

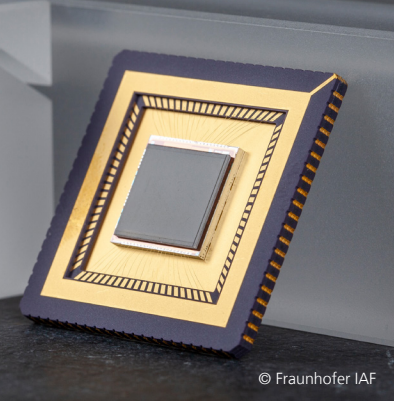


Fraunhofer
VVS

FRAUNHOFER-SEGMENT FOR DEFENSE
AND SECURITY VVS

**WE CARRY OUT RESEARCH INTO THE
SECURITY OF MANKIND, SOCIETY AND
THE STATE – FOR A LIFE OF FREEDOM**





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FRAUNHOFER SEGMENT FOR DEFENSE AND SECURITY VVS

We carry out research into the security of mankind, society and the state – for a life of freedom

In times of social and political unrest, defence and security become increasingly important. We develop technologies, products and services for the early detection of dangerous situations, so that they can be counteracted, consequential damage can be minimised and, as a result, the overall level of risk can be reduced.

The Fraunhofer Segment for Defence and Security pursues research and development in the areas of **defence and civil security**.

Our wide-ranging expertise and research have delivered highly practicable solutions and operational support, both at the national and international level. In defence research, our excellent judgement and consultancy skills make us indispensable independent experts and partners of the German Ministry of Defence (BMVg). We research and develop technologies and system solutions for the Ministry, its government bodies and for the German Armed Forces (Bundeswehr). Our technical solutions and systems in civil security are designed to deliver the best possible protection for society. We cover the interests and activities of our member institutes, acting as their representative both within and outside the organisation. We create joint benefits through mutual support, by complementing one another professionally, through a division of labour and by coordinating the areas in which we specialise.

The Fraunhofer Segment for Defence and Security **provides comprehensive security models**: Our research focuses on security and protection against military, technical, terrorist, natural and criminal threats. From this, we deduce the **areas of application** for our research:

- Systems and technologies for use on land, in the air, water, space and cyberspace
- Information gathering, provision of information and decision-making support
- Networked operations
- Protection and impact
- Electronic warfare
- Cross-system technologies
- Resilience and protection of critical infrastructures
- Combating of terrorism and crime
- Border security
- Crisis and disaster management
- Digital transformation

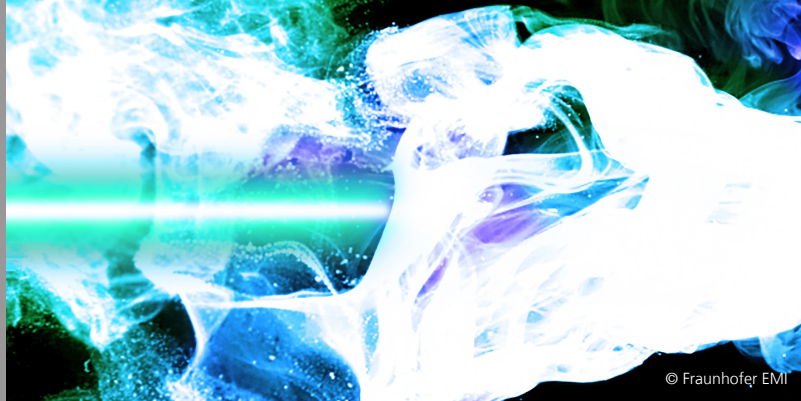
We carry out research into the security of mankind, society and the state – for a life of freedom.

