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

ANNUAL REPORT 2019/2020

Anniversary edition: In 1959, the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, in Freiburg became the sixth institute in the Fraunhofer-Gesellschaft. For 60 years we have been successfully researching in order to increase security and resilience, for assertiveness and protection of systems of the Bundeswehr and in recent years, additionally, for more sustainability through less consumption of resources in our society. The cover image shows the eponym of the institute Ernst Mach in artistic editing who congratulates the institute with a wink.

ANNUAL REPORT 2019/2020

Dear reader,

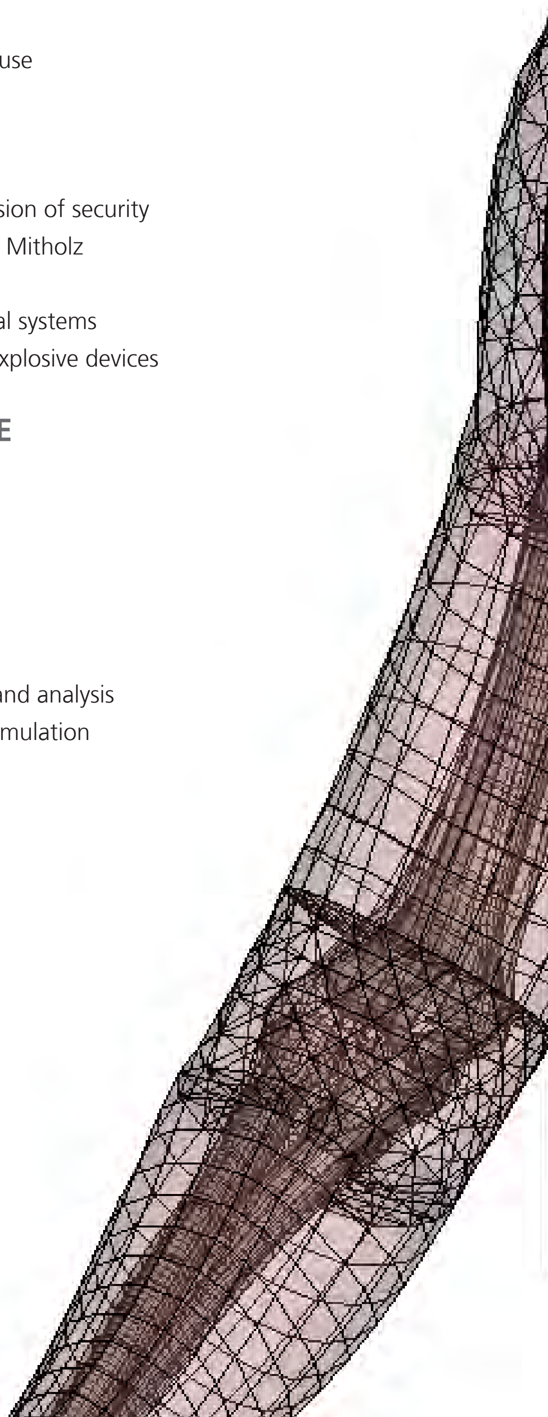
The internet of things, digitalization, globalization, artificial intelligence – corona – what's next? The corona crisis is a disruption – for society, the supply chains, global trade as well as for childcare centers, retirement homes, the local café around the corner, and most families.

Disruptions are always challenging. After this crisis, many things will no longer be as they used to be. We will forever miss some things, but other, new things can emerge from it. Disruptions are not the black swan nobody could have expected. They are the standard. If we look in the history books, we quickly realize that pandemics are a recurring phenomenon. We must expect them to happen – again and again. Thus, we should gain as much knowledge as we can from the current experience – because only if we learn from experience, we can prepare better for the next disruptive event. Resilience is the key word for this crisis. Only those systems and individuals who overcome it without a lasting slump in performance can call themselves resilient. Engineers try to master the crisis and the disruption employing the five phases prepare, protect, prevent, respond, and recover.

At EMI, we also conduct research on this topic, especially in our business unit Security and Resilience. We analyze the capability of infrastructure systems to withstand disruptions and to remain available for society. Furthermore, we are looking for ways to increase their resilience. To this end, we conduct smaller and larger experiments, develop computer models and simulate the behavior of industrial facilities, supply systems, railroad connections or airports during disruptive events. In the present annual report, we present a small selection of our research conducted in the different business units. You will see that our experiments and diagnostics have become even more dynamic. Our scientists are working on future large-scale equipment of the German Federal Armed Forces as well as on safe urban environments, battery powered automobiles, and on the EMI nanosatellite ERNST. And again, the focus is put on the availability of a system even during disruptive events and beyond. This is a challenge that we have happily been willing to face for many years and continue to do so. I want to thank all partners, customers and colleagues from the scientific community, economy and politics for the trust you have continously placed in us. Enjoy reading!

Sincerely yours,
Stefan Hiermaier

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



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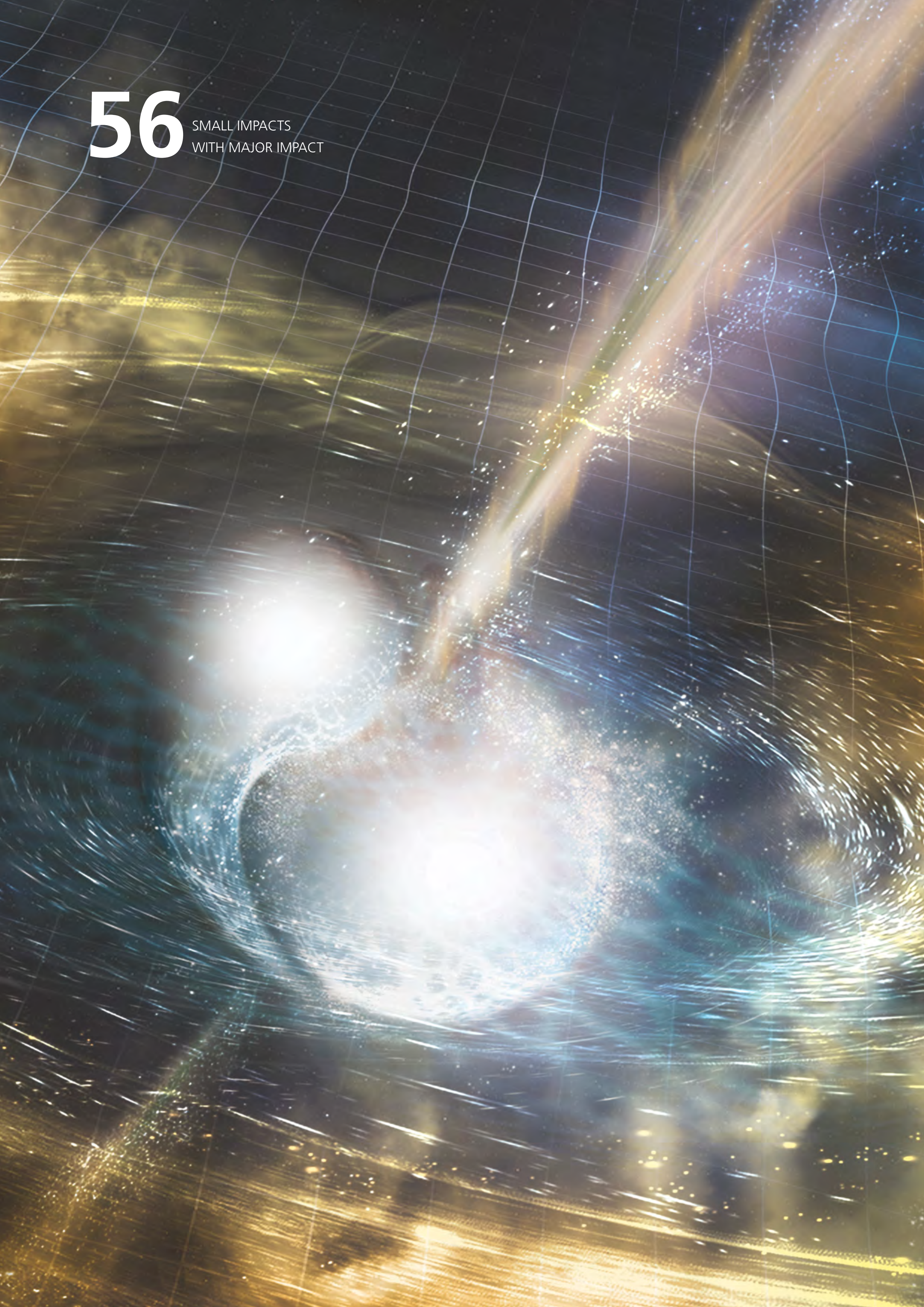

BUSINESS UNIT DEFENSE

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 for land, air and sea. As a strategic partner of the German Federal Ministry of Defence (BMVg) regarding high-speed dynamics research and technology, Fraunhofer EMI explores scientific and technological issues regarding protection, armor and effect, as well as defense-related security and systems within national or European research programs.

With the support of the BMVg, Fraunhofer EMI was able to complement its high-energy laser laboratory by an extremely powerful high-energy laser system. The multi-mode industrial fiber laser system allows research on intense laser effects in the short-distance laboratory environment. From early on, long-term suitable protective concepts for soldiers and systems can now be investigated. For example, materials for military systems can be tested regarding their "laser robustness". Further research results achieved are presented in the following.

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High-speed recording of an aluminum sample during laser irradiation.

Fraunhofer EMI has now got significantly expanded experimental capabilities to examine the effects of high-intensity laser radiation and scaling effects at short distance in the laboratory. Basic research can now be extended up to a power of 120 kilowatts.

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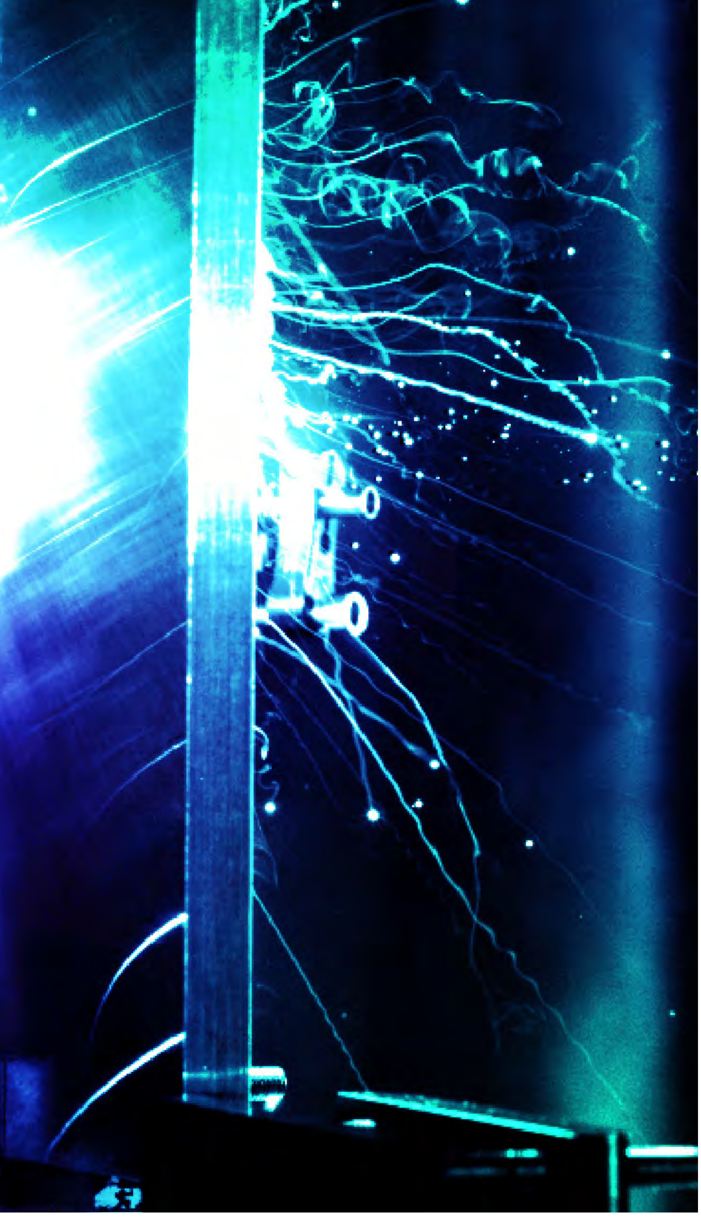
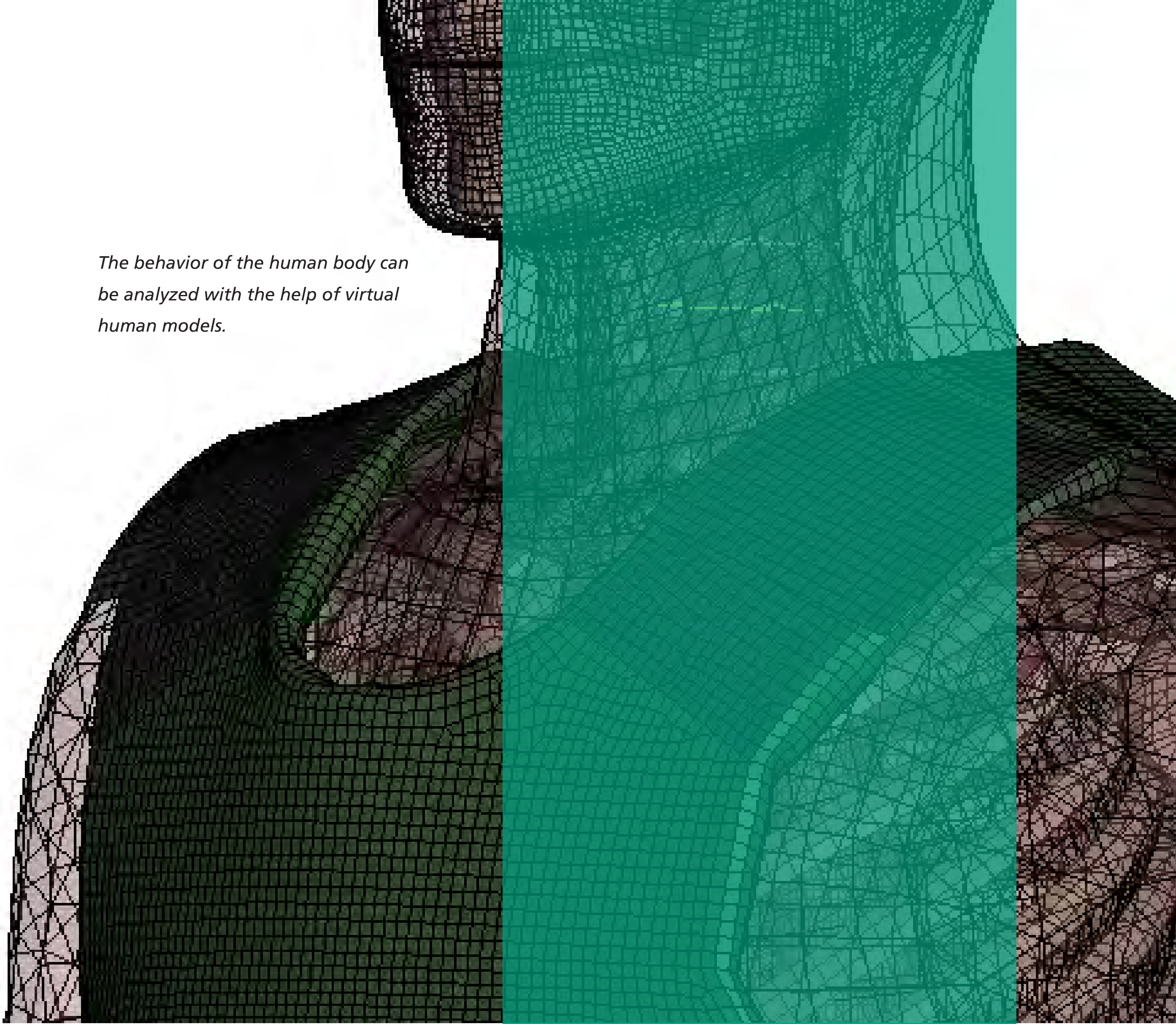


Industrial laser with an output power of up to 120 kilowatts.

SCALING EFFECTS OF HIGH-ENERGETIC LASER RADIATION

Fraunhofer EMI has upgraded its special laboratory for investigations of the effects of intense laser radiation with an extremely powerful high-energy laser. According to the manufacturer, this laser is currently the worldwide most powerful industrial laser for continuous-wave operation on the basis of fiber laser technology. Thus, in the future, considerably extended experimental capabilities will be available to investigate the effects of high-intensity laser radiation and scaling effects at short distance in the laboratory. Basic research can now be extended up to a power of 120 kilowatts. The output power of the new laser was specified according to the assessment of experts, who expect the introduction of laser weapons with a power of well over 100 kilowatts from the middle of this decade. EMI has thus created the basis for supporting the German Armed Forces with scientific analyses of laser effects and for carrying out investigations regarding the protection of soldiers in conjunction with the application of high-energy laser weapons. Exemplarily, the new laboratory offers the capability to test the laser resistance of materials for future defense systems. The robustness against laser irradiation can now be investigated and evaluated over an extremely wide power range.

In the context of basic research, the laser will be used for the analysis of the laser-matter interaction in this new power range, where so far only few scientific studies have been carried out. The laser can now be used to achieve very high energy inputs into the material samples in time intervals which are very short compared to typical time scales of heat diffusion processes. Closely related to this topic are scientific questions on thermal effects and thermo-mechanical material behavior and their scaling with the laser power. With the new laboratory capability, phenomena of material failure in particular with regard to temperature dependence and heating rate dependence can now be examined over an extremely wide power range. The novel testing capabilities considerably expand the basis of experimental data, which can then be further used for modeling for the numerical simulation as well as for the development of new fields of application.



The behavior of the human body can be analyzed with the help of virtual human models.

Up to now, virtual human body models have mainly been applied in applications where clothing does not play a significant role, for example, car-to-car or car-to-pedestrian simulations. The Human Body Dynamics Team of Fraunhofer EMI has developed a method to put on a soft ballistic vest to a virtual human body model in a standing posture.

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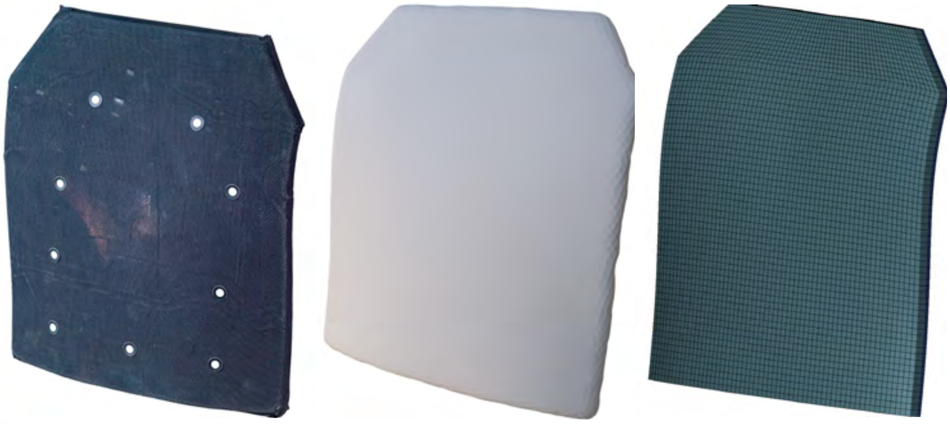
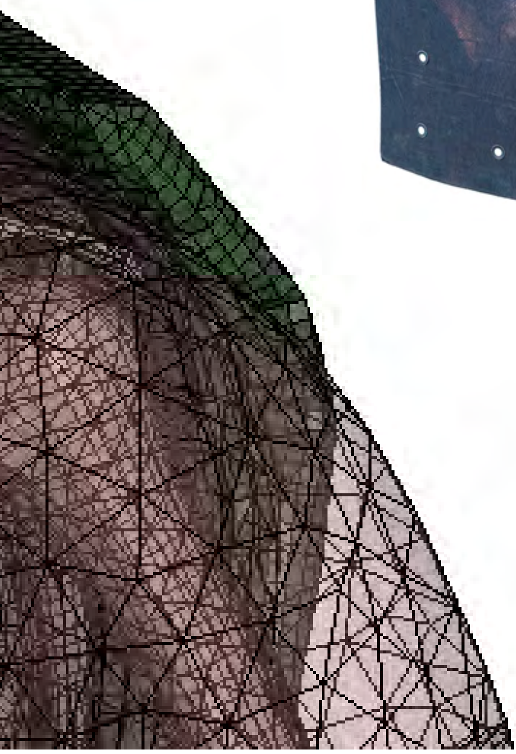


Development of FE model of the hard ballistic part of the body armor (from left to right: real component, 3D scan, FE model).

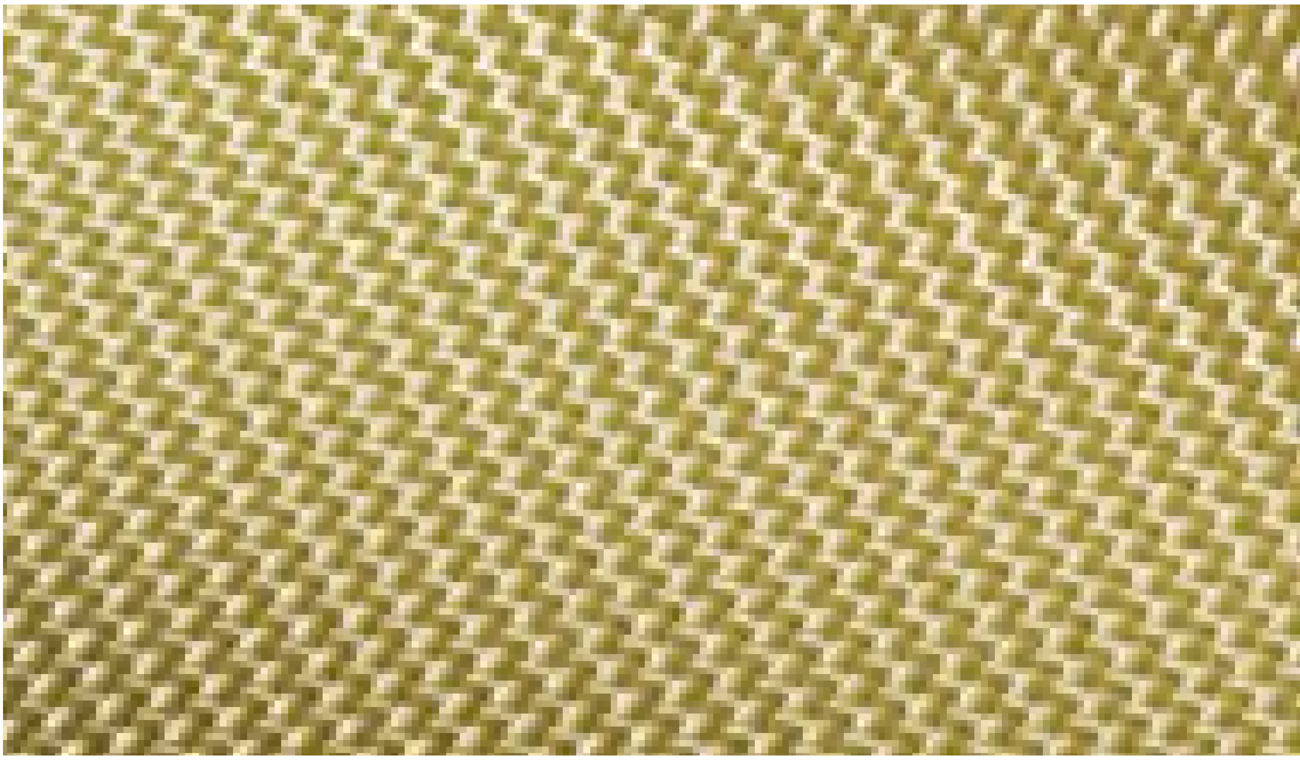


DESIGN OF PERSONAL ARMOR SYSTEMS USING LATEST VIRTUAL HUMAN BODY MODELS

Not only the dynamic response of technical materials and components can nowadays be analyzed using simulation tools, also the response of the human body can be studied by involving virtual human body models. Human body models represent actual humans in detail, including not only the outer body shape, but also bones, muscles, ligaments, tendons, and internal organs. Originated from automotive industry, human body models have started to contribute to the improvement of crash safety measures for both, occupants and pedestrians. Especially when crash scenarios strongly deviate from standard crash-test requirements, when non-standard body postures as well as body positions are of interest, or when the overall muscular stress level of the person involved needs to be taken into account, human body models are generally the only choice.

Link human body models to personal armor systems

In the field of defense, the design of personal armor systems, which is primarily driven by empirical knowledge and experimental data, can significantly benefit from the application of human body models, too. The link to involve such models to virtual body armor design was the lacking capability to transform modular-based textile components from a two-dimensional planar configuration to arbitrarily shaped and usually double-curved body contours. This until recently unsolved problem has been addressed by researchers of Fraunhofer EMI. In pre-stage forming simulations, the textile components that have been modeled in 2D get transferred to the three-dimensional body shape given by the wearer in the situation of interest. The modeling method is designed to work with human body models of different distributors and considers arbitrary postures, body sizes, statures and genders.



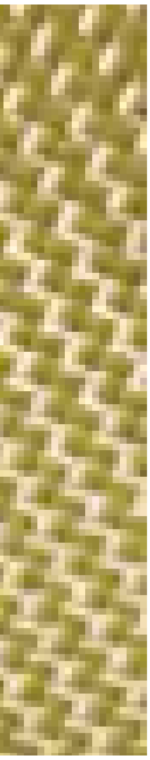
Aramid fabric for use in the soft ballistic part of a body armor.

One base model – multiple applications

In the current case, a soft ballistic vest has been put on the torso of a 50th percentile male (GHBMC M50-P). The generated model opens a wide range of applications for simulation engineers. Using a multitude of single simulations, strengths and weaknesses of existing protective solutions can be analyzed in detail. By virtual testing, the impact of different projectile types, impact velocities, inclination angles, impact locations, the distribution of multiple hits, either regularly or statistically defined, a ballistic designed vest or any other kind of protective armor system can be tested numerically in advance. Hence, the virtual design of protective clothes is able to contribute to improved future body armor systems and last but not least, to protect the lives of men and women during their mission. When looking at new threats, the same approach will help to identify material limits that would be necessary to defeat a certain threat. Material suppliers could adjust manufacturing processes to produce materials with enhanced protection levels.

