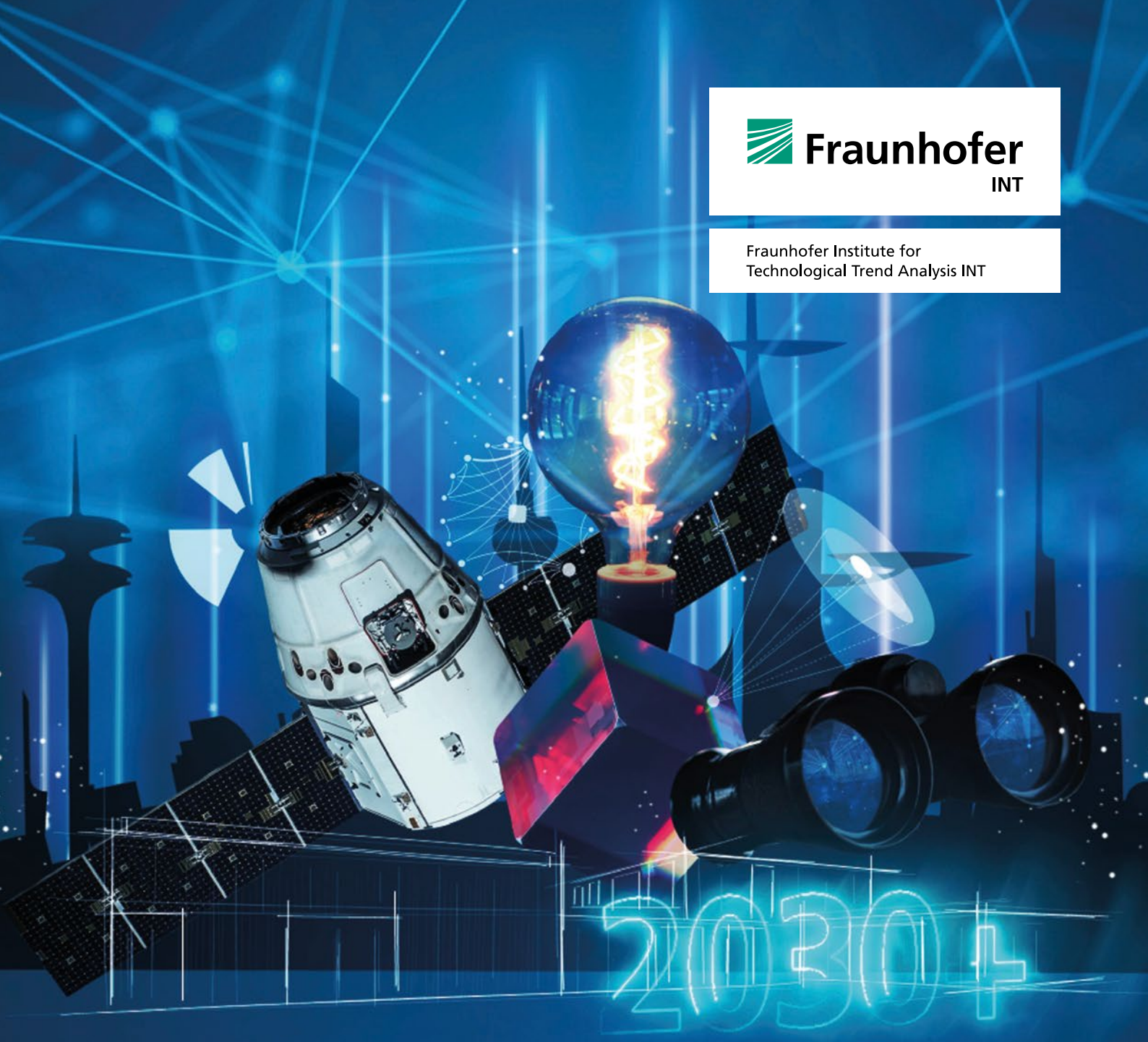


Fraunhofer INT

Fraunhofer Institute for
Technological Trend Analysis INT

Annual Report 2022

The crisis as an opportunity

Foreword

Dear readers,

"The year after" – loosely based on the title of a well-known doomsday movie, it turns out that even in the year after, the Euskirchen flood disaster of July 2021 is the dominant topic in the institute's everyday life.

A large part of the institute's infrastructure is still destroyed, only partially deconstructed, and far from usable in any way. Containers still serve as temporary laboratories; however, they have proven to be unsuitable as experimental environments for high-precision measurements over the course of the year. And a large proportion of employees still rely on home offices, as numerous office workstations are unusable. The institute's internal view tells us: we are still in the midst of the immediate effects of the disaster.

However, if you believe the official view of the authorities, the crisis is over. In the spring, it was therefore decided to end the relaxation of the award procedure for construction services and to return to the time-consuming and labor-intensive standard procedures – with the result that even the simplest processes, such as the installation of a workshop floor, have still not been commissioned, let alone processed, a year and a half after the flood.

In his satire "Parkinson's Law", historian Northcote Parkinson describes how administrations grow and, through continually introducing new sets of rules, generate work dedicated exclusively to overcoming the internal friction of the expanding organization – a self-reinforcing process. As a result, the ratio of results to effort continuously deteriorates and approaches zero – an effect that can currrently be observed in many places. The disease even has a name: Parkinson calls it "Injelitance", an affliction that befalls almost every large organization over time, and which knows only one cure: a complete eradication of the tangled regulations, daring to adopt a new approach, and rebuilding from scratch. If one aims to achieve the "Germany speed" conjured up by Chancellor Scholz, this approach is probably without alternative.

We also started with a new approach in the middle of the year. Understanding the significant duration required for estimating large construction projects and drawing from last year's experience with the limitations of container operations, the necessity arose to identify an interim solution that would genuinely enhance working conditions in a sustainable manner. Laboratories must be situated within permanent buildings that are temperature-stable and in close proximity to the experimental halls. This means that only the existing buildings in the Appelsgarten property can be considered. A logical consequence is the rededication of library and office space in

> **Despite numerous formal hurdles, there is hope that we can make significant strides in securing the necessary funds for major construction projects in the year 2023."**
>
> Prof. Dr. Dr. Michael Lauster

the new buildings, which have suffered relatively little damage, and their immediate conversion. The need for office workstations is to be met by renting appropriate space at Euskirchen.

Even though my introduction above may have sounded a bit critical and negative: this approach has fallen on open ears with all our partners and we are experiencing great support from all sides. Despite numerous formal hurdles, everyone is working on the rapid implementation of the concept, and the hope is that in 2023 we will not only be able to secure financing for the interim solution and make a decision regarding the lease of office space, but that we will also be able to take major steps in raising the necessary funds for the major construction projects.

Something else that should not go unmentioned: at the end of 2022, Fraunhofer INT's future project, funded by the Executive Board of the Fraunhofer-Gesellschaft, will be launched (see p. 8-11). With a budget of three million euros over three years, this project will open up the possibility of developing new competencies for the institute and thus opening up new markets for our research services.

All in all, there is every reason to look back on the past year with a sense of reconciliation and to start the coming year with optimism, despite injelitance and some disappointing delays in reconstruction.

This annual report provides you with an overview of the numerous forward-looking research results that Fraunhofer INT has produced against all odds over the past year.

I hope you enjoy reading; stay curious and join us in looking to an exciting future for Fraunhofer INT.

Your

Prof. Dr. Dr. Michael Lauster

Content

The business units and groups of Fraunhofer INT

Fraunhofer INT's various research activities are organized into six business units. They are supported by three working groups.

6+3

Technology foresight and strategic planning

"Defense Technology Foresight" (WZA)

The business unit "Defense Technology Foresight" (WZA) conducts long-term, technology-oriented future research (technology foresight for public customers in the defense sector, in particular the Federal Ministry of Defense (BMVg) and its subordinate departments.

"Public Technology and Innovation Planning" (TIP)

The business unit "Public Technology and Innovation Planning" (TIP) supports the design of strategic research and innovation planning for public, non-military clients such as the European Commission, the EU Parliament and other national and international actors.

"Corporate Technology Foresight" (CTF)

The "Corporate Technology Foresight" (CTF) business unit conducts technology-oriented future and innovation research and supports organizations in answering strategic questions.

"Technology Foresight and University Hub" (TFU)

The "Technology Foresight and University Hub" (TFU) group tests and develops technology foresight tools and methods and maintains Fraunhofer INT's university connection.

"KATI Lab" (KLAB)

The "KATI Lab" (KLAB) group is continuously developing the KATI (Knowledge Analytics for Technology & Innovation) technology foresight assistance system and is looking at how data can be used for foresight processes.

Reliability of radiation effects in electronics

"Electromagnetic Effects and Threats" (EME)

The business unit "Electromagnetic Effects and Threats" (EME) deals with electromagnetic fields and their effects on electronics.

"Nuclear Security Policy and Detection Techniques" (NSD)

The business unit "Nuclear Security Policy and Detection Techniques" (NSD) performs theoretical simulations and experimental measurements to research and develop methods for identifying nuclear and radioactive materials.

"Nuclear Effects in Electronics and Optics" (NEO)

The business unit "Nuclear Effects in Electronics and Optics" (NEO) researches the effects of ionizing radiation and performs irradiation tests with electronic, optoelectronic and optical components and systems.

"Scientific and Technical Infrastructure" (WTI)

The group "Scientific and Technical Infrastructure" (WTI) supports the business units with a precision mechanics workshop and an electronics workshop.

The contact persons and contact details for the business units and groups can be found on pages 48-49.

Business Administration and Central Services (BZD)

The department handles all commercial and administrative tasks and provides the central infrastructure of the Institute ready.

Using the crisis as an opportunity – Fraunhofer INT 2030+ flood relief project

A project as an introduction to shaping the future of Fraunhofer INT

The flood event of July 14/15, 2021, forced Fraunhofer INT to take stock of both the current situation and the future development of the institute under completely new conditions. For the continued existence of the institute, a strategic development under the changed framework conditions is essential. The necessary measures offer the task and opportunity to rethink parts of the institute's long-term strategy.

In the course of 2022, this situation gave rise to a plan for the perspective development of Fraunhofer INT up to the year 2030 and beyond. The anchor point is the vision already formulated in the 2018 strategy process: to become a trusted partner in research and knowledge transfer, not only for defense-related matters under the Federal Ministry of Defense (BMVg), but also for civilian initiatives under the Federal Ministry of Education and Research (BMBF). With the new conditions created by the flood, we can and must now continue to pursue this vision. Accordingly, we have planned a lot:

By cleverly combining the two unique selling propositions (USP) – experimental equipment and the ability for long-term technology analysis and foresight – the institute will expand its portfolio in the business areas of the two existing research fields as well as establish a new research field "Space". Particular attention will be paid to designing product developments specifically for existing and new customers from industry and economy in order to further establish the institute's civilian funding component consistently in the Fraunhofer model. The new research field "Space" forms a logical link between the two existing research areas in terms of content and economics.

The potential for new revenue and business models is extremely high in this topic, in which Fraunhofer INT has already been very active for about eight years, coordinating activities and networking with industrial customers on behalf of many Fraunhofer institutes as part of the Fraunhofer AVIATION & SPACE Alliance (see p. 38). The commercial space market will experience massive growth in the coming years, as civil, near-earth space flight (earth observation, etc.) is of immense importance in meeting global challenges such as the climate crisis.

In this ambitious program, the institute is supported by the Fraunhofer-Gesellschaft in many ways. From direct and immediate support in coping with the many challenges immediately after the flood, to ongoing assistance (backup computer center at Fraunhofer FKIE), to the possibility of launching a project financed by the Executive Board Fund to jump-start the development described above. This project, "INT2030+", thus builds a bridge from the now to the future of Fraunhofer INT.

