Fraunhofer
INT

Annual report

2021

Fraunhofer Institute for Technological Trend Analysis INT

Foreword

Dear readers,

This is a special foreword. At least for me it's special, because it is the tenth time that I have had the privilege of writing an annual report for Fraunhofer INT. That is why it begins the way the first one began.

Typically, one uses auspicious dates like these as an opportunity to look back a little, highlight the most important events and, above all, celebrate successes.

There are quite a few things worth mentioning: two successfully completed strategy cycles at the institute and a significant restructuring; the fusing of two departments into a new one, and the founding of new business units.

Our business with the Bundeswehr has been expanded and new collaborations were formed with the German Federal Ministry of Defence (BMVg) and its subordinate departments. The civil side of the business was set up on a broader basis, showing solid, continuous growth.

The Fraunhofer Space Alliance branch laid the foundation for its own business unit, and the expansion of aerospace into a lead market brings the opportunity for Fraunhofer INT to establish itself as the preferred partner for aerospace at Fraunhofer. Numerous cooperation projects were set up with higher education institutes, the Institute for Technology Analysis and Foresight in the field of Security Research at RWTH Aachen University has become an established part of the institute and not least, Fraunhofer INT now has five(!) professorships.

All in all, a good balance sheet, worthy of a dazzling presentation in the tenth foreword. And obviously so stable, that even the pandemic couldn't cause an economic slump.

So, everything is fine, keep it up? That was hardly what fate had in store. On the night of July 14, 2021, we were dealt what I, in the forward I wrote last year with the scientific objectivity I had then, labeled a 'wild card': A conceivable but nonetheless highly unlikely event that can have unexpected consequences.

The district and town of Euskirchen, Germany, was hit by a flood disaster of unprecedented proportions, causing large-scale destruction and claiming human lives. Fraunhofer INT did not escape unscathed. The entire infrastructure was flooded, the basement and the first floor of every building became unusable, covered in water and mud, and a large portion of our experimental equipment was unusable too. On the morning of July 15, Fraunhofer INT found itself at the center of a crisis zone, with no electricity, telecommunications or internet and without even the basic supplies for the simplest of tasks. Numerous employees also suffered personal losses and damage to property.

Blessing in disguise: none of our employees or their families suffered serious injury or death.

Within a matter of minutes, during which water and mud did its worst, Fraunhofer INT became a real-life laboratory. It became an experiment in what I, in the foreword of the 2020 Annual Report, described as "the capability of a system to continue functioning in the wake of a crisis with emergency operating facilities and to return to a normal state as quickly as possible" – not knowing, of course, that we too would soon be in need of this capability.

And immediately we were faced with the question of how to run a research institute with the destructions described above, in order to get excellent research results again in a short space of time. Or, in other words, how resilient is Fraunhofer INT?

All good things come in threes, so the saying goes, and that was the case here too. Firstly, you need highly motivated employees with total loyalty to their institute, switching their lab coats and pencils for heavy duty gloves and rain boots and, without hesitation, clearing mud for weeks, hauling broken furniture and cleaning cable ducts on their knees...

Secondly, you need a network of reliable colleagues and friends to provide a shelter, offer workers and equipment, organize collections for the victims and generally help out in all respects with rebuilding...

And thirdly, you need a certain amount of luck, for example, that all the data survived a violent server shutdown and the research could largely be picked up from where it was interrupted on Wednesday night.

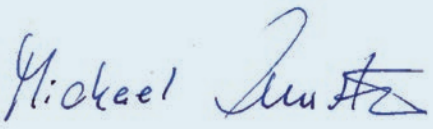
All of these things make Fraunhofer INT an extremely resilient organization. I would like to express my sincere thanks to all institute employees, the colleagues in Munich and Wachtberg, and our friends at the Bundeswehr, who supported us during this crisis.

Although we are already making great progress in the clean-up processes, it will certainly be a long time before the institute can return to normal operations with its infrastructure intact. But one thing is also certain: together, we will rebuild Fraunhofer INT, and in the meantime, excellent research for the state and society will continue as usual, albeit in interim structures.

In the 2021 Annual Report, you'll find articles on exciting topics we're working on at the institute, in defiance of the pandemic and the flood.

Stay with us and let's take a positive look into the future together.

We hope you enjoy reading the report!



Prof. Michael Lauster

Content

Profile of Fraunhofer INT

The Fraunhofer Institute for Technological Trend Analysis INT provides scientifically sound judgment and counseling on the entire spectrum of technological developments and considers their interaction with social and economic issues. On this basis, the institute conducts technology-oriented innovation research, which makes long-term strategic research planning possible. Fraunhofer INT draws on this expertise in projects that are tailored to the customer's needs.

In addition to this expertise, the institute conducts its own experimental and theoretical research into the effect of ionizing and electromagnetic radiation on electronic components and systems as well as on radiation detection. For this purpose, the institute is equipped with the latest measurement technology. The main laboratory and large-scale appliances are radiation sources, electromagnetic simulation facilities and detector systems, which are not available in this combination in any other civil facility in Germany.

For over 40 years, the INT has been a reliable partner of the German Federal Ministry of Defense, advising them and conducting research studies in the fields of technology analysis and strategic planning as well as on the effects of radiation. Moreover, the Fraunhofer INT also conducts research for and successfully advises other civil and public clients and companies on a national and international scale, from medium-sized enterprises through to DAX 30 groups.

The business units in this Annual Report

WZA

Defense Technology Foresight

TIP

Public Technology and Innovation Planning

CTF

Corporate Technology Foresight

NSD

Nuclear Security Policy and Detection Techniques

EME

Electromagnetic Effects and Threats

NEO

Nuclear Effects in Electronics and Optics

Organigram

DIRECTOR'S OFFICE

Director

Prof. Dr. Dr. Michael Lauster
Phone +49 2251 18-117/ -217
michael.lauster@int.fraunhofer.de

Vice-Director

Dr. Stefan Metzger
Phone +49 2251 18-214
stefan.metzger@int.fraunhofer.de

DEPARTMENT TECHNOLOGICAL ANALYSES AND STRATEGIC PLANNING (TASP)

Head

Dr. René Bantes
Phone +49 2251 18-185
rene.bantes@int.fraunhofer.de

Deputy

Hans-Martin Pastuszka
Phone +49 2251 18-298
hans-martin.pastuszka@int.fraunhofer.de

DEPARTMENT NUCLEAR AND ELECTROMAGNETIC EFFECTS (NE)

Head

Dr. Stefan Metzger
Phone +49 2251 18-214
stefan.metzger@int.fraunhofer.de

Stellvertretung

Dr. Jochen Kuhnhenn
Phone +49 2251 18-200
jochen.kuhnhenn@int.fraunhofer.de

DEPARTMENT BUSINESS ADMINISTRATION AND CENTRAL SERVICES (BZD)

Head

Prof. Dr. Harald Wirtz
Phone +49 2251 18-237
harald.wirtz@int.fraunhofer.de

Deputy

Sabrina Langemann
Phone +49 2251 18-226
sabrina.langemann@int.fraunhofer.de

The institute in figures

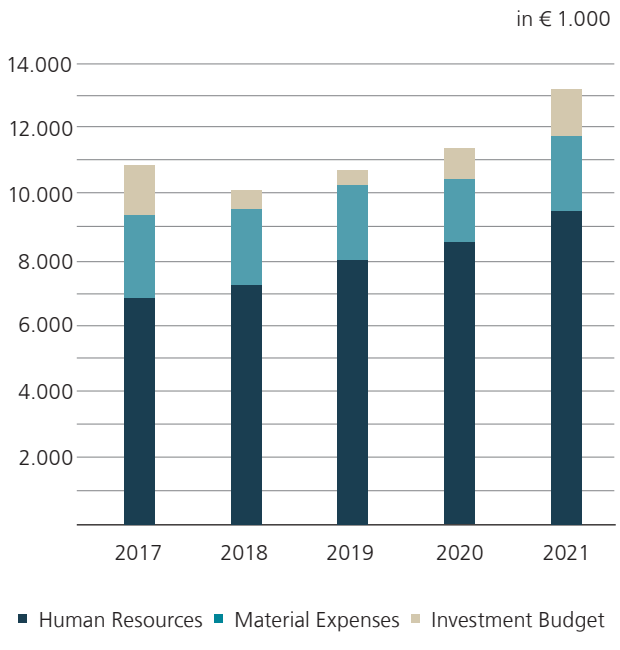
Human Resources and Budgetary Performance

The flooding in July 2021 rather rained on our economic performance. In the first half of the year, we were still predicting an economically successful year. But due to the extensive damage to our laboratories and the work required to get us back in working order, we were unfortunately unable to continue with many projects initially in the second half of the year. Despite being in a good position with orders, we were unfortunately unable to achieve our original earnings targets. Because we built up a strategic reserve during the successful preceding years, we were able to close the financial gaps which arose from these events. Thanks to our highly motivated employees we are, with some provisos, largely up and running again now, and have begun work on the delayed projects.

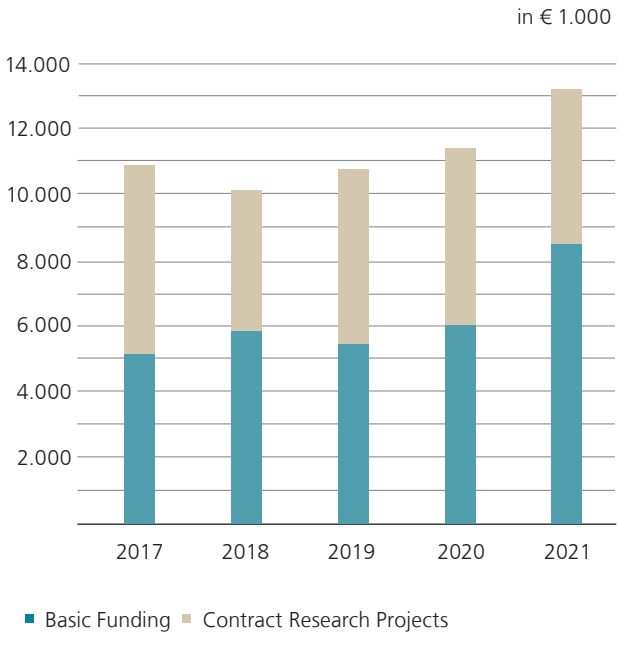
Human resources

We increased our personnel capacity somewhat in 2021. By the end of the year, we had employed 132 members of staff with 116.3 FTEs, of whom 68 were scientists (62.1 FTEs). As a result, we cover a wide range of natural and engineering sciences, as well as economic, social and sociological sciences. The researchers are supported by graduate engineers, technicians and administrative professionals. There are also undergraduate and research assistants as well as trainees. Additionally, Fraunhofer INT commands a network of freelance scientists who are regularly involved in the work of the institute.

Budget from 2017-2021



Financial Development from 2017-2021



Budget

The Fraunhofer-Gesellschaft distinguishes between operating expenses and investment. Operating expenses cover personnel and material expenses, while Investment covers purchases of capital equipment such as scientific and technical equipment for the institute. Operating expenses increased to 11.8 million euros in 2021. In addition, investments amounted to 1.4 million euros resulting in a total budget expenditure of 13.2 million euros. These investments include the first re-purchases for items destroyed by the flooding.

In addition to base funding from the German Federal Ministry of Defence (BMVg), which has enabled a coordinated research program to be conducted, the institute also receives standard base funding from federal-state funds, which is allocated within the Fraunhofer-Gesellschaft in accordance with performance-based criteria. The institute generates the remainder of the required funding for the budgeted expenditure by handling a number of contract research projects. In addition to public authorities, project customers include companies from various industries, from medium-sized enterprises to DAX 30 groups, as well as associations and international organizations. For this reason, the share of revenue from projects for the economy has been steadily growing over the past few years. In the public sector, Fraunhofer INT has been providing comprehensive advice to the German Federal Ministry of Defence (BMVg) regarding research and technology planning for the past 40 years. The BMVg is also the biggest client of the research institute in Euskirchen. In addition, research contracts were also carried out for other ministries and official public institutes. EU projects which are conducted alongside partners from a number of European countries also account for a large portion of the revenue.

Employees

	2019		2020		2021	
	Occupied positions	Amount of people	Occupied positions	Amount of people	Occupied positions	Amount of people
Scientists	60.2	65	58.9	64	62.1	68
Graduates	24.0	25	25.0	26	30.0	30
Technicians, other	17.1	19	18.1	20	16.1	18
Assistants, trainees	6.8	14	8.5	15	8.1	16
Total	**108.1**	**123**	**110.5**	**125**	116.3	132

Budgeted expenditure in € 1,000

Expenses	**2019**	**2020**	**2021**
Operating expenses	10,211.2	10,420.9	11,790.8
of which personnel	7,996.8	8,523.0	9,391.2
of which non-personnel	2,214.4	1,879.9	2,399.6
Capital expenditure	472.7	933.6	1,416.1
Total	**10,683.9**	**11,354.5**	**13,206.9**
Financing			
Base funding	5,475.5	6,040.5	8,351.3
Contract research	5,208.4	5,314.0	4,855.6

Members of the Advisory Board 2021

Members of the Advisory Board 2021

Advice from industry, politics and administration

The institute is advised by an advisory board, which is composed of leading figures in economics, science, politics and administration.

Chair

Mr. Udo Becker; Executive Vice President Kreissparkasse Euskirchen

Due to the COVID-19 pandemic, the advisory board meeting was held in virtual form via Microsoft Teams in both 2020 and 2021. Another face-to-face meeting is planned for 2022.

Members

- Mr. Udo Becker; Executive Vice President Kreissparkasse Euskirchen
- Mr. Klaus Burmeister; foresightlab
- Dr.-Ing. Karsten Deiseroth; IABG mbH
- Sabine Lackner; Vice President THW Bonn
- Dr.-Ing habil. Frank Sabath; WIS Munster
- Ms. Britta Schade; ESA / ESTEC
- Prof. Katharina Seuser; Bonn Rhein-Sieg University of Applied Sciences
- MinR'in Sabine ten Hagen-Knauer; German Federal Ministry of Education and Research (BMBF), Bonn
- Prof. Dr. Christiane Vaeßen; Region Aachen Zweckverband
- MinR Norbert Michael Weber; former BMVg Bonn
- Dr. Hans-Ulrich Wiese; former member of the Fraunhofer Executive Board
- Prof. Axel Zweck; VDI Technologiezentrum

The Fraunhofer-Gesellschaft

#WeKnowHow

The Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. It is a trailblazer and trendsetter in innovative developments and research excellence. The Fraunhofer-Gesellschaft supports research and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

The Fraunhofer-Gesellschaft's interdisciplinary research teams turn original ideas into innovations together with contracting industry and public sector partners, coordinate and complete essential key research policy projects and strengthen the German and European economy with ethical value creation. International collaborative partnerships with outstanding research partners and businesses all over the world provide for direct dialogue with the most prominent scientific communities and most dominant economic regions.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,000 employees, predominantly scientists and engineers, work with an annual research budget of €2.9 billion. Fraunhofer generates €2.5 billion of this from contract research.

Industry contracts and publicly funded research projects account for around two thirds of that. The federal and state governments contribute around another third as base funding, enabling institutes to develop solutions now to problems that will become crucial to industry and society in the near future.

The impact of applied research goes far beyond its direct benefits to clients: Fraunhofer institutes enhance businesses' performance, improve social acceptance of advanced technology and educate and train the urgently needed next generation of research scientists and engineers.

Highly motivated employees up on cutting-edge research constitute the most important success factor for us as a research organization. Fraunhofer consequently provides opportunities for independent, creative and goal-driven work and thus for professional and personal development, qualifying individuals for challenging positions at our institutes, at higher education institutions, in industry and in society. Practical training and early contacts with clients open outstanding opportunities for students to find jobs and experience growth in business and industry.

76
institutes and research units

Joseph von Fraunhofer

The prestigious nonprofit Fraunhofer-Gesellschaft's namesake is Munich scholar Joseph von Fraunhofer (1787-1826). He enjoyed equal success as a researcher, inventor and entrepreneur.

Figures valid: January 2022
www.fraunhofer.de/en.html

Fraunhofer Group for Defense and Security VVS

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

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

The Fraunhofer Group for Defence and Security pursues research and development in the areas of defence and civil security. Our wide-ranging expertise and research have delivered highly practicable solutions and operational support, both at the national and international level. In defence research, our excellent judgement and consultancy skills make us indispensable independent experts and partners of the German Ministry of Defence (BMVg). We research and develop technologies and system solutions for the Ministry, its government bodies and for the Bundeswehr. Our technical solutions and systems in civil security are designed to deliver the best possible protection for society. We cover the interests and activities of our member institutes, acting as their representative both within and outside the organisation.

The Fraunhofer VVS was founded in 2002 as the Group for Defense and Security VVS. In 2021, the Fraunhofer VVS welcomed its eleventh member, the Fraunhofer-Institute for Transportation and Infrastructure Systems IVI. In the fields of security research, Fraunhofer IVI specializes in algorithms for risk analysis, situation assessment & decision support, and thus represents an ideal addition to the portfolio of the Fraunhofer VVS.

Areas of application

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

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

Our members

- Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI
  - Protection, Security and Effects
- Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR
  - Radar – A Key Technology
- Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE
  - Command, Control and Reconnaissance
- Fraunhofer Institute for Applied Solid State Physics IAF
  Sensors for Safety, Security and Reconnaissance
- Fraunhofer Institute for Chemical Technology ICT
  Security, Safety and Energetic Materials Technology
- Fraunhofer Institute for Technological Trend Analysis INT
  Planning Support for State and Industry
- Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB
  From Networked Sensor Data to Decision
- Fraunhofer Institute for Experimental Software Engineering IESE
  Software and Systems Engineering
- Fraunhofer Institute for Integrated Circuits IIS
  Communication, Positioning Technologies and X-Ray for Safety and Security Applications
- Fraunhofer Institute for Structural Durability and Systems Reliability LBF
  Secure Processes for secure Structures
- Fraunhofer Institute for Transportation and Infrastructure Systems IVI
  Algorithms for risk analysis, situation assessment & decision support

Chairman

Prof. Dr.-Ing. habil. Jürgen Beyerer, Fraunhofer IOSB

Deputy Chairmen

Prof. Dr. rer. nat. Peter Martini, Fraunhofer FKIE
Univ.-Prof. Dr.-Ing. Dr. rer. pol. habil. Michael Lauster

Managing Director

Dipl.-Ing. Caroline Schweitzer, Fraunhofer IOSB
caroline.schweitzer@iosb.fraunhofer.de

Fraunhofer Group for Innovation Research

Understanding change, shaping the future

With the motto "Understanding change, shaping the future", around 1600 scientists from the six Fraunhofer Institutes IAO, ISI, INT, IMW, IRB and IIS-SCS work together in the Fraunhofer Group for Innovation Research. The research is centered on understanding innovation systems and their changes and supporting the actors and participants in shaping their future.

The future of innovation, major project management and innovation methods

In 2021, as with the previous year, the research work within the Group was defined by the pandemic. In order to better understand the effects of Covid-19 on the future of innovation, in 2021 we published an update to the 2018 discussion paper with the title "Innovation and Covid-19: Impetus for the future of innovation"1. In this context, the project "Crisis management and resilience – Corona (KResCo)" was created, which included the creation of recommendations for actions developed by the Group institute, intended for decision-makers in politics, economics, population protection and research.

This year marked the conclusion of the first major, collaborative activities from the Group institute: The founding project "FRAME – Fraunhofer Microelectronics Innovation Enhancement" has guided and supported the Research Fab Microelectronics with methodical approaches to innovation research in recent years as an exemplary major project. This helped birth the FRAME Approach to supporting complex research and development (R&D) major projects.

In 2021, an important step was taken in developing the method toolbox in the Fraunhofer Innovation Hub, in which the Group institute presents the innovation methods for which it offers other Fraunhofer institutes either direct support for their innovation process or support to third-party funded projects. At the end of the year, the toolbox already contained descriptions of over 50 methods across the entire innovation chain2. The plan is to make this toolbox accessible to companies outside the Fraunhofer network, so they can make use of the methods too.

1 | Available for download at: https://publica-rest.fraunhofer.de/server/api/core/bitstreams/b378b551-353e-4dcb-a73d-da7dff5135eb/content

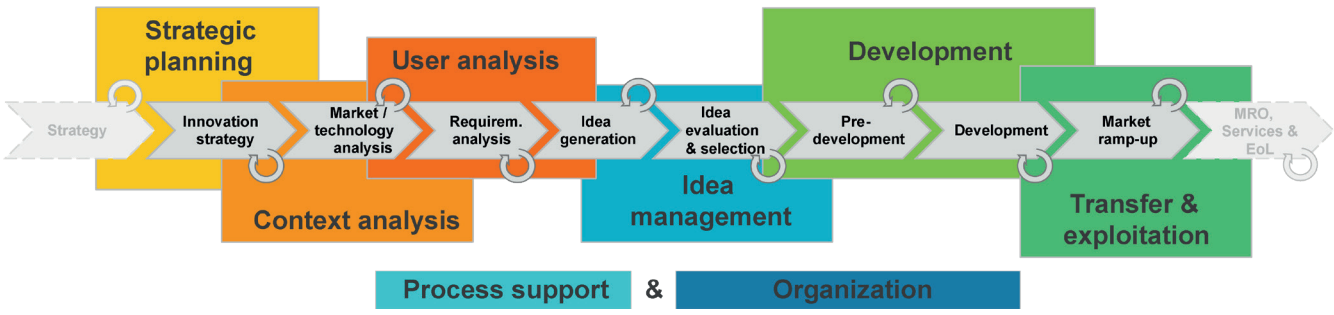
2 | Accessible for Fraunhofer employees via: https://innovationhub.fraunhofer.de/fraunhofer/innovationmethods

Significance of innovation research for the economy, politics, science and society

Not least because of the pandemic, discussions in Germany about the future of innovation systems and how they are designed are being held ever more in the public eye. The Fraunhofer Group for Innovation Research offers companies diverse opportunities for support, from practical guidelines and publications about methods and tools to interactive events. You can find an overview of the services offered and projects in the free newsletter and on the Group website.

Member institutes

- Fraunhofer Institute for Industrial Engineering IAO, Stuttgart, Germany
- Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, Germany
- Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany
- Fraunhofer Center for International Management and Knowledge Economy IMW, Leipzig, Germany
- Fraunhofer Information Center for Planning and Building IRB, Stuttgart, Germany



Flooding disaster at Fraunhofer INT

The flood as an opportunity

On Thursday, July 15, 2021, at 5:53 a.m., the following photos were shared in the Fraunhofer INT Microsoft Teams employee group. "Hello everyone. The INT is completely flooded: laboratory and extension building on the first floor 50-70 cm, basement totally flooded, the old building first floor approx. 10-20 cm. Power out since midnight." was the accompanying message from one Fraunhofer INT employee. When the flood water reached the institute during Wednesday night, a few employees were still on site monitoring experiments. Luckily, they were able to stay safe on the upper floors. They had to wait it out until the following morning before they were able to leave the institute. The employees who weren't immediately affected, first noticed that something wasn't right when they tried – from home, of course, due to Covid-19 – to access their emails, the intranet or the Fraunhofer INT website the next morning, to no avail. Several hours went by before it became clear what had happened, and it was weeks and months before the true extent of the damage was grasped.

Extreme weather in North Rhine-Westphalia and Rhineland-Palatinate

In mid-July 2021, severe weather conditions shook North Rhine-Westphalia and parts of Rhineland-Palatinate. Extreme storms on July 14, 2021, caused widespread flooding in Euskirchen, Germany, among other places, which affected the Fraunhofer INT site. The entire site was flooded. The power of the flood was so great that various parts of the building were totally submerged; at times, the entire building was under up to 86 cm of water and the basement was totally flooded.