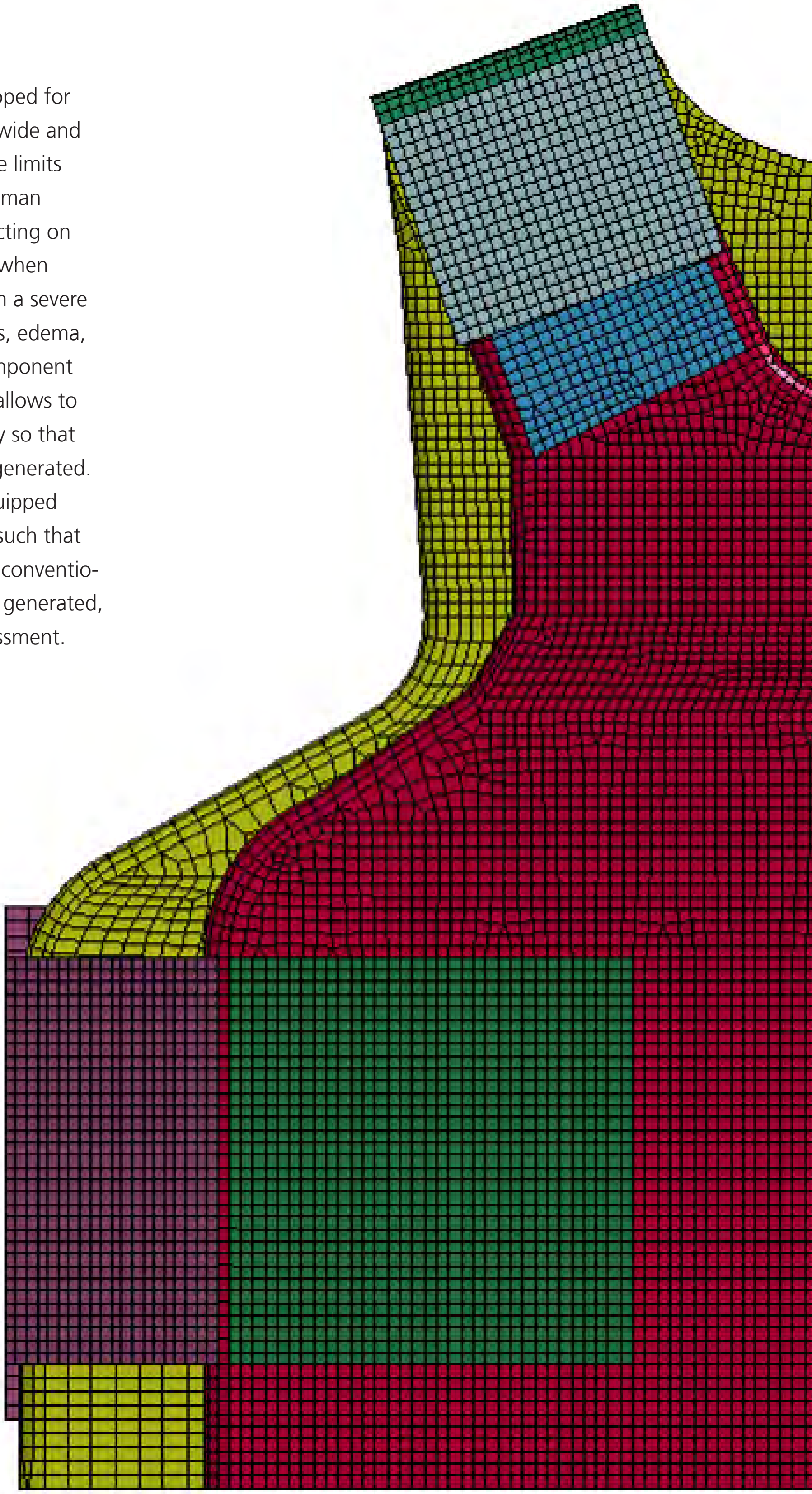
Experimental backup – the biofidelic dummy

For backing up numerical simulations with experimental data, it is planned to involve the so-called biofidelic dummy in near future. The distinguish-

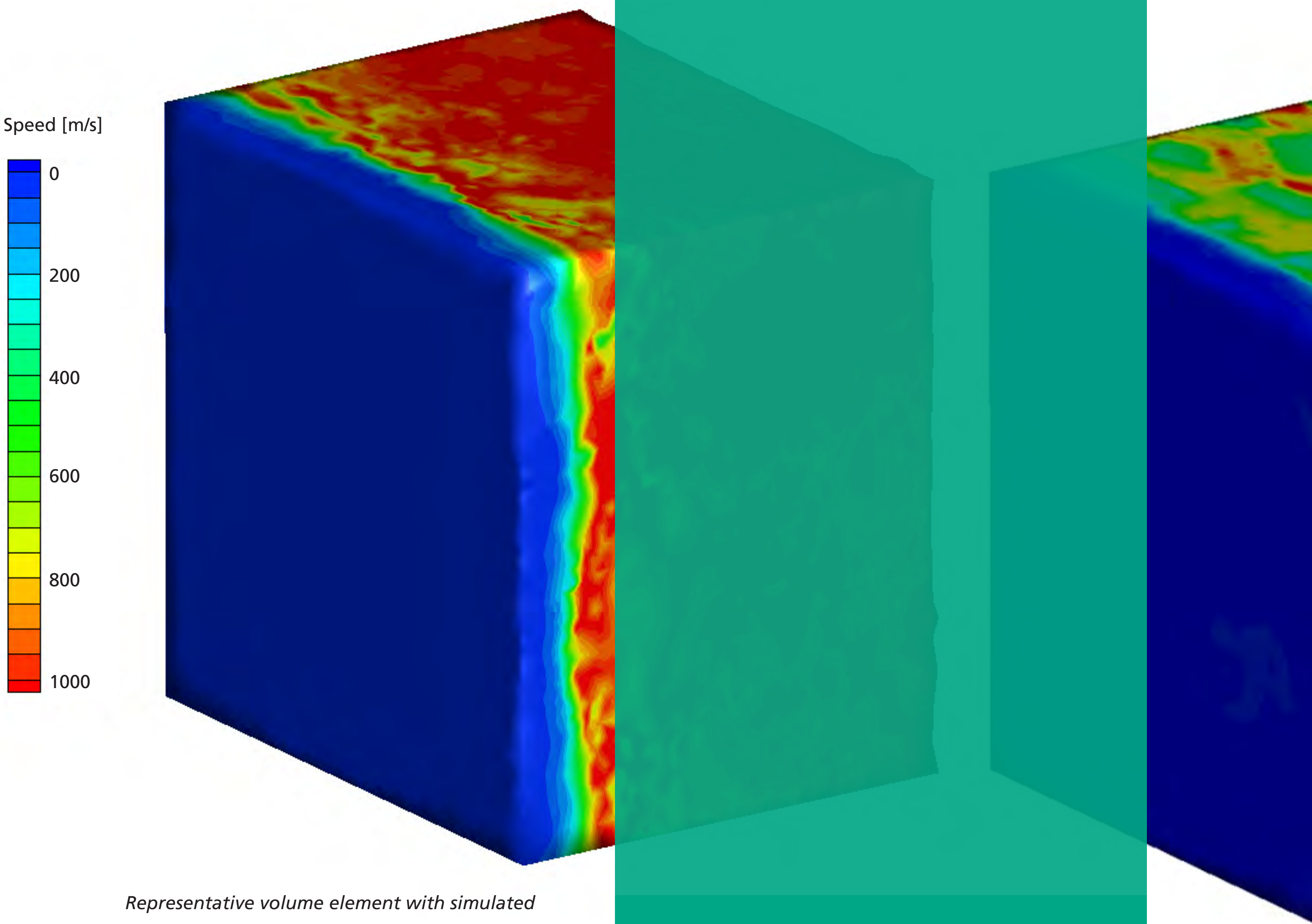


ing mark of this dummy, originally developed for pedestrian accident reconstruction, is its wide and flexible range of application and its failure limits that have specifically been adopted to human body requirements. If an external force acting on this dummy exceeds a certain threshold, when one would expect a human to suffer from a severe injury, e.g., rupture of bones or ligaments, edema, abrasion, blunt trauma, the dummy's component will fail accordingly. A technical autopsy allows to get insight into the interior of the dummy so that a comprehensive damage report can be generated. Last but not least, the dummy can be equipped with conventional measurement devices such that experimental results can be compared to conventional dummies and lots of test data can be generated, e.g., for the evaluation of injury risk assessment.

s.fhg.de/personal-armor-systems



Basic FE model of the soft ballistic part of the body armor in flat shape.



Representative volume element with simulated velocity and temperature distribution.

The application of hydrocodes for the simulation of initiation processes in plastic-bonded explosives (PBX) on the mesoscale is a challenging task. The thermo-mechanical behavior of the material shall be predicted, including possible initiation. For this purpose, EMI uses its own, highly specialized software SOPHIA, which is continuously further developed and improved.

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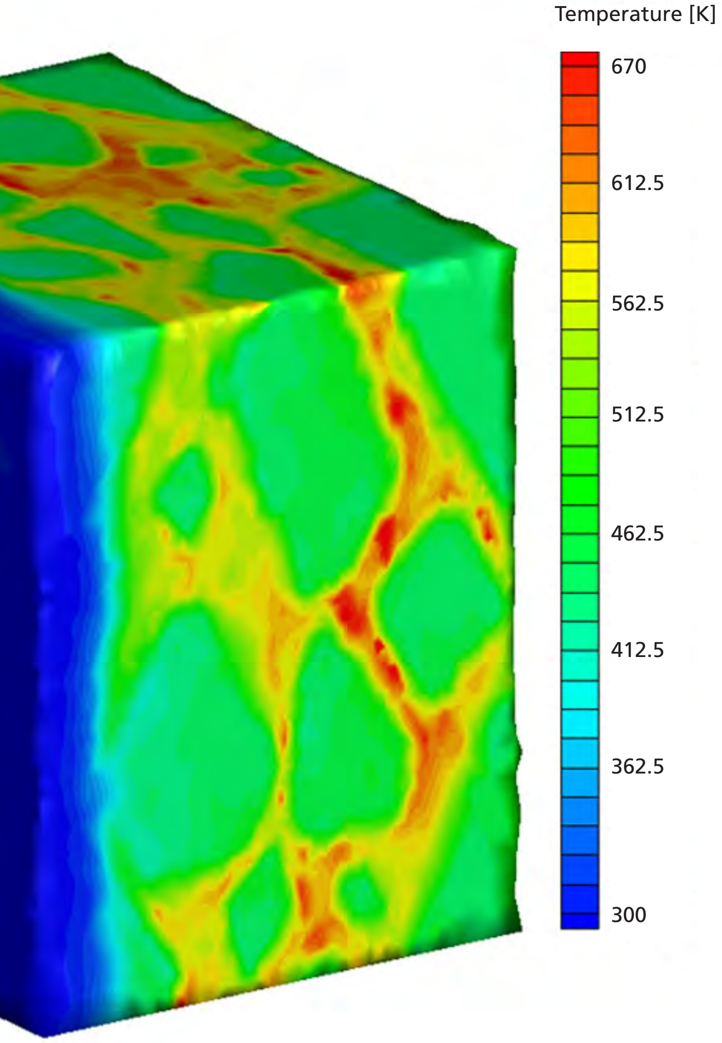
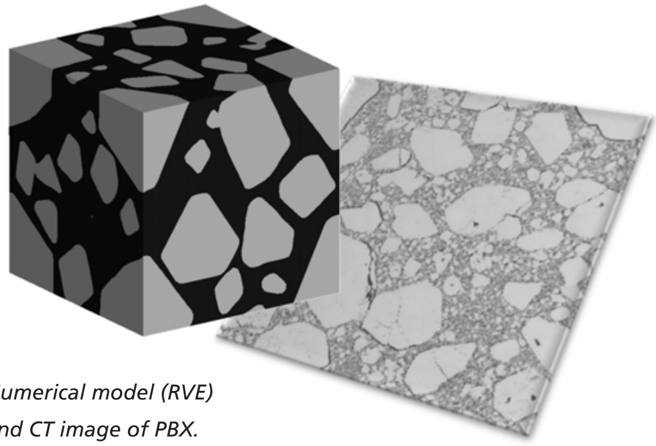




Numerical model (RVE) and CT image of PBX.

EXCELLENCE IN THE FURTHER DEVELOPMENT OF HYDROCODES

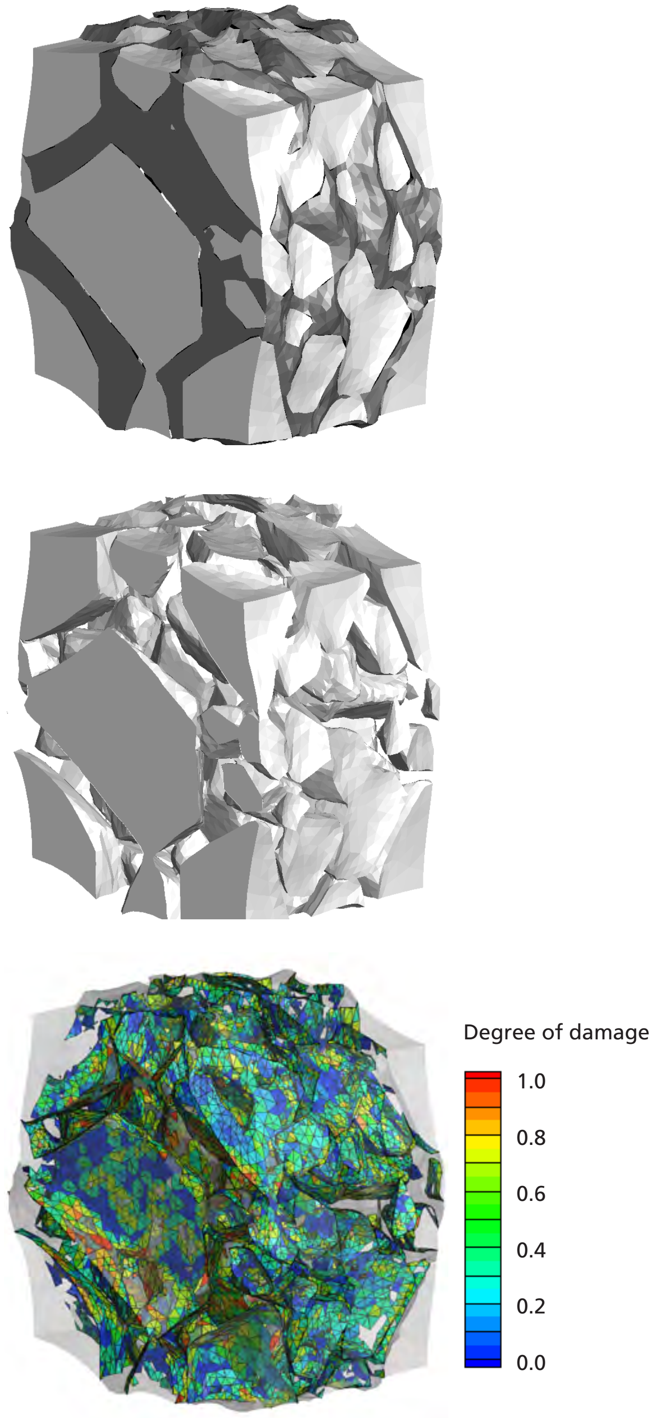
For many years, hydrocodes, numerical simulation methods for highly dynamic processes, such as crash, impact and explosions, have been used at the Ernst-Mach-Institut. In addition to the use of software from various providers, the institute's own hydrocodes are being continuously developed, applied in projects and also licensed for external customers.

A particularly demanding field of application is the simulation of initiation processes in plastic-bonded explosives (PBX) on the mesoscale. In this kind of numerical models, the heterogeneous structure, i.e., plastic-based binder and micrometer- to millimeter-sized explosive crystals, is represented in high spatial resolution. The challenge here is to replicate the behavior of the material under rapid mechanical or thermal loading up to possible initiation in order to be able to predict the time when a chemical reaction starts. Here, internal processes, such as the damage that is caused by detachment of crystals from binder or by breaking of crystals, play an important role. Using this type of models, security features of PBX, for example, the insensitivity to shock loads, are being investigated and optimized by changing the composition. The new methods required for this application are implemented in EMI's own software SOPHIA, which, in this context, is used for the mesoscale simulation of PBX for the German Federal Armed Forces.

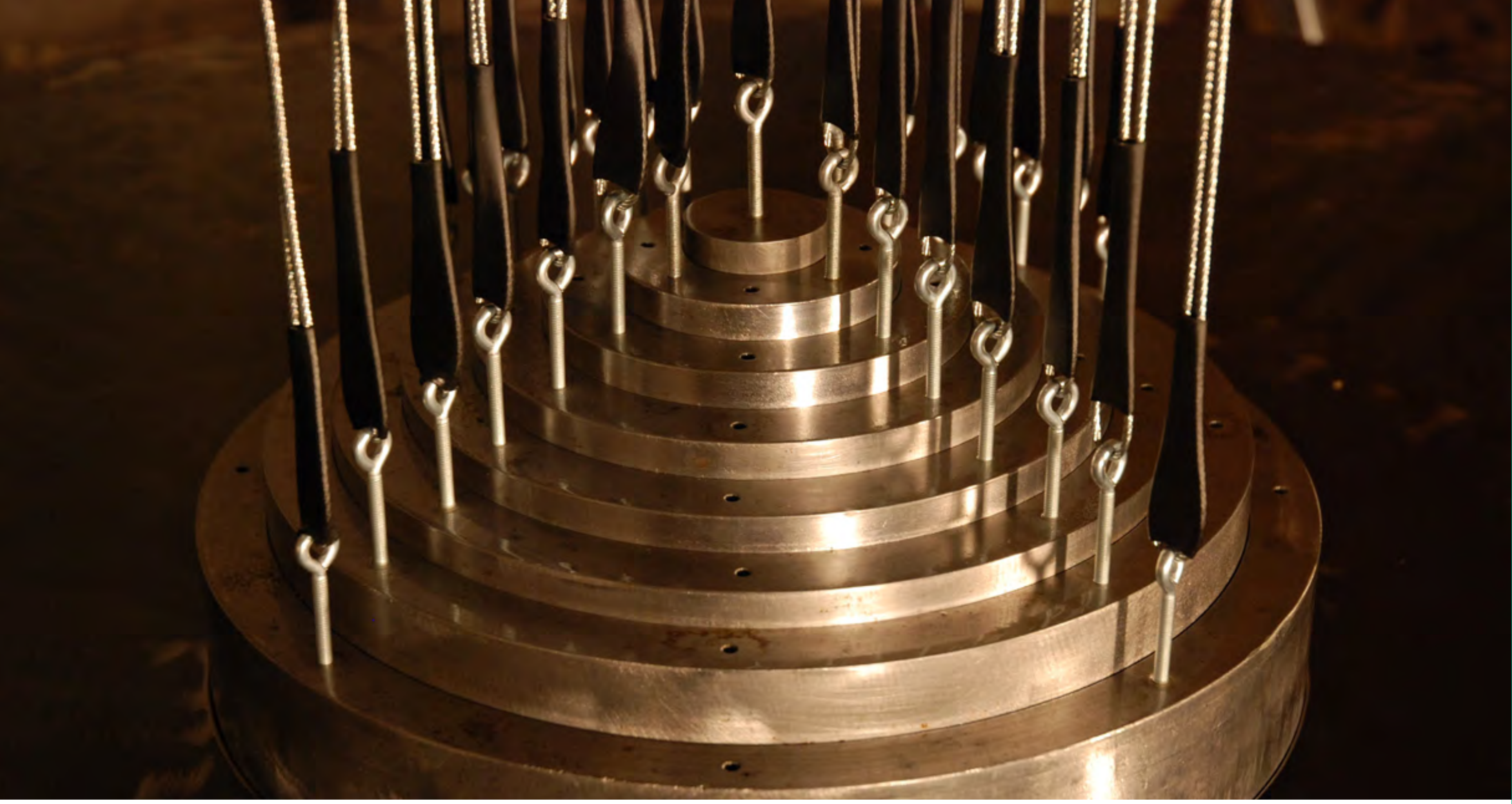
An essential subtask is the generation of representative structural models. For this purpose, computed tomographic images of explosive samples can be generated at the institute. The geometrical structure is extremely complex and has to be simplified for numerical simulations. EMI's own software tools are used for model generation. The tools generate geometric models with characteristic crystal shapes on the basis of given grain size distributions. The so-called "representative volume elements" (RVEs) are then converted into computational grids, which, together with the required material data and initial and boundary conditions, are the basis for finite-element calculations. Extensive optimizations are necessary to find the right balance between efficiency and accuracy of the calculation.

Meanwhile, methods are now available in SOPHIA that, in this combination, cannot be found in commercial and research codes of other institutions worldwide. This includes sophisticated algorithms for the calculation of temperatures in dynamically loaded materials, which have been combined with a special element formulation for tetrahedra. Tetrahedral elements offer maximum flexibility for the representation of geometrical structures. However, they tend to show numerical instabilities, particularly with hardly compressible materials, such as binder materials typically are. Therefore, special correction algorithms are developed and used. The figures on page 18 and 19 show an RVE in its initial state and the simulated velocity and temperature distributions. In the simulation, the right edge has been pushed to the left at a speed of 1000 meters per second. At the displayed point of time, the resulting wave has almost reached the left side.

The capability to represent material failure in three-dimensional models of PBX with fracture-mechanics-based, so-called "cohesive zone elements" is also unique. This technique is used, for example, for the separation of crystals from the surrounding binder matrix. During the calculation, cohesive elements are automatically inserted where the maximum strength is exceeded; they are used to calculate the decreasing traction during the cracking process. The picture on the right shows at the top a uniaxially compressed RVE, in the middle the corresponding crystal structure without binder and at the bottom the damage value for the cohesive zone elements.



Uniaxially pressed RVE (top), crystal structure without binder (middle), cohesive zone elements with degree of damage (bottom).



Annular arrangement for the measurement of the specific impulses when buried charges are detonated.

SCIENTIFIC METHODS TO SUPPORT THE DESIGN OF PROTECTION OF MOBILE PLATFORMS AGAINST IEDS

The detonation of IEDs (improvised explosive devices) can cause high impulse transfer into vehicles in operation and thus endanger the occupants. In the department Experimental Ballistics, scientific methods are being developed to better protect land vehicles against IEDs. A scaled experimental technology was set up to analyze the effect parameters of buried charges. This results in the possibility of an efficient evaluation of improvement measures directly on the vehicle, e.g., vehicle floors with different shapes.

In addition, an arrangement was developed that allows the specific impulse to measure when a buried charge is detonated as a function of the distance in the horizontal plane. After the reaction of the load, several concentric rings are accelerated. The local specific impulse can be determined from the respective velocities. By investigating different embedding materials, important influencing factors for the impulse transfer were worked out, which are used as the basis for the validation of simulation models.

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Investigation of the structural behavior of a soil-filled protective wall in a shock-tube test (detonation event in the far field).

SOIL-FILLED PROTECTION SYSTEMS

Soil-filled gabions can provide effective protection against shock waves resulting from detonation events. Therefore, the group Security of Structures is researching the potential of these structures as protective enclosure in order to design them as a wall system safe and efficient against hazards like blast loads.

At component level, such protective walls with different types of soil are tested on EMI's own shock-tube facility BlastStar. The soil-specific properties of the backfilled materials are determined in the laboratory.

This allows a detailed evaluation of the structural response under consideration of soil-mechanical and dynamic aspects, respectively. The results are supported by numerical analyses using hydrocode simulations. Thus, the structural behavior of these highly dynamically loaded protective walls can be recorded and evaluated effectively. In the future, research work will enable a faster and more accurate dimensioning of such structures and at the same time serve as part of basic research in the field of soil dynamics.

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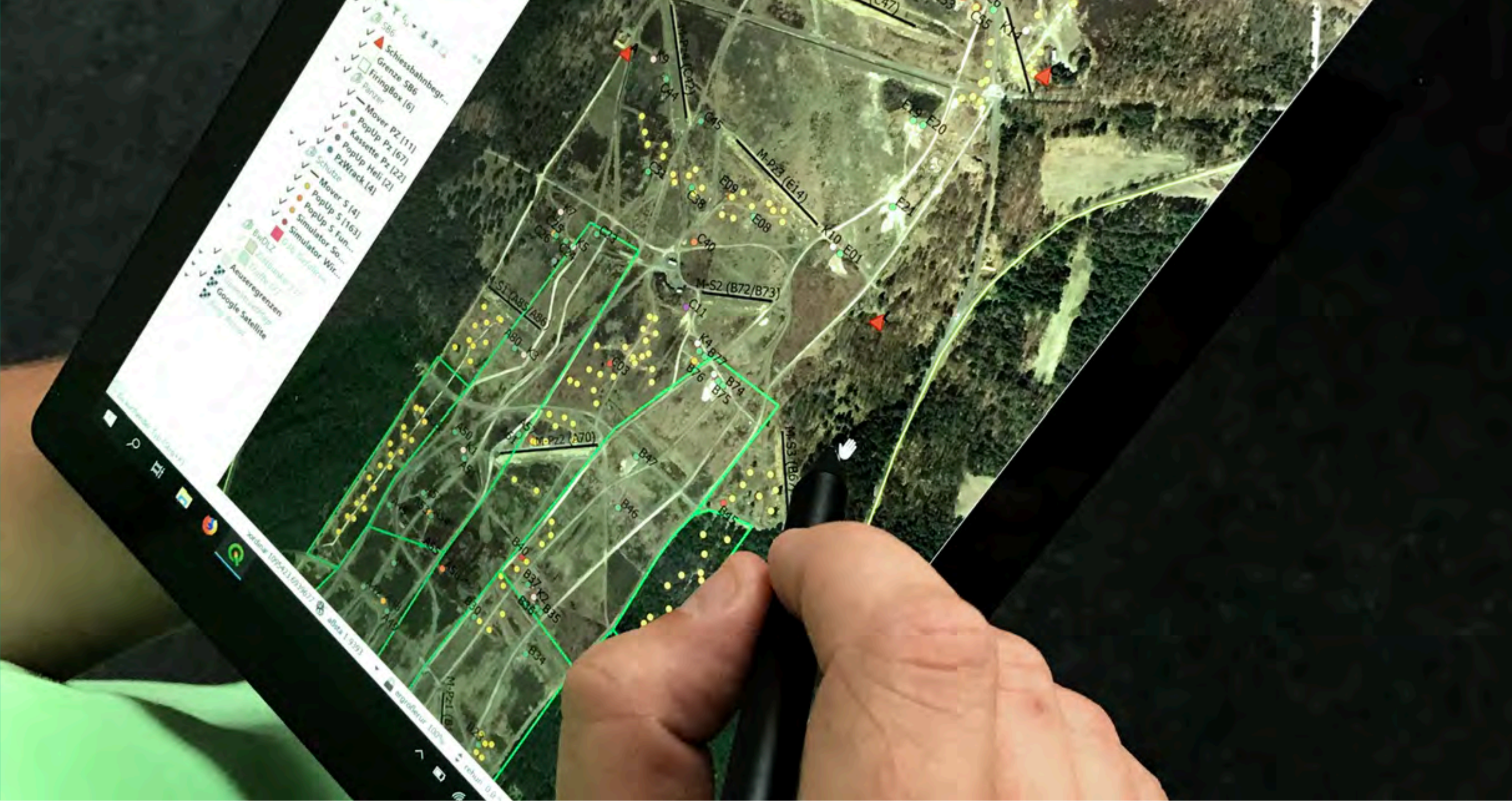

Adequate technologies for the digitalization of combat training can significantly increase safety in live firing exercises.

FUTURE COMBAT TRAINING SYSTEM

SAFE TRAINING IN REALISTIC SCENARIOS

To enable Bundeswehr soldiers to carry out their mission successfully and safely, they must be optimally prepared. An essential element is the training of realistic operational scenarios – especially in live firing ("train as you fight"). New technical approaches allow to enhance the training area structure.

As part of a research project on range safety in handgun training, research was started on how the digitization of military training facilities can provide at least the same or increased range safety – with improved training and extended training options. One focus was on generation and processing of sensor data with integrated weapons and portable target systems. The data thus accessible are used for a security system to determine and control the internal and external range safety. In doing so, the concept of dynamic hazard areas was developed, which requires a digital training area environment.

A first field demonstration is scheduled for 2020 at a Bundeswehr military training area.

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Failed bonded-mechanically fastened aluminum-CFRP sample after testing on the split Hopkinson tension bar.

SAFE JOINT CONNECTIONS UNDER VERY HIGH-RATE LOADING

Military aircrafts are subjected to very high-rate loading, as for example high-velocity impacts or blast loads. In order to design safely these types of structures, it is important not only to characterize the materials but also the joints connecting the different parts. However, for the relevant high loading rates, the high-rate servo-hydraulic testing machines cannot provide reliable oscillation-free load-displacement curves.