"Continue what is successful and seize additional opportunities"

INT 2030+ – a future program for Fraunhofer INT

Under the premise of "continuing what is successful and seizing additional opportunities", the INT2030+ project bundles five initiatives that will move Fraunhofer INT forward:

1. The combination of activities from the Fraunhofer AVIATION & SPACE and the competencies from the two departments of the institute in a new **research field "Space"**.
   – Fraunhofer INT becomes a place where the German and European space community meets.

2. The expansion of competencies and capacities in the field of **Data Driven Foresight.**
   – Fraunhofer INT becomes an innovation driver at the interface between data sciences, artificial intelligence and (technology-oriented) foresight.

3. **Strengthen existing competencies** in the field of reliability of electronics against ionizing and electromagnetic radiation through consistent development of laboratory environments.
   – Serve application fields with high societal impact, such as radiation or interference sensitivity of quantum computers, artificial intelligence, future mobile technologies (6G+) and smart production systems.

4. The establishment of a **TASP** (Technology Analysis and Strategic Planning) **incubator** with the following two subgoals:
   – a. **STRONGER**: The flood disaster in the summer of 2021 demonstrated that the transfer of research results to application in the field of disaster management does not function satisfactorily. The Fraunhofer-Gesellschaft can and must play an important role here. Building on what we have been doing successfully for many years, we want to offer a platform where users can meet with experts from authorities and organizations with security tasks (BOS), industry and the Fraunhofer-Gesellschaft for improved long-term capability planning.

   – b. As a future institute that is also located in the structural change region of the "Rheinische Revier" with its specific challenges, we continuously develop tools and methods in the **"Competence Center Strategic Foresight"** (CC-SF) with its affiliated **Foresight Cube** (a specially designed physical space that enables direct immersion in the foresight process). This includes, in particular, the development of specific formats to support strategic decision-making by small and mid-sized enterprises (SMEs) in structural change.

With a duration of three years and a financial endowment of three million euros, the project is substantial enough to make a real difference in the strategic development of the institute.

A brief portrait of the individual initiatives

New Space Economy

In recent years, the space industry has experienced a disruptive change. More and more private companies are successfully implementing space projects with commercial business models. The term "new space" is used to summarize this commercial use of space by private providers. In order for Fraunhofer INT's space division to develop into a national hub for space activities in the future and to become the preferred contact for primes as well as SMEs, Fraunhofer INT must promptly develop a deep understanding of the new space industry. To this end, it is important to establish a cross-sector network of institutional space, new space, industry and applied research at an early stage. With the location of the space office of the Fraunhofer AVIATION & SPACE at the institute, we are predestined for this task.

TASP-Incubator

The TASP Incubator (TASPI) sub-project continues to develop two innovations that were already started in preliminary research and are at different stages of development until they are ready for commercialization. The consistent development of tools and methods in the Competence Center – Strategic Foresight (CC-SF) and their focused use in the Foresight Cube is aimed in particular at better adapting the cost structure of foresight projects to the needs of SMEs in order to make foresight affordable for SMEs. The resulting SME-specific strategic foresight is to be developed into a USP for Fraunhofer INT.

The work for the "Strategic Planning Center - Disaster Management and Resilience" (STRONGER) specifically expands the interlocking and the visibility, operationalization and utilization of existing competencies in the business unit "Public Technology and Innovation Planning" (TIP). In particular, the

needs of the application side are to be placed at the center of innovation processes and the openness for innovative solutions and their implementation in the field of disaster management is to be sustainably improved. The Fraunhofer-Gesellschaft offers a wide range of solution approaches in the field of crisis resilience, and the relevant specialists can be integrated into corresponding research and development (R&D) activities at an early stage by means of STRONGER.

Data Driven Foresight (DDF)

The DDF sub-project aims to support and accompany a foresight process using data-driven methods. In this context, the KATI-system (Knowledge Analytics for Technology & Innovation), an assistance system for technology foresight, has been developed at Fraunhofer INT in recent years. Currently, data-driven approaches are used to provide selective support for specific issues. With DDF, a procedure is to be developed with which a strategic foresight process is supported over the entire length of the process. In addition to the development of new data-based foresight methods, this will also expand Fraunhofer INT's product portfolio and sustainably strengthen its market position in the field of foresight and innovation management.

NE Goes Digital

Mobile working within the company, desk sharing or even working from home have become established in many fields at the latest since the start of the Corona pandemic. The resulting advantages are increasingly being noticed by companies and transferred to other fields, such as digital manufacturing in Industry 4.0. In the future, these concepts will also be transferred to the laboratory environments at Fraunhofer INT. The digitization of laboratory facilities, for example through the automation of measurement routines and measuring instruments or interdisciplinary linking of facilities, is a useful tool that can also support the processing of extensive and complex studies.

All sub-projects from the "INT2030+" package started in fall of 2022 and are producing their first interim results. In this way, we are helping to shape the future of our institute step by step as part of the project.

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

Technology foresight and strategic planning

The world is complex, interdependencies are multi-layered and the speed of development is rapid. Recent years have shown that substantial changes can occur rapidly (energy crisis, pandemic), havehlong-term consequences but require short-term action (climate change, demographic change etc.).

Under the influence of these changes, social parameters like norms and values, as well as models of life and work, are continuously evolving. Technology is a central component of this socio-technological regime and technological developments thus influence our everyday lives and our future.

In this complex and dynamic environment individuals in positions of high responsibility must repeatedly make technology-related decisions with potentially major consequences, which are inevitably associated with uncertainties and risks. It is therefore essential to incorporate reliable information about current technological developments and science based assumptions about anticipated technological developments into decision-making processes. Due to this reliable and unbiased information about technologies and their future are important resources for of long-term, strategic planning. The scientifically based development of this information is the subject of applied, technology-oriented future research. With this goal in mind, Fraunhofer INT has been operating its technology analyse and strategic planning support unit for more than 40 years.

"Technologies are a central component of our everyday life, and technological advance-ments influence our daily lives and our future."

Wildfire risk management

Gaining importance at national and European level

Various factors determine the risk of wildfires

Pressing societal challenges such as climate change, social inequality, and ecological degradation are characterized by interactions between natural and socio-economic systems. Likewise, wildfire risk and its management are characterized by complex interdependencies between humans and the environment. For example, climate change is leading to increased prolonged drought and heat in many regions, while forests and vegetation are becoming more susceptible to fire due to drought and pest infestations. Such interaction favours the occurrence of forest and vegetation fires.

At the same time, a number of factors are changing that influence wildfire risk. For example, the management of rural areas incl. farming and grazing practices and thus the amount of available fuels is closely linked to urbanization processes and the depopulation of rural regions. Critical infrastructures such as electricity supply or transport can ignite fires (e.g. through sparking) and can be affected themselves, potentially leading to infrastructure disruption and cascading effects. Not least the extreme forest fires in the summer of 2022 have impressively shown how various factors of these can accumulate and lead to huge wildfires (the term "mega fires" is now frequently used in the literature). Also, more and more countries, previously less affected, such as those in Northern Europe, are becoming susceptible.. As a result, the topic of wildfire risk management is increasingly in the public focus.

Complex interplay of different actors

The multitude of factors influencing the risk of wildfires requires the development of complex measures. On the one hand, a wide variety of actors must be involved, such as forestry and agriculture, fire departments, but also infrastructure operators, spatial development, tourism and, last but not least, the population, which often (unintentionally) causes fires itself. Special consideration must be given to potential conflicts that may result from different aims and objectives of the various actors. From a nature conservation perspective, for example, it may make sense to leave forests as untouched as possible, whereas wildfire prevention increasingly relies on controlled fires to reduce the fuel load and thus prevent large fires. At the same time, forest farmers may have yet other interests regarding the treatment of forests. Another example is the European Union (EU) increasingly investing in the acquisition of firefighting aircrafts (rescEU), while experts in forest firefighting point out that "mega fires" in particular cannot be extinguished at all, but must merely burn in a controlled manner as far as possible.

Contact
Dr. Claudia Berchtold
claudia.berchtold@
int.fraunhofer.de
+49 2251-18116

Juliane Schlierkamp
juliane.schlierkamp@
int.fraunhofer.de
+49 2251-18169

Projects in the field of wildfire risk management

Within the framework of wildfire risk management, efforts are therefore being made at both national and European level to address the multitude of factors both preventively and reactively in a concerted manner. Fraunhofer INT participates/participated in various projects in this context:

- Concept development of a **European wildfire hub** to organize both the sharing of resources, such as firefighting aircraft, and knowledge (Tender for DG ECHO).
- **FIRE-IN** is a coordination and support action (CSA) and was successfully completed in 2022. The objective was to identify current and future wildland firefighting capability gaps and identify potential solutions. Additionally, recommendations for action were developed with the development of a Fire & Rescue Strategic Research and Standardization Agenda.
- **Firelogue** (Cross-sector Wild**fire** Risk Management Dia**logue**) is also a CSA under the European Green Deal that integrates innovations from various large-scale wildfire risk management research projects across stakeholders and wildfire risk management phases.
- Within the TASP-Incubator project (see p. 10) quantitative methods for the analysis of **science-policy interfaces** in the field of wildfire risk management are developed. First results were presented at the IX International Conference on Forrest Fire Research.

Firelogue website

Foresight for small and medium-sized enterprises

Testing foresight processes together on the basis of your own questions about the future

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

Small and medium-sized enterprises (SMEs) usually have excellent knowledge of their industry. This includes knowledge about technologies that are in use as well as those that are in development. However, SMEs tend to neglect technological developments that go beyond a short-term time horizon. This can be a serious risk to their business model, as technological opportunities may be underestimated. In the worst case, SMEs may be driven out of business, because they fail to recognize the significance of new technological developments.

Fraunhofer INT supports SMEs in the development of a customized foresight process and the definition of future-proof technological thrusts. The starting point of a collaborative project is the familiarization with the company, including the formulation of the main uncertainties and challenges that the company faces. These future issues are reviewed and prioritised in a joint workshop in order to derive the next steps. Based on this preliminary work, Fraunhofer INT identifies possible approaches to address these future issues, and – in close cooperation with the company – develops proposals on how to obtain a more reliable picture of the future. This can involve, for example, a broad screening of technology trends, in-depth research into a selected technology field, interviews with experts, or the use of specific foresight methods (e.g. roadmaps, scenarios). Depending on the type and scope of the topic, various data sources are used (especially scientific publications, patents and market data). SMEs thus gain access to information that is often only available to larger companies or can only be compiled with extraordinary effort. Based on these results, targeted initiatives can be launched that strengthen the SMEs' technology base in the medium term and improve their market position in the long term.

Fig. 1: Firefighting robot at the French Civil Defense Air Base in Nîmes.

Forest firefighting in Europe

The "FIRE-IN" project terminates – but the network remains

Coordinated by SAFE CLUSTER, 16 consortium partners have worked in three steps to improve national and European processes for understanding and developing the necessary capabilities to fight forest fires:

1. Identification and harmonization of operational capability gaps
2. Screening for suitable solutions
3. Definition of the Fire & Rescue Strategic Research and Standardization Agenda

To identify capability gaps, thematic working groups were initiated within the project on the following topics: "search and rescue and emergency medical response", "structure fires", "landscape fires", "natural hazards mitigation" and "CBRN-E" (chemical, biological, radiological, nuclear and explosive substances).

The screening for suitable solutions was conducted under the lead of Fraunhofer INT and involved the KATI-system developed at the institute. Capability gaps and screened solutions can be found on the project homepage. In addition, promising solutions were presented in dossiers, which can also be found on the project homepage.

More than five years after its start in May 2017, the project ended in October 2022 with a final symposium at the French Civil Defense Air Base in Nîmes. In addition to a tour of the base (see Figs. 1 + 2), the symposium was used for networking with other projects to promote continuation of the network that has been created and dissemination of the results.