INSTITUTES AND ASSOCIATED MEMBERS

- Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI
Protection, Security and Effects
- Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR
Radar – A Key Technology
- Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE
Command, Control and Reconnaissance
- Fraunhofer Institute for Applied Solid State Physics IAF
Sensors for Safety, Security and Reconnaissance
- Fraunhofer Institute for Chemical Technology ICT
Security, Safety and Energetic Materials Technology
- Fraunhofer Institute for Technological Trend Analysis INT
Planning Support for State and Industry

INSTITUTES AND ASSOCIATED MEMBERS

- Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB
From Networked Sensor Data to Decision
- Fraunhofer Institute for Experimental Software Engineering IESE
Software and Systems Engineering
- Fraunhofer Institute for Integrated Circuits IIS
Communication, Positioning Technologies and X-Ray for Safety and Security Applications
- Fraunhofer Institute for Transportation and Infrastructure Systems IVI
Algorithms for Risk Analysis, Situation Evaluation and Decision-Making Support
- Fraunhofer Institute for Structural Durability and System Reliability LBF
Secure Processes for Secure Structures



PROTECTION, SECURITY AND EFFECTS

The Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, develops and researches new approaches and solutions for applications in the business segments defense, security, space, automotive and aviation. The institute's competences are the investigation of impact, shock and penetration phenomena by experimental, simulation-based and analytical methods in order to improve the security, safety and reliability of components, structures and systems under dynamic loads.

Protection & bridging technologies

Fraunhofer EMI analyzes and develops protection concepts and new materials for high dynamic loadings, sensor systems for the application in ballistics as well as practice oriented engineering software. Solutions range from vehicle and personal protection systems against ballistic and explosive threats, the protection of service infrastructures and the development of materials to the reduction of vulnerabilities of aerostructures and vehicles.

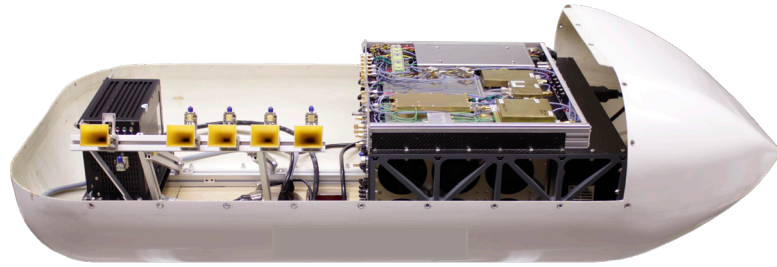
Protection of critical infrastructures

The main research focus lies on technologies to physically protect critical infrastructures. Our solutions include efficient building reinforcement and structural concepts, the development of dedicated, customized materials such as ultra high performance concretes and integrated sensor systems for real-time monitoring of static loading capacities. Thus, we can offer balanced security concepts of the protection of building infrastructures.

Hazard and risk analysis

Hazard and risk analysis research services provided by EMI support the risk management especially in case of terrorist events such as explosions, but also in case of industrial accidents, natural disasters and even of cross-linked, multimodal risks caused by such events.

Image: Formation of a vapor cloud in a laser-irradiated sample made of carbon-fiber-reinforced plastic.



KEY TECHNOLOGY RADAR

Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR researches customized concepts, techniques and systems for electromagnetic sensors from the microwave range through to the lower terahertz range. For its partners, the institute develops high frequency sensors for ultra-precise range or position determination as well as imaging systems with resolutions of up to 3.75 mm. The systems are also capable of tracking and classifying detected objects. Typical application areas for these devices include reconnaissance, surveillance and protection on various platforms in rural and urban environments. Radar is ideal for the acquisition of position data irrespective of the weather and lighting conditions. With several anechoic measurement chambers, technology centers for the production of analog and digital circuit boards as well as high frequency technology through to the lower terahertz range, the institute offers excellent possibilities for the development of modern electromagnetic sensor systems. The technologies used range from traditional waveguide techniques to highly-integrated silicon-germanium chips with frequencies of up to 300 GHz.

