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FRAUNHOFER INSTITUTE FOR HIGH-SPEED DYNAMICS, ERNST-MACH-INSTITUT, EMI

ANNUAL REPORT 2020/2021

Visualization of the dynamic X-ray analysis based on a crash simulation inspecting a Toyota Yaris with one occupant (Hybrid III dummy). Simulations were performed with LS-DYNA (Livermore Software Technology Corp.) on the 2010 Toyota Yaris Finite Element Model (CCSA).

Annual report 2020/2021

“For a resilient future.”

Dear reader,

One year after I have put the focus on the importance of resilience as a concept, we have repeatedly encountered the term “resilience” in our everyday lives. Our experience with resilience approaches and their application has contributed to the fact that we have been able to find a multitude of research and project partners to contribute to overcoming the crisis now and in future. Our partners are SMEs, Fraunhofer panels, businesses and university hospitals alike.

I hope that you all have coped well with the corona virus and the various resulting consequences. I am very well aware of the fact that for this reason, many of you cannot or can only to a limited amount do business with us. This impacts our institute continuously. For us, this is a reason to strategically position ourselves for the future to win you as partner in new and different ways, while we are continuing to offer you all of our outstanding knowledge and expertise.

As you can deduct from the technical contents of this annual report, we are constantly developing the core research topics of our business units using experimental and numerical methods. Novel diagnostics as well as the increasing integration of artificial intelligence are equally important as integrating the human factor via agent-based methods.

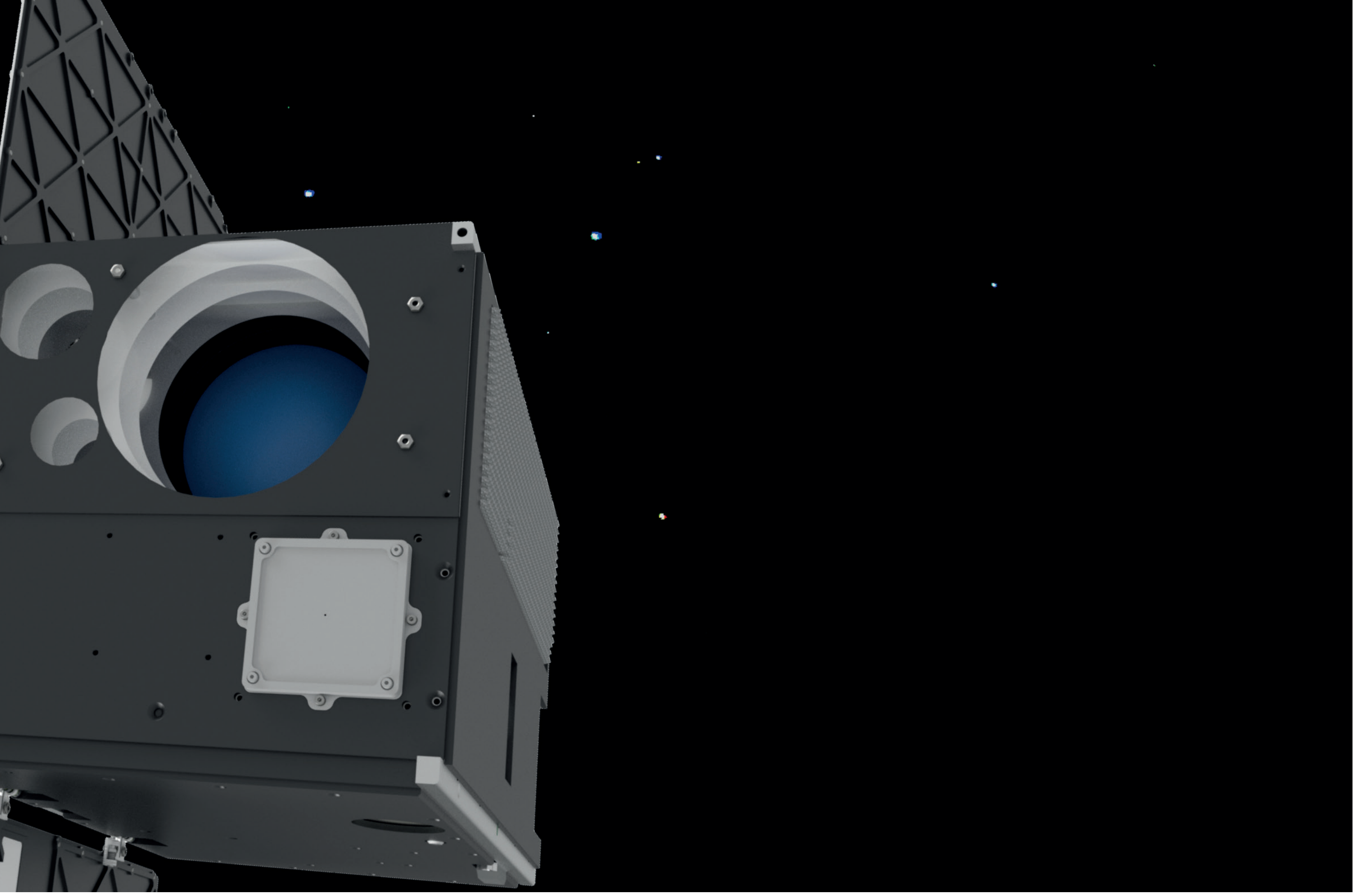
In this way, we were able to formulate the effect of laser weapons, which is complex due to its multi-physical subject matter, in our own damage model. To prevent damage even when practicing with live ammunition, we have digitalized exercise operations in cooperation with the Bundeswehr. We are continuously improving our research on crash events, especially such involving battery-powered vehicles, using our dynamic X-ray facilities. Insights, perspectives and AI-based evaluation methods have become core topics at EMI.

Our Spacecraft Technology department is about to launch our first spin-off into orbit. The start-up ConstellR has successfully ventured to provide the world with much-needed data on land surface temperature, which allows an optimized use of water and to reduce the risk of harvest losses. This is an innovation that cannot be valued highly enough when facing climate change, the global growth of population and nutrition problems across the globe.

I want to thank all our partners, customers and colleagues from research, economy and politics for the continued trust you have placed in us. Enjoy reading!

Sincerely,
Stefan Hiermaier

Prof. Dr.-Ing. habil. Stefan Hiermaier
Director of Fraunhofer EMI

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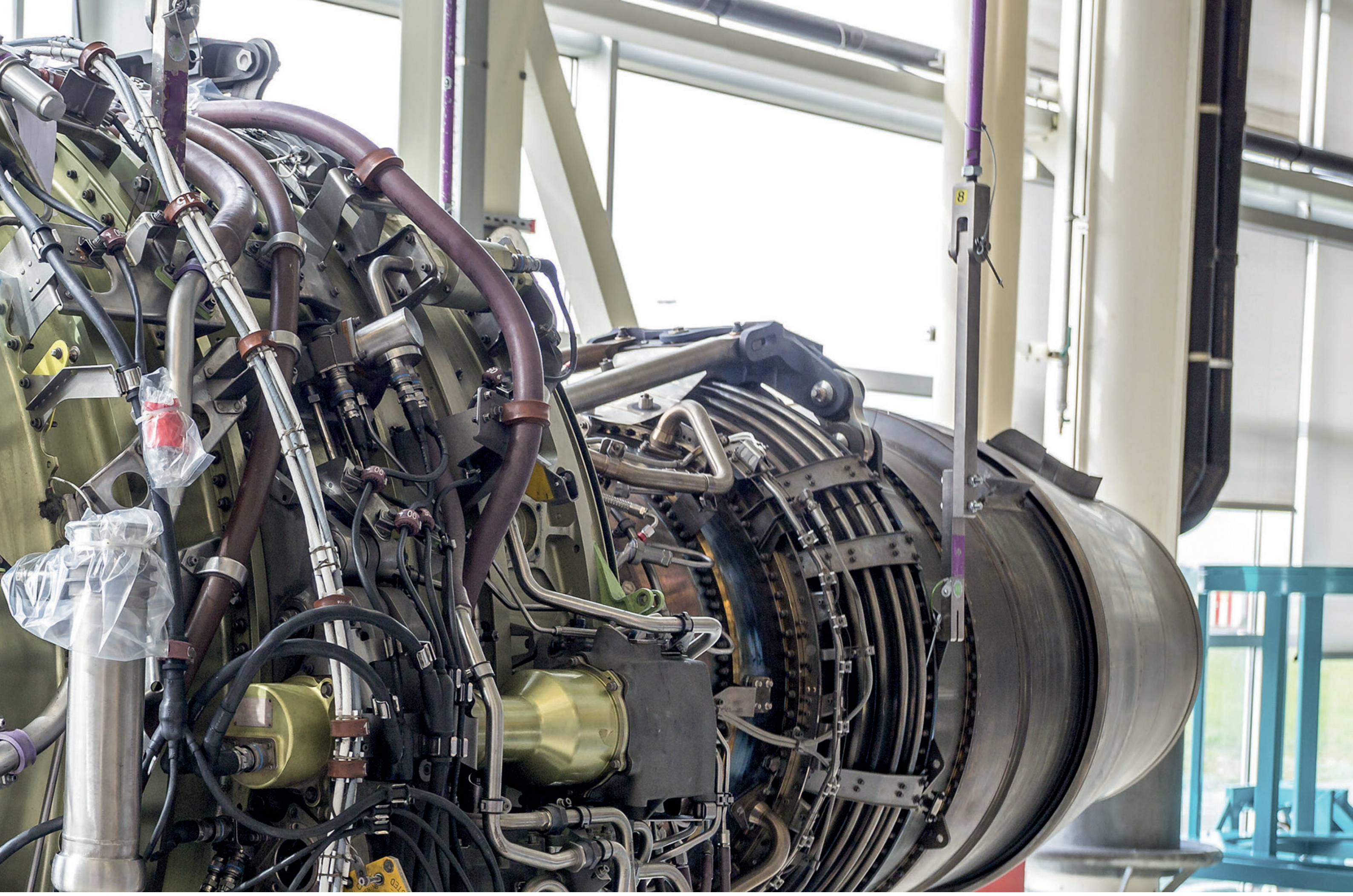
Technology for
robust sensors



Business unit Defense

False color rendering of process light emission during the perforation of a plate of carbon-fiber reinforced plastic by a high-energy laser beam. (To highlight the laser beam, it was intensified in the graphics.)

Business unit Defense

"The German Federal Armed Forces (Bundeswehr) need sustainable systems and technologies for land, air and sea."

As a strategic partner of the German Federal Ministry of Defence (BMVg) for research and technology in the field of high-speed dynamics and extreme material stresses, Fraunhofer EMI explores scientific and technological issues regarding protection and effectiveness, security as well as system aspects using state-of-the-art technologies. Our research identifies new solutions and expands the knowledge base available for analyzing equipment decisions – with respect to national as well as European security.

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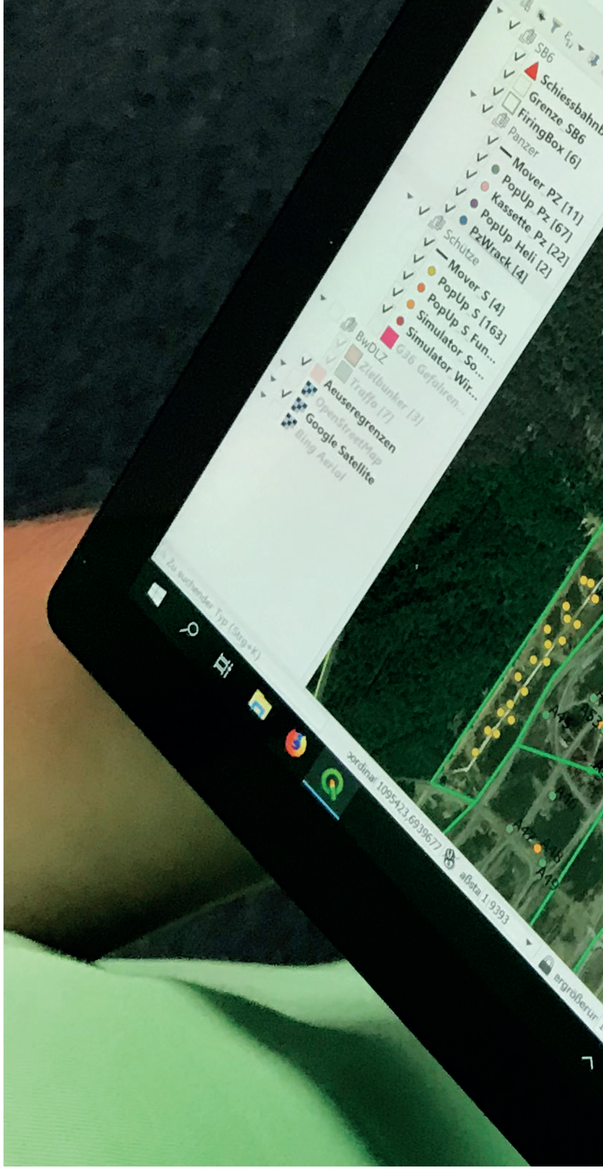
s.fhg.de/emi-defense

Future combat training system

Military training areas are an essential part of combat training for soldiers. However, the technology that has been established there for many years mostly enables only static exercises. Fraunhofer EMI is investigating how digital methods can help make scenarios more complex and ensure greater safety for exercise participants and bystanders.



Fraunhofer EMI is investigating how live-firing exercises can be made more modern and efficient by using sensor technology and methods of digitalization. The challenge is to ensure safety while meeting advanced requirements.

A key question here is: Which methods can ensure the safety of exercise participants and bystanders when modern technologies such as portable, self-moving, or virtually displayed targets are used for effective training?

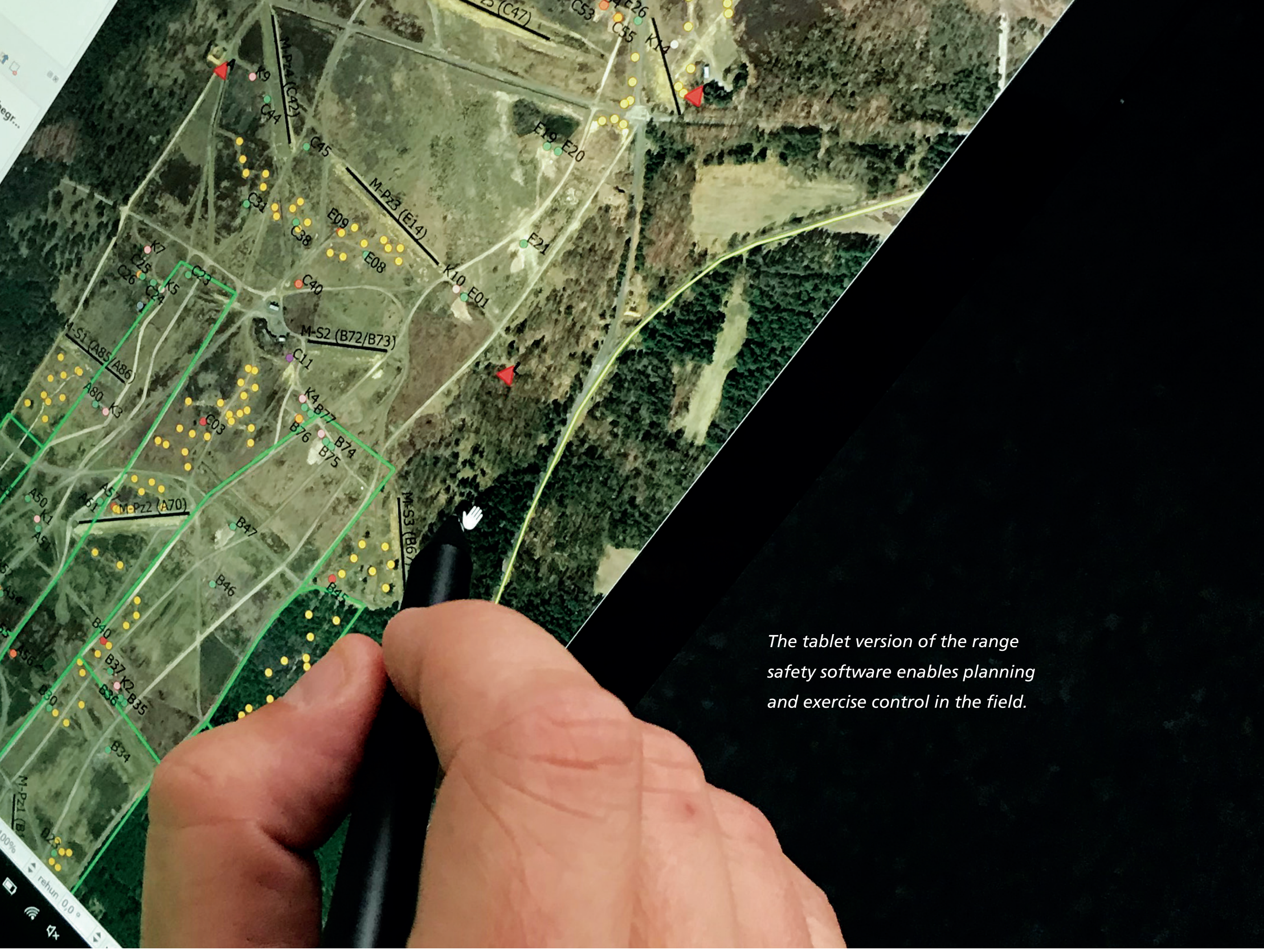
The potential of digitalization for combat training with live ammunition

In combat training, soldiers should be prepared for missions as realistically as possible. To do this, they practice live firing in predefined scenarios on military training areas. The display of targets, often realized by using pop-up targets, has so far been mostly static and is often still analogously controlled. A dynamic target presentation integrated into a digitized combat training system promises more complex scenarios for more intensive training.