Fig. 2: Training simulator at the French Civil Defense Air Base in Nîmes.

FIRE-IN website

Contact
Juliane Schlierkamp
juliane.schlierkamp@int.fraunhofer.de
+49 2251 18-169

Patents in KATI

Why, and how do we analyze patents?

KATI Lab website

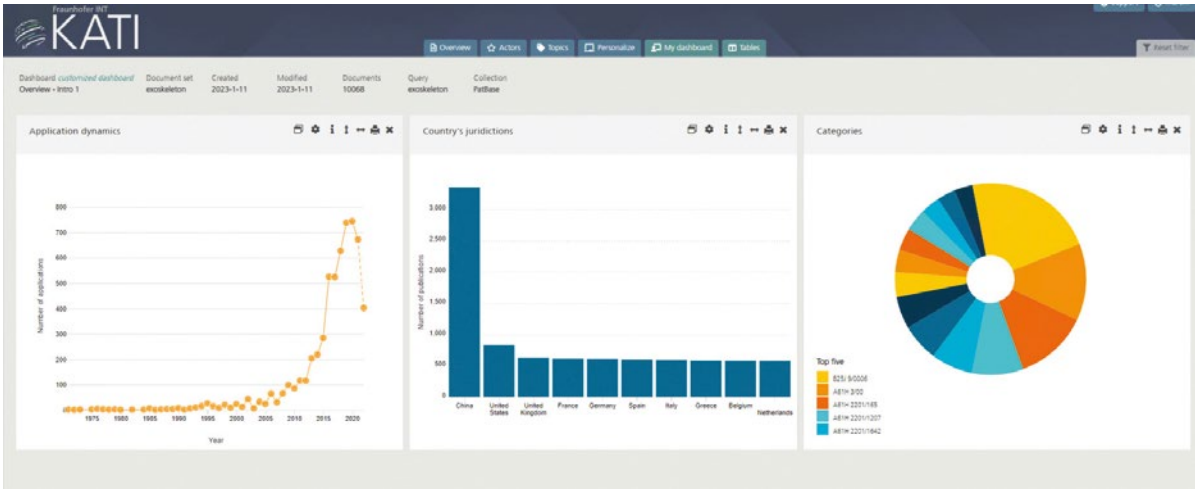
The process of technology foresight using data-based methods is called data driven foresight. With the KATI-system, scientists at Fraunhofer INT have had a system at their disposal for several years that implements this approach in practice. The basis for this is publication data. In the relevant scientific literature, patents are mentioned as another important source of data for technology foresight and innovation management. Our clientele also repeatedly asks for corresponding analyses. But what exactly do we expect from patent analyses? Which questions and use cases should be addressed? And how can patents be integrated into the KATI-system developed at Fraunhofer INT? These are the questions we want to explore in this report.

Why we analyze patents

Patents are a promising source of data because they shed light on technologies in practice: if there are concrete ideas for the application of a technology, there may also be patents. In addition, important insights can be gained about research in companies. More concretely, for example, the market leaders of a technology can be identified, and it can be approximated how much experience a company has in a field. Patent analyses can also be used to make well-founded statements about the maturity of a technology. These and other use cases were identified and sharpened in various projects, workshops and discussions with customers and colleagues. This was flanked by intensive literature research as part of a PhD project – naturally using the in-house KATI-system.

How we handle patent data

In order to perform patent analyses, the data must first be prepared in such a way that it can be processed and analyzed. To this end, the existing architecture of the KATI-system has been extended to include data and analysis options for patents. At first glance, publications and patents may seem quite similar. In both, scientific and technological knowledge is presented, they have an abstract and there is something like an author. However, if you take a closer look, you will notice some decided differences that need to be considered in the data model. For example, in addition to a group of authors (or inventors), patents also have owners, sometimes private individuals, often companies or universities. Furthermore, instead of only one publication date, there are several dates (so-called events), such as the application date or the expected expiration date, which characterize a patent and must be stored in the database.



User interface from the KATI-system

The patent data, like the scientific publications, were stored in a graph database. This facilitates the linking of patents with their metadata, such as inventor or filing date, various institutions and even other patents. The ontology, i.e. the underlying net-like schema with the connections of all data among each other, was modified accordingly. In this case, the cleanliness and timeliness of the data must also be considered, because old and unclean data provide less meaningful analyses. To avoid this, a regular update of the data is performed.

How we provide patent analyses

Finally, the user interface was adapted: the search page was tailored to patents and the analyses were adapted, tested and revised with a view to the new data. The latter in particular will continue to be constantly developed and optimized in the coming years, with the aim of getting the best out of the data and creating well-founded insights for early technology intelligence. The basis for this is formed by the various use cases that have already been identified and which are gradually being addressed and implemented. This continues to be done in close exchange with our collegium in the various business units and their customers. In this way, we are adding another important building block to Fraunhofer INT's portfolio of methods in a sustainable and forward-looking manner.

Contact
Melanie Martini
melanie.martini@
int.fraunhofer.de

Dr. Marcus John
marcus.john@
int.fraunhofer.de

Technology-oriented foresight for the Bundeswehr

Federal Ministry of Defence

Futurology uses scientific methods to develop provable statements about future developments that are possible, probable, and desirable from today's perspective. Future technological possibilities are determined by gradual progress in the individual technology areas, but also by scientific breakthroughs in basic research. In order to be able to make reliable projections for the future, at first it is essential to have a sufficiently deep understanding of the current state of research with its basic concepts, most important questions, crucial problems as well as the interdependencies of research areas. This analysis of the present generally requires most of the workload in futurology.

The speed of progress, which is important for a realistic projection, varies in different areas. Other factors are need or demand and, where applicable, new business models. It is therefore also important to know all the key research and technology players as well as national and international research and planning structures. Overall, all these factors must be considered to obtain reliable statements about the future of technologies.

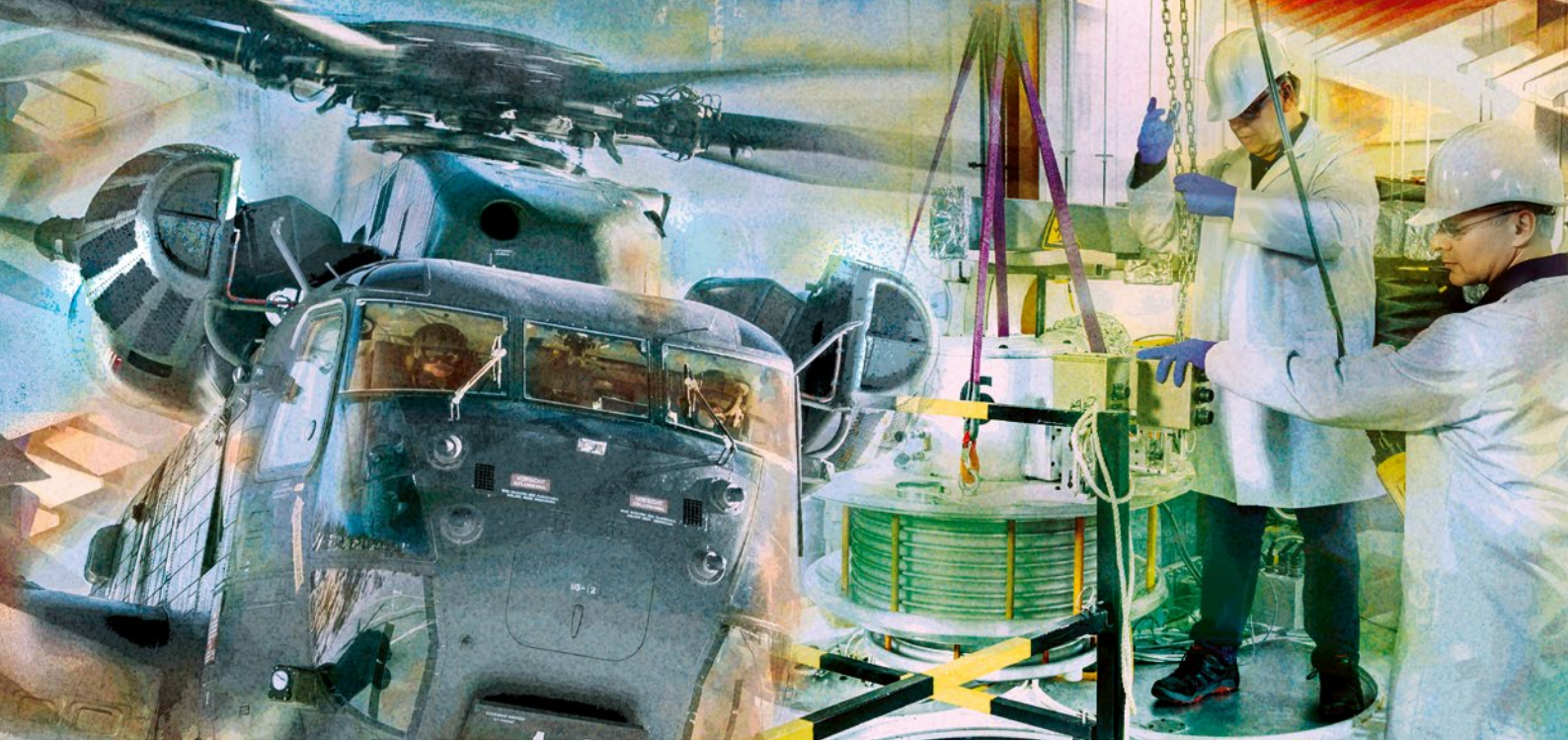
Defense Technology Foresight

The Federal Ministry of Defense (BMVg) and the Bundeswehr depend on resilient longer-term future anticipations (including the correction of any unrealistic expectations) for their planning in research and technology (R&T) and military capabilities. For this purpose, results of the general technology foresight must additionally be evaluated regarding their specific relevance for defense technology and military capabilities as well as considering national priorities.

Technology-oriented futures research for the needs of the German Armed Forces has been the central mission of Fraunhofer INT since its foundation in 1974. A large part of the corresponding research services has been commissioned for 2017 to 2022 through a comprehensive R&T study contract and developed by the business unit Defense Technology Foresight.

The interdisciplinary team at Fraunhofer INT, covers all scientific and technological areas with its expertise ("360°") and has many years of experience in the required methods and processes as well as with regard to the relevant issues and framework conditions of the commissioner.

Literature tip:
M. Grüne, G. Huppertz, U. Neupert and H.-M. Pastuszka: Integrating Scientific Defence-Technology Foresight With an MoD's Planning System - The German Approach. In: G. Rizzo, A.J. Masys (Eds.): Handbook of Foresight, Strategy and Futures Studies for Defense and Security, Springer Verlag, to be published in 2023.



The subprojects for the years 2017 to 2022

The most extensive subproject was the Defense Technologies Forecast (WTV) in the form of compact, structured analyses, projections and assessments of future technologies and concepts. This most important product of Fraunhofer INT's defense technology-oriented futures research is unique in Europe in this form in terms of technological content and continuity. The process for producing the 13 quarterly WTV analyses annually places particular emphasis on multi-level quality assurance and is subject to continuous further development.

Fraunhofer INT also conceived and implemented the annual R&T Future Situation Conference on behalf of the Research Director at BMVg. It is the central forum for all defense stakeholders involved in technology foresight for the BMVg and the Bundeswehr who are concerned with identifying and evaluating relevant future technologies. Based on a structured analysis and evaluation of the future topics submitted by the participants, the BMVg's R&T Future Situation Picture is developed and updated here.

In addition, analyses of international and national defense-technological research were prepared: two so-called Country Reports each year as well as the annual report "Military Scientific Research".