The range of services offered by Fraunhofer FHR include:

- Technology consulting, performance analyses and appraisals
- Development of user-specific imaging, detection, classification and tracking methods (signal processing and result presentation

in real time and knowledge-based)

- Hardware and software development for robust, interference-resistant radar systems for various platforms with high resolution and dynamics from the design right up to the operational product
 - Scanner and mobile systems for the active screening of persons and objects, detection of fire sources, monitoring of critical infrastructures
 - Perimeter, coastal and air surveillance, detection of small drones and floating bodies
 - Observation of gatherings of people, panic detection, detection of signs of life
- Design of active and passive radar sensors for close- and long-range applications
- Development of camouflage methods, deception, jamming of external radars and hardening of internal systems
- Radars for space reconnaissance: techniques, methods and systems for the reconnaissance and surveillance of the situation in space, mission support and analyses

Image: Intelligent multifunctional radar sensors for autonomous airborne platforms



COMMAND, CONTROL AND RECONNAISSANCE

The Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE develops technologies and processes with the goals of detecting life-threatening risks early and effectively minimizing and managing these risks. In cooperation with strategic partners we address the specific issues and challenges of command and control as well as reconnaissance. We cover the topics of data acquisition, information processing and analysis, dissemination and communication as well as the protection of the data and information products. Our work is focused on creating effective and efficient human-

machine systems, with the human factor playing the central role in the decision making process.

Our research is applied within the context of use of the German Federal Armed Forces (Bundeswehr), the civilian security agencies and throughout industry. We are developing methods and procedures for all aspects of security - be it on the ground, in the air, at sea, under water or in cyberspace.

Creating Situational Awareness out of Sensor Data

The latest sensor technology, networked communication systems and information-fusion are vital tools in threat detection. The FKIE conducts studies on systems and components designed for acquiring and processing relevant sensor data in different ways, from

collecting sensor data by sensors on robotic systems to recognizing threat indicators in cyberspace. As part of our holistic approach, we examine how to merge and aggregate information from these heterogeneous sources to provide a comprehensive situational picture. To ensure that threats are detected quickly and reliably we also work on human-computer interaction that best meet the users' context, task and information needs.

Providing Support for Command and Control

Our research areas support command and control processes including decision support. To consolidate decision making by comprehensive situational awareness we analyze application-specific information, process it for the users' needs and present it ergonomically for intuitive interaction. We explore command and control systems under information processing, architectural and ergonomic perspectives. In addition, the exchange of information between heterogeneous systems and secure communication in all situations are covered by our research. In the cyberspace domain, we support the detection of unauthorized access, and provide protective measures to ensure the security of critical systems, even those with the highest security constraints.



SENSORS FOR SAFETY, SECURITY AND RECONNAISSANCE

Fraunhofer Institute for Applied Solid State Physics IAF

offers a broad portfolio for safety, security and reconnaissance applications – reaching from high-resolution radar systems, laser spectroscopy, high-speed circuits and power amplifiers to infrared components as well as quantum sensors:

- Imaging millimeter-wave and infrared cameras for applications under restricted visibility conditions, e. g. strong smoke or dense fog
- High-resolution radar systems for fast and precise distance measurements, supporting helicopter pilots during landing maneuvers under whiteout or brownout conditions
- Infrared lasers for the standoff detection of smallest traces of hazardous substances in real time; for example on baggage at airports or train stations
- Directional radio links for very high data rates for broadband, wireless communication such as tactical data links
- Broadband jammers to suppress radio signals activating explosive devices
- Imaging, dual-color infrared sensors to protect aircrafts from approaching missiles
- Diamond-based quantum sensors for GPS-independent navigation

Due to their physical properties, III-V semiconductors and synthetic diamond are ideal candidates for state-of-the-art defense and security technologies. On the basis of these materials, Fraunhofer IAF develops pioneering components for high-frequency, power and optoelectronics as well as quantum technologies and is one of the few research institutions world-wide to cover the entire value chain in these fields: from material research and the design of components to the realization of complete modules and systems. For its research activities, the institute is equipped with a clean room and a MOCVD machine hall featuring cutting-edge semiconductor process and measurement technology.

The R&D activities of Fraunhofer IAF are certified according to ISO 9001/2015.