Digital range safety planning

In order to minimize the risk to persons inside or outside the training area during a live-firing exercise, a specific danger zone is defined for each exercise, taking into account the weapons and ammunition used and the planned sequences of the exercise. Range safety planning is mostly still done manually, and is therefore time-consuming and not very flexible.

Computer-based methods, such as the software developed by Fraunhofer EMI for digital, regulation-



The tablet version of the range safety software enables planning and exercise control in the field.

compliant range safety planning, can considerably simplify this process and make it more flexible. The fast, semi-automated calculation of danger zones enables the rapid variation of input parameters and facilitates the planning of even complex exercise scenarios. The inclusion of autonomously maneuvering robot targets makes the target display dynamic and thus more confusing in terms of safety considerations. Tools that can be used on-site, such as digital range safety planning and simulated training sequences, can make a significant contribution to ensuring shooting safety.

Detection of the weapon orientation

During live-firing excises, practitioners may only fire shots into an area that has been marked with the help of limit-of-fire markers. Compliance with this requirement is monitored on-site by range safety personnel

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who are assigned individually to the exercisers. This monitoring could be made drastically easier if the position and orientation of each handgun involved could be recorded in real time and automatically monitored during the entire exercise.

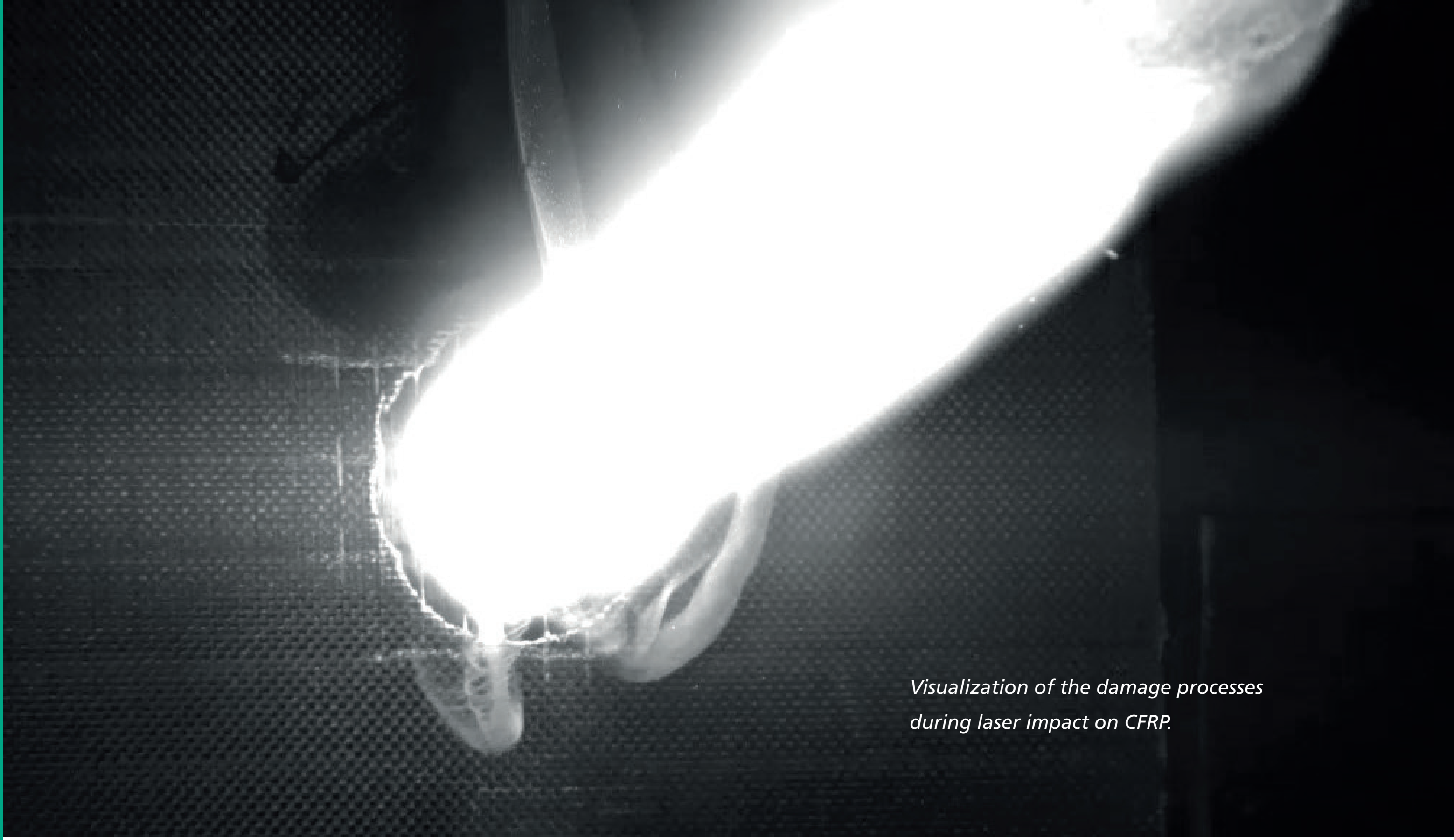
At Fraunhofer EMI, the first concepts for a corresponding sensor system were developed and set up as a functional illustrator, based on the modular grip of the G36 assault rifle. For this handle sensor system, it has already been demonstrated in an exercise how the position and orientation of the weapon are transmitted "live" to a higher-level combat training system. The focus of current work is on increasing the technological maturity of the functional illustrator, taking into account safety requirements.

Future combat training system

The mentioned aspects are part of a concept for a future-proof combat training system, which combines range safety, exercise planning, exercise control and evaluation in a holistic approach. The collection and analysis of relevant exercise data, for example the position of exercisers and targets, is just as important as reflecting this information back into the exercise process so that it can be adapted to the position and designed interactively. The first practical experience with a combat exercise system developed at Fraunhofer EMI for basic concept illustration as well as the challenges of everyday exercise was gained during a combat exercise together with the partners from the guard battalion at the Bundeswehr training range Wildflecken.

The panel of experts on "Digitalization of military training ranges" answers questions from the specialist audience. From left to right: Dr. Siegfried Nau (Fraunhofer EMI), Frank Jaspers (WTD 91), Brigadier General Andreas Henne (Territorial Command, project manager Further Development of Bundeswehr Training Areas and Shooting Facilities) and Lieutenant General Martin Schelleis (Inspector Joint Support and Enabling Service).

Function illustrator of a sensor system for recording the spatial orientation of a handgun.

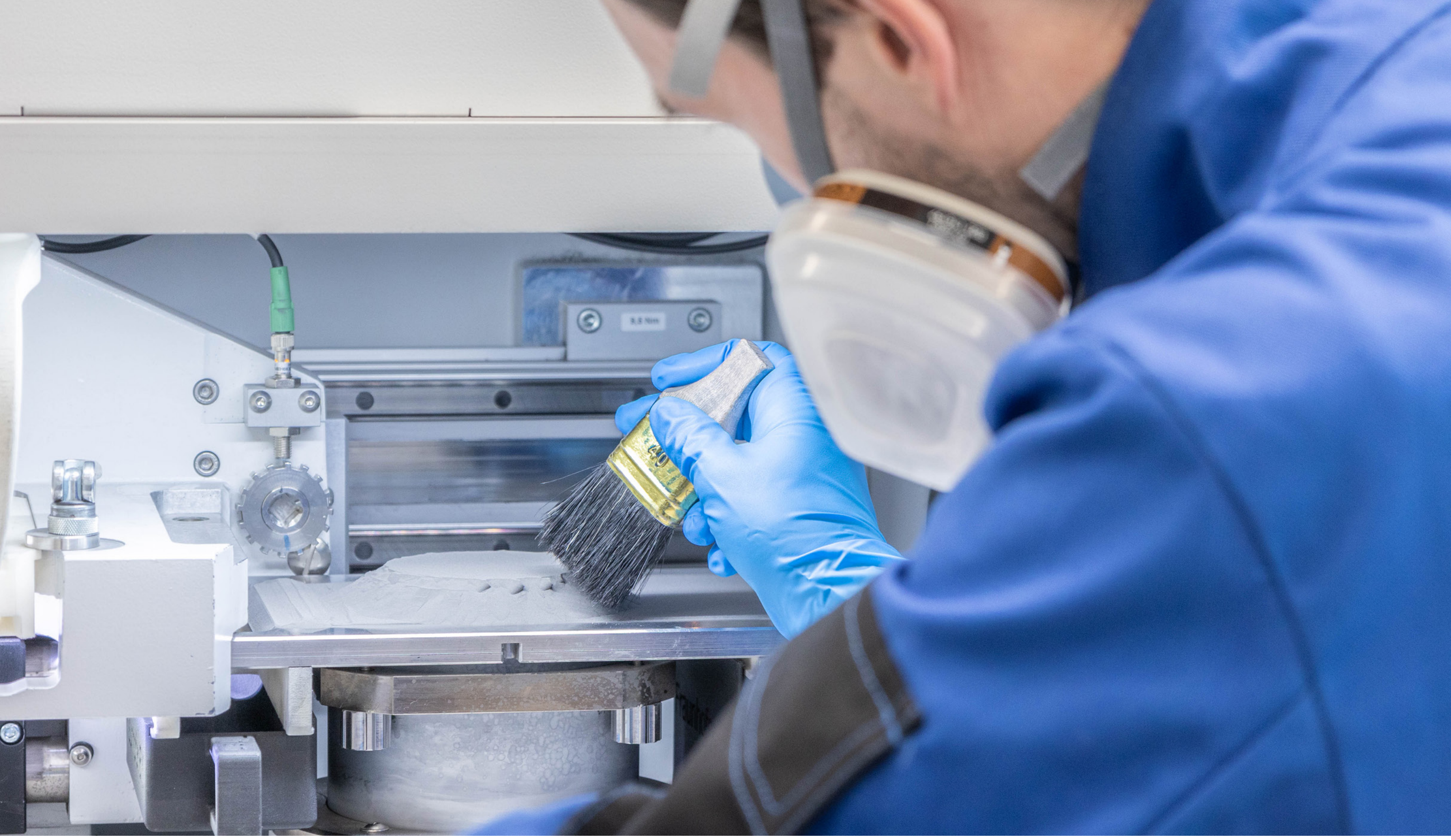


Visualization of the damage processes during laser impact on CFRP.

Damage model for laser weapon effects on composite structures

With the progress in laser technology, compact and efficient laser systems have become available for some years, which combine high output powers with a very good beam quality. This will enable future military applications. Against the background of these developments, the question arises for the Bundeswehr to what extent future systems can also be designed to be robust against the effects of high-energy laser radiation. Fraunhofer EMI operates special laboratories to observe the physical effects of high-energy laser beams on a wide range of materials. In cooperation with the Bundeswehr Research Institute for Materials, Fuels and Lubricants (WIWeB), the effects of such radiation on carbon-fiber reinforced plastic (CFRP) were also investigated, which is increasingly used in the aerospace industry due to its high mechanical stability and low weight. In the first series of tests with laser powers of up to ten kilowatts, the laser exposure was carried out using special high-speed measuring technology and the irradiated samples were later analyzed in a high-resolution computer tomograph. The evaluation of the test results shows that there is a linear relationship between the laser energy applied and the volume removed in the investigated samples. This relationship can be formulated mathematically as a simple damage model, which describes the extent of the damage that has occurred.

Further information:
s.fhg.de/effects-laser-weapons


First experiments with the new composite materials show the wide range of possible combinations.

New metal matrix design materials using 3D printing

With the powder-bed-based laser beam melting process, it is possible to design metal matrix composites (MMCs) that combine the advantageous properties of their components. For example, a soft, ductile steel can be reinforced by a hard, brittle material so that the resulting material has both high hardness and good elongation properties. First successful applications of this new approach to material design were demonstrated at Fraunhofer EMI.

Further information:
s.fhg.de/metal-matrix-design-materials

Battery cells under fire

Electrical energy storage systems are advancing into ever new fields of application in both the civil and military sectors. Due to their steadily increasing efficiency, they can replace other energy sources in more and more areas. By saving weight and space, they moreover offer new functionalities and enable a significant increase in the usability of devices and vehicles. However, the increasing electrification comes along with new types of hazards, comprising the release of toxic substances, fire or even an explosion in case of improper handling or under heavy loads. In the defense sector, this is particularly relevant with regard to application-specific loads such as bullet impact, blasting or other mechanical stresses as well as special requirements in terms of safety and reliability.

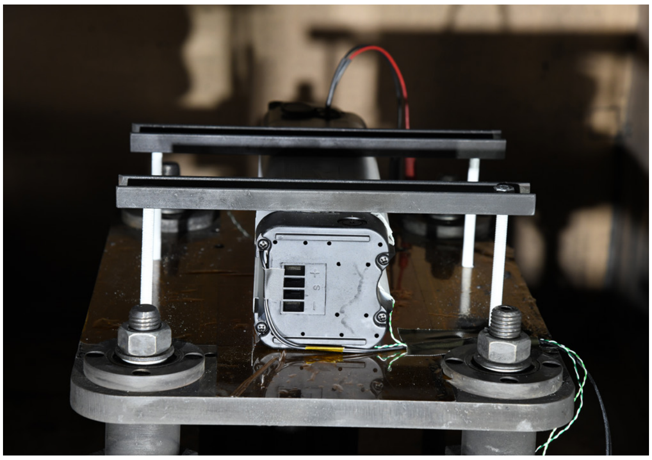
At EMI, tests were carried out on various lithium-ion batteries in order to classify potential hazards in the event of bullet impact and develop suitable safety measures. From portable battery systems to truck starter batteries, different types have been tested for their bullet resistance. The reactions observed ranged from a negligible drop in voltage to meter-long tongues of fire, explosions and heavy smoke.

A comparison between commercial rechargeable batteries was particularly impressive: While the impact in lead-acid batteries did not cause any noticeable effects, the examined lithium-ion batteries caught fire immediately and emitted large amounts of hot gases and particles. A simple transfer of accumulators from the civilian

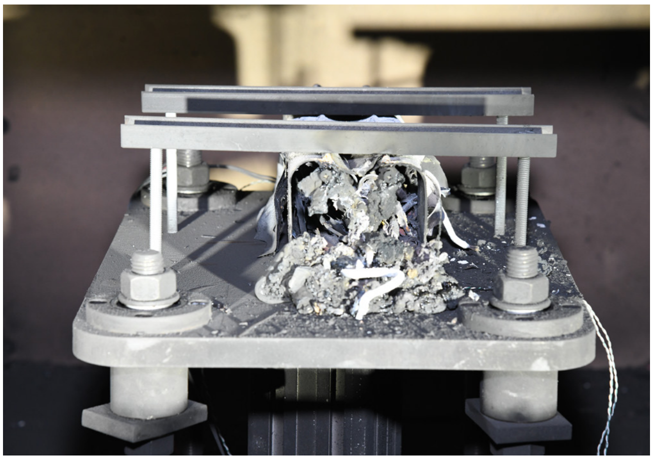
Section from a video recording of the bullet impact of an exemplarily selected lithium-ion bicycle battery (dimensions: 38 centimeters by 8.5 centimeters by 8.5 centimeters).

sector to the Bundeswehr could therefore entail considerable new security risks and should in no way be carried out without special prior testing or additional protective measures.

Fraunhofer EMI is investigating the relevance of safety aspects as well as the suitability of test regulations for lithium-ion batteries for defense technology.



Bullet impact of a lithium-ion bycicle battery: before the test.



Bullet impact of a lithium-ion bycicle battery: after the test.

Business unit Security and Resilience


Security is a fundamental social need.

Business unit Security and Resilience

"Our customers have recognized that resilience must also be part of their strategy to maintain a competitive advantage in the face of increasingly complex challenges. In many cases, it is no longer a question of whether, but rather when disruptions or failures in the own system occur. You can prepare well for this with our resilience tools."

Daniel Hiller, head of business unit Security and Resilience

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Resilience as a security concept of the future

The pandemic has shown that complex risks can pose an existential threat to the future of many companies. To be better prepared for the next crisis, Fraunhofer EMI is focusing on resilience as a new extended security concept. With the help of the projects KMU-Lagebild and FReE, companies are supported in measuring their resilience and then in increasing it in order to be prepared for the next crisis.

The business unit Security and Resilience makes an important contribution to resilience research with the projects KMU-Lagebild and the Fraunhofer Resilience Evaluator FReE

The corona pandemic has disrupted our society in many areas. Especially, the economy was hit hard: Many companies experienced disruptions in their supply chains, or important customers were lost. This pandemic will not be the last crisis to challenge our economy and society. If companies continue to rely solely on classic methods of risk analysis and risk management that only consider expected risks, the next crisis will generate further massive damage. Crises are often unpredictable and trigger complex cascading effects, which are not taken into account by traditional risk management.

Resilience as new security concept

This is precisely where researchers from the business unit Security and Resilience at Fraunhofer EMI come in. In order to establish resilience as a new security concept for organizations and companies, the project KMU-Lagebild (allowing companies to model their resilience quantitatively) as well as the development of the Fraunhofer Resilience Evaluator FReE were initiated.

Previously rather known from psychology, the concept of resilience is now being applied inter-disciplinarily, also in civil security research. In this context, the resilience of the company in question is assessed and a resilience analysis is carried out before, during and after a disruptive event. Crucial

Natural disasters such as Hurricane Irma (2017) highlight the importance of resilient infrastructures. © Adobe Stock

properties of resilient systems are resistance, the capacity to adapt and to absorb as well as the ability to recover and learn.

The projects FReE and KMU-Lagebild

FReE is an online tool that allows companies to assess their resilience. It is based on a structured questionnaire with 64 questions on the resilience of the enterprise, which are divided chronologically into the phases before, during and after a disruptive event. The answers result in compact summaries, on the basis of which the performance of the company in a wide range of areas becomes visible.