In-depth analyses on individual technologies and planning aspects completed the work. Thus, two technology analyses, an analysis on European defense research, and a conceptual preliminary investigation on semi-automatic actor analysis were prepared. As part of another subproject, an analysis of the effects of future technology developments on the work of the Center for Technical Quality Management (ZtQ) of the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw), tailored to the needs of the ZtQ, was prepared.

To be able to continue the research services described, a follow-up contract for a further four years has now been concluded.

Contact
Hans-Martin Pastuszka
hans-martin.pastuszka@
int.fraunhofer.de
+49 22 51 18 - 298

Dr. Ulrik Neupert
ulrik.neupert@
int.fraunhofer.de
+49 22 51 18 - 224

Book Project "New Technologies"

An overview of 13 years of technology foresight

To the bookshop

130+
Contributions about new technologies

Fraunhofer INT publishes monthly for the magazine "Europäische Sicherheit und Technik" in the section "Neue Technologien". Here, technology topics with great relevance are pursued, which Fraunhofer INT is working on within its 360° technology foresight.

In 2022, the contributions to this section from 2009 to 2021 were collected in a book titled "Neue Technologien". Contributions to the individual technological topics came from colleagues throughout the institute.

The first chapter of the book outlines the main aspects of the scanning and monitoring process at Fraunhofer INT. Here, there have been interesting developments in recent years towards an assistance system for the technology foresight process. The KATI assistance system being developed in this context is presented in the second chapter.

Chapter three contains the main part of the book, with more than 130 individual articles on new technologies. In order to facilitate a quick grasp of the contents, each article is subsequently preceded by a core statement that sums up the respective content in a nutshell.

The contributions are arranged in chronological order, by date of publication. The book thus provides a good overview of the most important technological developments over the past 13 years.

Contact
Jürgen Kohlhoff
juergen.kohlhoff@
int.fraunhofer.de
+49 2251 18-220

Country reports+

Knowledge management as a field of experimentation

> **Science is organized knowledge"**
>
> **Herbert Spencer,**
> The Genesis of Science

The so-called country reports are commissioned by the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) and document the research and analyses of a country's research landscape, especially with regard to technologies and developments with potential relevance for security and defense. For this purpose, the country-specific research actors are examined as well as their research programs and topics.

The documentation of general and specific research on this is part of the knowledge management processes. In the course of the "country reports+" activity, the tools and processes are reviewed for potential improvements and further areas of application. This includes expanding the content of what should be documented and findable for all employees. The wide range of data and information researched for the country reports makes them well suited as an experimental application example for methods, processes and technical tools.

The activity "country reports+" includes the following subgoals:

- Process documentation of data source selection and processing of country-specific key data that are relevant across countries and relate to research frameworks
- Process optimization of both the country-specific actor analysis in the area of research and development and the cross-country documentation and evaluation
- Assessment of the added value of including patent data
- Testing of an editorial workflow for the distributed capture, editing and classification of technical vocabulary including translations in the English language
- Recording, characterization and evaluation of tools used, possible developments and alternatives
- Implementation of a prototype that supports the mentioned processes; evaluation of effort/benefit of technically and procedurally different concepts for data integration and curation; test of different visualization options

It is expected that the lessons learned and improved practices from the ongoing "country reports+" activity will make future researches and analyses in this thematic area more efficient and strengthen cross-project knowledge management.

Contact
Dr. Silke Römer
silke.roemer@
int.fraunhofer.de

Study on nuclear fusion

Sunny views for energy supply?

Looking at the long-term time horizon, nuclear fusion could be a solution for increasing energy demand and independence from fossil fuels."

Prof. Dr. Reimund Neugebauer (Fraunhofer Newsletter January 2023)

What is it about?

The topic of energy was very present in the media in 2022 and preoccupied large sections of the population, not least due to reports of possible gas shortages or power outages in winter. The activities to ensure a sufficient energy supply are correspondingly diverse. A look at the sky, though, reveals an energy source with great potential: the Sun. The Sun is already being used in many ways, for example in the form of photovoltaics. But it is also the godfather of a form of energy generation that could solve many current problems of energy production: nuclear fusion, which takes place inside stars like our Sun. There, atomic nuclei are fused together in a plasma, releasing energy. For nuclear fusion to occur on Earth, conditions are to be created in a reactor similar to those prevailing in the center of the Sun. Amongst others, these include extremely high temperatures. An overview study by the Fraunhofer-Gesellschaft, in which Fraunhofer INT also participated, highlighted the topic of nuclear fusion from the perspective of applied research.

Nuclear fusion – a technology with a lot of potential

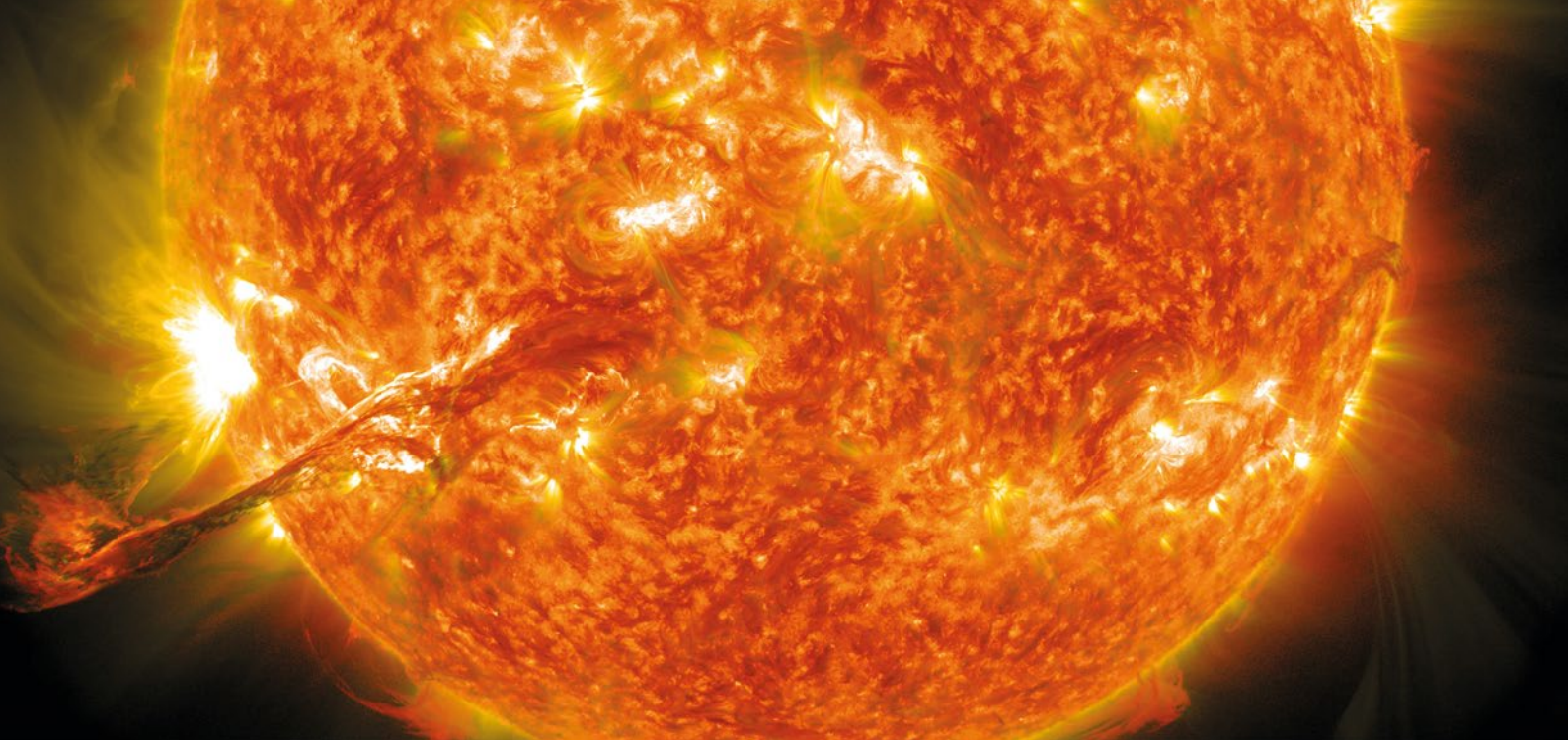
Nuclear fusion has inspired researchers for decades. It promises a clean, safe and at the same time abundant form of energy generation. Future fusion power plants could take over the so-called base load, which is still provided today by coal, gas and nuclear power plants. This would generate significantly less radioactive waste than nuclear power plants, which use the process of nuclear fission. In addition, no climate-damaging CO_2 would be emitted. These advantages are offset by an enormous amount of work and a number of unsolved problems in order to put the vision of nuclear fusion into practice. There are essentially two principles for generating energy from nuclear fusion.

Principles of nuclear fusion

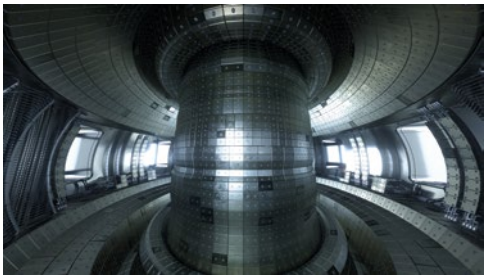
One principle is inertial fusion energy (IFE). This uses high-energy lasers (or heavy ions) to ignite a dense plasma. Several breakthroughs have been made with this principle in recent years, especially at the National Ignition Facility (NIF) in the USA. For the second principle, magnetic fusion energy (MFE), the heated relatively thin plasma is confined in a magnetic field. A well-known example of this type of nuclear fusion is the ITER (International Thermonuclear Experimental Reactor) research reactor under construction in France. Research on both principles is being carried out in numerous research institutions worldwide. However, the private sector and investments in private companies have also become much more important in recent years.

Contributions of Fraunhofer INT

In addition to providing substantive aspects of current nuclear fusion research from a literature review (state of the art), Fraunhofer INT also addressed the question of potential future



technologies in the context of technology foresight and possible collaborations, thus supporting the work of the other Fraunhofer institutes involved in the study. Another focus was the inventory of activities, programs and actors in research and industry. Here, Fraunhofer INT used specialized databases as well as the KATI-system developed at the institute to analyze the existing data quantitatively (both bibliometrically and patentometrically). The most active countries and institutions in the field of nuclear fusion and the two principles described were identified on the basis of statistics on scientific publications and analyzed with bibliometric methods. These findings were supplemented by an analysis of patents, which focused primarily on applied research and thematic priorities of the various players. These results were compared with the results of a more general search in web sources (existing research alliances and networks, self-representation of individual actors), in addition to the results of the search query in company databases, published data on research funding budgets and investments in existing companies and start-ups.



Experimental reactor

Contact
Dr. Evgenia Lieder
Evgenia.lieder@
int.fraunhofer.de

Dr. Miloš Jovanović
Milos.jovanovic@
int.fraunhofer.de

Tools and methods portfolio

Maturity assessment for civil security

The project MultiRATE

MultiRATE website

Contact
Björn Hoog
bjoern.hoog@
int.fraunhofer.de
+49 2251 18-175

In order to avoid communication problems between different teams of engineers and scientists, NASA developed a uniform scale for assessing the development status of new technologies, the "technology readiness level" scale, in the 1970s. Since then, similar maturity scales have also been established and further developed in other industries. However, today there is a lack of an objective uniform model, which means that assessments from different organizations often lead to different results. It is precisely this problem of a lack of common understanding of maturity or readiness that MultiRATE is trying to solve for civil security products in Europe.