For this reason, a high-rate material testing device, the "split Hopkinson tension bar", has been adapted at Fraunhofer EMI in order to enable the testing of aviation representative joints. For this purpose, samples made of typical aircraft material, carbon-fiber reinforced plastics (CFRP) and aluminum, have been manufactured. During the first test campaign on the adapted device, three kinds of joints have been tested successfully: bonded, mechanically fastened and hybrid bonded-mechanically fastened.

Thus, realizing tests with the split Hopkinson tension bar constitutes an adequate method for the high-rate characterization of joints. The obtained results demonstrate furthermore the potential relevance of hybrid joints to increase the safety of aircrafts: These types of joints both withstand high forces and absorb much energy until failure. Further joints will be characterized in the future using the developed setup.

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SIMULATION-BASED INVESTIGATION OF TARGET IMPACT ACCURACY OF WEAPONS

The accuracy of weapons is largely determined by the mechanical interaction between the barrel and the projectile during launch. Barrel vibrations and lateral oscillations of the projectile perpendicular to the barrel axis cause variations in the bullet's motion state after muzzle exit, resulting in a dispersion of target impact locations. Centrifugal forces also play a role in the case of rifled launch tubes. Aside from the effects on dispersion, the mechanical loads during launch may cause excessive damage to the projectile, which in the worst case poses a hazard to personnel and equipment. Experimental investigations on launch dynamics by means of on-board diagnostics are difficult due to the high level of longitudinal acceleration (sometimes more than 100,000 g). As for small-caliber projectiles, they are not suited simply because of the prevalent space limitations.

Numerical simulations are therefore used at Fraunhofer EMI as a fast and cost-effective alternative. Through the coupled use of structural-dynamic finite-element codes in conjunction with a lumped-parameter interior ballistics model and 6-DOF flight calculations, it is thus possible to gain valuable insights into the influence of individual parameters on the projectile unit accuracy.

Deformation of a small-caliber projectile after firing in experiment and simulation.

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TEST METHODS FOR THE SAFETY OF BATTERIES IN USE

Lithium-ion (LI) technology is nowadays indispensable in both military and civil environments. Their use ranges from battery packs for portable electronics to vehicle batteries and large stationary storage systems. Fraunhofer EMI researches to improve the safety of these batteries and carries out experimental tests with a focus on dynamic load cases (for example, the crash behavior of batteries).

For the safe use of LI batteries in the German Armed Forces, additional military conditions – such as shelling or blast loads acting on a vehicle – must be considered and tested. The risk potential under these special load cases as well as suitable protective measures can be investigated at Fraunhofer EMI thanks to a unique portfolio of experimental technology. In recent years, experiments have been conducted with small battery packs worn on the person. An expansion of the test facilities is currently being planned to extend the experiments to larger batteries that can be used in military vehicles.

While safety tests for civil applications are already specified in a large number of standards, Fraunhofer EMI is supporting with its research that this step can also be advanced for specific military requirements.

LI batteries in 6T-NATO format are also to be used in Bundeswehr vehicles.
© Bundeswehr (left)
© Epsilor (right)

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RISK FROM AGING AMMUNITION

Aging and spilled ammunition pose dangers. The risk analysis tools developed at EMI can be used to determine how high these risks are and whether risk reduction measures have to be taken or how these measures should be assessed. For example, Fraunhofer EMI is working with the Swiss authorities on the Mitholz case (see page 36).

View into a non-collapsed tunnel area with ammunition items thrown in by the explosion.

PRESENTATION FOR A PROMINENT AUDIENCE

During a visit of General Eberhard Zorn, Inspector General of the German Armed Forces, and Saxony's Prime Minister Michael Kretschmer to the military training area Oberlausitz in July 2019, Sven Nothdurft, Sebastian Hess and Dr. Siegfried Nau had the opportunity to present their innovative approaches to digital support for safe training with hand-held weapons in live fire at the highest military level.

General Zorn (center) and Saxony's Prime Minister Kretschmer (front left) on the military training area Oberlausitz. Dr. Siegfried Nau (right), Sebastian Hess (fourth from right) and Sven Nothdurft (second from right) present solutions for the digitalization of the Bundeswehr.
© Bundeswehr

BUSINESS UNIT SECURITY

Security is a fundamental social need.

BUSINESS UNIT SECURITY

The world affairs reveal that our societies face ever-increasing challenges to ensure their security. Repeatedly, we find ourselves confronted with threats of sorts and extent society as a whole never imagined. How can we address such threats while considering a world in constant change? This is the core question concerning research of the business unit Security.

In this connection, solutions have to be developed to offer answers to complex issues. The wide range of threats is also mirrored in the range of requirements to matching solutions that aim to counter such perils in urban and rural environments in a national and trans-national setting.

The following articles cover topics such as security of cities and their citizens with respect to deliberate explosive attacks as well as analyzing the resilience of trans-European networks against man-made and natural hazards.

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Robot using X-ray back-scatter imaging to examine a suspicious object.

In the two-year German-Austrian project DURCHBLICK led by Fraunhofer EMI and the Austrian AIT, research focused on a robot-assisted, high-performance sensor system for the examination of improvised explosive devices (IEDs). By integrating new technologies, bomb squads will have a better tool to help assess situations of danger. The results were presented at several international events, including the international congress of bomb-disposal (EOD) experts of the Federal Criminal Police Office (BKA) in 2018.

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Upon successful project closure, the results of DURCHBLICK were presented to many external guests in Efringen-Kirchen.

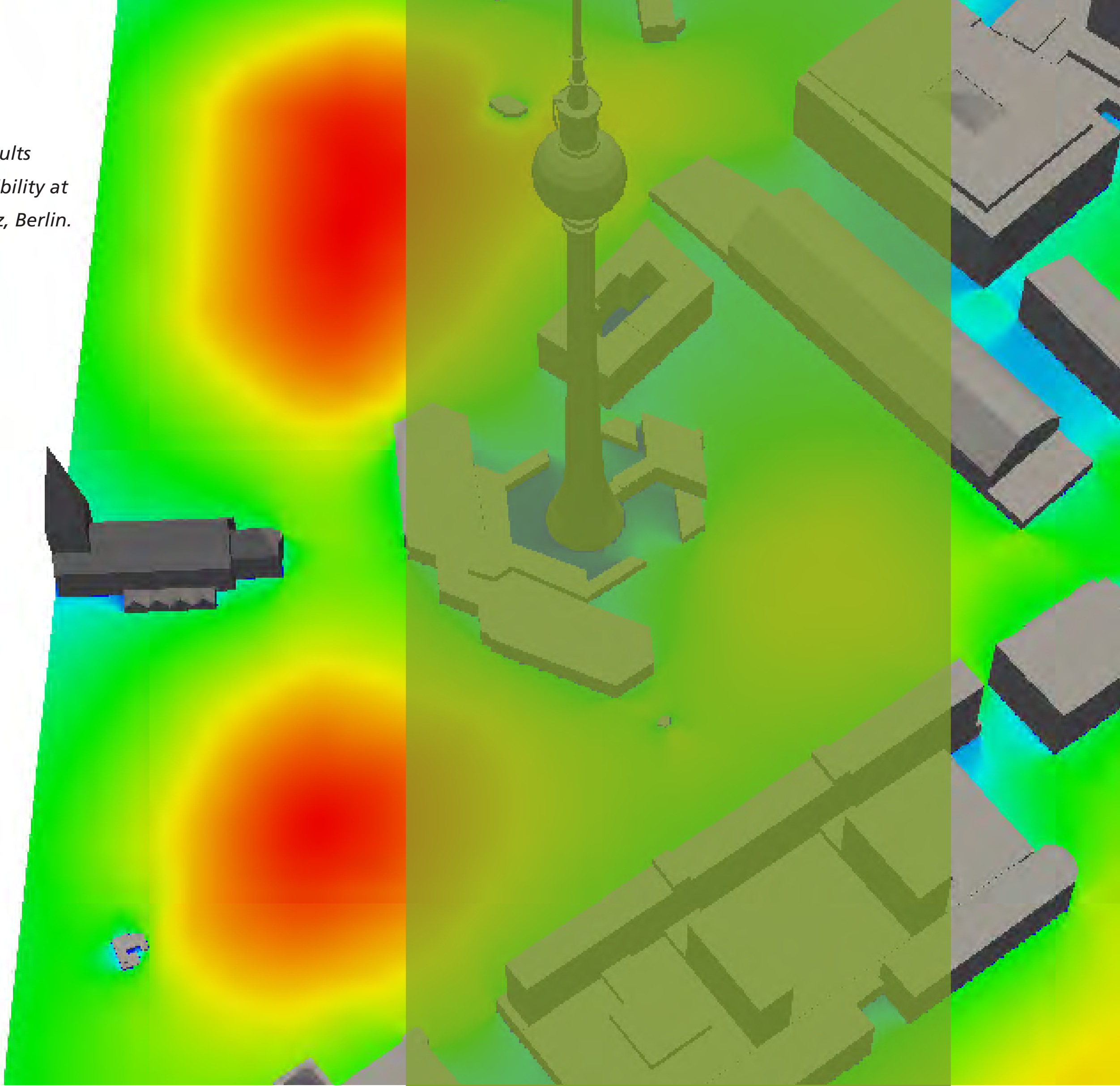
DUCHBLICK PROJECT CLOSURE

Due to the increasing dissemination of simple instructions for preparing improvised explosive devices (IEDs), Germany and Austria face serious threats to public security. Yet, technologies available to security forces only offer limited possibilities. The objective of the bilateral German-Austrian project DURCHBLICK was to investigate a robot-assisted, high-performance multi-sensor system to be used in such difficult settings. A key element was to enable novel sensor systems for deployment, which until then had not been available for this purpose before. It was an essential issue that also objects that are accessible from only one side can be examined.

Project research included the use of imaging methods by mobile X-ray backscatter technology as well as, together with the Freiburg Materials Research Center (FMF) at Freiburg University, the gamma camera to detect radioactive materials.

The goals set for the two-year project could be accomplished and it was shown that the investigated concept is viable and that the sensor technologies offer practical added value. In consultation with the end-users, several scenarios were defined for realistic tests on the sensor technology, and these experimental setups were also featured during the project closure events in Germany and Austria. During the project period and after, the results were disseminated in several popular-scientific publications of broad impact (interviews, magazine articles), in eight publications in scientific journals and by participating in seven conferences, workshops and specialized fairs. In this context, particular emphasis can be put on the presentation of our findings at the international congress of bomb-disposal (EOD) experts of the Federal Criminal Police Office (BKA) in November 2018.

Calculation results concerning visibility at Alexanderplatz, Berlin.



The design and architecture of public spaces have a considerable influence on the subjective sense of security for urban dwellers and may even prevent criminality. For the assessment and improvement of this sense of security, you have to identify places that are perceived as dark, out of sight and out of hearing range. In the project Stadtsicherheit-3D (urban security 3D), this is accomplished by a software tool, which is applied to existing three-dimensional city models. Focus was on three case-study areas in Berlin.

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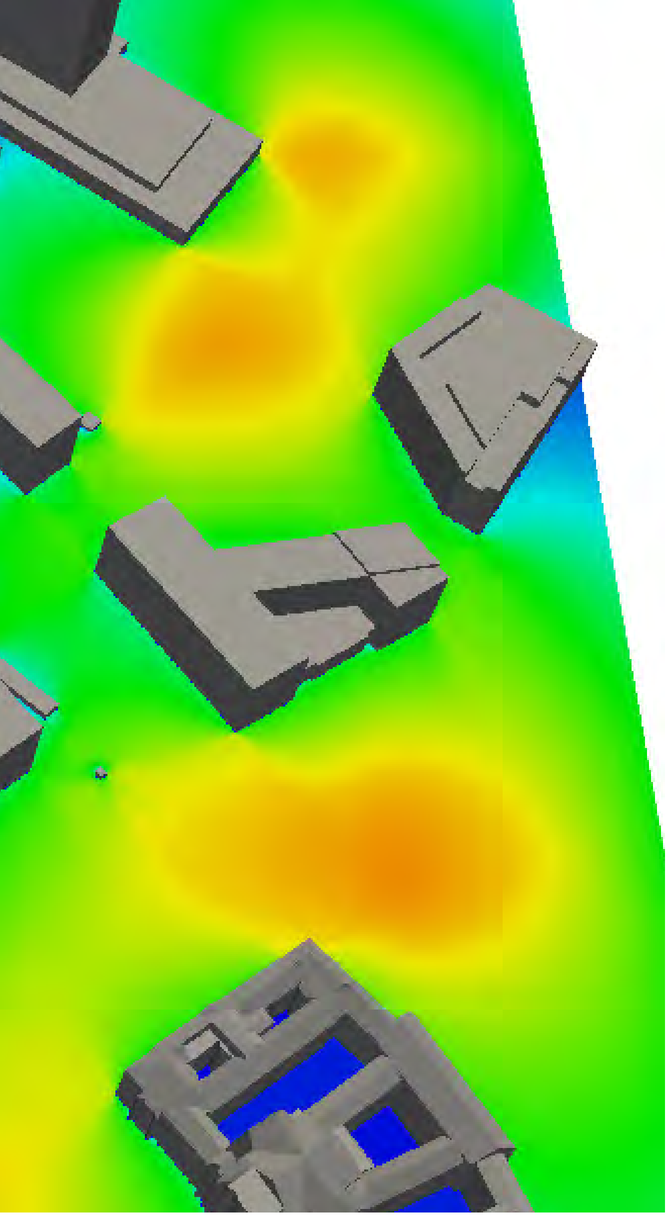

3D view on a building complex at the edge of the housing estate High-Deck-Siedlung in Berlin.

STADT-SICHERHEIT-3D – IMPROVING THE IMPRESSION OF SECURITY

Security as a topic not only touches on the important role of ensuring objective security, but also acknowledges the importance of the subjective sense of security. For this reason, the main focus in the project Stadtsicherheit-3D (urban security 3D) is on the assessment and improvement of the subjective sense of security among urban dwellers. Structural and spatial factors in urban environments, which foster the various perceptions of security as being present or rather absent, are identified and operationalized. Emphasis is placed on the identification of places that are perceived as dark, out of sight and out of hearing range. Based on experience from best-practice examples and on-site measurements, the identified elements are incorporated into the algorithms that serve as the core of a software-based planning tool. The software can then be applied to existing three-dimensional city models and thus allows an improved security assessment.

Tool as planning and design aid

For the first time, a software tool based on numerical modeling is developed with which security assessments can be made systematically and empirically. Further key factors that cannot be physically depicted are inquired interactively. The tool helps city planners and security experts to create more security in urban environments and can be used in participative decision processes.

s.fhg.de/stadtsicherheit-3D-en

Village of Mitholz with rockfall area in the right third in the background.
The remaining ammunition in the former ammunition depot is still dangerous today.

RISK ANALYSIS FOR FORMER AMMUNITION DEPOT MITHOLZ

In December 1947, part of the approximately 7000 tons of ammunition stored in the underground ammunition depot in Mitholz, Switzerland, exploded, killing nine people. Approximately 3500 tons of remaining ammunition containing several hundred tons of explosives are suspected in the collapsed facility and the rubble cone in front of the installation. Contrary to previous assumptions, a current risk analysis by the Swiss Department of Defence (DDPS) concludes that the risks of further possible explosions are significantly above the accepted limit values according to the Swiss Major Accident Ordinance. The Swiss Federal Office for the Environment (FOEN) as the responsible specialist agency has commissioned Fraunhofer EMI to evaluate the current risk analysis of the DDPS and its planned measures for risk mitigation. The second opinion by EMI has confirmed the assessment of the DDPS. Ongoing project work is dealing with complex questions about aging ammunition, the exact distribution of which is unknown under collapsed rock in the extensive area. Partial finds have shown that ammunition items are equipped with functioning fuses, the explosives are preserved in their original state, and explosive densities are present that make sympathetic detonation transmission possible.

More information on the pages of the DDPS.

s.fhg.de/ammunition-depot-mitholz

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In an emergency in the underground tunnel system, rescue workers need reliable guidance. © Helen Schäfer

SENSOR SYSTEM FOR UNDERGROUND TUNNELS

Fortunately, fires in underground tunnels are extremely rare, but they are all the more dangerous for the emergency services. Above ground, important information, for example from residents, is available and direct access to the fire site is possible. In the event of an underground fire, it is important to decide in advance from which tunnel direction access should be made. However, the information required for this is missing. The sensor system developed in the German-Indian project SenSE4Metro, which detects fire, smoke, water ingress and explosions, provides a remedy.

Final exercise

The final exercise of the project took place on October 7, 2018, in Berlin. A fire in an underground tunnel was simulated and the benefits of the project results were examined. Over a hundred firemen and Red Cross volunteers rescued injured people, played by actors, from a train in the Jungfernheide training tunnel. The passengers had to be brought outside via an emergency staircase, and carrying seriously injured passengers required quite a bit of strength. They were then given medical care. The developed sensor system was successfully used primarily for access planning.

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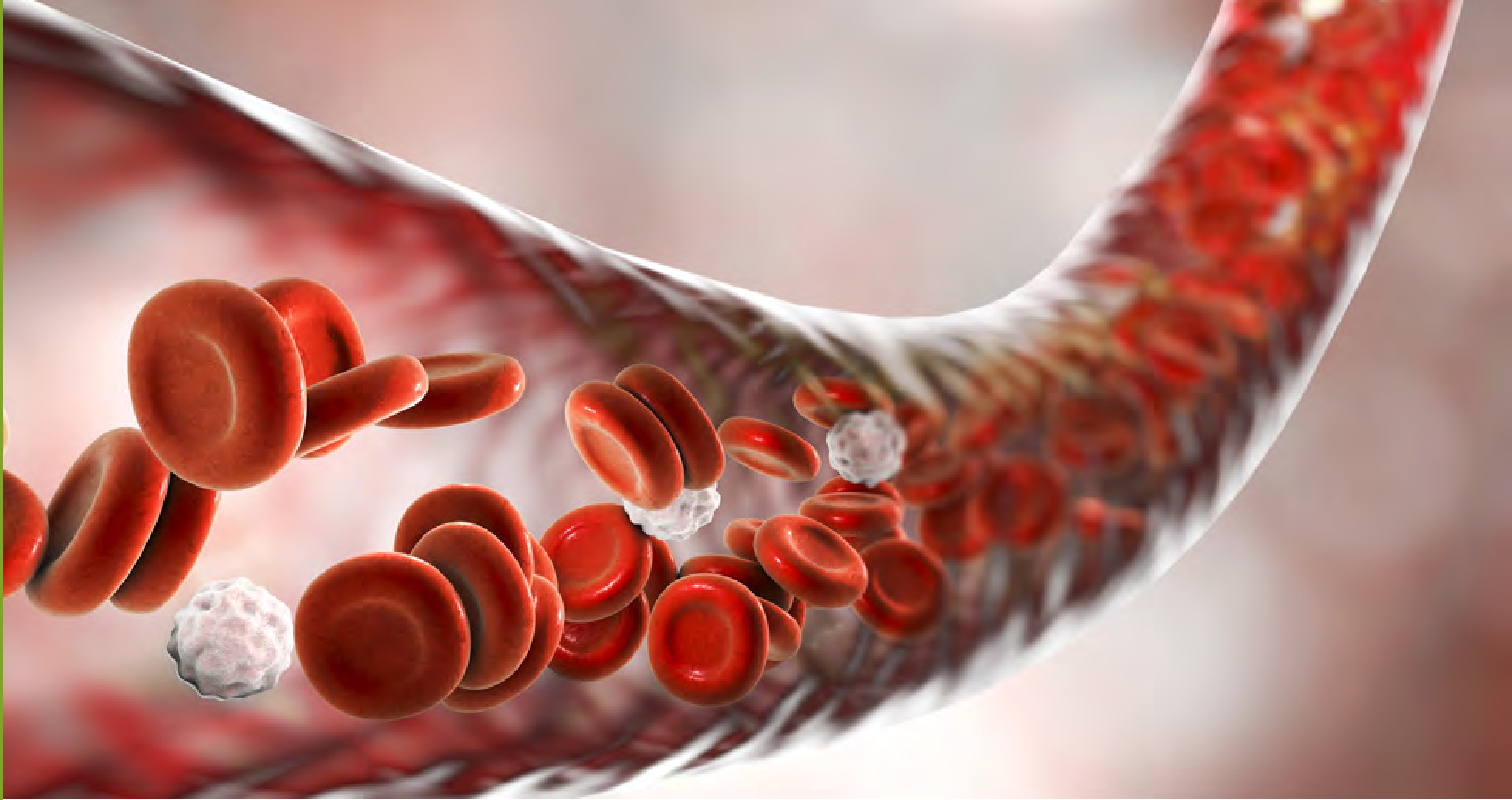

The protective principles of biological systems can be abstracted and transferred to technical systems. © Adobe Stock

BIOMOTS

BIOLOGICAL MODELING OF TECHNICAL SYSTEMS

The safety of technical systems is often not planned properly: On the one hand, they are extremely robust for foreseeable malfunctions, because partly redundant protection capacities are provided for each respective potential fault. This is inefficient and consumes unnecessary resources. On the other hand, there is no protection for unforeseen incidents. This leaves the system vulnerable, since the possibility of damage must be planned in advance. In contrast, biological systems are characterized by very high efficiency, resilience and sustainability. They react dynamically and adapted to their manner to different external disturbances. Decisive for the complete system are the selection and timing of the individual reaction mechanisms, which also influence each other in a complex biological network. As part of the BioMOTS project, a project team consisting of staff from Fraunhofer EMI and Fraunhofer ITEM has now shown, using the example of battery systems for electric vehicles, that biological protection principles can be abstracted and transferred to technical systems. For this purpose, principles of wound healing and pain reflex response were systematically characterized and transferred to a simulated battery system so that its resilience was significantly increased.

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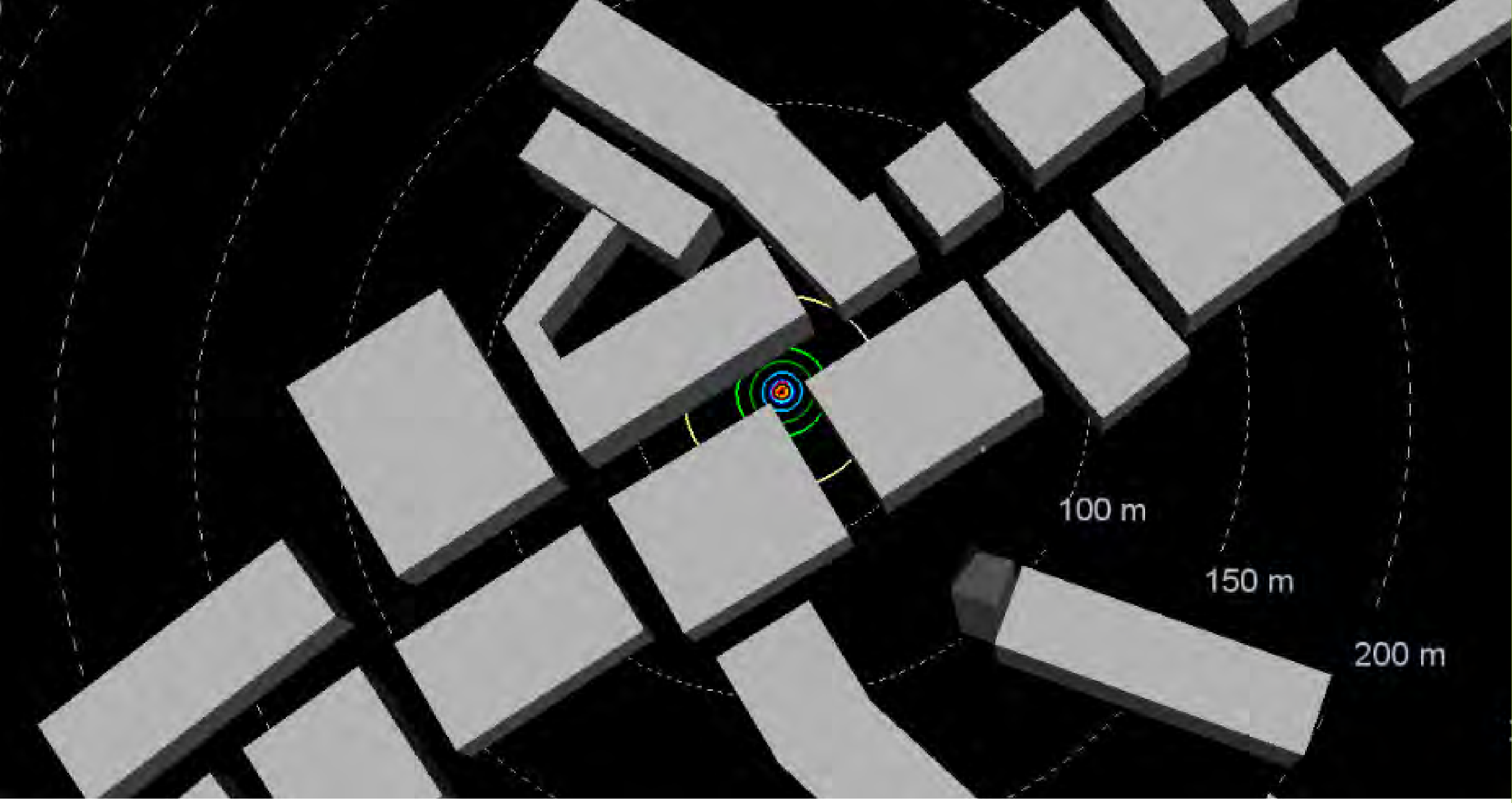

Possible results graphic for the risk analysis in an urban environment.

SUSQRA

PROTECTION AGAINST IMPROVISED EXPLOSIVE DEVICES

For the forensic investigation of an explosive event that was foiled or that actually took place, one of the main questions in court is the evaluation of the possible extent of damage. In this context, reconstructions of the explosions are time-consuming and expensive. Moreover, risk analyses are necessary prior to major events in order to prevent threats.

The project SUSQRA is funded by the German Federal Ministry of Education and Research (BMBF) and aims at the creation of an expert system to quantitatively analyze the expected damage of improvised explosive devices without experiments. For this purpose, numerical and analytical calculation methods are developed and validated with damage data from experiments. The SUSQRA analysis tool supports experts in the risk analysis prior to an event to identify threats, to develop security concepts and to establish protective measures. The SUSQRA demonstrator assists forensic experts after an explosive event to make statements regarding the used explosive, coating materials or distances of the fragments.

A clear graphical user interface of the SUSQRA demonstrator facilitates the experts' daily work. During the whole project, the feedback of the experts is constantly incorporated to continuously improve and adapt the SUSQRA demonstrator to the needs and requirements of the end-users.

s.fhg.de/SUSQRA-en

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BUSINESS UNIT AUTOMOTIVE

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

BUSINESS UNIT AUTOMOTIVE

Digitalization and virtualization are on the rise along the entire automotive development process chain – from material modeling to structural design to production. This increases the urgent need for valid data as input for a variety of computer-assisted processes. At the same time, already in 2016, the science journal Nature pointed to a significant reproducibility crisis, especially concerning data form the fields of physics and engineering. That is why our research group Digital Engineering deals with new concepts supporting sustainable digitalization with the aim to exploit and utilize the whole life cycle of research data by the consequent implementation of the FAIR guiding principles.

EMI itself generates valuable research data, for example, originating from a novel measuring and evaluation method that employs X-ray diagnostics to observe the dynamic behavior of hidden vehicle structures during crash.

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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).