In the project KMU-Lagebild, small and medium-sized enterprises (SME) are supported in carrying

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out a methodically comprehensive resilience assessment and to determine the impact of possible disruptions. SME represent the socially and economically predominant size of enterprises in the European Union, they are often referred to as the "backbone of the German economy". To create the SME situation picture, the company, its sub-units as well as all procedures and processes are modeled on the computer. Furthermore, procedures and processes are discretized in time by noting in figures which inputs enter the corporate system and are processed there. To evaluate the resilience, different disruptive scenarios can then be loaded, each directly showing in the SME situation picture how the system reacts to them. In this way, you can prioritize countermeasures and optimize the resilience of the company.

Blackout in New York City after Hurricane Sandy in 2012.
© Wiki Commons

The complexity of our cities increases: a night scene of Bangkok.
© Adobe Stock

Border controls are necessary to ensure security. © Getty Images

TRESSPASS

robusT Risk basEd Screening and alert System for PASSengers and luggage

To ensure security at the European Union's external borders, all travelers currently undergo the same border controls. However, as travel volumes grow, border authorities face the challenge of enabling higher flow rates at the same level of security in order to reduce the waiting time for travelers during border controls. The TRESSPASS project addresses these challenges by investigating the feasibility of risk-based border controls.

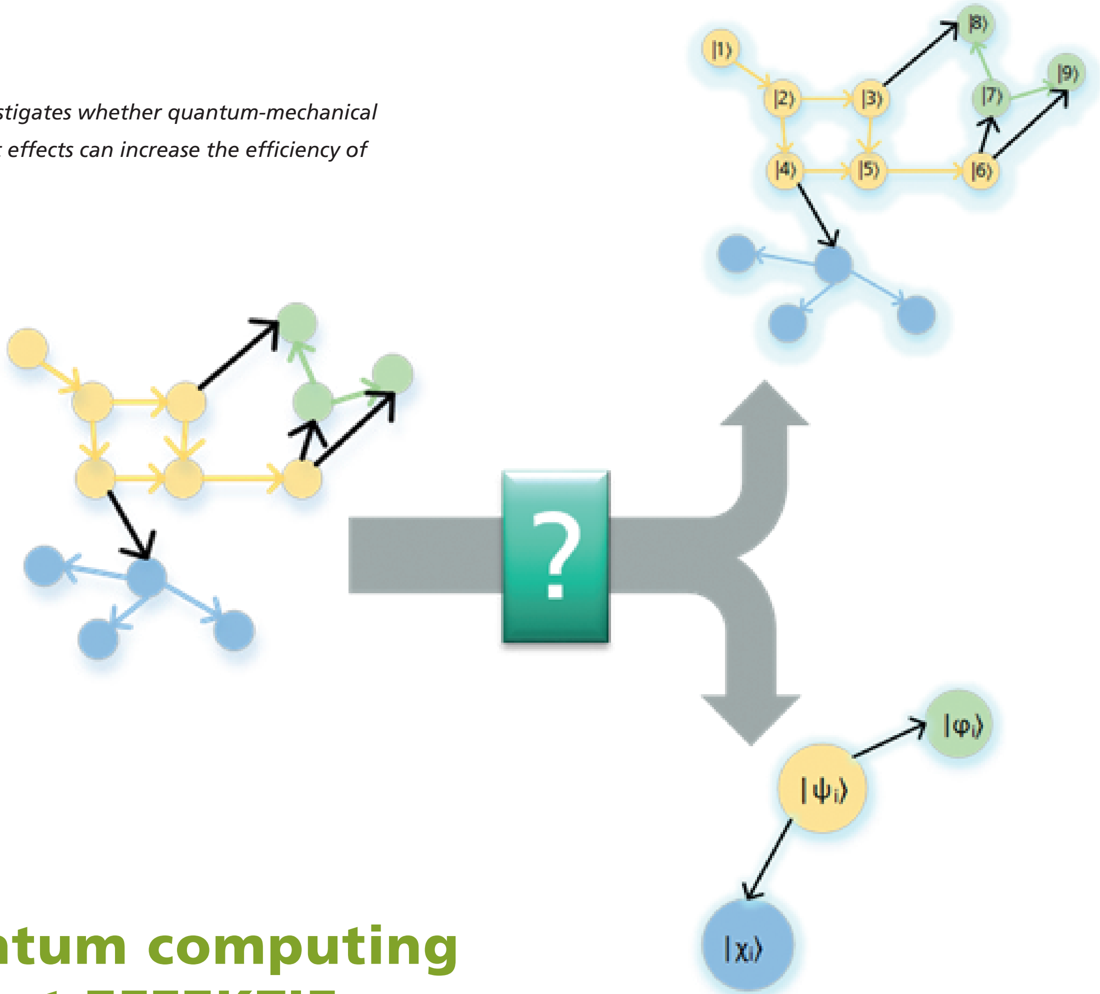
The basis for this is risk modeling and a systematic approach to quantifying risks. Based on data and using a four-step risk-management approach, the risk for each traveler is calculated. The number and type of security checks will thus be adjusted accordingly to different risk categories. The core implication of the approach is that the travelers with low risk, which constitutes the majority of the traveler flow, undergo very minimal checks, which increases the flow rate.

Currently, the flow-related efficiency and security effectiveness of this approach are being quantified by means of simulations; in parallel, the approach is being implemented and tested in three pilot projects and subsequently validated.

Further information:
www.tresspass.eu

TRESSPASS has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 787120.

EFFEKTIF investigates whether quantum-mechanical entanglement effects can increase the efficiency of simulations.



Quantum computing project EFFEKTIF

The project EFFEKTIF deals with the question whether quantum computing approaches can provide a more efficient assessment of the impact of disruptive events on critical infrastructures. The complexity of potential disruptive scenarios is growing with the continuously increasing size and interconnectivity of such networks. EFFEKTIF explores suitable strategies to adequately deal with increasingly complex disruptive scenarios with the help of quantum hardware. Thereby, the extent to which quantum-mechanical entanglement effects can increase the efficiency of problem-solving simulations will be estimated. This project addressing the research into the potential of quantum computing technology is one of six joint projects of the Fraunhofer Competence Center "Quantum computing Baden-Württemberg". In addition to Fraunhofer EMI, the University of Freiburg and Überlandwerk Mittelbaden GmbH & Co. KG are associated partners of the project.

Further information:
s.fhg.de/effektif-en

Business unit Automotive

Crash using X-ray car-crash (X-CC) technology.

Business unit Automotive

The new parameters in the automotive research environment are shaped by transformational processes towards sustainable, intelligent and, above all, safe forms of mobility, by ambitious climate goals, by novel technological developments and mobility concepts as well as by societal trends. In addition to innovations in the powertrain, digitization and automation are also driving factors of a comprehensive change in technology. This is reflected in the current research topics at Fraunhofer EMI, some of which are highlighted hereinafter.

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Crash: vehicle compatibility under X-ray

In the latest Euro NCAP MPDB test, the vehicle front penetrates an aluminum honeycomb barrier. For its evaluation, the plastic deformation of the barrier is measured accurately to the millimeter. But how deep does the vehicle intrude at which point in time? At which point during crash do deformations occur in the barrier? What is the maximum elastic deformation? Crash tests under X-ray deliver answers.

s.fhg.de/crashtest-video

Crash test under X-ray: How well do vehicles protect their collision partners?
A typical accident scenario on a country road: Two vehicles at medium speed meet in a frontal crash. Usually, the impact only affects a certain area of the vehicle front, not its full width. The effects of such a head-on crash are simulated in the crash laboratory. The test configuration is based on the Euro NCAP MPDB test (mobile progressive deformable barrier), which was introduced in 2020 and uses an overlap of 50 percent.

At the Crash Center of the Fraunhofer-Gesellschaft, the use of X-ray diagnostics (X-ray car crash, X-CC) makes it possible to analyze the temporal progress of deformations of inner, non-visible structures while the impacting vehicle forces its way into its collision partner. Information gained from the experiment is, in turn, employed to advance FE computer simulations and offers insights into how safety can be enhanced by vehicle design. The driver dummy in this test, THOR-50M, is a highly sophisticated and sensitive test device, developed to accurately estimate the risk of head, neck, chest and abdominal injury. The dummy was supplied to EMI by courtesy of our partner Kistler.

New crash test puts inner vehicle structure under the microscope
To protect the occupants in the test vehicle, the impact forces have to be directed to vehicle parts where the energy can be absorbed effectively and safely. Otherwise, vehicle parts might intrude too deeply into the collision partner (represented by the MPDB). Therefore, it is important for the deformation zone to collapse in a controlled manner, leaving the passenger compartment as undeformed as possible. A detailed look at how the vehicle

The photograph shows the team after the successful crash test.

velocity decreases during crash and what damages the vehicle causes in the deformable barrier gives evidence of how efficiently the two partners have interacted and to what degree they are compatible.

The test setup in the depicted case shows slightly changed conditions to perform X-ray diagnostics and to generate several pictures of the vehicle front structure during crash.

Further information:
s.fhg.de/new-crash-test

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The dummy THOR-50M was supplied to EMI by courtesy of our partner Kistler. It is a highly sophisticated and sensitive test device, developed to accurately estimate the risk of head, neck, chest and abdominal injury.

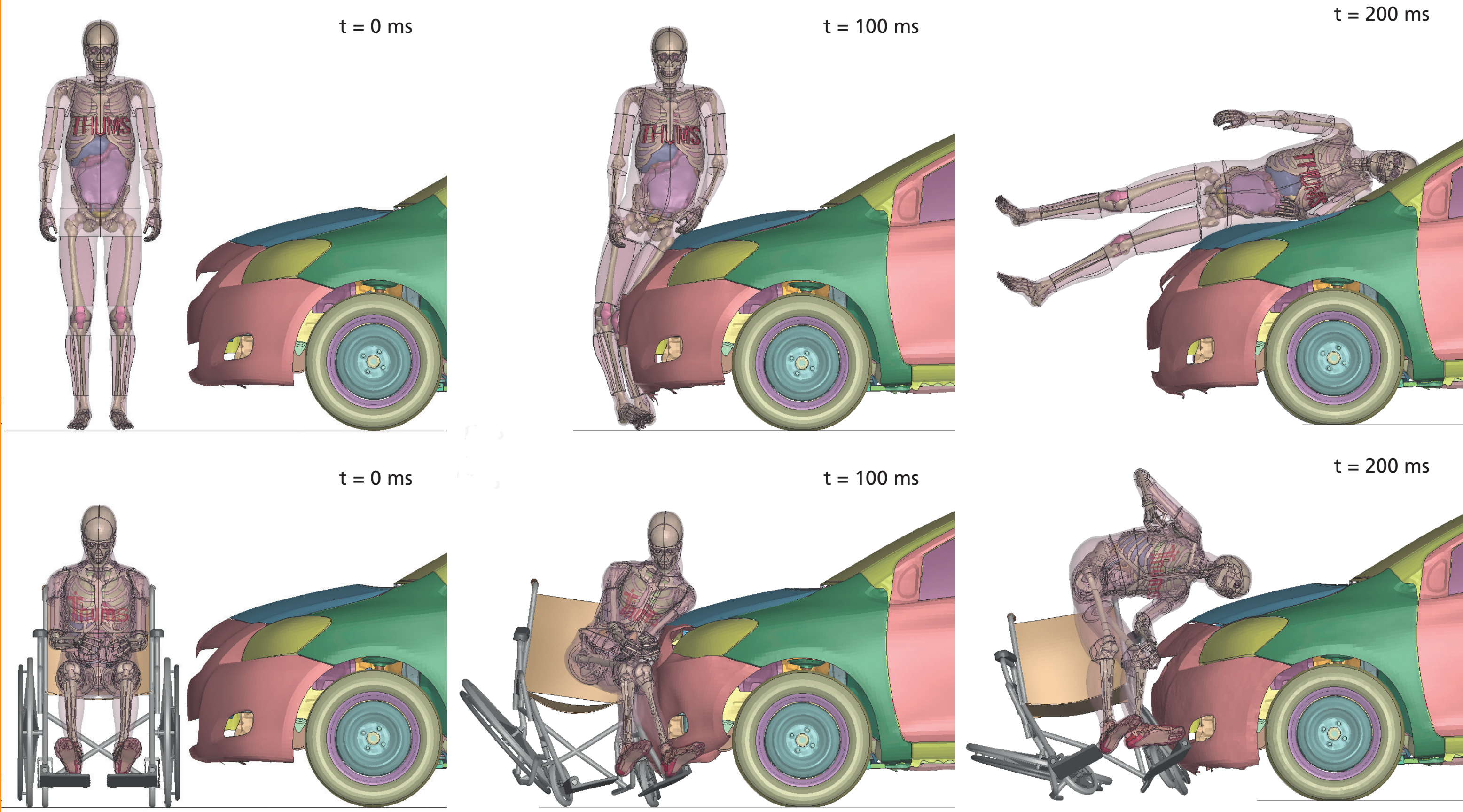
The barrier made of aluminum honeycombs represents the front of the collision partner. The honeycomb stiffness is comparable to a mid-range family car. According to protocol, the barrier is mounted on a trolley. The crash vehicle is not supposed to penetrate the honeycombs too deeply at any point. How deep penetration actually occurred can be seen in the deformation of the honeycomb structure after crash.

Reasons for the very good test results lie in the optimal data base: A finite-element (FE) model is freely available for the Honda Accord VIII, which was especially imported from the US. With this model, a testing situation with multiple diagnostics composed of X-ray flash and high-speed recording could be simulated in advance, helping to estimate the occurring forces and accelerations beforehand.

Evaluating the FE model and a high-resolution XXL computed tomography accomplished at Fraunhofer EZRT after crash finally brings the process of feeding the test results from the in-situ X-ray recordings back into the simulations full circle. In the end, precious insights are gained into how safety can be enhanced by vehicle design.

The test was successfully performed together with partners of Fraunhofer EMI, namely, Fraunhofer EZRT, ADAC and Kistler Instrumente GmbH. The project was funded by financial means of the Fraunhofer-Gesellschaft, which were allocated in the context of the German Future Prize 2019 nomination.

The dummy THOR-50M is being adjusted for the crash test under X-ray.



Pedestrian (top) and wheelchair user (bottom) in the event of a car collision at 30 kilometers per hour.

Wheelcharity – safe in the wheelchair

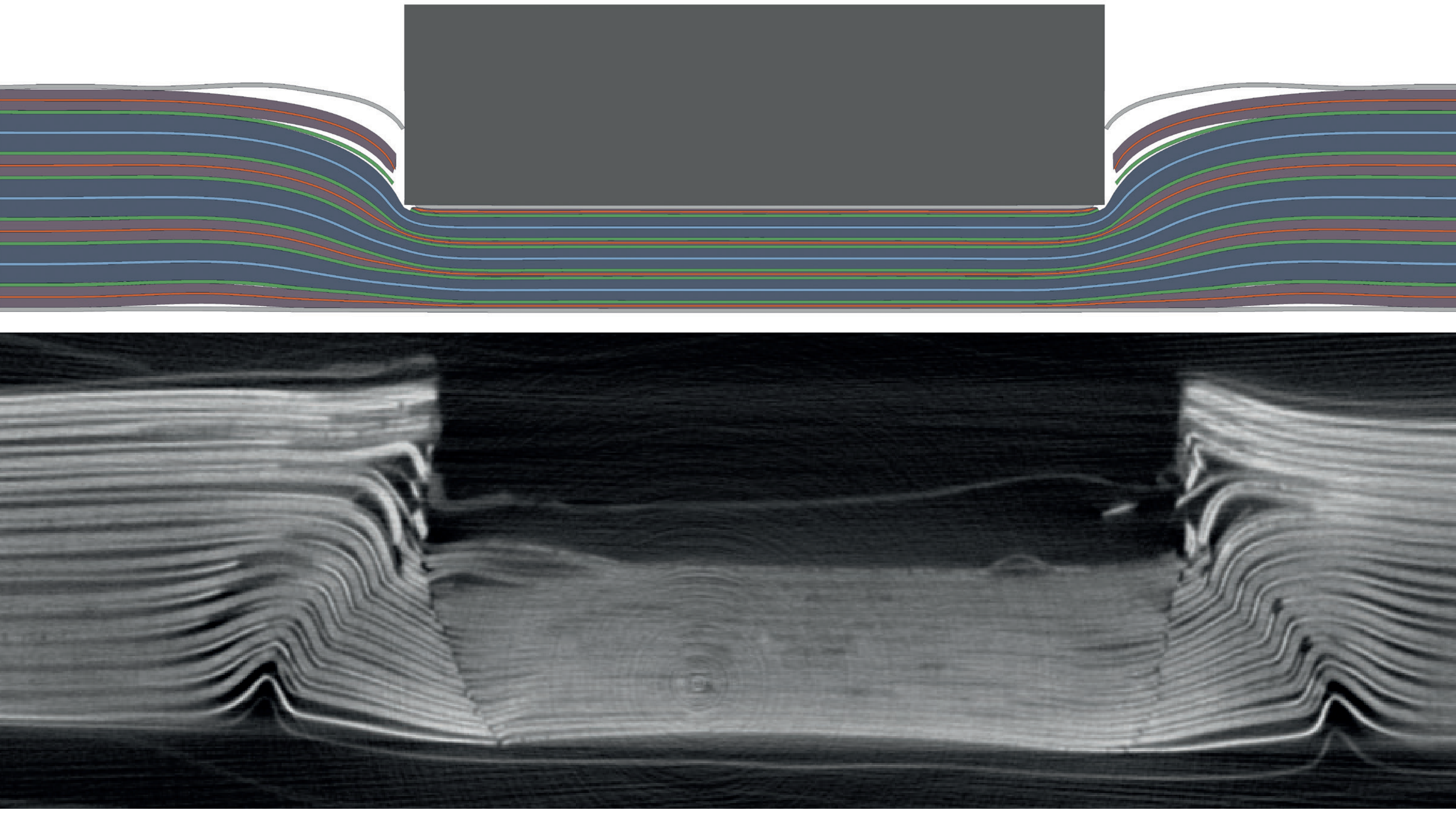
The objective of the EMI-internal project is to gain insights into the crash behavior of wheelchair users (WCUs), to identify possible risks of injury and to point out optimization potentials and to test them exemplarily for application. This happens in view of the fact that in road accidents WCUs are exposed to a higher mortality risk than pedestrians. Differences in posture, head height and center of mass may have effects on the collision behavior, which have not been studied yet.

