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LBF

Fraunhofer Institute for Structural
Durability and System Reliability LBF

Joining forces.
Shaping the future.

Annual report 2021

2021 at a glance

The annual report 2021 – digital
www.lbf.fraunhofer.de/annual-report

Environment, safety, the future – we at Fraunhofer LBF are also working on solutions to these global issues.”

Editorial notes.
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Design/Conception: www.gute-botschafter.de **Printing:** www.muellerditzen.de
Fotografie: LBF-Archiv, Ursula Raapke, Katrin Binner, Piotr Banczerowski, IPG Automotive GmbH, AdobeStock (BANU SEVIM, pegasosart, belyaaa, lirtlon, cegli, BigBlueStudio, mirkomedia, Doris Gräf, heike114, New Media & Films, oatawa, marvent, Oleg Breslavtsev, vegefox.com, Farknot Architect), pixabay (geralt), Piotr Krzeslak, AA+W

Sustainability, digitalization and lightweight design are key challenges of our time. We provide smart solutions in technical applications.”

Prof. Dr. Tobias Melz,
Institute Director

Sustainable. Secure. Forward-looking.

Dear Customers and Partners of Fraunhofer LBF!

In 2021, the entire world was once again faced with major and varied challenges, which will affect us economically, socially and politically in the coming years on both a personal and professional level. The dynamics of change and the pressure to act are palpable, while discussions and assessments are sometimes peremptory and emotional. This makes it difficult to identify positive prospects and address tangible solutions. Sometimes, it seems to simply take more shared courage, sincere understanding and determination to achieve swift and sustainable progress. “When we have to prove ourselves in a crisis, we also grow in strength.” (R. v. Weizsäcker). In this respect, I see the challenges we currently face as being excellent opportunities for our future.

Over the past year, we have continued to systematically pursue our agenda for the future. Within the framework of research and development projects, we have continuously advanced our core topics of lightweight design, sustainability and digitalization across all phases of product design, safeguarding and use, right through to closed-loop recycling for applications in mobility, plastics technology, and mechanical and plant engineering. In a large number of individual, co-operative and directly commissioned R&D projects, our team has developed new methods for the reliable and operationally stable design of products and processes, new and more efficient technologies for numerical, experimental and cyber-physical simulation, sustainable solutions for bio-based and recycled plastics, and new structural concepts for smart, efficient lightweight solutions. We have summarized a **selection of our projects** for you in this Annual Report based on our service areas.

Highlights of our activities include further developments within the **Circular Plastics Economy** cluster and the **Waste4Future** project that was launched last year, in which we are developing sustainable solutions for the recycling and use of plastics. Together with the recently launched **SUBI2MA** project, our team is continuously expanding its offerings in these research projects to specifically develop additive systems from renewable raw materials for the post-stabilization of recyclates, the degradation control of plastics or the provision of high-quality substitute plastics. We are also helping to shape a sustainable future through our **Green-Mat4H2** High-Performance Center, in which we are working with partners to provide new technologies for the reliability design of materials and components for hydrogen-powered systems.

To this end, last year we also worked on lightweight solutions for the mobility of the future. In several projects, we are researching new structural and design concepts with which we can specifically and atypically adjust vibration and acoustic properties of structures using so-called **vibro-acoustic metamaterials (VAMM)** for implementation in lightweight construction. These are of particular interest in mobile systems for vehicle construction, but they are also being developed for immobile applications. As part of the **ALBACOPTER®** project, an electric, autonomous flying transport drone is being developed – the initial flights with test systems have been carried out by our partners. The system and structural concept for a test system with a 7-meter span is currently being finalized and the production engineering stage is being initiated. As part of the **ECO_2-LInE** project, we are developing additively manufactured light-weight components made of natural fiber-reinforced plastics that will replace heavier, conventional metal structures in train car connections.

Under the banner of digitalization, we regularly develop individualized special tools for our customers, in particular for machine dynamic and multiphysical analyses and the development of systems and lightweight structures. In this context, last year we were able to make a widely applicable software solution for vibration problem analysis and structural optimization commercially available through a strong partnership with Altair Engineering Inc.

The digitalization of the development process of mechanical engineering systems has also been advanced through recent research collaborations on modeling and simulation of vehicles with different drives, project **ORCA**, on predictive machine maintenance with distributed AI, **ProKInect**, or on AI-based noise reduction in container ports as part of the **I²PANEMA** project.

It has been an exciting year, marked by shared challenges and many valuable research findings and utilization options. We are pleased to present some of our research work below and look forward to talking to you about it. We would like to extend our thanks to our customers and partners for their close, trusting cooperation through multiple direct collaborations. We, the Fraunhofer LBF team, will continue this in the future and work with you in this time of change to actively navigate through challenges in the best possible way. We wish you continued success and an insightful, inspiring read. Please get in touch, we look forward to hearing from you!

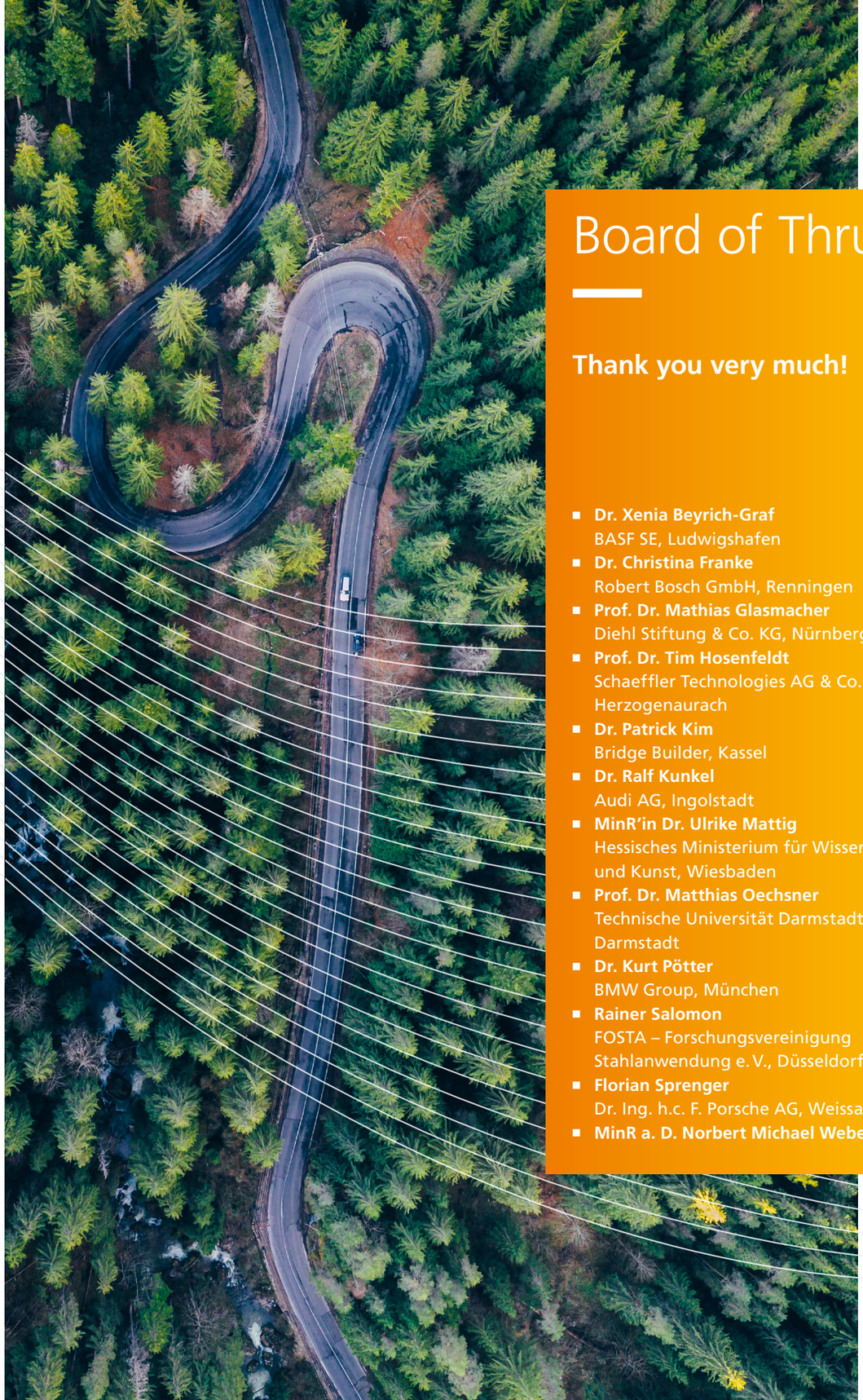
Best regards,

Prof. Dr. Tobias Melz,
Institute Director

2021 – printed as well as digital

With this annual report, we are using the digital channels in a new and closely interlinked way. You will find a lot of attractively prepared content within our online presence

www.lbf.fraunhofer.de/annual-report



Board of Thrusts

Thank you very much!

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- **Dr. Christina Franke**
  Robert Bosch GmbH, Renningen
- **Prof. Dr. Mathias Glasmacher**
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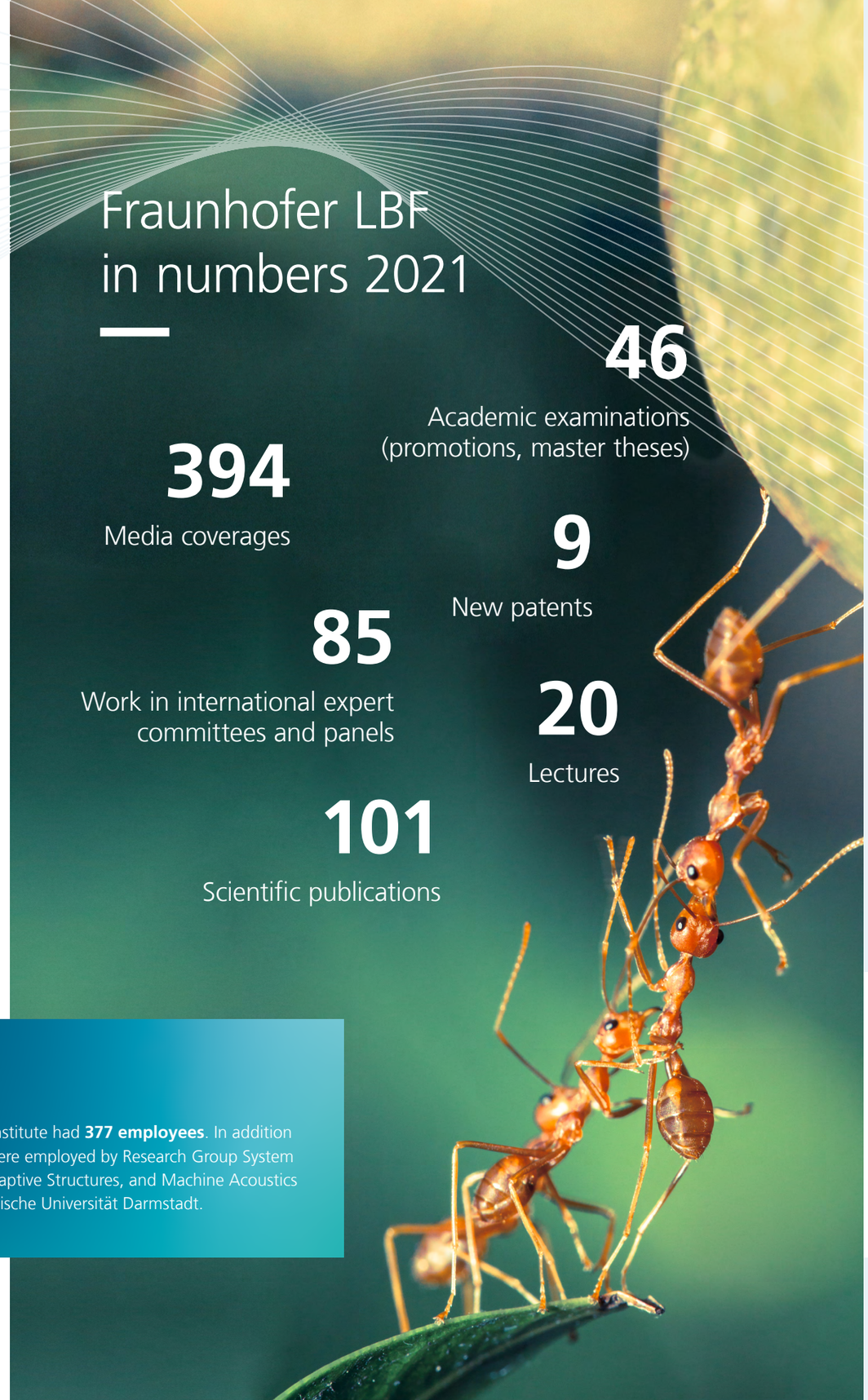