SECURITY, SAFETY AND ENERGETIC MATERIALS TECHNOLOGY

Fraunhofer Institute for Chemical Technology ICT offers its long-standing research experience in the field of explosives to the German Federal Ministry of Defence, the public sector and industrial customers in the form of extensive knowhow, laboratories and experimental workshops for R&D purposes at Fraunhofer ICT allow for carrying out projects from a laboratory up to a small production scale. Fraunhofer ICT draws on the competence of its employees in the development of improved chemical energy sources, energy supplies and systems for the German army and the development of new technologies and materials for defense against terrorist attacks. In particular Fraunhofer ICT offers R&D services in the following fields of technology:

Energetic materials

Development, manufacture and characterization of:

- Rocket propellants for defense and space applications
- Gas generators
- Gun propellants, explosives, new ignition systems
- Chemical fuels and systems
- Safety and protective systems

Modeling tools:

- Interior ballistics
- Reaction kinetics, combustion processes, thermodynamics

Detection technology:

- Detection of explosives in the area of civil security, for example for portal systems in the framework of national and European projects (EXPEDITE, EMPHASIS, among other projects)
- Test Center for the Detection of Liquid Explosives
- Electrochemical sensor technology

Safety and security technology:

- Technologies for counter IED and defense of terrorist attacks
- Non-lethal weapons

Technical safety and security

- Risk analyses in the handling of combustible and explosive materials
- Investigation and analysis of safety risks and accident scenarios in the design / operation of industrial testing units
- Safety and security assessments of energy storage devices

Energy supply systems

Electrochemical energy storage devices and converters:

- Redox-flow batteries
- Lithium ion batteries
- Fuel cell systems
- Safety investigations on energy storages and converter systems
- Energy management systems



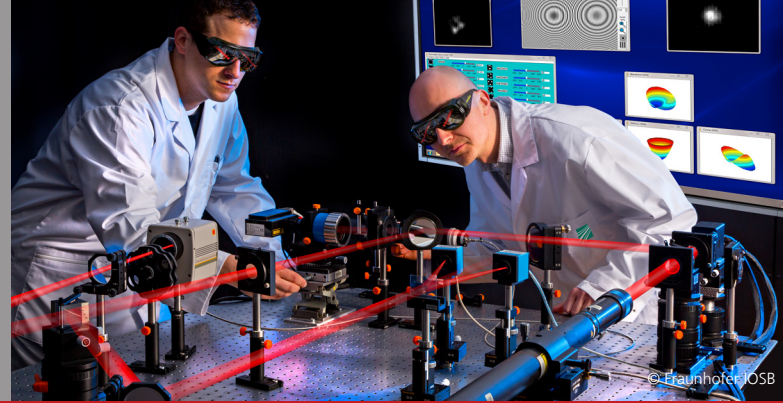
PLANNING SUPPORT FOR STATE AND INDUSTRY

The Fraunhofer Institute for Technological Trend Analysis INT provides scientifically sound assessments and counseling on the entire spectrum of technological developments. On this basis, the Institute conducts Technology Forecasting, making possible a long-term approach to strategic research planning. Fraunhofer INT constantly applies this competence in projects tailor-made for our clients. Over and above these skills, we run our own experimental and theoretical research on the effects of ionizing and electromagnetic radiation on electronic components, as well as on radiation detection systems. To this end, INT is equipped with the latest measurement technology. Our main laboratory and large-scale appliances are radiation sources, electromagnetic simulation facilities and detector systems that cannot be found in this combination in any other civilian body in Germany.

For more than 40 years, INT has been a reliable partner for the Federal German Ministry of Defense, which it advises in close cooperation and for which it carries out research in technology analysis and strategic planning as well as radiation effects. INT also successfully advises and conducts research for domestic and international civilian clients: both public bodies and industry, from SMEs to DAX 30 companies.

Business Units

- Defense Technology Foresight
- Public Technology and Innovation Planning
- Corporate Technology Foresight
- Electromagnetic Effects and Threats
- Nuclear Security Policy and Detection Techniques
- Nuclear Effects in Electronics and Optics



NETWORKED SENSOR DATA

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB is an established partner for networked optronics (electro-optical systems) as well as image acquisition, processing and analysis. The institute's spectrum of scientific competencies covers the entire lifecycle of optronics: starting from the light sources, moving on to the light propagation through the atmosphere, the gathering of information from data sensors up to preparation of information for decision-making.