Immediate clean-up

On July 16, the water had receded far enough that institute employees were able to visit the site for the first time and begin the initial clean-up work. Train tracks and roads were so badly damaged, however, that it was very hard to reach Euskirchen at all. Employees from outside the town were advised to stay at home and not try to come to the institute. In the first days after the flood, the clean-up was primarily focused on removing the mud and water from the building, along with furniture which was damaged beyond repair, carpets, books and other objects, and also moving experimental and IT equipment to the upper floors.

One of the biggest problems was the internal communication between the individual institute employees. At first, communication was only possible via Microsoft Teams and a newly set up Signal Group. But numerous employees didn't have access to these channels. Some of them were affected by the floods in their own homes and didn't have access to computers or the internet. What's more, the town center in Euskirchen and some of the neighboring towns and villages had no power, telecommunications or mobile signal for multiple days, and in some cases weeks – for a while it wasn't even possible to reach the emergency services. It wasn't until a week after the flood that it was sure that all Fraunhofer INT employees were thankfully unharmed, at least physically. A crisis hub was set up on site to help analyze the situation as quickly as possible, determine the next actions and take steps to resolve the damage.

Flooding disaster at Fraunhofer INT

Fraunhofer INT on July 15, 2021, the morning after the flood

Damage

The initial, basic clean-up operation revealed even more damage caused by the flood water to the buildings, inventory, experimental equipment and the laboratories. The infrastructure, which is the basis for the work carried out at the experimental department of Fraunhofer INT, was fundamentally damaged. Because the basement was completely flooded, the experimental equipment stored there was damaged beyond repair. But there are numerous individual stories and losses, which are somewhat hidden beneath the collective damage of the flood disaster. Raphael Wolf, a colleague in the experimental department of the institute, tells of his experiences with the laser system at Fraunhofer INT: "I saw the laser for the first time in 2012. It was my job to build a unique system from this laser and various optical components, a laser system for investigating radiation-induced single event effects (SEEs) in semiconductor components. In 2013, we were able to complete the first tests on components with the first version of the system. After comprehensive reworking, we were in the position to carry out tests on electronic components which hadn't been possible in this way in Germany up until that point. In 2019, we purchased a new laser and integrated it into the system. But that meant yet more comprehensive adjustments and tweaks. There were multiple setbacks, I often had to dismantle structures, rethink and rebuild again. I had to readjust the optical components countless times, measure and adjust beam paths again, write new software – I could go on forever. All in all, there was so much time, work and stress invested in this project. But it was worth all the trials and tribulations. In the end, we had a system in the basement that was totally unique to Fraunhofer INT and I had played such a big part in that. It was very hard for me to see the laser room after the flood, after all the time I had put into it. The entire laser system was completely destroyed by the water and can't be repaired. The flood has destroyed all my work from recent years and it can't be easily rebuilt in a short time, or indeed rebought." That is just one of the many personal stories showing how individual and emotionally charged losses can be in the wake of disaster like this.

First successes

One of the first big successes, one week after the flood, was establishing a temporary emergency computer center at Fraunhofer FKIE in Wachtberg. This allowed employees access to the VPN and thus to the institute network and other vital services for their work. Luckily, most of the IT equipment and the entire data inventory was able to be saved without losses. From this point on, the Fraunhofer INT employees were largely able to work from home again, providing their work didn't rely on experimental devices and on-site infrastructure and they hadn't been affected themselves by the flood. Nevertheless, in the last few months, people had been severely lacking in the face-to-face contact they needed to work collaboratively but also to help them work through the crisis together.

The experimental environment wo months after the flood.

Rebuilding

After the urgent clean-up phase was complete, work on a preliminary rebuilding concept for Fraunhofer INT started in collaboration with an architect's firm. In large parts of the new-building, including the laboratory wing and the offices, the dry-wall, the floor and the screed below were removed initially. Rebuilding these areas is planned for 2022 and 2023. Large parts of the institute were closed off for these construction works and couldn't be accessed. As part of the rebuilding process for the experimental infrastructure, some of the experimental equipment was checked, recalibrated and put back into operation. But some of the equipment needs to be repurchased. The IT infrastructure at the institute was also rebuilt step-by-step in the final months of 2021 and onwards.

Container village and branch office at Schillingstraße

To create replacement spaces for the experimental department and the practical areas such as the electronic and mechanical workshops, a container village was built on one of the institute parking lots. On September 17, 2021, around 40 office and laboratory containers were officially opened and furnished for work. To be able to offer those employees who had been almost exclusively working from home up until that point both office and meeting space, Fraunhofer INT also rented space in Euskirchen. Just half a year after the flood, the branch office at 1a Schillingstraße in Euskirchen was opened, after renovation, furnishing and IT infrastructure set up. There are currently approximately 30 workspaces available for employees there.

Looking to the future

Just half a year after the flood, at the end of 2021, there was still plenty of change at Fraunhofer INT. For the most part, employees from the non-experimental areas of the institute are able to work from home as usual. However, we mustn't forget that some individuals or their relatives and friends were affected by the environmental disaster privately too, which in turn affected the working situation. After now more than two years of pandemic, many employees are tired of the isolation of working from home and want to get back to more face-to-face meetings and conversations with colleagues. So, it's all the more positive that the Schillingstraße building opened in December, giving employees access to office space and opportunities to meet colleagues again.

At the end of the year, the experimental and practical areas of the institute also found themselves between rebuilding and restarting project work. Although some of the infrastructure and equipment for experiments was still being restored or repurchased, some business units were able to restart a considerable amount of their work despite the flood being such a fresh memory.

With some time to reflect on the events, it is clear that the disaster could also offer a big opportunity. It's the opportunity to not just repair the damage, but to rebuild the institute better than before, with new possibilities. Even though there is a long way to go before the institute considers itself to be in a normal state, which can sometimes feel overwhelming, it is equally important to look back and see just what Fraunhofer INT has already achieved since July 15, 2021 (and in general), thanks to its motivated employees, their considerable perseverance and a network of reliable partners. And with this certainty, Fraunhofer INT continues on its journey of

Flooding disaster at Fraunhofer INT

Container village at Fraunhofer INT

rebuilding.

At this point, we'd like to again sincerely thank all our partners, Fraunhofer research units, friends and supporters who have helped us both during the immediate emergency clean-up phase and also during the ongoing reconstruction. We'd like to especially thank the Bundeswehr service center in Bonn, the Informationstechnikbataillon 282 Kastellaun (the Cyber and Information Space battalion) and the C3 Department from the Fraunhofer headquarters. You can find more in-depth information on how the flood has affected the individual business units and groups in the relevant reports within this Annual Report. You will also be able to read about how the rebuilding of the institute is progressing in 2022, in our Annual Report 2022.

Milestones

July 15, 2021	Fraunhofer INT is flooded
24 hours	People are allowed inside the institute again, initial clean-up begins
48 hours	Emergency generator for power supply
5 days	Bundeswehr arrives to support the clean up process
8 days	IT emergency operation, access to VPN and institute intranet, possibility to work from home
10 days	All water is removed from basement
11 days	12 construction dryers are set up to dry out the building
12 days	Non-experimental work is mostly able to take place from home
3.5 weeks	WiFi in the old building
4 weeks	Telephones are functioning again
5 weeks	WiFi in the new building
5 weeks	Results from the pollution analyses – the mud is not contaminated
6 weeks	Experiment hall is mostly clean
7 weeks	Work starts on the rebuilding concept
2 months	Container village set up
2 months	First irradiation session since the flood
2 months	The cabled network is functioning again
3 months	Experimental devices and equipment are still being dismantled and refurbished
4-5 months	Demolition of drywall and screed in the new building
5 months	Branch office space opens

To be continued in the Annual Report 2022

Business Units

WZA
Defense Technology Foresight

TIP
Public Technology and Innovation Planning

CTF
Corporate Technology Foresight

TFU
Group Technology Foresight and University Hub

KLAB
KATI Lab Group

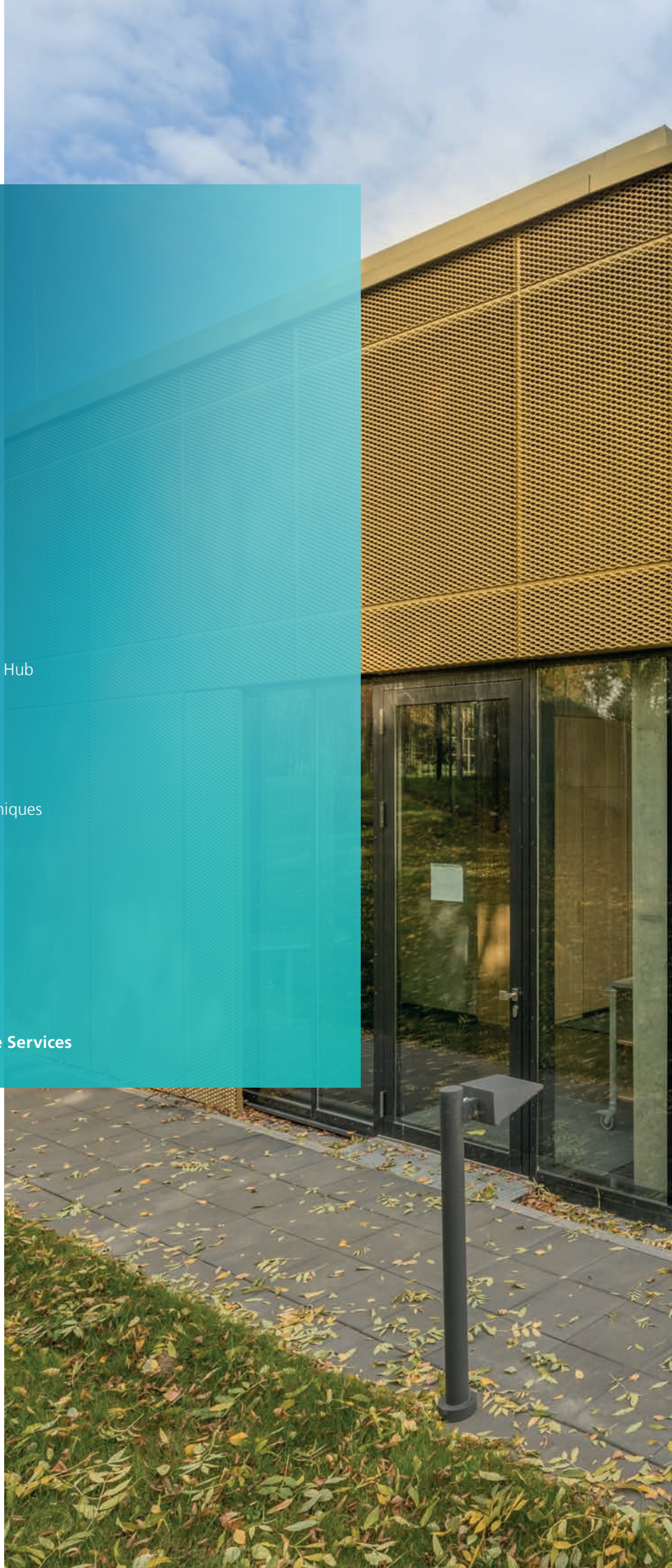
NSD
Nuclear Security Policy and Detection Techniques

EME
Electromagnetic Effects and Threats

NEO
Nuclear Effects in Electronics and Optics

Scientific and Technical Infrastructure

Business Administration and Corporate Services



Defense Technology Foresight – WZA

Focal topic

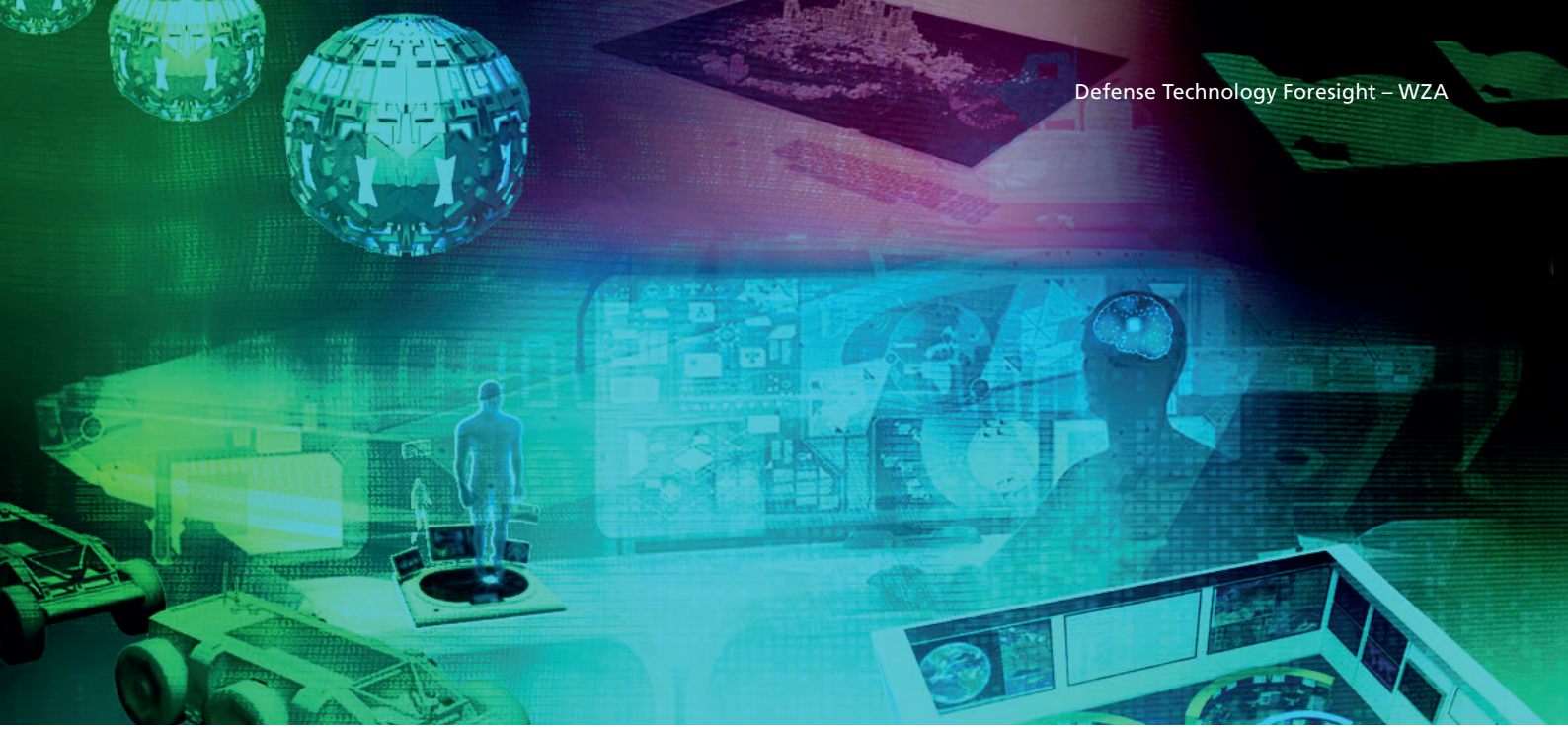
Defense Technologies Forecast for the Bundeswehr

The Defense Technology Foresight (WZA) business unit conducts long-term, technology-oriented futures research (technology foresight) for public clients in the defense sector. Its institutional mission is to operate the technology radar for the German Federal Ministry of Defence (BMVg) and the Bundeswehr, and to provide evidence-based, technology-oriented decision support for its clients' strategic planning processes. Furthermore, WZA is an important information broker for BMVg and Bundeswehr regarding the results of technology-oriented futures research, ensuring a continuous transfer of knowledge to this effect. In addition, it also provides services to international clients such as the European Defence Agency and NATO.

The interdisciplinary futures research of the business unit helps to ensure that clients are provided with reliable orientational and decision-supporting knowledge regarding probable future developments in science and technology and any possible military implications. As a result, WZA contributes to guaranteeing a broad analysis and assessment capability of clients in regard to long-term technological developments, their potential relevance to defense technology and, in this regard, a realistic further development of the Bundeswehr's range of capabilities.

The principal product of the WZA business unit is the Defense Technologies Forecast (Wehrtechnische Vorausschau, WTV), which is compiled for the Bundeswehr on a quarterly basis. This is the regular significant achievement of the business unit, which prepares a total of, annually, 13 WTV analyses and updates on selected technology issues as well as long-term future concepts. The biannual workshops with the client side on the relevant results, however, could not have been executed last year due to the pandemic and the flooding at Fraunhofer INT. With representatives from the now significantly broader civil user base for the WTV – expanded by multiple authorities and civil security organizations – there was a series of discussions on how this expertise of Fraunhofer INT can be more deeply integrated in the future.

Also, the 4th Future R&T Situation Picture conference was unable to take place again in 2021 due to the pandemic. During this event, a future R&T situation picture was to be drawn up for the R&T Director of the BMVg, with various organizations from the BMVg and the Bundeswehr that were expected to be participating. Instead, a future R&T situation picture was created from the future-relevant topics selected, prioritized and evaluated as most relevant for the WTV by Fraunhofer INT. This expanded the Future R&T Situation Picture from previous years, discussing newly identified future-relevant topics.



As part of the ongoing project to analyze the international defense technology research in partner countries, NATO and the EU, the countries covered in 2021 were Finland, Norway, Sweden and India.

In the past year, as part of an assignment by the Swedish Defence Materiel Administration (FMV), brief technology analyses were carried out on selected individual topics. At the NATO Science and Technology Organization (STO), WZA works with multiple representatives in the Research Task Group SAS-159 "How could Technology Development Transform the Future Operational Environment". Work on the multi-year project DECISMAR (Development of a Decision Support Toolbox for enhancing the feasibility study of the Upgrade of Maritime Surveillance through the integration of legacy assets with new innovative solutions) also began, subcontracted by a consortium of companies, as part of the EU Commission's European Defence Industrial Development Programme (EDIDP). In 2021, WZA scientists participated as Foresight Experts in the workshops on "Energy for Future Generation Infrastructure and Platforms" and "Propulsion for Air and Space", as part of the European Defence Agency's "Technology Foresight Workshops", which have been running since 2018. Across the business units, particular contributions were made to the EDA's study "High-Power Electromagnetic Munitions (HPEM)", here acting as coordinator and in other roles, and to the Fraunhofer-internal studies "Crisis management and resilience – Corona" (KResCo) and "Resilience of urban habitats" (RuLe).

The teaching and committee activities of WZA include providing specialist support to the Command and Staff College of the Bundeswehr. WZA had a stall and held a lecture at the "InnoDay 2021" of the Command and Staff College, organized in cooperation with the Cyber Innovation Hub of the Bundeswehr, there leading a discussion on the topic of innovation. WZA also presented the module "Methods for future analysis". Furthermore, the technical design of a course on "foresight methods" at the University of Applied Sciences Ravensburg-Weingarten was supported by WZA. Finally, one team member of WZA continued to support the NATO program "Science for Peace and Security" by providing expert opinions in the "Independent Scientific Evaluation Group" (NATO-SPS-ISEG) as a member of this group.

International

Further expansion of activities involving NATO, the European Defence Agency (EDA) and the EU Commission

Public Technology and Innovation Planning – TIP

Strategic research and development planning for the civil public sector

The Public Technology and Innovation Planning (TIP) business unit supports the design of strategic research and innovation planning for national and European public sector clients. Services range from advice on research agendas at governmental/European level to strategic capability planning at agency/organizational level.

The Business unit's thematical focus of methodological support is the field of disaster management and resilience. However, areas outside these security research topics are playing an increasing role, such as the development in rural areas or in the area of space applications (Pg. 60).

To this end, TIP offers a wide range of innovation and technology management methods:

- Assessing and identifying technological and innovation needs, e.g., by using participatory methods
- Screening of possible (future) technological and non-technological solutions
- Analysis of organizational, societal and political factors of the potential solutions
- Development of research roadmaps for policy-makers
- Creating innovation road maps for users
- Identifying and developing critical success factors and key performance indicators for the needs-based evaluation of new technological and non-technological solutions
- Continued development and adaptation of knowledge transfer methods to establish cooperation and networks

TIP's expertise is reflected in numerous third-party funded activities that were successfully conducted in 2021, despite serious challenges for the department due to the pandemic and the flooding of the institute. In many ways, 2021 was a significant feat for the business unit, meaning it is even more proud of its achievements.

In the focus area of the business unit, the EU Horizon 2020 (H2020) Project RiskPACC (2021-2024) was started and is coordinated by TIP. It is using a co-creative approach to facilitate interaction between citizens and Civil Protection Authorities (CPAs) to jointly identify their needs and develop potential procedural and technical solutions to build enhanced disaster resilience.

A further H2020 project kicked-off in 2021, also coordinated by TIP, is Firelogue (2021-2025), launched as a coordinating and support action under the European Green Deal to connect and accompany 3 major innovation projects on forest fire risk management. The new project PANDEM-2 (H2020, 2021-2023), is focused on developing new concepts to improve public health management and communication during pandemics.

Excellent networking and extensive third-party funded activities covering the 2021 highlights of the promising start of two H2020 project coordinations and the successful conclusion of a coordinated national project.

The H2020 project IN-PREP (2017-2021) was successfully completed, creating a training platform and a handbook on cross-border collaboration in crisis situations. Within the H2020 project FIRE-IN (2017-2022), TIP provides systematic support to an international network of fire services and first responders in needs assessment, solution finding and innovation planning. In the H2020 project STRATEGY (2020-2023), TIP and the Nuclear Security Policy and Detection Techniques (NSD) business unit are collaborating to develop standards for civil security.

On a national level, the Fraunhofer project KResCo, headed by TIP, was successfully completed, deriving policy recommendations from the COVID-19 pandemic measures (Pg. 52).

TIP, together with the Technology Foresight and University Hub (TFU) group, the Defense Technology Foresight (WZA) business unit and the Electromagnetic Effects and Threats (EME) business unit, focused in 2021 on the resilience of urban habitats as part of the Fraunhofer-internal project RuLe. Coordinated by the Federal Agency for Technical Relief (THW), the Research Network for German Users (ForAn) was started (2021-2024), which TIP contributes to advising on participation in European security research.

As part of the BMBF project InnoBOSK, TIP, together with WZA and TFU, supported the networking and improved future innovation planning for users with small and medium enterprises (Pg. 56).

TIP conducted an initial study for the German Federal Office of Civil Protection and Disaster Assistance (BBK) on the interdependencies between artificial intelligence applications and critical infrastructures.

Within the BMBF project UrbanAware TIP supported the Cologne Fire Service in the application of a Horizon Europe Project. Outside security research, TIP is involved in the H2020 Project SHAPES (2019–2023), which concerns the development of digital solutions for supporting and extending healthy and independent living for older individuals.

The national "Neue Wege der Prävention BAU" [New prevention methods] project (2020-2023) is running under the INT-internal leadership of the Corporate Technology Foresight (CTF) business unit and aims to contribute to minimizing accidents in the construction industry.

TIP also contributed to the informal expert group on Strengthened Security Research and Innovation (SSRI) as part of the Community for European Research and Innovation for Security coordinated by DG HOME, and to the expert committee on torrential rainfall of the Presidential Council of the German Fire Protection Association (vfdb). TIP represents the Fraunhofer Segment for Defense and Security (VVS) in the EARTO Working Group Security and Defense Research and is a member of the Bonn Network for International Disaster Prevention and Risk Management. TIP is also active in the Fraunhofer Group for Innovation Research, the Civil Security Research Innovation Cluster (InCluSiF – Innovationscluster Zivile Sicherheitsforschung) and as a consultant for large research projects.

Corporate Technology Foresight – CTF

The Corporate Technology Foresight (CTF) business unit supports organizations in addressing strategic issues. To this end, our main priority is technology-oriented future and innovation research. In the process of this, we look back on longstanding expert knowledge from the areas of technological foresight and strategic planning.

Businesses that act with foresight and want to position themselves resiliently for the future need to deal with trends, drivers and the resulting opportunities and risks in a structured manner. In the future technologies sector in particular, looking solely at product technologies is not sufficient – more importantly, a comprehensive view must be taken at the component and system levels as well as of sub-technologies and customer requirements. Only then can new business model ideas be generated.