Fraunhofer LBF in numbers 2021

46
Academic examinations (promotions, master theses)

394
Media coverages

9
New patents

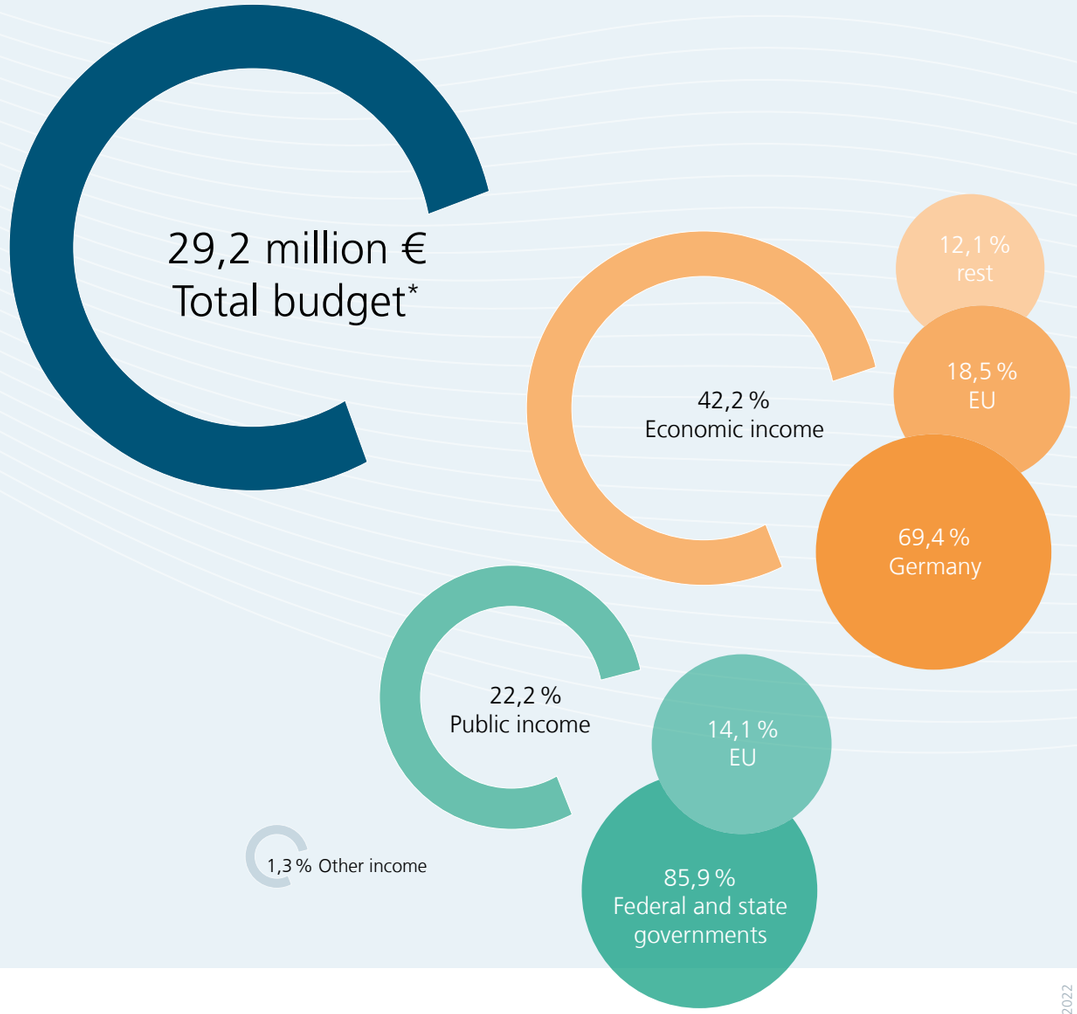
85
Work in international expert committees and panels

20
Lectures

101
Scientific publications

Personnel

In 2021 the institute had **377 employees**. In addition 39 persons were employed by Research Group System Reliability, Adaptive Structures, and Machine Acoustics SAM at Technische Universität Darmstadt.



Status: 14.03.2022

Operational budget 2021 [T €]

Economic income	11.531
Public income	6.068
Other income	324
Internal programs	5.697
Institutional funding (Grufi)	3.673
Total	**27.293**

Investments [T €]

from institutional funding	1.818
Project investments	92
Total	**1.909**

***** Total budget = Operating budget + investments

Digital Engineering

Area of Expertise

The product development of the future is fast, efficient, flexible and digital. In Fraunhofer LBF, we develop innovative modeling and simulation solutions from product creation and use to the end of life. In conjunction with new cyber-physical methods and tools, it is also possible to implement end-to-end validation of products and product functions at the component level throughout the development process. Increasingly scarce development capacities can be utilized efficient by supplementing and replacing specific experimental analyses, as well as through numerical methods and validation processes.

www.lbf.fraunhofer.de/digital-engineering-en

“We develop the tools to make your digital product development efficient.”

Using resources wisely for secure, stable and efficient processes

Industrial value creation is characterized by ever shorter product life cycles and, at the same time, increasing product diversity – sometimes with individually tailored properties – as well as the distributed development, realization and use of products. In addition, there are increasing requirements for sustainability and resource efficiency, as well as increased functional complexity of systems in different operating and usage scenarios.

Against this background, product development processes are coming under increasing pressure in terms of efficiency, costs and flexibility, e.g. due to the reduction of available prototype systems or the increasing need for early decision-making and safeguarding processes to accompany development. Alternative development tools and realistic digital models are therefore needed to ensure that the requirements for quality, safety and reliability of the products can still be met. The aim here is to increase the predictive quality of the actual component and system behavior through suitable modeling in such a way that, among other things, the number of prototype systems can be reduced and physical validations can be supplemented and optimized by virtual analyses.

In the **Digital Engineering** area of expertise, researchers are developing new methods and, where necessary, customized tools that aim to virtually map development, safeguarding and validation processes. For instance, innovative modeling and simulation solutions allow for extended functional properties in plastic components and in mechanical systems to be considered in the early design and realization process already. At the same time, usage data from practice, production and operation are integrated for validated modeling and simulation. This allows influences, stresses or damage at the material, component and overall system level to be realistically digitally reproduced. In this way, the number of possible variants for the later realization of a product can be reduced to a minimum at an early stage of the design and development process.

Optimized design of hybrid commercial vehicles

Development of efficient and low-emission buses and trucks with hybrid drives

Further information online

www.lbf.fraunhofer.de/orca-en

The complete electrification of commercial road transport is proving much more difficult than in private transport due to the high range requirements. In the medium term, hybrid vehicles in particular offer the opportunity to reconcile economic and environmental requirements in this area. The EU-funded research project ORCA (Optimized Real-world Cost-competitive modular hybrid Architecture) is therefore focused on developing particularly efficient and low-emission hybrid concepts for commercial vehicles.

The aim of the project is to develop technologies and tools for reducing emissions and increasing the range of hybrid commercial vehicles in electric mode, as well as lowering total cost of ownership (TCO) compared to current concepts. A key focus here is on the comprehensive analysis of the vehicle's energy management. This requires the modeling of all the systems involved, including any potential interactions. Within this framework, Fraunhofer LBF was involved in the development of a multi-scalable simulation platform.

A model for thermal management of the entire vehicle was created, including the cooling circuits for the engine, energy storage and auxiliary consumers as well as the cab heating system. During the simulations, the energy efficiency benefits of heat recovery and storage technologies were demonstrated and quantified within the context of different usage scenarios.

Efficient and environmentally friendly commercial hybrid trucks: ORCA research results are validated during real-world operation.

EFFICIENT TRANSPORT, HYBRID DRIVE TECHNOLOGY, THERMAL MANAGEMENT IN VEHICLES, CNG VS. DIESEL

The ORCA project is characterized by close cooperation between science and industry across Europe. This has enabled innovative concepts to be implemented in a way that directly focuses on practical applications.

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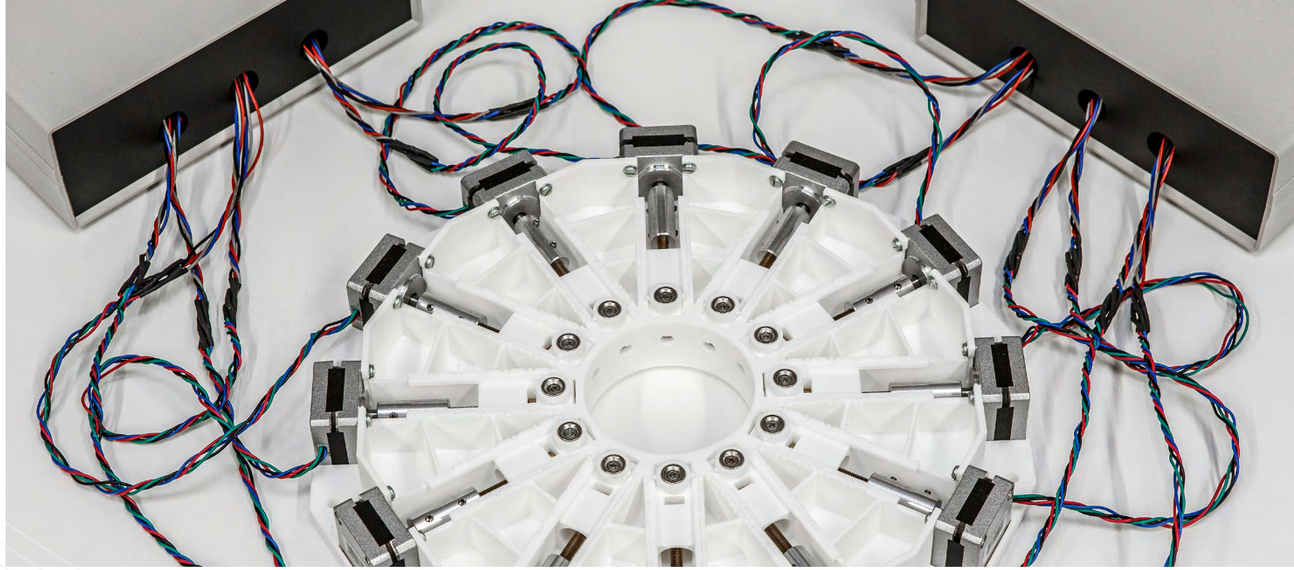

3D-printed materials are tested for their anisotropic mechanical behavior. he results are then used as the basis for structural simulation.