Our **defence research** follows the mission statement »scientific advice and technology for the German armed forces «; this concludes feasibility studies and development of procedures as well as technology assessment, testing and development of demonstrators and contract research for the industry. In the fields of **research for civil security, technological concepts and solutions for authorities and organizations** (e. g. fire department and police) as well as for companies of the security industry are being developed by Fraunhofer IOSB.

Characteristic examples:

- **Laser protection:** novel, non-linear optical filters protect sensors and eyes from dazzling / destruction in the visible and infrared range
- **Space-based early warning:** satellite-based, electro-optical sensor-systems for the detection of ballistic missiles during launch or after cloud break
- **Terrain databases for simulation systems:** ad-hoc generation of 3D environmental models acquired by imaging sensors for a quickly available terrain simulation database
- **Intelligent video surveillance:** algorithm-based recognition of behaviour patterns in public spaces (e.g. hitting, kicking, falling)
- **Digital map table:** position visualization in distributed environment on almost any end device based on standardized geo- and sensor-data interfaces
- **Drone defence (counter-UAS):** early and reliable detection and classification of mini-drones using coupled sensor stations and self-developed tracking units
- **Robot systems for environments hostile to humans:** such as the dismantling of landfills or nuclear facilities
- **Cyber security learning lab:** compact, practical qualification of specialists and managers from industry, utilities and public administration

Image: Holography Laboratory



SOFTWARE AND SYSTEMS ENGINEERING

Fraunhofer Institute for Experimental Software Engineering
IESE is one of the world's leading research institutes for applied research in the area of software and systems engineering. We research trendsetting key technologies for smart ecosystems and accompany our customers and partners on the path to digital transformation. The focus of our work is especially on scalable systems engineering with guaranteed qualities in the areas of Safety and Security as well as software-driven innovation.

The offers of Fraunhofer IESE include:

- **Virtual Engineering**
 - Development of customized virtual engineering environments
 - Coupling of simulators and virtual hardware (Digital Twin)
- **Data Engineering**
 - Technology development regarding Big Data analytics and AI applications
 - Development of quality and prediction models
 - Big Data Potential Analyses
- **Engineering of Safety Concepts**
 - Assessment of the safety of software-intensive applications
 - Safety of autonomous systems
 - Modeling and analysis of safety aspects
 - Safety of adaptive systems
- **Simulation**
 - Validation of safety concepts
 - Establishment of simulation environments
 - Validation of design decisions through simulation
- **System and Software Architectures**
 - Development of operational and system architectures in accordance with NAF and ADMBw
 - Evaluation and analysis of system and software architectures
 - Testing and simulation of architectures

Image: From the past to the future – Industrie 4.0 in the defense sector



COMMUNICATION, POSITIONING TECHNOLOGIES AND X-RAY FOR SAFETY AND SECURITY APPLICATIONS

Founded in 1985, Fraunhofer Institute for Integrated Circuits IIS in Erlangen, Germany is the largest of the Fraunhofer-Gesellschaft institutes.

Backed by a wide range of know-how in the field of security, we develop x-ray applications such as 3D computed tomography for inspecting air freight or ocean containers, 2D radioscopy or fast x-ray detectors that feature a high degree of radiation stability.

In the field of communications, one of the institute's core areas of expertise is wireless communication. This includes software defined radio technology for tactical radio communications, high-quality voice and data services for security and military personnel and RFID systems used in security applications and logistics processes.

Fraunhofer IIS provides extensive know-how and experience in the field of positioning and navigation technologies and among other applications develops systems for the localization and precise positioning of people and objects within critical infrastructures. In this area the institute also develops GNSS receivers that are robust against to spoofing or jamming.

Fraunhofer IIS is also engaged with the integrated cyber security of networked and distributed systems in the IoT. We research secure narrowband communication channels especially for industrial processes and applications.