MultiRATE (Holistic framework for the MatUrity evaLuaTIon of ReAdiness level for security), a project funded by the Horizon Europe program with a duration of four years, was launched in December 2022. In addition to Fraunhofer INT, twelve other organizations from eleven different European countries are working on this project. It deals with the development of an evaluation tool to assess the maturity of technologies and processes for European civil security, e.g. for law enforcement or disaster resilient societies. The special feature of the tool is that the object of investigation or innovation is evaluated from seven different perspectives. In addition to the technical maturity, the social attitude towards a technology, its market suitability, production capacities, security maturity, its integration level or ethical-legal aspects can be determined individually, but also a holistic evaluation will be possible. The aim of the project is for the tool to support different actors in critical decision-making related to objective self-assessment, acquisition of equipment or investment.

Fraunhofer INT's task focus is on the development of methods for determining the maturity level in the category "security". In doing so, previous methods are to be harmonized as well as further developed. In short, research will be conducted on topics such as IT, OT, cyber, but also physical security, and a method and tool for evaluating an innovation's security readiness level will subsequently be derived and developed.

MULTIRATE

Technology radars for the industry

Keeping an eye on technology developments in a structured manner

In corporate foresight, technology radars are often used to keep an eye on relevant technology developments. In this context, companies are confronted with questions such as:

- When will a technology reach market maturity?
- How relevant is a technology for a company's own business?
- What is the degree of maturity of a technology?

In the initial phase of implementing such radars, some companies prefer temporary support in order to initiate a sustainable development of the foresight process within the company.

The methodical set-up of such technology radars, which do not necessarily have to be presented in a classic radar form, follows some basic rules. First, relevant sources of information must be identified and the gained initial data must be stored in a structured manner. The identification of appropriate information sources is individually set-up with the companies and depends on many aspects. Important key points are, for example, the number of employees available for scouting and monitoring as well as the type and number of accessible sources. Once a few initial relevant trends and topics have been collected, a structuring step follows and an inital set of search fields can be derived. Relevance criteria – i.e., what technologies are prioritized on the radar for the company – must also be defined. For these steps, Fraunhofer INT provides individual support to companies in order to develop a tailored and manageable methodology.

In addition to methodological support, assistance is often requested for the initial filling of the radar. Based on Fraunhofer INT's technology scouting and monitoring, technology trends and topics can be identified within a predetermined framework (delimited technology areas vs. broad scanning). Companies that already have their own technology radar can also be supported by an independent assessment of Fraunhofer INT concerning potential white spots.

Last year, Fraunhofer INT was able to provide methodological and content support for the development and expansion of technology radars in SMEs and DAX 30 corporations.

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

Corporate Technology Foresight

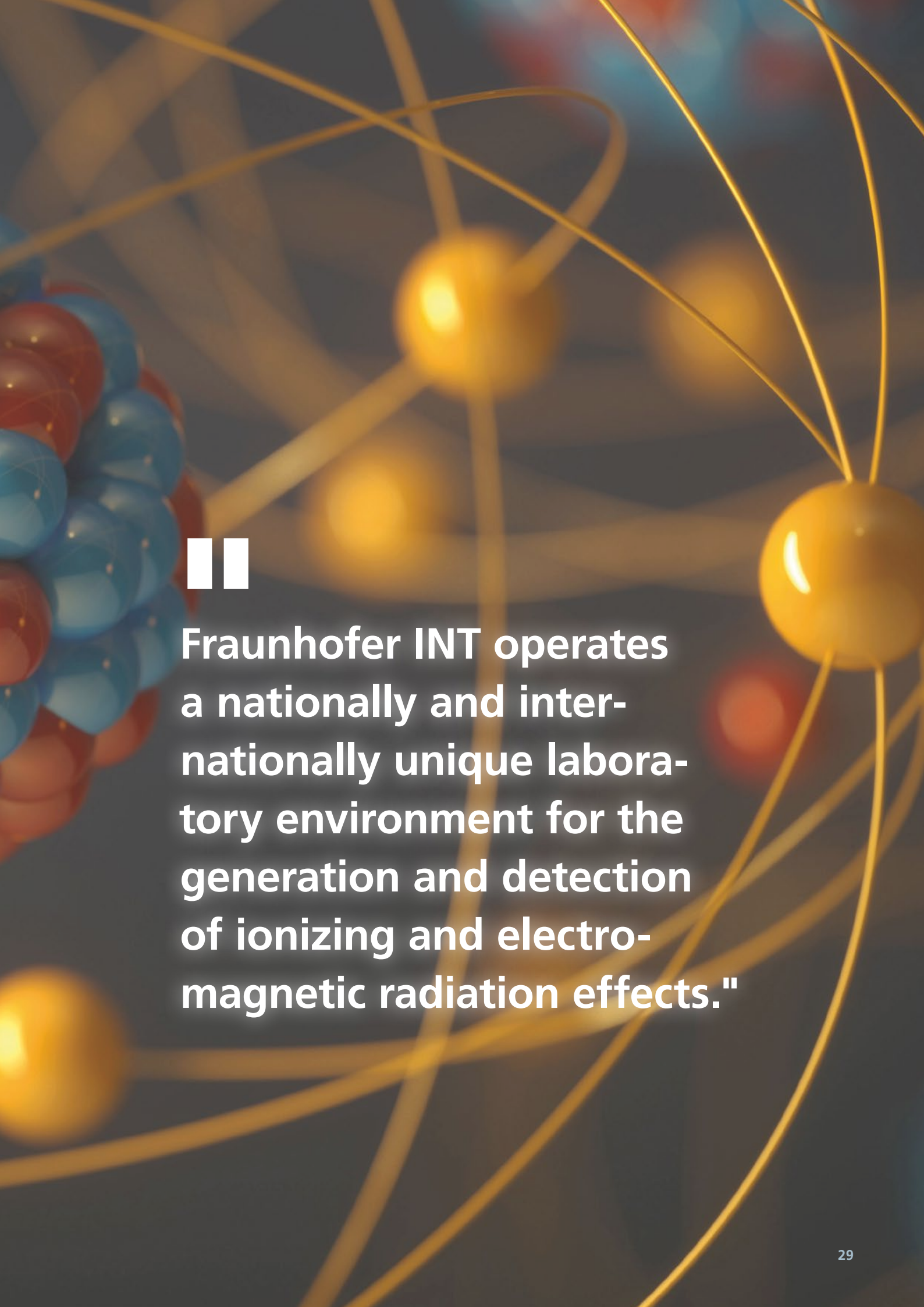
Radiation effects

As part of the research field "Reliability of electronics", Fraunhofer INT conducts specialized research on nuclear and electromagnetic radiation effects that is unique in Germany. This includes:

- Investigation of the influence of deliberately caused electromagnetic interference effects on electronic systems
- Investigation of the effect of ionizing radiation on electronic, optoelectronic and optical components and systems
- On-site detection and identification of nuclear and radioactive materials and analysis and assessment of nuclear and radiological threats.

The focus is on scientifically and economically relevant topics related to microelectronics in order to meet the advancing trends of miniaturization, increasing complexity of electronic component circuits, increasing system integration and bandwidth as well as the use of new semiconductor materials (e.g. wide bandgap). The exposure to ionizing radiation or high power electromagnetic fields in emergent applications such as autonomous driving, electric propulsion, AI systems, quantum computing, or 5G/6G mobile communications will be investigated. This is done for a wide range of uses, from satellite reliability to critical infrastructure protection for both civil and military needs. The main focus is the identification of techniques to protect against these threats.

For this purpose we operate a unique laboratory environment, both nationally and internationally, for the generation and detection of ionizing and electromagnetic radiation and ist effects in a broad energy range and particle spectrum. The impact of the radiation effects on the behaviour of the electronic components and systems is detected with state-of-the-art measurement technology, which is continuously developed further as a particular aspect of the research activities.



"Fraunhofer INT operates a nationally and internationally unique laboratory environment for the generation and detection of ionizing and electromagnetic radiation effects."

High-power electromagnetic attacks on sensors

Internet of Things

More than 55 billion Internet of Things devices are expected to be networked worldwide by 2025."

Vodavone Business, September 2022

The Internet of Things (IoT) refers to a network of devices equipped with sensors, software and other technologies that communicate with other devices and systems over the Internet. The number of these devices has increased dramatically in recent years, including sensors. Sensors play a crucial role in IoT as they are responsible for collecting and transmitting data. However, the devices or its sensors are vulnerable to high power electromagnetic (HPEM) attacks. Attacks of this type can cause errors in sensor measurements and in some cases even damage the sensors themselves. This has led to increased research on the vulnerability of sensors to HPEM attacks and the development of countermeasures to mitigate the impact of the threats. Fraunhofer INT has been studying the susceptibility of sensors to HPEM attacks and working on implementing protective measures against these types of attacks.

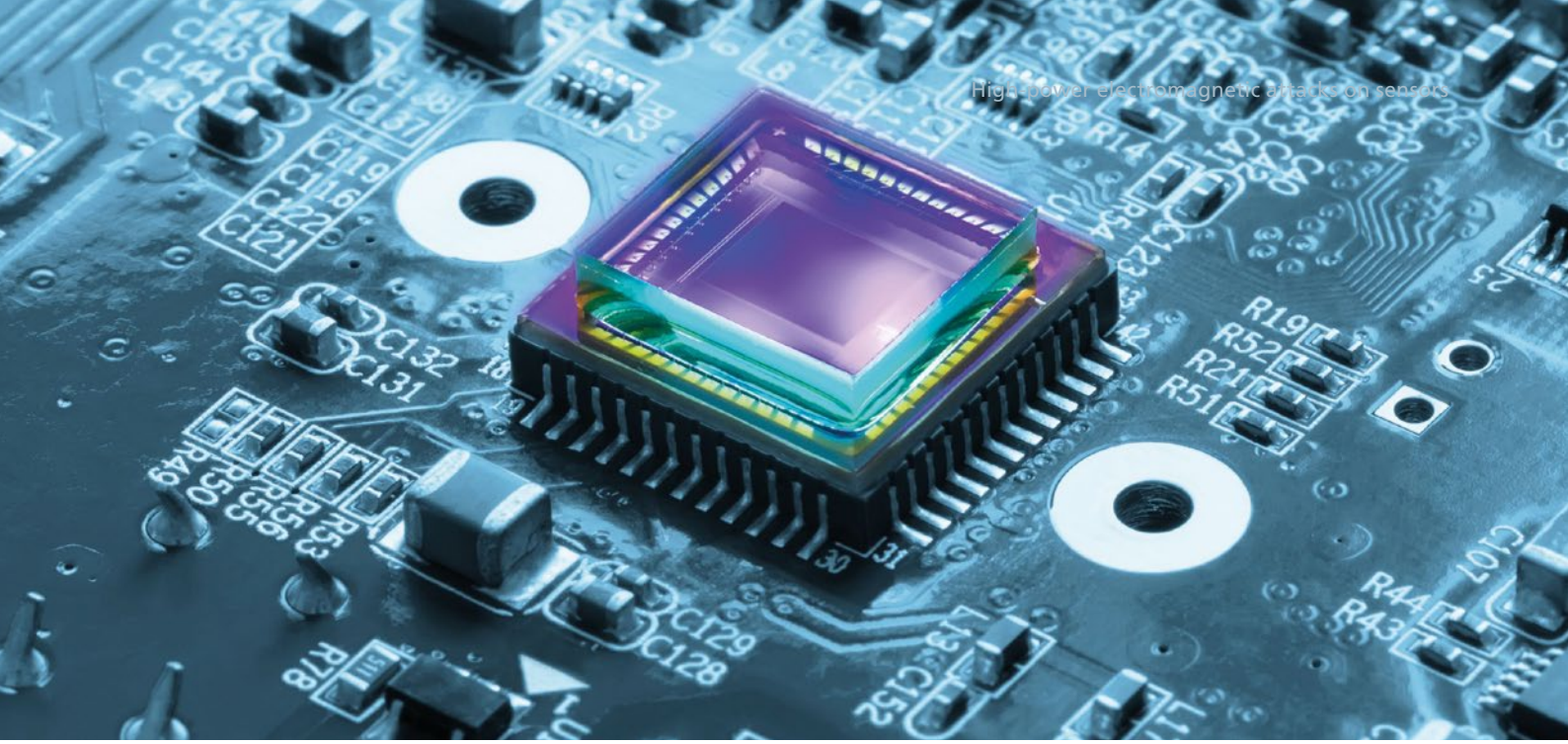
The study of sensors is challenging, especially when they are embedded in larger systems. For this reason, our research focuses primarily on individual sensors. This approach enables a better understanding of the behavior of individual sensors under HPEM attacks and the identification of vulnerabilities that can be addressed in the design of sensors.

