields of > 2,000 V/m
- Lightning (LEMP) and simulation of the nuclear electromagnetic pulse (NEMP)
- Simulation and properties of vehicle electrical systems
- Three shielded anechoic chambers for system and component tests

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Sensor System Validation

IABG assists its customers right from 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.

Customer Benefits

- Integrated, systematic approach for assessing safety and reliability (functional safety according to ISO 26262)
- Validation of intended functionality and avoidance of violation of safety goals (Safety of the Intended Functionality (SOTIF) according to ISO/SAE J 21448)
- Quantifiable results using IABG's own analysis framework
- Comprehensive experience with buffer memory tests through IABG's own test bench developments and the operation of customer-specific test benches
- Operation of numerous established test benches for environmental simulation as part of product qualification including climate, vibration and EMC
- Decades of industry experience including active participation in expert groups and standardisation bodies

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Functional Safety

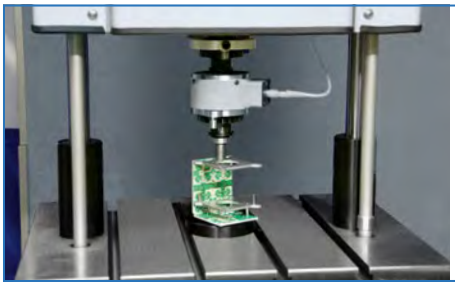
- Process consulting and safety engineering according to ISO 26262 at system, hardware and software levels all along the V-model
- Assessment – conformity of the development with relevant standards and guidelines
- Audits – verification of product safety

Safety of Intended Functionality (SOTIF)

- Safety analyses of sensor architectures according to ISO PAS 21448
- Deduction of system boundaries during operation
- Deduction of system and sensor performance requirements
- Identification of critical corner cases for additional detailed investigation

Hardware-in-the-Loop Testing

- Scenario-based and physics-based modelling and simulation
- Model integration
- Scalable end-to-end HIL test solutions based on the ADAS iiT platform
- Test services, evaluations and support



Product Qualification

- Verification and validation of vehicle components
- Test evaluations and reports
- Validation of mechanical, modal, climatic and EMC requirements
- Integration tests

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IABG. The Future.

Functional Safety and Human Factors

The human interaction and integration with technology is reaching new levels – highly automated and fully automated driving has now become the mid-term goal of all automobile manufacturers.

Dependability plays a major role here. Dependability addresses different system characteristics including the safety and availability of a system. The integration of digitised systems makes demands on safety (the effect of technology on humans and the environment) and security (the effect of humans and the environment on technology).

Safety involves avoiding inacceptable risks or the physical damage of a system and its components, protecting the environment from harm and preventing failure of safety-critical processes through the test objects. Safety, therefore, goes beyond purely functional safety and also encompasses, for example, the electrical safety of the power train or the chemical safety of the battery.

Security is concerned with crime prevention, i.e. measures to prevent unauthorised manipulation of a system, a machine or a network environment. This is more comprehensive than straight Cyber Security. For example, an ADAS radar can be influenced by jamming and spoofing.

Our holistic approach includes system availability as well as **Human Factors**. We apply an *all hazards* policy in our projects which can be summed up with the abbreviation ***TAHOI***[1].

We support automotive manufacturers and suppliers in achieving their goal of developing products with maximum safety and security, and bringing them to market. To this end we provide our customers with our expertise and experience.

Our Services / Solutions

Consulting • Training • Engineering • Method Development • Audits and Assessments

- For processes, products and safe operation
- Considering the aspects of Safety, Security, Availability and Human Factors
- Across all phases of the life cycle and all work products
- Including analyses, requirements management, validation and verification

We work in compliance with the following standards and regulations (excerpt):

ISO 26262; SAE J3061; UL 2900; IEC 62443; TISAX; ISO PAS 21448; IEC 62879.

[1] **TAHOI**: **T**echnical failures, **A**cts of god, **H**uman errors, **O**rganizational failures, **I**ntentional acts

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Cyber Security

Our experts help companies and public authorities alike to arm themselves better against cyber attacks and protect themselves effectively against data theft and loss as well as against financial damage.