Using X-ray technology enables the observation of the dynamic behavior of hidden vehicle structures under crash conditions. In addition to novel measurement technology, necessary algorithms for analysis and evaluation are developed within the scope of industrial and research projects.

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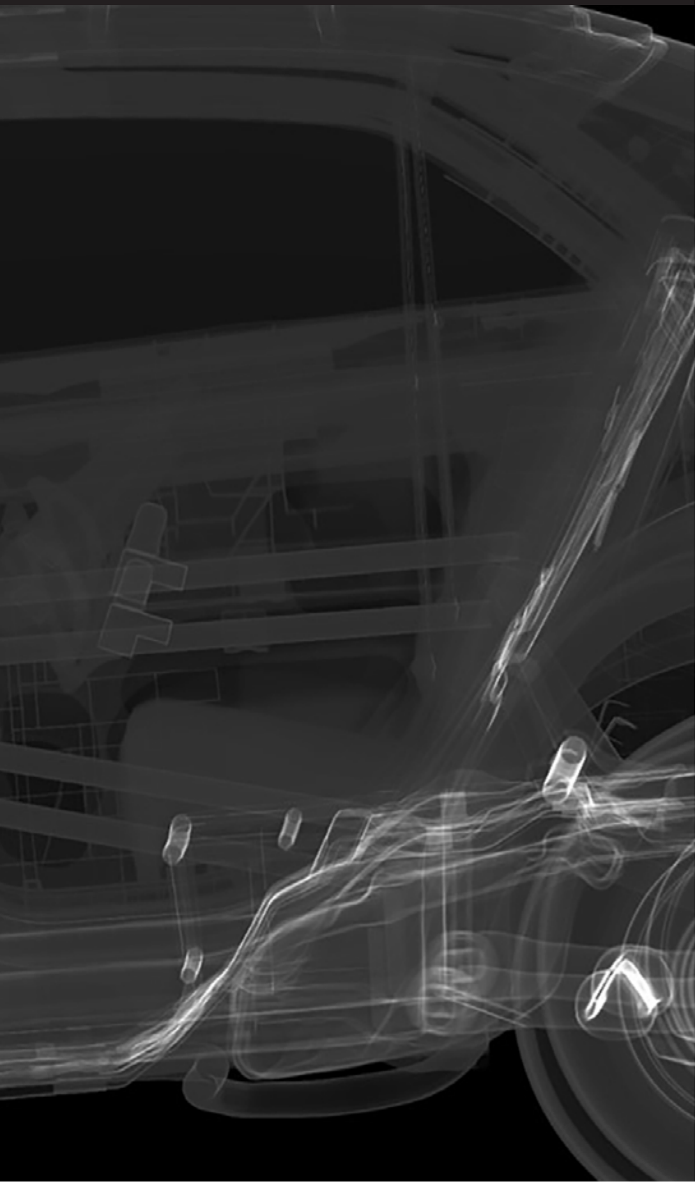
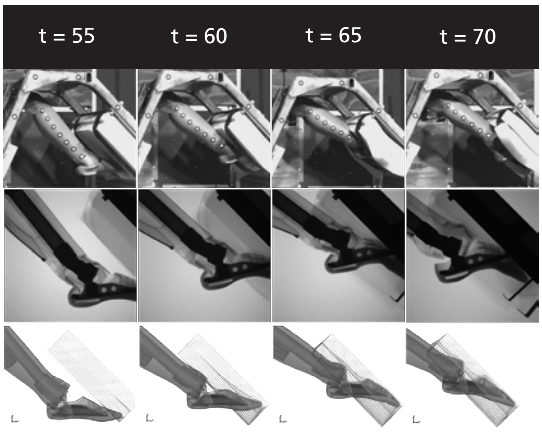


X-RAY CAR CRASH

CRASH TEST UNDER X-RAY

Within the scope of industrial and research projects, a novel measuring and evaluation method is currently developed at EMI, which enables the observation of the dynamic behavior of hidden vehicle structures during crash. This method helps to capture precious information for the validation and optimization of numerical crash simulations.

In cooperation with the Fraunhofer Development Center X-ray Technology EZRT, researchers of Fraunhofer EMI develop the hard- and software



Generic loading case: Applying the dynamic X-ray analysis to the impact of a pivoted lower leg of a crash-test dummy at high acceleration (30 g). Simulations were performed with LS-DYNA (Livermore Software Technology Corp.).

required for the application of the novel measuring and evaluation method. With regard to measurement technology, considerable progress has been made on the design of a specialized detector, which is optimized for very high energies and frame rates. For the analysis of the collected data, algorithms for the automated identification and tracking of vehicle features are devised. Computation of simulated X-ray images facilitates the optimization of the experimental test setup and allows for a comparison of the numerical crash simulation and the real-world experiment in X-ray images. Using methods from the field of data assimilation, 3D information, which is not contained in the 2D X-ray image, is augmented by incorporating information from the numerical crash simulation. This approach allows for a reconstruction of the crash behavior of the vehicle in the real-world experiment and a comparison with the corresponding crash simulation. The project is accompanied by numerous generic load cases of varying complexity. In this context, the dynamics of a pivoted leg of a typical crash-test dummy was studied as it impacts on a foamed-plastic barrier at 30 g acceleration. In this example, the application of the novel measuring and evaluation method demonstrates the possibilities of a detailed analysis of the dynamic behavior, which is unfeasible using conventional observation methods such as high-speed cameras.

The research group Digital Engineering addresses solutions for the digital management of research data and cross-domain data spaces. © FE model: NHTSA/DOT

In the light of digital transformation and increasingly data-driven research approaches, it is an essential goal to address the entire life cycle of research data and to sustainably exploit the data in versatile ways by the consistent implementation of the FAIR guiding principles (FAIR: findable, accessible, interoperable, reusable). The purposes of digital data management, which builds upon semantic technologies, include maximizing the added value from research data.

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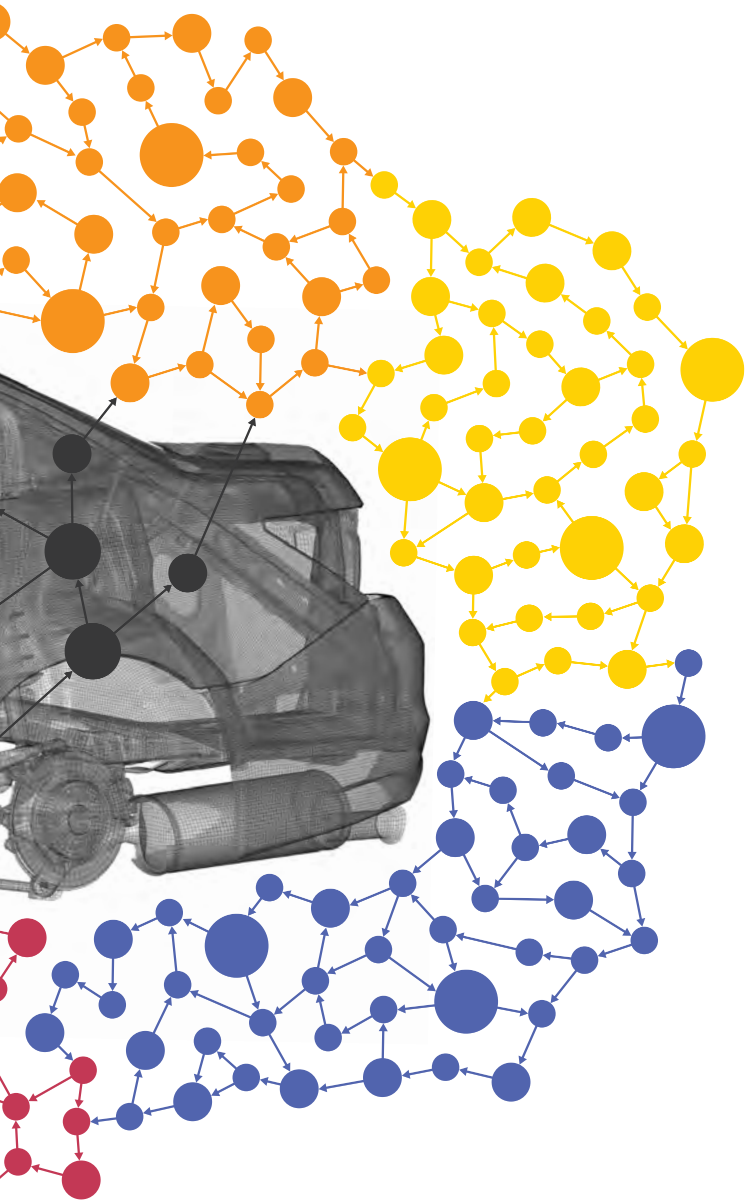


DIGITAL DATA MANAGEMENT

Digital transformation is increasingly entering classical engineering disciplines. Especially in materials science and engineering, groundbreaking innovations due to modern methods of data processing emerge. That is why the research group Digital Engineering addresses concepts to sustainably digitalize the management of data originating from the various research areas at EMI.

FAIR data: findable – accessible – interoperable – reusable data

In recent years, the pace how heterogeneous and unstructured data are generated worldwide has dramatically accelerated. In addition to their inaccessibility, the bigger part of data assets is not reusable because they are poorly annotated and lack rich metadata. Especially in the light of increasingly data-driven research approaches, the large quantity of information contained in data assets is of crucial value to future R&D activities. The greater goal of the scheme is therefore to address the entire life cycle of research data and exploit it by the consistent implementation of the FAIR guiding principles. To this aim, metadata play a superior role as they form the base to describe and exploit the meaning of data. Semantic technologies allow for the integration of metadata as context information in order to harness the knowledge from the underlying data.

Interoperability

The comprehensive reuse of data is also inhibited because institutions accumulate heterogeneous data assets in so-called data silos – where they partly lie waste. This is counteracted by semantic data enrichment, which renders transdisciplinary and cross-domain interoperability possible. Due to their high expressiveness, ontologies as knowledge organization systems permit to preserve and infer domain knowledge. They formally represent the explicit description of the shared concepts within a domain, their logical relations among them as well as the governing rules and restrictions. This entails a human- and machine-interpretable specification of the underlying data structures and contents and promotes interoperability across heterogeneous data, models and systems. The outcome of this is a productivity gain potentially crucial to success as misconceptions, costly mistakes and extra work can be prevented.

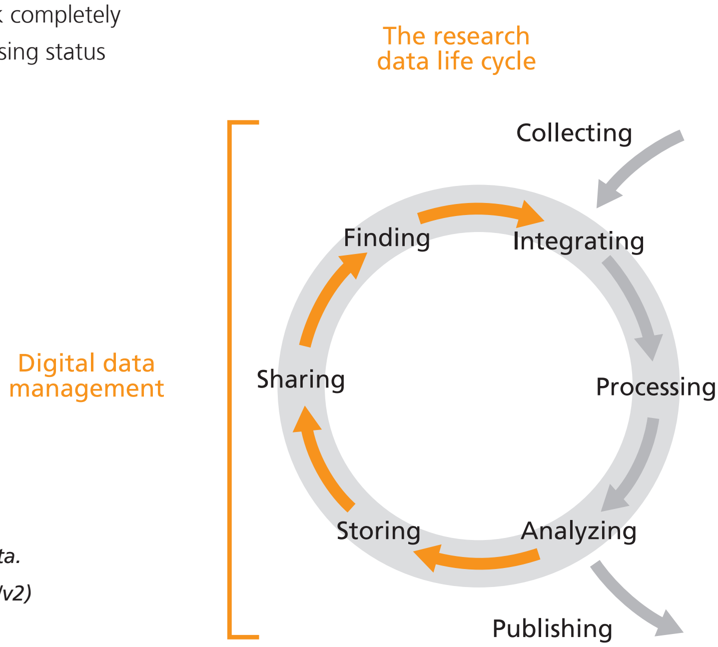
Simple semantic network consisting of two resource description framework (RDF) graphs.

Research activities are not limited to the goal of maximizing the internal value creation from research data present at institutions like EMI: In cooperation with external partners, also cross-company data spaces, such as the International Data Spaces, are harnessed for materials science and engineering. This way, the reuse, the versatile exploitation and combination of data provide the conditions for inferring new conclusions and producing research results of higher value. Furthermore, modern data processing methods from materials informatics can be employed – for example, by the automated analysis of large bulks of data by means of intelligent algorithms. If nothing else, interoperable data and models create the basis for innovative digital workflows, for example, in model-based systems engineering.

Reproducibility

The exact knowledge on the data provenance is essential to precisely address and trace back completely the current as well as the previous processing status of resources along a process chain.

To this end, data and their evolution are described by semantically interoperable metadata, so-called RDF graphs (resource description framework). If these build on ontologies, their context becomes transparent to its full extent and is rendered interpretable. The single entities are logically linked to form a semantic network – resulting in a knowledge graph, and thus, the transition from data to information to knowledge is accomplished. Based on these principles, the entire life cycle of resources is depicted. This serves the objective of universal transparency concerning the current or past status of materials, technical systems and data accumulating from each process step and improves the overall data quality.



Digital data management sustainably exploits the entire life cycle of research data. (Source: f1000research.com/articles/6-1618/v2)

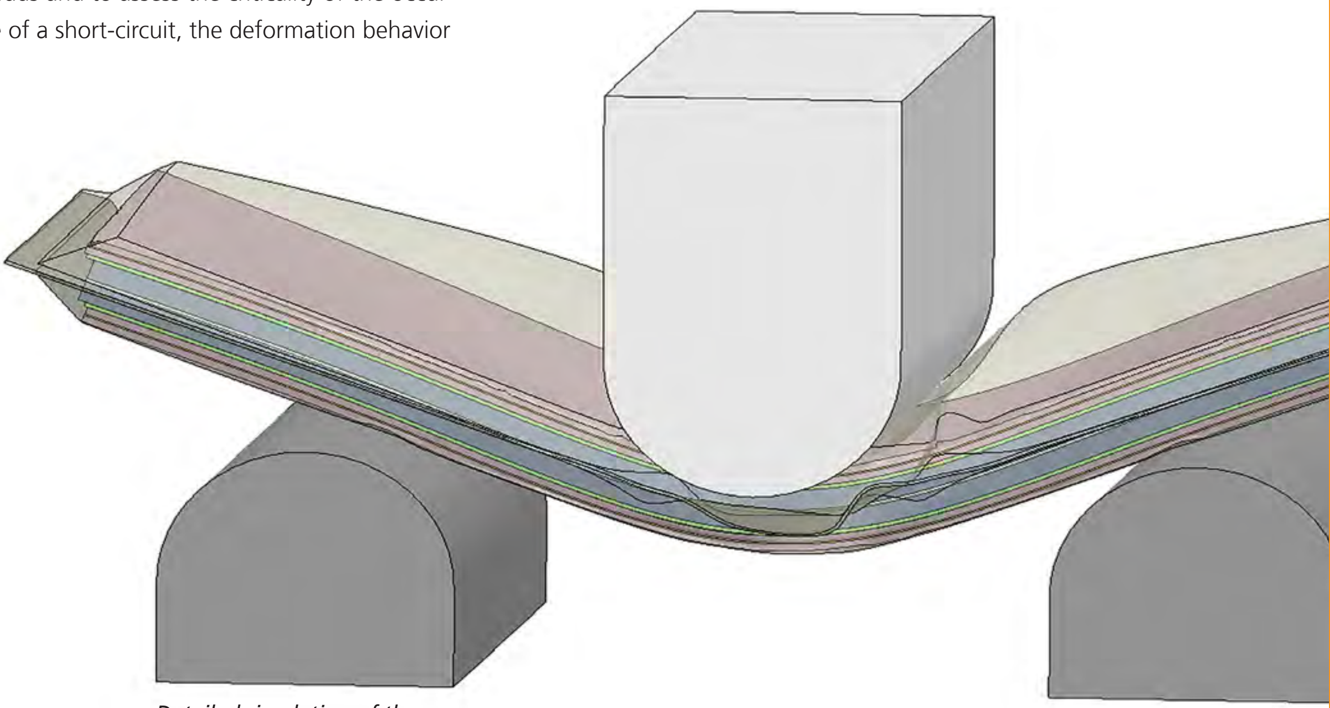
BATTMOBIL

BATTERY MODELS FOR INCREASED CRASHWORTHINESS OF ELECTRIC VEHICLES

A short-circuit caused by external forces, as they occur in crash situations, leads to an uncontrolled discharge of the battery cell. As a consequence, the battery cell heats up locally and, if it comes to the worst, this results in an explosive reaction of the cell.

Within the BATTmobil project, the deformation behavior of battery cells is investigated experimentally as well as by means of simulations. It shows that their behavior is determined essentially by their inner structure. As long as this structure remains largely intact, battery cells can withstand astonishingly large deformations. For predicting possible failure loads and to assess the criticality of the occurrence of a short-circuit, the deformation behavior is simulated. Within this context, it is decisive that the experimentally identified failure mechanisms are modeled correctly.

Thus, correspondingly validated simulation models enable a detailed insight into the cell behavior and can be applied in order to increase the crashworthiness of battery modules and vehicle structures. BATTmobil is a research project funded by the State Ministry of Baden-Württemberg for Economic Affairs, Labour and Housing Construction. Research partners within the project are Fraunhofer EMI and Fraunhofer IWM.



Detailed simulation of the deformation of lithium-ion battery cells for the examination of short-circuit behavior.

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The inner structure of the dummy. The flexible hip allows the seated posture of a wheelchair user. Loading cases regarding this VRU type are to be investigated at EMI.

MORE ROAD SAFETY FOR EVERYONE – RESEARCH WITH BIOFIDELIC DUMMIES

The protection of vulnerable road users (VRU) is a critical aspect of road safety. Consumer protection organizations have already established guidelines for the sake of VRU protection, which govern the development of new vehicles and, up to now, mainly concentrate on pedestrians and cyclists.

Research at EMI wants to investigate the protection of further VRU groups in detail such as wheelchair users or electric-scooter riders, as they considerably differ from other VRU with regard to posture, size or velocity. Statistics show a higher mortality rate for wheelchair users in road accidents compared to pedestrians.

For future research on these loading cases, biofidelic dummies will be used at EMI. Based on first activities by the engineering office Priester & Weide in 2013, such pedestrian dummies were continuously advanced by the HTW Dresden and crashtest-service.com GmbH to enhance similarity to real humans with regard to injury replication, anatomy and kinematics. For example, the bone substitute of epoxy resin aluminum powder reveals similar fracture properties as the biological role model. To understand how factures of the bone substitute occur in various loading cases, the method of time-resolved and highly dynamic X-ray technology devised at EMI will be used. The comparison with simulation data from finite-element human models is supposed to create new insights for the benefit of VRU protection.

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The optimal utilization of results from real-world crash tests for the validation and optimization of numerical crash simulations requires the integration of experimental and virtual data sets.
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"GREY-BOX-PROCESSING"

DATA PROCESSING AND ANALYSIS AT THE INTERFACE BETWEEN EXPERIMENT AND SIMULATION

The continuously increasing requirements on future vehicle systems regarding safety, costs, development times and the environmental impact lead to growing challenges within the automotive development process. To overcome these challenges, the continuation of the digitalization and virtualization of the development process is of vital importance. A reliable virtual vehicle development calls for simulation methods and models, which are optimized and validated based on the results of few real-world experiments.

To allow for a reduction of the amount of time- and cost-intensive crash tests, the detection of the greatest possible amount of information about the experimental behavior as well as the optimal utilization of this information is necessary. For this reason, along with novel measurement systems, methods for data processing and analysis at the interface between experiment and simulation are developed at Fraunhofer EMI. These new methods allow for the transfer of complexly structured experimental data sets into the simulation environment in the shape of a virtual solution corridor. The resulting integration of virtual and experimental data sets allows for the identification and assessment of deviations between experiment and simulation as well as for the determination of improvement measures derived from physically based characteristic values.

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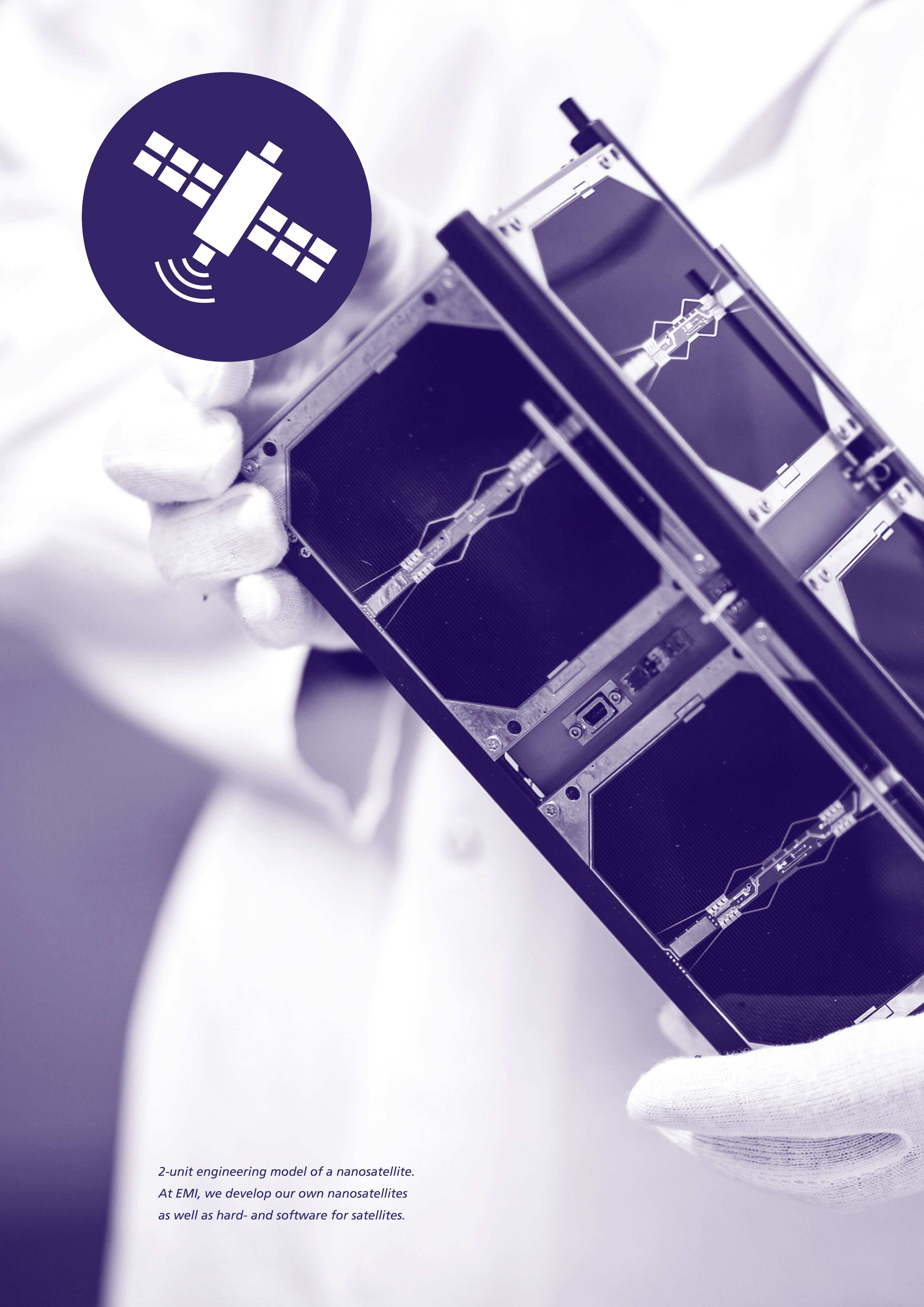
BUSINESS UNIT SPACE



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

A novel optical 3D measuring method developed at EMI allows measuring the dynamic evolution of a complete hypervelocity impact fragment cloud in unprecedented quality for the first time. This method has already been successfully used in the ESA project MIRAD and in other research projects.

The engineering qualification model of ERNST, our nanosatellite demonstrator, has been completely integrated in 2019 and was space qualified during several campaigns. On this occasion, we also put a new thermal vacuum chamber and a shaker table into operation.

The use of satellite data, i.e., the downstream, is increasingly attracting attention in the business unit Space. ConstellR, Fraunhofer EMI's first spin-off, will focus on downstream applications after starting business in the course of 2020. ConstellR will offer high-precision and continuous temperature measurements of our planet employing a constellation of CubeSats.

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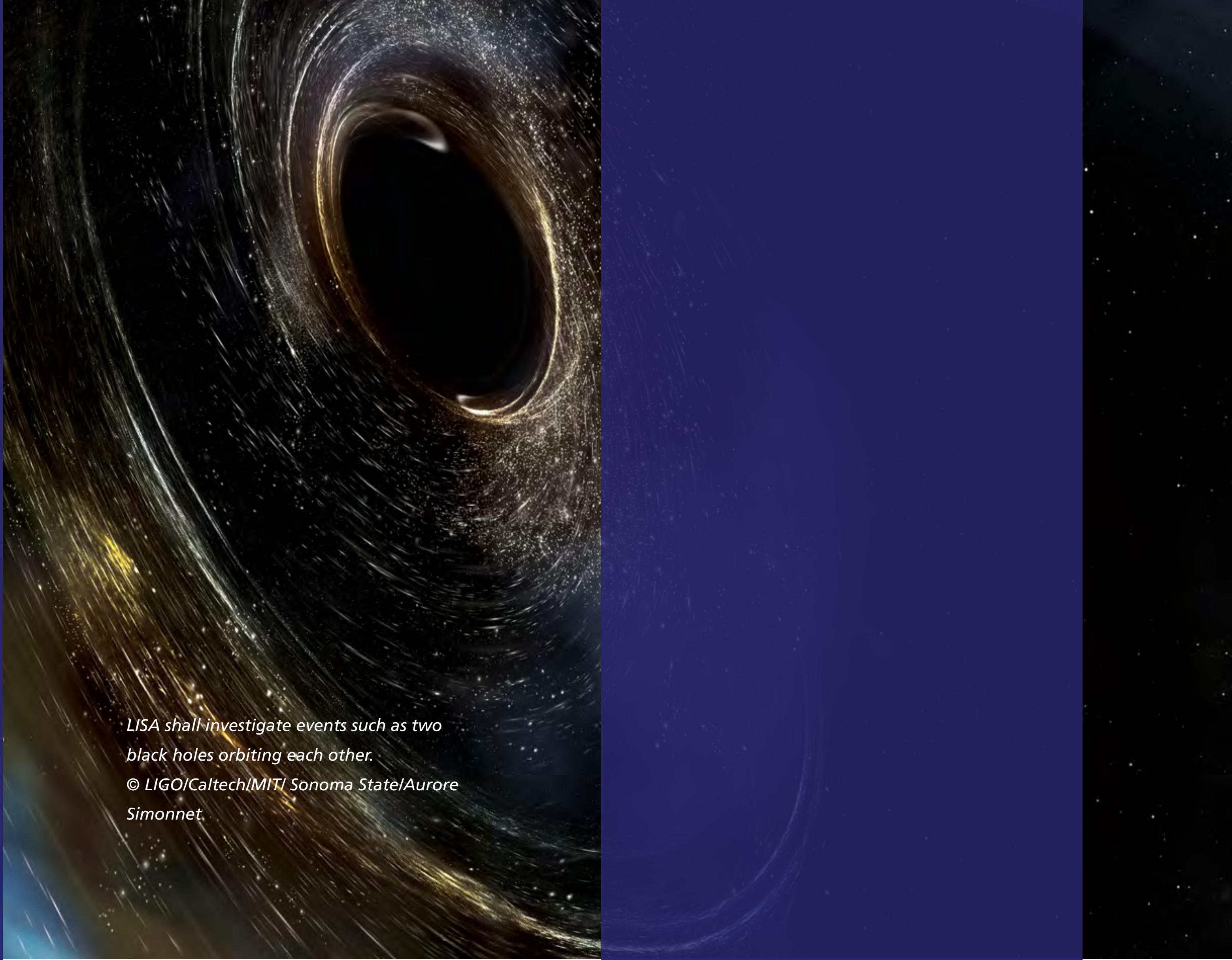

LISA shall investigate events such as two black holes orbiting each other.
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Hypervelocity impacts on spacecraft surfaces cause fragments to be ejected. The fragment tracking method developed at Fraunhofer EMI allows detailed measurements of the properties of these fragments for the first time. The model developed shall be used to predict the influence of the space particle environment on the orbit and attitude of satellites.