A safety analysis based on the numerical simulation of the WCU-vehicle collision shows that the movement pattern of the WCU differs from the pedestrian: For example, the pedestrian bends around the vehicle front in a smooth motion while the WCU impact appears to be rather abrupt. This can be explained by the additional contact with the wheelchair, the different posture and the lower center of mass.

In further work, structures were developed that can potentially optimize the safety of WCUs. The structure can effectively absorb acting forces and makes it possible to change the trajectory of the WCU.

In addition, a future comparative study will address similarities and differences between the numerical simulation and the experimental crash tests with biofidelic dummies.

Further information:
s.fhg.de/wheelcharity-en



Insights into the failure behavior of battery cells in simulation (top) and experiment (CT image, bottom).

BATTmobil – battery safety

In the event of accidents involving electric vehicles, it depends on the integrity of the battery whether there will be an internal short circuit in the cell and thus possibly a vehicle fire. In the BATTmobil project, funded by the ministry of economic affairs (state BW), Fraunhofer EMI and Fraunhofer IWM investigated the crash safety of batteries.

A systematic approach to combine experimental and numerical methods was applied to analyze the mechanical properties of the battery cell and its failure as a function of different mechanical loads.

Based on the experiments, predictive simulation models were developed. Thanks to the applied approach, a generalization of the obtained findings is possible. The joint research work will be continued in BATTmobil-2.

Further information:
s.fhg.de/battmobil-crashsafety

Business unit Space

2-unit engineering model of a nanosatellite.
At EMI, we develop our own nanosatellites
as well as hard- and software for satellites.

Business unit Space

"With unique methods, we improve safety in space travel …

… and develop resilient small satellite systems for innovative applications in Earth observation."

Prof. Dr. Frank Schäfer, head of business unit Space

With our expertise regarding hypervelocity impacts, we improve the passive safety of spacecraft and analyze the formation of debris clouds resulting from satellite collisions. This allows for a risk analysis based on physical principles allowing for better understanding of the true environment. We research new methods to increase the resilience of commercial off-the-shelf (COTS) components for space applications and use novel manufacturing processes for the development of compact scientific payloads. We develop small satellite systems for real-time applications in Earth observation.

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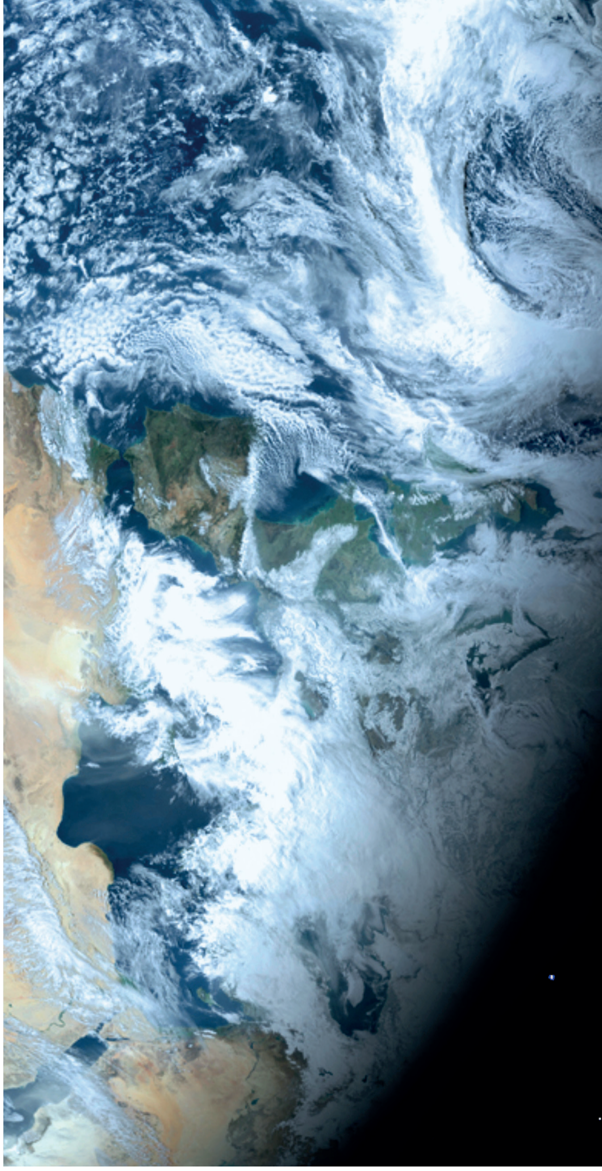
ERNST on the finish line

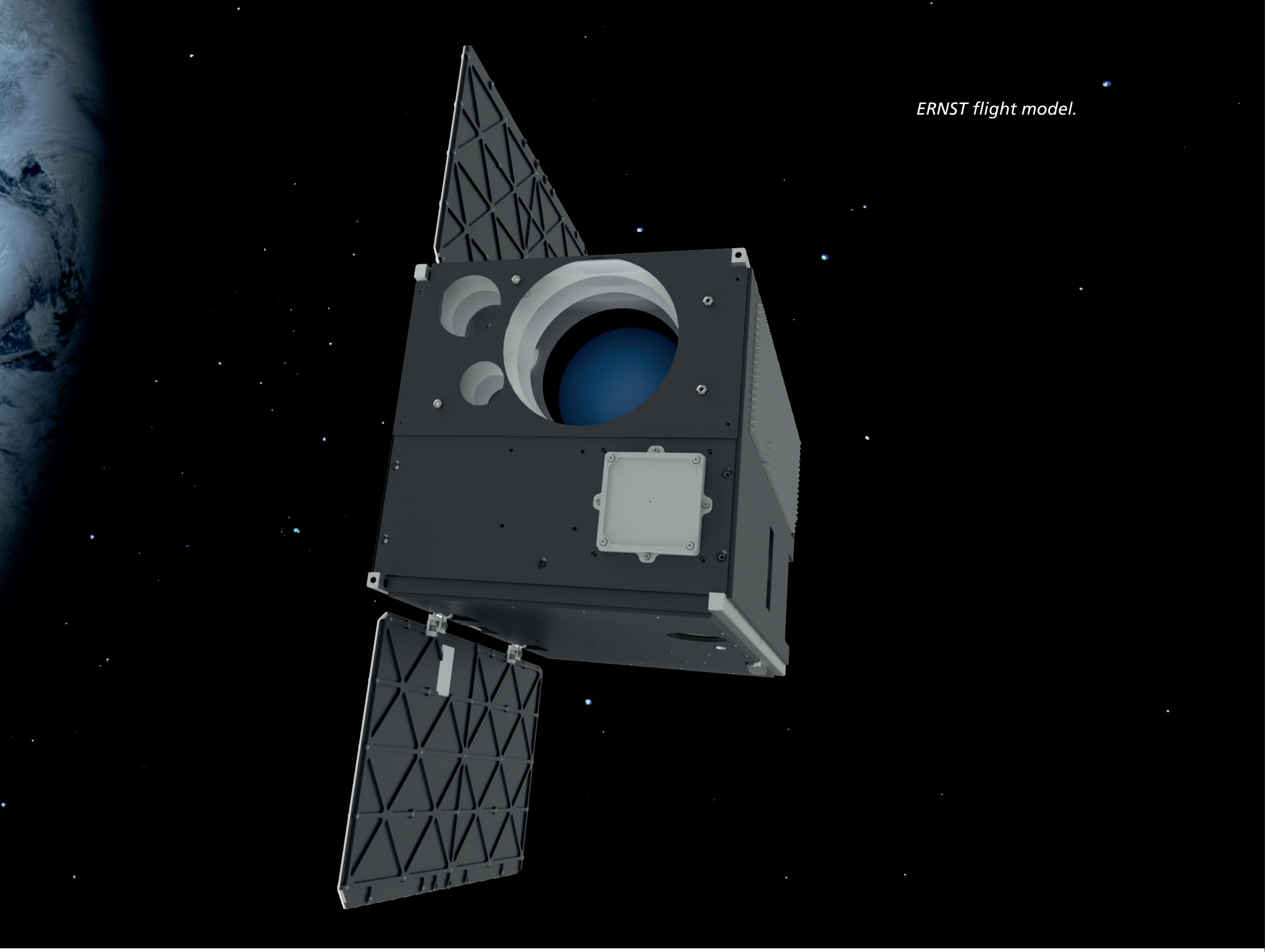
Fraunhofer EMI is developing the nanosatellite ERNST to demonstrate the potential of CubeSat-based small satellites for ambitious Earth observation tasks. Following the successful verification of the engineering qualification model, the critical design review marked the transition to the production and testing phase of the ERNST flight model, which is scheduled for launch in January 2023.



Innovations in the space sector are currently advanced by commercial suppliers. The most prominent company of this "New Space" industry is SpaceX. With the development of novel rocket launch systems and mega-constellations of small satellites, SpaceX is emblematic for the core elements of New Space. Small satellites are not a new invention – however, they have, due to the development of high-performance systems, evolved from a niche product within the course of the last years. In the US, the hub of New Space, small satellites have moved into the focus of defense-related applications. For example, for space-based early warning systems for the detection of missiles, hundreds of small satellites that are connected via optical communication shall complement or even replace the classical, exclusive military satellites. The motivation lies in a fast response and high resilience through less expensive mass-produced small satellite constellations.

ERNST as demonstration mission for high-performance CubeSat-based small satellites

ERNST is the first small satellite that supports military tasks in Germany. The goal of this mission is to demonstrate and to exploit the potential of this satellite class for the German Armed Forces (Bundeswehr). The main payload is an infrared camera for the detection of missile launches. In cooperation with the Fraunhofer IOSB, the unique data obtained by ERNST will be used to demonstrate an advanced detection concept and to verify corresponding numerical simulations. From a technical viewpoint, the integration of the infrared payload is particularly challenging. It includes a cryocooler that, due to its high demand of electrical



ERNST flight model.

energy and high emission of thermal energy as well as the excitation of vibrations, presents a major challenge to a satellite as small as 236 by 236 by 340 cubic millimeters. These dimensions correspond to 12U, that is, a cuboid consisting of twelve combined ten-centimeter cubes, the latter being the basic unit of so-called CubeSats. ERNST will be the first nanosatellite based on CubeSat technology that demonstrates a cryocooled payload in orbit.

In addition to the main payload, ERNST features a camera for Earth observation in the visible spectrum and a radiation detector developed by Fraunhofer INT. The latter, named FORS (Fraunhofer Onboard Radiation Sensor), measures high-energy protons and electrons and provides information on the influence of the radiation environment in orbit on the functionality of small satellites electronics.

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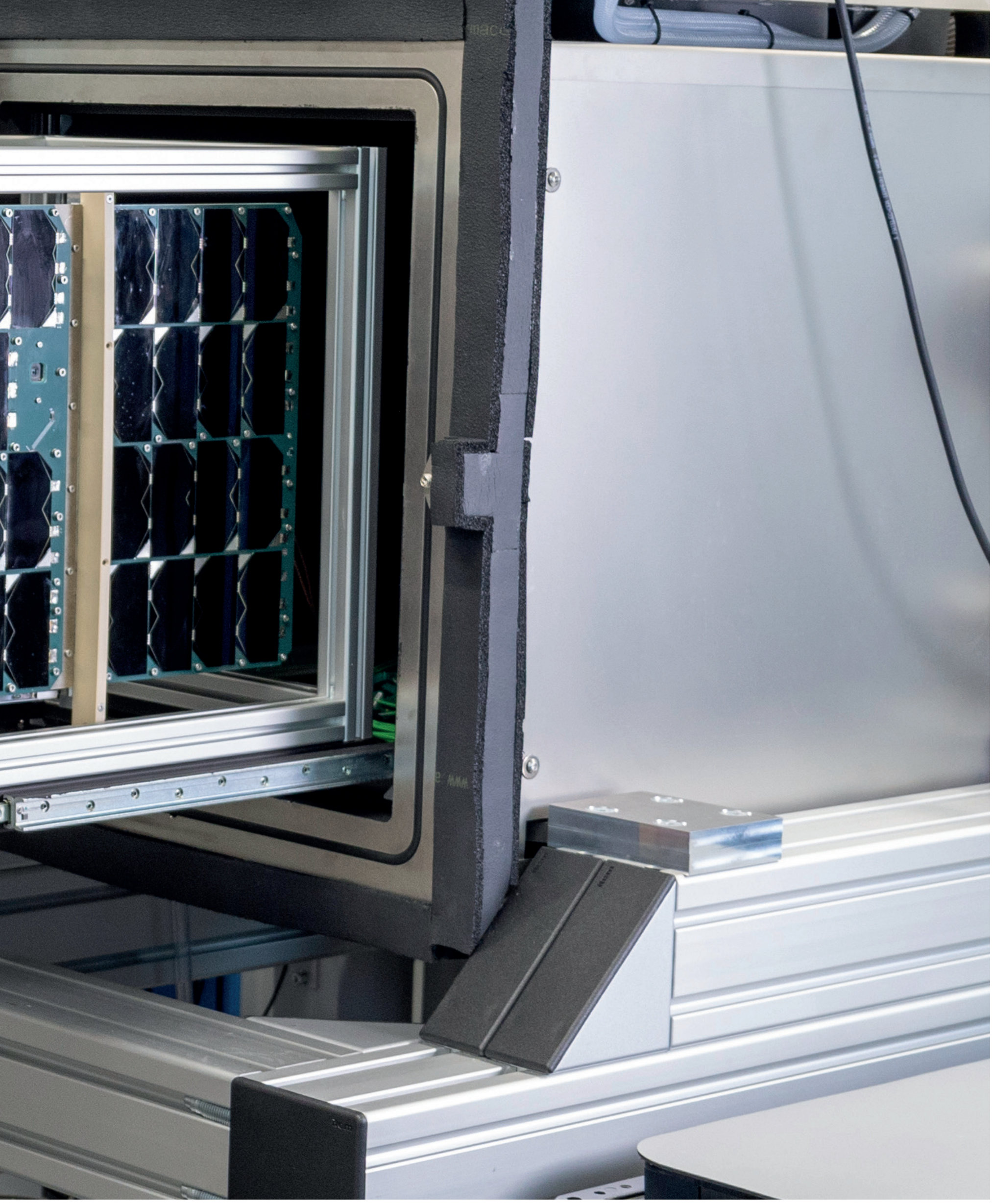
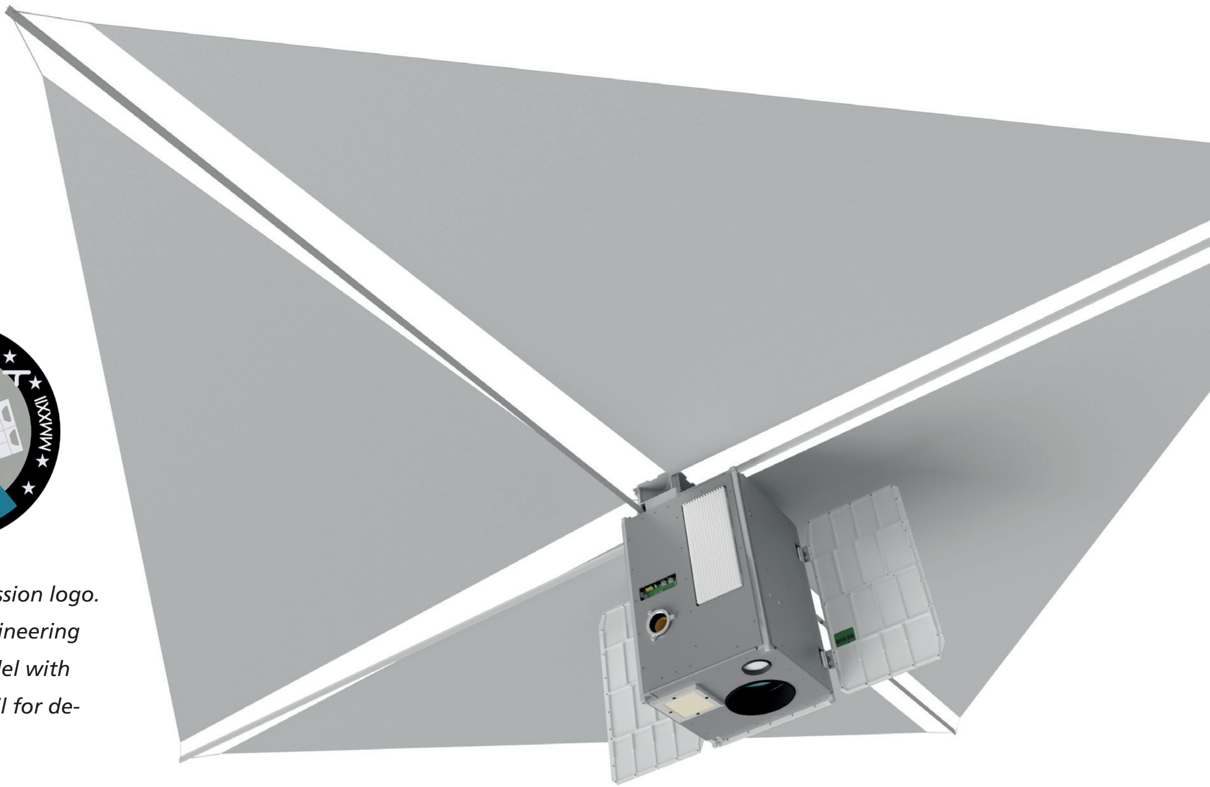
The ERNST engineering model in the thermal vacuum chamber for long-term verification.