The Corporate Technology Foresight (CTF) business unit supports organizations in addressing strategic issues. To this end, our main priority is technology-oriented future and innovation research. In the process of this, we look back on longstanding expert knowledge from the areas of technological foresight and strategic planning. In order to include other relevant aspects, from the field of business or wider society, for example, we cooperate with excellent partners such as the Fraunhofer Group for Innovation Research. Customer-specific analyses and technology-oriented research methods can be used to expand the existing short-term perspective (3-5 years) held by many businesses to a long-term perspective (5-20 years). As part of these analyses, future technologies that are relevant to the company can be identified and assessed, attention can be focused on technological "white spots" or complex technology fields and their company-specific implications can be broken down. This information creates a sound basis for the development of long-term technology strategies.

Projects

Hydrogen for the local economy
Hydrogen is one of the building blocks that can significantly contribute to the future reduction of CO_2 emissions and reducing energy costs worldwide. The office for economic development Euskirchen in cooperation with CTF, held an initial workshop on the topic of hydrogen for the local economy, connecting various actors and assessing their needs. It also included a presentation by Fraunhofer INT on hydrogen in general, its various opportunities for connection and potentials for different industries. During the event participants also had the opportunity to discuss interests, opportunities, challenges and risks which can and should be considered from the point of view of the companies in the future.

Future research for small and medium-sized enterprises (SME)

According to the definition of SMEs in 2021, the EU Commission counts 99.4% of all German companies as small and medium-sized enterprises (SMEs). They generated around 2.32 billion euros and are therefore, rightly, considered the backbone of the German economy. Especially for technology intensive SMEs which, in comparison to larger firms, have a rather short-term, needs-oriented product and process development chain, there is great uncertainty due to the ever-faster advancement of technological change. They face many questions such as "what will we do in the future?" and "what is disruptive for current business?". At the same time, they face the challenge that strategic development based on pure instinct is no longer sufficient. Together with SMEs, the CTF business unit led orientation workshops and developed formats for structuring such strategic future-oriented questions and deriving strategic moves.

Strategic forecasting for the European Space Agency (ESA)

As part of a "de-risk" process, Fraunhofer INT, together with Ecole Polytechnique Fédérale de Lausanne (EPFL), was awarded the contract by the European Space Agency (ESA) to identify the requirements for expansion of and/or redesign of the existing (technology) foresight activities. Over a period of five months, the key requirements for the instruments for strategic technology foresight were identified, using interviews and workshops with ESA experts, representatives from national aerospace agencies and external foresight experts. These requirements allowed the team to sketch the outline of a future "Technology Foresight System". The planned follow-up project should take this to proof-of-concept stage.

The relationships between the most varied technological, societal, economical or political spheres of influence are extremely complex. As a consequence of this, the flow of information, not only in the scientific community, but also in the media, is growing stronger and stronger. A systematic, scientifically founded analysis is therefore required to prepare properly for future needs.

Group Technology Foresight and University Hub – TFU

TFU in a nutshell

The core tasks of the TFU Group currently include:

- Coordination and continuous development of connections with higher education
- Knowledge management
- Active development and testing of tools and methods
- Project work

The future is not here (yet), but it does not just appear out of nowhere, instead it is rooted in the past and the present. In 2021, the Tools and Methods (TM) group had a fresh start. Part of the TM group was transformed into the Technology Foresight & University Hub (TFU) with an expanded range of tasks. The other part of the group became the KATI Lab (Pg. 30).

As TM did before, TFU takes on the scanning and testing of tools and methods to drive and coordinate both development and implementation. This is all done with a view to the central theme of technology foresight and also includes broader subjects such as knowledge management. While this aspect of the work is clearly reflected in the first half of the new group name, the second half of the title points to the future, expanded work of this group – making connections with higher education institutions via a university hub. Fraunhofer INT has been working with higher education institutions for a long time, including the Hochschule Bonn Rhein-Sieg University of Applied Sciences and RWTH Aachen University. These existing affiliations have led to thesis projects and student assistants working on projects. With the founding of TFU, these existing activities are to be continued and better coordinated, in order to intensify their close integration with further methodical development.

Alongside numerous courses on various aspects of the technology foresight methodology (e. g. on quantitative methods) and questions on future technology in various areas (e. g. the future of mobility), issues specific to the institute were also gainfully researched in a variety of dissertation projects (from bachelor's to PhD). The topics were as diverse as the research areas of Fraunhofer INT itself. Fundamental questions were discussed on the role of foresight studies in decision-making processes, the role of various drivers in future mobility concepts and the transfer of scientific knowledge in policy documents.

These activities were reflected in the projects in which TFU cooperated with other Fraunhofer INT groups and business units. In all these projects, TFU provided methodological and content-related support and used the expertise gained in the context of the affiliation with academic institutions. The Fraunhofer project "KResCo" (Crisis management and resilience – Corona) investigated the decisions and developments of various countries and research organizations during the pandemic and developed a methodology that incorporates both data and expert knowledge to create a classification system for the coronavirus research (Pg. 54). This classification system was used to look more closely at the response of various

European research organizations to the pandemic, in terms of their research, and to place it in the context of the national research in individual countries. The projects "Fraunhofer Microelectronics Innovation Enhancement" (FRAME) and "Foresight Fraunhofer" were successfully concluded, the latter in the form of the Fraunhofer Foresight Days. The institute was by no means unaffected by the flood disaster in July 2021. So, it is all the more remarkable that the Resilience of Urban Habitats (RuLe) project includes studies on a torrential rain scenario. The findings from this project can thus play a valuable role in better coping with future disasters. They have, for example, been presented at the Fraunhofer Solution Days. We should also note that TFU played a role in a project with the German Science Council and the Federal Ministry for Food and Agriculture (BMEL) which focused on the topic of food and agriculture research. Beyond that, work continued on the national reports for the Defense Technology Foresight (WZA) business unit. Alongside these projects and activities, TFU was also responsible for developing small-scale software tools that can increase the efficiency of quantitative analyses. One example of this is the programming of a software to translate search queries with respect to different search syntax constraints of various scientific literature databases.

In 2021, a major project was launched to merge the two pillars of the TFU Group. The envisaged Competence Center – Strategic Foresight (CC-SF) will enable scientists and a pool of research assistants to take the above-mentioned links with higher education to a new level in the future. The CC-SF, which will also feature an innovation laboratory, will focus on and further develop the methodological spectrum of Fraunhofer INT. The expertise gained from the CC-SF will also feed into future projects.

The CC-SF is still in its infancy, but work on the future of this new and exciting project draws on the experience of many previous projects and activities. This broad portfolio forms the basis for the new TFU Group's progress and allows it to embrace the future in an optimistic manner. The future may not be here (yet), but it has certainly begun.

KATI Lab Group – KLAB

The KATI Lab Group, founded in 2021, explores data-driven foresight, tackling which data can be used for foresight processes, how they can be collected and which methods can be used.

Foresight processes rely on accessing and processing vast amounts of data, information and knowledge, and approaching this content from different angles to draw relevant conclusions. What data can you use? How do you tap into it and what methods do you need? These are the core questions of data-driven foresight, the focus of the newly founded KATI Lab. The KATI Lab was officially founded in 2021 from the former Group Tools and Methods (TM). The Technology Foresight and University Hub (TFU) group (Pg. 28) was also formed from former TM.

The KATI Lab works on two core tasks. On the one hand, it focuses on expanding the scientific basis behind data-driven foresight, that is, answering the question of how you can generate knowledge from the abundance of available data and how you can integrate this usefully into a foresight or innovation process. This primarily involves developing and evaluating suitable methods. Supporting other business units in their projects is a key part of this, as well as helping address their questions using suitable data and methods.

The second important pillar is the further development and marketing of the KATI system (Knowledge Analytics for Technology & Innovation). This was developed over the last few years, out of the motivation to make the Science Observatory – the continual monitoring and analyzing of every possible area of science and technology – at Fraunhofer INT more efficient. The KATI system is used on a daily basis by scientists at the institute, set up with state-of-the-art methods from the fields of data mining, bibliometrics and visualization, to find new possibilities when tapping into and analyzing scientific sources.

The last year was defined by the pandemic and the fact of having to work in virtual space. So, it was an advantage that the KATI Lab, which is responsible for the development of KATI, had already been working closely together for several years. Due to the strong focus on software development, it was relatively easy for the team to start working from home. At the same time, this focus is also a bit of an Achilles' heel: When the waters of the Erft flooded the basement at Fraunhofer INT in July 2021 and the power went out, the servers of course also failed. As a result, the KATI team was really limited in their work on further developing the system initially. It would not have taken much – only 3 cm – and the system hard drives would have been flooded. However, thanks to the tireless work of the Fraunhofer INT IT team, KATI was up and running again just two weeks after the floods.

Over the last year, KATI Lab has been primarily focused on three outstanding projects. The first is KATI4 Fraunhofer, promoted by the Executive board, to make the KATI

System available to all employees at the Fraunhofer-Gesellschaft. The primary challenge for the team with this project is integrating KATI into the existing IT infrastructure of the entire Fraunhofer-Gesellschaft. This meant, for example, that the login procedure had to be switched to a single-sign-on process. Together with the relevant departments at the headquarters, a ticket system also had to be set up so that support questions and error logs could be worked through more efficiently. At Fraunhofer INT, colleagues simply needed to know who to call in the KATI Lab team – but with a potential 28,000 users, that system would soon collapse.

The second large project was collecting the dimensions data for KATI, which is described in the report on page 50.

Finally, in September 2021, the team completed a project for the Bundeswehr Office for Defense Planning which had begun practically at the same time as the Covid-19 pandemic, in March 2020. A non-technical study for the department of future analysis and the innovation departments at the office for planning investigated how (partially) automated processes for data and text analysis could support the departments' work. Together with the Public Technology and Innovation Planning (TIP) business unit and the Technology Foresight and University Hub (TFU) group, the KATI Lab made great steps in assessing the needs of the departments and collecting a variety of use cases. The second step was then to investigate which methods and data were relevant for addressing the use cases and to draw up possible solutions. One challenge for this project was that all the planned interviews and workshops had to be carried out online. Particularly at the start, when all the participants still had to get used to the technology, this was a big challenge. Only the conclusion workshop was able to take place in person and was particularly enjoyed by all the participants.

Due to the pandemic, trade fair appearances were few and far between and primarily took place virtually. As well as the Hannover Messe, this also affected the various scientific conferences in which KATI Lab participated in one form or another, such as the International Conference on Scientometrics & Informetrics and the Global Tech Mining Conference. Only in November, was KATI presented live at the InnoDays of the Bundeswehr Command and Staff College in Hamburg. The various courses at RWTH Aachen University and the Rhenish Friedrich Wilhelm University of Bonn, in which KATI Lab participated, were also carried out almost completely online. The FU Berlin was the only university where initial experience with the concept of hybrid teaching could be gained.

Nuclear Security Policy and Detection Techniques – NSD

PhD "Digital Pulse Processing Methods for Simultaneous Efficient Detection and Identification of Neutron and Gamma Radiation of Novel Detection Materials"

In the past year, a PhD on the simultaneous detection and identification of neutron and gamma radiation with pulse shape analysis in novel detection materials was completed in the business unit.

The Nuclear Security Policy and Detection Techniques (NSD) business unit investigates technical questions in the field of nuclear security policy, evaluates existing and develops new detection techniques and processes for nuclear and radioactive materials, with the help of theoretical and experimental research and development. In addition to fundamental research on that topic, the business unit also works on research projects for industry and public clients. Furthermore, the national judgment capability in the field of nuclear and radiological weapons and the associated asymmetric threats is deepened and expanded.

By combining the assessment of technical issues regarding nuclear security policies and the continued development of nuclear detection techniques and processes, the business unit is able to act as well competently on associated issues in international organizations as to examine specific questions posed to national authorities and companies in regard to protection against nuclear hazards. The expertise is also used to work on a variety of projects, such as the Horizon 2020 Project STRATEGY (Facilitating EU pre-Standardisation process Through streamlining and vAlidating inTeroperability in systems and procEdures involved in the crisis management cYcle) in cooperation with the Public Technology and Innovation Planning (TIP) business unit. The project deals with the development of a European framework of pre-standardization in crisis management.

In cooperation with the Faculty of Georesources and Materials Engineering at RWTH Aachen University a PhD was completed. The focus here was on the analysis and comparison of digital Pulse Shape Discrimination Methods (PSD) by investigating the new detector material CLYC:Ce. It enables simultaneous detection and identification of gamma and neutron sources, whereby the gamma rays are detected via a scintillation process and the neutrons via a nuclear reaction with the isotope Lithium-6 contained in the CLYC:Ce.

The dynamic part of the Qualification Test System for Radiation Detection Devices QuTeSt was further developed in collaboration with the Scientific and Technical Infrastructure (WTI) group for the use in the investigation of portal monitors for vehicles. There is now a greater available track length, the source can be elevated up to five meters, and can reach a driving speed of 2.2 m/s. The updated system was used during a measurement campaign in spring, which included successful dynamic testing both of a truck portal monitor and various handheld measuring devices for the detection of radioactive material.

Part of results of the work carried out was presented at multiple international

conferences. The opportunities to make new contacts and meet up with existing ones was, however, very limited this year, since any conferences which did take place were virtual. For the first time, the annual conferences of ESARDA (European Safeguards Research and Development Association) and the INMM (Institute of Nuclear Materials Management) took place as a joint event under the title "Advancing Together: Innovation and Resilience in Nuclear Materials Management". This conference is one of the largest scientific events of its kind in the field of nuclear monitoring and verification methods. It is characterized by highlighting both political issues and the technical detection-related aspects. Test results obtained by using the dynamic QuTeSt system about a portable measuring device were presented.

Furthermore, within the framework of the Science and Technology Conference SnT2021 run by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), results were presented which show the influence of different firmware versions on the measurement results for radioactive sources, using the example of the handheld measuring device D3S from Kromek. An influence of the internal evaluation of the measured values was shown, so that the evaluation of the measured data must always consider the used device and its qualification, i.e. hardware and measurement value evaluation, is necessary.

Also the NSD business unit was affected by the flooding. While the office work could be continued almost largely uninterrupted, the experimental infrastructure was seriously affected. A significant amount of the measuring equipment present was damaged and will be replaced; the tests and repairs with the manufacturers, as well as new purchases, are ongoing.

The business unit continued to participate in standardization activities for radiation detectors; in the DIN/VDE in Germany and internationally in the appropriate IEC or ISO committees. Here the focus is on the standards on illegal transport of radioactive materials (illicit trafficking).

Fortunately, the simulation activities were able to resume relatively soon after the flooding and are now running without restrictions.

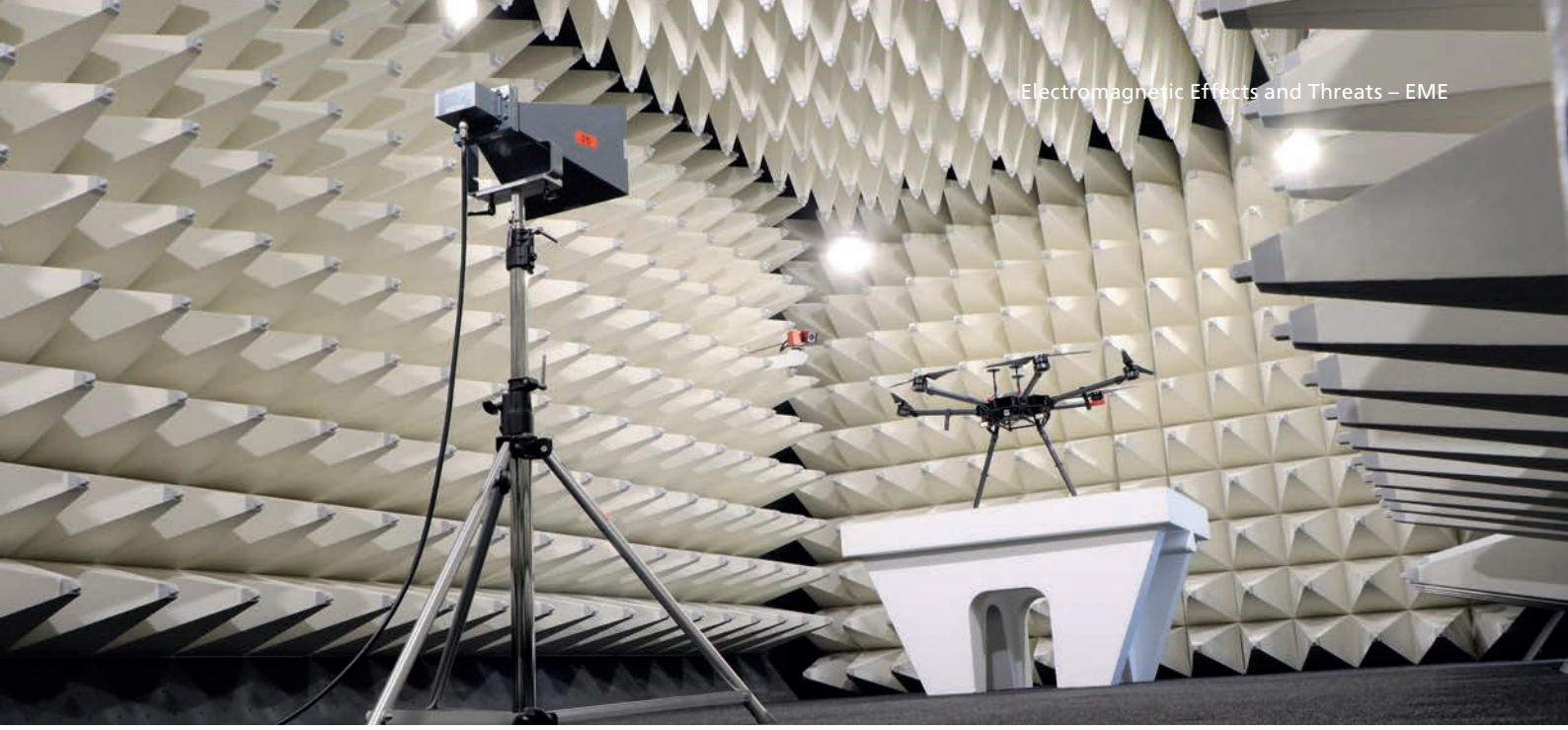
Electromagnetic Effects and Threats – EME

The business unit is engaged in a wide range of standardization activities. This work includes the DIN working group for TEM waveguides and reverb chambers, the German Defense Equipment (VG) standard groups on NEMP and lightning protection and electromagnetic compatibility, as well as participation in the IEC Joint Working Group Reverberation Chamber as the national representative, and the advancement of HPEM standardization at NATO level.

The Electromagnetic Effects and Threats (EME) business unit is tasked with contributing to creating the ability to provide judgment in the field of electromagnetic effects in regard to military threats, using a portion of the base funding from the German Federal Ministry of Defence (BMVg). As this task is only carried out to a certain extent at the German Federal Ministry of Defense (BMVg), the business unit conducts its own theoretical and experimental research, including the continued development of measurement technology, in consultation with the authorities and in collaboration with companies in the defense sector. Beyond the research receiving base funding and contract research projects for the BMVg, work for clients outside of the defense sector (civil security research) and industry projects is also of significance.

The business unit's experimental work on electromagnetic threats caused in particular by high-power microwaves (HPM), includes studies on electromagnetic field coupling into structures and specific systems as well as the vulnerability of electronics to high-intensity fields (high power electromagnetics, HPEM). The test objects range from IT devices and systems based on current IT technology and, in particular, wired and wireless data transfer technology (network engineering), to civil communication technology and components of critical infrastructures. Furthermore, fundamental investigations and experimental work are ongoing on methods for detecting electromagnetic threats, in particular from HPEM.

The business unit has access to a TEM (transverse electromagnetic mode) waveguide for frequencies up to several gigahertz, developed in-house and located in a shielded hall. Using this equipment, linear coupling measurements for determining transfer functions and investigations on electromagnetic compatibility (EMC) can be carried out at a wide range of frequencies. Moreover, studies into the susceptibility of objects measuring up to several meters in size can be conducted using constant and pulsed fields with field strengths measuring up to several kilovolts per meter (kV/m). For measurement tasks outside of the institute, the business unit uses a mobile HPM irradiation facility, which was also developed in-house. This system can also generate field strengths of several kilovolts per meter (kV/m) at a wide range of frequencies using various antennae for irradiation. These systems are complemented by a reverberation chamber equipped with high-power sources for generating even higher field strengths in the gigahertz range in order to account for the growing range of modern sensor and communications technology applications at these frequencies. The business unit also operates numerous high-frequency and microwave measuring equipment. A construction project for an



anechoic chamber, which was partially funded by the central strategy fund of the Fraunhofer-Gesellschaft, was completed, resulting in a new test environment for the business unit.

This business unit, like the other areas of the institute, was seriously affected by the flood disaster in July 2021. In the experimental area, all test environments and shielded measuring rooms have to be disassembled, restored, repaired and rebuilt again. The ongoing projects, including the doctoral candidates working in the business unit, were able to continue or be completed, albeit under significantly more difficult conditions.

As part of the research for the BMVg, a project commissioned by the Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS) in Munster to develop methods and standardizing HPEM test procedures was continued in 2021. The cooperation with the Swedish Defense Research Agency (FOI) on this topic was continued in 2021 within the framework of a technical agreement entitled "Development of High Power Microwave Test Methodology and Procedures".

The business unit is supervising a doctorate "IEMI and Information Security", on the topic of HPEM sensor disruption sensitivity and the effect of HPEM on information security. In 2021, as part of the Marie Curie ETN EU project "Pan-European Training, Research and Education Network on Electromagnetic Risk Management – PETER", for which the business unit is one of 19 project partners, a doctorate on the topic of "EMI Risk Management on the scale of the Smart Grid as a network of systems" was continued. The results for risk management regarding electromagnetic interference for critical infrastructures such as the Smart Grid were presented at the virtual conference EMC Europe 2021 and at the Kleinheubacher Tagung 2021 (the German forum of the URSI). The project "SMARTKRIT – Smart, adaptive energy management in the case of crises using existing autonomous transport system fleets" was also completed as part of the Fraunhofer Young Research Class 2019 program on the topic of "Resilience of Critical Infrastructures". The business unit also participated in the project "Resilience of Urban Habitats RuLe" in 2021, funded by the Fraunhofer-Gesellschaft.

The extensive work on standardization at the business unit also continues. This work includes the DIN working group for TEM waveguides and reverb chambers, the German Defense Equipment (VG) standard groups on NEMP and lightning protection and electromagnetic compatibility, as well as participation in the IEC Joint Working Group Reverberation Chamber as the national representative, and the advancement of HPEM standardization at NATO level.

Nuclear Effects in Electronics and Optics – NEO

NEO performs irradiation tests based on internationally recognized standards and advises companies regarding radiation qualification and hardening.

The Nuclear Effects in Electronics and Optics (NEO) business unit at Fraunhofer INT specializes in the effects of ionizing radiation on electronic, opto-electronic and optical components and systems. NEO performs these irradiation tests based on internationally recognized standards and advises companies regarding radiation qualification and hardening, for example for satellites or accelerators. Furthermore, the knowledge obtained is also used for the development of radiation sensors. Fraunhofer INT performs irradiation tests primarily at its own irradiation facilities; however, it also has access to external facilities. Its irradiation facilities are unique in Europe and allow the re-creation of all relevant types of radiation, for example, for satellites and the effects induced by these in the laboratory. In addition, the business unit has access to state-of-the-art measurement technology in order to measure even the smallest changes to characteristic parameters.

In the first half of the year, the focus was on continuing the developments of the previous year, on the one hand on investigations into single-event-effects (SEE) and on the other, most notably into the evaluation of commercial off-the-shelf (COTS) electronic components under the influence of radiation. In both cases, it is about research questions on the causes and effects, as well as on the development of new measuring methods and processes.