Various sensor types have been investigated, including temperature and barometer sensors. The results have shown that these sensors are particularly susceptible to HPEM attacks and, as a result, can exhibit significant measurement errors. Additionally, comparisons have been made between the vulnerability of different sensor types to identify trends and patterns in their behavior.

The EME department is currently working on several projects and experiments related to HPEM and sensors. These include studies on coupling effects that can lead to errors in sensor measurements, as well as research

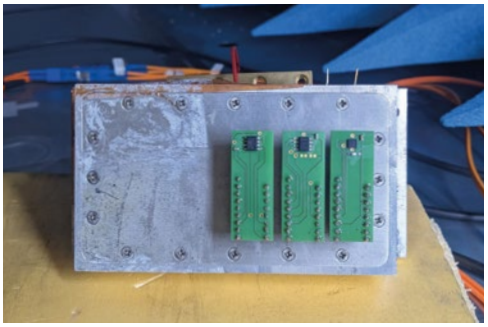
Positioning of the box with sensors and the probe for field strength measurement inside the GTEM cell.

on wireless communication errors and their impact on sensor networks. Sensor networks are an essential component of the IoT. The communication protocols used to transmit data between sensors and other devices can have a significant impact on their performance and security. To minimize errors and maximize security, various communication protocols and their use in sensor networks have been studied, with a focus on fault diagnosis.



Information security is crucial for the proper functioning of IoT systems. The focus is on the first two principles of information security: availability and integrity. These principles ensure that sensor readings are accurate and cannot be tampered with by unauthorized parties.

With the increasing use of sensors in the Internet of Things, there are significant concerns about their security. HPEM attacks can compromise entire systems. Researching the vulnerability of sensors to these attacks and developing measures to defend against them is therefore essential. Understanding the potential risks and implementing protective measures for sensors and sensor networks is definitely a hot topic.



View of three individual sensors. Only these are exposed during the measurements. All other electronic components are protected in a shielded housing.

Contact
Louis Cesbron Lavau
louis.cesbron.lavau@int.fraunhofer.de
+49 2251 18-155

Commissioning of a new computing cluster

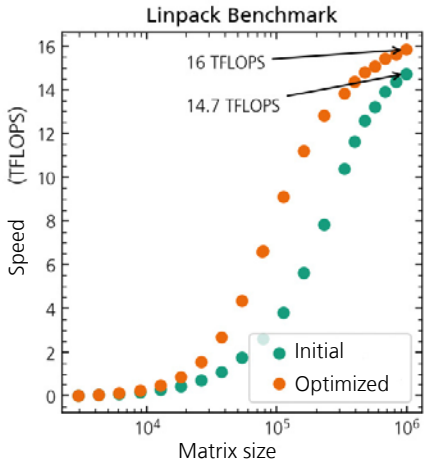
New computing power for scientific simulations at Fraunhofer INT

16 000 000 000 000

Simulation calculations are becoming an increasingly important part of scientific work. They can be used for a variety of tasks, from planning an experiment to data analysis. Numerical experiments can also be carried out that would be impossible in the laboratory.

To implement a new cluster for scientific simulation calculations, four new computing nodes were procured from funds of the BMVg investment program. These were integrated into the new computing cluster together with an existing first node. It will cover the demand for computing power for scientific simulation calculations in the next few years. The application areas are mainly simulations of the transport and interaction of radiation with matter and calculations of the propagation of electromagnetic fields. The existing 50 processor cores and 1.3 TB of main memory could now be supplemented by a further 320 cores and 8 TB of main memory with the new nodes. After initial commissioning and integration into the institute's IT infrastructure, the configuration and software of the computing nodes were optimized to achieve the highest possible computing performance.

In the end, the four new nodes in the cluster achieved a performance of 16 trillion floating point operations per second (FLOPS) in the Linpack Benchmark, about 7 times as much as with the first computing node. The Linpack Benchmark is used, among other things, to compare the world's most powerful computers. Until 2002, Fraunhofer INT's new cluster would have been the fastest supercomputer in the world in this Benchmark, a computing power that is still sufficient for the tasks at Fraunhofer INT today. In the course of the optimization process, it was also possible to gain many useful insights into the way in which future simulations can be performed with the highest possible performance. The computing cluster is now available for scientific simulation calculations and other tasks.



Results of the Linpack Benchmark for different problem sizes. The cluster achieved up to 14.7 TFLOPS in its initial setup, after the optimizations up to 16 TFLOPS were reached. Especially for medium problem sizes, the optimizations have an extremely positive effect.

Contact
Dr. Olaf Schumann
olaf.schumann@
int.fraunhofer.de

New experimental environment

Extension of the test environments for electromagnetic effects

In 2022, the experimental testing capabilities of electronics against electromagnetic interference signals at Fraunhofer INT were significantly expanded. A shielded anechoic chamber was put into operation, which can be operated as a full anechoic chamber (FAC) or a semi anechoic chamber (SAC) depending on the requirements of the experimental setups (see fig. 1). The promising design in the frequency range up to 40 GHz in combination with the extensive technical equipment in the form of an integrated turntable as well as an automated antenna mast opens up a multitude of new application possibilities under consideration of common test standards. A shielded and air-conditioned cabin for centralized operation of the powerful semiconductor amplifiers for signal generation for sensitivity tests in the frequency range from 9 kHz to 40 GHz was also built directly adjacent.

Fig. 1: Fully anechoic absorber chamber

In addition to the stationary environments, a mobile shielding tent was purchased, which, in combination with existing compact and powerful high-frequency sources, enables immunity tests to be carried out directly at the customer's premises.

In addition, a new mode stirred reverberation chamber (see fig. 2) with a multiplied test volume of about 2.4x1.25x1.15 m³ in the frequency range from 400 MHz to 40 GHz supplements the test possibilities at particularly high test field strengths. In addition, there is a GTEM cell (Gigahertz Transverse Electromagnetic Cell) with a test volume of approx. 0.6x0.6x0.5 m³ in the frequency range from 9 KHz to 18 GHz for tests with almost plane waves.

The shielded chamber containing a large TEM-cell could also be retreaded. Together with all the new test environments mentioned above, it will be possible in the future to draw on a particularly broad spectrum of measurement and test procedures customary in the industry in the area of interference radiation and interference immunity. This means that special cases can be addressed and basic research can be carried out e.g. by comparing test results gathered in different test environments.

Fig. 2: New mode stirred reverberation chamber

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

Others

Diversity@Fraunhofer INT

"Diversity" Workshops

Two diversity workshops were implemented at Fraunhofer INT mid-May 2022 by coaches Annika von Redwitz and Dr. Anja Kellermann. The term "diversity" refers to the recognition of the diversity of all people. In human resources, however, it is also about promoting the cultural and ethnic diversity of employees. In order to make this workshop a perfect fit for Fraunhofer INT, interviews were conducted in advance with numerous employees. Based on this, the coaches designed an entertaining day with a lot of input on the "diversity dimensions" and the "unconscious bias" in which various interactive methods were used purposefully.

In several "world café" rounds, the participants were able to raise and discuss important aspects of "intercultural cooperation", "generational diversity", "opportunities and challenges of diversity" and "people with disabilities", adopt other perspectives and understand problems that were not visible to them before. The item "diversity in everyday (work) life" also created interesting insights and helped to develop a better mutual understanding.

Initial results of the participants, such as reflecting on one's own bias or communicating attentively as well as asking respectfully, were quickly implemented. The wishes for a barrier-free institute and an inclusive space will be incorporated into the reconstruction plans of Fraunhofer INT.

The workshops were funded by the Fraunhofer-Gesellschaft's "Diversity" funding program.

Conference of the Deutsche Gesellschaft für Wehrtechnik e. V.

Applied research for defense and security in Germany

Once again, Fraunhofer INT participated in the event "applied research for defense and security in Germany" organized by the Deutsche Gesellschaft für Wehrtechnik e. V. (DWT). The conference took place from March 8 to 10, 2022 at the Maritim Hotel Bonn and included a lecture program of panel and poster sessions as well as an exhibition.

As in previous years, Fraunhofer INT participated in the accompanying exhibition at the joint booth of the Fraunhofer Defense, Prevention and Security Division (VVS). This year, the institute presented a high power electromagnetics (HPEM) detector, which can be used to detect threats from high-power microwaves. In addition, participants were able to test the assistance system for technology foresight KATI developed at Fraunhofer INT live and conduct individual search queries with scientists of the institute and discuss the results.

Prof. Dr. Dr. Michael Lauster, director of Fraunhofer INT, also chaired the sessions "energy and EMP" and "dimension space I: responsive space". In 2022, the format took place for the fifth time. It is Germany's largest defense and security conference in the field of research and technology and is held on a rotational basis every two years. In addition to the DWT, the organizers included the Fraunhofer VVS, the German Armed Forces, the German Aerospace Center (DLR) and the R&T Committee of the Confederation of German Steel Recycling and Waste Management Companies (BDSV).

Fraunhofer INT at the Hannover Messe

New technologies and industrial transformation

The coaches at the diversity workshop

In 2022, Fraunhofer INT again participated in the Hannover Messe. As in previous years, Fraunhofer INT was part of the Fraunhofer joint booth, which this time was positioned in Hall 5 on the topic of "digital ecosystems". On the one hand, Fraunhofer INT presented 3D-printed models illustrating analyses of future technologies from the KATI-system. In addition, visitors were also able to test KATI live and conduct analyses on their own topics. Moreover, our new technology cards celebrated their premiere at the fair. Using 120 cards with various technological, social, ecological, political and economic trends and developments, visitors were able to playfully discuss various future scenarios for their company or industry together with Fraunhofer INT scientists, thus gaining new insights and perspectives.

Exhibits of Faunhofer INT at the Hannover Messe

Under the slogan "we know solutions", the Fraunhofer-Gesellschaft presented more than 40 different exhibits at its joint booth from the subject areas "manufacturing", "production", "communications", "cognitive systems" and "adaptronics and digital planning" in addition to the Fraunhofer INT exhibits.

After the Hannover Messe was completely canceled in 2020 due to the pandemic and was only implemented as a digital format one year later, in 2022 the event could be held in person at the exhibition center in Hannover as usual. However, the Hannover Messe was moved from its otherwise typical date in the spring to May 30-June 2, 2022, because lower COVID-19 incidence numbers were expected during the summer months. Furthermore, the event was held as a hybrid format. The Hannover Messe is the most important international industrial trade fair for new technologies and industrial transformation.

Exhibition at the DWT conference

Fraunhofer AVIATION & SPACE

What does the SPACE central office do?

Fraunhofer INT operates the central office for SPACE within Fraunhofer AVIATION & SPACE. In 2022, the SPACE alliance, which was founded at Fraunhofer INT in 2014, has been expanded to include the aviation area. The AVIATION central office is located at Fraunhofer IFAM in Bremen. The two central offices work closely together. Due to the thematic division, the alliance is also headed by two spokespersons: Prof. Dr. Dr. Michael Lauster as Director of Fraunhofer INT and Prof. Dr. Bernd Mayer as Director of Fraunhofer IFAM. Since the expansion, Fraunhofer AVIATION & SPACE includes 30 institutes that conduct research on aerospace technologies.