12U satellite bus for the integration of various payloads for multi-sensor networks

The advantage of CubeSats is their standardization. High-performance CubeSat components are commercially available. For ERNST, we benefit from the high development level of these components and integrate commercial subsystems developed by diverse market leaders, including the onboard computer, power processing, X-band transmitter and the attitude control system, which has been demonstrated during NASA's Insight Mars mission. These subsystems are complemented by in-house developments, for example the data processing unit and a de-orbit system. The latter deploys a drag sail with a size of 2.4 square meters that increases the atmospheric drag of the system after the end of a mission. Thus, it contributes to a sustainable use of orbit in terms of space debris prevention. The payloads are integrated on an additively manufactured optical bench. This method ensures a flexible integration of different payloads into the ERNST bus in the context of a responsive space using small satellites. The launch of ERNST in 2023 will be the first step to this for the German Ministry of Defence (BMVg).





Above: ERNST mission logo. Right: ERNST engineering qualification model with unfolded drag sail for de-orbiting.

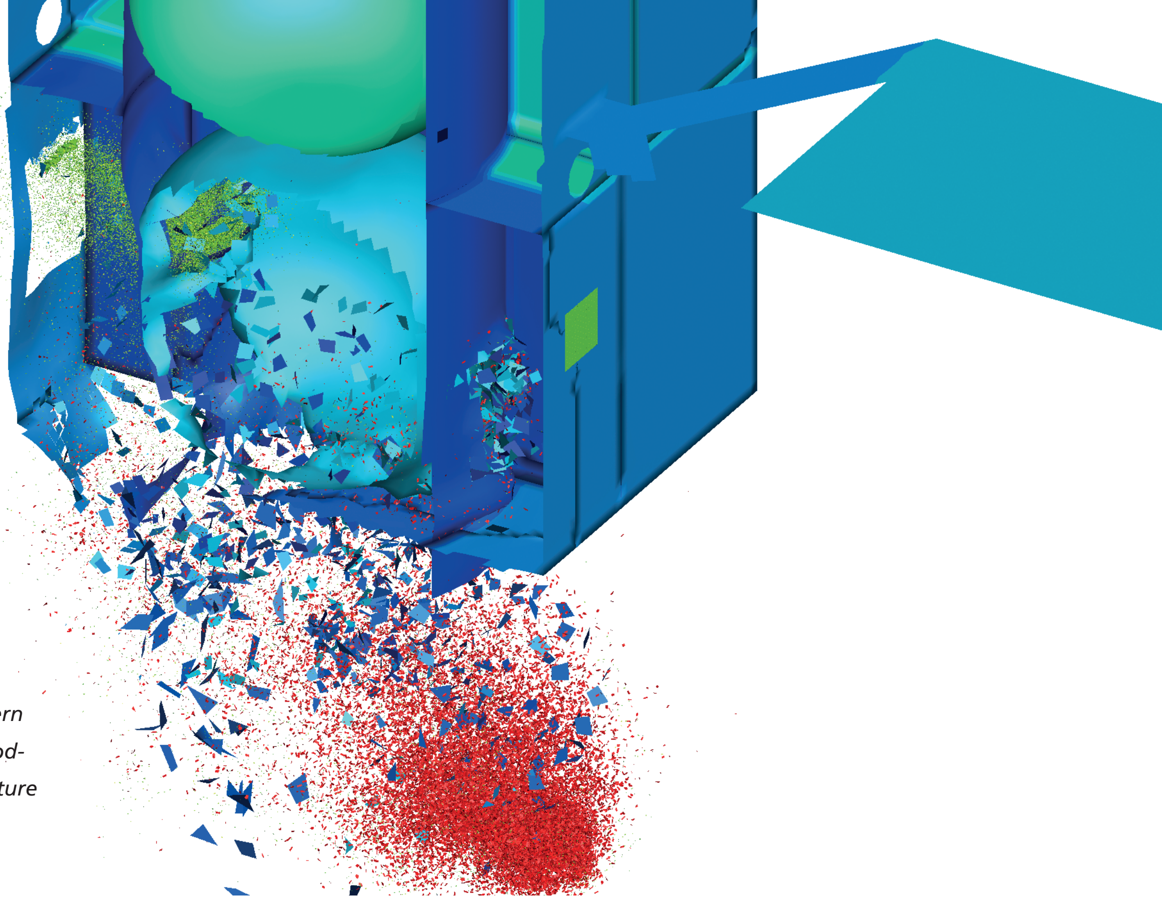


Image of the fragmentation pattern after the collision of a satellite modeled with the new sandwich structure substitute model and a CubeSat.

Fragmentation in orbit puts satellites at risk

The number of fragments in orbit – originating from explosions and collisions – has reached a critical level. In the project DiFraO (disruptive fragmentation events in orbit), material models and substitute models for complex structures have been developed in order to understand the extent of fragmentation and its dynamics.

We have conducted lab experiments and carried out numerical simulations with the EMI in-house code SOPHIA in order to predict the fragmentation dynamics following an impact of an object onto a satellite. The focus was on sandwich components since they are an important structural material of primary and, partly, secondary satellite structures.

The investigation included the deduction of a substitute model for satellite sandwich structures and its application to large-scale impact scenarios. The DiFraO project was funded by the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw).

The center of the picture shows the Nanoracks External Platform (NREP) of the ISS. Soon the EMI payload will be installed there. © NASA

Three, two, one – lift-off!

EMI technology for high-precision temperature monitoring will be demonstrated on the ISS
A key technology developed at EMI will be demonstrated on the ISS with the aim to enable high-precision temperature recordings of Earth in the future by means of so-called microsatellites. The project received support within the framework of an EXIST-funding for scientific start-ups by the German Federal Ministry for Economic Affairs and Energy.

These kinds of satellites are not much larger than a shoe box and are therefore considerably more cost-effective compared to conventional space missions.

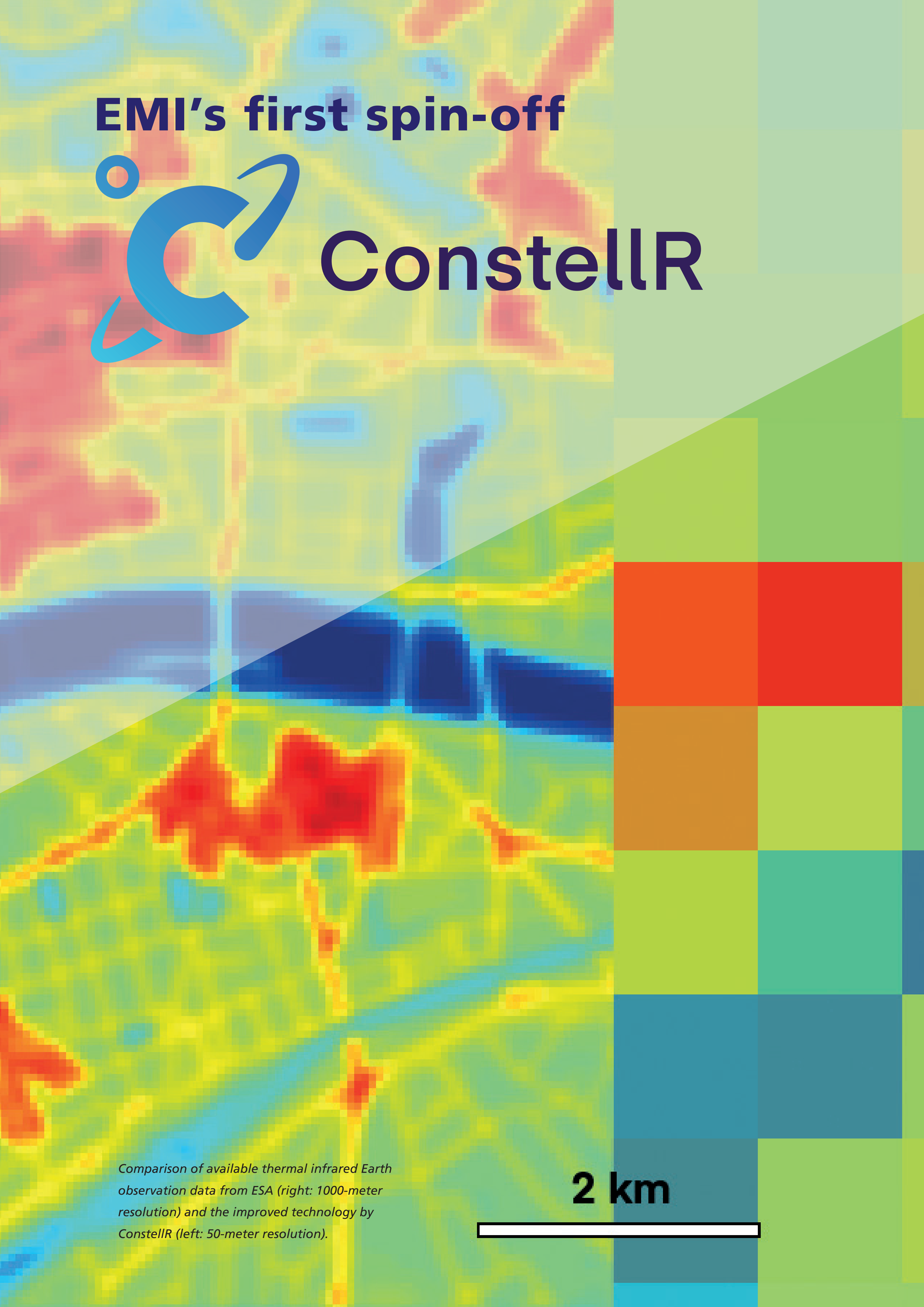
The Fraunhofer spin-off ConstellR wants to commercialize this technology with the aim to support global food security.

Before the technology for high-precision temperature monitoring can be employed on a regular basis, it will be tested on the International Space Station ISS.

After minute preparatory activities at EMI, the optical payload will be transported to the ISS by NASA and Nanoracks in February 2022 for its in-orbit demonstration.

EMI’s first spin-off

ConstellR



Comparison of available thermal infrared Earth observation data from ESA (right: 1000-meter resolution) and the improved technology by ConstellR (left: 50-meter resolution).

The Fraunhofer EMI has introduced its first spin-off, ConstellR, on April 28, 2020. ConstellR's founders Marius Bierdel, Dr. Max Gulde and Christian Mittermaier are planning a microsatellite constellation for measuring our planet's surface temperature. The aim is to support global food security by monitoring agriculture using satellite-based remote sensing with data of unprecedented accuracy.

According to the United Nations, the global food production has to be increased by more than 50 percent within 30 years in order to ensure a sufficient world food supply. Against the backdrop of climate change and the scarcity of land and water, a more efficient and responsible resource management is vital. Food production depends significantly on the availability of water, which in turn depends on temperature. The precise knowledge of land surface temperature allows the optimized use of water and thus reduces the risk of harvest losses and irreversible damage. Smart resource management in agriculture is only one of many applications that profit substantially from precise and globally available temperature data.

The three founders will continue their research at the Fraunhofer EMI until August 2022 in the framework of an EXIST-funding for scientific start-ups by the German Federal Ministry for Economic Affairs and Energy. In the EXIST project, the camera technology will be demonstrated on the Nanoracks External Platform (NREP) of the International Space Station ISS. In February 2022, the scientific payload will be transported to the ISS. Until the finalization of the project in August 2022, the three researchers will be members of the Geoanalytics Group within the System Solutions Department at EMI managed by Prof. Dr. Frank Schäfer.

In fall 2020, a license agreement was signed by ConstellR and the Fraunhofer-Gesellschaft regarding technologies that have been developed at EMI and are currently undergoing the patent application process.

The ConstellR founding team has very successfully participated in accelerator programs and was able to achieve high rankings in various competitions.

Since October 2018, ConstellR has been financially supported by Fraunhofer Venture within the venture building program AHEAD and, since March 2020, by the spin-off support of the Sustainability Center, a cooperation of the University of Freiburg and the Fraunhofer-Gesellschaft.

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Business unit
Aviation

The increasing number of aerial drones in airspace poses a threat to aviation. Fraunhofer EMI explores methods for the evaluation of collision scenarios as a basis for adequate safety measures.

Business unit Aviation

“If you can walk away from a landing, it’s a good landing. If you can use the airplane the next day, it’s an outstanding landing.”

*Chuck Yeager (1923–2020),
US test pilot and first human in history confirmed to have exceeded the speed of sound in level flight.*

In the spirit of Chuck Yeager, safety is the top priority in aviation. For this reason, scientists at EMI conduct research on safety-relevant technologies for the aviation industry. The following contributions present a small overview of these activities.

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Technology for robust sensors

Sensor systems are key elements for capturing environmental properties and are increasingly important in industry 4.0 for the intelligent control of processes. However, under harsh operating conditions, such as high temperatures, high mechanic loads or aggressive environments, standard electronics cannot be used. Eight Fraunhofer institutes have therefore bundled their competences regarding sensors, microelectronics, assembly, board design, laser applications and reliability analysis to establish a technology platform for sensor systems running under extreme conditions.

Jet engines set high demands on sensor systems running under extreme conditions.
© Adobe Stock

Increasing demand for intelligent sensor systems for harsh environments

Reliable sensor systems are increasingly important in the industry for the intelligent control of industrial processes. In a typical sensor system, a number of sensors take information from the environment and transform it into electrical signals. A dedicated signal conditioning circuitry performs, for example, offset compensation, amplification, filtering and analog-to-digital conversion. Further processing is often done by a microcontroller with calculation and storage capacity for identification and calibration data. Standard interfaces like CAN or RS485 are commonly used for the connection to a higher-level system making them capable to interact with industry 4.0 processes.

While in many everyday objects highly integrated sensor systems are already state of the art, the situation in an industrial environment is clearly different. Here, the use of sensor systems up to now was often impossible because the extreme ambient conditions of industrial processes such as high operating temperatures, strong mechanical loads or a humid or chemically aggressive environment do not allow a reliable operation of sensitive electronic components. However, due to the need to save energy and resources as well as the demand for environmentally friendly processes, a detailed process control is necessary, and monitoring of vital process parameters under extreme conditions becomes increasingly essential. Applications can be found in various fields, such as the steel industry, jet engines, stationary turbines as well as deep drilling for oil, gas or geothermal energy.

Goal of the Fraunhofer lighthouse project eHarsh

The realization of such sensor systems requires a multidisciplinary approach including, for example,

the design of reliable sensor elements, integrated high temperature circuits, and appropriate assembly and housing techniques. Therefore, eight Fraunhofer institutes have concentrated their competencies and have initiated the Fraunhofer lighthouse project eHarsh. In a common approach, the project partners develop all necessary technologies for the design and test of robust sensor systems for harsh environments. Two demonstrators are planned to show the successful implementation of the technology platform: The first is a pressure sensor system for avionic applications – for example used at a jet engine – with a sensor, microelectronics and dedicated ceramic board design for temperatures up to 300 degrees centigrate with peak temperatures at the sensor top of up to 500 degrees centigrate. The second demonstrator is a sensor system for geothermal applications at temperatures of up to 300 degrees centigrate and pressures of up to 2000 bars.