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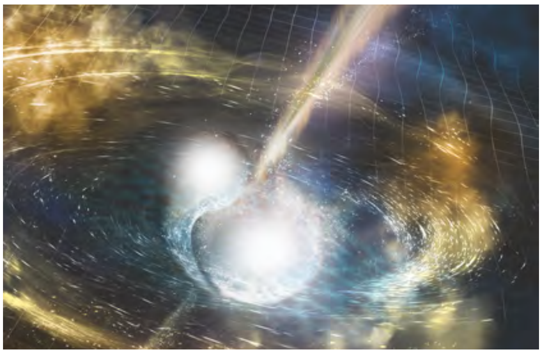

LISA shall investigate events such as the collision of two neutron stars.
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SMALL IMPACTS WITH MAJOR IMPACT

HOW MICROMETEOROIDS CAN DISTURB SENSITIVE SATELLITE PAYLOADS

Hypervelocity impacts do not only create craters: The excavated matter is ejected from the crater as fragments (ejecta) at high velocities. During geological impact events, some of the ejecta escapes into space, while other parts accumulate around the crater. When particles (space debris or micrometeoroids) impact spacecraft, the same processes take place: The momentum the fragments carry away causes an additional disturbance of the satellite's attitude; the deflection is stronger than as if the impactor had merely been "swallowed". Until now, only little has been known about the properties of these fragments, specifically, their velocities.

ESA's LISA mission (Laser Interferometer Space Antenna), which is planned for 2034, shall measure gravitational waves that, e.g., result from the collision of black holes. The three satellites are planned to permanently maintain laser connections over a distance of several million kilometers. A particle impact deflecting one of the satellites can interrupt the laser connection. Such interruptions pose a risk to the mission.

During the MIRAD study (Micro-particle Impact Related Attitude Disturbances), impact tests were carried out on spacecraft representative CFRP samples. With the fragment tracking method developed at EMI within the past years, the properties of the ejected fragments can be measured in detail for the first time. Specifically, the combined measurement of mass, velocity and trajectory of single fragments is unique and has never been conducted with such precision before.

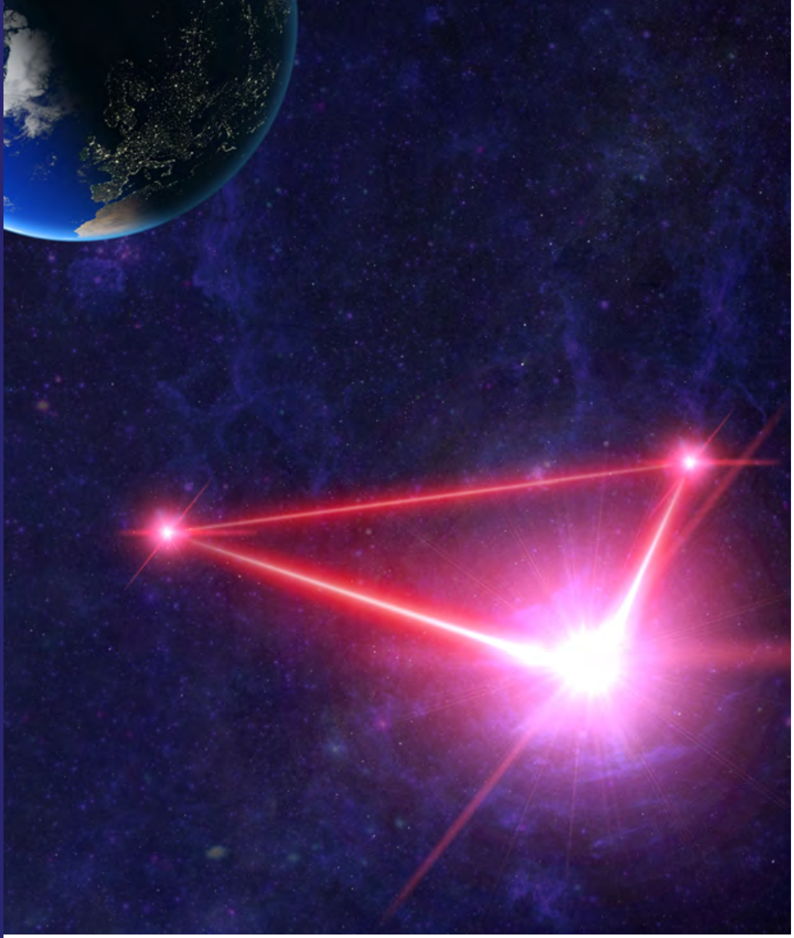

Illustration of the LISA constellation.
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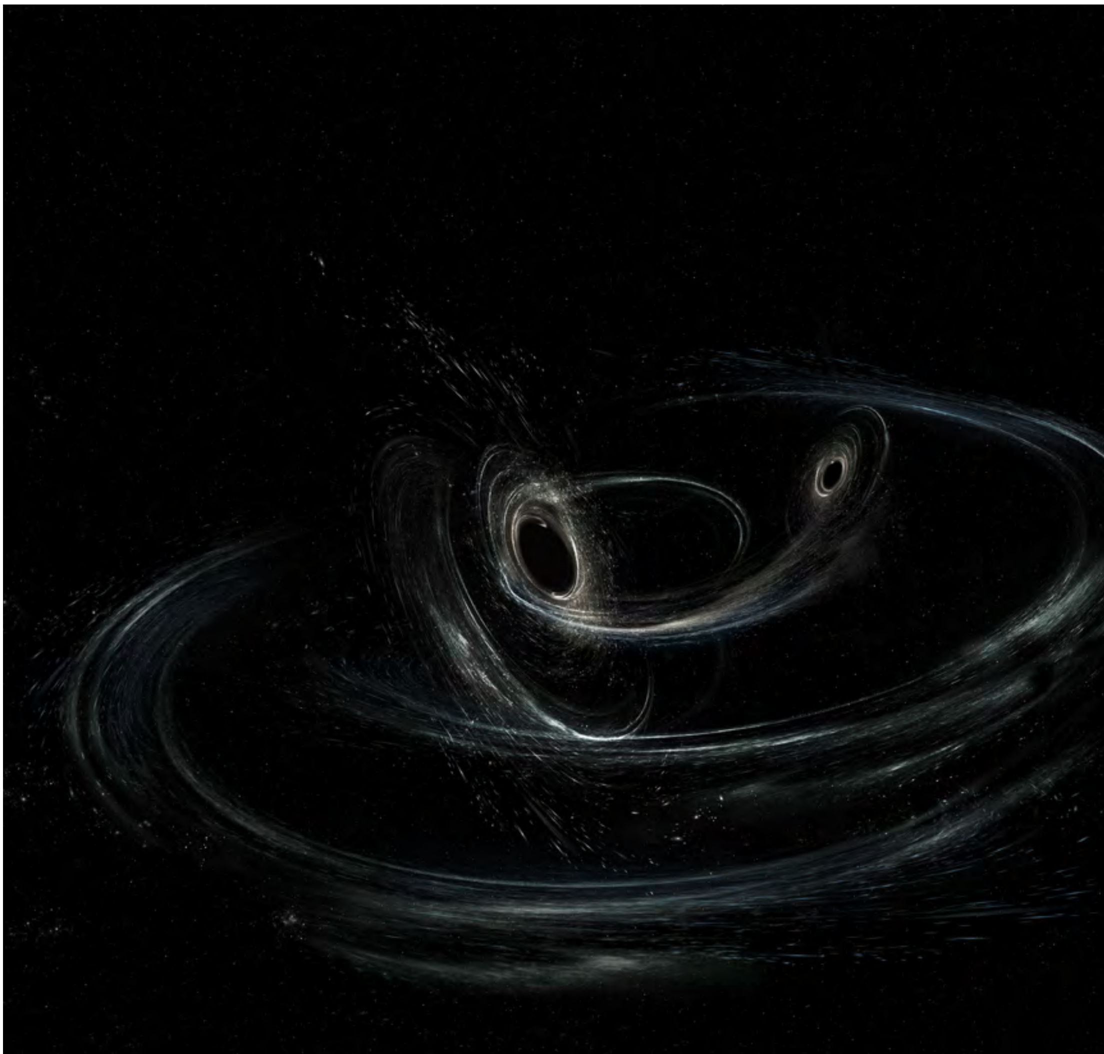
The model developed at Fraunhofer EMI from this data can predict the measured properties of the fragments and the ejected material. Using this model, the influence of the space particle environment on orbit and attitude of spacecraft can be predicted, which is especially important for spacecraft with highly sensitive payloads. Currently, it is being evaluated whether the model can be transferred to geological materials, and, consequently, also to the description of planetary impact events.



Two black holes orbiting each other (illustration).
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Satellite image of Hamburg, false color representation based on visible and near infrared spectrum images.
© European Union, contains modified Copernicus Sentinel data [2019], processed from Sentinel Hub

FLEXIBLY RECONFIGURABLE IMAGE PROCESSING ONBOARD SATELLITES

In space-based Earth observation, high-resolution sensors generate immense amounts of data. Onboard data processing enables providing this information to the user with shorter latency periods, even up to real-time capable systems. The EMI data processing unit (DPU) features the latest generation of FPGA-based processors and allows high-performance image processing onboard small satellites. The DPU software was developed aiming at the highest possible flexibility. It can be configured in a graphical user interface. The customized configuration can be tested in a simulation environment and subsequently be transferred to orbit for execution. This flexibility allows shorter development times for future Earth observation satellites. With the EMI DPU, new applications can now even be realized after the launch of a satellite. This approach fits in neatly with the New Space business models. Besides different microsatellite missions of our customers, the EMI DPU will also be employed in EMI's ERNST nanosatellite. The launch of ERNST is scheduled for 2022.

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A TREASURE FOR SCIENCE

INVESTIGATION OF THE ISS PROTECTION SHIELD

The Columbus module of the International Space Station (ISS) has been orbiting Earth since 2008. Natural micrometeoroids and anthropogenic space debris are impacting the module ever since. Columbus is well protected against this threat, because the meteoroid and debris protection system (MPDS) has been developed and tested at EMI. Due to its large surface area and its long stay in orbit, many small impact craters accumulated – which is a treasure for science! The models to predict such impacts rely on data: in-situ impact sensor measurements or material brought back to Earth. The most recent large data set of this kind was obtained from the Hubble space telescope solar arrays, which were replaced in 2002 for the second time and subsequently analyzed on ground.

In September 2018, a team of DLR (German Aerospace Center), Universität Oldenburg, TU Braunschweig and Fraunhofer EMI could convince NASA and ESA to conduct a video survey of the outer surface of the Columbus module with the ISS robotic arm. Using these data, several thousands of craters were identified and analyzed using an automated process developed at EMI. The smallest visible craters have a diameter of less than half a millimeter, the largest ones are about eight millimeters in size. The newly obtained data allow to better prepare future missions against such impacts.

s.fhg.de/columbus-module

The ISS robotic arm scans the outer surface of the Columbus module. On the entire resulting video data set, several thousands of craters are visible.
© NASA/ESA

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NEW EQUIPMENT AND SERVICES FOR SPACE QUALIFICATION

In the space sector, Fraunhofer EMI stands for comprehensive and high-quality experimental and numerical simulations of hypervelocity impact processes such as the ones occurring during collisions of space debris with spacecraft or of asteroids and planetary surfaces. As part of our activities regarding small satellites, we have expanded our test spectrum for space qualification for components and CubeSats.

We simulate the structural dynamic loads of a rocket launch with an electrodynamic shaker for payloads of up to 25 kilograms. Shock loads, which, for instance, result from the pyrotechnical separation of rocket stages, are simulated using a pneumatic actuated resonance plate. A thermal vacuum chamber is used for simulating the thermal radiation environment in orbit. The vacuum chamber will be expanded by a sun simulation, which has been put to use outside the chamber for testing of the ERNST solar generator. Furthermore, we are installing a cleanroom area in the test lab.

Our new competences in space qualification are available to external customers as testing services.

Thermal vacuum chamber with 12U CubeSat ERNST.

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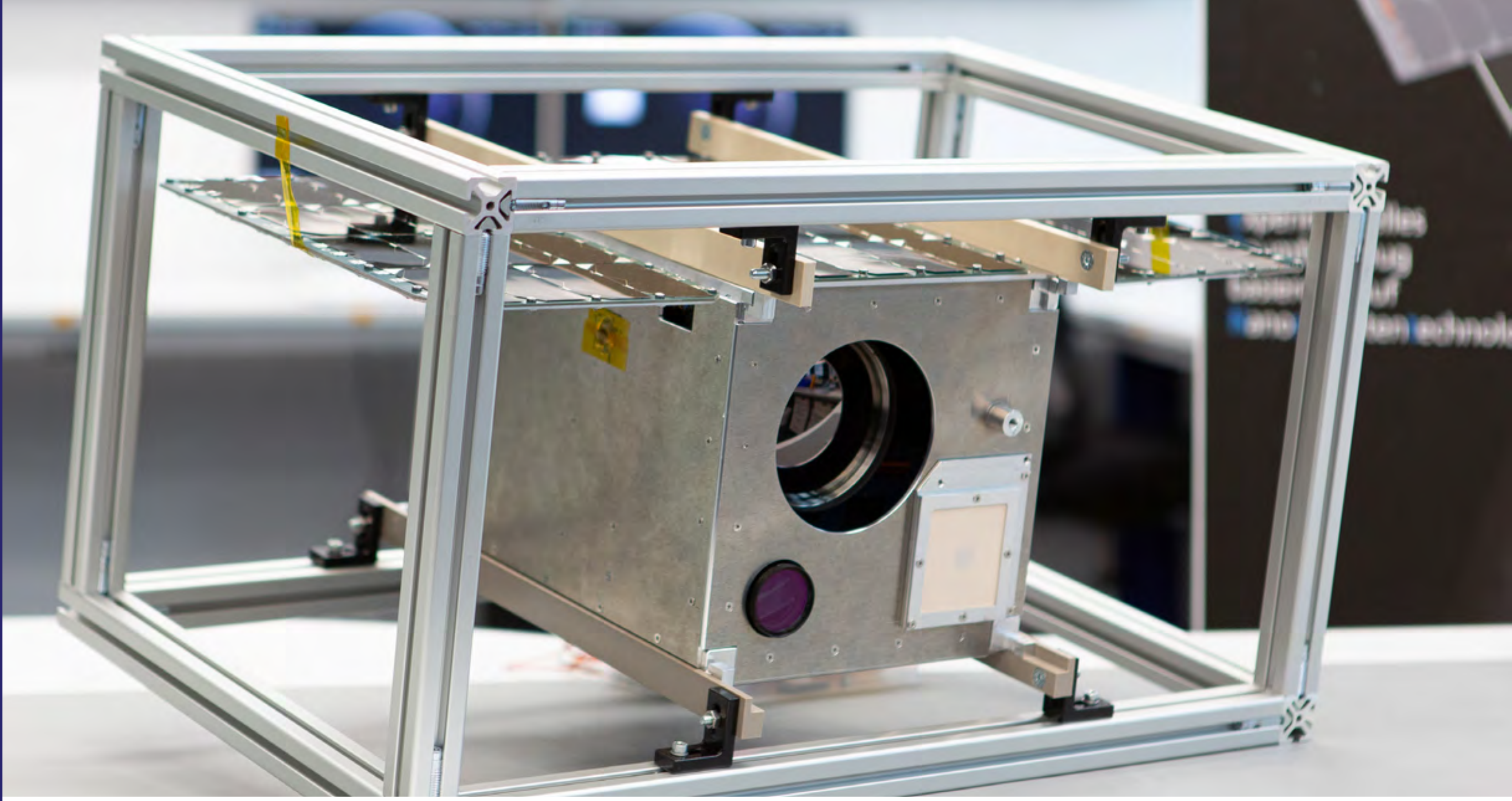

ERNST engineering qualification model (EQM) in the mounting platform.

SPACE QUALIFICATION OF THE ERNST NANOSATELLITE

Fraunhofer EMI is currently developing the first Fraunhofer satellite ERNST. ERNST is a 12U nanosatellite that will demonstrate the potential and agility of this satellite class for the German Federal Armed Forces with a kryo-cooled infrared payload. In 2019, we completed the integration of the ERNST engineering qualification model (EQM). The EQM comprises all components and functionalities of the future spacecraft model. However, the expensive, high-quality space components are not employed for all subsystems. We are running the ERNST EQM in simulated non-stop operation for the verification of the system's functionality, with the satellite bus and the payloads performing test procedures. The satellite is powered by a solar generator simulator, which provides the typical power output of solar cells depending on the simulated orbit position. We test the robustness of the satellite against the special environmental loads of a space mission with vibrational and thermal vacuum tests. In 2020, additional tests are planned at Fraunhofer INT for measuring the antennas' transmission capacity and the electromagnetic compatibility on the system level.

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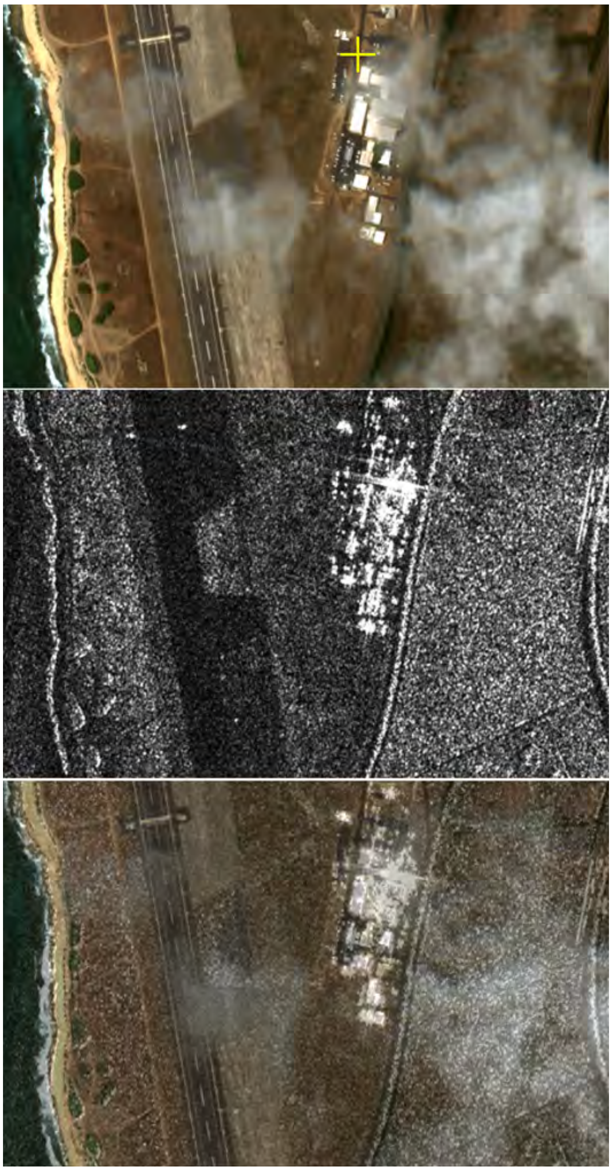
MILITARY UTILITY OF SMALL SATELLITES



SkySat and RADARSAT-2 image details that show an area of the Pacific Missile Range Facility runway.

In the Micro Satellite Military Utility Project Agreement (MSMU PA) project, which is performed under the umbrella of the Responsive Space Capability Memorandum of Understanding (RSC MoU), Fraunhofer EMI investigates the military utility of small satellites for the German Federal Armed Forces in cooperation with nine partner countries. The benefit of satellites is demonstrated by means of the data that the group obtains as an independent observer during military exercises, e.g., the RIMPAC (Rim of the Pacific) 2018. A large number of small satellites from the partners are used for collecting the data. In a so-called "hybrid space architecture", military and commercial satellite capacities are combined, allowing for a better spatial coverage, a higher persistence, a larger number of experimental sensor types, and a smaller latency of the information products generated with the satellite capacities. One of EMI's contributions is the experimental Rapid Sensor Analysis Tool (RASCAT), which is used for the analysis of sensor availability at a particular location on Earth. This tool can also be used for overflight warnings. In 2020 and 2021, further exercises are planned.

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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. © Adobe Stock

BUSINESS UNIT AVIATION

Ensuring a maximum of safety is the basis for the certification of a new airplane type. In addition to the proper functioning of the used components during operation, it has to be ensured that external influences do not lead to the crash of the aircraft. Besides the widely known bird impact, other external hazards exist, such as lightning strike or a possible collision with drones. These topics are investigated at EMI and are briefly outlined in the following articles.

In addition to safety, efficiency (fuel consumption per passenger kilometer) is decisive for the success of a new aircraft type. Additive manufacturing of metals opens up new possibilities to the industry regarding the design of load-bearing structures, allowing weight reduction and increased efficiency. At EMI, this freedom of design is explored and demonstrated by the example of a highly loaded cargo door fitting.

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Dangerous approach of a drone during a helicopter operation in urban airspace.
© Drone: Adobe Stock
© Helicopter: MEV Verlag

The growing number of drones increases the risk of collisions in airspace. How high is the risk of such a collision? At Fraunhofer EMI, we investigate this question. A software tool will evaluate the effects of different collision scenarios.

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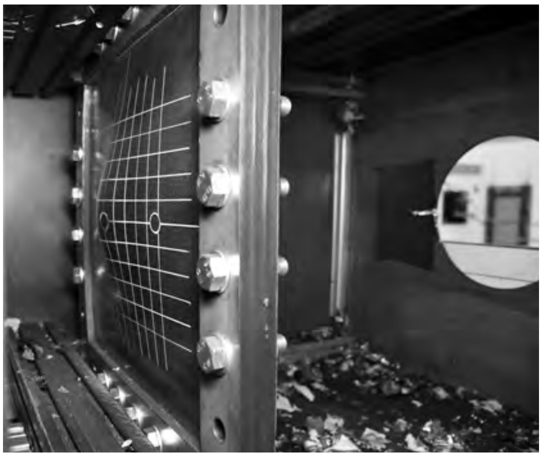

A look inside the test stand after impact of a drone battery onto an aluminum sheet.

CONTESTED AIRSPACE

DRONES POSE THREAT TO AIR TRAFFIC

The strongly increasing number of aerial drones in airspace within recent years has led to a significant increase in reported incidents, some of which have had a massive effect on air traffic. Since reliable information on the vulnerability of aircraft to collisions with drones has not been available thus far, in the worst case, the flight operation of entire airports is currently disrupted after a drone sighting. This is why at Fraunhofer EMI, we explore methods with which we can assess the criticality of collision scenarios in order to provide the basis for the definition of adequate safety measures.

We have already conducted initial experiments on our tests stands regarding the hazardous potential of drone collisions: First, the drone components with the highest damage potential were identified – due to their mass and compact design, mostly motors and batteries. These components were then characterized in both quasi-static tests as well as in impact experiments on deformable targets made from aviation-typical materials at different velocities.

In particular, helicopters are more likely to collide with a drone due to their lower flight altitude and because they often operate in urban airspace. For this reason, Fraunhofer EMI and other partners are planning a joint research project with the goal of developing models that allow analyzing the effects of collisions between drones and helicopters comprehensively.

The approach taken in the project combines experimental, numerical and analytical methods. The aim is to provide a software tool at the end of the project that allows an efficient analysis of a multitude of different collision scenarios. On the experimental side, a new test stand is planned to be developed that allows accelerating entire drones weighing several kilograms to velocities of up to 150 meters per second.

Every airplane is struck by lightning several times during its lifetime.
© panthermedia.net

THE EFFECT OF LIGHTNING STRIKE ON AIRPLANES

Every airplane is struck by lightning several times during its lifetime. Modern commercial aircraft such as the A350 or the B787 feature a high proportion of carbon-fiber reinforced composites. In contrast to the traditionally used aluminum alloys, composites are poor electrical conductors. In order to prevent lightning strike from causing local damage of composite structures, metallic meshes or foils are integrated into the structure.

Within the framework of the European research project Clean Sky 2, lightning strike experiments on composites with a copper mesh for lightning protection have been conducted at Fraunhofer EMI.

Clean Sky 2

This project is funded by the European Union

This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. CS2-AIR-GAM-2019.

The analyzed structure is impacted with an amperage current of 200 kiloamperes for a short period of time. We have observed that the copper grid was heavily damaged in the lightning strike zone. Consequently, a novel simulation approach was developed in order to be able to model the influence of the copper grid during impact loading caused by lightning. This new modeling approach contributes significantly to the understanding of the complex multi-physical issues concerning lightning strike in aviation.

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ADDITIVELY MANUFACTURED AIRCRAFT COMPONENT

ADDED VALUE THROUGH LIGHTWEIGHT DESIGN

The goal of reducing greenhouse gas emissions boosts aviation research. The newly gained freedom of design in additive manufacturing and the potentially careful use of resources by direct generation of the structural material render this new technology particularly interesting for sustainable and lightweight aircraft components. However, the safety and reliability of all components and systems are an absolute priority in aviation. For this reason, the hurdle for the implementation of new technologies in safety-relevant, highly loaded components is high.

At EMI, we thus investigate the additive manufacturing of a high-performance aluminum material and the targeted use of new construction and optimization methods for a highly loaded fitting within the framework of the European research program Clean Sky 2 Joint Undertaking. Our objective – besides lightweight design – is to generate a particularly reliable fail-safe design. As a direct reference, we use a conventional, milled component. Additive manufacturing will only be put to use if an added value is clearly evident in comparison with established technologies.

s.fhg.de/additive-manufacturing-aircraft-components

The lightweight component manufactured using laser sintering.