Our Services

- Investigation of the requirements for a secure link-up of all systems and components involved
- Creation of concepts for secure mobile and stationary network architectures like new-generation mobile communications networks, wireless LAN, ad-hoc networks, Galileo PRS, wide and local area networks
- Provision of remote access security (remote maintenance, OTA)
- Creation of risk/threat analyses
- Penetration tests for individual components and systems
- Creation of IT security concepts
- Knowledge and consideration of various standards and guidelines for cyber security like ISO 27001, IEC 62443 ...
- Promotion of information security awareness; support through training courses at the IABG Advanced Cyber Range

Test Benches for Active Chassis Components

We configure and implement test facilities at the highest of technical standards. They offer reliable operation, easy handling, flexible use, cost-effective maintenance and can be adapted to solve specific problems. In this way we ensure cost-efficiency and a guaranteed future.

Our Services

- Customer support and advice in creating product specifications, designing and implementing test benches
- Products/test benches for springs, roll stabilisers, steering systems, sensors, electric drives and actuators, development test benches and parameter verification
- General contractor for special test benches
- After sales and support

Examples

- HIL test benches for chassis control systems
- Endurance test bench for vehicle alternators
- Endurance test bench for ESC steering systems
- HIL test bench for ESC steering systems
- HIL test bench with climatic chamber for rear-axle steering systems
- HIL test bench for rear-axle steering systems

Climatic / Environmental Simulation

In our laboratory, we subject parts and components to rapid ageing and run function checks under extreme environmental conditions. For many years now, our experience and know-how have been channelled directly into the development of our customers' products.

We test in compliance with standard specifications such as MIL-STD 810, RTCA/DO-160, ISO 16750, DIN EN 60068-2 as well as according to manufacturers' standards.

Test capabilities
High altitude chamber – up to 3,800 m above sea level
Vacuum chamber – up to 20,000 m above sea level
Temperature chamber
Climatic chamber
Vehicle chambers
Combined chamber
Solar simulation facility
Conditioning units
Splash water test chamber
Mobile corrosion chamber
Dust test chambers

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Wheel / Tyre Testing

High-Speed External Drum Test Bench

A multiaxial test bench (radial impact, slip angle and camber angle) for testing wheels, brake disks, wheel assemblies and tyres. Tests in compliance with the following regulations:

- AK-LH 08
- PV-5608
- Wheel rolling test
- Cleat test
- SAE J-328
- FIAT Standard
- Ford Standard
- Land Rover Engineering Standard
- Japanese Industrial Standard JIS D 4103:1998
- Customer-specific requirements

Technical Data	
Speed	up to 300 km / h
Brake pressure	up to 150 bar dynamic
Max. axial load	40 kN
Max. radial load	40 kN
Slip angle	± 15°
Camber angle	± 5°
Drum diameter	2,000 mm
Drum width	500 mm

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Flat-Trac ® III
CT Flat Track Tyre Test Bench

High-level precision tyre measurements under stationary and dynamic operating conditions for optimising the quality of tyre and vehicle simulation models.

- Determination of characteristics; stationary and dynamic measurements
- Standardised test procedures (e.g. TIME)
- Definition of tyre parameters
- Special tyre measurements
- Customer-specific demands

Technical Data	
Max. setting values	
Tyre diameter	910 ± 0.25 mm
Tyre width	450 ± 0.25 mm
Speed	250 ± 1 km/h
Spindle drive	2.800 ± 20 Nm 1,100 ± 13 rpm
Slip Angle	± 30 ± 0.01 °
Adjustment speed	50 ± 1 °/s
Inclination Angle	-12 ... 45 ± 0.01 °
Adjustment speed	5 ± 0,1 °/s
Wheel load Fz	25,000 ± 1 % N
Movement speed vz	300 ± 3 mm/s
Tyre pressure	700 ± 5 kPa
Max. measured values	
Longitudinal force Fx	10.000 ± 1 % N
Lateral force Fy	15.000 ± 1% N
Camber torque Mx	10.000 ± 1% Nm
Driving and braking torque / Rolling resistance torque My	3.000 ± 1% Nm
Bore or self-aligning torque Mz	3.000 ± 5 Nm