In 2021, in spite of the ongoing pandemic, multiple campaigns that had previously been delayed by multiple months were able to be continued at external, international accelerators.

Lastly, the business unit presented at several virtual events and published contributions in international peer-reviewed journals. NEO not only contributed with guest lectures but was also involved in the organization of the conference.

On July 14, 2021, everything changed for the NEO business unit within just a few hours. Significant amounts of the experimental infrastructure, as well as all the employees' offices, were hit by the flood.

After it had been confirmed that the radioactive sources were secure, the weeks that followed were predominantly taken up with

clean-up works, securing the equipment that was still usable and preparing to restart work.

Multiple laboratories and the testing systems they contained were completely destroyed, including the laser SEE test system, the X-ray irradiation facility and test rigs like the cryostat for investigating radiation effects at very low temperatures. Other laboratories were at least partially unusable.

Just two months after the flood, thanks to the outstanding commitment of the employees at Fraunhofer INT, the first experiments were able to begin again and the Co-60 systems were provisionally up and running again. From December 2021, neutron irradiations could be performed again.

Despite all these efforts, the effects of the flood will continue to have a big impact on 2022. Investments should result in a gradual return to scheduled operation from what continues to be provisional operation. NEO will use the opportunities that this disaster presents to modernize the infrastructure and to implement new study and investigation methods.

Fraunhofer INT

Effect of gamma radiation on glass

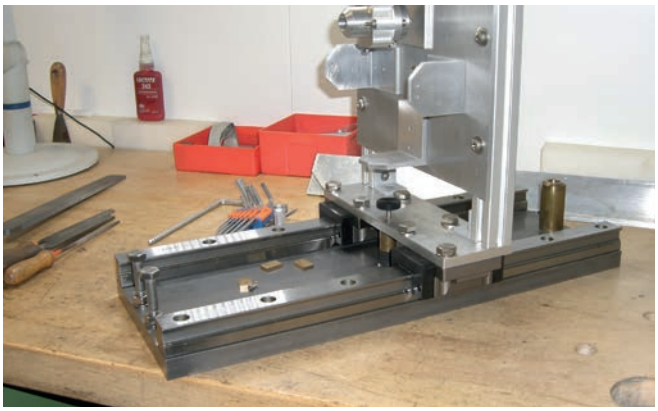
You can find a video showing the effect of gamma radiation from the cobalt-60 sources with two different types of glass here.

Dr. Jochen Kuhnhenn

Scientific and Technical Infrastructure – WTI

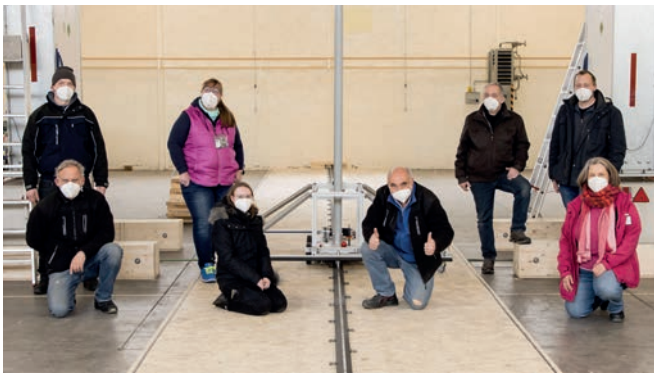
The experimental work in the three business units, Nuclear Security Policy and Detection Techniques (NSD), Nuclear Effects in Electronics and Optics (NEO), and Electromagnetic Effects and Threats (EME) is supported by comprehensive scientific and technical infrastructure. The Scientific and Technical Infrastructure (WTI) working group includes a precision engineering workshop and an electronics workshop. The precision engineering workshop manufactures specialist parts for the experimental equipment and for completing projects. The electronics workshop develops electronics for experiments and projects and maintains and repairs experimental electronics, devices and systems.

After the flooding on July 14, 2021, and up until the end of the year, the working group was predominantly focused on repairing the flood damage. The working group's workspaces were completely destroyed and needed a full clean-up. By moving into a container office, some very limited work was able to restart. The clean-up works and preparation for rebuilding are continuing in 2022.



Precision engineering workshop

For the Nuclear Effects in Electronics and Optics (NEO) business unit, a sample holder was created for fixing the irradiation system TK1000B for a customer project. Four sample containers supplied by the customer are fixed to the holder. The samples in the containers are then irradiated in the machine later on. The photo shows the holder and one of the mounted sample containers.



Electronics workshop

For outside measurements in the Nuclear Security Policy and Detection Techniques (NSD) business unit, the dynamic part of the Qualification Test System for Radiation Detection Devices QuTeSt was modified for longer measuring distances, greater measuring heights and higher speeds. This included planning and carrying out the dismantling and building of the measuring system and the customer measuring portal.

The photo shows the WTI working group, the lower section of the test system in the center, which is guided on a track, and to the left and right are the two measuring portals from Arktis. In contrasting colors you can see the two colleagues from the NSD business unit who lead and execute the measuring campaign.

Office management supports the business unit by:

- providing organizational support for projects, helping generate reports for experimental tests
- regarding radiation protection
- helping to prepare and implement
- workshops
- creating questionnaires (also online)

Business Administration and Corporate Services – BZD

The Business Administration and Corporate Services department performs all commercial and administrative tasks and provides the central infrastructure for the institute.

In 2021, the Central Infrastructure Services Group was split into two groups, Central IT Services (ZIT) and Construction, Estates and Internal Services (BLI). The department also comprises the Finance, Human Resources and Legal Affairs (FPR) and Marketing and PR (MPR) groups, alongside the independent area of Library and Specialized Information Services.

The **Finance, Human Resources and Legal Affairs** group is responsible for corporate procurement, bookkeeping, accounting, controlling, human resources, travel management and event management. In the last year, preparations were carried out for the Fraunhofer-wide introduction of SAP at the start of 2022. This system now includes and supports almost all business processes within the institute. This is an important step forward in digital transformation for Fraunhofer, making it a pioneer among the large German research institutes.

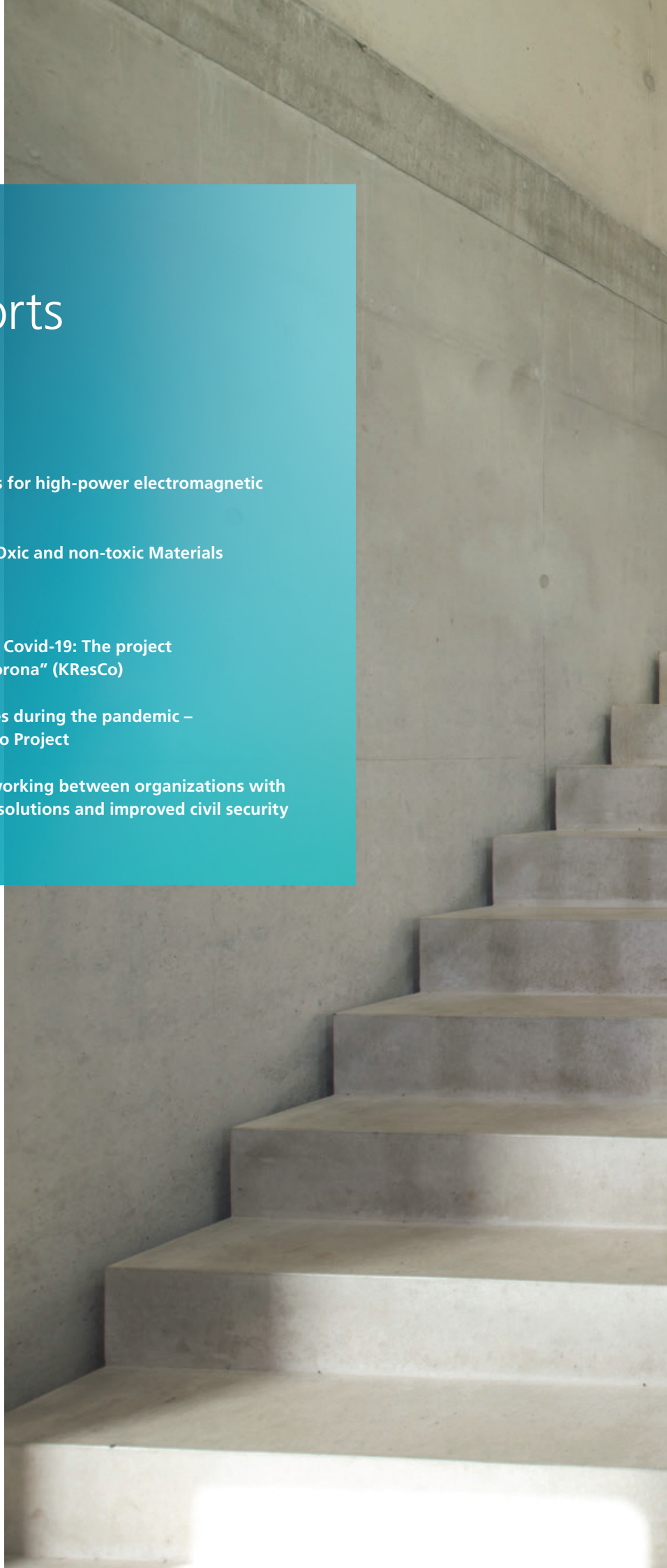
The **Central IT Services** group runs the entire IT infrastructure and provides first-level support for users. The flooding in July, which among other things destroyed the entire computer center, presented a real challenge for the group. Our team managed to set up a replacement computer center at the sister institute Fraunhofer FKIE in Wachtberg, within just two weeks, allowing the colleagues to return to work. Because we had already created the technical and organizational conditions for working from home in the previous year due to the Covid-19 pandemic, all office activities were able to restart again after just a short interruption.

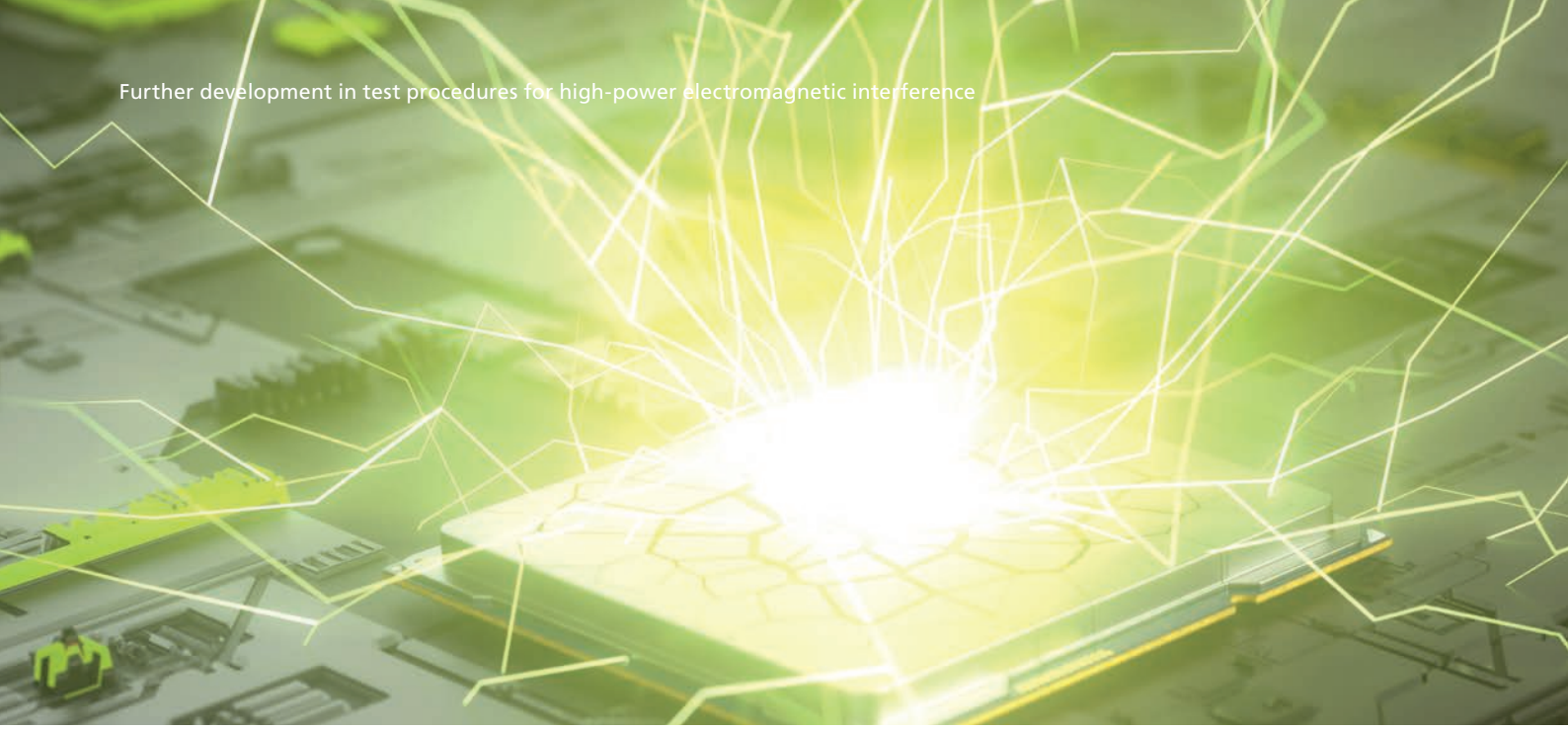
The newly created **Construction, Estates and Internal Services (BLI)** group was also presented with a difficult task due to the flooding. The flood water had completely engulfed the basement and stood at 70 cm high on the first floor. This meant that significant parts of the estate were seriously damaged and electrical systems and heating were destroyed. After the initial clean-up work, the first task was to set up the institute facilities provisionally so that work could begin. After that, planning began for the rebuild, which is now underway. The BLI group is tasked with managing all the user-side renovation works, which are being carried out by Bau- und Liegenschaftsbetrieb NRW (building and real estate management North Rhine-Westphalia) on behalf of the German Institute for Federal Real Estate.

The **Marketing and PR** group is responsible for implementing all central measures to communicate and promote the work results of the different business units and groups at the institute. This includes, inter alia, traditional PR work, online communications and social media, drafting and preparing brochures and information materials as well as organizing appearances at trade shows and conferences. In 2021, as previously, almost all specialist and industry trade fairs and exhibitions were canceled due to the Covid-19 pandemic, meaning the main focus was on expanding the digital information offerings. After the flooding, there was also the task of crisis communication.

The **Library and Specialized Information Services** division primarily focuses on procuring and managing the media required for the scientists' work and supporting them in research and acquiring information. Depending on a project's requirements, licenses for additional specialist databases and other sources of information are obtained and issued. Our library was also seriously affected by the floods. Some of the books were able to be saved and stored, but the library spaces were nevertheless damaged and the repair work is currently ongoing. The current plan is to equip the spaces with office workplaces for a transitional period, meaning we will have to make do without a physical library as far as possible in the coming years. The trend in recent years was towards more intensive use of digital information in any case. As far as possible, we will also try to use this crisis as an opportunity to transform and develop the Library and Specialized Information Services into a modern, digital information services provider.

Research Highlight-Reports





Further development in test procedures for high-power electromagnetic interference

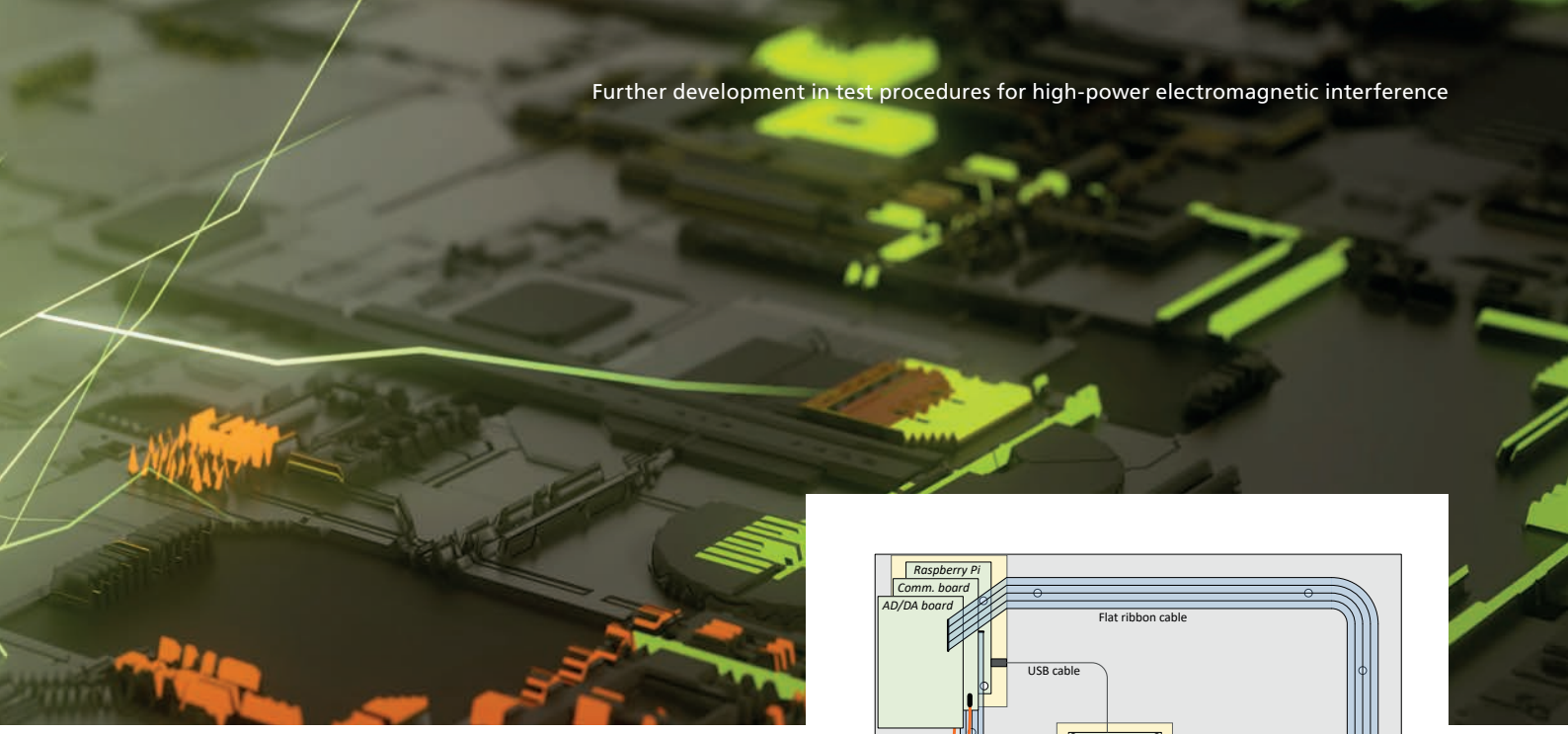
In collaboration with a German and a Swedish partner institute, a reference test setup was developed which, as a stable variant in extended procedure and laboratory comparisons, opens up new insights for the further development of the testing standards codified to date.

The EME business unit has been researching the disruptive effects of strong electromagnetic fields on the regular operation of electronic equipment and systems for decades. Specialist disciplines of the field of electromagnetic compatibility (EMC) include High Power Electromagnetics (HPEM) or Intentional Electromagnetic Interference (IEMI), the latter of which implies an intention to cause harmful effects. Comparable research questions are pursued at a national level, for example, with a focus on military issues at the Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS) in Munster. On an international scale, there are also similar specialist research institutes.

Standards to harmonize test procedures

A common feature in the efforts to investigate the robustness of devices to withstand unusual electromagnetic interference in a laboratory, is that a number of national and international standards can be relied upon. These include, for example, specifications for the design and implementation of load tests. The various types of test environments are taken into account and the physical and technical characteristics including permissible tolerances are specified.

However, a range of questions arise here in the course of the continuous development of standards. There is interest in transferring measuring results between various types of test setup, as well as the direct comparison of environments that are nominally equal, at least according to the standards. Product standards for industrial EMC also provide detailed specifications regarding the design of test setups that could be adapted specifically for the area of high power testing.



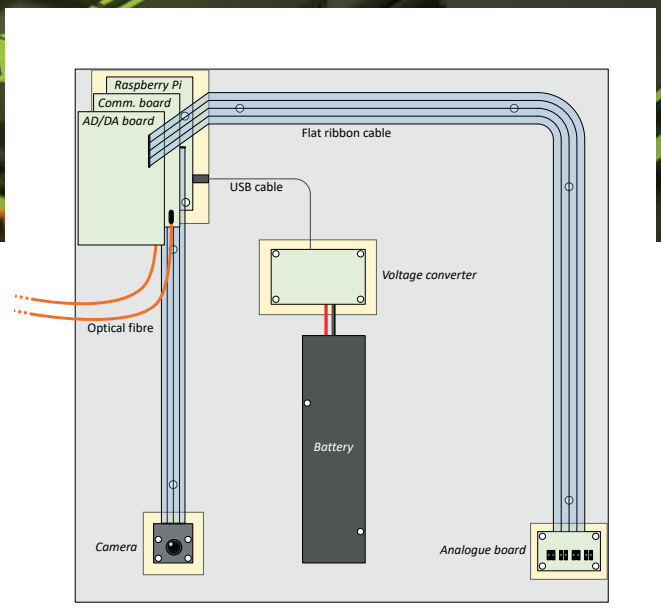


Figure 1: Schematic of the test setup

Uncertainty budget in the process chain

In order to be able to trace possibly subtler effects in connection with test design and execution, the uncertainty budget of these measurements both using and probing high-frequency fields must be critically assessed. As well as fluctuations in the signal generation and transmission, the test environment itself, in which a test specimen is subjected to the interference fields, can exhibit idiosyncrasies regarding the distribution of the field energy. Furthermore, the alignment, cabling and operating status of the device to be tested often do play a role in testing. In order to better control all these influences on the uncertainty budget, one option is to design a defined reference test specimen. Its stable response behavior should allow peculiarities in the signal chain and the test environment to be more clearly mapped out.

Cooperation project for the further development of test methods

As part of a Technical Agreement between the Federal Republic of Germany and the Kingdom of Sweden, a research project in which Fraunhofer INT, WIS Munster and the Swedish Defence Research Agency (FOI) will participate, has been drawn up to further explore the research questions discussed above. A key component of the activities is a specifically designed reference test setup, which does represent a generic test device from the area of IT systems. This specification illustrates the increasing relevance of computer systems in various processes in society, but particularly in critical infrastructures. In addition to the existing partners, participation will be open to other laboratories, to increase the data basis to work with and to help gain further findings in comparison measurements.

Designing a reference test setup

The final, implemented concept of a reference test setup is based on a single-board computer from the Raspberry Pi family of systems which was then expanded with additional hardware. In addition to a digital camera module, an analogue sensor component is introduced via an analogue-digital converter board. The option of self-sufficient battery operation was implemented to minimize external influences. The only cabling to the outside is a fiber-optic connection for serial communication between the control room and test environment. Because all components are fixed on a square, hard-foam board with edges of 40 cm length, measurements that comply with the standards are possible even in test environments with small test volumes.

During the load test, the operator can monitor the system state on a specifically implemented graphic user interface on a PC from the control room of the respective test environment. Color-coded display elements provide immediate visual feedback about the occurrence of all error patterns having been defined based on explorative measurements.

Gathered experiences and research perspectives

The system shows versatile, stable response. In multiple scientific publications further characteristics could be elucidated, for example regarding the moderate series variation of the core component, the good repetition accuracy for individual measurements and the dependence of the system response on the direction of irradiation. The influence of variations in the time structure of the typically intermittent test signals could be examined as well, as could the system behavior with different component wiring layouts.

Current investigations relate to the comparison of different test environments and laboratories. The results achieved up until now should be entered into a database by the end of the project running period in fall 2022, thereby making them accessible for further analyses.