The Nuremberg location is furthermore home to the L.I.N.K. test and application center, a one-of-a-kind facility featuring state-of-the-art equipment for supporting security system development projects and testing.

In the field of security applications Fraunhofer IIS is also involved in the development of virtual reality systems designed for training security and public safety personnel. Fraunhofer IIS offers a wide range of services, from technology and business consulting, feasibility studies, research and development, technology licensing, to independent testing and measurements and various IC technologies for security applications.



ALGORITHMS FOR RISK ANALYSIS, SITUATION EVALUATION AND DECISION-MAKING SUPPORT

Varying threats of a greatly complex nature and with atypical patterns call for specially trained response forces and the availability of high-performance command and communication technologies. Since 2003, the Fraunhofer Institute for Transportation and Infrastructure Systems IVI has been developing modular command and control systems in accordance with the extremely short innovation cycles of modern ICT technologies. These systems are being applied both at large events as well as in day-to-day situations.

MobiKat[®] was developed in cooperation with end-users as a modular system for operational command and the management of resources. It is used for effective situation management and to save human lives during natural disasters, large-scale technical breakdowns, extreme weather conditions, major events and others. The system is freely configurable and runs on various hardware configurations for all command levels.

Its main features are:

- Display of geographical information about the operation site – e. g., traffic network, aerial images, buildings, land use, terrain information
- Visualization of operation-specific information – e. g., flooding zones, tapping points for extinguishing water, critical infrastructures, current water levels, weather conditions, construction sites

- Overview of available staff and resources, damages, affected persons
- Algorithms for optimized decision support
- Synchronization of all situational information

In the event of assassinations, terrorist attacks or hostage takings, the specialized units and forces of the police in particular are faced with extreme challenges. These kinds of operations have a great risk potential and require the highest level of professionalism, as well as the best technical equipment available. The »SE-Netz« technology has become established as a nation-wide standard among special police units. This pioneering software architecture with flexible functionalities has an extremely high safety standard level and forms the basis for MePol – a novel communication system for regular police service.

Building on a profound knowledge of the newest information and communication technology basics, new command functionalities are continuously being developed. These functionalities use a broad algorithm spectrum – including multi-criteria optimization and fast search algorithms for logistics planning – and are implemented as software applications.



SECURE PROCESSES FOR SECURE STRUCTURES

In the central research fields of reliability, lightweight construction, vibration control and polymer technology, the scientist teams at the **Fraunhofer Institute for Structural Durability and System Reliability LBF** systematically develop innovative solutions and tailor-made methods from product design to verification. Their goal is always for the system to work reliably and safely!

Process efficiency

The development and evaluation of **safe and reliable structures** in mobility carriers and systems on land, in the water and in the air are the core competences of the institute. To this end, the research teams continuously work on pioneering and further developing methods of the experimental-virtual reliability simulation which accompanies and safeguards development when reproducing complex operational and operating conditions. Another focus is the development of solutions and methods for the integration of sensors and actuators for the condition monitoring of critical components and structures as well as for the adaptation of structural and system properties to the acute operating conditions. Likewise, the institute develops processes and methods for the development of tailor-made properties of plastics, e.g. in terms of flame-retardant requirements.

Reliable in use

The solutions developed ensure the **reliable operation** of equipment and vehicles under real operating conditions. Reliable vibration reduction not only improves the precision of machines, but also minimizes their wear. Vibroacoustic measures reduce the burden on humans and the environment. The continuous, in-service state detection in turn allows the detection and assessment of the damage impact. As a result, maintenance measures are oriented to the actual condition of structures, which increases the effectiveness of the measures and enables higher availability of the systems.