The collective term SPACE covers research and development on technologies related to the operation and use of space-based infrastructure. To structure this broad field, the alliance has divided the technologies into the technology fields "protection & reliability", "surfaces & optics", "materials & processes", "sensor systems & analyses", "energy & electronics", "communications & navigation", "ground segment", "launcher and downstream applications"

In general, the alliance offers its 30 Fraunhofer institutes a platform for exchanging information on the specifics of the industry. In addition, the office coordinates cross-institute activities, ensures a visible and bundled external presence, and offers customers and cooperation partners a point of contact for space-related issues at Fraunhofer.

Fraunhofer AVIATION & SPACE

Fraunhofer Group for Innovation Research

Understanding change, shaping the future

Innovations are the key to being able to make confident decisions and follow individual paths even in difficult times, and to being permanently resilient against crises. Knowledge of complex interdependencies within innovation systems is therefore critical to the success of business, politics, science and society. Changes in industries, markets and technologies must therefore be recognized and understood at an early stage in order to be able to actively shape the long-term effects.

As a competent partner with a unique combination of socio-economic and socio-technical research, the Fraunhofer Group for Innovation Research provides orientation, facilitates positioning and supports actors in shaping the future of the innovation system. Under 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 group – with the aim of understanding innovation systems and their change and passing on interdisciplinary knowledge.

The Fraunhofer Group for Innovation Research offers companies a wide range of support options for the design of innovation systems – from practical guides and publications, to methods and tools, to interactive event formats. An overview of the services offered as well as projects can be found in the free newsletter and on the group's website.

Fraunhofer INNOVATION

Fraunhofer Segment for Defense & Security

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, defense 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.

In the Fraunhofer Segment for Defense and Security (Fraunhofer VVS) twelve institutes have joined forces to provide wide-ranging expertise and research for highly practicable solutions and operational support, both at national and international level. Our research focuses on security and protection against military, technical, terrorist, natural and criminal threats.

We pursue research and development in the areas of defense and civil security. In defense research, our excellent judgement and consultancy skills make us indispensable independent experts and partners of the German Ministry of Defence (BMVg). We research and develop technologies and system solutions for the Ministry, its government bodies and for the German Armed Forces (Bundeswehr). Our technical solutions and systems in civil security are designed to deliver the best possible protection for society. We cover the interests and activities of our member institutes, acting as their representative both within and outside the organisation.

Fraunhofer VVS was founded in 2002. In 2023, we welcomed our twelfth member, the Fraunhofer-Institute for Applied Optics and Precision Engineering IOF. In the fields of security research, Fraunhofer IOF specializes on encryption technologies for secure communication. In the fields of defense research, Fraunhofer IOF is focused on laser and fiber technology, thus representing an ideal addition to the portfolio of the Fraunhofer VVS.

Fraunhofer VVS

Institute for Technology Analysis and Foresight in the Field of Security Research

Addition in the field of engineering

The Institute for Technology Analysis and Foresight in the Field of Security Research held by Prof. Lauster at the RWTH Aachen University complements the classical offer in the curriculumof engineering studies. The aim is to teach students quantitative and qualitative methods of foresight within the framework of application-oriented teaching and learning concepts. This includes both the epistemological foundation of methods and the investigation of the extensive canon of foresight methods with regard to its suitability and optimization possibilities. The research focus of the institute lies in the analysis of the foresight process in technological fields as well as the adaptation, new and further development of corresponding procedures and methods. The continuously generated research findings support scientifically based decision-making on issues related to the temporal development of technologies.

The courses are offered during the semester as lectures or block seminars. The lecture "Methods of Future Studies – Technology Analysis" and the lecture "Methods of Future Studies – Technology Foresight" are attended by almost 200 students each semester. In addition to the lectures, seminars are offered, in which specific lecture contents are further deepened. In the summer semester the seminars "Ethics in Technology" and "Safety and Security Research" are offered. In the winter semester the seminars "Epistemology and Philosophy of Science for Engineers" and "Data Driven Foresight – Quantitative Methods in Futures Research" take place.

LTVS | RWTH AACHEN UNIVERSITY

The Fraunhofer-Gesellschaft

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. A trailblazer and trendsetter in innovative developments and research excellence, the Fraunhofer-Gesellschaft supports science and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work with partners from industry and government to turn pioneering ideas into innovative technologies, coordinate and implement system-relevant research projects and strengthen the German and European economies with a commitment to value creation that is based on ethical values. International collaboration with outstanding research partners and companies from around the world brings the Fraunhofer-Gesellschaft into direct contact with the most prominent scientific communities and most influential economic regions.

Founded in 1949, the Fraunhofer-Gesellschaft now operates 76 institutes and research units throughout Germany. Currently around 30,800 employees, predominantly scientists and engineers, work with an annual research budget of about 3.0 billion euros, 2.6 billion euros of which is designated as contract research. Around two thirds of Fraunhofer contract research revenue is generated from industry contracts and publicly funded research projects. The German federal and state governments contribute around another third as base funding, enabling the Fraunhofer institutes to develop solutions now to problems that will drastically impact industry and society in the near future.

The impact of applied research goes far beyond the direct benefits to the client. Fraunhofer institutes strengthen companies' performance and efficiency and promote the acceptance of new technologies within society while also training the future generation of scientists and engineers that the economy so urgently requires.

As a scientific organization, the key to our success is highly motivated employees engaged in cutting-edge research. Fraunhofer therefore offers its researchers the opportunity to undertake independent, creative and, at the same time, targeted work. We help our employees develop professional and personal skills that will enable them to take up positions of responsibility within Fraunhofer itself or at universities, within industry and in society at large. Students involved in projects at Fraunhofer institutes have excellent career prospects on account of the practical vocational training they enjoy and the opportunity to interact with contract partners at an early stage in their career.

The Fraunhofer-Gesellschaft is a recognized non-profit organization named after Joseph von Fraunhofer (1787–1826), an illustrious researcher, inventor and entrepreneur hailing from Munich.

Figures as of: March 2023
www.fraunhofer.de/en

Fraunhofer INT in profile

The Fraunhofer Institute for Technological Trend Analysis INT provides scientifically sound assessments and counseling on the entire spectrum of technological developments. On this basis, the Institute conducts Technology Forecasting, making possible a long-term approach to strategic research planning. Fraunhofer INT constantly applies this competence in projects tailor-made for our clients.

Over and above these skills, the Institute runs its own experimental and theoretical research on the effects of ionizing and electromagnetic radiation on electronic components, as well as on radiation detection systems. To this end, Fraunhofer INT is equipped with the latest measurement technology. The main laboratory and large-scale appliances are radiation sources, electromagnetic simulation facilities and detector systems that cannot be found in this combination in any other civilian body in Germany.

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

22nd meeting of the Fraunhofer INT Board of Trustees
Euskirchen, May 19, 2022

Curators

- **Udo Becker**
  Kreissparkasse Euskirchen
- **MinR`n Sabine ten Hagen-Knauer**
  Federal Ministry of Education and Research Bonn
- **Vice President Sabine Lackner**
  THW Bonn
- **Dr.-Ing. Frank Sabath**
  WIS Munster
- **Britta Schade**
  ESA/ESTEC Noordwijk
- **Prof. Dr. Katharina Seuser**
  Bonn-Rhein-Sieg University of Applied Sciences
- **MinR Dr. Dirk Tielbürger**
  Federal Ministry of Defence Bonn
- **Prof. Dr. Christiane Vaeßen**
  Aachen Region Zweckverband
- **MinR (ret.) Norbert Michael Weber**
  Federal Ministry of Defence Bonn
- **Prof. Dr. Dr. Axel Zweck**
  Association of German Engineers Düsseldorf
- **Dr. Karsten Deiseroth**
  IABG

Fraunhofer INT in figures

Facts and figures

Human resources

In 2022, we have hardly changed the personnel capacity. At the end of the year, we had 134 employees with 117.3 full-time equivalents, including 70 scientists (63.7 full-time equivalents). We thus cover a broad range of natural and engineering sciences, but also economics, social sciences and sociology.

The researchers are supported by graduate engineers, technicians and administrative staff. In addition, there are student and research assistants as well as trainees. Fraunhofer INT also has a network of freelance scientists who are regularly involved in the institute's work.

Employees

	2020		2021		2022	
	Occupied positions	Amount of people	Occupied positions	Amount of people	Occupied positions	Amount of people
Scientists	58,9	64	62,1	68	63,7	70
Graduates	25,0	26	30,0	30	28,5	30
Technicians, others	18,1	20	16,1	18	18,1	21
Assistants, trainees	8,5	15	8,1	16	7,0	13
Total	**110,5**	**125**	**116,3**	**132**	**117,3**	**134**

Budget in 1.000 €

	2020	2021	2022
Operating budget	10.420,9	11.790,8	12.693,1
- of which personnel	8.523,0	9.391,2	9.651,2
- of which non-personnel	1.879,9	2.399,6	3.041,9
Capital expenditure	933,6	1.416,1	4.299,5
Total	**11.354,5**	**13.206,9**	**16.992,6**

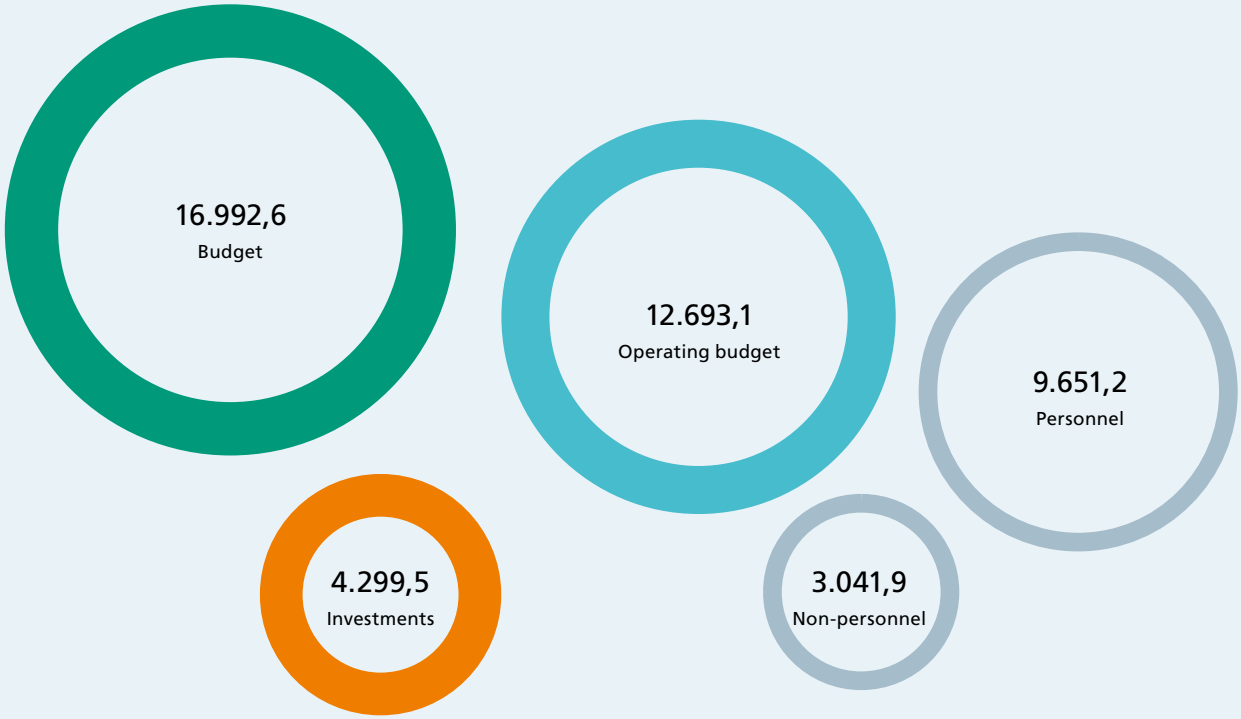
Financing in 1.000 €

	2020	2021	2022
Base funding	6.040,5	8.351,3	11.155,9
Contract research	5.314,0	4.855,6	5.836,7
Total	**11.354,5**	**13.206,9**	**16.992,6**

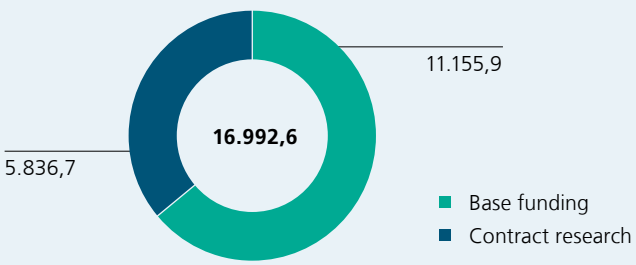
Budget

The operating budget has increased to 12.7 million € in 2022. The first tranche of our investment program increased the investment budget to 4.3 million €. This investment program will renew and modernize the institute's experimental equipment to ensure the future viability of our research.