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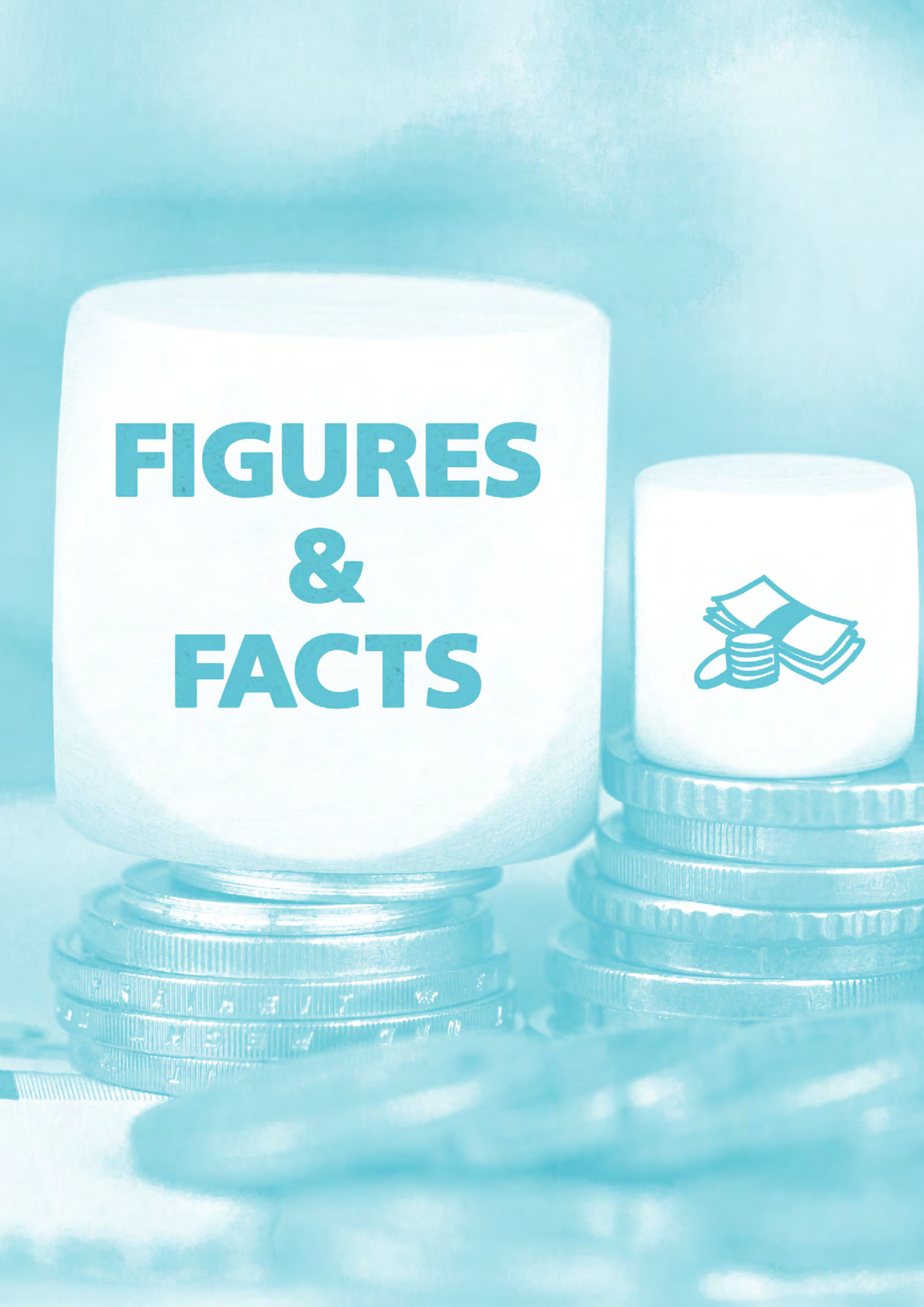
Clean Sky 2

This project is funded by the European Union

This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. CS2-AIR-GAM-2019.

ADMINISTRATION


FIGURES
&
FACTS

ADMINISTRATION

The current transformation in the context of new work forms is also reflected in the processes at Fraunhofer EMI. Thanks to the digital transformation, we are able to collaborate over broad distances and time zones. To make this sort of work style possible at Fraunhofer EMI, we have successfully established flexible working hours and mobile working in 2019. This supports our employees in maintaining a harmonious work-life balance. We promote a culture of trust and cooperation, and we have made a big step towards being a more attractive employer.

Alongside this transformation, the implementation of SAP is in progress at Fraunhofer. As a test institute, we have started to run several business processes with SAP in May 2020. We greatly benefit from the fact that we are already well positioned in regard to the modernization and automation of many processes.

In research, we need creative and original ideas. Therefore, we create agile structures and cooperative forms of organization under the slogan "New Work@Fraunhofer". The question of how we want to work in the future will continue to accompany us, and we will find new answers.

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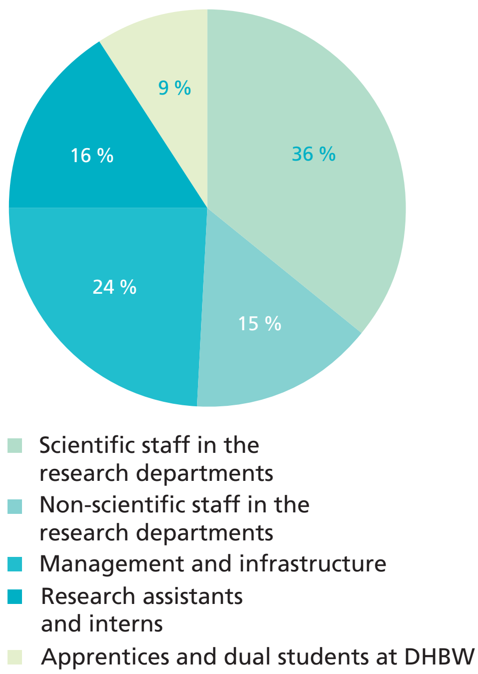
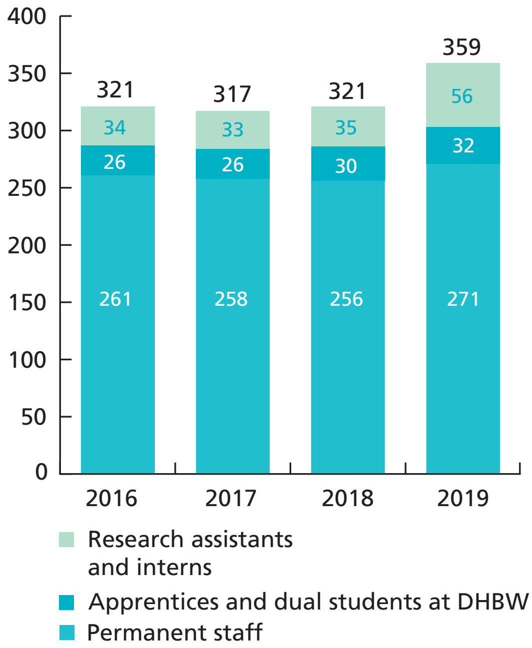
STAFF STRUCTURE

At the end of 2019, 359 people were employed at Fraunhofer EMI: 271 employees as permanent staff, 32 as apprentices and dual students, and 56 as research assistants and interns. 183 members of the permanent staff were directly involved in research and 88 worked in the fields of management and infrastructure. The proportion of female employees of the permanent staff increased to 27 percent.

20 of the 32 apprentices worked in the fields of precision mechanics, electronics, media design and administration. The remaining 12 worked at Fraunhofer EMI within the scope of their vocational training or university studies at the Baden-Württemberg Cooperative State University (DHBW).

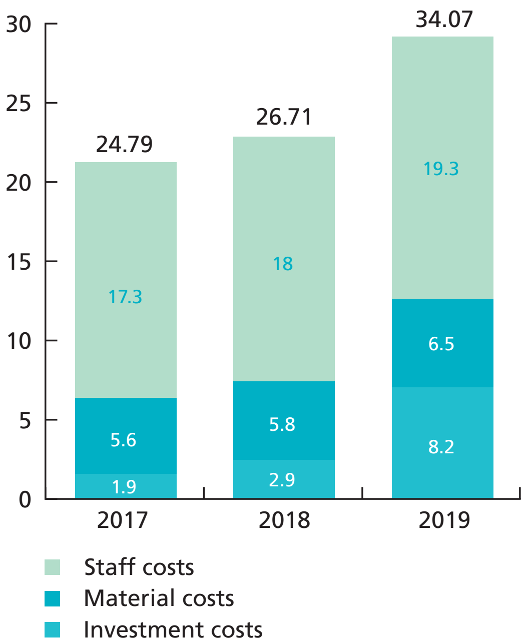




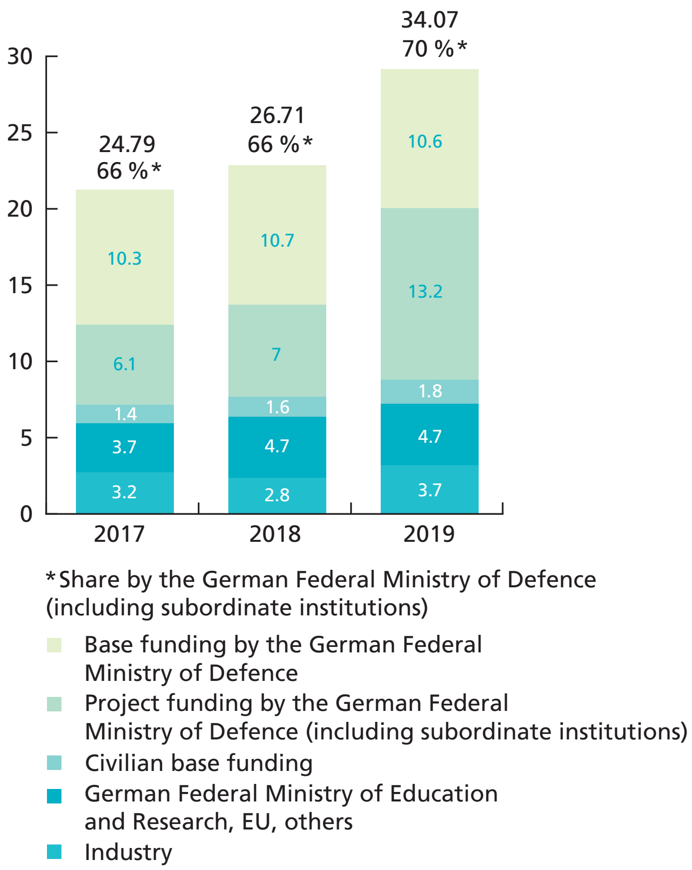
FINANCES

In comparison to last year, the overall budget of Fraunhofer EMI has increased by 27.5 percent to 34.07 million euros. 25.84 million euros are allotted to the operating budget (staff costs and material costs) and 8.2 million euros to the investment budget. At this point, the project on high-energy laser effects should be particularly mentioned as it comprises an investment volume of 5.28 million euros. 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). In 2019, the biggest share of the operating and investment budget, namely 70 percent, were financed by the German Federal Ministry of Defence. The amount of industrial revenues amounted to an excellent result of altogether 41.2 percent.

Finances of the overall budget in million euros



Funding of the overall budget in million euros



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The EMI advisory board at its meeting on July 19, 2019, in Freiburg.

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.

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Managing Director of MBDA Deutschland GmbH, Schrobenhausen

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Chief Executive Officer carhs.training GmbH, Alzenau

MinR Dipl.-Phys. Claus Mayer
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President of the Bundeswehr University Munich, Neubiberg

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

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Management THIELEN Business Coaching GmbH, Munich

The headquarters of the Fraunhofer-Gesellschaft in Munich.

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.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research institutions. The majority of our 28,000 staff are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.3 billion euros is generated through contract research. Around 70 percent of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining 30 percent 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 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.

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www.fraunhofer.de

Fraunhofer

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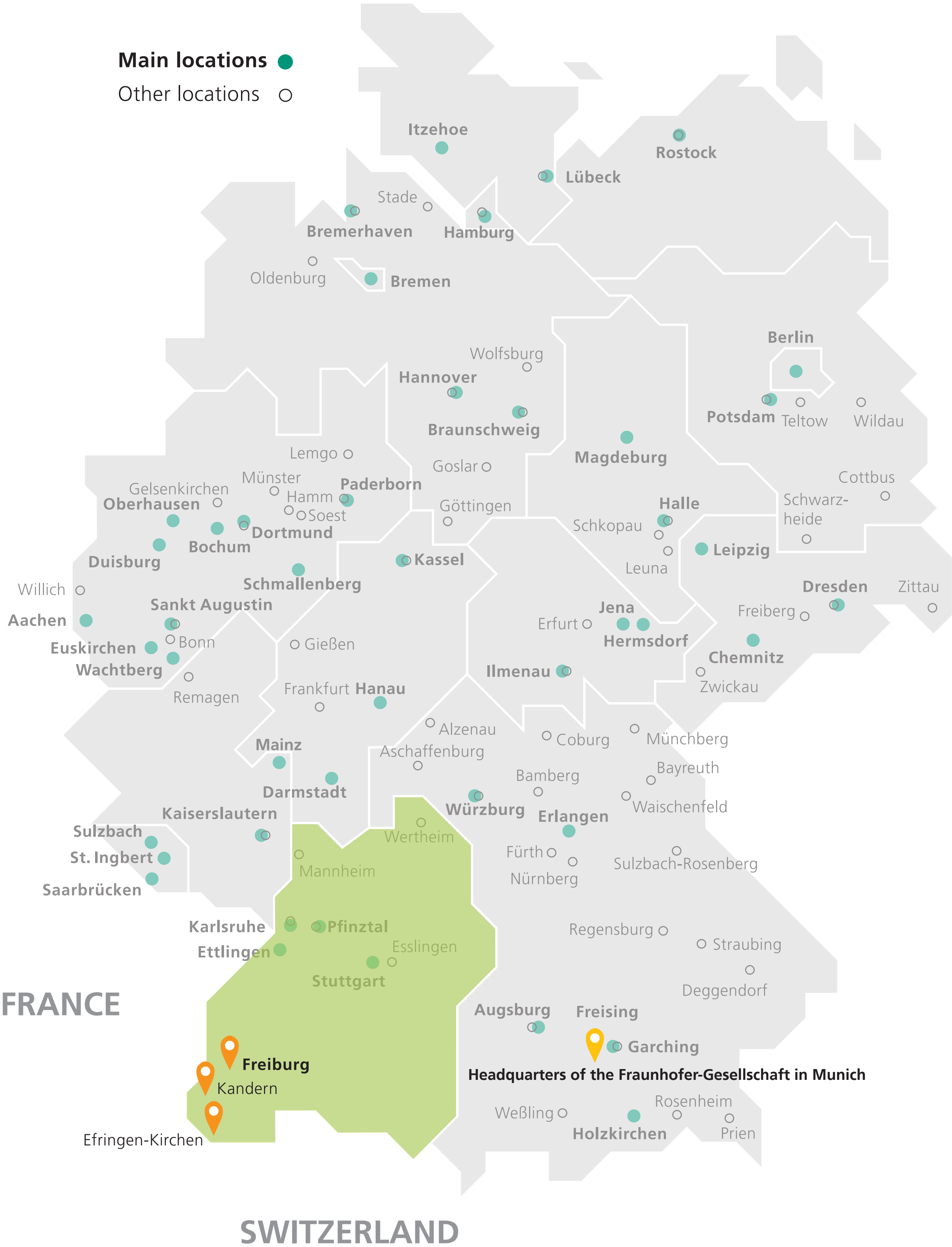
PUBLISHING NOTES


Main locations
Other locations
Itzehoe
Rostock
Lübeck
Stade
Bremerhaven
Hamburg
Oldenburg
Bremen
Berlin
Wolfsburg
Hannover
Braunschweig
Potsdam
Teltow
Wildau
Magdeburg
Lemgo
Goslar
Cottbus
Gelsenkirchen
Münster
Paderborn
Oberhausen
Hamm
Göttingen
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Schwarz-heide
Soest
Dortmund
Schkopau
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Leuna
Schmallenberg
Dresden
Zittau
Willich
Sankt Augustin
Jena
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SWITZERLAND

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EMI MOSAIC

70 YEARS OF FRAUNHOFER

A WEEKEND WITH LASER SHOW, ESCAPE GAME AND SCIENCE ON STAGE: THAT WAS HOW FRAUNHOFER EMI, IAF, IPM, ISE AND IWM CELEBRATED THE ANNIVERSARY OF FRAUNHOFER

With a big party for the public, the five Fraunhofer Institutes in Freiburg celebrated the 70-year anniversary of the Fraunhofer-Gesellschaft on Saturday, September 28, 2019. More than 5000 people came to celebrate and learn more about research at the Freiburg Institutes. Oral presentations, interactive experiments, live music, a laser show and an escape game combined into a diverse program.

More than 5000 guests were attracted by hands-on and interactive Fraunhofer research

Exhibits on the topics of "sensors and data", "materials and functions", "light and space", "mobility and sustainability" were on display. Crowd-puller was the model of the crash-test facility of Fraunhofer EMI. The stand staff explained the processes during a car crash on the original scale and showed how X-ray imaging comes into play. There was also entertainment for the junior researchers: In the "kids and science" tent, children could do water experiments, make solar cells or get their faces painted.

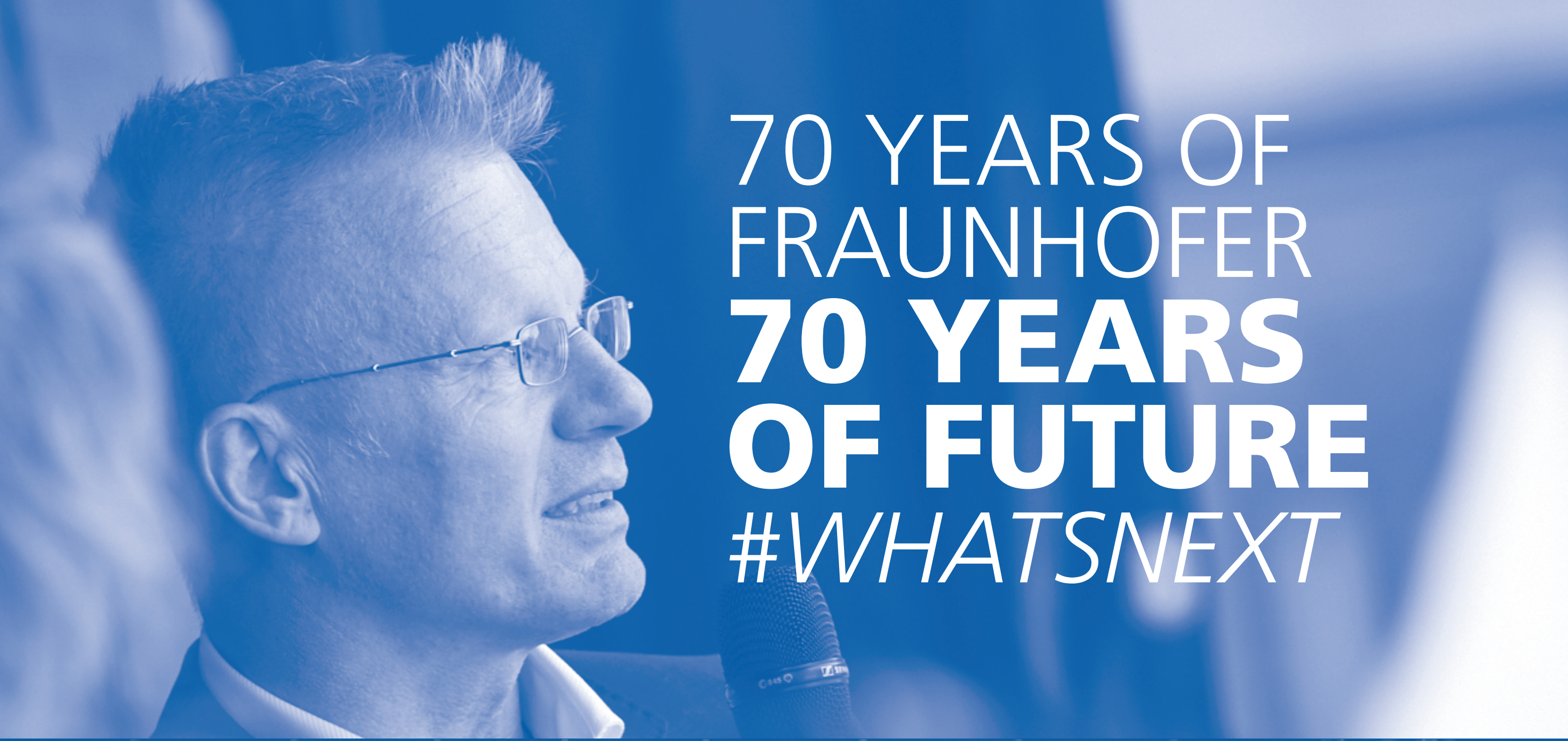
Escape game as recruiting tool

The escape game was fully booked: Eight groups tried to crack the code and to untangle the mystery. Next to it, a recruiting stand invited interested students to learn about career possibilities at Fraunhofer.

Stage show with research and music

The center of attention was the big stage featuring presentations on Fraunhofer research. Along with the five directors of the Fraunhofer Institutes, the mayor of Freiburg Martin Horn opened the event. He congratulated on the anniversary, "It is great that the Fraunhofer Institutes celebrate their event on university premises. University and Fraunhofer are crucial for the implementation of the ambitious sustainability goals in Freiburg. As one of the biggest employers in our city, the Fraunhofer-Gesellschaft brings world-class research to Freiburg." The Fraunhofer-Gesellschaft has about 2500 employees in Freiburg.

s.fhg.de/70-years-of-fraunhofer



70 YEARS OF FRAUNHOFER **70 YEARS OF FUTURE** *#WHATSNEXT*

Top: Professor Stefan Hiermaier welcomes the guests and thanks the citizens of Freiburg for their huge interest in Fraunhofer research in their city.
Middle: The directors of the five Fraunhofer Institutes in Freiburg together with mayor Martin Horn (fourth from right), Professor Gunther Neuhaus from the University of Freiburg (second from left), Joseph von Fraunhofer (sixth from right) and ARTE-presenter Anja Waltereit (center).
Bottom: Professor Frank Schäfer during his presentation on New Space.

006 – LICENCE TO RESEARCH
60 years of EMI

The motto *006 – LICENCE TO RESEARCH* and a glamorous secret-agent style set the scene for EMI's anniversary celebration on November 28, 2019, on behalf of 60 years of research On Our Applied Science's Service. More than 300 guests had accepted the invitation by EMI director Professor Stefan Hiermaier to the Europa-Park Rust conference center including notables from the Fraunhofer Executive Board, from the Fraunhofer Groups as well as from politics economy and industry.

The evening program met the dashing Bond style. The EMI Bond Stars set the pace with their Bond medley as musical opening and demonstrated what 30 EMI employees can accomplish on stage apart beyond everyday work. In a smooth transition, the eagerly anticipated premiere of the Fraunhofer EMI corporate video called the audience's attention and concluded the opening round with impressive images.

In his welcoming speech, Hiermaier looked back upon 60 years of research at EMI with evident pride and showed himself optimistic for the future. The scientific agenda featured speakers such as the recent Fraunhofer Executive Vice President Technology Marketing and Business Models Professor Ralf. B. Wehrspohn. He appeared impressed by the commitment of all employees for the anniversary celebration and by the institute's success in scientific realms.

In tightly packed three-minute pitches, competition was on for six interdisciplinary scientific teams applying for the in-house fast-track program "EMIdea". The audience was convinced by the project ideas "Shock the cell" (how shock waves can be used against tumor cells) and "GUARDIAN – saving lives purposefully!" (how private cell phones can support rescue forces in locating buried people). They will each receive prize money of 40,000 euros.

Later on, the evening blended into a party with great atmosphere and music.


unter
Druckbelastung
for Model
Calibration
Komponenten
durch
Lasershock
Fraunhofer
Schock den Tumor
40.000 €
GUARDIAN
40.000 €


EUROPA PARK
EUROPA PARK





PUBLICATIONS, EDUCATIONAL ACTIVITIES, SCIENTIFIC EXCHANGE 2019/2020

PUBLICATIONS

Publications in books, specialist journals and proceedings with peer review

Arrigoni, M.; Bedon, C.; C, K.; Urschel, F.; Haberacker, C.; Huesken, G. et al. (2019): Preliminary framework for blast risk assessment of built infrastructures. Edited by A. Stolz. European Commission; European Reference Network for Critical Infrastructure Protection (ERNCIP) thematic group (JRC Technical Report).

Ashraf, S.; Hassan Said, A.; Hartmann, R.; Assmann, M.-A.; Feliu, N.; Lenz, P.; Parak, W. J. (2019): Analyse quantitativer Partikelaufnahme von Zellen über verschiedene Messmethoden. In Angewandte Chemie 131, pp. 2–19. DOI: 10.1002/ange.201906303.

Ashraf, S.; Hassan Said, A.; Hartmann, R.; Assmann, M.-A.; Feliu, N.; Lenz, P.; Parak, W. J. (2019): Quantitative particle uptake by cells as analyzed by different methods. In Angewandte Chemie (International ed. in English) 58, pp. 2–18. DOI: 10.1002/anie.201906303.

Backe, S.; Balle, F.; Hannemann, B.; Schmeer, S.; Breuer, U. P. (2019): Fatigue properties of multifunctional metal- and carbon-fibre-reinforced polymers and intrinsic capabilities for damage monitoring. In Fatigue & Fracture of Engineering Materials & Structures 42 (1), pp. 143–151. DOI: 10.1111/ffe.12878|.

Balle, F.; Beck, T.; Eifler, D.; Fitschen, J. H.; Schuff, S.; Steidl, G. (2019): Strain analysis by a total generalized variation regularized optical flow model. In Inverse Problems in Science and Engineering 27 (4), pp. 540–564. DOI: 10.1080/17415977.2018.1475479.

Belesioti, M.; Makri, R.; Fehling-Kaschek, M.; Carli, M.; Kostopoulos, A.; Chochliouros, I. P. et al. (2019): A new security approach in telecom infrastructures: The RESISTO concept. In: Proceedings of the 15th International Conference on Distributed Computing in Sensor Systems (DCOSS). 15th International Conference on Distributed Computing in Sensor Systems (DCOSS). Santorini Island, Greece, 29.–31.5.2019: IEEE, pp. 212–218.

Czetina, A.; Hofstätter, M.; Schraml, S.; Hubner, M.; Sulzer, P.; Rothbacher, D. et al. (2019): Robot assisted analysis of suspicious objects in public spaces using CBRN sensors in combination with high-resolution LIDAR. In: 2019 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR). 2019 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR). Würzburg, 2.–4.9.2019: IEEE, pp. 256–262.

Dlugosch, M.; Fritsch, J.; Hiermaier, S.; Lukaszciewicz, D. (2019): Efficiency-driven model simplifications in crash simulations of FRP-metal hybrid material systems in automotive body structures. In: Proceedings of the NAFEMS World Congress 2019. NAFEMS World Congress 2019. Québec City, Canada, 17.–20.6.2019.

Dutschke, B.; Hunzinger, M.; Sättler, A. (2019): A numerical analysis of the in-bore motion of small caliber projectiles. In V. K. Saraswat, G. S. Reddy, C. Woodley (Eds.): Proceedings of the 31st International Symposium on Ballistics. 31st International Symposium on Ballistics. Hyderabad, India, 4.–8.11.2019. Lancaster: DEStech Publications (vol. 1), pp. 1027–1039.

Fehling-Kaschek, M.; Faist, K.; Miller, N.; Finger, J.; Häring, I.; Carli, M. et al. (2019): A systematic tabular approach for risk and resilience assessment and improvement in the telecommunication industry. In M. Beer, E. Zio (Eds.): Proceedings of the 29th European Safety and Reliability Conference (ESREL 2019). 29th European Safety and Reliability Conference (ESREL 2019). Hannover, 22.–26.9.2019: Research Publishing Services, pp. 1312–1319.

Finger, J.; Fehling-Kaschek, M.; Fischer, K.; Stolz, A.; Anastassiadou, K. (2019): Road infrastructure resilience during natural and man-made disasters. In: Proceedings of the XXVIth World Road Congress. XXVIth World Road Congress. Abu Dhabi, United Arab Emirates, 6.–10.10.2019.

Fischer, K.; Hiermaier, S.; Riedel, W.; Häring, I. (2019): Statistical driven vulnerability assessment for the resilience quantification of urban areas. In: Proceedings of the 13th International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP 2019. 13th International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP 2019. Seoul, South Korea, 26.–30.5.2019, pp. 1–8.

Fischer, K.; Trometer, S. (2019): Vulnerability analysis of urban areas, assessment of disruptive events based on 3D city models to increase resilience. Verwundbarkeitsanalyse urbaner Gebiete – Bewertung von disruptiven Ereignissen und die Schnittstelle zu 3D-Stadtmodellen zur Steigerung der Resilienz. In gis.Science (4), pp. 152–160.