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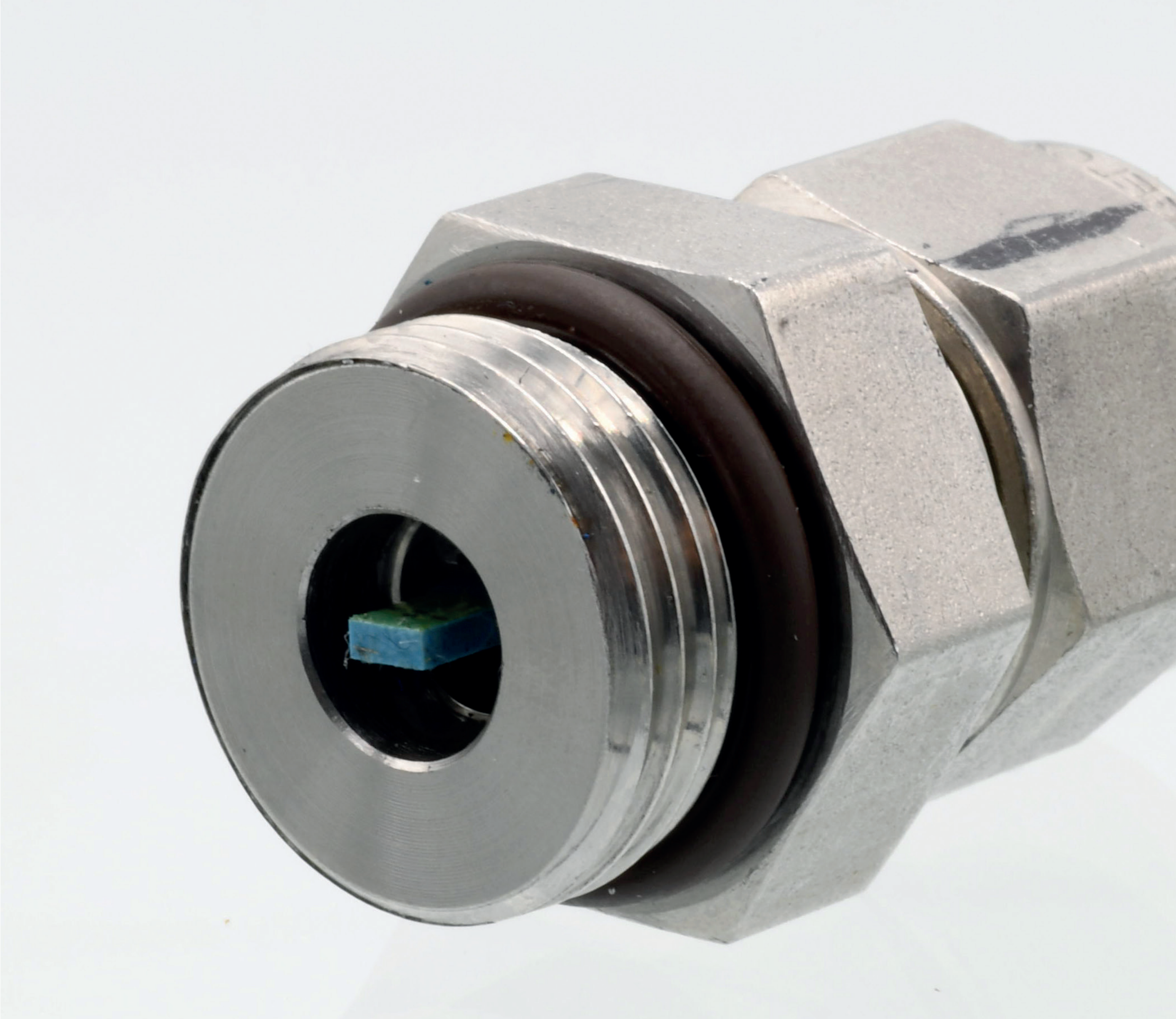
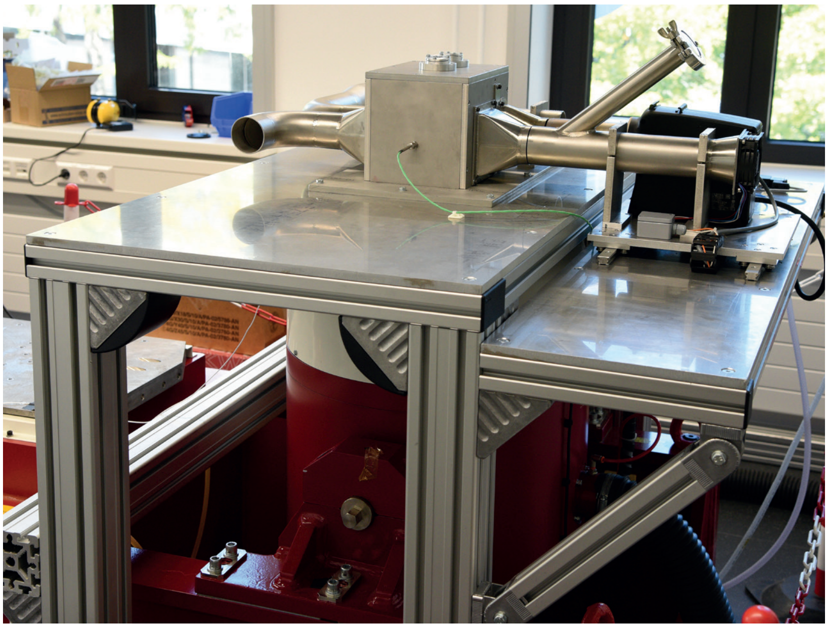


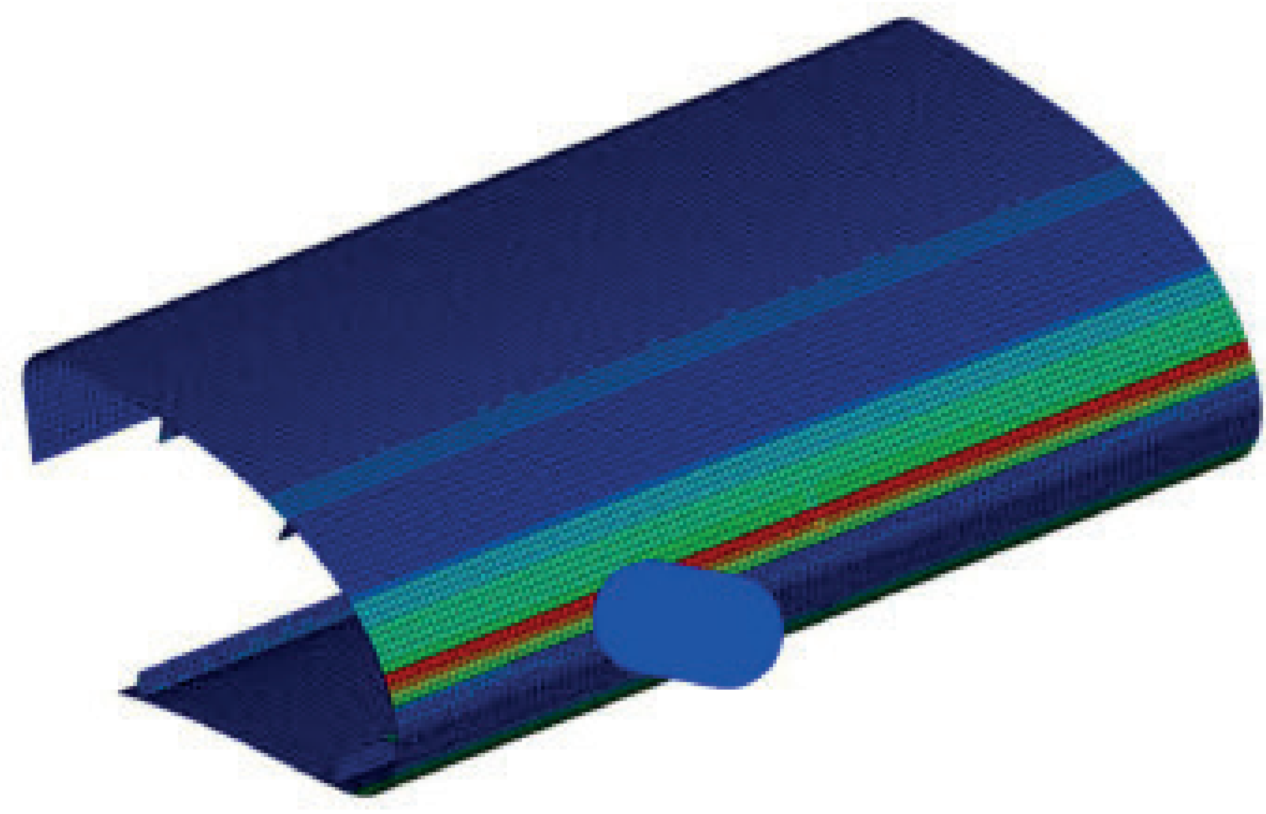
Development of the eHarsh technology platform and testing under harsh conditions

In the project, various technologies and components have been investigated, such as high-temperature ceramic-based pressure and temperature sensors, an integrated chipset for signal conditioning and processing, featuring operating temperatures of up to 300 degrees centigrate as well as various assembly and board technologies. All developments were accompanied by a reliability analysis as well as a comprehensive characterization regarding robustness. For testing the components and demonstrators under harsh environmental conditions, Fraunhofer EMI has set up dedicated test stands that can be used to generate combined loads that are specifically tailored to the area of application of the demonstrators. In the further course of the project, these demonstrators will be completed and tested extensively under the harsh conditions of the planned applications.

In the eHarsh project, a ceramic sensor element for measuring pressure and temperature has been developed. In the picture, it is placed inside a stainless steel housing ready to be mounted to a test stand for dynamic pressure testing.

Test stand for testing the jet engine sensor demonstrator under combined temperature and vibration loading.





Finite-element model of bird impact onto a morphing leading edge.

Safety of morphing structures

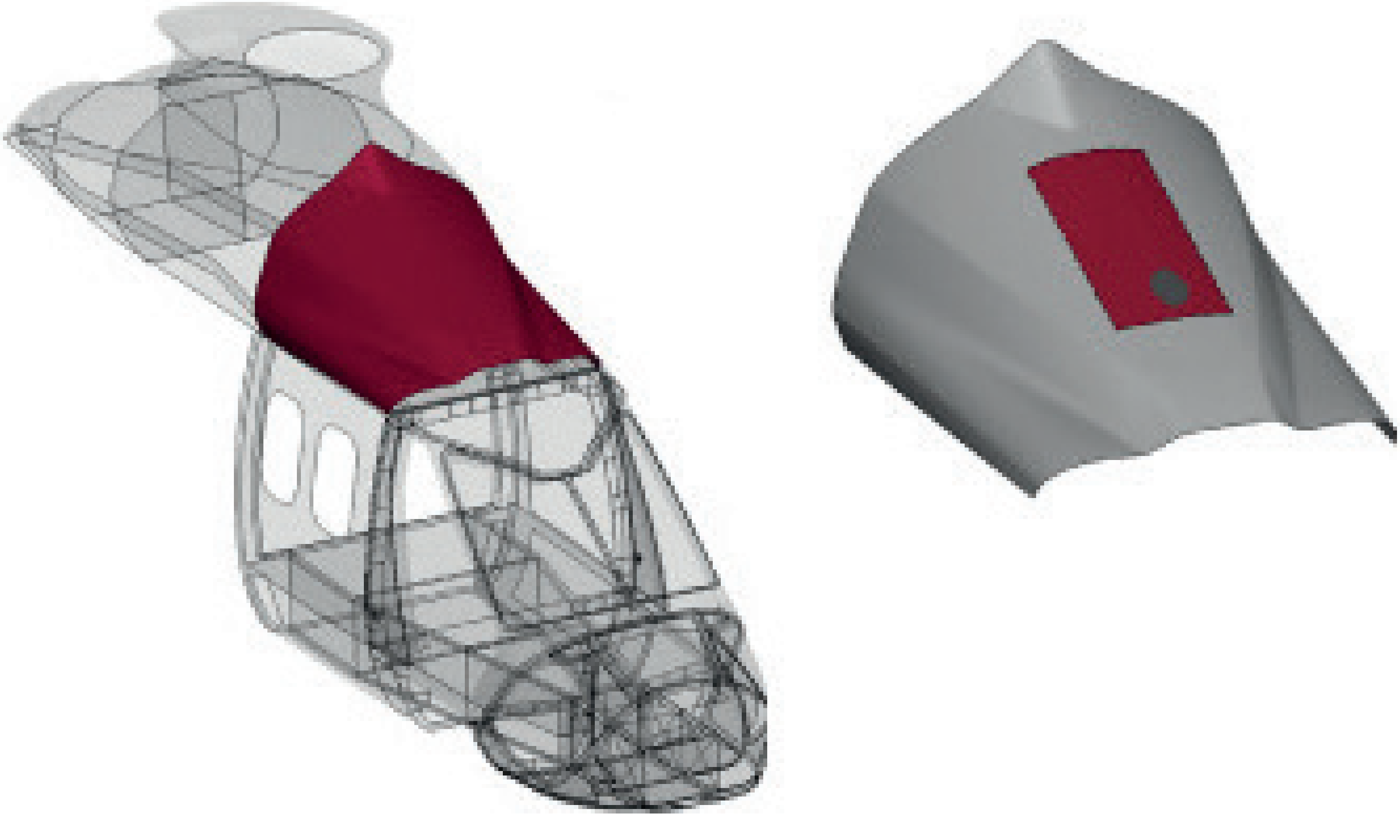
Morphing – a technology of the future

The Fraunhofer-Gesellschaft contributes to the air traffic of the future with the "morphing leading edge" that adapts to aerodynamic requirements. During take-off and landing, it increases the camber of the aircraft wing and thus, its lift, without gaps opening up that generate drag and noise, as is usually the case.

The hazard posed by collision with birds

In the worst case, a collision with birds can cause severe damage to an aircraft and thus, emergency landing. Within the research program Clean Sky 2, EMI scientists used numerical simulations to investigate to what extent a morphing leading edge can meet the high safety requirements in aviation. The results have been published in Composites Part C (see link).

Link to paper:
s.fhg.de/ paper-morphen



Analyzed rotorcraft component.

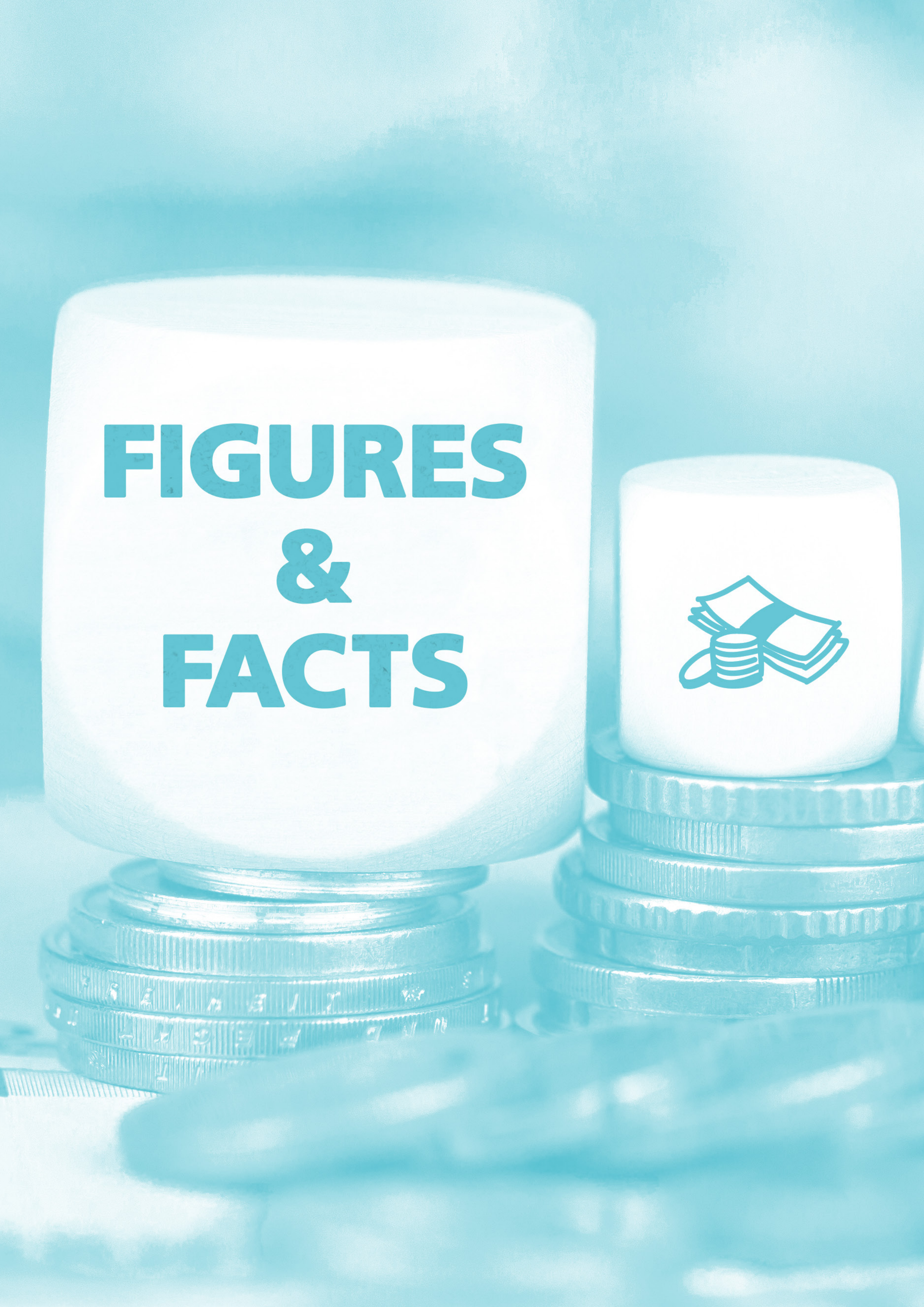
CFRP – thought differently

Do composite materials always have to be symmetrical?

Carbon-fiber-reinforced composites (CFRP) are characterized by excellent weight-specific properties (strength, stiffness), which makes them ideal for applications in the aerospace industry. For the production of CFRP structures, thin plies of unidirectionally arranged fibers are stacked on top of each other and oriented according to the requirements. Currently, symmetrical laminate structures are used to prevent component warpage. However, impact loads are not a symmetrical event acting on the component. Researchers at Fraunhofer EMI have investigated whether unconventional, warpage-free laminate structures can lead to increased performance using a rotorcraft as an example demonstrator. The results have been published in Composites Part C (see link).

Link to paper:
s.fhg.de/paper-cfk

Administration


FIGURES
&
FACTS

Administration

"We are well positioned and allowed to look ahead with optimism."

Petra Gross, Head of Administration

After a year under the impression of the pandemic, Fraunhofer EMI has proved its resilience. Many administration processes had already been digitally established, thus paving the way for a smooth switchover to working from home in March 2020. We initiated the task force "New Work" in order to have a diversely composed team develop models for a better work-life balance and flexible forms of working. Our workplace health management extended its offers to fit the mobile-work situation, new digitization processes for recruiting and human-resource development are advancing. Collaborative systems such as Microsoft Teams have decisively relieved our ways of cooperation and made us even more efficient in some areas.

In the face of last year's adversity, we are still well positioned and allowed to look ahead with optimism.