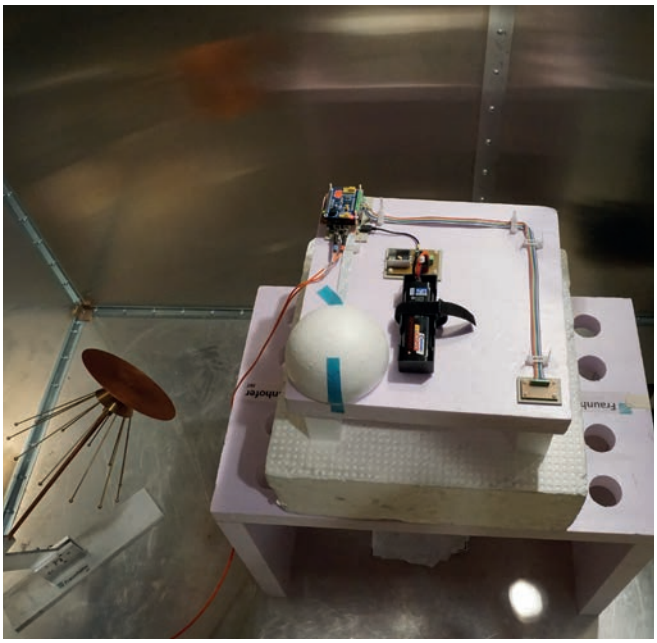


Figure 2: Test construction in the reverberation chamber

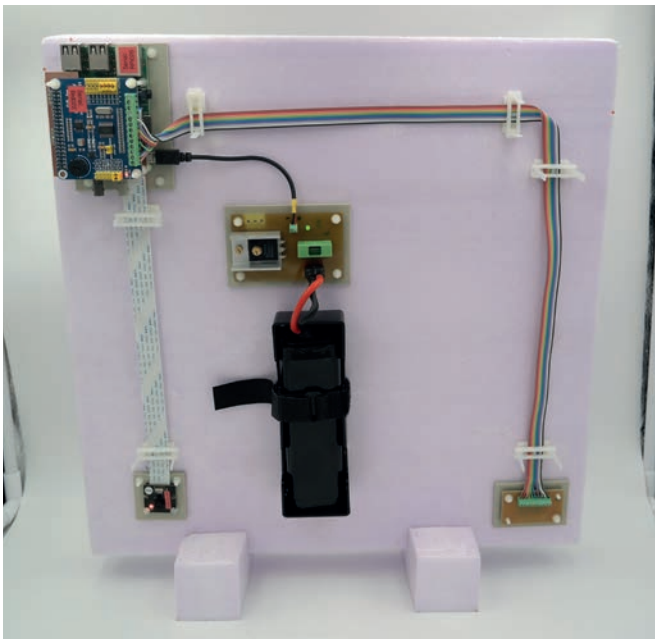


Figure 3: Reference test setup, comprising single-board computer, additional modules and power supply on an assembly plate

QUANTOM® – QUantitative ANalysis TOxic and non-toxic Materials

The aims of the QUANTOM® research project are to develop, build and test an innovative waste measurement system for the nondestructive material analysis and plausibility testing for radioactive waste contained in 200 l drums. The three partners, Framatome GmbH, AiNT GmbH and Fraunhofer INT, are collaborating in a project funded by the German Federal Ministry of Education and Research (BMBF) as part of the grant initiative "FORKA – Forschung zum Rückbau kerntechnischer Anlagen" (Research for the decommissioning of nuclear facilities).

Various activities produce radioactive waste. In the area of nuclear energy, waste is generated both in uranium processing and during the operation of the nuclear power plants themselves. Radioactive materials and sources are also used in medicine, industry and research. Due to the long half-lifes of several of the isotopes, the waste needs to be appropriately stored for a long period.

For low- and intermediate-level waste, the Konrad repository in Germany is to be available from 2027. The radioactive waste stored in Konrad must meet certain criteria. There are limitations regarding the activity inventory of radionuclides contained in the waste and also specific limit values for the non-radioactive components, for example, water pollutants like cadmium or arsenic.

Legacy waste currently often has an insufficient and inconsistent waste declaration compared to today's standards, which prevents the qualification and final storage. Until now, the checking of radioactive waste for complete characteristics for final storage usually requires the laborious task of opening the waste packages, taking samples and to investigate the samples by laboratory analysis. These tests cause radiation exposure of the operating personnel. Moreover, after successful visual checks and sampling, the waste needs to be repackaged, which leads to an increase in waste volume. Furthermore, once the containers are opened, the legacy waste must be reclassified as new waste, and is thus subject to more restrictive requirements. In summary, destructive analysis leads to higher costs for final disposal.

Non-destructive assay avoids this disruptive testing of waste packages. Two established processes for this are the gross detection of neutrons and sectional gamma scanning. However, these can only provide information about the mass of fissile material and the radionuclide specific activity

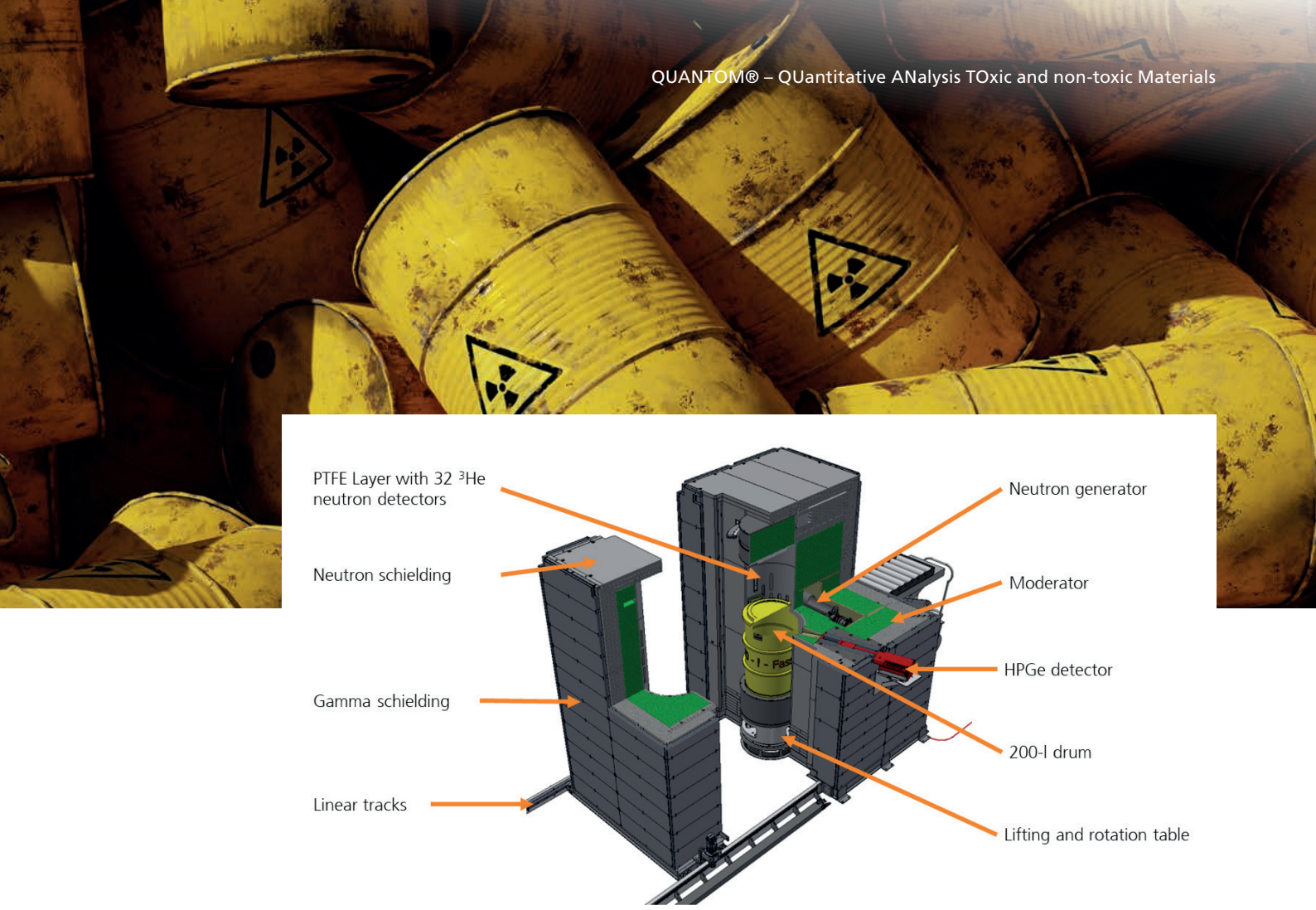


Figure 1: Section drawing of the Quantom system with a description of the individual component parts

inventory contained, not about the non-radioactive elements or the corresponding material composition.

This is where the QUANTOM® project comes in. Prompt Gamma Neutron Activation Analysis is carried out for non-destructive analysis. In this process, fast neutrons with high penetration, are able to get inside the waste package. In a surrounding moderator (see Figure 1) and the waste matrix, the neutrons lose part of their energy and are then captured by the atomic nuclei of the packaged material. The atomic nuclei hereby emit characteristic gamma rays which act as a sort of fingerprint of the elements contained in the waste container. The gamma rays then penetrate to the outside and are detected there using a detector. This allows the identification of the elements in the waste package. From the intensity of the radiation, the amount of the respective element can be calculated, which thus allows the composition of the waste to be determined. The inspected drum is turned and lifted during the investigation, so that always a different section is measured. This determines the spatial distribution of elements in the container.

The system was under construction from 2019 in the technical centers of partner AiNT and was successfully completed in 2020. Framatome is responsible for procurement, mechanical construction of the system and the development of the system controls. The consortium partner AiNT develops the measuring and evaluation processes to be able to calculate the distribution of elements within the drum based on the measured data. Fraunhofer INT is responsible for measuring the neutron flux both at the source position and in the vicinity of the waste drum.

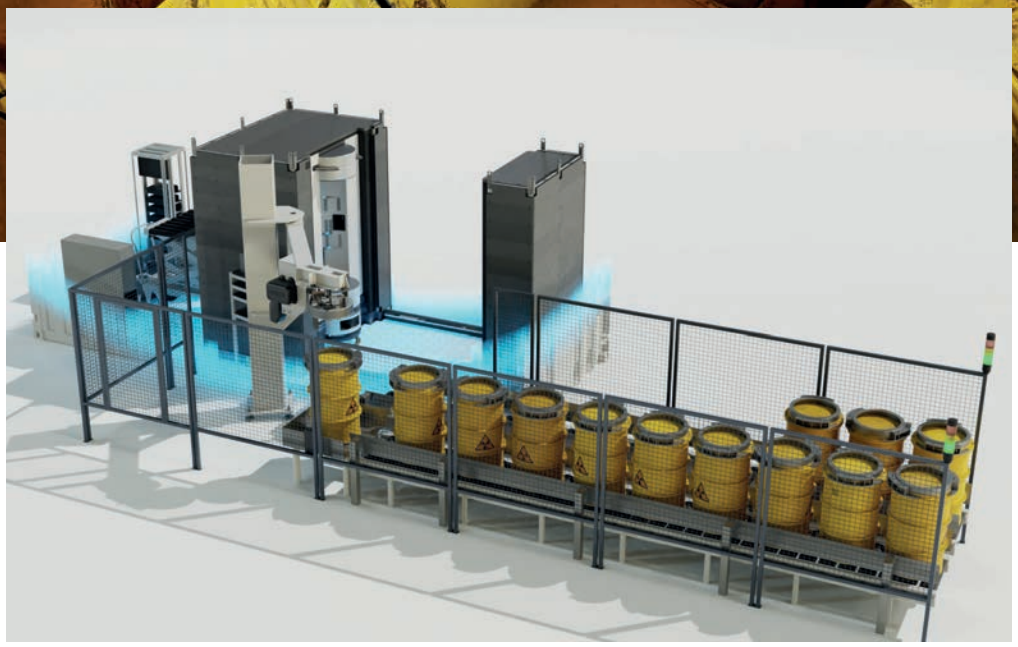


Figure 2: When the Quantom system is in automated operation, the waste drums are guided in and out on a conveyor belt

Figure 2 shows a view of the current planning state of the system. The drums enter the system via a conveyor belt. The crane collects a drum and sets it in the measuring chamber, where it is irradiated with neutrons. The container is surrounded by graphite in the measuring chamber which moderates the neutrons and improves the efficiency of the system. This chamber is closed for measuring. The drum is placed on a turning and lifting table in the chamber, which rotates to place different sections in front of the detector to be measured. In total there are two high-resolution gamma detectors (HPGe) to speed up the measuring process.

The neutron field inside the system is itself influenced by the contents of the waste matrix inside the drum, which has an effect on the measured results. Therefore, it is essential to know how the neutrons are distributed inside of the waste matrix in order to complete a qualitative analysis. AiNT is developing a software module for this purpose that calculates this distribution as part of the evaluation. Fraunhofer INT has developed and built a system for this purpose that measures the thermal neutron flux at 32 points around the container and also determines the source strength of the neutron generator with the help of a further neutron detector (fission chamber).

Suitable components were selected for this purpose and the arrangement of the detectors was optimized for the purpose using Monte-Carlo N-Particle Transport Code simulations (MCNP is a program for simulating nuclear processes). The system was first put into operation at Fraunhofer INT and then integrated into the overall system at the AiNT technical center. The software control system for the neutron detectors was also realized at Fraunhofer INT. The validation of mass reconstruction algorithm and neutron flux detection has been successfully completed with non-radioactive packages.

In future, QUANTOM® will provide a system for the non-destructive analysis of waste packages without having to repackage them. This will significantly reduce the exposure of personnel to radiation and avoid an increase in waste volume. QUANTOM® is planned to be a mobile measuring system, integrated into a standard container. This enables the measuring system to be used wherever the waste is stored or conditioned, helping eliminate any unnecessary transportation of radioactive waste. The project is therefore making a significant contribution to the safer and more efficient disposal of radioactive waste.

Figure 3: Finished prototype system

SPONSORED BY THE
Federal Ministry of Education and Research

QUANTOM

The collaborative project QUANTOM® is financed by the German Federal Ministry of Education and Research, grant number 15S9406A / B / C. The project partners are responsible for the content of this publication

KATI – One lid for many data pots

Just in time for the Hannover Messe 2021, Digital Science and Fraunhofer INT announced a collaborative project to make the KATI system available to interested parties outside of the Fraunhofer-Gesellschaft. This provided the basis for marketing KATI – a milestone in the development of KATI and the history of the institute.

What are the advantages of expanding KATI to include the Dimension data provided by Digital Science? What technical challenges had to be overcome in order to utilize these advantages? It all began a year before, in March 2020, with an initial conversation between Christian Herzog and Mario Diwersy from Digital Science and the responsibles at the Fraunhofer INT, sounding out the possibility of a cooperation. It quickly became clear that both parties saw a great opportunity and so, while discussions were taking place about the formalities, technical work began on collecting the comprehensive dataset.

The structure of the data

The Dimensions database contains bibliographic data of more than 120 million publications, including details on the title, authors, journal and year of publication of a paper. In this respect, relatively few adjustments were needed to the data model developed at Fraunhofer INT, which is based on the use of a so-called graph database or RDF store. The latter stands for Resource Description Framework and enables modeling of the relationships between the 'resources', which are linked to one another by relations. In KATI, for example, a 'resource' could be a paper or an author. These can be linked together by the relationship 'written by'. This creates something called 'triples', comprising two resources and a relationship:

Paper A – written by – Author X

This type of data preparation has proven to be very powerful and forms the basis for many options and features that the KATI system offers its users.

Despite these principle similarities, there are some updates and expansions in the Dimensions data, which made it necessary to carry out a few adjustments in the KATI engine room.

One is the fact that Dimensions describes institutions using a unique identifier. This facilitates a whole range of analyses that can be carried out with KATI.

Another important difference is that Dimensions doesn't use just one classification system, but multiple. These include:

- Fields of Research, based on an Australian–New Zealand classification system and comprising two hierarchical levels. They correspond to a classical division into scientific disciplines and subdisciplines.
- The Sustainable Development Goals, which were put into effect on January 1, 2016, by the UN.
- Various other systems that primarily come from the field of medicine.

Digital Science automatically allocates each publication to the various classes and uses classification algorithms specifically trained for this. As such, this is an article-based classification that is not based on the assignment of a particular journal to one or more classes, allowing a more detailed and precise allocation of publications to the various classes.

The structure of the system

To be able to take this slightly different structure of the data into account, the KATI system itself also had to be adjusted. This initially affected the data model on which the system is based. Subsequently, the so-called transformer was modified. This program is responsible for processing the raw data into the triples discussed above, which are then loaded into the corresponding databases in the next step. Then, these triples are made searchable using an appropriate search engine. The KATI Lab has programmed a 'pump' for this purpose, which ensures that the searchable data is copied from the actual graph database into the search index.

All of these adjustments initially took place in the backend, the engine room, so to speak. But adjustments had to be made to the front end, to the actual user interface, too. This affected all components of the KATI system, both the design of the search interface and the resource-side, and the analysis-side with the various dashboards.

For example, the design of the filters on the search page had to be adapted to account for the fact that you can now filter the results according to several category systems and that these are also partly arranged hierarchically.

Naturally, the biggest changes were in the analysis part of the KATI system, as all visualizations used on the dashboards required adjustments. Behind each of these visualizations there are one or more database queries which are responsible for providing the necessary data. All of these queries had to be modified to correspond to the changed data structure. This comprised more than 30 visualizations for which more than 30 database queries had to be created or adjusted.

The KATI Lab team used this opportunity to completely redesign the entire user interface. This meant adjusting both the structure of the code, to make it easier to maintain and expand in the future, as well as the look of the interface. Important elements such as the filters for the search results or the workspace were redesigned and given more functionality. Other important improvements included the dashboard design, which now, for example, offers the possibility to influence the appearance of the visualizations.

By including the Dimensions data, the KATI team has now created a new version of the system which can be made available to interested parties from outside the Fraunhofer-Gesellschaft, paving the way for commercial marketing. In Digital Science, we have a strong, expert partner at our side for this. As part of the process, the group was able to demonstrate that both the data model and the overall concept of the KATI system are designed so flexibly that they can be expanded to include further data pools. We are currently working on including patent data to open up an important information source for technology foresight at Fraunhofer INT. The institute is thus very well positioned for further developments in the area of data-driven foresight.

A year of research in the context of the Covid-19: The project “Crisis management and resilience – Corona” (KResCo)

In December 2021, the consortium project “KResCo” (Crisis management and resilience – Corona) was concluded after a year of intensive research. The project, which was funded by the Anti-Coronavirus Program at the Fraunhofer-Gesellschaft, examined various areas of society, analyzed their practices and made recommendations for actions.

In close collaboration, five different Fraunhofer institutes identified recommendations for different societal subsystems, to draw sustainable learnings from the Covid-19 pandemic and to improve society’s resilience. These institutes cooperated in the work packages (WPs) and thus combined their expertise and methods for a non-technological, systematic and holistic view.

Research data management (WP2) was carried within the project, led by Fraunhofer IRB with the aim of deriving good practices and lessons for future research. It was a first time that the use of the concept of data governance was used within such a project – a system of rules and decision structures that can be used in research organizations to generate the best possible applications and quality of research data.

Fraunhofer ISI led the work packages “Political decisions for the containment of the Corona pandemic” (WP3) and “Economy and society” (WP4) creating a dataset from multiple European databases. This allowed the recording of various phenomena around the political measures with pandemic-related health, societal, economical and political consequences and further criteria (incidences, hospital capacity/utilization and many more) in a time period.

In work package “International innovation networks” (WP5), the Fraunhofer IMW investigated cross-border, bilateral cooperations and the consequences of the pandemic for research, development and innovation between German stakeholders and their partners in Israel, Sweden, Switzerland, South Korea and Thailand.

The work package “Civil protection and security” (WP6), led by Fraunhofer IAO, focused on the area of hazard prevention and civil protection in a series of Europe-wide interviews and through intensive research.

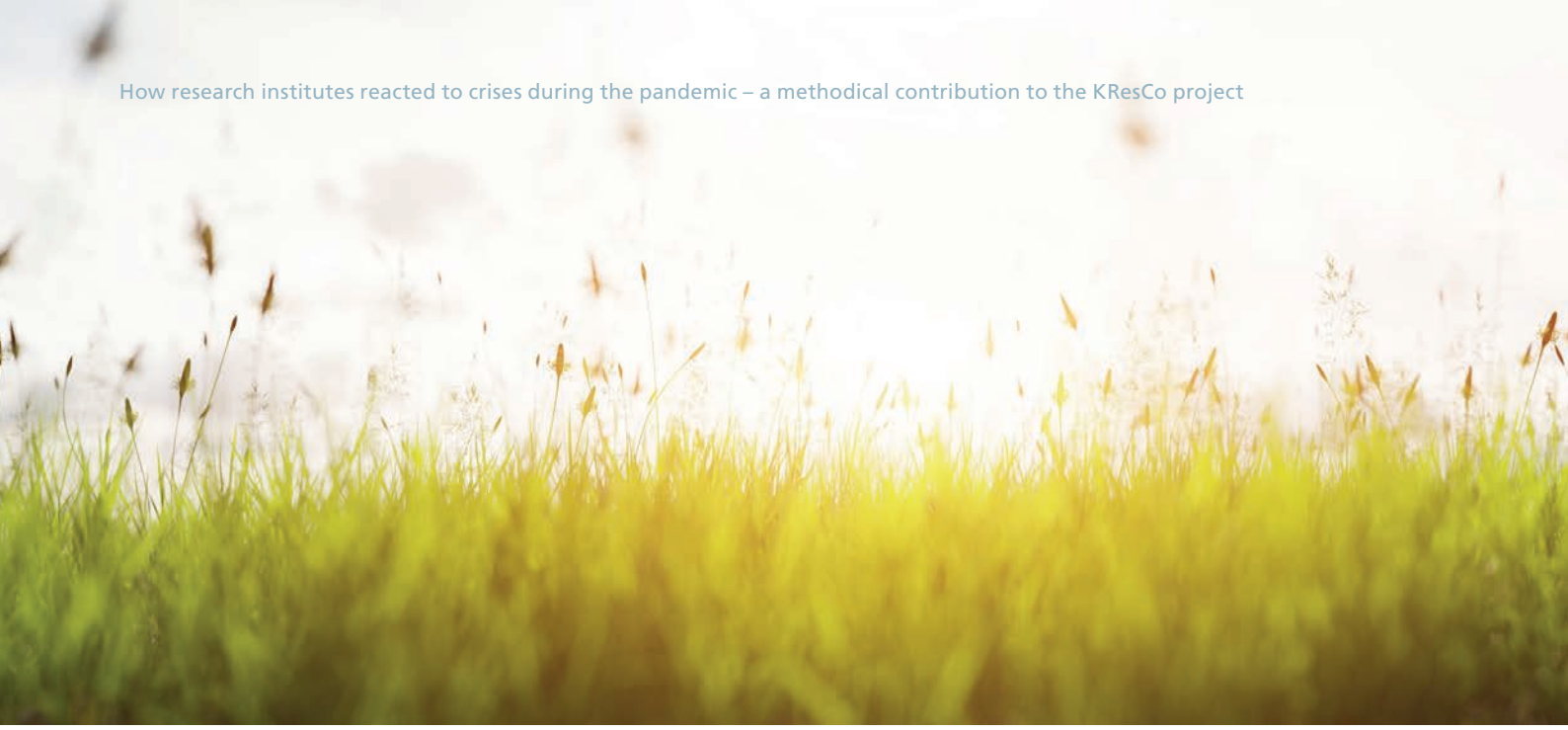
Fraunhofer ISI led the work package “Application-oriented research” (WP7), conducting a series of Europe-wide

interviews and further methods to closely examine the organizations for applied research (particularly Research & Technology Organizations, RTOs).