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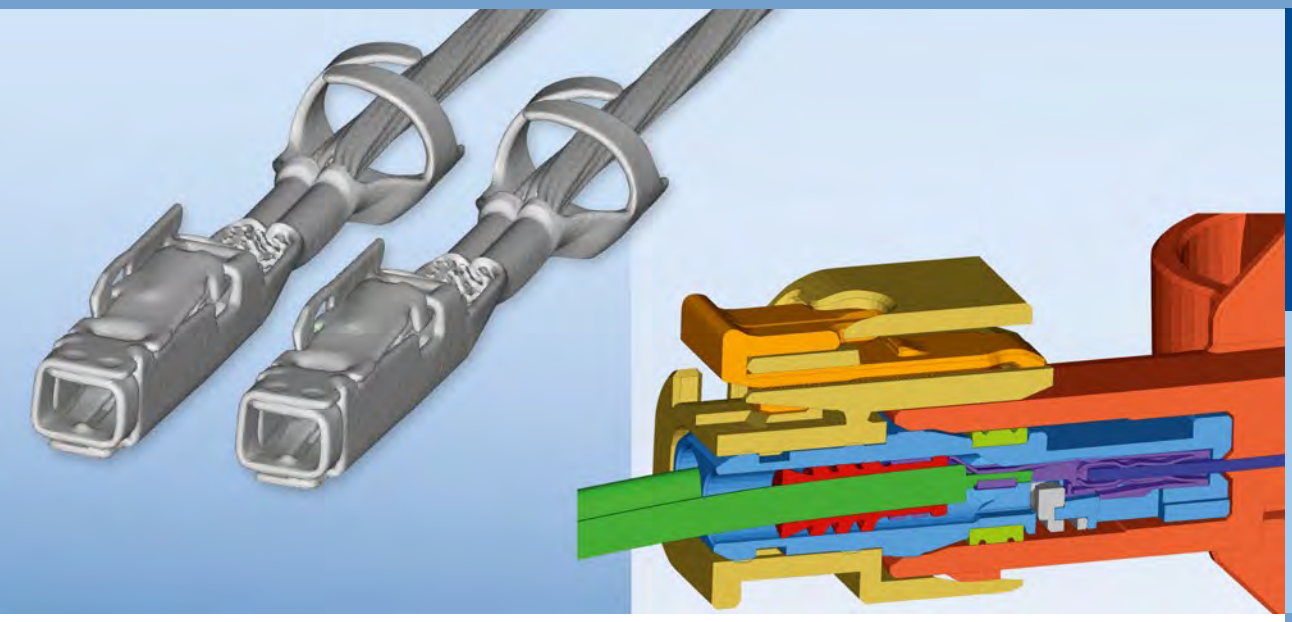

Qualification of Electrical Connectors

Causes of damage • Optimisation • Qualification

Electrical contact systems play a decisive role in the reliability of technical systems. Mechanical loads from external forces and vibrations under corrosive environmental conditions place high demands on complex connectors. Sliding movements and electrochemical processes can influence the wear behaviour of surfaces in the contact system and thus affect their electric conductivity.

In order to guarantee functionality during the required service life, these effects must be understood and taken into account in the design and verification phase.

The installation of a verification chain of simulations and tests requires knowledge of the relevant damage mechanisms and the corresponding the corresponding external loads and internal stresses and strains.

This knowledge provides the background to evaluate and improve the system's reliability. IABG follows an interdisciplinary approach and harnesses the necessary simulation, testing and analysis methods to evaluate and optimise the performance of a system design.