Petra Gross
Head of Administration (until August 2021)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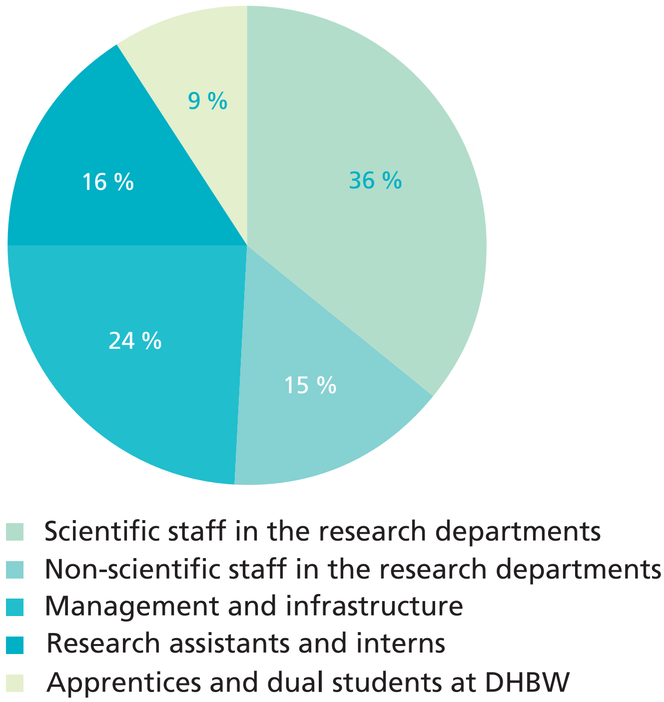
Staff structure

At the end of 2020, 377 people were employed at Fraunhofer EMI: 291 employees as permanent staff, 30 as apprentices and dual students, and 56 as research assistants and interns. 198 members of the permanent staff were directly involved in research and 93 worked in the fields of management and infrastructure. The proportion of female employees of the permanent staff increased to 27.8 percent.

19 of the 30 apprentices worked in the fields of precision mechanics, electronics, media design and administration. The remaining 11 worked at Fraunhofer EMI within the scope of their vocational training or university studies at the Baden-Württemberg Cooperative State University (DHBW).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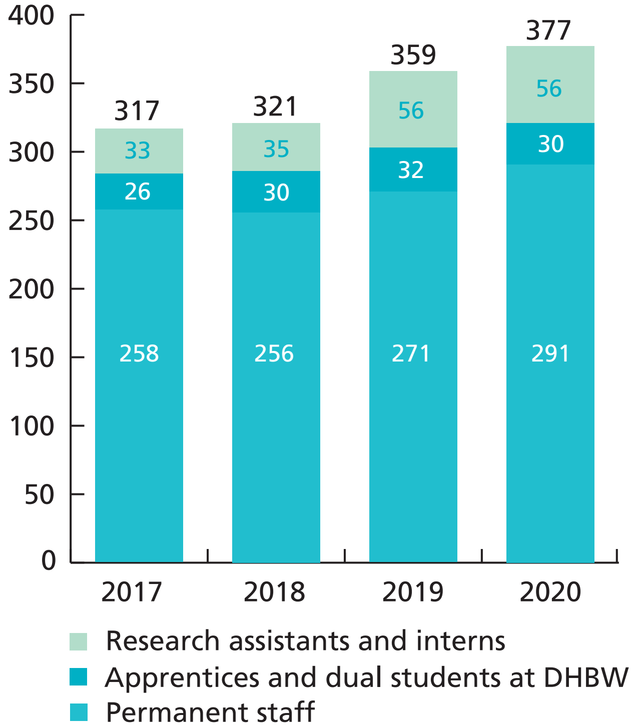
Scientific staff in the research departments
Non-scientific staff in the research departments
Management and infrastructure
Research assistants and interns
Apprentices and dual students at DHBW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2017
2018
2019
2020
Research assistants and interns
Apprentices and dual students at DHBW
Permanent staff


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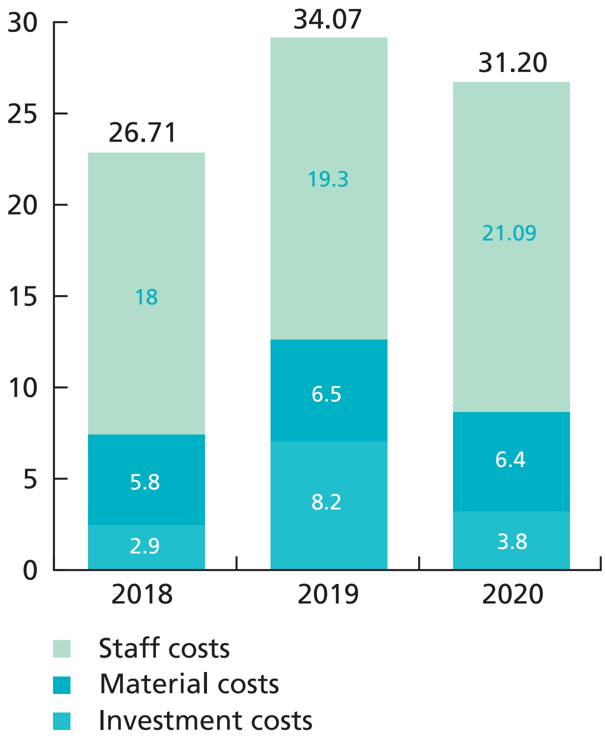
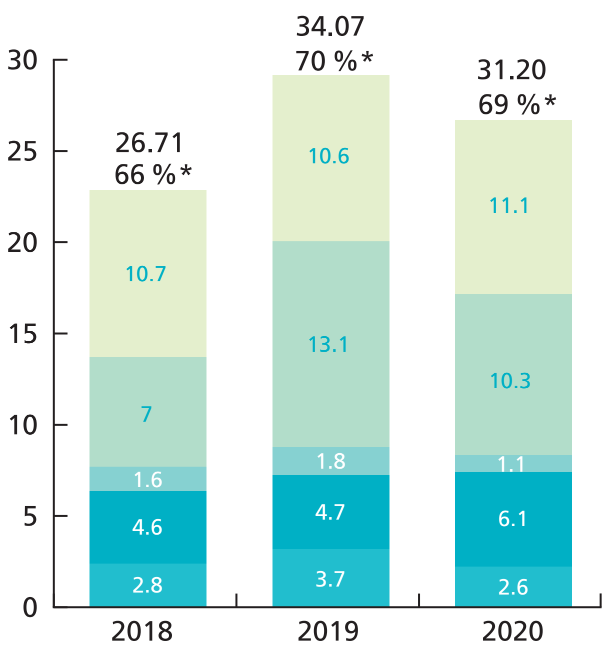
Finances

In comparison to last year, the overall budget of Fraunhofer EMI has decreased by about 3 million euros to 31.2 million euros. 27.45 million euros are allotted to the operating budget (staff costs and material costs) and 3.75 million euros to the investment budget. Fraunhofer EMI is financed by external revenues from the industry and the public sector as well as by the institutional base funding of the German Federal Ministry of Defence (BMVg) and the Federal Ministry of Education and Research (BMBF). The amount of 14.5 million euros external revenues even exceeded previous year's results. In 2020, the biggest share of the operating and investment budget, namely 69 percent, were financed by the German Federal Ministry of Defence.

Finances of the overall budget in million euros



Finances of the overall budget in million euros



*Share by the German Federal Ministry of Defence (including subordinate institutions)

Profile of the institute

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The advisory board meeting was held online on July 17, 2020.

Advisory board

The advisory boards of the various Fraunhofer Institutes advise the directors of the institutes and the executive board of the Fraunhofer-Gesellschaft. The advisory board also enhances the institute's contacts to other organizations and to the industry.

Hanna Böhme
Managing Director Freiburg Wirtschaft Touristik und Messe GmbH & Co. KG, FWTM, Freiburg

Dipl.-Ing. Thomas Gottschild (Chairman)
Managing Director of MBDA Deutschland GmbH, Schrobenhausen

MinRin Sabine ten Hagen-Knauer
Head of Division 524: Civil Security Research, German Federal Ministry of Education and Research (BMBF), Bonn

Rainer Hoffmann
Chief Executive Officer carhs.training GmbH, Alzenau

MinR Dipl.-Phys. Claus Mayer
Head of Division 33: Automotive and Manufacturing Industries, Logistics, Ministry of Economics, Employment and Housing, Baden-Württemberg, Stuttgart

Prof. Dr. Merith Niehuss
President of the Bundeswehr University Munich, Neubiberg

Oberst i. G. Jürgen Schmidt
Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support, BAAINBw, Head of Department Battle, Koblenz

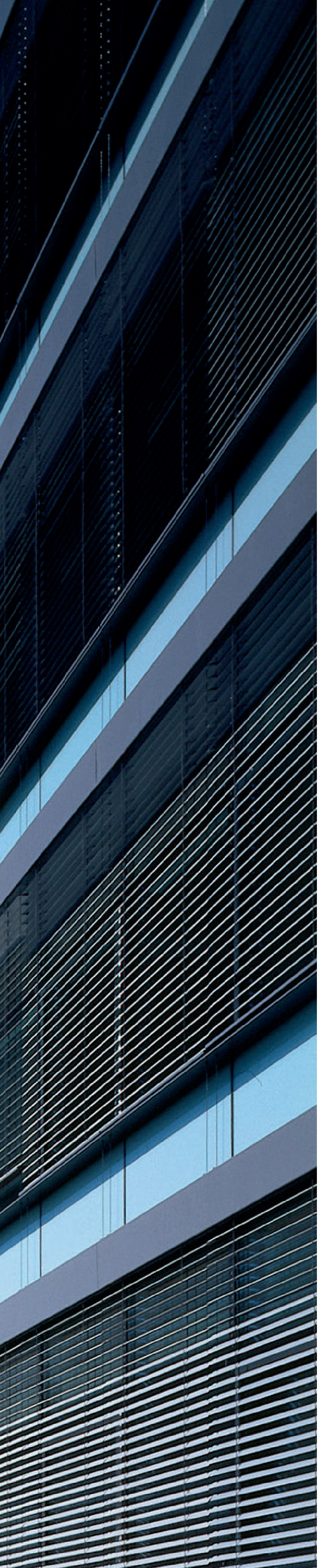
Dr. Tobias Schmidt
Head of Department and Head of Development at location Unterlüss, Rheinmetall Waffe und Munition GmbH, Unterlüss

Prof. Dr.-Ing. Rodolfo Schöneburg
Director Safety/Durability/Corrosion Protection, Mercedes-Benz Cars Development, Daimler AG, Sindelfingen

MinR Dr. Dirk Tielbürger
Head of Division A III 6, German Federal Ministry of Defence, Bonn

Dr. Isabel Thielen
Management THIELEN Business Coaching GmbH, Munich

The headquarters of the Fraunhofer-Gesellschaft in Munich.



The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions. The majority of our 29,000 staff are qualified scientists and engineers who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research. Around two thirds of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining third comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: Our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society and help train the future generation of scientists and engineers that the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

Fraunhofer

For more information, visit www.fraunhofer.de/en

Publications, Educational activities, Scientific exchange 2020/2021

Publications

Publications in books, specialist journals and proceedings with peer review

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Léost, Y.; Collins, P.; Haase, T.; Mermagen, J. (2020): Modeling of a car wheel and numerical investigations for crash application. CAE Grand Challenge. Hanau (virtual event), 30.9.2020.

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Miller, N. (2020): A proposed methodology to evaluate resilience of power grids against natural disasters. Global Resilience Research Network Webinar Series, 24.11.2020.

Nasr, E.; Huschka, M.; Dlugosch, M. (2020): Evaluation of ontology matchers for materials sciences and engineering. MSE Congress 2020. Online-Kongress, 23.9.2020.

Pfaff, A.; Riedel, W. (2020): Research on application concepts for effectors and protection component design and manufacturing studies using industrial 3D metal printers. European Military Additive Manufacturing Symposium 2020. Erding, 16.1.2020.

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Sauer, M.; Herrmann, M. (2020): Multi-scale approach to binder/crystal interfaces in PBX. Interfaces in Polymer Composites for the Energetic Materials Community. US Air Force Office of Scientific Research. Online-Workshop, 17.9.2020.

Schwarz, A.; Hübner, C.; Wenz, F.; Kappe, K.; Lichti, T. (2020): On the way to mass production of unit-cell based auxetic materials. 6th Cellular Materials CellMat 2020. Online-Kongress, 7.10.2020.

Seminar lectures at EMI

Gulde, M. (2020): Gemeinsam ins All: So sieht's aus beim Exist-Projekt und ConstellR. EMI-Hausseminar, 18.11.2020.

Huschka, M. (2020): Knowledge Engineering mit Ontologien und Wissensgraphen. Abteilungsseminar Werkstoffdynamik 1.60, 6.3.2020.

Jenerowicz, M. (2020): Innovative Schutzausrüstung – Methoden zur Modellierung und Simulation für den Körperschutz. Abteilungsseminar Werkstoffdynamik 1.60. EMI Freiburg, 14.10.2020.

Lectures

Balle, F. (Sommersemester 2020): Lab Course Engineering Materials and Testing Methods. Übung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Balle, F. (Wintersemester 2020/2021): Lightweight Design and Materials. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Balle, F. (Sommersemester 2020): Methoden der Materialwissenschaften. Praktikum. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Balle, F. (Sommersemester 2020): Methoden der Materialwissenschaften. Ringvorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Balle, F. (Sommersemester 2020): Technische Funktionswerkstoffe. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Balle, F. (Wintersemester 2020/2021): Werkstofftechnik und -prozesse. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Balle, F.; Henning, H.-M.; Kilchert, S.; Ganzenmüller, G. C.; Hiermaier, S.; Hess, S. et al. (Wintersemester 2020/2021): Studienseminar Sustainable Systems Engineering. Seminar. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Scientific exchange, Lectures

Becker, M.; Balle, F.; Staab, D. (Wintersemester 2020/2021): Materials Selection and Sustainable Development for Mechanical Engineering. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Ganzenmüller, G. C.; Hiermaier, S. (Wintersemester 2020/2021): Fundamentals of Resilience. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Ganzenmüller, G. C.; Stilz, M.; Hiermaier, S. (Wintersemester 2020/2021): Konstitutive Gleichungen und Diskretisierungsverfahren zur Versagensmodellierung/Physics of Failure. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Häring, I. (Sommersemester 2020): Functional Safety: Active Resilience. Vorlesung und Embedded Excercises. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

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Hiermaier, S. (Sommersemester 2020): Climate Change: Impact, Key Technologies, and Policymaking. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Hiermaier, S.; Balle, F.; Ganzenmüller, G. C. (Sommersemester 2020): Sustainable Systems Engineering. Studienseminar. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Hiermaier, S.; Ganzenmüller, G. C. (Sommersemester 2020): Werkstoffdynamik/Dynamics of Materials: Numerik dynamischer Deformationsprozesse. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Hiermaier, S.; Kilchert, S. (Sommersemester 2020): Material Flow Analysis. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Kilchert, S.; Ganzenmüller, G. C.; Hiermaier, S. (Wintersemester 2020/2021): Materialebenszyklen/Material Life Cycles. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Kilchert, S.; Hiermaier, S. (Wintersemester 2020/2021): Lebenszyklusanalyse. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Matura, P.; Hiermaier, S. (Wintersemester 2020/2021): Kontinuumsmechanik. Vorlesung und Übung, Wintersemester 2020/2021.

May, M. (Sommersemester 2020): Adhesive Bonding. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

May, M. (Wintersemester 2020/2021): Composite Materials. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

May, M. (Wintersemester 2020/2021): Dynamics of Materials. Universitat de Girona, Wintersemester 2020/2021.

May, M. (Sommersemester 2020): Sustainable Systems Engineering/ Adhesive Bonding. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Osterholz, J. (Sommersemester 2020): High-Energy-Density Physics. Vorlesung. Heinrich-Heine-Universität Düsseldorf, Sommersemester 2020.

Sauer, M. (Wintertrimester 2020/2021): Laborpraktikum. Universität der Bundeswehr München, Wintertrimester 2020/2021.

Sauer, M. (Wintertrimester 2020/2021): Numerische Simulationsverfahren. Vorlesung. Universität der Bundeswehr München, Wintertrimester 2020/2021.

Sauer, M. (Wintertrimester 2020/2021): Werkstoffcharakterisierung. Vorlesung. Universität der Bundeswehr München, Wintertrimester 2020/2021.

Schäfer, F. (Sommersemester 2020): Shock Waves in Rocks II. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Steinhauser, M. (Sommersemester 2020): Advanced Methods in Computational Sciences. Vorlesung und Übung. Universität Basel, Sommersemester 2020.

Steinhauser, M. (Sommersemester 2020): Computational Materials Science with Atomistic and Coarse-grained Methods. Vorlesung. Universität Basel, Sommersemester 2020.

Stolz, A. (Sommersemester 2020): Design and Monitoring of Large Infrastructures. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Stolz, A. (Sommersemester 2020): Konzeption großer Infrastrukturen/ Design of Large Infrastructures – Übung. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2020.

Stolz, A. (Wintersemester 2020/2021): Strukturelle Robustheit: Resiliente Entwurfsprinzipien/Structural Robustness: Resilient Designs. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Stolz, A.; Hiermaier, S. (Wintersemester 2020/2021): Informatik-Bachelorprojekt am Lehrstuhl Nachhaltige technische Systeme. Projekt. Albert-Ludwigs-Universität Freiburg, Wintersemester 2020/2021.

Visiting Scientists at EMI

Jain, Atin, 16.11.2020–31.7.2021.

Medina Escobar, Sergio, 27.5.2020–31.7.2020.

Oliveira Resende, Pablo, 1.6.2018–31.5.2022.

Padmanabha, Vivek, 15.4.2019–15.4.2022.

Tsukomoto, Akira, 3.7.2019–19.8.2020

PhD

Fischer, F. (2020): Mikrocomputertomographie mit photonenprozessierenden Pixeldetektoren und iterativer Rekonstruktionsmethodik – Bildeigenschaften bei reduzierter Dosis. Dissertation. Albert-Ludwigs-Universität Freiburg.