Eventually, Fraunhofer INT collected the results and identified recommendations for action from the individual societal areas in the final work package (WP8). These results were then published for the identified target groups in the form of policy briefs for decision-makers in the fields of health policy, interior politics, research policy and organizations for applied research, civil protection and security, as well as research data management. The project also identified general recommendations that override the mentioned target groups or societal sub-systems. These focused on the following topics: Improvement of networking, the added value of systemic (not purely technological) and inter-disciplinary research and the improvement of the information bases and information exchange with better data.

The project was successfully concluded with a digital event (held online due to the pandemic) with 170 participants. The presentations and the results and the project work itself can be found on our project website: www.kresco.fraunhofer.de

For more information and for questions surrounding the project and the results, feel free to get in touch via:
larissa.mueller@int.fraunhofer.de
kresco@int.fraunhofer.de



How research institutes reacted to crises during the pandemic – a methodical contribution to the KResCo project

The project "Crisis management and resilience – Corona" (KResCo) aimed at analyzing the political decisions and their effects in the context of the Covid-19 pandemic and formulating relevant recommended actions (see also Pg. 52).

The objective of the project's work package 7 was to analyze and compare the research activities in various European countries and the Research and Technology Organizations (RTOs) represented there. The work was completed in cooperation with the groups TFU and WZA, using quantitative methods.

The research activities for each country were analyzed using the publications in Web of Science. A methodology was developed for this, in which an expert used an iterative process to create a classification system for the coronavirus-related research. Initially, there were six classes and corresponding search queries defined by the expert. In the next step, the publications on coronavirus research were classified into the appropriate classes using a machine learning approach based on natural language processing. The publications that were the results of the queries for the classes served as training data. Finally, ten different classes were defined according to this methodology (for example, »Prevention« or »Vax&Drugs&Ther«). The results were evaluated by said subject expert and recommendations for changes to the classification system as well as to the individual search queries for the classes were considered. The countries analyzed and their relevant research organizations were: Germany with the Fraunhofer-Gesellschaft (FhG), the Netherlands with the Netherlands Organisation for applied scientific research (TNO) and Austria with the Austrian Institute of Technology (AIT).

This innovative type of analysis allowed, on the one hand, a comparison over time between 2020 and 2021, and on the other hand, a comparison at country and RTO-level. Figure 1 illustrates a comparison of the research activities in Germany and the Netherlands with respect to the project reaction in the relevant research institutes. There are several things to note about this. Firstly, that FhG and TNO place a strong focus on "prevention". At FhG, it is also noteworthy that a very high percentage of projects are assigned to "Vax&Drugs&Ther". At TNO, the class "Social&Mental" is the second most-represented and is far above the country-specific activity and that of the FhG. While the area "Cov-Symptoms" played a big role in both the German and Dutch research landscape (15.4% and 12.2%), it was not evident in

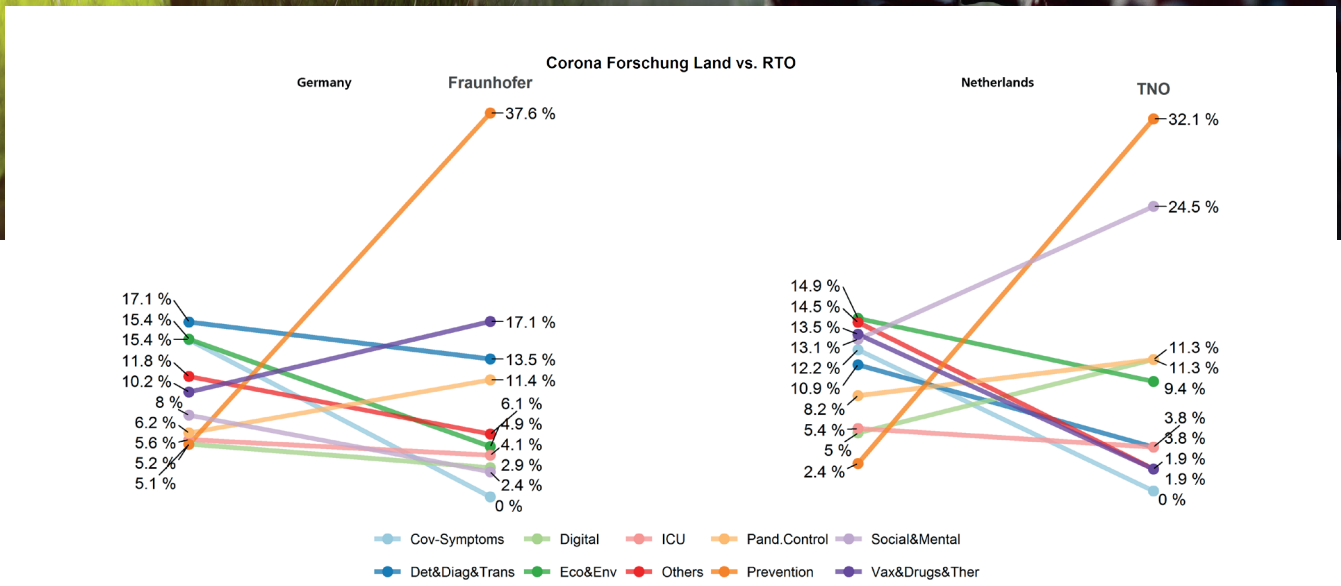


Figure 1: Comparison of the coronavirus research within a country and the "Research and Technology Organization" (RTO). Left: Corona-related research in Germany vs. reaction to the coronavirus at the Fraunhofer-Gesellschaft. Right: Corona-related research in the Netherlands vs. reaction to the coronavirus at the TNO.

the FhG and TNO projects. Both institutes are again significantly more active in the field of "Pand.Control" than compared to the country-specific research. Overall, many similarities can be drawn between the research activity of the RTOs, as well as many common differences in comparison to the country-specific research.

This approach is therefore a good example for the active development of methods to open up perspectives on quantitative data that have not been used in this way before.

This innovative type of analysis allowed, on the one hand, a comparison over time between 2020 and 2021, and on the other hand, a comparison at country and organization level.

InnoBOSK – Innovation forum for networking between organizations with security tasks and SMEs for innovative solutions and improved civil security research

One of the key problems in civil security research and the innovation activities of authorities and organizations with security tasks (BOS) is the lack of communication and idea exchange between BOS, as the end user, and the solution providers (especially small and medium-sized enterprises – SMEs). Until now, there was no specific cluster in Germany that worked as an umbrella for the different civil security services and united both risk prevention by the police and the non-police activities.

This lack of exchange was not least due to the fact that BOS are very diversely organized due to the federal structure in Germany and strongly differ regarding their research affinity and capability for needs assessments. This makes it extremely difficult for SMEs to have a basic overview of the actual needs of BOS regarding research and technology, which hinders any needs-oriented approach to developing new solutions.

In 2021, the project "InnoBOSK", funded by the funding initiative "Innovation forum for Medium-Sized Firms" of the German Federal Ministry of Education and Research (BMBF) and led by German Federal Institute for Materials Research, created for the first time a system for close and direct networking between SMEs and end-users/BOS in civil security research in Germany. The project included various workshops and an innovation forum in which a needs assessment was carried out, based on a Fraunhofer INT methodology, surveying the research and innovation needs of BOS. The results were consolidated, prioritized and shared with the SMEs involved. Fraunhofer INT also carried out a trend-scouting activity for BOS regarding currently relevant technologies within the topics "Drives and Energy Forms", "Techniques and Methodologies for Education" and "Networked Resources and Management Tools" and provided the results in the form of technology profiles.

At the same time, by designing and operating a platform for (long-term) cooperation, "InnoBOSK" also enabled direct exchange and knowledge transfer between the stakeholders. This should lead to close networking of end users and solution providers in the long term and therefore help avoid undesirable developments and investments in "Solutions without problems", or even the remit of further developments. Finally, active exchange between the stakeholders can also culminate in activities such as forming research consortia and development projects. For those SMEs which took part, being provided with this exclusive information on

Berlin fire brigade during a civil protection exercise; Source: BAM

the research needs of BOS in a structured format also means improved competitiveness and market opportunities in the German, European and global markets.

The "InnoBOSK network" and the digital platform can be joined at any time, providing access to the detailed project results. To receive the access data, please email: innobosk@bam.de.

»New network for better tailored solutions in civil security.«

Others

Fraunhofer Space Alliance

Institute for Technology Analysis and Foresight in the Field of Security Research at RWTH Aachen University

Shortly noted

Fraunhofer Space Alliance

This article will be the last on the Fraunhofer Space Alliance to appear in a Fraunhofer INT Annual Report. This is not because the Space Alliance is being dissolved, but rather it's being expanded to become the Fraunhofer Alliance Aviation & Space. The reason for this change is that the Fraunhofer-Gesellschaft has identified the aerospace industry as a strategically significant market segment and will dedicate itself to it by creating what is known as a Lead Market. From 2022, the Fraunhofer Space Alliance will therefore approach the national and international aerospace industry as the Alliance Aviation & Space.

For this purpose, the former Space Alliance office will be expanded to include an additional branch office at Fraunhofer IFAM in Bremen, and Institute Director Prof. Bernd Mayer will be the experienced and expert spokesperson for aviation. For many years now, Fraunhofer IFAM has had a leading role in the EU research programs CleanSky 1 and 2, and in the national aviation research program (Luftfahrtforschungsprogramm, LuFo) run by the German federal government. Because of its special aerospace connections both inside and outside the Fraunhofer-Gesellschaft, Fraunhofer IFAM is exceptionally well placed to be the central office for aviation.

Due to the pandemic, the first half of the year was largely made up of digital 'external' appearances, including the comprehensive reworking of the Alliance's web presence. The existing social media activities were also bolstered by a LinkedIn account, which proved to be an invaluable instrument for networking during the Covid-19 crisis.

At the end of September, the Alliance was able to celebrate its first external appearance since Space Tech Expo 2019: The team manned a small information stand at the Day for German Aerospace in Aachen, which was especially positive in terms of regional networking. October brought another highlight, with the International Astronautical Congress in Dubai, UAE. This annual event was able to take place face-to-face after a virtual edition in 2020. The Space Alliance was part of the German Pavilion, hosted by the German Aerospace Industries Association (BDLI).

The biggest and most important event in 2021, however, was the Space Tech Expo in Bremen, which was able to be held in-person again in November, for the first time since 2019 and the pandemic. It was clear that, after a long pause, the institutes were keen to be back at a big industry event in person: Over 40 exhibits from 18 institutes, including many guests from the Fraunhofer areas of expertise nano technology, smart structures and additive manufacturing, showed the impressive breadth and depth of what Fraunhofer is able to offer to the aerospace sector.

Apart from the events, the appointment of Dr. Nadya Ben Bekhti-Winkel to the Commission expert group on Policies & Programmes of the EU Directorate General for Defence Industry and Space Industry (DG DEFIS) is a milestone that allows Fraunhofer to participate in the design of future key research programs. The central office of the Alliance was able to play a key role in the preliminary study for the UN:IO-project, funded by the European Commission. UN:IO is being developed by a network of European start-ups to become the European satellite communication constellation. Within the study, the central office is responsible for the task of scientific quality assurance. Further information: https://www.unio.global

Thomas Loosen, Tassja Wagner

Institute for Technology Analysis and Foresight in the Field of Security Research at RWTH Aachen University

The aim of the Institute for Technology Analysis and Foresight in the Field of Security Research, led by Prof. Lauster at RWTH Aachen University, is to introduce students to quantitative and qualitative future research methods within the framework of applied teaching and learning concepts. Students not only learn about the epistemological foundation of these future research methods but also analyze the extensive canon of methodology in terms of its suitability and optimization possibilities. The institute's research focus is the analysis of foresight processes in the field of technology as well as the adaptation, new and further development of corresponding processes and methods. The knowledge obtained from the research on an ongoing basis supports scientifically substantiated decision-making on matters associated with the temporal development of technologies.

The substantive and methodological work of the chair were gradually advanced over the past year. Due to the Covid-19 pandemic and the resulting restrictions, in 2020, the entire range of curricula at the chair successfully converted to digital formats. In this context, the didactic approach to teaching and learning concepts, among other things, was adapted to the new, virtual conditions. In the past year, these digital formats were expanded and supplemented with new tools for collaboration.

Courses are offered in the form of lectures during the semester as well as one- or two-day block events (seminars). In the 2021 summer semester, 186 students enrolled in the online lecture "Methods of future research – technology analysis". In the 2021/2022 winter semester, the online lecture "Methods of future research – technology foresight" was taken by 256 students. In addition to lectures, seminars are offered; these seminars take a deep dive into specific aspects of the lectures. The seminars "Ethics in technology" and "Science and knowledge theory" took place in the summer and winter semesters, respectively. As both the lectures and seminars are highly popular, new seminar formats will be added in the coming year. To that end, a seminar on safety research and future research as well as one on data-driven foresight, have been developed for the summer and winter semesters, respectively.

Another success story is the establishment of the lecture series "Methods of future research" at the University of Applied Sciences Ravensburg-Weingarten. Students on the Technology Management and Optimization course attend the lectures led by Prof. Lauster and learn about the methodological principles of future research following an application-based approach. The series of lectures took place digitally in block format and was well received by the students.

In 2021, the cooperation between the Institute for Technology Analysis and Foresight in the Field of Security Research and Fraunhofer INT was further strengthened. Scientists at Fraunhofer INT increasingly supported the teaching activities, while students worked on their bachelor's and master's theses at Fraunhofer INT, thus generating additional synergy effects. Some students from the courses also completed internships or were employed as research assistants.

Two master's theses and four bachelor's theses were supervised and successfully completed at the institute in the past year. Furthermore, since 2019, Christian Hemmers has been working on a further doctoral thesis focusing on the foresight processes for SMEs.

Christian Hemmers, Dr. Stephanie Hansen-Casteel

Shortly noted

Fraunhofer Solution Days 2021

In summer 2021, the Fraunhofer Solution Days took place for the second time. Fraunhofer expertise and solutions for improved resilience and safety, as well as the latest findings on next-generation computing, were presented over the two themed days. Fraunhofer INT participated in two projects on the "Safe Society and Industry" day on June 22, 2021. Project Manager Larissa Müller presented the Fraunhofer project "Crisis management and resilience – Corona" (KResCo) (Pg. 52). The second project presented was "Resilience of Urban Habitats" (RuLe) – a collaboration between the three Fraunhofer INT business units, Public Technology and Innovation Planning (TIP), Defense Technology Foresight (WZA), Electromagnetic Effects and Threats (EME), as well as the Technology Foresight and University Hub (TFU) group. The RuLe project should develop technologies, concepts and structures to improve the resilience of urban habitats against risks such as extreme weather events or terrorist attacks.

There were lectures for both projects and a discussion group with the project leaders, including a question and answer session and a series of "Meet the Experts" workshops, in which the participants worked on and discussed various research questions and topics with the scientists who are involved in the projects.

The Fraunhofer Solution Days took place for the first time in 2020. The Fraunhofer virtual-only format arose in response to the numerous canceled industry fairs and events due to the pandemic, intending to introduce interested parties to the latest Fraunhofer innovations and projects despite the pandemic situation.

InnoDay 2021

On November 11, 2021, Fraunhofer INT participated in the first InnoDay at the Bundeswehr Command and Staff College in Hamburg. The InnoDay brings together innovation drivers from the sphere of the Bundeswehr and creates a platform for exchanging ideas. The research question in focus for the event was: How can innovations be implemented in the Bundeswehr? In the large congress center at the Bundeswehr Command and Staff College, companies, research institutes and also members of the Bundeswehr themselves presented innovative ideas, concepts and technologies at their exhibition stands. The event was accompanied by a lecture event in which short, snappy talks were presented and discussed. Fraunhofer INT took part in the exhibition with an exhibit on the detection of High Power Electromagnetics (HPEM). The detection system lays the foundation for preventing attempts at sabotage of complex electronics using HPEM. KATI, the assistance system for technology foresight developed at Fraunhofer INT, was also presented. There were also complementary short speeches held on both exhibits. The Defense Technology Foresight (WZA) business unit, which offers the Bundeswehr expertise in the area of technology foresight and the key technology Defense Technologies Forecast (WTV), also held short speeches presenting these activities.

(Copyright: Bundeswehr)

Fraunhofer INT Institute Seminar

Since January 2021, the Fraunhofer INT Institute Seminar has been taking place virtually, easily accessible to external participants via Microsoft Teams. The Institute Seminar has been running for many years at Fraunhofer INT. In a series of lectures, experts from Fraunhofer INT and external guest speakers give short presentations on exciting topics from science and industry and lead discussions. Over the years it has become a tradition for new employees especially to present at the Institute Seminar on their research topics from before they joined the institute or on their theses. Prior to the pandemic, the event took place in the large seminar hall at the institute. Due to the pandemic, however, from March 2020, the lectures had to be paused until they could be switched into digital format in 2021. A total of 14 lectures were held live in 2021. You can register your interest using the registration form on the Fraunhofer INT website. After the lectures, participants have the opportunity to ask questions. The Institute Seminar takes place on Wednesdays at 1:00 p.m. You can find an overview of the current lectures and the registration form here:

Appendix

University Courses, Lectures and Exercises

Baaden, P.: Lecture and exercise »Wissenschaftliches Arbeiten in der Agrar- und Ernährungsökonomie«, bachelor degree course »Agrarwissenschaften«, University of Bonn, summer term 2021

Baaden, P.: Lecture and exercise »Methods in Management Research«, master degree course »Agricultural and Food Economics«, University of Bonn, winter term 2021/2022

Bantes, R.: Lecture and seminar »Trends in Forschung und Entwicklung«, bachelor degree course, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, summer term 2021

Chmel, S.: Lecture and exercise »Physics«, bachelor degree course »Naturwissenschaftliche Forensik« (2. semester), Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, summer term 2021

Chmel, S.: Lecture and exercise »Measuring Techniques«, bachelor degree course »Naturwissenschaftliche Forensik« (3. semester), Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, winter term 2021/2022

John, M.: »Leben und Arbeiten mit dem Cochlea Implantat- Funktionsweise, Chancen, Risiken und Erfahrungen im Hinblick auf die medizinische Rehabilitation«, module as part of the advanced course for rehabilitation medicine, Akademie für Sozialmedizin Berlin, January 19, 2021

John, M.: »Das Cochlea Implantat: Funktionsweise, Entwicklung, Chancen, Risiken und Erfahrungen im Hinblick auf die logopädische Praxis«, Schule für Logopädie, Medizinische Akademie, BG Klinikum Unfallkrankenhaus Berlin, October 2021

John, M.: »Quantitative Methoden der Zukunftsforschung. Eine sehr kurze Einführung in Data Driven Foresight«, lecture »Methoden der Zukunftsforschung II« by Prof. Dr. Dr. Lauster, RWTH Aachen University, May 11, 2021

John, M.; Baaden, P.: »Where Do We Go Tomorrow? Publication and patent data analysis as a tool for technology foresight«, lecture »Methods in Management Research« by Prof. S. Bröring, University of Bonn, December 8, 2021

John, M.: Seminar »Publikationsanalysen als Beispiel für Data Driven Foresight – Eine Einführung in die quantitativen Methoden der Zukunftsforschung«, master degree course »Zukunftsforschung«, Freie Universität Berlin, winter term 2021/2022

Jovanović, M.: Seminar »Technik, Politik u. Gesellschaft - Prognostik, Szenarien, Folgenabschätzung«, master degree course »Technik- und Innovationskommunikation«, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, summer term 2021

Kohlhoff, J.; Hemmers, C.: Exercise »Methoden der Zukunftsforschung«, master degree course »Technologie- Management & Optimierung«, University of Applied Sciences Ravensburg-Weingarten, online-lecture, May 31, 2021 - June 21, 2021

Martini, M.; Baaden, P.: »Text Mining and Natural Language Processing«, lecture »Methods in Management Research« by Prof. S. Bröring, University of Bonn, December 14, 2021

Lauster, M.: Lecture and exercise »Methoden der Zukunftsforschung- Technologieanalysen«, degree courses »Maschinenbau« and »Wirtschaftsingenieurwesen«, RWTH Aachen University, summer term 2021

Lauster, M.: Seminar »Ethik für Ingenieure«, degree courses »Maschinenbau« and »Wirtschaftsingenieurwesen«, RWTH Aachen University, summer term 2021

Lauster, M.: Seminar »Interdisziplinäres Seminar Technologiefolgenabschätzung« degree courses »Maschinenbau«, »Wirtschaftsingenieurwesen« and »Soziologie«, RWTH Aachen University, summer term 2021

Lauster, M.: Lecture and exercise »Entwicklungen in Forschung und Technologie / Anwendung Zukunftsforschung«, degree course »Technikmanagement und Optimierung«, University of Applied Sciences Ravensburg-Weingarten, summer term 2021

Lauster, M.: Lecture and exercise »Methoden der Zukunftsforschung-Technologievorausschau«, degree courses »Maschinenbau« and »Wirtschaftsingenieurwesen«, RWTH Aachen University, winter term 2021/2022

Lauster, M.: Seminar »Einführung in die Wissenschafts- und Erkenntnistheorie«, degree courses »Maschinenbau« and »Wirtschaftsingenieurwesen«, RWTH Aachen University, winter term 2021/2022

Höffgen, S.: Lecture »Radiation Environment and Effects«, lecture »Spacecraft System Analysis«, Julius-Maximilians-Universität of Würzburg, winter term 2021/2022

Metzger, S.: Lecture »Experimental Techniques in Particle Physics«, master degree course »Physik«, RWTH Aachen University, winter term 2021/2022

Wirtz, H.: »Investition und Finanzierung« bachelor degree course »Betriebswirtschaftslehre« (extra occupational), Hochschule Fresenius, winter term 2020/21, summer term 2021, winter term 2021/22

Wirtz, H.: »Corporate Finance« bachelor degree course »Betriebswirtschaftslehre« (extra occupational), Hochschule Fresenius, winter term 2021/22

Wirtz, H.: »Qualitäts-, Change und Innovationsmanagement« bachelor degree course »Betriebswirtschaftslehre« (extra occupational), Hochschule Fresenius, winter term 2020/21, summer term 2021

International Cooperation

Berchtold, C.; Grigoleit, S.; Kaluza, B.; Chmel, S.: Horizon 2020 project »IN-PREP« (An Integrated next generation PREParedness programme for improving effective interorganisational response capacity in complex environments of disasters and causes of crisis), 19 project partners

Bornhöft, M. C.; Chmel, S.; Friedrich, H.: Horizon 2020 project »STRATEGY« (Facilitating EU pre-standardization process through streamlining and validating interoperability in systems and procedures involved in the crisis management cycle), 23 project partners

Friedrich, H.; Köble, T.; Risse, M.: Arktis Radiation Detectors Ltd., Zurich, Switzerland

Geschäftsfeld NEO: EU-project »RADNEXT« (RADiation facility Network for the EXploration of effects for indusTry and research) (https://radnext.web.cern.ch/)

Grigoleit, S.; Berchtold, C.; Müller, L.: Horizon 2020 project »SHAPES« (Smart & Health Aging Promoting Empowering Systems), 36 project partners

Grüne, M.; Pastuszka, H.-M.; Bantes, R.: EDA Workshops on Technology Watch and Foresight, Brussels/online

Köble, T.: ESARDA VTM Working Group

Linde-Frech, I.; Vollmer, M.: Representation of Fraunhofer VVS in the »Security and Defense Working Group« of the European Research and Technology Organisations (EARTO)

Linde-Frech, I.: Moderation of the panel discussion »Commercialisation of R&I results«, at the CERIS – SSRI webinar »Uptake stories: 3 avenues from Research & Innovation to deployment«, by Directorate-General for Migration and Home Affairs

Linde-Frech, I.: Participation in the panel »Assessing the operational relevance of security technologies«, at the Community of European Research and Innovation for Security (CERIS) - SSRI webinar »Evaluation of innovative security technologies: Building credibility as a step towards uptake«, by Directorate-General for Migration and Home Affairs