3D printed parts with orientation

Directional material properties of printed test specimens

3D printed components are also increasingly being used in structural applications. In this context, it is necessary to be able to describe the mechanical properties in detail and to prepare suitable methods for the design. These points are being investigated in the AddiSim project involving selectively laser sintered (SLS) PA12 components. A major focus is on determining the influence of the position and orientation of the components in the build chamber. Parts with identical construction but printed in different orientations have very different mechanical properties.

The aim of the project is to obtain a simplified method for the structural simulation of additively produced components based on mechanical investigations. Using this procedure, extensive results on the behavior of the printed material are determined based on a detailed measurement of the build chamber. The method generated at Fraunhofer LBF includes important findings for the safe and lightweight dimensioning of SLS-produced components.

3D PRINTING, SELECTIVE LASER SINTERING, TENSILE TESTING, SIMULATION

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Further information online

www.lbf.fraunhofer.de/3d-parts

Safety for the autonomous mobility of the future

Simulation-based development and testing makes Level 4 and 5 vehicles particularly safe

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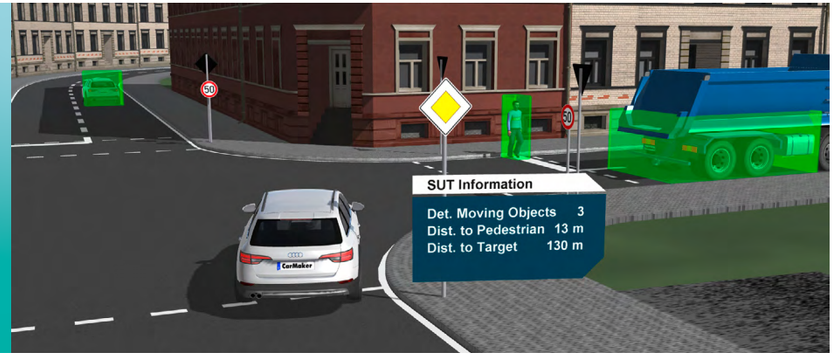
Before automated vehicles can drive on the roads, it is essential to ensure that they are safe. This requires numerous simulated tests, because not all situations can be tested in real traffic. In the SET Level project, Fraunhofer LBF is working with partners from industry and science to develop efficient simulation technology. This should be flexible enough to be used for different applications and stages in vehicle development and enable a significant proportion of the required road tests to be carried out in simulation, which in turn will safeguard and shorten approval processes.

To achieve this, researchers at Fraunhofer LBF are developing methods and tools as part of the project to test the interaction between vehicle systems and automated driving functions using closed-loop simulation in a scenario-based environment. This process involves creating component models of the vehicle, such as powertrains, brakes, steering or vehicle dynamics, as well as of the automated driving functions, such as the vehicle control system (motion control) and interfaces, in order to incorporate these models in different integration environments.

SIMULATION, TEST, VEHICLE, AUTOMATED DRIVING

Further information online

www.lbf.fraunhofer.de/autonomous-mobility



Simulation-based testing makes it possible to evaluate the performance of automated driving functions in a wide range of traffic situations at low cost and risk. (© IPG Automotive GmbH)

Artificial intelligence for reliable elastomer products.

AI failure analysis of technical elastomers

Using artificial intelligence to identify complex cases of damage and make analytics more efficient and accurate

Technical elastomers in the form of seals or vibration control applications are indispensable today. These high-tech products are used in cars, aircraft or hydraulic and pneumatic systems, and are exposed to the highest requirements in terms of temperature, media and mechanical loads. In the event of damage, it generally means entire machines or systems come to a standstill. Economic losses due to production downtime or the endangerment of users' lives or limbs are possible consequences. AI failure analyses from Fraunhofer LBF can prevent these scenarios.

If damage has occurred, a failure analysis is required to remedy it and prevent future damage. Damage to elastomer products can have many causes, including aging, manufacturing defects, and mechanical, thermal or climatic stresses. Among others, one popular method for analysis can be seen in VDI 3822. However, performing an extensive analysis using this method requires experience and expertise. The situation is further complicated by the fact that similar damage patterns can result from different causes or complex stresses.

Wouldn't it be simple to have artificial intelligence perform this analysis?

Teams of experts from Fraunhofer LBF are developing a model trained with machine learning that automatically performs the failure analysis based on imaging, physical and chemical methods as well as other provided information, and independently evaluates the causes of the damage. In order to successfully train the AI, a very large amount of data is required. Together, we look at your existing damage and evaluate it according to our taxonomy.

With you as a partner, we can make failure analysis more efficient!

AI FOR RELIABLE ELASTOMER PRODUCTS.

Further information online

www.lbf.fraunhofer.de/ai-damage-analysis

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Smart Solutions

Area of Expertise

In an environment in which value chains, production flows, as well as materials and components are being optimized as much as possible, our researchers are developing smart monitoring systems to prevent damage, limit the need for maintenance and minimize unplanned failures. The targeted influence of vibrational properties of structures in mobile systems, machine learning and promising metamaterials play a major role here.

www.lbf.fraunhofer.de/smart-solutions-en

Everything in view and everything under control to increase technical availabilities

Intelligent sensor technology for the targeted collection and assessment of large amounts of data, increasing networking, function distribution and real-time, cross-system data communication, as well as function enhancement and mechatronization, are all drivers of digitization in modern products. Artificial intelligence and data-based services not only enable process chains in production to be analyzed, simplified and optimized. In fact, they also allow for structural monitoring that is adapted to current environmental and operating conditions, as well as actively influencing factors such as the vibration characteristics of machines and vehicles.

„Innovative materials and AI-based solutions for intelligent condition monitoring and noise control.“

In the **Smart Solutions** area of expertise, scientists are researching and developing hardware and software solutions, based, among other things, on digital engineering modeling approaches, for smart maintenance applications, for predicting and preventing unplanned machine and system failures, and for increasing technical availability. Another topic is the targeted influencing of the vibration-related properties of structures in mobile systems such as vehicles and in machines and systems. In both cases, machine learning methods are used for the advanced analysis of growing volumes of data, in conjunction with intelligent sensors and sensor networks, as well as integrated actuator technology. In this context, work with so-called metamaterials is going even further. These have high potential for the structurally-integrated influencing and adjustment of qualities such as acoustic or structural dynamic properties for the purpose of the reduction or alternative adjustment undesirable or harmful vibrations and sound radiation. The linking of methods established in relation to reliability as well as in vibration and materials engineering with new data-driven, digital approaches that the work aims to achieve is moreover an important building block for the development and realization of intelligent lightweight structures.

Winner of the special award *for outstanding entrepreneurial and scientific performance at the ceremony celebrating the 25th anniversary of the "Center for Transportation & Logistics – Neuer Adler e. V." (CNA), which was held in Nuremberg on October 28, 2021*

Award

Speakers on the crane reduce the amount of noise when setting the container down on the truck by transmitting adaptively calculated inverted noise. (©Fraunhofer IML)

I²Panema – the IoT and active noise control at port and industrial facilities

Active noise control reduces noise at container terminals

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www.lbf.fraunhofer.de/i2panema-en

I²PANEMA is an european research project that aims to harness the power of the Internet of Things (IoT) to make ports more efficient and sustainable, and reduce their impact on neighboring residential areas.

The noise emissions from business operations at ports and logistics centers often lead to conflicts over the hours of operation. Active noise control (ANC) can help to reduce noise emissions of this kind and, in turn, to deescalate these conflicts. As part of the project, a demonstrator system has been set up on a real-life port gantry crane. This has been equipped with microphones and speakers. The reference microphones record the noises emanating from the container. These are used to calculate suitable inverted noise signals, which are then transmitted via a speaker array. The remaining noise outside of the working area is detected by error microphones. The ANC system adapts to changes in propagation conditions in order to minimize the residual noise. The use of weatherproof speakers and microphone housings mean that the system is already geared up for permanent use.

The demonstrated system has managed to cut the sound pressure level by half. Theoretical analyses indicate that reductions of up to 20 dB_A could be achievable by using two-dimensional speaker arrays. In light of the fixed noise quotas that limit the number of containers that can be handled, the efficiency of port operations can be increased considerably by using a system of this kind.

LOGISTICS, NOISE PREVENTION, ACTIVE NOISE CONTROL

Optimization and reliable design of a smart screw connection subjected to operational stresses

Smart screw connection as a closed overall system (right) or with attachable add-on module (left). (© Fraunhofer CCIT)

Further information online

www.lbf.fraunhofer.de/screw-connection

In many applications, regular monitoring of screw connections that are critical to function and safety is only possible at great expense in terms of both time and money. However, this is absolutely necessary to ensure safe operation and is in some cases a legal requirement. With the smart screw connection, Fraunhofer CCIT has developed a completely new condition/structural health monitoring system that makes it possible to transmit applied preload forces in a wireless, self-powered manner at adaptive time intervals or on-demand. The system uses commercially available DIN screws and can therefore be retrofitted to existing screw connections. Continuous self-powered (via energy harvesting) and wireless remote monitoring makes it possible to detect changes in the load on complex, bolted and safety-relevant structures at an early stage, evaluate the changes and in this way significantly increase the reliability of the structures (digital networking of systems).

This system can be used in a wide range of technical applications, such as offshore structures, wind turbines, plant construction and mechanical engineering, bridges and building facades.

FATIGUE STRENGTH, SMART SCREW CONNECTION, SELF-POWERED REMOTE MONITORING

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Resilience of urban areas

Heavy rainfall events as a challenge for the future

Further information online

www.lbf.fraunhofer.de/urban-living-spaces

How do we make urban areas safe in the future? How do we safeguard supply in cities, even in the event of a crisis situation? These and other issues are key challenges that we will face in the future. For example, heavy rainfall events resulting from climate change demonstrate that existing strategies and technological approaches to solutions are quickly reaching their limits.

Against this backdrop, seven Fraunhofer institutes working in the field of safety and security research have pooled their expertise and jointly launched the project "Resilience of Urban Areas" (abbreviated to "RuLe" in German). The aim of the project is to identify critical components of the urban infrastructure within an analytical framework, analyze their resilience in the face of adverse impacts and identify strategies for prevention and response.

Using various sensors, the precipitation and runoff quantities are recorded at numerous points and sent to a central control system for evaluation. Depending on the scenario being demonstrated and the chosen strategy, electric drainage pumps may turn on or intentionally fail to operate.

Based on various specific issues, the functional demonstrator allows the resilience evaluation models that have been theoretically developed at Fraunhofer LBF to be recreated and verified in practice. The system also serves as a development platform for new types of intelligent sensor technology designed to measure environmental parameters that previously had not been recorded at all or only very roughly.

HEAVY RAIN, RESILIENCE, SCENARIO REPRESENTATION, SENSOR TECHNOLOGY, MONITORING

System to simulate heavy rainfall events.