Ganzenmüller, G. C.; Patil, S.; Maurer, M.; Sauer, M.; Jung, M.; Hiermaier, S. (2019): A simple glassy polymer model. A practical framework for the strain-rate and temperature dependent behaviour of polycarbonate. In Journal of Dynamic Behavior of Materials 30 (20), p. 1288. DOI: 10.1007/s40870-019-00216-9.

Ganzenmüller, G. C.; Plappert, D.; Trippel, A.; Hiermaier, S. (2019): A Split-Hopkinson Tension Bar study on the dynamic strength of basalt-fibre composites. In Composites Part B: Engineering 171, pp. 310–319. DOI: 10.1016/j.compositesb.2019.04.031.

Gärtner, M.; Gulde, M.; Hergarten, S.; Ebert, M.; Kenkmann, T.; Putzar, R.; Schäfer, F. (2019): The first microsecond of a hypervelocity impact. In: Proceedings of the Large Meteorite Impacts and Planetary Evolution VI Conference (LMI VI). Large Meteorite Impacts and Planetary Evolution VI (LMI VI). Brasília, Brazil, 30.9.–3.10.2019.

Gerster, T.; Herrmann, J.; Harwick, W. (2019): Dynamische Werkstoffprüfung für mehr Sicherheit beim Lkw-Crash. In H. J. Christ (Ed.): Tagung Werkstoffprüfung 2019. Werkstoffe und Bauteile auf dem Prüfstand. Tagung Werkstoffprüfung 2019. Neu-Ulm, 3.–4.12.2019. Deutsche Gesellschaft für Materialkunde e. V. (DGM). Sankt Augustin: Inventum GmbH, pp. 225–230.

Häring, I.; Pfeiffer, M.; Vogelbacher, G.; Stottmeister, A.; Restayn, E.-M.; Ross, K.; Ramin, M. von (2019): Risk and resilience analysis of public civil buildings against shelling with explosive sources in urban contexts. In European Journal for Security Research 45 (2), pp. 1–37. DOI: 10.1007/s41125-019-00046-9.

Heider, N.; Denefeld, V.; Aurich, H. (2019): Analysis of global momentum transfer due to buried mine detonation. In V. K. Saraswat, G. S. Reddy, C. Woodley (Eds.): Proceedings of the 31st International Symposium on Ballistics. 31st International Symposium on Ballistics. Hyderabad, India, 4.–8.11.2019. Lancaster: DEStech Publications (vol. 2), pp. 2430–2433.

Heider, N.; Denefeld, V.; Aurich, H. (2019): Analysis of global momentum transfer due to buried mine detonation. In Defence Technology 15 (5), pp. 821–827. DOI: 10.1016/j.dt.2019.06.016.

Heider, N.; Denefeld, V.; Aurich, H.; Koch, M. (2019): Safety analysis of PBX filled munitions under moderate mechanical loading. In V. K. Saraswat, G. S. Reddy, C. Woodley (Eds.): Proceedings of the 31st International Symposium on Ballistics. 31st International Symposium on Ballistics. Hyderabad, India, 4.–8.11.2019. Lancaster: DEStech Publications (vol. 2), pp. 2417–2429.

Höflinger, F.; Saphala, A.; Schott, D. J.; Reindl, L. M.; Schindelhauer, C. (2019): Passive indoor-localization using echoes of ultrasound signals. In: 2019 International Conference on Advanced Information Technologies (ICAIT). 2019 International Conference on Advanced Information Technologies (ICAIT). Yangon, Myanmar, 6.–7.11.2019: IEEE, pp. 60–65.

Huschka, M.; Dlugosch, M. (2019): Konzept zur Digitalisierung der Datenverarbeitung aus werkstoffwissenschaftlicher Forschung. In H. J. Christ (Ed.): Tagung Werkstoffprüfung 2019. Werkstoffe und Bauteile auf dem Prüfstand. Tagung Werkstoffprüfung 2019. Neu-Ulm, 3.–4.12.2019. Deutsche Gesellschaft für Materialkunde e. V. (DGM). Sankt Augustin: Inventum GmbH, pp. 341–348.

Igumnov, L.; Ipatov, A.; Petrov, A.; Litvinchuk, S.; Pfaff, A.; Eremeyev, V. (2019): A comparison of boundary element method and finite element method dynamic solutions for poroelastic column. In H. Altenbach, W. Müller, B. Abali (Eds.): Higher Gradient Materials and Related Generalized Continua, vol. 120. Cham: Springer (Advanced Structural Materials, vol. 120), pp. 121–134.

Jäcklein, M.; Kappe, K.; Pfaff, A.; Bierdel, M.; Hoschke, K.; Wickert, M. et al. (2019): Dynamic compression of 3D printed metallic microstructures with in-situ X-ray imaging. In Z. Major, E. P. Klement, M.-C. Miron, V. M. Miron (Eds.): Proceedings of the 10th International Symposium on Impact Engineering (ISIE 2019). Linz: Trauner Verlag, pp. 233–241.

Jain, A. K.; Grumber, C.; Gelhausen, P.; Häring, I.; Stolz, A. (2019): A toy model study for long-term terror event time series prediction with CNN. In European Journal for Security Research 143 (11). DOI: 10.1007/s41125-019-00061-w.

Kotter, P.; Kisters, T.; Schleicher, A. (2019): Dynamic impact tests to characterize the crashworthiness of large-format lithium-ion cells. In Journal of Energy Storage 26, p. 100948. DOI: 10.1016/j.est.2019.100948.

Losch, K.; Schuff, S.; Balle, F.; Beck, T.; Redenbach, C. (2019): A stochastic microstructure model for particle reinforced aluminium matrix composites. In Journal of Microscopy 273 (2), pp. 115–126. DOI: 10.1111/jmi.12766.

Oliveira, P. R.; May, M.; Panzera, T. H.; Scarpa, F.; Hiermaier, S. (2020): Reinforced biobased adhesive for eco-friendly sandwich panels. In International Journal of Adhesion and Adhesives 98, p. 102550. DOI: 10.1016/j.ijadhadh.2020.102550.

Pearce, D., Antunes, A.; Coustenis, A.; Daly, M.; Fraeman, A.; Greshake, A.; Libourel, G. et al. (Eds.) (2019): Planetary Protection Classification of Sample Return Missions from the Martian Moons. Consensus Study Report. National Academies of Sciences, Engineering, and Medicine. Washington, D. C.: National Academies Press.

Pfaff, A.; Bierdel, M.; Hoschke, K.; Wickert, M.; Riedel, W.; Hiermaier, S. (2019): Resource analysis model and validation for selective laser melting, constituting the potential of lightweight design for material efficiency. In Sustainable Production and Consumption 21, pp. 182–191. DOI: 10.1016/j.spc.2019.12.004.

Putzar, R.; Zheng, S.; An, J.; Hovland, S. (2019): A stuffed Whipple shield for the Chinese space station. In International Journal of Impact Engineering 132, p. 103304. DOI: 10.1016/j.ijimpeng.2019.05.018.

Sauer, C.; Heine, A.; Bagusat, F.; Riedel, W. (2019): Ballistic impact on fired clay masonry bricks. In International Journal of Protective Structures, 204141961989370. DOI: 10.1177/2041419619893708.

Schäfer, F.; Kenkmann, T.; Hiermaier, S. (2019): Obituary for a brilliant materials scientist-on Klaus Thoma's death. In Meteoritics & Planetary Science 54 (1), pp. 254–255. DOI: 10.1111/maps.13196.

Schneider, J.; Ramin, M. von; Stottmeister, A.; Stolz, A. (2019): Masonry failure and debris throw characteristics under dynamic blast loads. In Chemical Engineering Transactions 77, pp. 217–222. DOI: 10.3303/CET1977037.

Schneider, J. M.; Ramin, M. von; Stottmeister, A.; Stolz, A. (2019): Characterization of debris throw from masonry wall sections subjected to blast. In Engineering Structures, p. 109729. DOI: 10.1016/j.engstruct.2019.109729.

Soot, T.; Dlugosch, M.; Fritsch, J. (2019): Processing of numerical simulations and experimental X-ray car crash data for deviation analyses and model quality assessment. In: Proceedings of the NAFEMS World Congress 2019. NAFEMS World Congress 2019. Québec City, Canada, 17.–20.6.2019.

Staab, F.; Balle, F. (2019): Ultrasonic torsion welding of ageing-resistant Al/CFRP joints: Properties, microstructure and joint formation. In Ultrasonics 93, pp. 139–144. DOI: 10.1016/j.ultras.2018.11.006.

Straßburger, E.; Patel, P. (2019): Ballistic impact damage and fragmentation in different types of glass and glass ceramic. In V. K. Saraswat, G. S. Reddy, C. Woodley (Eds.): Proceedings of the 31st International Symposium on Ballistics. 31st International Symposium on Ballistics. Hyderabad, India, 4.–8.11.2019. Lancaster: DEStech Publications (vol. 2), pp. 1639–1650.

Tu, H.; Fung, T. C.; Tan, K. H.; Riedel, W. (2019): An analytical model to predict the compressive damage of concrete plates under contact detonation. In International Journal of Impact Engineering 134, p. 103344. DOI: 10.1016/j.ijimpeng.2019.103344.

Vivek, P.; Sitharam, T. G. (2020): Granular Materials Under Shock and Blast Loading. Singapore: Springer (Springer transactions in civil and environmental engineering).

Vogelbacher, G.; Finger, J.; Häring, I. (2019): Towards visibility and audibility algorithms for assessing perceived safety and security in public areas based on digital 3D city models. In M. Beer, E. Zio (Eds.): Proceedings of the 29th European Safety and Reliability Conference (ESREL 2019). 29th European Safety and Reliability Conference (ESREL 2019). Hannover, 22.–26.9.2019: Research Publishing Services, pp. 1986–1993.

Watson, E.; Kunert, N.; Putzar, R.; Maas, H.-G.; Hiermaier, S. (2020): Four-view split-image fragment tracking in hypervelocity impact experiments. In International Journal of Impact Engineering 135, p. 103405. DOI: 10.1016/j.ijimpeng.2019.103405.

PUBLICATIONS

Publications in books, specialist journals and proceedings without peer review

Aurich, H.; Heider, N.; Denefeld, V.; Koch, M. (2019): Experimental characterization of reaction thresholds for polymer bonded high explosives under moderate mechanical loading. In: Proceedings of the 50th International Annual Conference ICT. 50th International Annual Conference ICT. Karlsruhe, 25.–28.6.2019.

Backe, S.; Beck, T.; Balle, F. (2019): Short-time approach for fatigue life estimation of multifunctional composites. In: Proceedings of the 22nd International Conference on Composite Materials (ICCM22). 22nd International Conference on Composite Materials (ICCM22). Melbourne, Australia, 11.–16.8.2019.

Baker, E.; Ramin, M. von; van der Voort, M. (2019): Focus area 2B: fragmentation. In E. Baker, M. von Ramin, M. van der Voort (Eds.): Improved Explosives and Munitions Risk Management Workshop: Focus Area 2B: Fragmentation. L-234. NATO MSIAC. Improvised Explosives and Munitions Risk Management. Granada, Spain, 10.–14.9.2019.

Bierdel, M.; Pfaff, A.; Kilchert, S.; Köhler, A. R.; Baron, Y.; Bulach, W. (2019): Nachhaltigkeit der Additiven Fertigung. Vergleichende ökonomische und ökologische Bewertung von additiven und konventionellen Fertigungstechnologien. In wt Werkstattstechnik online 109 (6), pp. 427–429.

Butenweg, C.; Hoffmeister, B.; Holtschoppen, B.; Klinkel, S.; Rosin, J.; Schmitt, T. (Eds.) (2020): Seismic design of industrial facilities 2020. Proceedings of the 2nd International Conference on Seismic Design of Industrial Facilities (SeDIF-Conference). 2nd International Conference on Seismic Design of Industrial Facilities (SeDIF-Conference). Aachen, 4.–5.3.2020. RWTH Aachen. 1. Edition. Aachen: Apprimus Verlag.

Butenweg, C.; Kubalski, T.; Rosin, J. (2019): Improved seismic design concepts for masonry buildings in Germany. Stuttgart: Fraunhofer Verlag.

Drolshagen, G.; Klaß, M.; Putzar, R.; Koschny, D.; Poppe, B. (2019): Impact fluxes on the Columbus module of the ISS: survey and predictions. In: Proceedings of the 38th International Meteor Conference. 38th International Meteor Conference. Bollmannsruh, 3.–6.10.2019.

Fischer, K.; Trometer, S. (2019): Verwundbarkeitsanalyse von städtischen Gebieten infolge von Erdbebenereignissen. In: 16. D-A-CH-Tagung Erdbebeningenieurwesen und Baudynamik. Innsbruck, 26.–27.9.2019, pp. 97–104.

Heine, A.; Früh, P.; Riedel, W. (2019): Steps toward characterizing and modeling UHA steels for armor design purposes. In: Proceedings of the Light Weight Armour for Defense & Security Conference (LWAG) 2019. Light Weight Armour for Defense & Security Conference (LWAG) 2019. Roubaix, France, 8.–9.10.2019.

Horch, C.; Schimmerohn, M.; Bierdel, M.; Busch, S.; Gulde, M.; Höffgen, S. et al. (2019): The ERNST mission: MWIR imaging and advanced technology demonstration in a 12 U nanosatellite. In: Proceedings of the 70th International Astronautical Congress. 70th International Astronautical Congress. Washington, D. C., USA, 21.–25.10.2019.

Klomfass, A.; Heilig, G. (2019): A universal co-simulation interface for blast-loading of structures. In: Proceedings of the 18th International Symposium for the Interaction of Munitions with Structures (ISIEMS). 18th International Symposium for the Interaction of Munitions with Structures (ISIEMS). Panama City Beach, FL, USA, 21.10.–25.10.2019.

Putzar, R.; Watson, E.; Schimmerohn, M.; Kärräng, P.; Millinger, M. (2019): How hypervelocity impacts can affect the LISA mission – The MIRAD study. In: Proceedings of the 70th International Astronautical Congress. 70th International Astronautical Congress. Washington, D. C., USA, 21.–25.10.2019.

Ramin, M. von (2018): Glas, Stahl, Mauerwerk: Praxistaugliche Sicherheitskonzepte für Fassaden. In N. Gebbeken, T. Lindner, S. Hiermaier (Eds.): Tagungsband 8. Workshop Bauprotect. Schutz der baulichen Infrastruktur vor außergewöhnlichen Einwirkungen. 8. Workshop Bauprotect. Neubiberg, 13.–14.11.2018. Stuttgart: Fraunhofer Verlag, pp. 59–72.

Ramin, M. von (2020): Methodology for classifying building damage in dynamically loaded structures. In C. Butenweg, B. Hoffmeister, B. Holtschoppen, S. Klinkel, J. Rosin, T. Schmitt (Eds.): Seismic design of industrial facilities 2020. Proceedings of the 2nd International Conference on Seismic Design of Industrial Facilities (SeDIF-Conference). 2nd International Conference on Seismic Design of Industrial Facilities (SeDIF-Conference). Aachen, 4.–5.3.2020. RWTH Aachen. 1. Edition. Aachen: Apprimus Verlag, pp. 419–432.

Ramin, M. von; Pfeiffer, M.; Schneider, N.; Schmitt, D. (2019): RAFOB-RAM, a risk analysis software tool for forward operating bases. In: Proceedings of the 18th International Symposium for the Interaction of Munitions with Structures (ISIEMS). 18th International Symposium for the Interaction of Munitions with Structures (ISIEMS). Panama City Beach, FL, USA, 21.10.–25.10.2019.

Sauer, C.; Heine, A.; Riedel, W.; Hartmann, N.; Harwick, W.; Kilchert, S. et al. (2019): Non-monotonous strain rate dependence of yield stress for tungsten heavy alloy. In L. Peroni, M. Scapin (Eds.): Proceedings of the 24th DYMAT Technical Meeting. Temperature Dependence of Material Behaviour at High Strain-Rate. 24th DYMAT Technical Meeting. Stresa, Italy, 9.–11.9.2019. Torino: Politecnico di Torino.

Sauer, M.; Durr, N.; Lück, M.; Nixon, M. E.; Koundinyan, S.; Diggs, A. et al. (2019): Comparison of software codes and discretization schemes for mesoscale simulation of dynamic mechanical loading of PBX. In: Proceedings of the 50th International Annual Conference ICT. 50th International Annual Conference ICT. Karlsruhe, 25.–28.6.2019.

Schimmerohn, M.; Matura, P.; Watson, E.; Durr, N.; Altes, A.; Cardone, T. et al. (2019): Numerical investigation on the standard catastrophic breakup criteria. In: Proceedings of the 70th International Astronautical Congress. 70th International Astronautical Congress. Washington, D. C., USA, 21.–25.10.2019.

Steinhauser, M. O. (2019): Particle-based modeling of hypervelocity impact and fragmentation in materials. In: Proceedings of the First International Orbital Debris Conference (IOC). First International Orbital Debris Conference (IOC). Sugar Land, TX, USA, 9.–12.12.2019.

Trippel, A.; Harwick, W. (2019): High-strength alloyed steel: modelling dynamic and multiaxial loading conditions. In: Proceedings of the 12th European LS-DYNA Conference 2019. 12th European LS-DYNA Conference 2019. Koblenz, 14.–16.5.2019.

Weibel, D.; Beck, T.; Balle, F. (2019): Fatigue damage mechanisms of CF-PPS from high to very high cycles. In: Proceedings of the 22nd International Conference on Composite Materials (ICCM22). 22nd International Conference on Composite Materials (ICCM22). Melbourne, Australia, 11.–16.8.2019.

Wuttke, C.; Butenweg, C.; Rosin, J.; Kubalski, T. (2019): Verbesserte seismische Nachweiskonzepte für Mauerwerksbauten in deutschen Erdbebengebieten. In: 16. D-A-CH-Tagung Erdbebeningenieurwesen und Baudynamik. Innsbruck, 26.–27.9.2019, pp. 713–722.

SCIENTIFIC EXCHANGE, LECTURES

Lectures at congresses, symposia, colloquia, external seminars and important working conferences

Aurich, H.; Heider, N.; Denefeld, V. (2019): Material properties and ammunition safety. Prepatory Meeting for HERSHE PA, 6.6.2019.

Aurich, H.; Heider, N.; Denefeld, V. (2019): Experimental characterization of reaction thresholds for polymer bonded high explosives under moderate mechanical loading. 50th International Annual Conference ICT 2019. Fraunhofer ICT. Karlsruhe, 26.6.2019.

Aurich, H.; Sättler, A.; La Cioppa, V.; Holzwarth (2019): Untersuchungen zur Wirkung von Tandem-Hohlladungen. 3. Tagung »Effektoren für zukünftige Einsatzszenare«. WTD 91. Meppen, 13.11.2019.

Backe, S.; Beck, T.; Balle, F. (2019): Ermüdungseigenschaften und Schädigungsverhalten metallfaser- und C-faserverstärkter Kunststoffe. 22. Symposium Verbundwerkstoffe und Werkstoffverbunde. Kaiserslautern, 26.6.2019.

Backe, S.; Beck, T.; Balle, F. (2019): Short-time approach for fatigue life estimation of multifunctional composites. 22nd International Conference on Composite Materials (ICCM22). Melbourne, Australia, 11.8.2019.

Balle, F. (2019): Multifunktionale Metall-C-Faser-Kunststoff-Laminate (MCFK) leitfähig – schadenstolerant – überwachbar. Werkstofftechnisches Kolloquium. TU Chemnitz, 6.3.2019.

Balle, F.; Backe, S.; Hannemann, B.; Schmeer, S.; Breuer, U. P. (2019): Hybride Faser-Kunststoff-Laminate mit C- und Metallfaserverstärkung (MCFK): Leitfähiger, langlebiger und überwachbar. Werkstoffwoche 2019. Dresden, 18.9.2019.

Becker, M.; Balle, F. (2019): Serielles Ultraschallpunktschweißen von Aluminium/Stahl-Verbunden. 22. Symposium Verbundwerkstoffe und Werkstoffverbunde. Kaiserslautern, 26.6.2019.

Becker, M.; Balle, F. (2019): Multi-spot ultrasonic welding of Al/steel-joints for automotive applications. International Congress on Ultrasonics (ICU). Bruges, Belgium, 3.9.2019.

Becker, M.; Balle, F. (2019): Multi-spot ultrasonic welding of Al/steel-joints. 28. FMF-Kolloquium. Schluchsee, 14.10.2019.

Denefeld, V.; Aurich, H.; Heider, N. (2019): Simulation der Einbettung einer skalierten Ladung in Wasser, Vergleich mit Referenz in Sandy Gravel. IABG Lichtenau, 18.9.2019.

Denefeld, V.; Heider, N.; Aurich, H. (2019): Einflussgrößen für den Impulsübertrag durch vergrabene Ladungen. 23. Tagung »Schutz gegen IED und ballistische Bedrohung«. WTD 91. Meppen, 7.5.2019.

Denefeld, V.; Heider, N.; Aurich, H. (2019): Analysis of global momentum transfer due to buried mine detonation. 31st International Symposium on Ballistics. Hyderabad, India, 4.11.2019.

Dutschke, B. (2019): Numerical study on the launch dynamics in small caliber weapons. DEA-1060 Interior/Exterior Ballistics Workshop. Pfinztal, 2.4.2019.

Dutschke, B. (2019): A numerical analysis of the in-bore motion of small caliber projectiles. 31st International Symposium on Ballistics. Hyderabad, India, 7.11.2019.

Fehling-Kaschek, M.; Faist, K.; Miller, N.; Finger, J.; Häring, I.; Carli, M. et al. (2019): A systematic tabular approach for risk and resilience assessment and improvement in the telecommunication industry. 29th European Safety and Reliability Conference (ESREL 2019). Hannover, 25.9.2019.

Finger, J.; Fehling-Kaschek, M.; Fischer, K.; Stolz, A.; Anastassiadou, K. (2019): Road infrastructure resilience during natural and man-made disasters. XXVIth World Road Congress. Abu Dhabi, United Arab Emirates, 6.10.2019.

Fischer, K.; Hiermaier, S.; Riedel, W.; Häring, I. (2019): Statistical driven vulnerability assessment for the resilience quantification of urban areas. 13th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP). Seoul, South Korea, 26.5.2019.

Fischer, K.; Schneider, N.; Roller, C.; Stolz, A. (2019): Dynamic bearing capacity of reinforced concrete plates subjected to blast loading – Comparison between model, experiment and real events. 18th International Symposium for the Interaction of Munitions with Structures. Panama City Beach, FL, USA, 21.10.2019.

Fischer, K.; Trometer, S. (2019): Verwundbarkeitsanalyse urbaner Gebiete – 3D-Bewertung von disruptiven Ereignissen zur Steigerung der Resilienz. GIS-Runde. TU München, 14.3.2019.

Fischer, K.; Trometer, S. (2019): Verwundbarkeitsanalyse von städtischen Gebieten infolge von Erdbebenereignissen. 16. D-A-CH-Tagung Erdbebeningenieurwesen und Baudynamik. Innsbruck, Austria, 26.9.2019.

Gärtner, M.; Gulde, M.; Ebert, M.; Kenkmann, T.; Putzar, R.; Watson, E. et al. (2019): Looking into the first microsecond of a hypervelocity impact. Paneth Kolloquium. Nördlingen, 29.10.2019.

Gärtner, M.; Gulde, M.; Hergarten, S.; Ebert, M.; Putzar, R.; Schäfer, F. (2019): Looking into the first microsecond of an asteroid impact. DMG Annual Meeting. Heidelberg, 24.5.2019.

Gulde, M. (2019): Land surface temperature monitoring. Global Resilience Research Network Summit 2019 (GRRN). Video-Pitch, 19.2.2019.

Gulde, M. (2019): Unsere Moonshot-Vision. Fraunhofer Netzwertsymposium. München, 27.2.2019.

Gulde, M. (2019): Land surface temperature monitoring. Seraphim Capital Product Day, 1.5.2019.

Gulde, M. (2019): Land surface temperature monitoring. Creative Destruction Labs, 17.7.2019.

Gulde, M. (2019): Land surface temperature monitoring. Climate KIC, 9.9.2019.

Gulde, M. (2019): Land surface temperature monitoring. Copernicus Masters ESA Challenge, 18.9.2019.

Gulde, M. (2019): Land surface temperature monitoring. Copernicus Masters Overall Challenge, 26.9.2019.

Gulde, M. (2019): Taking our planet's temperature in the time of climate change. Berlin, 12.11.2019.

Gulde, M. (2019): The emerging need for land surface temperature data. Seraphim Capital Insight Event. London, 13.11.2019.

Gulde, M. (2019): Closing the gap in agritech. SmallSat Conference. Bremen, 21.11.2019.

Gulde, M. (2019): Feeding humanity. Copernicus Masters Awards Ceremony, 4.12.2019.

Heider, N.; Denefeld, V.; Aurich, H.; Koch, M. (2019): Safety analysis of PBX filled munitions under moderate mechanical loading. 31st International Symposium on Ballistics. Hyderabad, India, 4.11.2019.

Heine, A. (2019): Steps toward characterizing and modeling UHA steels for armor design purposes. Light Weight Armour for Defense & Security Conference (LWAG) 2019. Roubaix, France, 9.10.2019.

Hiermaier, S. (2019): Innovationsökosystem in der Green City. FhG-Symposium Netzwert »Momentum«. Leistungszentrum Nachhaltigkeit. Freiburg, 27.7.2019.

Hiermaier, S. (2019): Resilience of Complex Systems/Resilience – an Engineering Discipline. Global Resilience Research Network Summit 2019 (GRRN). Freiburg, 9.4.2019.

SCIENTIFIC EXCHANGE, LECTURES

Hiermaier, S. (2019): Evening Talk zu Resilience Engineering. ETH Zürich, 11.12.2019.

Huschka, M. (2019): Konzept zur Digitalisierung der Datenverarbeitung aus werkstoffwissenschaftlicher Forschung. Werkstoffwoche 2019. Dresden, 19.9.2019.

Huschka, M. (2019): Konzept zur Digitalisierung der Datenverarbeitung aus werkstoffwissenschaftlicher Forschung. Tagung Werkstoffprüfung 2019. Neu-Ulm, 4.12.2019.

Lässig, T.; Bagusat, F.; Pfändler, S.; May, M.; Riedel, W.; Heisserer, U. et al. (2018): Influence of the consolidation pressure on the shock wave propagation in UHMWPE composites. 1st World Conference on Advanced Materials for Defense (AuxDefense 2018). Lisbon, Portugal, 3.9.2018.

Liesegang, M.; Beck, T.; Balle, F. (2019): Orbitales Ultraschallschweißen rohrförmiger Titan-/CFK-Verbunde für Anwendungen in der Luftfahrt. 22. Symposium Verbundwerkstoffe und Werkstoffverbunde. Kaiserslautern, 26.6.2019.

Osterholz, J. (2019): Effekte und Anwendungen hochenergetischer Laserstrahlung. Future Security 2019. Berlin, 15.3.2019.

Putzar, R. (2019): Protection techniques for satellites. Lehrgang Fundamentals of Space Situational Awareness 2019. Institut für Raumfahrtsysteme der Technischen Universität Braunschweig. Köln, 13.11.2019.

Ramin, M. von; Khoe, Y. S. (2018): Klotz Group Engineering Tool v3.0 – an engineering tool for debris hazard prediction. International Explosives Safety Symposium and Exhibition. San Diego, CA, USA, 6.8.2018.

Ramin, M. von; Stottmeister, A.; Schneider, J. (2018): Development of dynamic lung injury models for complex blast scenarios. 20th International Physical Security Forum IPSF. Bad Reichenhall, 22.4.2018.