Neupert, U.; Ruhlig, K.; Gabel, O.; Huppertz, G.; Michael, K.: Försvarets Materielverk (FMV)-projects »Teknisk Prognos« 2021-1, 2021-2

Pusch, T.; Suhrke, M.: Swedish Defence Research Agency, Technical Agreement »Development of highpower microwave test methodology and procedures«

Pusch, T.; Ribeiro Arduini, F.; Suhrke, M.: European Training Networks (ETN) Marie Curie »Pan-European Training, research and education network on Electromagnetic Risk management – PETER«, 19 project partners

Römer, Silke: Participation in the NATO STO SAS-123 Research Task Group (RTG) »Futures Assessed alongside socio-Technical Evolutions (FATE)«, ten nations; RTG received the 2021 SAS Panel Excellence Award

Vollmer, M.; Berchtold, C.; Neisser, F.; Müller, L.; Düerkop, S.; Mrosek, K.: EU-H2020-project RiskPACC Integrating Risk Perception and Action to enhance Civil protection- Citizen interaction, 20 project partners

International Reviews

Grigoleit, S.: International Journal of Environmental Research and Public Health

Höffgen, S.; Steffens, M.; Kuhnhenn, J.: RADECS 2021

John, M.: 11th Global TechMining Conference, November 17-19, 2021, Virtual Event, Science Advisory Committee

Jovanović, M.: Scientometrics

Jovanović, M.: ISSI Konferenz 2021

Kuhnhenn, J.: ICSO 2020 (held in 2021)

Kuhnhenn, J.; Steffens, M.: »IEEE Transactions on Nuclear Science«, ISSN: 0018-9499, IEEE

Metzger, S.: Advances in Space Research

Suhrke, M.: IEEE Transactions on Electromagnetic Compatibility

Suhrke, M.: IEEE Letters on Electromagnetic Compatibility Practice and Applications

Steffens, M.: »Applied Radiation and Isotopes«, ISSN: 0969-8043, Elsevier

Thorleuchter, D.: Applied Sciences

Thorleuchter, D.: Arabian Journal for Science and Engineering

Thorleuchter, D.: Electronics

Thorleuchter, D.: Future Internet

Thorleuchter, D.: Futures

Thorleuchter, D.: Information

Thorleuchter, D.: International Journal of Information Science

Thorleuchter, D.: International Journal of Internet Research Ethics

Thorleuchter, D.: Jordanian Journal of Computers and Information Technology

Thorleuchter, D.: Mathematics

Thorleuchter, D.: Technological Forecasting & Social Change

Collaboration in Committees

Chmel, S.: Coordinator of the Fraunhofer EU-network

Chmel, S.: Head of work group »AG Management« of the Fraunhofer EU-network

Chmel, S.: Member of the advisory board of the Institute for Detection Technologies at the Bonn-Rhein-Sieg University of Applied Sciences

Höffgen, S.: Radiation Working Group of the ESA Component Technology Board (CTB) as assigned by DLR

Kuhnhenn, J.: Program Committee für ICSO 2020 (held in 2021)

Kuhnhenn, J: Session Chair RADECS 2021

Kuhnhenn, J.: Photonic Working Group des ESA Component Technology Board (CTB) as personal member

Linde-Frech, I.: Member of the informal expert group on »Strengthened Security Research and Innovation (SSRI)« under Directorate-General for Migration and Home Affairs' newly founded »Community for European Research and Innovation for Security« (CERIS, formerly Community of Users for Safe, Secure and Resilient Societies (CoU))

Linde-Frech, I.; Neisser, F.: Members of the »Bonn Network International Civil Protection and Disaster Risk Reduction«

Linde-Frech, I.; Vollmer, M.: Members of the BMBF-funded »Research Network for German Users ForAn« under the coordination of the Agency for Technical Relief THW

Neupert, U.; Walther, G.: Members of the Independent Scientific Evaluation Group (ISEG) of the NATO research programme »Science for Peace and Security«

Suhrke, M.: Ombudsperson Fraunhofer INT

Thorleuchter, D.: Spokesman of the Special Interest Group »Information- and Communication Systems« of the German Computer Society (Gesellschaft für Informatik e.V. (GI))

Thorleuchter, D.: Editorial Board of Advances in Engineering: an International Journal (ADEIJ)

Thorleuchter, D.: Editorial Board of the International Journal of Information Science

Thorleuchter, D.: Editorial Board of the Journal of Advanced Computer Science & Technology

Thorleuchter, D.: Editorial Board of the Journal of Autonomous Intelligence

Thorleuchter, D.: Editorial Board of the Journal of Information Systems Engineering & Management

Vollmer, M.; Linde-Frech, I.: Members of the »Innovation Cluster Civil Security Research InCluSiF«

Vollmer, M.: Member of the expert group »Starkregen«, that has been tasked to analyze the overall operation in context of the heavy rainfall event in summer 2021

Weimert, B.: Board member »Netzwerk Zukunftsforschung«

Weimert, B.: Member of the coordination team »Netzwerk Technikfolgenabschätzung«

Weimert, B.: Associate Editor and Editor »Zeitschrift für Zukunftsforschung«

Participation in Norming Processes

Adami, Ch.: NA140-00-19AA
Preparation of VG-Normen VG96900-96907, NEMP- und Blitzschutz

Adami, Ch.: NA140-00-20-02UA
Preparation of VG-Normen VG95370 ff., Elektromagnetische Verträglichkeit

Adami, Ch.: NATO HPM Standardization
Köble, T.: DIN und VDE DKE/GK851 »Aktivitätsmessgeräte für den Strahlenschutz«

Köble, T.: IEC/SC 45B WG 15 »Radiation protection instrumentation« - »Illicit trafficking control instrumentation using spectrometry, personel electronic dosimeter and portable dose rate instrumentation«

Köble, T.: ISO/TC 85/SC 2/WG 20 »Illicit trafficking in radioactive material«

Suhrke, M.: National Representative of the Joint Task Force Reverberation Chamber of the IEC

Suhrke, M.: GAK 767.3/4.4
TEM-Wellenleiter/Reverberation Chamber, DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Lectures and Presentations

Adami, Ch.:
»Concepts of HPEM munitions and scenarios«, EDA-Workshop #2 »High Power Electromagnetic Munitions (HPEM)«, May 19-21, 2021

Adami, Ch.:
»Entwicklung eines Detektionssystem für elektromagnetische Hochleistungs-Störversuche«, InnoDay, Bundeswehr Command and Staff College, Hamburg, November 11, 2021

Cesbron Lavau, L.:
»Susceptibility of Sensors to IEMI Attacks«, 2021 Joint IEEE EMC+SIPI and EMC Europe, July 26 - August, 20, 2021

Cesbron Lavau, L.:
»Susceptibility of COTS sensors to IEMI using pulse modulated signals« (poster), Kleinheubacher Tagung 2021, September 28-30, 2021

Grüne, M.; Pastuszka, H.-M.:
»Transfer of Technology Watch and Foresight Results into the Defence Organisation – The German Experience«, 8th EDA Workshop on Technology Watch and Foresight, online April 29, 2021

Kuhnhenn, J.:
Invited presentation »Radiation Testing of Photonic Technologies«, RADOPT 2021: Workshop on Radiation Effects on Optoelectronics and Photonics Technologies, November 16, 2021, St. Etienne, France

Lanzrath, M.
»IEMI vulnerability of smart grids«, 2021 Joint IEEE EMC+SIPI and EMC Europe, July 26 - August 20, 2021

Lanzrath, M.:
»HPEM C-UAV: UAS-HPEM-Wechselwirkungsuntersuchungen«, HPEM-Sachstandsbesprechung, WTD81, Greding, December 7, 2021

Martini, M.:
Lecture, InnoDay, Bundeswehr Command and Staff College, Hamburg, November 11, 2021

Neupert, U.:
»Wehrtechnische Zukunftsanalyse«, Lecture at the Military Academy of the German Armed Forces, Hamburg, November 23, 2021

Neupert, U.:
»NATO Emerging Disruptive Technologies – Die Fraunhofer INT-Sicht«, Lecture at the Military Academy of the German Armed Forces, Hamburg, November 23, 2021

Pusch, T.:
»Concepts for quantifying IEMI resilience of critical infrastructures«, 2021 Joint IEEE EMC+SIPI and EMC Europe, July 26 - August 20, 2021

Ribeiro Arduini, F.:
»EMI Risk Management on the Scale of the Smart Grid as a Network of Systems«, Forschungsfortschritt, PETER Network-Wide Event 2, April 12-16, 2021

Ribeiro Arduini, F.:
»A Methodology for Estimating the Criticality of Energy Infrastructures in the Context of IEMI«, 2021 Joint IEEE EMC+SIPI and EMC Europe, July 26, - August 20, 2021

Ribeiro Arduini, F.:
Chair Special Session »Risk-based EMC«, 2021 Joint IEEE EMC+SIPI and EMC Europe, 26. Juli – August 20, 2021

Ribeiro Arduini, F.:
»Vulnerability of smart grid-enabled protective relays to IEMI«, Kleinheubacher Tagung 2021, September 28-30, 2021

Risse, M.:
»Qualification Test System for Radiation Detection Devices – QuTeSt«, The 7th International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications ANIMMA 2021, virtual, June 23, 2021

Risse, M.:
»Radiation Detection for OSI –The Influence of Firmware on Detector Performance«, CTBT: Science and Technology Conference - SnT2021, virtual, June 30, 2021

Risse, M.:
»Dynamic qualification tests of radiation measurement equipment – Using the D3S as an example of a wearable RIID for homelandsecurity«, INMM/ESARDA Joint Annual Meeting 2021, virtual, August 26, 2021

Schumann, O.:
»Neutronenstrahlung«, seminar »Radiologische Risiken« des BBK, virtual, December 7, 2021

Suhrke, M.:
Chair Workshop »Protection of Critical Infrastructures against Intentional Electromagnetic Interference«, 2021 Joint IEEE EMC+SIPI and EMC Europe, July 26 – August 20, 2021

Vollmer, M.:
Lecture »Begrifflichkeiten in RuLe«, in the workshop »Resilienz urbaner Lebensräume« of the project »RuLe – Resilienz urbaner Lebensräume«, July 16, 2021

Publications

Adlakha-Hutcheon, Gitanjali; Bown, Kevin J.; Lindberg, Anna; Nielsen, Thomas Galasz; Römer, Silke; Maltby, J.F.J.:
The use of FATE for illuminating disruptions
(Operations Research and Analysis Conference (OR&A) <14, 2020, Online>)
In: NATO Allied Command Transformation -ACT-: 14th NATO Operations Research and Analysis Conference, OR&A 2020: Emerging and Disruptive Technology, 5-6 October 2020, virtual conference. Brussels: NATO STO, 2021, 10 pp.
URN urn:nbn:de:0011-n-6333859 URN urn:nbn:de:0011-n-633385-17

Alessi, Antonino; Gelardi, Franco Mario:
Electron paramagnetic resonance spectroscopy (EPR)
In: Agnello, S.: Spectroscopy for materials characterization. Hoboken/NJ: Wiley, 2021, pp. 253-280
DOI 10.1002/9781119698029.ch9

Arduini, Fernando R.; Ghosalkar, Samikshya; Nateghi, Arash; Lanzrath, Marian; Fisahn, Sven; Schaarschmidt, Martin:
Vulnerability of smart grid-enabled protection relays to IEMI: Presentation held at Kleinheubacher Tagung, 28.–30.09.2021, Miltenberg
(Kleinheubacher Tagung <2021, Miltenberg>) 2021
URN urn:nbn:de:0011-n-6476952

Arduini, Fernando R.; Lanzrath, Marian; Pusch, Thorsten; Suhrke, Michael; Garbe, Heyno:
A methodology for estimating the criticality of energy infrastructures in the context of IEMI
(International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC SIPI) <2021, Online>)
In: Institute of Electrical and Electronics Engineers -IEEE-: IEEE International Joint EMC/SI/PI and EMC Europe Symposium 2021: 26 July - 20 August 2021, Virtual Event. Piscataway, NJ: IEEE, 2021, pp. 743-748
DOI 10.1109/EMC/SI/PI/EMCEurope52599.2021.9559348

Baaden, Philipp; Wustmans, Michael; Richter, Daniel; John, Marcus; Bröring, Stefanie:
Representing the research landscape of the circular economy: Presentation held at 11th Annual Global Tech Mining Conference, 17.-19.11.2021, Virtual Event
(Global TechMining Conference (GTM) <11, 2021, Online>) 2021
URN urn:nbn:de:0011-n-6456983

Basu, Anwesha; Singh, A.K.; Ragnarsson, I.; Carlsson, B.G.; Kardan, A.; Hagemann, G.B.; Sletten, G.; Herskind, B.; Hübel, H.; Chmel, Sebastian; Wilson, A.N.; Rogers, J.; Janssens, R.V.F.; Carpenter, M.P.; Khoo, T.L.; Kondev, F.G.; Lauritsen, T.; Zhu, S.; Korichi, A.; Fallon, P.; Nyako, B.M.; Timar, J.:
Highly deformed band structures due to core excitations in ^{123}Xe
In: Physical Review. C, Vol.103 (2021), No.1, Art. 014301, 14 pp.
DOI 10.1103/PhysRevC.103.014301

Bauer, Wilhelm; Edler, Jakob; Lauster, Michael; Martin, Alexander; Morszeck, Thomas; Posselt, Thorsten; Weissenberger- Eibl, Marion A.; Grill, Bernhard; Heuberger, Albert; Riedel, Oliver; Spath, Dieter; Schimpf, Sven; Bantes, René; Herrmann, Florian; Growitsch, Christian; Klages, Tina; Kroll, Henning; Pflaum, Alexander; Worms, Diana; Fraunhofer-Verbund Innovationsforschung:
Innovation and Covid-19: Food for Thought on the Future of Innovation: Update 2021
Stuttgart: Fraunhofer-Verbund Innovationsforschung, 2021
URN urn:nbn:de:0011-n-6378417

Bauer, Wilhelm; Edler, Jakob; Lauster, Michael; Martin, Alexander; Morszeck, Thomas; Posselt, Thorsten; Weissenberger- Eibl, Marion A.; Grill, Bernhard; Heuberger, Albert; Riedel, Oliver; Spath, Dieter; Schimpf, Sven; Bantes, René; Herrmann, Florian; Klages, Tina; Kroll, Henning; Pflaum, Alexander; Worms, Diana; Fraunhofer-Verbund Innovationsforschung:
Innovation und COVID-19: Impulse für die Zukunft der Innovation: Update 2021
Stuttgart: Fraunhofer-Verbund Innovationsforschung, 2021 URN urn:nbn:de:0011-n-6335001 URN urn:nbn:de:0011-n-633500-10

Berchtold, Claudia; Walker, Stephen (Contributor); Petersen, Katrina (Contributor); Cadar, Lavinia (Contributor); Boin, Charlotte (Contributor); Galanopoulou, Katerina (Contributor); Chmel, Sebastian (Contributor); Levink, Milou (Contributor); Groot, Gerwin de (Contributor); Gnecchi, Gianmario (Contributor):
Deliverable D2.9 - Handbook of cross-organisational preparedness and response operations
Euskirchen, 2021
URN urn:nbn:de:0011-n-6477579

Berchtold, Claudia; Müller, Larissa; Walter, Gerald; Mrosek, Karin; Labour, Melanie (Contributor); Cooke, Michael (Contributor); Seidel, Katja (Contributor); Saris, Jamie (Contributor); Prendergast, David (Contributor); Redmond, Niamh (Contributor); Lombard-Vance, Richard (Contributor); Desmond, Deirdre (Contributor); Hoogerwerf, Evert-Jan (Contributor); Fiordelmondo, Valentina (Contributor); Scott, Michael (Contributor); Goodfellow, Nicola (Contributor); McEvoy, Emma (Contributor); Scullin, Claire (Contributor); Sarlio-Siintola, Sari (Contributor); Alapuranen, Nina (Contributor); Donnelly, Mark (Contributor); Zurkuhlen, Alexia (Contributor); Meenen, Bettina (Contributor); Ghrissi, Meftah (Contributor); Gonidis, Fotis (Contributor); Bogdos, George (Contributor); Shek, Wai Hang (Contributor); Fertoin, Thomas Geiger (Contributor); D'Arino, Lucia (Contributor); Jensen, Rune (Contributor); Isaris, Paul (Contributor); Dratsiou, Ioanna (Contributor); Metaxa, Maria (Contributor); Romanopoulou, Evangelia (Contributor); Varella, Annita (Contributor); Finlay, Dewar (Contributor):
Deliverable D3.9 - Final user requirements for the SHAPES platform
Euskirchen, 2021
URN urn:nbn:de:0011-n-6478568

Berchtold, Claudia; Petersen, Katrina (Contributor); Cadar, Lavinia (Contributor); Boin, Charlotte (Contributor); Galanopoulou, Katerina (Contributor); Chmel, Sebastian (Contributor); Levink, Milou (Contributor); Groot, Gerwin de (Contributor):
Deliverable D7.6 Knowledge capitalisation - report on lessons learnt using IN-PREP in exercises/demos
Euskirchen, 2021
URN urn:nbn:de:0011-n-6478678

Blanc, Jeremy; Achten, Frank; Alessi, Antonino; Amezcua, Adrian; Kuhnhenn, Jochen; Pastouret, Alain; Ricci, Daniel; Toccafondo, Iacopo:
Characterization of radiation-resistant multimode optical fibers for large-scale procurement
In: IEEE Transactions on Nuclear Science, Vol.68 (2021), No.7, pp.1407-1413
DOI 10.1109/TNS.2021.3074633

Bornhöft, Charlotte; Thomausket, Bruno (Berichter); Nabbi, Rahim (Berichter); Lauster, Michael (Berichter):
Digital Pulse Processing Methods for Simultaneous Efficient Detection and Identification of Neutron and Gamma Radiation of Novel Detection Materials
Aachen: Universitätsbibliothek der RWTH Aachen, 2021 Zugl: Aachen, Univ., Diss., 2021
DOI 10.18154/RWTH-2021-07949

Bornhöft, Charlotte; Lieder, Evgenia:
Small Modular Reactors
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.3, pp.72
URN urn:nbn:de:0011-n-6443539

Brandt, Heike:
Architectured Materials
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.1, pp.77
URN urn:nbn:de:0011-n-6245076

Brandt, Heike; Langner, Ramona; Freudendahl, Diana:
Werkstofftrends: MXene
In: Werkstoffe in der Fertigung, (2021), No.2, pp.3

Brandt, Heike:
Hochentropie-Keramiken
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.12, pp.77

Brandt, Heike; Langner, Ramona; Freudendahl, Diana:
Werkstofftrends: Additiv gefertigte Batterien
In: Werkstoffe in der Fertigung, (2021), No.6, pp.3

Cesbron Lavau, Louis; Suhrke, Michael; Knott, Peter:
Susceptibility of COTS sensors to IEMI using pulse modulated signals: Poster presented at Kleinheubacher Tagung 2021, Miltenberg, 28.-30.09.2021
(Kleinheubacher Tagung <2021, Miltenberg>)
2021 URN urn:nbn:de:0011-n-6457552

Cesbron Lavau, Louis; Suhrke, Michael; Knott, Peter:
Susceptibility of sensors to IEMI attacks
(International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC SIPI) <2021, Online>)
In: Institute of Electrical and Electronics Engineers -IEEE-: IEEE International Joint EMC/SI/PI and EMC Europe Symposium 2021: 26 July - 20 August 2021, Virtual Event. Piscataway, NJ: IEEE, 2021, pp. 533-537
DOI 10.1109/EMC/SI/PI/EMCEurope52599.2021.9559197

Dorado Chaparro, Javier; Fernández-Bermejo Ruiz, Jesús; Santofimia Romero, Maria J.; Bolaños Peño, Cristina; Unzueta Irurtia, Luis; Garcia Perea, Meritxell; Toro Garcia, Xavier del; Villanueva Molina, Felix J.; Grigoleit, Sonja; Lopez, Juan C.:
The SHAPES Smart Mirror Approach for Independent Living, Healthy and Active Ageing
In: Sensors. Online journal, Vol.21 (2021), No.23, Art. 7938, 40 pp.
DOI 10.3390/s21237938

Fekete, Alexander; Bross, Lisa; Krause, Steffen; Neisser, Florian; Tzavella, Katerina:
Bridging gaps in minimum humanitarian standards and shelter planning by critical infrastructures
In: Sustainability, Vol.13 (2021), No.2, Art. 849, 17 pp.
DOI 10.3390/su13020849

Freudendahl, Diana:
Bioinspirierte Unterwasserklebstoffe
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.7, pp.104
URN urn:nbn:de:0011-n-6378203

Freudendahl, Diana; Brandt, Heike; Langner, Ramona:
Werkstofftrends: Wärmeleitende Kunststoffe
In: Werkstoffe in der Fertigung, (2021), No.1, pp.3

Freudendahl, Diana; Langner, Ramona; Brandt, Heike:
Werkstofftrends: 2D-Magnete
In: Werkstoffe in der Fertigung, (2021), No.4, pp.3

Grigoleit, Sonja; Kaluza, Benjamin; Berchtold, Claudia; Chmel, Sebastian; Müller, Larissa (Contributor); Lieder, Evgenia (Contributor); Sendrowski, Philip (Contributor); Sdongos, Evangelos (Contributor); Cadar, Lavinia (Contributor); Schwoch, Gunnar (Contributor); Marzoli, Marcello (Contributor); Kostaridis, Antonis (Contributor); Perlepes, Leonidas (Contributor); Petersen, Katrina (Contributor); Roberts, Mark (Contributor); Stevenson, Peter (Contributor); Nottebaum, Pia (Contributor); Levink, Milou (Contributor); Groot, Gerwin de (Contributor); Kanis, Aleid (Contributor); Argyris, Ilias (Contributor); Makri, Effie (Contributor); McAlister, Mannix (Contributor); Vivien, Benoît (Contributor); Inglese, Guillaume (Contributor); Sousa, Luis (Contributor); Filippidis, Lazaros (Contributor); Ferrucci, Fabrizio (Contributor); Fotopoulos, Anax (Contributor):
Deliverable D7.5 - Training programme evaluation
Euskirchen, 2021

Heuer, Carsten:
Biomimetische Riechsysteme
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.11, pp.94

Hollmann, Vanessa:
Biomimetische UAVs
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.2, pp.77
URN urn:nbn:de:0011-n-6245507

Hollmann, Vanessa:
Augmented Sensing
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.10, pp.102

Jernej, Irmgard; Faust, Markus; Lammegger, Roland; McKenzie, Lain; Kuhnhenn, Jochen; Knothe, Christian; O'Riorden, Steve; Barbero, Juan; Brown, Paula; Lelievre, V.; Agú, Martin; Alessi, Antonino; Amtmann, Christoph; Betzler, Alexander Pieter; Dougherty, Michele; Ellmeier, Michaela; Hagen, Christian; Hauser, A.; Hartig, M.; Lamott, André; Leichtfried, M.; Magnes, Werner; Mahapatra, Amaresh; Mariojouls, Stephane; Monteiro, David; Pollinger, Andreas; Salomon, A.; Weinand, Udo; Wolf, Raphael:
Design and test of the optical fiber assemblies for the scalarmagnetic field sensor aboard the JUICE mission (International Conference on Space Optics (ICSO 2020)
<2021, Online>)
In: Cugny, B.: International Conference on Space Optics, ICSO 2020: Virtual Conference, 20 March - 2 April 2021. Bellingham, WA: SPIE, 2021. (Proceedings of SPIE 11852), Paper 1185264, 16 pp.
DOI 10.1117/12.2600052

John, Marcus; Fritsche, Frank; Gülden, Christian:
Where to start reading? Introducing the reference-citation plot
(International Conference on Scientometrics and Informetrics (ISSI) <18, 2021, Online>)
In: Glänzel, Wolfgang (Editor): 18th International Conference on Scientometrics & Informetrics, ISSI 2021. Proceedings: Virtual Event, 12-15 July 2021, KU Leuven, Belgium. Leuven: ISSI, 2021, pp. 539-544