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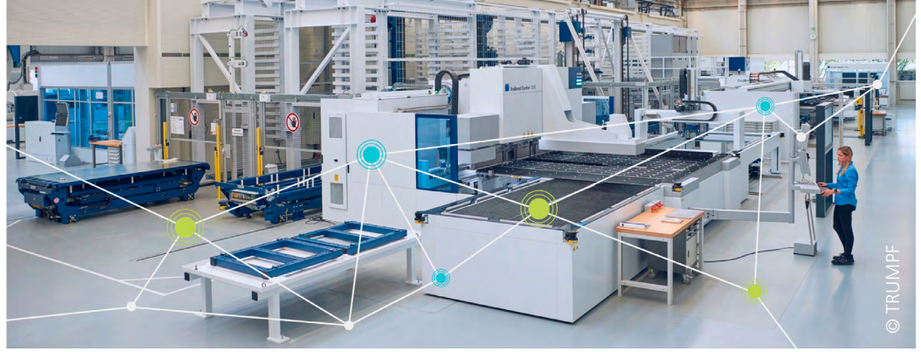

ProKInect

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

ProKInect – machine tool conditioning monitoring on a cross-manufacturer basis

Durable and reliable machines thanks to collaborative artificial intelligence

Companies operating modern machine tools have very stringent requirements with regard to machine availability and reliability. However, existing approaches to preventive and predictive maintenance do not allow quality nonconformities resulting from incipient wear or a malfunction during the production process to be traced back to a specific part or component with absolute certainty. For this reason, companies that manufacture modern machine tools – along with the companies that operate them and the people who use them – need to be able to understand the interactions between a whole host of components responsible for determining quality and the machine tool itself, to detect any changes in condition at an early stage and to take proactive steps to prevent production downtimes.

A knowledge-based AI architecture and comprehensible AI models

Through its ProKInect research work, the Fraunhofer Institute for Structural Durability and System Reliability LBF is improving the clarity and comprehensibility of AI systems in the area of condition monitoring and predictive maintenance. The primary aim is to take expert knowledge concerning failure-induced symptoms, causal relationships and ongoing maintenance and to systematically convert this into transparent AI models in a seamless and automated manner. The expert knowledge of relevance to condition monitoring is being converted into knowledge-based probabilistic causal models that allow the differential diagnosis of various fault causes on the basis of the symptoms and additional information recorded. To facilitate ongoing condition diagnostics, Fraunhofer LBF is developing hybrid AI models that are based on the network structures obtained from the probabilistic causal models and feature the same levels of trainability and performance as artificial neural networks.

CONDITION MONITORING, ARTIFICIAL INTELLIGENCE, PROGNOSTICS AND HEALTH MANAGEMENT

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www.lbf.fraunhofer.de/prokinect-en

Reliability Design

Area of Expertise

Reliable functioning has always been a key requirement for products. We continuously develop new methods and tools for the reliable design of materials, components and systems. The research and development activities in this area of expertise are aimed at understanding and describing all phases of product development, use and application along with their interactions, in an increasingly comprehensive manner, so that validation and assurance processes can be continuously moved forward into the early design process.

www.lbf.fraunhofer.de/reliability-design-en

Achieving more with less in terms of complexity, stability and reliability

Ever lighter material solutions and structures on the one hand and ever more complex products and systems on the other are shaping product development in many industrial sectors. At the same time, however, the requirements regarding the reliability of such systems are increasing. After all, malfunctions and failures in this context can quickly have critical economic, ecological or health effects.

Our research makes reliable products possible by using reliable processes.”

The **Reliability Design** area of expertise represents a key scientific focus of Fraunhofer LBF. This is not just a matter of ensuring the service life of materials, components and products. Rather, the research and development activities in this area of expertise are aimed at understanding and describing all phases of product development, use and application along with their interactions, in an increasingly comprehensive manner, so that validation and assurance processes can be continuously moved forward into the early design process. In the spirit of “design to reliability”, digital engineering solutions are linked with new design and simulation methods. Based on realistic application data in relation to typical mechanical, climatic, electrical and combined multiphysical loads, tools and processes are being developed that take into account the reliable design of structures as early as the design stage. In this way, “safety margins”, which, in many cases, are still common today, can be reduced further and further in the future while maintaining or increasing the reliability of materials, components and products, thus enabling modern solutions that push the limits of what is feasible.

Investigation of the fatigue strength behavior under exposure to compressed hydrogen compared with electrochemically supplied hydrogen

Further information online

www.lbf.fraunhofer.de/high-pressure-hydrogen

With a view to ensuring the reliability of components exposed to hydrogen, Fraunhofer LBF is working together with 24 other Fraunhofer institutes on the internal Fraunhofer research project called "H2 DII – A hydrogen economy for Germany", which aims to answer some key questions around the establishment of a hydrogen economy in Germany. The areas being researched include the production of hydrogen using electrolysis and the creation of a secure infrastructure and technologies for its transport, storage, distribution and use.

To enable investigations into cyclic material behavior under exposure to hydrogen, the Fraunhofer Institute for Structural Durability and System Reliability LBF has been using a special test facility for several years. This allows force-controlled and strain-controlled tests to be conducted with compressed hydrogen at partial pressures ranging from 7 to 50 bar. In addition to carrying out reference investigations in an inert nitrogen atmosphere at a pressure of 10 bar, it is also possible to control the temperature of the autoclave with adjustable temperatures ranging from -40 °C to +130 °C.

The research project has not only been investigating the characteristics of materials under exposure to compressed hydrogen, but has also developed an electrochemical cell that makes it possible to apply electrochemically supplied hydrogen to a material sample while subjecting it to an external load at the same time. Following optimization of the test parameters, it has been possible to show that the fatigue-strength-reducing effect of a compressed hydrogen environment can be replicated using electrolytically supplied hydrogen in the case of the forging steel under investigation (1.5132) and a load level in the low-cycle fatigue range. Currently, the investigations are continuing with the aim of qualifying this testing technology for service lives involving higher numbers of cycles.

HYDROGEN EMBRITTLEMENT, FATIGUE STRENGTH, ESTIMATION OF SERVICE LIFE

Test facility for conducting temperature-controlled fatigue tests under exposure to compressed hydrogen and nitrogen.

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Which material properties influence the service life? We look very closely.

Improved service life of elastomers

Prediction based on chemical structure and mechanical properties

In the project "ProElasto", our researchers are investigating which material properties influence the service life of an elastomer. For this purpose, the chemical cross-linking structure and the mechanical properties of a carbon black-filled elastomer are being systematically investigated in cyclic fatigue tests with regard to service life.

To determine the service life of the material, the cyclic fatigue tests are performed at two load levels. The number of cycles to failure at a fixed load level can be correlated with the degree of cross-linking and the average sulfur bridge length, as can the mechanical properties. A longer service life can be achieved either with a lower degree of cross-linking or with a longer average sulfur bridge length. The next step is to determine the extent to which the results can be transferred from the elastomeric compound investigated to other elastomeric compositions. The aim here is to carry out as few tests as possible. In addition, it might also be possible to include other structure-determining influences, such as the processing conditions, in a model for predicting the service life in cyclic fatigue tests.

STRUCTURE-PROPERTY RELATIONSHIPS, CYCLIC FATIGUE TESTING, PREDICTION

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Investigating the service life of aged elastomer components

A methodology for experimentally investigating the service life of elastomer components aged using a thermo-oxidative process

Further information online

www.lbf.fraunhofer.de/elastomer-components

The "AltElast" research project involved investigating the effects of thermo-oxidative aging on the fatigue strength of a carbon-black-filled NR material. The aim was to develop a methodology that would take account of the irreversible changes in the network structure with a view to predicting the level of service life degradation. This was based on identifying aging effects via short, concentrated laboratory experiments, and then applying these to the long-term behavior using numerical approaches (Arrhenius laws). Both material samples and components were investigated to assess whether the methodology could be successfully carried across from the former to the latter.

Ultimately, the aim of the project was to devise a complete test process that would not only define the necessary time-concentrated aging experiments but would also provide a computational evaluation method that could be used to capture the data and apply it to real-life temperature conditions. Within this context, the intention was also to consider and assess – in a very specific way – the spread of the experiment results as well as the related interpretation of the computational results.

As a result, industrial users now have access to a numerical verification concept that will enable them to design products that are fit for their intended purpose while increasing the reliability of the systems used.

AGING, ELASTOMER COMPONENTS, SERVICE LIFE

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Artificial aging of engineering elastomers using a thermo-oxidative process

Further information online

www.lbf.fraunhofer.de/polymerblends-en

Improved flowability in the spiral test of the polyamide 6 blend (right) compared to ommercially available thermally conductive polyamide 6 (left)

Development of thermally conductive polymer blends

Filled polymer blend with increased fluidity

Applications that involve the transfer of heat demand materials with sufficient thermal conductivity. Such materials are required in electronic components and lighting technology, for example. In the case of plastics, sufficient thermal conductivity is achieved by adding fillers in high concentrations. This causes profound changes in the other properties typically associated with plastics, and often not for the better. For instance, it can affect the mechanical properties, frequently in the form of low impact strength. In the course of the "HEATCOP" project, researchers from the Fraunhofer Institute for Structural Durability and System Reliability LBF investigated how typical properties of plastics can be improved in a targeted manner through blending without reducing the thermal conductivity.

Forschungsnetzwerk Mittelstand

IGF project 19502N titled "New strategies for reducing the filler content in thermally conductive plastic compounds" by the Forschungsgesellschaft Kunststoffe e. V. (FGK) research association was funded via the Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" e. V. (German Federation of Industrial Research Associations)

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

as part of the funding program of the collective industrial research (IGF) initiative by the Federal Ministry of Economics and Technology based on a decision by the German Federal Parliament (Bundestag).

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“We develop sustainable, recyclable and bio-based plastic solutions for a green future!”

Circular Economy

Area of Expertise

Plastic materials have a large amount of untapped potential applications. We are intensively working on solutions for resource-efficient, sustainable and bio-based plastics so that they can be used in an environmentally friendly way. Our particular strength is profound expertise in the additivation of plastics in order to adapt highly-specific material properties. Thus, biopolymers made from renewable raw materials can also be adjusted and upgraded for demanding technical applications in terms of their service life, degradation or performance. On the other hand, innovative additive systems allow for enhanced processability and improved end properties for recycled material.

www.lbf.fraunhofer.de/circular-economy-en

Renewable and upcyclable raw materials also for demanding technical applications

Plastics are an integral part of our everyday lives. They offer the widest range of options in material technology solutions for a large number of applications. A wide range of properties can be imprinted in a targeted manner: Foodstuffs are hygienically packaged in a safe and durable way using plastics. As insulating and sealing materials with special fire protection properties, they are a modern building material. As engineering plastics, they offer effective and efficient functional features and lightweight construction potential in primary and secondary components – often being shaped in a highly complex manner with defined insulating, vibration damping, sensory or actuator functions.

Yet while their extraordinarily positive technical properties cannot be denied, plastics are increasingly the subject of critical discussion. They are emblematic of modern environmental problems, in the form of microplastics or the pollution of the oceans, which we help to reduce through our research work.

In the **Circular Economy** area of expertise, Fraunhofer LBF scientists are working on sustainable, durable and environmentally compatible plastics solutions, from the molecule, formulation and chemical-physical characterization to synthesis and validation, from use to the “end of life” and recycling – thereby transforming linear processes into circular ones. The particular strength of LBF is the profound expertise in additivation of plastics in order to adapt highly-specific material properties. Thus, biopolymers made from renewable raw materials can also be adjusted and upgraded for demanding technical applications in terms of their service life, degradation or performance.

Beyond that, innovative additive systems allow for enhanced processability and improved end properties for recycled material. Additive systems can significantly expand the possibilities for material recycling of conventional polymers in terms of upcycling. Another field of research involves the development of bioadditives as substitutes for commercial systems which, in terms of quality and performance, achieve comparable properties to conventional additives and in some cases significantly surpass them, e.g. for the weather resistance or flame retardancy of polymers.