Ramin, M. von; Stottmeister, A.; Schneider, J. (2018): Physics-based injury models for improved explosives and munitions risk management. NATO MSIAC Improved Explosives and Munitions Risk Management Workshop. Granada, 10.9.2018.

Sauer, M.; Durr, N.; Lück, M.; Nixon, M. E.; Koundinyan, S.; Diggs, A. et al. (2019): Comparison of software codes and discretization schemes for mesoscale simulation of dynamic mechanical loading of PBX. 50th International Annual Conference ICT 2019. Karlsruhe, 25.6.2019.

Sauer, M.; Paul, A.; Zweigle, T.; Paul, H.; Matura, P.; May, M. et al. (2018): Simulationsbasierte Nachweisführung der Festigkeit eines Faserverbundbauteils bei Unterwasser-Stoßwellenbelastung. DWT-Konferenz Angewandte Forschung für Verteidigung und Sicherheit in Deutschland. Bonn, 21.2.2018.

Schaufelberger, B.; Matura, P.; Böhler, M. (2019): Arbeiten des Fraunhofer EMI im Rahmen des Projektes GAS-O-CHROM. Abschlusstreffen des Projekts GAS-O-CHROM. Sulzburg, 8.10.2019.

Schaufelberger, B.; Pernau, H.-F.; Böhler, M.; Matura, P. (2019): Analyse und Simulation des temperaturabhängigen Massenverlustes im Buchenholzschwelbrand (Testfeuer TF2 nach DIN EN 54). 13. Anwendertreffen der FDS Usergroup. Berlin, 17.11.2019.

Schimmerohn, M.; Sholes, D.; Sinn, T.; Horch, C.; Schäfer, F. (2019): Developing a robust dragsail de-orbit subsystem for nanosatellites. 33rd AIAA/USU Conference on Small Satellites. Logan, UT, USA, 3.8.2019.

Schneider, J. (2019): Addressing current research gaps in physical security (EXERTER and MULTISCHUTZ). International Physical Security Forum 2019. Oslo, Norway, 7.5.2019.

Schneider, J. (2019): Masonry failure and debris throw characteristics under dynamic blast loads. Loss Prevention 2019. Delft, Netherlands, 17.6.2019.

Staab, F.; Balle, F. (2019): Mikrostruktur- und Eigenschaftsanalyse ultraschalltorsions-geschweißter Al/CFK-Verbunde. 22. Symposium Verbundwerkstoffe und Werkstoffverbunde. Kaiserslautern, 26.6.2019.

Staab, F.; Balle, F. (2019): Joining of ageing resistant structures out of light metals and carbon composites by ultrasonics. 22nd International Conference on Composite Materials (ICCM22). Melbourne, Australia, 11.8.2019.

Staab, F.; Balle, F. (2019): Ultrasonic welding of ageing resistant hybrid transition structures for future aircraft applications. International Congress on Ultrasonics (ICU). Bruges, Belgium, 3.9.2019.

Staab, F.; Balle, F. (2019): Ultrasonic welding of ageing resistant hybrid transition structures for future aircraft applications. 28. FMF-Kolloquium. Schluchsee, 14.10.2019.

Steinhauser, M. O. (2019): Modeling and simulation of hypervelocity impact phenomena. 13th International Conference on the Mechanical Behavior of Materials. Melbourne, Australia, 11.6.2019.

Steinhauser, M. O. (2019): Modeling and simulation of fracture and failure in hypervelocity impact. 10th International Conference on Computational Methods. Singapore, 9.7.2019.

Steinhauser, M. O. (2019): Particle-based modeling of hypervelocity impact and fragmentation in materials. 1st International Orbital Debris Conference. Sugar Land, TX, USA, 9.12.2019.

Stolz, A. (2019): Sprengwirkungshemmende Fenster- und Fassadenkonstruktionen. Rosenheimer Fenstertage 2019. Rosenheim, 9.10.2019.

Stolz, A. (2019): Blackout – großflächiger Stromausfall – Kaskadeneffekte – Softwaretool CAESAR. Klausurtagung II/2019 der RegStTerrAufg Ost. Neumarkt, 29.11.2019.

Straßburger, E. (2019): Untersuchung der Effizienz von geschotteten transparenten Panzerungen mit Spinell und des Einflusses von Fugen. 23. Tagung »Schutz gegen IED und ballistische Bedrohung«. WTD 91. Meppen, 7.5.2019.

Straßburger, E.; Patel, P. (2019): Ballistic impact damage and fragmentation in different types of glass and glass ceramic. 31st International Symposium on Ballistics. Hyderabad, India, 4.11.2019.

van Keuk, J.; Rakus, D.; Sättler, A. (2019): Simulation TK-Ablösung für 30-mm-Pfeilgeschoss. 7. Sitzung »Rohr-Geschoss-Dynamik/TK-Ablösung«. ISL. Saint-Louis, 20.8.2019.

van Keuk, J.; Rakus, D.; Sättler, A. (2019): Simulation TK-Ablösung für 30-mm-Pfeilgeschoss. 8. Sitzung »Rohr-Geschoss-Dynamik/TK- Ablösung«. RWM. Unterlüß, 20.11.2019.

van Keuk, J.; Sättler, A.; Schmitt, S.; Heiser, R.; Berger, C. (2019): Stand SimIB_V1.4/SimIB-1D. 27. Sitzung Taskforce »Innenballistik-Simulation«. Diehl GmbH & Co. KG. Röthenbach a. d. Pegnitz, 1.10.2019.

Vogelbacher, G. (2019): Vortrag zum Projekt Stadtsicherheit-3D. Sicher leben in der Stadt – Herausforderung für Forschung und Praxis. Duisburg, 8.10.2019.

Vogelbacher, G.; Finger, J.; Häring, I. (2019): Towards visibility and audibility algorithms for assessing perceived safety and security in public areas based on digital 3D city models. 29th European Safety and Reliability Conference (ESREL 2019). Hannover, 23.9.2019.

Weibel, D.; Beck, T.; Balle, F. (2019): Very high cycle fatigue properties of crimp and non-crimp carbon fibre reinforced polyphenylene sulfide (CF-PPS). 22nd International Conference on Composite Materials (ICCM22). Melbourne, Australia, 11.8.2019.

Wuttke, C.; Butenweg, C.; Rosin, J.; Kubalski, T. (2019): Verbesserte seismische Nachweiskonzepte für Mauerwerksbauten in deutschen Erdbebengebieten. 16. D-A-CH-Tagung Erdbebeningenieurwesen und Baudynamik. Innsbruck, Austria, 26.9.2019.

Seminar lectures at EMI

Aurich, H.; Heider, N.; Denefeld, V. (2019): Material properties and ammunition safety. Besuch des Air Force Research Laboratory. EMI Kandern, 28.5.2019.

Aurich, H.; Heider, N.; Denefeld, V. (2019): Material properties and ammunition safety. US-GE PA Meeting HERSHE. EMI Freiburg, 6.6.2019.

Aurich, H.; Heider, N.; Denefeld, V. (2019): Safety assessment of PBX-ammunition. NATO I-AMMO Working Group Meeting. EMI Freiburg, 23.10.2019.

Aurich, H.; Heider, N.; Denefeld, V.; Dutschke, B. (2019): Sensitivitätsanalysen für rohrverschossene Sprengmunition. Besuch der Güteprüfer des BAAINBw. EMI Efringen-Kirchen, 28.1.2019.

Butz, I. (2019): Röntgenanalyse: von Pflanzen im Weltraum bis zu Autos in der Crashhalle. EMI-Doktorandenseminar. EMI Efringen-Kirchen, 7.6.2019.

Butz, I. (2019): Röntgenanalyse: von Pflanzen im Weltraum bis zu Autos in der Crashhalle. Kuratoriumssitzung. EMI Freiburg, 19.7.2019.

Denefeld, V.; Straßburger, E.; Heider, N. (2019): Schutz von mobilen Plattformen gegen IED-Bedrohungen. EMI-Symposium. EMI Freiburg, 11.12.2019.

Dutschke, B. (2019): Numerische Untersuchungen zur Rohr-Geschoss-Dynamik in Handwaffen. EMI-Doktorandenseminar, 12.7.2019.

Dutschke, B. (2019): Numerische Untersuchungen zur Rohr-Geschoss-Dynamik in Handwaffen. EMI-Symposium. EMI Freiburg, 10.12.2019.

Gulde, M. (2019): Vortrag über das Fraunhofer AHEAD-Programm. EMI-Hausseminar. EMI Freiburg, 10.4.2019.

Gulde, M. (2019): Vortrag über das Spin-off ConstellR. EMI-Hausseminar. EMI Freiburg, 15.11.2019.

Heider, N.; Aurich, H.; Denefeld, V. (2019): Material properties and ammunition safety. Besuch des Los Alamos National Laboratory. EMI Freiburg, 11.4.2019.

Ramin, M. von (2019): Risikoanalyse für die sichere Munitionslagerung – nationale Entwicklungen, internationale Herausforderungen. EMI-Symposium. EMI Freiburg, 10.12.2019.

Sauer, M. (2019): Multiskalenmodellierung von Explosivstoffen – Ergebnisse einer internationalen Forschungskooperation. EMI-Symposium. EMI Freiburg, 10.12.2019.

Sauer, M.; Bagusat, F.; Lässig, T.; Maurer, M.; Pfändler, S. (2019): Materials at Highest Strain Rates Group. Visit of Dana Dattelbaum, Los Alamos National Laboratory (USA). EMI Freiburg, 11.4.2019.

Schaufelberger, B. (2019): Vorstellung des Projektes BATTmobil. EMI-Hausseminar. EMI Freiburg, 5.6.2019.

Schneider, J. (2019): Charakterisierung des Splitterverhaltens von Glasscheiben unter kurzzeit-dynamischer Belastung mittels Computer-Vision. EMI-Hausseminar. EMI Efringen-Kirchen, 3.7.2019.

Schopferer, S. (2019): Sicherheit und Schutz geladener Batterien unter einsatzspezifischen wehrtechnischen Belastungen. EMI-Symposium. EMI Freiburg, 11.12.2019.

van Keuk, J.; Sättler, A.; Schmitt, S.; Heiser, R. (2019): Stand SimIB_V1.4/SimIB-1D. 26. Sitzung Taskforce »Innenballistik-Simulation«. EMI Efringen-Kirchen, 14.5.2019.

Courses of the Carl-Cranz-Gesellschaft

Niklas, W.; Engelmann, F. (2019): Quantitative Gefährdungs- und Risikoanalyse zur Festlegung von Gesamtsicherheitsanforderungen – Methodik und Anwendungsbeispiele. CCG-Seminar VS 1.53 » Funktionaler Sicherheitsnachweis für wehrtechnische Systeme«. EMI Efringen-Kirchen, 19.3.2019.

Straßburger, E. (2019): Endballistik kleinkalibriger Geschosse – Keramik für den ballistischen Schutz. CCG-Seminar VS 1.43 »Endballistik – Grundlagen und Anwendungen«. ISL. Saint-Louis, 27.6.2019.

Lectures

Balle, F.: Engineering Materials and Testing Methods. Laborpraktikum. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.: Lab Course Engineering Materials and Testing Methods. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.: Lightweight Design and Materials. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Balle, F.: Materials Selection and Sustainable Development for Mechanical Engineering. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Balle, F.: Methoden der Materialwissenschaften. Ringvorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.: Methodenpraktikum. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.: Studienseminar Sustainable Systems Engineering. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.: Technische Funktionswerkstoffe. Vorlesung und Übung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Balle, F.; Hartwick, A.; Richter, S.: Sustainable Materials – Functional Materials: Einführung. Einführung für Erstsemesterstudierende. Albert-Ludwigs-Universität Freiburg, 18.10.2019.

Balle, F.; Hiermaier, S.; Weidlich, A.; Ganzenmüller, G. C.; Hess, S.; Kilchert, S.; Rodenbücher, B.: Studienseminar Sustainable Systems Engineering. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Fischer, K.: Fundamentals of Resilience. Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Fischer, K.: Quantitative Risk Assessment. Vorlesung als Gastredner. Hochschule Furtwangen, Wintersemester 2019/2020.

Häring, I.: Funktionale Sicherheit – Aktive Resilienz / Functional Safety: Active Resilience. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Hiermaier, S.: Fundamentals of Resilience. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Hiermaier, S.: Kontinuumsmechanik. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Hiermaier, S.; Ganzenmüller, G. C.: Konstitutive Gleichungen und Diskretisierungsverfahren zur Versagensmodellierung/Physics of Failure. Vorlesung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Hiermaier, S.; Ganzenmüller, G. C.; Kilchert, S.: Materiallebenszyklen/Material Life Cycles. Vorlesung mit Übung. Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

SCIENTIFIC EXCHANGE, LECTURES

May, M.: Composite Materials. Vorlesung.
Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Osterholz, J.: High-Energy-Density Physics. Vorlesung.
Heinrich-Heine-Universität Düsseldorf, Wintersemester 2019/2020.

Osterholz, J.: High-Energy-Density Physics. Vorlesung.
Heinrich-Heine-Universität Düsseldorf, Sommersemester 2019.

Sauer, M.: Finite Methoden und Stoffgesetze Hochdynamik.
Vorlesung und Laborpraktikum.
Universität der Bundeswehr München, Wintertrimester 2019.

Sauer, M.: Numerische Simulationsverfahren. Vorlesung.
Universität der Bundeswehr München, Wintertrimester 2019.

Sauer, M.: Werkstoffcharakterisierung. Vorlesung.
Universität der Bundeswehr, Wintertrimester 2019.

Sauer, M.: Finite Methoden und Stoffgesetze Hochdynamik.
Vorlesung und Laborpraktikum.
Universität der Bundeswehr München, Wintertrimester 2020.

Sauer, M.: Numerische Simulationsverfahren. Vorlesung.
Universität der Bundeswehr München, Wintertrimester 2020.

Sauer, M.: Werkstoffcharakterisierung. Vorlesung.
Universität der Bundeswehr, Wintertrimester 2020.

Steinhauser, M. O.: Advanced Methods in Computational Sciences: Monte Carlo Simulations. Vorlesung. Universität Basel, Frühjahrssemester 2019.

Steinhauser, M. O.: Anwendungen Computational Sciences. Vorlesung. Universität Basel, Herbstsemester 2019.

Steinhauser, M. O.: Computational Materials Science with Atomistic and Coarse-grained Methods. Vorlesung. Universität Basel, Frühjahrssemester 2019.

Steinhauser, M. O.: Computational Materials Science: Simulation of Shock Waves in Solids and Biomembranes. Vorlesung in der Ringvorlesung Computational Sciences. Universität Basel, Herbstsemester 2019.

Steinhauser, M. O.: Physikalische Chemie IV: Molekulare Dynamik und elektronische Struktur. Vorlesung. Universität Basel, Herbstsemester 2019.

Stolz, A.: Baudynamik. Vorlesung. Hochschule Koblenz,
Sommersemester 2019.

Stolz, A.: Konzeption großer Infrastrukturen / Design of Large Infrastructures. Vorlesung. Albert-Ludwigs-Universität Freiburg, Sommersemester 2019.

Stolz, A.: Strukturelle Robustheit: Resiliente Entwurfsprinzipien/
Structural Robustness: Resilient Designs. Vorlesung und Übung.
Albert-Ludwigs-Universität Freiburg, Wintersemester 2019/2020.

Visiting Scientists at EMI

Gaetano Auteri, 24.6.2019–16.9.2019.

Lukas Becker, 24.6.2019–16.9.2019.

Lukas Gaenzle, 6.8.2018–31.5.2019.

Maik Geiermann, 1.7.2019–22.9.2019.

Malte Meyer, 1.7.2019–22.9.2019.

Pablo Resende-Oliveira, 1.6.2018–31.5.2022.

Prof. Akira Tsukamoto, 3.7.2019–19.8.2020.

Robert Kranz, 24.6.2019–16.9.2019.

Thomas Sheehan, 16.6.2019–31.8.2019.

Vivek Padmanabha, 15.4.2019–15.4.2022.

PhD

Backe, S. (2019): Metallfaser- und kohlenstofffaserverstärkte Kunststoff-Laminate (MCFK): Ermüdungseigenschaften und Potenziale zur Schädigungsüberwachung. Dissertation. TU Kaiserslautern, Kaiserslautern.

Büchler, A. (2019): Interface Study on Laser-Structured Plated Contacts for Silicon Solar Cells. Dissertation. Albert-Ludwigs-Universität Freiburg, Freiburg.

Daneshi, A. (2019): Micro Chip Formation Mechanism in Grinding of Nickel-base Superalloy – Inconel 718. Dissertation. Albert-Ludwigs-Universität Freiburg, Freiburg.

Heusinger, V. (2019): Eingangsdatenspezifische Artefaktreduktion für algebraische Rekonstruktionsverfahren in der Computertomographie am Beispiel von Halbleiterdetektoren. Dissertation. Albert-Ludwigs-Universität Freiburg, Freiburg.

Nissle, S. (2019): Zur Kraftübertragung zwischen Formgedächtnislegierungen und Faserkunststoffverbunden in aktiven Hybridstrukturen. Dissertation. TU Kaiserslautern, Kaiserslautern.

Sasikumar, A. (2019): Improving Compression after Impact Response of Composite Laminates through Ply Level Hybridization with Thin Plies and Unsymmetrical Designs. Dissertation. Universitat de Girona, Girona.

Seifert, W. (2019): Einfluss von Adhäsivstoffen auf das ballistische Verhalten geklebter Keramik-Metall-Verbunde. Dissertation. Universität der Bundeswehr, München.

Yuan, L. (2019): Development and Characterization of Piezoelectric AlScN-based Alloys for Electroacoustic Applications. Dissertation. Albert-Ludwigs-Universität Freiburg, Freiburg.

Bachelor, Master and Diploma theses

Auteri, G. (2019): Charakterisierung von PDV-Messparametern für EFI-Zündmittel und Ableitung von Auslegungsregeln für einen Messplatz. Bachelorarbeit. DHBW Mannheim.

Bajwa, S. (2019): Potentiale des Kunststoffschweißens als alternative Fügetechnologie für opto-elektronische Sensoren. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Becker, L. (2019): Konzeption und Konstruktion einer Messeinrichtung zur Messung der Masseneigenschaften von Handfeuerwaffen. Bachelorarbeit. EMI-Bericht A 26/19. DHBW Mannheim.

Berger, C. (2019): Vergleich optischer Messverfahren zur Charakterisierung von Gasströmungen. Bachelorarbeit. EMI-Bericht A 01/19. KIT.

Bhattacharya, D. (2019): Development of a low damage laser cutting process for aluminium foil metallization on the rear side of p-type PERC solar cells. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Chang Kuo-I (2019): An adaptive surrogate modeling approach to cup drawing using Gaussian process regression. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Eberhardt, D. (2019): Erkennen und Verfolgen von Glassplittern auf Highspeed-Aufnahmen mit Hilfe von künstlichen neuronalen Netzen. Bachelorarbeit. EMI-Bericht A 29/19. DHBW Lörrach.

Förster, B. (2019): Verbesserung eines Einspann-Systems durch metallischen 3D-Druck. Diplomarbeit. EMI-Bericht A 02/19. Hochschule für Technik und Wirtschaft Dresden.

Gärtner, M. (2019): Analysis of jetting during hypervelocity impacts. Bachelorarbeit. EMI Report A 39/19. Albert-Ludwigs-Universität Freiburg.

Geiermann, M.: Auslegung und Konstruktion einer temperierbaren Prüfanordnungen zur mechanischen Charakterisierung von Explosivstoffen. Bachelorarbeit. EMI-Bericht A 27/19. DHBW Mannheim.

Herr, M. (2019): Experimentelle und numerische Untersuchung von Impaktvorgängen auf Keramik-Gummi-Verbundplatten (experimenteller Teil). Masterarbeit. EMI-Bericht A 19/19. Technische Hochschule Mittelhessen.

Hochdorfer, F. (2019): Charakterisierung und Bewertung additiv gefertigter Verbundwerkstoffe. Bachelorarbeit. EMI-Bericht A 31/19. DHBW Mannheim.

Hubig, M. (2019): Messmethoden zur Temperaturbestimmung bei der Laserwirkung. Bachelorarbeit. EMI-Bericht A 32/19. DHBW Mannheim.

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

Kranz, R. (2019): Charakterisierung von PDV-Strahleigenschaften zur Messung an EFI-Zündmitteln. Bachelorarbeit. DHBW Mannheim.

Krummenacher, M. (2019): Interaction of amphyphilic bottle brush and star polymers with a biological membrane: a coarse-grained molecular dynamics study. Masterarbeit. EMI Report A 37/19. Universität Basel.

Kunert, N. (2019): Automatische Bestimmung der Größe und Flugbahn von Hypervelocity-Impakt-Ejekta. Bachelorarbeit. EMI-Bericht A 13/19. NTA Isny.

Leppert, P. (2019): Konzeptentwicklung zur Implementierung von bistabilen Mechanismen in additiv gefertigten Gitterstrukturen. Masterarbeit. EMI-Bericht A 06/19. Hochschule Offenburg.

Mayer, E. (2019): Geschäftsmodellanalyse: Neue Geschäftsmodelle in der Raumfahrt. Bachelorarbeit. EMI-Bericht A 20/19. SRH Hochschule für Logistik und Wirtschaft Hamm.

Mayer, E. (2019): Konkurrenzanalyse: Akteure auf dem europäischen Markt für Kleinsatelliten. Bachelorarbeit. EMI-Bericht A 21/19. SRH Hochschule für Logistik und Wirtschaft Hamm.

Miller, N. (2019): A Proposed methodology to evaluate resilience of power grids against Natural Disasters. Masterarbeit. EMI Report A 40/19. Albert-Ludwigs-Universität Freiburg.

Mopidevi, O. S. S. (2019): Modelling and design of rotor kite experimental setup for airborne wind energy. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Moser, D. (2019): Methodenentwicklung zur Werkstoffstrukturierung durch Selektives Laserschmelzen (SLM). Masterarbeit. EMI-Bericht A 16/19. Hochschule Offenburg.

Müller, T. (2019): Entwicklung eines Messmoduls zur drahtlosen Datenübermittlung in einer stark stoßbelasteten Umgebung. Bachelorarbeit. EMI-Bericht A 30/19. Wilhelm-Büchner-Hochschule.

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

Neven-du-Mont, S. (2019): Demonstration eines Solarmoduls mit III-V-Multifunction Solarzellen. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Ortlieb, M. (2019): Entwicklung eines Detektors zur Erfassung von kurzzeitdynamischen Stoßwelleneffekten. Bachelorarbeit. EMI-Bericht A 41/19. Wilhelm-Büchner-Hochschule.

Ragupathi, B. (2019): Analysis of local mechanical strength of magnetic pulse welding joints of dissimilar metals. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Rupakula, G. D. (2020): Numerical analysis of a novel high-rate mode II fracture toughness test. Masterarbeit. EMI Report 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.

Schmieder, L. (2019): Method for impact flux analysis on ISS surfaces. Masterarbeit. EMI Report A 23/19. Albert-Ludwigs-Universität Freiburg.

Schmohl, R. (2019): Topologische Optimierung und Konstruktion von Leichtbauteilen für die additive Fertigung. Bachelorarbeit. EMI-Bericht A 05/19. Fachhochschule Aachen.

Sivakumar, P. K. (2019): Direct tension bar for testing at intermediate strain rate. Masterarbeit. Albert-Ludwigs-Universität Freiburg.

Uebbing, S. (2019): Analyse eines Impaktdetektionsverfahrens mit Segeln aus dünnen Folien. Masterarbeit. EMI-Bericht A 03/19. TU Braunschweig.

Zadim, D. (2019): Experimentelle Analyse der Zuverlässigkeit der Kommunikation mit Nanosatelliten im UHF-Band. Bachelorarbeit. EMI-Bericht A 14/19. Albert-Ludwigs-Universität Freiburg.

SCIENTIFIC EXCHANGE, LECTURES

Publication series of Fraunhofer EMI

Heusinger, V. (2019): Eingangsdatenspezifische Artefaktreduktion für algebraische Rekonstruktionsverfahren in der Computertomographie am Beispiel von Halbleiterdetektoren. Stuttgart: Fraunhofer Verlag (Schriftenreihe Epsilon-Punkt – Forschungsergebnisse aus der Kurzzeitdynamik).

Workshops and events

60 Jahre EMI, Jubiläumsfeier, 28.11.2019.

EMI-Symposium, 10.–11.12.2019.

EXERTER End User Workshop 2019, 19.–20.11.2019.

Gedenkkolloquium Professor Klaus Thoma, 18.7.2019.

2nd Global Resilience Research Network (GRRN) Summit, 9.–11.4.2019.

NATO-Sitzung, 22.–25.10.2019.

Projekttreffen EXERTER, 18.–21.11.2019.

SecureGas Workshop, 9.–11.9.2019.

Workshop SUSQRA 11.–12.3.2019.

Participation in professional boards, associations and program committees

Aurich, H.: Task Force »Sandy Gravel« (Bodenproblematik).

Balle, F.: Aktives Mitglied im DGM-Fachausschuss »Hybride Werkstoffe und Strukturen« (Gründungsmitglied).

Balle, F.: Aktives Mitglied im DVM-Arbeitskreis »in-situ-Prüfung im Elektronenmikroskop« (Gründungsmitglied).

Balle, F.: Gutachter für die Deutsche Forschungsgesellschaft (DFG).

Balle, F.: Gutachter für die Netherlands Organisation for Scientific Research (NWO).

Balle, F.: Gutachter für wissenschaftliche Journals in 2019: Composite Science and Technology, Composites A, Composite Interfaces, Composite Materials, Fatigue and Fracture of Engineering Materials and Structures, Polymers, Sandwich Structures and Materials, Metals, Journal of Materials Processing and Technology, Materials Letters, Materials Science and Engineering A, NDT & E International, Ultrasonics, Carbon.

Balle, F.: Mitglied im Editorial Board und Mitherausgeber der Zeitschrift »Ultrasonics« (Elsevier).

Balle, F.: Mitglied im Gemeinschaftsausschuss (GA) »Verbundwerkstoffe« der DGM, DGG, DGO, DVS, VDI und DKG.

Balle, F.: Mitglied im Internat. Advisory Commitee: »International Conference on Very High Cycle Fatigue (VHCF)«.

Balle, F.: Mitglied im Programmbeirat der DGM-Tagung »Ressourceneffizienz und Additive Fertigung«.

Balle, F.: Mitglied im Programmbeirat der DGM-Tagung »Verbundwerkstoffe und Werkstoffverbunde«.

Balle, F.: Mitgliedschaften in folgenden Verbänden: Deutsche Gesellschaft für Materialkunde (DGM), Deutscher Verband für Materialforschung und -prüfung e.V. (DVM), Deutscher Hochschulverband (DHV), The Minerals, Metals & Materials Society (TMS), USA.

Heine, A.: Abstract Reviewer, 31st International Symposium on Ballistics, ISB 2019.

Heine, A.: Member of the Scientific Committee, Lightweight Armour Group, LWAG 2019.

Hiermaier, S.: Fachbeirat der BaSt.

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

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Rosin, J.: Deutsche Expertin im korrespondierenden europäischen Normungsausschuss CEN/TC 265/WG 10, Projektleiterin des Teil 2 EN 14620.

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Schimmerohn, M.: External DLR Delegate, Deputy Chairmen of Working Group 3 at the 37th Inter-Agency Space Debris Coordination Committee (IADC) Meeting, 7.–10.5.2019, Rome, Italy.

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Stolz, A.: Koordinator »Resistance of structures to explosion effects« im Rahmen des the ERNCIP (European Reference network for Critical Infrastructure protection) framework.

Scientific prizes and awards

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