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VDI 3822-compliant damage analysis

- Determination of the primary damage mechanism (e.g. wear or fretting corrosion)
- Deduction of possible damage causes
- Damage reconstruction via 2D in-situ x-ray analysis

Modelling and comparison of models

- Generation of CAD data from CT scans of real components
- Construction of an FE model including cable routeing and contact surfaces
- Inclusion of material-specific parameters
- Experimental verification of vibration behaviour
- Validation of deformations and sliding movements with real-time radiography
- Experimental determination of parameters and model adjusting

Load determination through simulation and testing

- Load determination by means of vehicle and test bench measurements
- Simulation of stress and strain on cables, components and contacts
- Load data analysis and derivation of damage-equivalent test loads (FatiResponse)
- Simulation of external and internal deformations, contact forces and sliding movements

Load capacity determination

- Vibration tests under various climate and environmental conditions
- Abrasion tests on contact systems
- Continuous or intermittent measurement of frictional wear and change in resistance
- Statistical test planning and evaluation

Verification and optimisation of the system‘s reliability

- Comparison of loads and load capacity parameters
- Computational estimation and experimental verification of function and durability
- Computational and experimental parameter studies
- Optimisation of component design, cable routeing and system integration

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safeHAD SOTIF

How safe is safe enough?

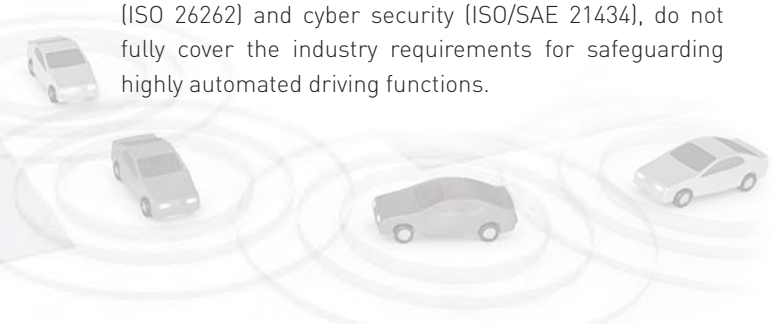
Highly Automated and Autonomous Driving

The IABG **safeHAD** method makes the SOTIF standard usable in practice and delivers reliable information to prove the safety of highly automated driving functions – customer-specific and efficient.

Safe highly automated driving (HAD) is a key challenge for manufacturers

The verification of functions for highly automated driving is the central focus of all manufacturers and suppliers. The effort involved for the proof of safety is enormous. Current concepts require hundreds of thousands of scenarios and hundreds of millions of test kilometres.

Current verification methods – virtual or real – are extremely limited with regard to completeness, representativeness, reproducibility, especially in critical situations. Furthermore, current standards, e.g. for functional safety (ISO 26262) and cyber security (ISO/SAE 21434), do not fully cover the industry requirements for safeguarding highly automated driving functions.



We have made the SOTIF standard usable for real-world use

- The resulting SOTIF standard for the intended function safety (ISO/DIS 21448) complements the current standards and addresses additional safety risks that arise additionally from the complexity of the application environment.
- With **safeHAD** we have developed a method that makes the SOTIF standard usable in practice in your development process.
- **safeHAD** determines probabilities of occurrence of accidents of various degrees of severity - from roughly in the concept phase to precisely in the release procedure.
- In early phases, design alternatives can be compared, analysed and evaluated in order to identify system weaknesses early in time and avoid wrong decisions.
- In the later phases of product development, **safeHAD** provides a robust safety assessment for the release of the function and approval of the system.
- The method can be applied both to subsystems and to the overall system.

How you benefit from applying the safeHAD method

- You save time and money by using **safeHAD** to identify weak points in good time and avoid costly and time-consuming error correction at a later date.
- You improve the quality and competitiveness of your products by identifying and verifying requirements for the function and system components at an early stage.
- With **safeHAD** you can evaluate your systems in compliance with the SOTIF standard and thus provide reliable proof of safety within the scope of type approval.
- Save your resources: we advise, guide you through the process and handle application of the method - tailored to your function and your system components.

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IABG

AUTOMOTIVE

INFOCOM

MOBILITY, ENERGY & ENVIRONMENT

AERONAUTICS

SPACE

DEFENCE & SECURITY

About IABG

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.

As a development partner we provide quality control services and develop solutions in the areas of functional efficiency, quality, design, and materials. We offer a broad spectrum of products and services, ranging from numerical analysis to experimental testing to the realisation of turnkey, customised test systems that we operate for the customer.

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