It is our goal to give used plastics a second life as recyclates.”

Waste4Future: Advancing plastics recycling to the next level

Fraunhofer lighthouse project develops technology for the complete recycling of plastic waste

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From the perspective of creating a closed raw materials cycle, only a fraction of plastics currently get recycled. Large percentages are incinerated for the purpose of energy recovery. This inevitably generates CO_2 emissions, which are something that must be avoided because of their impact on the climate.

The aim here is to recycle the carbon contained within the plastic. The first way to achieve this is by optimizing the mechanical recycling process by using an optimized AI-assisted sorting technology to specifically separate those plastic fractions that are less severely affected by aging. In a downstream compounding step, these can then be converted into high-quality granulate for use in conventional plastics processing. Secondly, to deal with those plastic fractions that cannot be melted down to create new, high-quality products, innovative solutions need to be devised for the area known as chemical recycling (pyrolysis and gasification).

These plastic fractions within the flow of recyclables are to be converted into raw materials for the chemical industry.

In light of its extensive know-how in the area of plastics technology, Fraunhofer LBF is involved in two work packages. To enable the age condition to be correlated with the various items of sensor data, the scientists involved in the project are providing plastic fractions that have undergone defined levels of aging for the purpose of training the AI algorithms. They are also developing a new compounding line, where additives are to be subsequently added to plastic fractions in various conditions of aging in a targeted manner with an eye on future applications in order to create high-quality batches with minimal variations in quality.

RECYCLING, RAW MATERIALS, AI, CARBON CYCLE

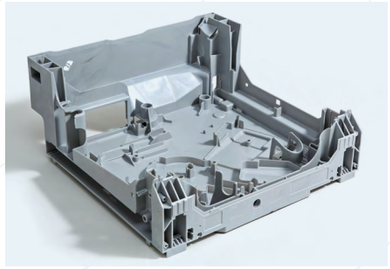
Recyclates for sustainable structural components in household appliances

Fraunhofer lighthouse project develops technology for the complete recycling of plastic waste

In cooperation with Robert Bosch GmbH and BSH Hausgeräte GmbH, the Fraunhofer Institute for Structural Durability and System Reliability LBF has carried out extensive investigations into the morphological and mechanical properties of recycled plastics to assess their suitability for use in high-stress applications and has compared the results with the brand-new material currently in use.

The starting material consisted of used polypropylene battery housings, which first had to be comminuted, cleaned and dried before undergoing further processing in a subsequent compounding process. In the course of this, the molten material was filtered; mixed with additives, stabilizers and fillers; and then granulated. To enable a comparison with the brand-new material, extensive analytical and mechanical investigations were then carried out on material samples. This involved examining how the service life was affected by the molar mass distribution, the degree of crystallinity or the level of contamination by metals or foreign polymers, the interplay of static and cyclic loading on notches and the joint line, as well as the temperature, load ratio and aging.

By way of a prototype application, the recyclate was used – and validated – as a substitute for the brand-new material that is currently being employed to make an injection-molded dishwasher base subjected to high levels of stress during operation. On the basis of component tests and numeric calculations, it proved possible to demonstrate that the recyclate has the structural durability to withstand the cyclic loads during operation.



Forging the perfect virtuous cycle: Used starter battery housings can be used to make new household appliances – in this case: a dishwasher base.

RECYCLATES, SUSTAINABILITY, RELIABILITY

Further information online

www.lbf.fraunhofer.de/recyclates

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Efficient prevention of fires

Sustainable flame retardant with good processing properties for textiles

Further information online

www.lbf.fraunhofer.de/flame-protection

As with most plastics, aliphatic polyamides (PA) are flammable and therefore have limited suitability for use in fire-sensitive areas. The addition of flame retardants is an effective way to inhibit or prevent combustion. However, existing flame retardants for PAs are not suitable or only partially suitable for the manufacture of textiles. Furthermore, no flame retardants made from renewable raw materials are available for biobased PAs. At Fraunhofer LBF, new synthesis routes have been developed to create innovative, polymeric flame retardants that bridge these gaps. The polymers with phosphorus-containing side groups are based on both renewable and fossil raw materials.

By varying the molar mass and using different comonomers or substituents, the melting viscosity, compatibility and mode of action can be individually adapted to the base polymer and the intended application. The macromolecular structure also prevents migration. A particular challenge here was to develop flame retardant additives that could withstand the high processing temperatures of PA, which can be as high as 300 °C.

POLYMER ADDITIVES, RENEWABLE RAW MATERIALS, FLAME RETARDANTS

Knitted stocking made of PA 6.6 with 10 wt% polymeric flame retardant produced by our project partner, the Institute of Textile Technology at RWTH Aachen University (ITA).

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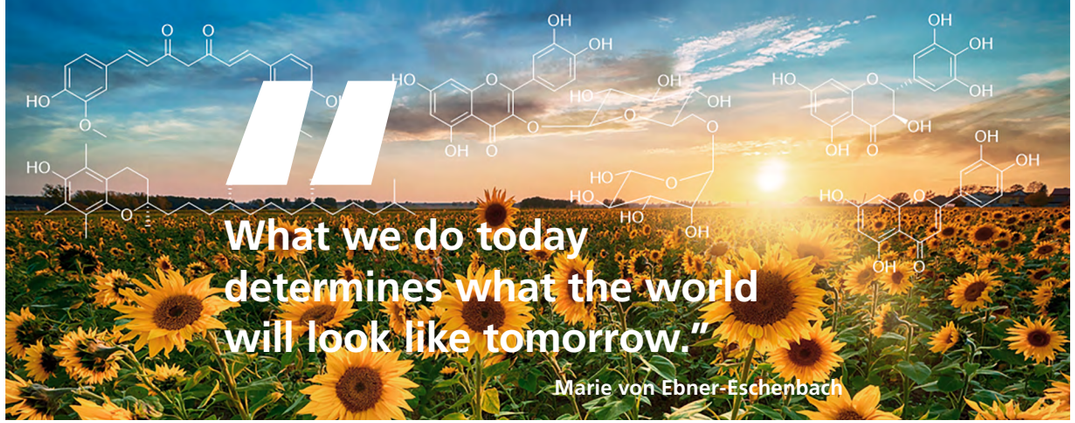

Nature offers an abundance of compounds that have highly effective antioxidative properties but still have to be specially tailored for use in plastic.

Plastics economy

Biostabilizers as part of the sustainability transition

In the course of their life cycle – from processing and use all the way through to recycling – plastics are subjected to all kinds of stresses, ultimately leading to the loss of their mechanical and visual properties. Therefore, it is only through the use of additives that the plastic becomes capable of meeting the stringent requirements that are imposed on it in terms of service life, continuous operating temperature and quality. Under the umbrella of the Cluster of Excellence Circular Plastics Economy (CCPE), the Fraunhofer Institute for Structural Durability and System Reliability LBF is cooperating with other partner institutes within the cluster to develop and evaluate new and innovative stabilizer systems based on biogenic building blocks.

The stabilizers used to date have mainly been of petrochemical origin and, due to their low molecular weight, carry a risk of migration from the polymer matrix. In order to avoid such contamination involving fossil-based derivatives and with a view to creating sustainable alternatives and establishing a circular economy, there is an opportunity to use naturally occurring structures instead. When incorporated into polyolefins such as polypropylene and into biopolymers such as polylactic acid and natural rubber, the new stabilizer systems that have been developed at Fraunhofer LBF using naturally occurring compounds exhibit a stabilizing effect that is at least equal to that of their commonly used commercial counterparts and, in some cases, is even better. As far as customers are concerned, this allows them to add high-performance alternatives to their product range while at the same time responding to the demand for new and sustainable solutions from politicians and wider society.

PLASTIC ADDITIVES, PROCESS STABILIZERS, BIOGENIC BUILDING BLOCKS

Further information online

www.lbf.fraunhofer.de/plastics-economy-en

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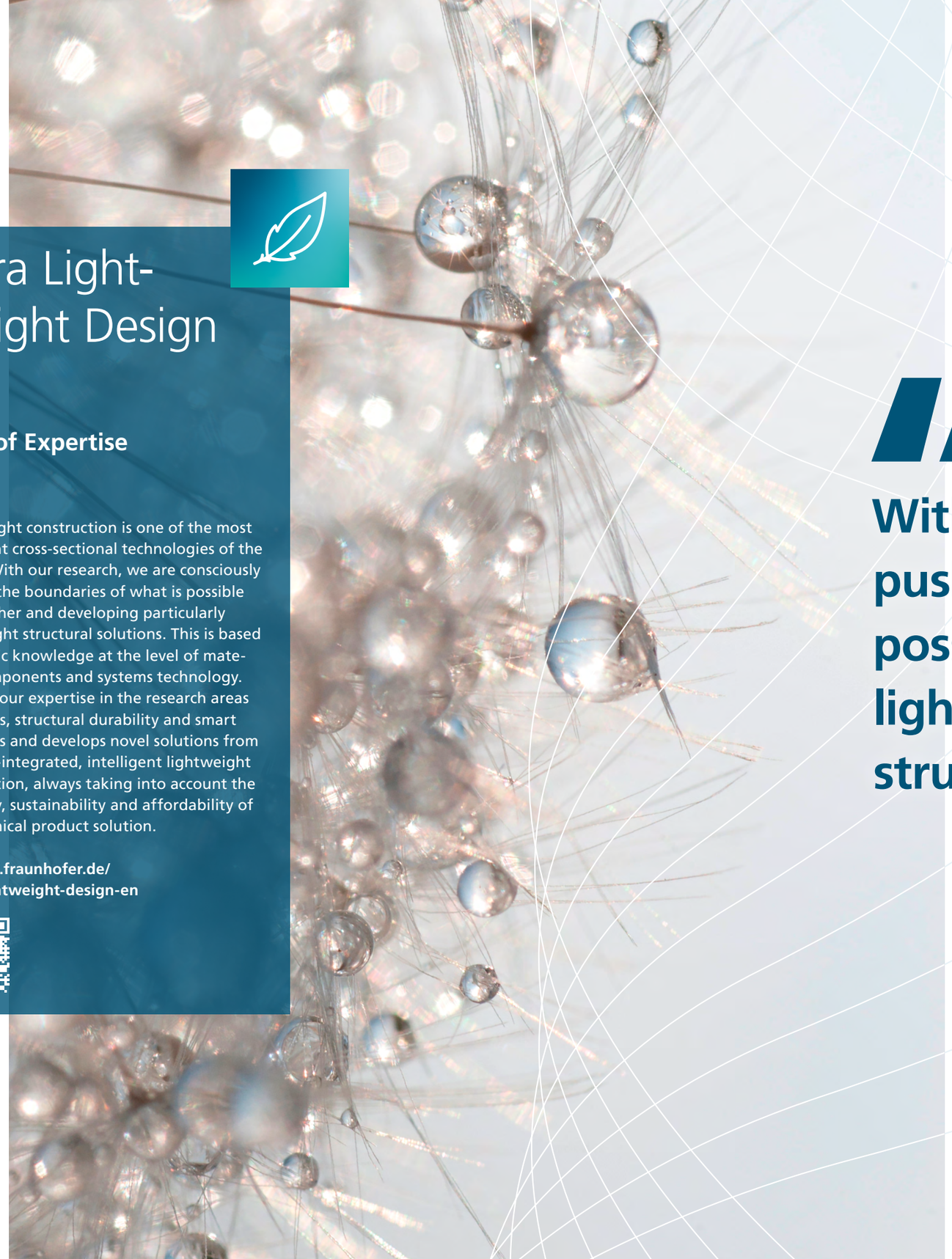

Ultra Light-weight Design

Area of Expertise

Lightweight construction is one of the most important cross-sectional technologies of the future. With our research, we are consciously pushing the boundaries of what is possible ever further and developing particularly lightweight structural solutions. This is based on holistic knowledge at the level of materials, components and systems technology. We pool our expertise in the research areas of plastics, structural durability and smart structures and develops novel solutions from function-integrated, intelligent lightweight construction, always taking into account the reliability, sustainability and affordability of the technical product solution.

www.lbf.fraunhofer.de/ultra-lightweight-design-en

More efficiency for commercially successful products thanks to lightweight technology

Lightweighting has long since ceased to be a "technical niche solution" for aircraft and innovative sports vehicles. Rather, affordable lightweight solutions for the best possible mass and energy efficiency in all mobile systems – such as in the production and operation of products – are key to achieving climate policy goals in vehicle manufacturing, mechanical and plant engineering, energy and the construction industry. Without lightweight construction, the possibility of commercially successful products, such as those in electromobility, would become less and less, perhaps rendering them impossible. What is more, successful, safe lightweight construction requires comprehensive expertise in reliability and structural durability.