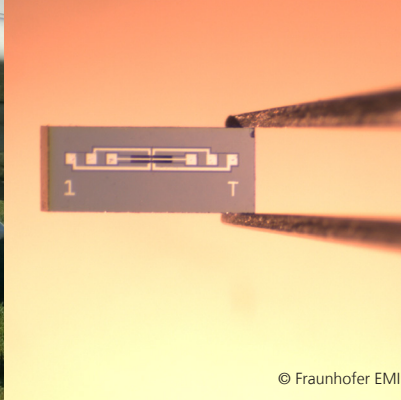
Our services at a glance

- **Structural safety and reliability for improved operational capability**
 - Realistic reproduction of complex operating conditions in the experiment and simulation
 - Condition monitoring during operation and damage detection
 - Customized additivation of plastics
- **Vibration and noise reduction to improve effectiveness and precision**
- **Flame retardants for plastics**
- **Shock reduction to improve protection**

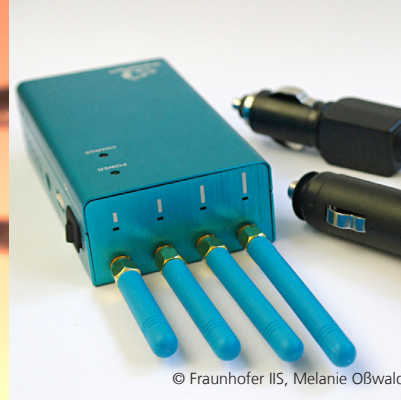
Image: Reliable vibration reduction increases the precision of machines and minimizes their wear.



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© Fraunhofer IIS, Melanie Oßwald



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OUR MEMBERS

Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI

Protection, Security and Effects

Founded 1959, Staff 320, Annual budget 25 Mio. Euro
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Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR

Radar - A Key Technology

Founded 1957, Staff 320, Annual budget 35 Mio. Euro
Executive director: Prof. Dr.-Ing. Peter Knott,
Director: Prof. Dr.-Ing. Dirk Heberling
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Fraunhoferstrasse 20, 53343 Wachtberg, Germany

Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE

Command, Control and Reconnaissance

Founded 1963, Staff 450, Annual budget 38 Mio. Euro
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Fraunhofer Institute for Applied Solid State Physics IAF Sensors for Safety, Security and Reconnaissance

Founded 1957, Staff 305, Annual budget 40 Mio. Euro
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Tullastrasse 72, 79108 Freiburg, Germany

Fraunhofer Institute for Chemical Technology ICT Security, Safety and Energetic Materials Technology

Founded 1959, Staff 539, Annual budget 43 Mio. Euro
Director: Prof. Dr.-Ing. Peter Elsner
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Joseph-von-Fraunhofer-Strasse 7, 76327 Pfinztal, Germany

Fraunhofer Institute for Technological Trend Analysis INT Planning Support for State and Industry

Founded 1974, Staff 120, Annual budget 10 Mio. Euro
Director: Univ.-Prof. Dr.-Ing. Dr. rer. pol. habil. Michael Lauster
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Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

From Networked Sensor Data to Decision

Founded 2010, Staff 790, Annual budget 65 Mio. Euro

Director: Prof. Dr.-Ing. habil. Jürgen Beyerer

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Fraunhofer Institute for Experimental Software Engineering IESE

Software and Systems Engineering

Founded 1996, Staff 213, Annual budget 15 Mio. Euro

Director: Prof. Dr.-Ing. Peter Liggesmeyer

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Fraunhofer-Platz 1, 67663 Kaiserslautern

Fraunhofer Institute for Integrated Circuits IIS

Communication, Positioning Technologies and X-Ray for Safety and Security Applications

Founded 1985, Staff 970, Annual budget 184 Mio. Euro

Executive director: Prof. Dr. Albert Heuberger

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Fraunhofer Institute for Transportation and Infrastructure Systems IVI

Algorithms for Risk Analysis, Situation Evaluation and Decision-Making Support

Founded 1999, Staff 150, Annual budget 15.6 Mio. Euro

Director: Prof. Dr. Matthias Klingner

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Zeunerstrasse 38, 01069 Dresden, Germany