Jovanovic, Milos:
Technological Trend Analysis
In: Ball, Rafael (Editor): Handbook Bibliometrics. Berlin: De Gruyter, 2021, pp. 311-318
DOI 10.1515/9783110646610-031

Jovanovic, Milos; Baaden, Philipp; Fritsche, Frank:
Reference distributions of reviews in the web of science - The effects of company policy from 1992-2010
(International Conference on Scientometrics and Informetrics (ISSI) <18, 2021, Online>)
In: Glänzel, Wolfgang (Editor): 18th International Conference on Scientometrics & Informetrics, ISSI 2021. Proceedings: Virtual Event, 12-15 July 2021, KU Leuven, Belgium. Leuven: ISSI, 2021, pp. 545-550

Knapp, Daniel; Richter, Daniel; Fietkiewicz, Katja J. (Erstgutachter); Jovanovic, Milos (Zweitgutachter):
Cynefin als Grundlage einer Klassifikation von Entscheidungsunterstützung am Beispiel von Projekten des Fraunhofer INT: Abschlussarbeit zur Erlangung des Grades Master of Arts [M.A.] im Studiengang Informationswissenschaft und Sprachtechnologie
Düsseldorf, Univ., Master Thesis, 2021
URN urn:nbn:de:0011-n-6456482

Kohlhoff, Jürgen:
Raumtemperatursupraleiter
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.4, pp.104
URN urn:nbn:de:0011-n-6336689

Langner, Ramona; Brandt, Heike; Freudendahl, Diana:
Werkstofftrends: Textile Energiespeicher
In: Werkstoffe in der Fertigung, (2021), No.3, pp.3

Langner, Ramona; Brandt, Heike; Freudendahl, Diana:
Werkstofftrends: Transiente Elektronik
In: Werkstoffe in der Fertigung, (2021), No.5, pp.3

Lo Piccolo, Guiseppe Mattia; Morana, Adriana; Alessi, Antonino; Boukenter, Aziz; Girard, Sylvain; Ouerdane, Youcef; Gelardi, Franco Mario; Agnello, Simonpietro; Cannas, Marco: Ultraviolet-visible light-induced solarisation in silica- based optical fibres for indoor solar applications
In: Journal of non-crystalline solids, Vol.552 (2021), Art. 120458, 5 pp.
DOI 10.1016/j.jnoncrysol.2020.120458

Loosen, Thomas (Red.); Haberlach, Angela (Red.); Frederick, Gina (Red.); Makome, Angelique (Red.); Büttgen, Jan-Lukas (Red.); Wagner, Tassja (Red.); Fraunhofer-Institut für Naturwissenschaftlich-Technische Trendanalysen -INT-, Euskirchen:
Fraunhofer-Institut für Naturwissenschaftlich-Technische Trendanalysen. Jahresbericht 2020
Euskirchen: Fraunhofer INT, 2021
URN urn:nbn:de:0011-n-6363305

NATO, Science and Technology Organization, Systems Analysis Studies Research Task Group 123:
Futures Assessed alongside socio-Technical Evolutions (FATE): Final report of the SAS-123 Research Task Group
Neuilly-sur-Seine: NATO, STO, 2021
ISBN 978-92-837-2322-6 DOI 10.14339/STO-TR-SAS-123 URN urn:nbn:de:0011-n-6446139

Neisser, Florian; Kox, Thomas:
Zur Verankerung von Zukunft in der Gefahrenabwehr: Antizipationspraktiken und Herausforderungen im Kontext von Feuerwehren
In: Zeitschrift für Zukunftsforschung, (2021), No.1, pp.158-181

Pinzger, Britta:
Living Materials
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.9, pp.95

Pusch, Thorsten R.; Suhrke, Michael; Jörres, Benjamin:
Characterization of a reference test setup for the development of HPEM standards
In: IEEE letters on electromagnetic compatibility practice and applications : L-EMCPA, Vol.3 (2021), No.1, pp.3-6
DOI 10.1109/LEMCPA.2020.3035893

Risse, Monika; Clemens, Peter; Glabian, Jeannette; Köble, Theo; Schumann, Olaf:
Dynamic qualification tests of radiation measurement equipment - Using the D3S as an example of a wearable RIID for homeland security: Paper presented at INMM/ESARDA Joint Annual Meeting 2021, August 23-September 1, 2021
(Institute of Nuclear Materials Management (INMM Annual Meeting) <2021, Online>)
2021
URN urn:nbn:de:0011-n-6429588

Risse, Monika; Clemens, Peter; Glabian, Jeannette; Schumann, Olaf; Köble, Theo; Friedrich, Hermann; Berky, Wolfram; Bornhöft, Charlotte; Chmel, Sebastian:
Qualification Test System for Radiation Detection Devices - QuTeSt: Paper presented at 7th International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications, ANIMMA 2021, June 21-25, 2021, Prague, Czech Republic
(International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications (ANIMMA) <7, 2021, Prague>)
2021
URN urn:nbn:de:0011-n-6429594

Risse, Monika; Bornhöft, Marie Charlotte; Glabian, Jeanette; Köble, Theo; Friedrich, Hermann:
Radiation Detection for OSI - the Influence of Firmware on Detector Performance: Video presented at CTBT: Science and Technology 2021 Conference, 28 June 2021 to 2 July 2021, Vienna, Austria
(Science and Technology Conference (SnT) <8, 2021, Online>)
2021

Ruhlig, Klaus:
Explainable Artificial Intelligence
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.6, pp.85
URN urn:nbn:de:0011-n-6354266

Schwinde, Stefan; Shestaeva, Svetlana; Stempfhuber, Sven; Lukowicz, Henrik von; Kuhnhenn, Jochen; Schröder, Sven:
Au coatings for spaced based reflectors
(International Conference on Space Optics (ICSO 2020) <2021, Online>)
In: Cugny, B.: International Conference on Space Optics, ICSO 2020: Virtual Conference, 20 March - 2 April 2021. Bellingham, WA: SPIE, 2021. (Proceedings of SPIE 11852), Paper 118521Q, 8 pp.
DOI 10.1117/12.2599299

Spargo, Maureen; Goodfellow, Nicola; Scullin, Claire; Grigoleit, Sonja; Andreou, Andreas; Mavromoustakis, Constandinos X.; Guerra, Bárbara; Manso, Marco; Larburu, Nekane; Villacañas, Óscar; Fleming, Glenda; Scott, Michael:
Shaping the future of digitally enabled health and care
In: Pharmacy, Vol.9 (2021), No.1, Art. 17, 9 pp.
DOI 10.3390/pharmacy9010017

Tavel, Peter; Dubovska, Eva (Contributor); Meier, Zdenek (Contributor); Trnka, Radek (Contributor); Pesoutová, Markéta (Contributor); Cohlová, Jana (Contributor); Pinaka, Rania (Contributor); Stamatiadis, Vagelis (Contributor); Gioulekas, Fotios (Contributor); Tzikas, Athanasios (Contributor); Gounaris, Konstantinos (Contributor); D'Arino, Lucia (Contributor); Jensen, Rune (Contributor); Roche, Pedro (Contributor); Sarlio-Siintola, Sari (Contributor); Purola, Aletta (Contributor); Rocha, Pedro (Contributor); Isaris, Paul (Contributor); Labor, Melanie (Contributor); Grigoleit, Sonja (Contributor); Seidel, Katja (Contributor); Prendergast, David (Contributor); Saris, Jamie (Contributor); Martins, Ana (Contributor); Guerra, Bárbara (Contributor); Berchtold, Claudia (Contributor); Gonidis, Fotis (Contributor); Shek, Waihang (Contributor); Andreou, Andreas (Contributor); Dratsiou, Ioanna (Contributor); Mavromoustakis, Constandinos X. (Contributor); Nevmerzhitskaya, Julia (Contributor); Romanopoulou, Evangelia (Contributor):
Deliverable D2.7 - SHAPES personas and use cases
Olomouc, 2021
URN urn:nbn:de:0011-n-6477553

Thorleuchter, Dirk:
Lifelong Machine Learning
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.5, pp.69
URN urn:nbn:de:0011-n-6434166

Vollmer, Maike; Fiedrich, Frank (First supervisor); Fekete, Alexander (Second supervisor):
Implementing innovations in disaster management to increase resilience - laws, policies, and organizational determinants
Wuppertal: UB Wuppertal, 2021 Zugl.: Wuppertal, Univ., Diss., 2021 DOI 10.25926/2ryt-7w16

Weimert, Birgit; Römer, Silke:
Bestandsaufnahme der Szenariomethodik - Ansätze einer kritischen Analyse
In: Zeitschrift für Zukunftsforschung, Vol.2021 (2021), No.1, pp.91-133

Wiemken, Uwe:
Aufklärung, Technik und Offene Gesellschaft: Können wir die Vernunft noch retten? Ein Menschheitsprojekt
Baden-Baden: Tectum Verlag, 2021
ISBN 978-3-8288-4280-9 ISBN 3-8288-4280-1 ISBN 978-3-8288-7331-5 ISBN 978-3-8288-7332-2

Wilson, Rachele S.; Keller, Alexander; Shapcott, Alison; Leonhardt, Sara D.; Sickel, Wiebke; Hardwick, Jane L.; Heard, Tim A.; Kaluza, Benjamin F.; Wallace, Helen M.:
Many small rather than few large sources identified in long-term bee pollen diets in agroecosystems
In: Agriculture, ecosystems & environment, Vol.310 (2021), Art. 107296, 8 pp.
DOI 10.1016/j.agee.2020.107296

Yildirim, Baycan:
Mikroroboter
In: Europäische Sicherheit & Technik: ES & T, Vol.70 (2021), No.8, pp.64
URN urn:nbn:de:0011-n-6390059

Personalia

Bornhöft, M. C.:
Doctoral thesis »Digital Pulse Processing Methods for Simultaneous Efficient Detection and Identification of Neutron and Gamma Radiation of Novel Detection Materials«, RWTH Aachen University, 2016-2021

Cesbron Lavau, L.:
Promotion »IEMI and Information Security«, RWTH Aachen University, 2019-ongoing

Ribeiro Arduini, F.:
Promotion »EMI Risk Management on the Scale of the Smart Grid as a Network of Systems«, Leibniz University Hannover, 2020-ongoing

Wölk, D.:
Doctoral thesis »Untersuchung und Entwicklung von Analysemethoden zu neutroneninduzierten SEE«, University of Cologne, 2017-ongoing

Vollmer, M.:
Promotion »Implementing innovations in disaster management to increase resilience – laws, policies, and organizational determinants«, University of Wuppertal, completed, doctoral examination on March 10, 2021

Other Events

July 16-13, 2021
Nuclear & Space Radiation Effects Conference (NSREC)

September 12-17, 2021
RADiations Effects on Components and Systems (RADECS)

Press Releases

Neues 9,75 Mio. € Horizont-2020-Projekt zur Stärkung der Bereitschaft und Reaktionsfähigkeit der EU auf künftige Pandemien
February 2, 2021

Fraunhofer INT und Digital Science kombinieren Technology Foresight Tool KATI und Dimensions-Daten
April 9, 2021

Impulspapier verschafft Zeitreise in die Zukunft der Innovation – wie sich die Pandemie auf Innovationssysteme auswirkt
May 26, 2021

RiskPACC-Projekt startet: Fraunhofer INT führt Projekt zur Erhöhung der Widerstandsfähigkeit gegenüber Katastrophen an
June 10, 2021

Jetzt aus der Starkregenkatastrophe lernen: vfdb setzt Expertenkommission ein – erste Ergebnisse für Herbst angekündigt
September 13, 2021

Fraunhofer INT führt erste Bestrahlung nach Hochwasserkatastrophe durch
September 23, 2021

Honorarprofessur für den Physiker René Bantes
October 29, 2021

Projekt »UN:IO«: Fraunhofer-Institute INT und IAF unterstützen Vorbereitungen für ein souveränes europäisches Satellitennetz
December 23, 2021

Institute Course

»Zur Verankerung von Zukunft in der Gefahrenabwehr. Antizipationspraktiken und Herausforderungen im Kontext von Feuerwehren.«
Neisser, F., Fraunhofer Institute for Technological Trend Analysis INT, Kox, T., Ludwig Maximilian University of Munich, online, January 27, 2021

»Passiv-Radar für Lawinen-Detektion«
Cesbron Lavau, L., Fraunhofer Institute for Technological Trend Analysis INT, online, February 10, 2021

»Effekte und Anwendungen hochenergetischer Laserstrahlung«
Osterholz, J., Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, online, February 24, 2021

»Warum dauert das alles immer so lange? Innovation im militärischen Beschaffungswesen«
Bantes, R., Fraunhofer Institute for Technological Trend Analysis INT, online, April 14, 2021

»The Future of Sound – Technologiefrühaufklärung im Bereich Cochlear Implantat«
John, M., Fraunhofer Institute for Technological Trend Analysis INT, online, May 26, 2021

»Forschung für die Energie- und Rohstoffwende«
Grevé, A., Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT, online, June 2, 2021

»Das Projekt Foresight Fraunhofer«
Schirrmeister, E., Fraunhofer Institute for Systems and Innovation Research ISI, Jovanović, M., Fraunhofer Institute for Technological Trend Analysis INT, online, June 9, 2021

»Analyse des Transfers wissenschaftlicher Erkenntnisse in Policy Documents mittels Altmetriken am Beispiel des Forschungsfeldes Wildfire Risk Management«
Schlierkamp, J., Fraunhofer Institute for Technological Trend Analysis INT, online, September 8, 2021

»Privatisierung von Daten im Kontext von Intrusion Detection Systemen«
Martini, M., Fraunhofer Institute for Technological Trend Analysis INT, online, September 15, 2021

»Was bestimmt eine erfolgreiche Implementierung von Innovationen im Katastrophenmanagement?«
Vollmer, M., Fraunhofer Institute for Technological Trend Analysis INT, online, September 22, 2021

»Weltraumschrott - Wie könnte man den LEO sicherer machen?«
Ben Bekhti-Winkel, N., Fraunhofer Institute for Technological Trend Analysis INT, online, October 6, 2021

»Geschäftsfeld TFU – Aktuelle Projekte«
Jovanović, M.; Wagner, S.; Baaden, P.; Römer, S., Fraunhofer Institute for Technological Trend Analysis INT, online, October 27, 2021

»What's up with KATI? – Neuigkeiten aus dem Datenraum!«
John, M., Fraunhofer Institute for Technological Trend Analysis INT, online, November 17, 2021

»3 unpopuläre Thesen zur Energiewende«
Speiser, P., Air Liquide, online, December 1, 2021

Business Units and Contacts

Director's Office

Director

Prof. Dr. Dr. Michael Lauster
Phone +49 2251 18-117 / -217
michael.lauster@int.fraunhofer.de

Vice-Director

Dr. Stefan Metzger
Phone +49 2251 18-214
stefan.metzger@int.fraunhofer.de

Commercial Director

Prof. Dr. Harald Wirtz
Phone +49 2251 18-237
harald.wirtz@int.fraunhofer.de

DEPARTMENT TECHNOLOGICAL ANALYSES AND STRATEGIC PLANNING (TASP):

Head

Dr. René Bantes
Phone +49 2251 18-185
rene.bantes@int.fraunhofer.de

Deputy

Hans-Martin Pastuszka
Phone +49 2251 18-298
hans-martin.pastuszka@int.fraunhofer.de

DEPARTMENT NUCLEAR AND ELECTROMAGNETIC EFFECTS (NE):

Head

Dr. Stefan Metzger
Phone +49 2251 18-214
stefan.metzger@int.fraunhofer.de

Deputy

Dr. Jochen Kuhnhenn
Phone +49 2251 18-200
jochen.kuhnhenn@int.fraunhofer.de

DEPARTMENT BUSINESS ADMINISTRATION AND CENTRAL SERVICES (BZD):

Head

Prof. Dr. Harald Wirtz
Phone +49 2251 18-237
harald.wirtz@int.fraunhofer.de

Deputy

Sabrina Langemann
Phone +49 2251 18-226
sabrina.langemann@int.fraunhofer.de

WZA

Defense Technology Foresight

Hans-Martin Pastuszka
Phone +49 2251 18-298
hans-martin.pastuszka@int.fraunhofer.de

Dr. Ulrik Neupert
Phone +49 2251 18-224
ulrik.neupert@int.fraunhofer.de

CTF

Corporate Technology Foresight

Dr. Anna Julia Schulte-Loosen
Phone +49 2251 18-379
anna.schulte@int.fraunhofer.de

Dr. Diana Freudendahl
Phone +49 2251 18-373
diana.freudendahl@int.fraunhofer.de

TIP

Public Technology and Innovation Planning

Isabelle Linde-Frech
Phone +49 2251 18-367
isabelle.linde-frech@int.fraunhofer.de

Dr. Sonja Grigoleit
Phone +49 2251 18-309
sonja.grigoleit@int.fraunhofer.de

TFU

Group Technology Foresight and University Hub

Dr. Miloš Jovanović
Phone +49 2251 18-265
milos.jovanovic@int.fraunhofer.de

Dr. Silke Römer
Phone +49 2251 18-313
silke.roemer@int.fraunhofer.de

Further Contacts

Marketing and Public Relations

Gina Frederick
Phone +49 2251 18-125
gina.frederick@int.fraunhofer.de

Library and Specialized Information Services

René Bennemann
Phone +49 2251 18-170
rene.bennemann@int.fraunhofer.de

NSD

Nuclear Security Policy and Detection Techniques

Dr. Theo Köble
Phone +49 2251 18-271
theo.koeble@int.fraunhofer.de

Dr. Monika Risse
Phone +49 2251 18-253
monika.risse@int.fraunhofer.de

EME

Electromagnetic Effects and Threats

Dr. Marian Lanzrath
Phone +49 2251 18-184
marian.lanzrath@int.fraunhofer.de

Christian Adami
Phone +49 2251 18-312
christian.adami@int.fraunhofer.de

NEO

Nuclear Effects in Electronics and Optics

Dr. Jochen Kuhnhenn
Phone +49 2251 18-200
jochen.kuhnhenn@int.fraunhofer.de

Dr. Stefan Höffgen
Phone +49 2251 18-301
stefan.hoeffgen@int.fraunhofer.de

KLAB

Group KATI Lab

Dr. Marcus John
Phone +49 2251 18-231
marcus.john@int.fraunhofer.de

Frank Fritsche
Phone +49 2251 18-332
frank.fritsche@int.fraunhofer.de

Central Infrastructure and Information Security

Christoph Schemoschek
Phone +49 2251 18-252
christoph.schemoschek@int.fraunhofer.de

How to reach us

By road

Autobahn A1: leave at exit 110 »Euskirchen« or Autobahn A61: leave at exit 26 »Swisttal-Heimerzheim«

By air

Nearest airports:

- Cologne/Bonn (60 km)
- Düsseldorf (100 km)

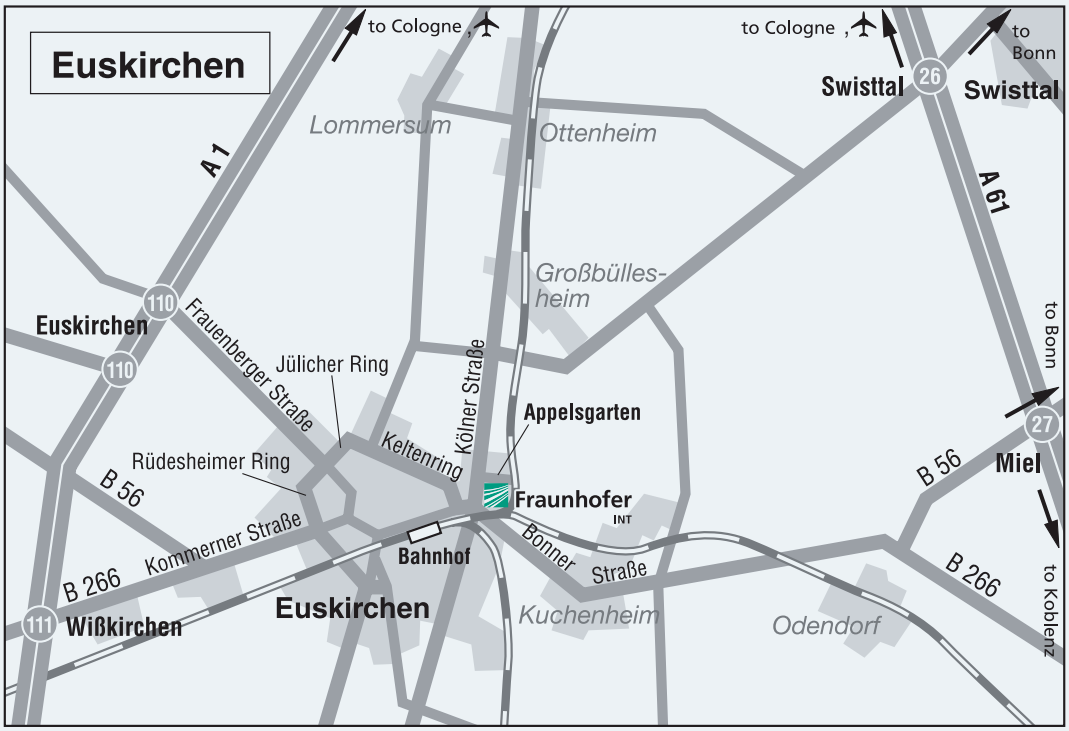
By rail

Nearest Inter-City Main Stations:

- Bonn Central Station
- Cologne Central Station

From there regular rail connections to Euskirchen.
From Euskirchen Station with Bus No 875 in direction »Großbüllesheim-Wüschheim«; or Bus No 806 in direction »Heimerzheim Fronhof« to »Appelsgarten«

Fraunhofer-Institut
für Naturwissenschaftlich- Technische Trendanalysen INT | Appelsgarten 2 | 53879 Euskirchen



Publishing Details

Editor

Angela Haberlach, Gina Frederick,
Angelique Makome, Jan-Lukas Büttgen

Editor's Address

Fraunhofer Institute
for Technological Trend Analysis INT
Marketing and Public Relations

Appelsgarten 2
53879 Euskirchen
Telefon +49 2251 18-0
Fax +49 2251 18-277

Design, Realisation, Production:

kreativrudel GmbH & Co. KG, Bonn

Printing

Fraunhofer Verlag – Mediendienstleistungen

General inquiries via Email to:
pr@int.fraunhofer.de

Picture Credits

p. 3	Jens Howorka/Blendfabrik
p. 15	Fraunhofer-Verbund Innovationsforschung
pp. 20-21	Tobias Vollmer
p. 25	fotogestoeber/Shutterstock.com
p. 27	Ghinzo/Pixabay.com
p. 29	karen roach/Shutterstock.com
p. 31	metamorworks/Shutterstock.com
p. 37	Jens Howorka/Blendfabrik
pp. 40-41	Tobias Vollmer
pp. 42-43	kmls/Shutterstock.com
pp. 44-45	MC MEDIASTUDIO/Shutterstock.com
pp. 46-49	Dotted Yeti/Shutterstock.com
p. 47	Framatome GmbH/Aachen Institute for Nuclear Training GmbH (AiNT)
p. 48	Framatome GmbH/Aachen Institute for Nuclear Training GmbH (AiNT)
p. 49	Framatome GmbH/Aachen Institute for Nuclear Training GmbH (AiNT)
pp. 50-51	wan wie/Shutterstock.com
pp. 54-55	Photocreo Bednarek – stock.adobe.com
pp. 56-57	BAM
pp. 58-59	Tobias Vollmer
p. 61	Foxy burrow/Shutterstock.com
p. 63	Bundeswehr
p. 78	Tobias Vollmer

Annual report 2021

Fraunhofer Institute for Technological Trend Analysis INT