In the **Ultra Lightweight Design** area of expertise, LBF is pushing the limits of what is possible even further. This is based on holistic knowledge at the level of materials, components and system technologies. In addition, methods of material construction as well as those of constructive and systemic lightweight construction are combined. Fraunhofer LBF pools its expertise in the research areas of plastics, structural durability and smart structures and develops novel solutions from function-integrated, intelligent lightweight construction, always taking into account the reliability, sustainability and affordability of the technical product solution. Scientists conduct interdisciplinary research and develop solutions, for example, for functionalized polymers, functionally integrated fiber composite systems, mono and multi-material systems, numeric al and experimental methods of reliability and durability assessment of lightweight solutions, and the use of integrated sensors and actuators for the monitoring and property optimization of structures.

"With our research, we are pushing the boundaries of what is possible and developing radically lightweight, property optimized structural solutions."

Reducing CO_2 by using new manufacturing processes and materials for sustainable lightweight components of land vehicles

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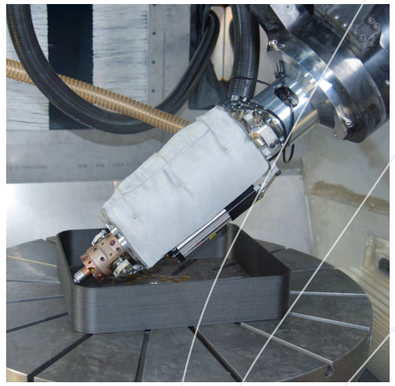
Lightweight design is a design philosophy that is applied in the publicly funded "ECO_2-LInE" project with the rethinking of the design of special seats and benches, train car connections and pickup attachments. Using the novel additive manufacturing process SEAM, lightweight natural fiber-reinforced plastic components are being developed to replace metal structures. But how can the entire life cycle of these components become more sustainable, from material selection, manufacturing and use through to their recycling? Fraunhofer researchers from Darmstadt (LBF) and Chemnitz (IWU) are investigating this question together with their partners in the research project.

In the research project, 10 partners will use the highspeed additive manufacturing process known as SEAM (screw extrusion additive manufacturing) to develop large components made of sustainable natural fiber-reinforced plastics for various cross-industry applications. In order to make the best possible use of the lightweight potential, the design takes into account the process-dependent material and component properties.



Production of the first demonstrator using the SEAM process. (© Fraunhofer IWU)

Once the project has been successfully completed, the users involved will be able to market the sustainably manufactured natural fiber-reenforced components, expand their production and therefore secure jobs in Germany. The new construction methods offer your customers numerous advantages in terms of weight reduction, energy savings, reduction of greenhouse gas emissions and durability.

LIGHTWEIGHT DESIGN, ADDITIVE MANUFACTURING, SUSTAINABILITY, VEHICLE ENGINEERING, PLASTICS

Further information online

www.lbf.fraunhofer.de/land-vehicles

Design of ALBACOPTER® 0.5 (© Fraunhofer IOSB)

lighthouse project*

Experimental Vertical Take-Off and Landing Glider (VTOL-G)

The development of drones is booming. They are used in a variety of ways: in leisure applications, for example, drones are used to perform aerobatics, drone racing or filming; in professional applications, they are used as a surveillance tool or to transport important goods. Drone manufacturers are enjoying an increase in demand. In the "ALBACOPTER®" lighthouse project, a Fraunhofer team is researching drones of an extended payload class. The focus is on the development of eVTOL gliders, the first variant of which will have a take-off mass of 125 kg.

In the ALBACOPTER® team, Fraunhofer LBF is responsible for the aerodynamic and structural mechanical design and construction of the wings and fuselage. The fuselage is designed using the frame construction method from pultruded profiles and nodal elements with the requirement to safely integrate all necessary components such as the wings, battery, transport box, sensor systems and electronics. In addition, the Darmstadt team is developing the electrical energy storage system, including its own battery management system. The challenge is to meet the very high energy requirements for the vertical flight phase without the system overheating. Furthermore, the cell structure must be designed with as little mass as possible. The total mass of the so-called ALBACOPTER® 0.5, including the payload, is limited to 125 kg.

EVTOL GLIDERS, TRANSPORT DRONES, AERODYNAMICS, STRUCTURAL DESIGN, COMPLEX BATTERY SYSTEMS

Further information online

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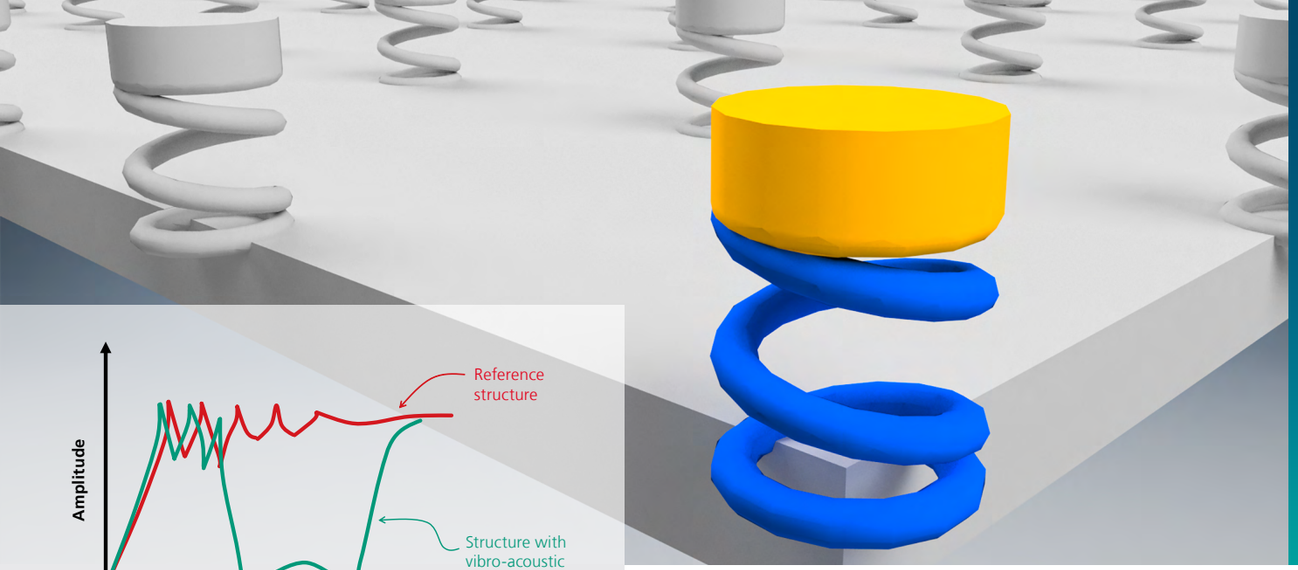
* About the project: "ALBACOPTER®" is a lighthouse project of the Fraunhofer-Gesellschaft. It was launched on January 1, 2021, and the project duration is four years. The participating institutes are IVI, IOSB, IEM, ICT, IMS and LBF.



Regularly arranged resonators comprising stiffness (blue) and mass (yellow) create the special properties of vibro-acoustic metamaterials.

Use of local resonances

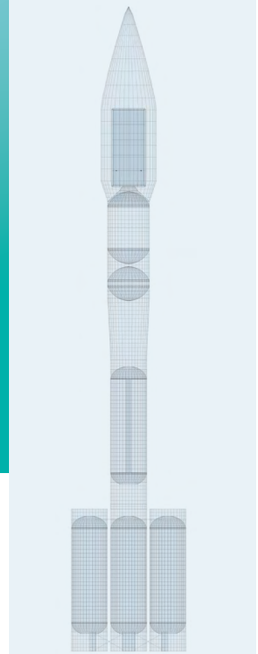
Vibroacoustic metamaterials generate stop bands through the use of resonances.

Construction:

- Periodically arranged on an overall structure
- Each resonator represents a spring-mass system that is tuned to one or more resonance frequencies.

Result:

By the vibration behaviour of the local resonances negative effective mass properties are generated. It results in a lightweight structure with a strong reduction of vibrations and acoustic radiation.



Numerical model of a rocket as a use case for vibro-acoustic metamaterials.

New possibilities for lightweight construction using vibro-acoustic metamaterials

Using vibro-acoustic metamaterials to mitigate vibrations in various applications

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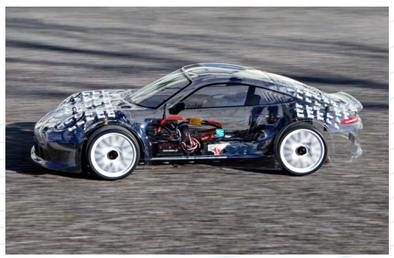
Mechanical engineering and mobility are to become even more economical. For this to succeed, the components used must be designed to be increasingly efficient and lighter. However, these solutions are often associated with vibration-related issues. In the "Silent Running" and "viaMeta" projects, applications in the aerospace and automotive sectors are being developed that use vibro-acoustic metamaterials to optimize structural dynamic behavior. Vibro-acoustic metamaterials represent an innovative approach to vibration reduction and offer advantages with regard to influencing vibration behavior compared to conventional measures.

"viaMeta" – lightweight potential for vehicles

In the future, the decision regarding which vehicle to buy will be significantly influenced by efficiency and comfort. However, in new vehicle designs, the conventional measures used to reduce noise and vibrations are often at odds with the desire for energy efficiency and weight reduction. Vibro-acoustic metamaterials can play a significant role in this context.

Due to the small-scale nature of the unit cells, vibro-acoustic metamaterials can be easily integrated with a high degree of design freedom and can comply with static, vehicle dynamic and crash-relevant design requirements that are crucial in automotive engineering.



Exemplary implementation of vibro-acoustic metamaterials on a vehicle model.

The **"viaMeta"** project, funded by the Federal Ministry for Economic Affairs and Energy (BMWi), brings together Fraunhofer LBF and partners from science and industry to develop a design system for metamaterials and modeling for the simulation and optimization of material components in a virtual vehicle prototype. Their effects in terms of lightweight construction and comfort will then be evaluated using demonstrators in real vehicles.