Fraunhofer Institute for Structural Durability and System Reliability LBF

Secure Processes for Secure Structures

Founded 1938, Staff 420, Annual budget 32 Mio. Euro

Director: Prof. Dr.-Ing. Tobias Melz

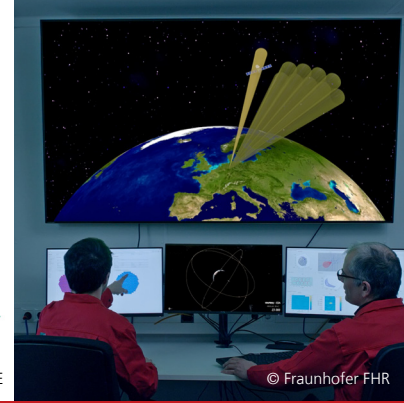
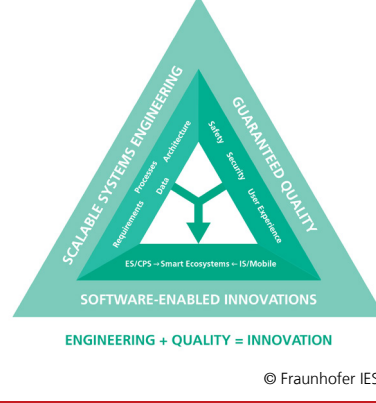
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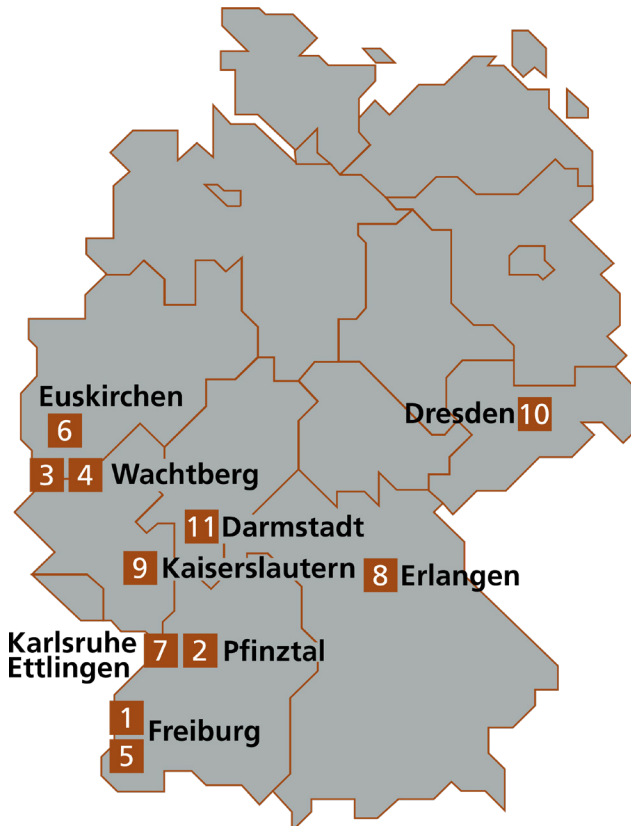
OUR DISTINCTIVE FEATURES

- Coordination of large-scale projects
- System solutions to complex issues
- Excellent infrastructure and laboratory equipment
- Continuous availability of technical expertise at the highest level
- Superb network with research, industry and government
- Thorough judgement and consultancy skills in defence R&T
- Interdisciplinary work and broad technology portfolio

RANGE OF SERVICES

- Feasibility studies
- Strategic foresight, scenarios and roadmapping
- Technological needs and trend analyses
- Assessment of (third-party) systems
- Development of prototypes and processes
- Pilot series production
- Development of methods, technologies, components and systems

LOCATIONS OF OUR INSTITUTES



1. Applied Solid State Physics IAF
2. Chemical Technology ICT
3. High Frequency Physics and Radar Techniques FHR
4. Communication, Information Processing and Ergonomics FKIE
5. High-Speed Dynamics, Ernst-Mach Institute, EMI
6. Technological Trend Analysis INT
7. Optronics, System Technologies and Image Exploitation IOSB
8. Integrated Circuits IIS
9. Experimental Software Engineering IESE
10. Transportation and Infrastructure Systems IVI
11. Structural Durability and System Reliability LBF

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