Budget 2022 in 1.000 €



Financing 2022 in 1.000 €



Appendix

Lectures

Baaden, P.: Lecture "Explorative Methods in Entrepreneurship Research", master's degree program "Management and Economics", Ruhr-Universität Bochum, winter term 2022/2023

Bantes, R.: Lecture "Trends in Forschung und Entwicklung", bachelor's degree program "Technik-Journalismus und visuelle Technik-Kommunikation", Bonn-Rhein-Sieg University of Applied Sciences, summer term 2022

Bantes, R.: Seminar "Trends in Forschung und Entwicklung", bachelor's degree program "Technik-Journalismus und visuelle Technik-Kommunikation", Bonn-Rhein-Sieg University of Applied Sciences, summer term 2022

Bantes, R.: Seminar "Sicherheitsforschung und Zukunftsforschung", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, summer term 2022

Chmel, S.: Lecture and exercise "Physics", bachelor's degree program "Naturwissenschaftliche Forensik", Bonn-Rhein-Sieg University of Applied Sciences, summer term 2022

Chmel, S.: Lecture and exercise "Measuring Techniques", bachelor's degree program "Naturwissenschaftliche Forensik", Bonn-Rhein-Sieg University of Applied Sciences, winter term 2022/2023

Freudendahl, D.: Lecture "Neue Materialien und Werkstofftrends", master's degree program "Technik-Management und Optimierung", Ravensburg-Weingarten University of Applied Sciences, winter term 2021/2022

John, M., Martini, M.: Seminar "Data Driven Foresight", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, winter semester 2022/2023

John, M.: Lecture "Publikationsanalysen als Beispiel für Data Driven Foresight – Eine Einführung in die quantitativen Methoden der Zukunftsforschung", Free University of Berlin, master's degree program "Zukunftsforschung", winter term 2021/2022 and winter term 2022/2023

Jovanović, M., Wiemken, U.: Seminar "Technik, Politik u. Gesellschaft - Prognostik, Szenarien, Folgenabschätzung", master's degree program "Technik- und Innovationskommunikation", Bonn-Rhein-Sieg University of Applied Sciences, summer term 2022

Jovanović, M.: Seminar "Projektmanagement für Studierende", study programs in information science as well as Studium Universale, Heinrich Heine University Düsseldorf, winter term 2021/22

Jovanović, M.: Seminar "Projektmanagement für Studierende", study programs in information science as well as Studium Universale, Heinrich Heine University Düsseldorf, summer term 2022

Lauster, M.: Lecture "Methoden der Zukunftsforschung - Technologieanalyse", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, summer term 2022

Lauster, M.: Lecture "Methoden der Zukunftsforschung - Technologievorausschau", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, winter term 2022/2023

Lauster, M.: Lecture "Technologiefrüherkennung und Zukunftsforschung", master's degree program "Technik Management & Optimierung", Ravensburg-Weingarten University of Applied Sciences, summer term 2022

Lauster, M.: Seminar "Ethik für Ingenieure", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, summer term 2023

Lauster, M.: Seminar "Wissenschafts- und Erkenntnistheorie", bachelor's and master's degree program "Maschinenbau", Rhine-Westphalia Technical University of Aachen, winter term 2022/2023

Metzger, S.: Lecture "Experimental Techniques in Particle Physics", master's degree program "Physik", Rhine-Westphalia Technical University of Aachen, winter term 2022/2023

Wirtz, H.: Lecture "Corporate Finance", bachelor's degree program "Betriebswirtschaftslehre", Hochschule Fresenius, winter term 2021/2022, winter term 2022/2023

Wirtz, H.: Lecture "Finanzwirtschaft, Rechnungslegung und Controlling", bachelor's degree program "Betriebswirtschaftslehre", Hochschule Fresenius, summer term 2022

Theses

Abdelrahim, Y.: Master's thesis "Strategische Planungsmethoden für KMUs – Entwicklung eines Auswahl- und Bewertungskonzeptes", Rhine-Westphalia Technical University of Aachen, 2022

Butgereit, D.: Bachelor's thesis "Kompetenz- und Akteursanalyse der Fraunhofer-Gesellschaft in den Bereichen Downstream-Technologien und Nachhaltigkeit", Rhine-Westphalia Technical University of Aachen, 2022

Frederick, G.: Master's thesis "Podcasts als Kommunikationsinstrument von außeruniversitären Forschungseinrichtungen am Beispiel des Fraunhofer INT", Technical University of Berlin, 2022

Laschke, P.: Master's thesis "Untersuchung der Anwendung eines datengetriebenen Assistenzsystems zur Unterstützung von RTOs am Beispiel von KATI: eine qualitative Interviewstudie", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Nickels, C.: Bachelor's thesis "Kompetenz- und Akteursanalyse der Fraunhofer-Gesellschaft in den Bereichen Launchertechnologien", Rhine-Westphalia Technical University of Aachen, 2022

Steinberg, A.: Bachelor's thesis "Anpassungsfähigkeit von KMUs auf sich verändernde externe Rahmenbedingungen im Vergleich zu großen Unternehmen und Konzernen am Beispiel des Automotive Sektors", Rhine-Westphalia Technical University of Aachen, 2021–2022

Yesil, E; Kiyildi, A.: Project work "Identifikation von Trends in der ›New Space‹ – Branche", Rhine-Westphalia Technical University of Aachen, 2022

Supervised theses

Cesbron Lavau, L.: Heidtmann, G.: Bachelor's thesis "Empfindlichkeitsuntersuchungen an COTS Drucksensoren unter HPEM", Rhine-Westphalia Technical University of Aachen, 2022

Bantes, R.: Niewiadomski, S.: Bachelor's thesis "Wasserstoff als nachhaltiger Energieträger für alternative Antriebe in der Pkw-basierten individuellen Mobilität: Ein Blick auf den aktuellen Stand der Technik I", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Jovanović, M.: Plattner, R.: Bachelor's thesis "Gamifications und Motivation – Eine Studie am Beispiel eines Workshops zur Mobilität der Zukunft", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Jovanović, M.: Rabe, L. R.: Master's thesis "Die Smart City Bonn in den Augen ihrer Bevölkerung. Eine kritische Auseinandersetzung mit der Kommunikation einer Smart-City-Strategie", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Jovanović, M.: Fail, I.: Bachelor's thesis "Eine vergleichende Analyse der Literaturdatenbanken Web of Science und Dimensions durch Topic Modeling", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Jovanović, M.: Keller, D.: Master's thesis "Diskussionen im Techniksektor: eine Datenanalyse der Internetbeiträge von Elon Musk und seiner Online-Communitys", Bonn-Rhein-Sieg University of Applied Sciences, 2022

Martini, M.: Imran, I.: "What is the best (= in terms of usability and utility) way to visualize IPC/CPC classes in Patent Analysis?", University of Siegen, 2022

Gremien und Netzwerke

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

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

Adami, Ch.: Member "WG6, E3AT NATO Susceptibility Test Procedures Against Radio Frequency Directed Energy Systems"

Chmel, S.: Coordinator "Fraunhofer EU-Netzwerk"

Chmel, S.: Head "AG Management" of the Fraunhofer EU-Network

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

Gabel, O.; Huppertz, G.; Klein, M.: Members "NATO RTO-STG SAS-159 How could Technology Development Transform the Future Operational Environment"

Neupert, U.: Member "Independent Scientific Evaluation Group (ISEG)" of the NATO research programme "Science for Peace and Security"

Pusch, T.: Member "GAK 767.3/4.4 TEM-Wellenleiter / Reverberation Chamber, DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE"

Pusch, T.: Member "DKE AK 767.13.19 Reverberation Chamber, DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE"

Pusch, T., Ribeiro Arduini, F., Suhrke, M., Lanzrath, M.: Members "ETN Marie Curie Pan-European Training, research and education network on Electromagnetic Risk management – PETER"

Suhrke, M.: National representative "Joint Working Group Reverberation Chamber der IEC"

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

Thorleuchter, D.: Editorial board member "Advances in Engineering: an International Journal (ADEIJ)"

Thorleuchter, D.: Editorial board member "International Journal of Information Science"

Thorleuchter, D.: Editorial board member "Journal of Information Systems Engineering & Management"

Thorleuchter, D.: Reviewer board member "Information"

Vollmer, M.: Member "Expertenkommission Starkregen"

Vollmer, M.; Linde-Frech, I.: Members "Innovations-Cluster Zivile Sicherheitsforschung InCluSiF"

Weimert, B.: Board member "Netzwerk Zukunftsforschung"

Weimert, B.: Member coordination team "Netzwerk Technikfolgenabschätzung"

Weimert, B.: Co-publisher and editor "Zeitschrift für Zukunftsforschung"

Publications

Stay up to date

Follow us on social media!

On our social media channels, you can find news from everyday research, interesting research results, lectures, events and current job postings.

YouTube

LinkedIn

Instagram

Twitter

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 Analysis 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

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

Central IT

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

CTF

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

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

WZA

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

TIP

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

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

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

WTI

Sven Ruge
Phone +49 2251 18-344
sven.ruge@int.fraunhofer.de

EME

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

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

NSD

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

Publishing Details

Publisher
Fraunhofer Institute for Technological Trend Analysis INT
Appelsgarten 2
53879 Euskirchen
Phone: +49 2251 18-0
www.int.fraunhofer.de

Diector
Prof. Dr. Dr. Michael Lauster

Redaction und Production

Angela Haberlach, Angelique Makome, Gina Frederick
pr@int.fraunhofer.de

Printing
Fraunhofer Verlag – Mediendienstleistungen

Picture Credits

P. 2	Jens Howorka/Blendfabrik
P. 4-5	Tobias Vollmer
P. 7	Tobias Vollmer
P. 9	Valentina Vindermudt
P. 10	greenbutterfly/Shutterstock.com
P. 12-13	Blue Planet Studio/Shutterstock.com
P. 15	Lumppini/Shutterstock.com
P. 21	Konzeptbüro Horst Schneider
P. 25	nasa/unsplash.com, Efman/Shutterstock.com
P. 27	Net Vector/Shutterstock.com
P. 28-29	ktsdesign/Shutterstock com
P. 31	Andrew Berezovsky/Shutterstock.com
P.34-35	Tobias Vollmer

Annual Report 2022

Fraunhofer Institute for Technological Trend Analysis INT