"Silent Running" – vibro-acoustic metamaterials to reduce vibrations in space travel applications

The use of vibro-acoustic metamaterials was demonstrated in the **"Silent Running"** project on a cylindrical component representing, for example, the upper stage of a launcher. For this purpose, a scaled cylindrical structure made of fiber-plastic composite with vibro-acoustic metamaterials in differential design (i.e., resonators were additionally applied to the target structure) was used as the final demonstrator.

Overall, the solution developed in the project was able to achieve the desired vibration reduction behavior in the range of 100 to approx. 200 Hertz by factors of up to 60 decibels. A broadband damping behavior was observed in the frequency range up to 600 Hertz. This confirms the effectiveness of the concept and demonstrates the high potential of vibro-acoustic metamaterials for space travel structures.

VIBROACOUSTIC METAMATERIALS, PASSIVE VIBRATION REDUCTION, COMFORT, LIGHTWEIGHT CONSTRUCTION

Further information online

www.lbf.fraunhofer.de/viameta-en

www.lbf.fraunhofer.de/silentrunning-en

Future Mobility

Area of Expertise

Sustainable, networked and autonomous – these features are the hallmarks of future mobility. With our core competencies in Lightweight Construction, Reliability Design and Digital Engineering tools, we design innovative vehicle concepts. Here, we combine the work of the other areas of expertise in relation to their application in mobility solutions, e.g. cyber-physical methods for the validation of new mobility technologies that accompany the development of alternative drive concepts, component-integrated battery systems or innovative ultra-lightweight construction solutions. One focus of the work is electromobility, using both battery-electric and fuel cell systems.

www.lbf.fraunhofer.de/future-mobility-en

“With our methods, we are also supporting and shaping the implementation of future innovative vehicle concepts.”

Pooling expertise for sustainable, connected and autonomous mobility

Mobility is undergoing a sustainable transformation process. It is increasingly understood as a networked system of different mobility solutions and operator models. The demands on mobile resource efficiency have once again massively increased, not least due to criticism regarding increasing pressures in relation to climate change and the decarbonization required. They make it necessary to develop new drive technologies, lighter construction methods and alternative mobility concepts.

The progressive electrification of mobile systems, the intermodality of modes of transport and the introduction of increasingly automated driving functions are an essential building block in the movement toward future mobility, from a technical and organizational perspective. The same applies to the increased use and development of new small and micro vehicles in the field of private transport, such as pedelecs, cargo bikes, e-scooters – or increasingly drones.

The topic of shared mobility also offers technical challenges ranging from smart digital solutions, app developments, and distributed functions to material technology – especially because, in this context, it is necessary to master entirely new usage scenarios. New future mobility solutions whether on land, by road or rail; on water or in the air – must function safely and reliably, while, at the same time, being cost-effective and efficient to implement and operate. Yet they must also meet the ever-increasing requirements in terms of the number of mobility carriers, individualization and sustainability in the passenger vehicle, commercial vehicle and special vehicle sectors. The consistent focus on a thermoplastic and thermoplastic-based approach has led to questions being asked about suitable lightweight solutions, reliable system design, intelligent structural and monitoring functions, sustainable materials and even the use of biomaterials.

In this context, the **Future Mobility** area of expertise at Fraunhofer LBF combines the work of the other areas of expertise in relation to their application in mobility solutions, e.g. cyber-physical methods for the validation of new mobility technologies that accompany the development of alternative drive concepts, component-integrated battery systems or innovative ultra-lightweight construction solutions. One focus of the work is electromobility, using both battery-electric and fuel cell systems.

Faster, further, higher.

Hybrid energy storage for more power and range

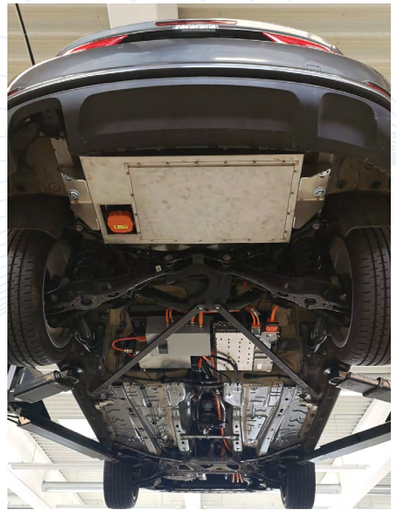
Further information online

www.lbf.fraunhofer.de/energy-storages

The "HyPowerRange" project funded by the BMWi aims to optimize the performance, capacity, cooling power requirements and costs of energy storage systems for battery electric vehicles. To this end, high-performance and high-energy cells are directly coupled on the DC side in a hybrid energy storage system. This cost-effective approach reduces, for example, the temperature-dependent aging of the storage unit, especially at high current loads, and at the same time reduces its cooling requirements.

The development of such an optimized energy storage system requires the most accurate possible knowledge of the power and load data occurring during driving operation. An operational development and testing environment was therefore established at the Fraunhofer LBF for multiphysical testing of the energy storage system. With regard to the installation situation in the subsequent vehicle test carrier, the energy storage system was prepared for integration into the laboratory test environment by means of adapted connection stiffnesses. The properties of the longitudinal frame support on the body side, developed by the project partner Abt E-line, were also taken into account. In addition to vibration excitation from driving operation and outside temperatures up to +35 °C, the energy storage system was validated with a transient current profile and analyzed in terms of its performance and temperature behavior.

ELECTRIC DRIVE, BATTERY SYSTEM, MULTI-PHYSICS TESTING



HyPowerRange energy storage system in the test vehicle.

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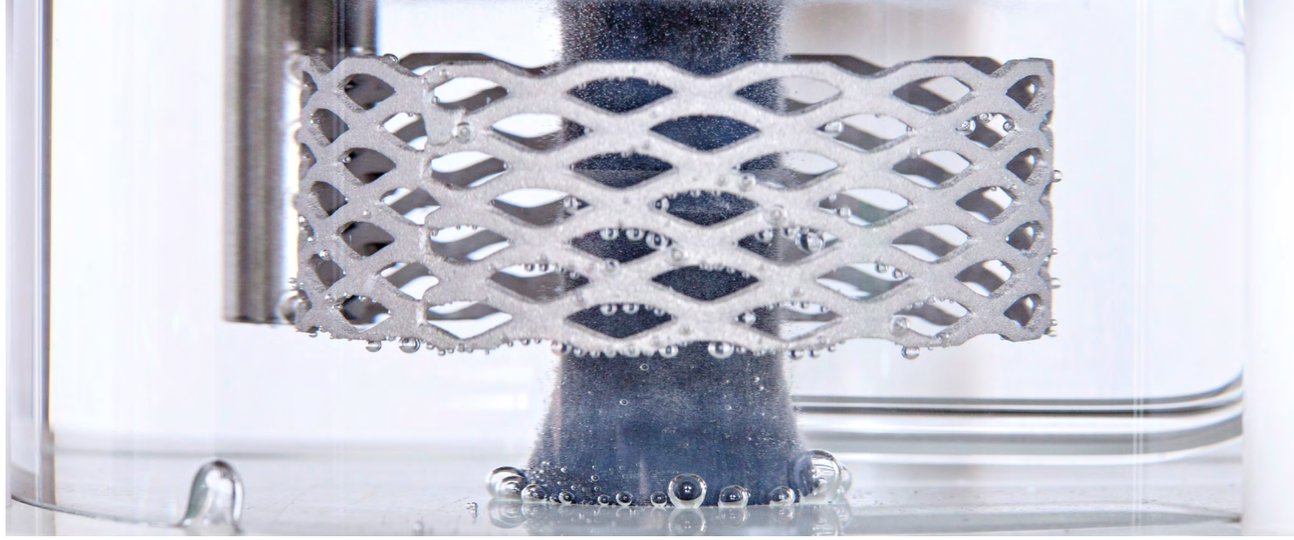

At Fraunhofer LBF, we also conduct research into the safety and system reliability of hydrogen components.

Customized "green" materials for "green" hydrogen in Hesse

Hydrogen performance center in Hesse

Hydrogen is considered one of the cornerstones for a climate-neutral, sustainable energy source for both stationary energy supply and mobile applications. In addition to sustainable production ("green hydrogen"), challenges exist in the reliable design of hydrogen technologies and their components, as well as in reducing the need for critical materials, such as in electrolysers.

In the Fraunhofer-Gesellschaft's new "GreenMat4H2 – Green Materials for Hydrogen" performance center, scientists from the Fraunhofer Institute for Materials Recycling and Resource Strategy IWKS and the Fraunhofer Institute for Structural Durability and System Reliability LBF are dedicated to solving these challenges with the aim of developing "green" material solutions for the hydrogen economy and ensuring the reliability of hydrogen-powered systems.

Activities span the entire life cycle of hydrogen, from production to storage/transportation to use. Among other things, research efforts focus on, the development and validation of sustainable materials and the development of analytical and validation methods for reliability assessment and lifetime estimation of materials, parts, and components in hydrogen systems.

SUSTAINABILITY, GREEN HYDROGEN, RELIABILITY, MATERIALS DEVELOPMENT

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Hydrogen-based drive systems are paving the way for climate-neutral aviation.

Innovative thermal management in fuel cell air compressors

Integrated end winding cooling based on duromers

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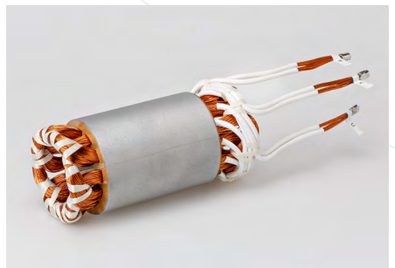
Fuel cell systems play a significant role in decarbonization, especially in commercial and aviation vehicles, which require high-capacity energy storage systems with the lowest possible weight. One application in aviation, for example, is the substitution of auxiliary power units. The "HABICHT" project is aimed at achieving a significant increase in system power density to 30 kW/kg, with a focus on maximizing the speed of the electric drive of the turbo compressor, which is used to supply air to the fuel cell. This is achieved through innovative thermal management with regard to cooling design and materials.

In order to be able to evaluate the technical feasibility of the process, an initial geometry demonstrator was set up in cooperation with partner institutes (IISB, IFAM and SCAI), which allows the positioning and realization of the simulated cooling concepts to be investigated in addition to electrical aspects.

Application-specific experimental investigations will be carried out at subcomponent level in the next phase of the project with the aim of achieving implementation in the overall system.

COOLING CONCEPT, DESIGN, THERMALLY CONDUCTIVE RESINS

Geometry demonstrator developed in HABICHT.



Further information online

www.lbf.fraunhofer.de/thermal-management

"With the virtual congress, Fraunhofer LBF has attracted some industry attention."

Participant feedback
on the "InCeight Casting C[8]" congress

Event highlights 2021

There was a series of virtual events in which LBF both participated and acted as leader. From "civil dialog" through workshops on special topics to a virtual congress.

In the second half of the year, we were finally able to meet with interested parties face-to-face at trade fairs again.

InCeight Casting C⁸ – first congress of 2021

Increasing automation and digitalization are enlarging the circle of those involved in the product development process for cast components and are also influencing the quality assurance of manufacturing processes such as those of cast products. These current challenges need to be understood by different disciplines. Our "InCeight Casting C⁸" congress enabled this overarching exchange of experience and knowledge for the first time.
Attend the second congress taking place: March 6–8, 2023 in Darmstadt, Germany.

#LBFutureMobility: Sustainable road freight transport

Under the #LBFutureMobility: Sustainable road freight transport, five Fraunhofer institutes presented results from the internal research project "HANNAe-II," which focused on generator-electric drives for medium-duty trucks in distribution transport.