Frissane, H. (2020): Contribution au développement d'un codede calcul sans maillage utilisant la méthode SPH pour des applications en mécanique des chocs. Dissertation. Université de Technologie de Belfort-Montbéliard.

Liesegang, M. (2020): Kontinuierliches Ultraschallschweißen ebener und rohrförmiger Titan/CFK-Verbindungen – Sonotroden, Prozessentwicklung und Verbundeigenschaften. Dissertation. Albert-Ludwigs-Universität Freiburg.

Sandoval Murillo, J. L. (2020): From thermal randomness to ordered structures – The effect of mechanical gradients on the thermodynamics of phase separation during extrusion processes. Dissertation. Albert-Ludwigs-Universität Freiburg.

Scharte, B. (2020): Resilience Engineering – Oder von der Kunst, in der zivilen Sicherheitsforschung mit Komplexität umzugehen. Dissertation. Albert-Ludwigs-Universität Freiburg.

Schube, Jörg (2020): Metallization of silicon solar cells with passivating contacts. Dissertation. Albert-Ludwigs-Universität Freiburg.

Seifert, W. (2020): Einfluss von Adhäsivstoffen auf das ballistische Verhalten geklebter Keramik-Metall-Verbunde. Dissertation. Universität der Bundeswehr München.

Zahedi, A. (2020): Development and Applications of Laser Generated microstructures on CBN grinding wheels. Dissertation. Albert-Ludwigs-Universität Freiburg.

Bachelor, Master and Diploma theses

Altas, C. (2021): Implications of COVID-19 spread for critical infrastructure – identifying change points and inferring relations to COVID-19 interventions. Master Thesis. EMI-Bericht A 03/21. Universität Basel.

Bajwa, S. (2020): Potentiale des Kunststoffschweissens als alternative Fügetechnologie für opto-elektronische Sensoren. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Ballal, N. (2020): Analysis of numerical crash simulation data using dimensionality reduction and machine learning. Master Thesis. EMI-Bericht A 45/20. Technische Hochschule Ingolstadt.

Basavaraju, R. (2020): Development of an experimental methodology for planar-plate shear impact tests. Master Thesis. EMI-Bericht A 49/20. Albert-Ludwigs-Universität Freiburg.

Bhadeliya, A. (2020): Correlation of fracture mechanical properties and microstructure parameters of ductile cast iron at increased loading rates. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Bhandary, A. (2020): Edge passivation of pSPEER solar cells by post-metallization deposition and annealing processes. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Böhler, M. (2020): Modellierung des thermomechanischen Materialverhaltens von Polyoxymethylen (Polyacetal). Bachelorarbeit. EMI-Bericht A 28/20. DHBW Lörrach.

Borchert, R. (2020): Hardware-in-the-Loop-Simulation einer Tracking-Anwendung für die Infrarotnutzlast eines Nanosatelliten. Masterarbeit. EMI-Bericht A 19/20. Hochschule Offenburg.

Bouwman, T. (2020): Development of design diagrams by means of numerical analysis for the assessment of airport runways and supply-routes vulnerability. Master Thesis. EMI-Bericht A 26/20. Hochschule Furtwangen.

Burjukadi, N. (2020): Strain-rate sensitive metamaterials made from non-viscoelastic base material. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Channammagari, H. (2020): Assessment of rate dependent mode II interlaminar fracture toughness of composites using a novel experimental approach. Master Thesis. EMI-Bericht A 22/20. Albert-Ludwigs-Universität Freiburg.

Charalampidou, S. (2020): Resilience and sustainability of the built environment subjected to hazards – towards an integrated quantitative assessment. Master Thesis. EMI-Bericht A 47/20. TU Berlin.

Christ, N. (2020): Implementierung und Evaluation einer Interpolationsmethode zur Vervollständigung von Messdaten aus Fahrzeugsicherheitsversuchen. Masterarbeit. EMI-Bericht A 42/20. Karlsruher Institut für Technologie.

Damm, M. (2020): Erarbeitung einer marktorientierten, auf den Endverbraucher fokussierten Ergebnisdarstellung für die LCA von PV-Modulen. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Djago, Y. (2020): Quantifizierung von Unsicherheiten in der Risikomodellierung. Masterarbeit. EMI-Bericht 40/20. Otto-von-Guericke-Universität Magdeburg.

Föhrenbacher, E. (2020): Semi-automatic assessment of mass movement hazards with fast engineering approaches using spatial and digital urban data. Master Thesis. EMI-Bericht A 43/20. RWTH Aachen.

Gmeiner, C. (2020): Design und Verifikation einer robusten Steuereinheit für ein De-Orbitsystem für einen Nanosatelliten. Masterarbeit. EMI-Bericht A 10/20. Albert-Ludwigs-Universität Freiburg.

Gundawar, R. (2020): Fast simulation of smart gas grid for largescale infrastructure resilience assessment and a related machine learning approach. Master Thesis. EMI-Bericht A 14/20. Universität Duisburg/Essen.

Henríquez-Wehr, M. (2020): Selective raytracing for thermal analysis, Universität Stuttgart, Institut für Raumfahrtsysteme. Bachelorarbeit. Universität Stuttgart.

Hezel, F. (2020): Bewertung und Charakterisierung von keramikpartikelverstärkten SLM-Stahlwerkstoffen. Masterarbeit. EMI-Bericht A 15/20. Hochschule Furtwangen.

Huber, J. (2020): Konzeptentwicklung von additiv gefertigten Wärmeleitstrukturen für Cubesats durch strukturintegrierte Heatpipes. Bachelorarbeit. EMI-Bericht A 39/20. Hochschule Offenburg.

Juncker, J. (2020): Charakterisierung des Splitterverhaltens von Glasscheiben unter kurzzeitdynamischer Belastung. Bachelorarbeit. EMI-Bericht A 07/20. Hochschule Furtwangen.

Jurzinski, P. (2020): Konstruktion und Inbetriebnahme einer Einrichtung zur Probenvermessung. Bachelorarbeit. EMI-Bericht A 30/20. DHBW Lörrach.

Klein, P. (2020): Entwicklung eines innovativen Prüfverfahrens für Sandwichstrukturen. Masterarbeit. EMI-Bericht A 25/20. Universität Stuttgart.

Kraft, C. (2020): Auslegung und Bewertung von additiv gefertigten Auslegung und Bewertung von additiv gefertigten Materialien unter dynamischer Last – Erarbeitung eines ballistischen Schutzkonzeptes. Bachelorarbeit. DHBW Mannheim.

Kumar, K. (2020): Analysis of a topology optimized heavy rail. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Linnenberg, M. (2020): Characterization and assessment of 3D-printed steel materials. Masterarbeit. Karlsruher Institut für Technologie.

Loreth, J. (2020): Smart Coating – Experimentelle und numerische Analysen. Bachelorarbeit. EMI-Bericht A 18/20. DHBW Lörrach.

Manam, B. U. (2021): Measuring the mixed-mode-I/II fracture toughness in composite materials using wedge loaded asymmetric DCB specimen. Master Thesis. EMI-Bericht A 01/21. Albert-Ludwigs-Universität Freiburg.

Nasr, E. (2020): Evaluation of automatic ontology matching for materials sciences and engineering. Master Thesis. EMI-Bericht A 02/20. Albert-Ludwigs-Universität Freiburg.

Scientific exchange, Lectures

Rajendran, R. S. (2020): Local micro analysis of the mechanical PCB performance under shock and impact loading. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Ranganatha, M. (2020): Robust signal coding for ultrasound indoor localization. Master Thesis. EMI-Bericht A 08/20. SRH Hochschule Heidelberg.

Restayn, E.-M. (2020): Development and improvement of a score-cardbased risk and resilience self-assessment for critical infrastructure systems – Further example applications companies countering Covid-19. Master Thesis. EMI-Bericht A 44/20. Hochschule Furtwangen.

Rupakula, G. D. (2020): Numerical analysis of a novel high-rate mode II fracture toughness test. Master Thesis. EMI-Bericht A 04/20. Albert-Ludwigs-Universität Freiburg.

Rüthnick, P. (2020): Bewertung hybrider Luftfahrt-Verbindungen unter dynamischer Last. Masterarbeit. EMI-Bericht A 03/20. TU Berlin.

Sankalp, P. (2020): The Freiburg glassy polymer model. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Schirner, L. (2020): Thermalmodellierung kleiner Satelliten. Bachelorarbeit. EMI-Bericht A 16/20. Albert-Ludwigs-Universität Freiburg.

Schmidt, A. (2020): Konzeptentwicklung und Auslegung eines Schutzgehäuses unter Impaktbelastung. Masterarbeit. EMI-Bericht A 46/20. FH Bielefeld.

Stiller, P. (2020): Auslegung einer elastischen Aufhängung für eine Laborwaffe. Bachelorarbeit. EMI-Bericht A 29/20. DHBW Lörrach.

Stürmer, D. (2020): Prospective life cycle assessment of alternative populsion systems in passenger vehicles. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Sudheendran, V. (2020): Influence of PV waste management on the environmental footprint of electricity production from photovoltaic systems. Master Thesis. Albert-Ludwigs-Universität Freiburg.

Tang, Y.-S. (2021): Modeling of the failure of a single-lap hybrid joint under tensile loading. Master Thesis. EMI-Bericht A 50/20. Albert-Ludwigs-Universität Freiburg.

Wahl, J. P. (2020): Konzeptentwicklung und Dimensionierung bistabiler Mechanismen für die additive Fertigung von Metamaterialien. Masterarbeit. EMI-Bericht A 20/20. Hochschule für angewandte Wissenschaften Hamburg.

Waseem, A. (2020): Flood hazard susceptibility modeling using open source spatial data: application of frequency ratio model to Bavaria. Master Thesis. EMI-Bericht A 12/20. TU Darmstadt.

Patents

Deutsche Patentanmeldung: 10 2019 109 789.4/PCT/EP2020/060096: Röntgencrash.

Deutsche Patentanmeldung: 102019109789.4/Internationale Patentanmeldung: PCT/EP2020/060096 – Verfahren und Computerprogramm zum zeitaufgelösten Berechnen einer Deformation eines Körpers.

Method and apparatus for comparing a simulation of a physical object with measurement data of the physical object, and method and an apparatus for generating a finite element representation of measurement data of a physical object (2020) am 30.4.2020. Veröffentlichungsnr: EP 20172375.6.

Gulde, M. (2020): Deutsche Patentanmeldung: 10 2020 201496.5 – Verfahren zur Georeferenzierung von Fernerkundungsdaten am 19.2.2020.

Gulde, M. (2020): Internationale Patentanmeldung: PCT/EP2020/065339 – Verfahren zur Bestimmung der Möglichkeit des Zugriffs eines in einem Satelliten enthaltenen Sensors auf eine Zielregion und Satellitenzugriffsystem am 8.6.2020.

Publication series of Fraunhofer EMI

Seifert, W. (2021): Einfluss von Adhäsivstoffen auf das ballistische Verhalten geklebter Keramik-Metall-Verbunde. Stuttgart: Fraunhofer Verlag (Schriftenreihe Epsilon-Punkt – Forschungsergebnisse aus der Kurzzeitdynamik).

Workshops and events

Workshop anlässlich des Daimler Sustainability Dialogue am 5.11.2020 (Arbeitsgruppe Verkehrssicherheit).

Participation in professional boards, associations and program committees

Fehling-Kaschek, M.: Program Committee of CPS4CIP.

Günther, S.: Fraunhofer-Vertreterin im Steering Committee des JTI Clean Sky 2 Airframe ITD.

Günther, S.: Mitglied im Beraterkreis für SAP PBP Strategisches Portfoliomanagement der Fraunhofer-Gesellschaft.

Günther, S.: Mitglied im Technischen Rat der Fraunhofer-Gesellschaft für Clean Sky 2.

Günther, S.: Mitglied in WG 4 Safety and Security in ACARE (Advisory Council for Aeronautics Research in Europe).

Günther, S.: Vertretung von S. Hiermaier im Institutsleitungsrat (ILR) der Fraunhofer-Gesellschaft für Clean Sky 2.

Heine, A.: LWAG Lightweight Armour Group.

Hiermaier, S.: Fachbeirat Verkehrsinfrastruktur bast.

Hiermaier, S.: Mitglied im Beirat des Leistungszentrums Profilregion Mobilitätssysteme Karlsruhe.

Leismann, T.: Mitglied im Wissenschaftlichen Programmausschuss Zivile Sicherheitsforschung des BMBF.

May, M.: American Institute of Aeronautics and Astronautics – International Working Group.

May, M.: Composites United, Arbeitsgruppe »Strukturelle Integrität und UAG Composite Fatigue«.

May, M.: Fraunhofer-Vertreter im Project Management Committee Clean Sky 2 – Airframe.

May, M.: Senior Member American Institute of Aeronautics and Astronautics.

May, M.: Stellvertretender Fraunhofer-Vertreter im Steering Committee Clean Sky 2 – Airframe.

May, M.: Stellvertretender Sprecher Fraunhofer VVS im Kontext FCAS.

Putzar, R.: Past Chairman der Aeroballistic Range Association (ARA).

Putzar, R.: Repräsentant des Ernst-Mach-Instituts in der Aeroballistic Range Association (ARA).

Ramin, M. von: Mitarbeit in der Klotz Group.

Ramin, M. von: Mitarbeit in der NATO PFP(AC/326-SG/C) AASTP-4 Custodian Working Group.

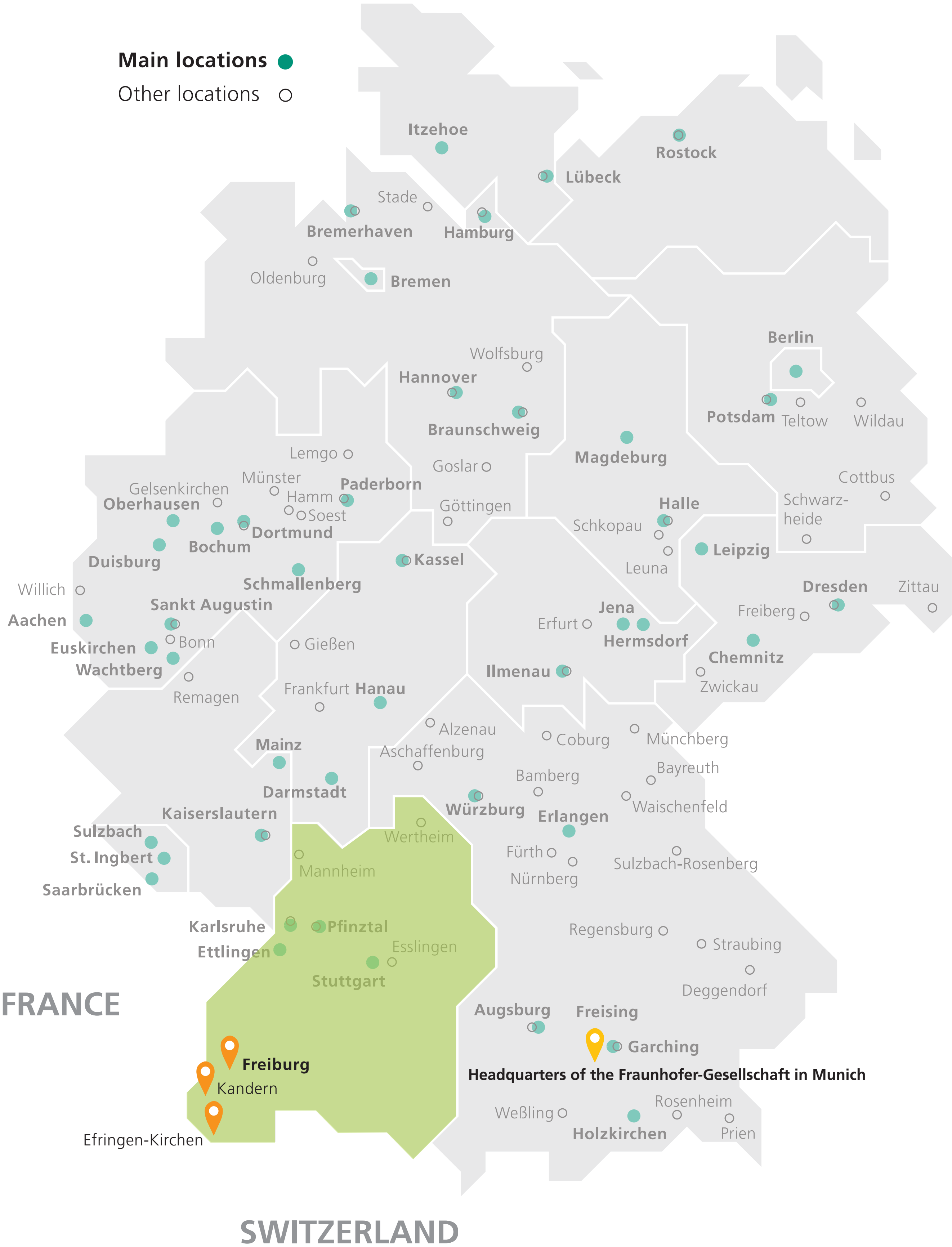
Ramin, M. von: Mitglied beim American Concrete Institute (ACI).

Ramin, M. von: Mitglied beim Deutschen Ausschuss für Stahlbeton (DAfStb).

Rosin, J.: Mitglied im europäischen Normungsausschuss CEN/TC 265/WG 10 (»Site built metallic tanks for the storage of liquids«), Projektleiterin des Teil 2 EN 14620.

Rosin, J.: Mitglied im Normungsausschuss NA 104, DIN-Normenausschuss Tankanlagen (»NATank«).

Schimmerohn, M.: Chairman of Working Group 3 of the Inter-Agency Space Debris Coordination Committee (IADC), external DLR Delegate.



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Publishing notes

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