#LBFutureMobility

Top-class keynote speeches from politics (HMWK), environmental research (Agora Verkehrswende) and logistics (Rheintal-Transporte, Nagel-Group) complemented the program. The event was concluded with a roundtable discussion with additional representatives of the Institute for Energy and Environmental Research (IFEU) in Heidelberg and the "Fridays for Future" movement.

Trade fair: Multifunctional lightweight design for tomorrow's mobility

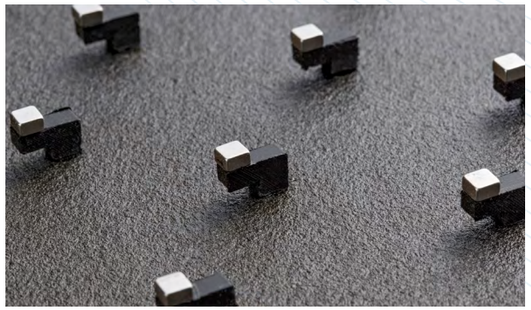
Mobility must be competitive, sustainable and safe. Lightweight design plays a significant role in this. Fraunhofer LBF scientists have been researching the lightweight potential of vehicles and their components for over 80 years. At "IAA Mobility" in Munich, Germany, they presented completely new approaches to sustainable, reliable lightweight construction for climate-friendly mobility. With the lightweight cargo bike (Lasten-LeichtBauFahrrad, L-LBF) and the "checkerboard battery housing," sustainable materials, a lightweight frame construction, higher battery capacity, efficient manufacturing processes and other function-integrated solutions have been realized.

The Fraunhofer stand at the IAA Open Space at Königsplatz in Munich. (© Markus Jürgens)

"Under the hashtag #LBFSpotlights, we offer regular online seminars."

"Vibro-acoustic metamaterials" Motivation – Potential – Solutions

Vibro-acoustic metamaterials influence harmful vibrations by means of a resonator effect. They could be used as a novel vibration reduction measure in a wide range of industries, for example in mechanical and vehicle engineering, or in the aerospace sector. Vibro-acoustic metamaterials reduce disturbing structure-borne sound or help to stabilize equipment and increase comfort. Numerical and experimental methods are being developed at Fraunhofer LBF to close the research gap in the systematic design process for vibro-acoustic metamaterials and to make them usable for industrial applications.



"Recyclates from the yellow bag"

Recyclates are not waste but valuable raw materials. LBF experts provided information on the compatibility and characterization of recyclates and the possibilities of making them usable for technical applications. Approximately 180 participants, mostly from industry, demonstrated the relevance of the topic and how established Fraunhofer LBF is here.

Systematic Research!

We apply our core competences of structural durability, system reliability, smart structures and plastics across divisions and achieve optimal benefits for our customers with innovative system solutions.

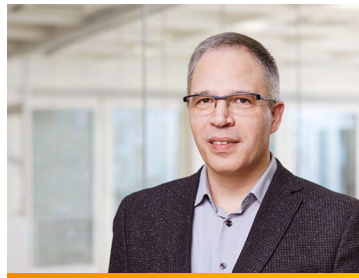
Structural Durability

Structural Durability as one of the most powerful methods in lifetime oriented design of components and structures forms the basis of our instituts research activities since its founding.The mobility

“We create lightweight construction. Reliable.”

industry, mechanical and plant engineering and renewable energies benefit from equally light and reliable products designed for the entire operating and utilization phase. In terms of structural durability, we have reached a historic milestone with the 8-step block program from Ernst Gaßner. Today, we combine state-of-the-art numerical, metrological and experimental methods of structural durability with a solution quality that meets our standards. Methods and procedures for the fatigue life oriented assessment of structures and proof of safety and structural integrity are our core competencies. They can be found in successful products, in material and component innovations as well as in novel processes, such as in additive manufacturing. As part of digitalization, these core competencies within powerful instruments are supplemented by cyber-physical simulation and a description of cyclical material characteristics extending continuously from the LCF through the VHCF regime.

With a strong focus on applicability, our research and work is dedicated to the fatigue life oriented design of safe components, assemblies and systems in road and railway vehicle construction as well as in shipping and aviation, but also in crane manufacturing and for wind turbines. Our two divisions are specialized in everything from the material to the complete structure and will support you expertly, e.g. for questions of structural durability of metallic materials and components, development and application of numerical methods, the description of complex kinematics using multi-body simulation (MBS), the construction and verification of such models up to the complete vehicle or the derivation of time-lapse test programs for laboratory testing.



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Smart Structures

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The research work in this area focuses on analyzing, influencing and optimizing the vibration behavior of components and structures as well as increasing the reliability of mechanical systems. To improve the system properties, we consider innovative passive and active structural measures in addition to lightweight construction principles. We provide support during the feasibility study, design and implement prototypical customeroptimized solutions. We develop adapted tools for system design and assist during their transfer to commercial implementations. For this we develop and use modern methods of numerical and experimental structural and reliability analysis, structural dynamics and signal processing.

Smart sensor and actuator systems and electronic subsystems are developed to implement reliable active structural solutions, and control technology solutions are derived from embedded systems.

There exists an integrated design chain with our two departments „Experimental Analysis and Electromechanics" and "Structural Dynamics and Vibration Technology" to help you make your products quieter, to make it more comfortable and intelligent: metrological analysis, numerical methods for concept evaluation,

„We develop methods and processes for smart and reliable Lightweighting structures for our customers."

design and simulation, production of prototype mechanical, electromechanical and electronic functional models, methods and tools for ensuring function and reliability in the laboratory and in field trials.

Plastics

Only cutting-edge products with reliable and rapid access to innovative and high-performance materials can be offered competitively on the world market today. Tailored plastics, plastic additives, plastic composites and plastic processing technologies play a central role in meeting high global demands in the areas of mobility, energy, environment, communication, health, nutrition and safety. **Plastics** enable tremendous savings in resources and energy as well as a wide variety of options in lightweight design. Particularly when they are fiber-reinforced, particle-filled, foamed or integrated into sandwich structures, plastics can withstand the highest degree of loading and absorb a great deal of energy. They can be supplemented with an additional range of functions such as protection from UV rays and the affects of weathering, reduced fire behavior, functions for the development of special optical properties, electric and thermal conductivity and with sensor and actuator functions. At the same time, increasing demands on sustainability require new solutions in terms of a circular economy and recycling or the development of bioplastics.

All components relevant for the implementation of sophisticated plastic applications, running the scope from basic natural science disciplines such as chemistry and physics, material sciences and material technology in processing to expertise in analytics, testing and modeling, are united at a high level under one roof.

This is what the following four departments – complementary in their disciplines and methods – "Plastics Components and Process Control", "Material Analytics and Characterization", „Additivation and Durability" and also "Synthesis and Formulating", stand for.

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„We develop long-lasting and safe plastics with improved recyclability as well as new technologies for an efficient circular economy."

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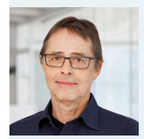

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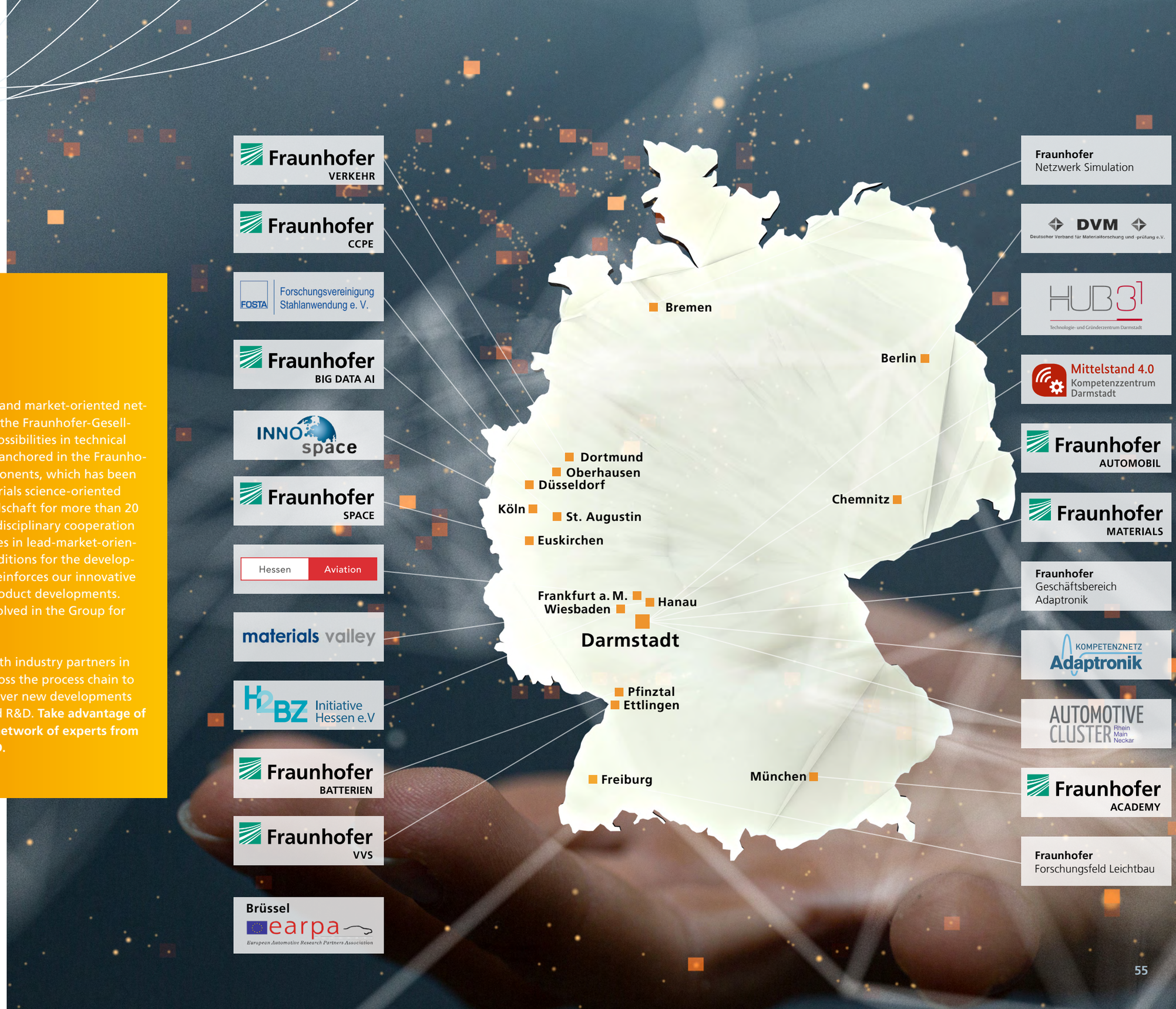
Networks

With our involvement in alliances and market-oriented networks both within and outside of the Fraunhofer-Gesellschaft, we expand your and our possibilities in technical and economic terms. LBF is firmly anchored in the Fraunhofer Group for Materials and Components, which has been pooling the expertise of the materials science-oriented institutes of the Fraunhofer-Gesellschaft for more than 20 years. In addition, the close, interdisciplinary cooperation with our specialized sister institutes in lead-market-oriented alliances creates excellent conditions for the development of our system services and reinforces our innovative strength for the design of your product developments. Since 2019, we have also been involved in the Group for Defense and Security (VVS).

At the same time, we can work with industry partners in the business-related networks across the process chain to competitively and efficiently discover new developments from business, science and applied R&D. **Take advantage of our extensive opportunities in a network of experts from business, science and applied R&D.**



ISSN 1864-0958

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