Fraunhofer
INT

FRAUNHOFER INSTITUTE FOR TECHNOLOGICAL TREND ANALYSIS INT

ANNUAL REPORT 2017

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FOREWORD

Dear Reader,

Yesterday, Today, Tomorrow – the German title of an episode of the TV series »Star Trek – The Next Generation«, in which a higher power throws Jean-Luc Picard, Captain of the Starship Enterprise, back and forth between past, present and future. On his journey through time, he has to realize that an action he is going to perform in the future (has already performed?) has wiped out mankind (or will wipe it out?). This forces him to modify or completely reject any plans he has already made in a given present time, because of the future consequences that arise from them.

It increasingly seems as if our own difficulties are similar to the situation faced by the Captain of the Enterprise:

Even less than a century ago, it was fair to say that the present was the »exclusive« product of the past, and that the state of the world at the time was – at least in principle – owed to the way the lines of history developed. The emergence of modern technologies, spreading so rapidly around the world in comparison with earlier inventions, is forcing us to take a new look at things. Even if applied only locally, these technologies can have global effects and cause repercussions hitherto unknown.

A striking example from the last century was the invention of nuclear weapons combined with intercontinental missiles. Guaranteed mutual annihilation, where the first to shoot is the second to die, has triggered a rethink: a glimpse into the future showed that the use of these weapons would mean virtually total extermination for mankind. It became clear to those in charge at the time that nuclear warheads are – if at all – only suitable as a political tool, but never for real use. A look at present events gives reason to fear that many of today's political leaders are not able to see so clearly.

But it is not necessary just to think of such martial products and their doomsday scenarios. What will also seriously impact our future are the results of »civilian« research, modern biology for example. Only a few years ago, a genetic mechanism was discovered that made it possible to excise single genes from DNA with unprecedented precision, and replace them with others. CRISPR-Cas/9, or simply CRISPR, works with all living things, can be widely applied to a DNA strand and is extremely simple and cheap – actually an ideal tool for any geneticist. This will soon allow us to do things that were previously reserved for evolution. In future, changing living organisms at will and even creating new beings will be an exercise for first-year biology students. The idea of »improving« man becomes very real: eradicating a few illnesses here, enhancing some desirable qualities there, and Homo sapiens will soon have constructed another being out of itself – a being that detaches itself from its own evolution and goes its own new ways.

So doing, we as the constructors work according to completely different principles from those that apply for evolution, which uses chance as a mechanism for change and tests the ecological conditions to find criteria for a choice – without proceeding teleologically, i. e. striving for a predetermined goal. On the other hand, constructing man orients himself according to an ideal concept he himself chooses, and then he acts systematically. Yet how do we know that the ideals we have today will continue to exist in the future; whether the people we construct will really look upon themselves as ideal, or whether by choosing a specific future which seems so perfect today we do not irreversibly destroy all other possible futures?

These and many other questions have to be posed and carefully answered. And we need to act quickly, because the technologies are already available. Taboos, such as absolutely forbidding interference with the human germ line, have already been broken. Without wanting to be alarmist: with regard to understanding the negative aspects of our technologies, and to finding ways of curbing their impact, time is pressing.

Not researching is no option, and this is also probably true for unlimited universal research. The future is the mirror, and its image has to reflect the present.

For more than 40 years, INT has conducted research on nuclear weapon threats and technology analysis and foresight in many areas around the world. The Institute thus offers assessment and advisory skills to decision-makers who need to consider such questions in their strategic planning. Our scientists are constantly watching the time horizon, their analyses envelope our present, between the past and possible futures. Like Captain Picard, they move through time in search of answers to the questions that the future will raise for us.

Again, some of their search results are documented in this Annual Report. So join us on a journey into the unknown territory of the future, true to the Enterprise crew's motto: »To boldly go where no man has gone before.«

I hope you enjoy reading,
Best wishes,

Prof. Dr. Dr. Michael Lauster

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DEPARTMENTS AND BUSINESS UNITS

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, we run our 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, INT is equipped with the latest measurement technology. Our 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, INT has been a reliable partner for the Federal German 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. INT also successfully advises and conducts research for domestic and international civilian clients: both public bodies and industry, from SMEs to DAX 30 companies.

THE BUSINESS UNITS IN THIS ANNUAL REPORT:

BUSINESS UNIT
DEFENSE TECHNOLOGY FORESIGHT

BUSINESS UNIT
PUBLIC TECHNOLOGY AND INNOVATION PLANNING

BUSINESS UNIT
CORPORATE TECHNOLOGY FORESIGHT

BUSINESS UNIT
NUCLEAR SECURITY POLICY AND DETECTION TECHNIQUES

BUSINESS UNIT
ELECTROMAGNETIC EFFECTS AND THREATS

BUSINESS UNIT
NUCLEAR EFFECTS IN ELECTRONICS AND OPTICS

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Deputy Director
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FRAUNHOFER INT FACTS AND FIGURES

Staff

Permanent staff numbers at INT increased slightly. At year end for this sector, personnel numbered 101 people, of which 94.3 were full-time equivalent. Of these, 60 were scientists (56.3 full-time equivalent). With this staff we cover a wide range of natural and engineering sciences, as well as economics, humanities and social sciences. The scientists are supported by graduate engineers, technicians and administrative staff. More support comes from student and scientific assistants, as well as trainees. INT also has access to a network of freelance scientists who regularly work together with the Institute.

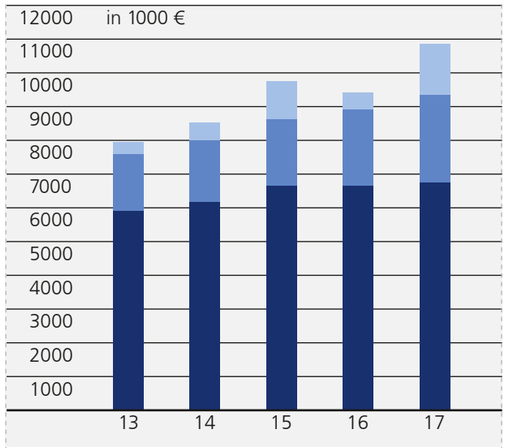
Budget

The Fraunhofer Gesellschaft distinguishes between operating and investment budgets. The operating budget covers all staffing and administrative expenditure, the investment budget concerns the procurement of capital goods such as scientific apparatus and technical equipment. The operating budget in 2017 rose by a clear 4 % to € 9.3 million. Together with investments totaling € 1,514 million, the total budget amounted to € 10.8 million. With financing for several projects it was possible to renew and expand IT infrastructure. This above all benefits research on cognitive systems in the Department TASP, but also possibilities for numeric simulation in the Department NE.

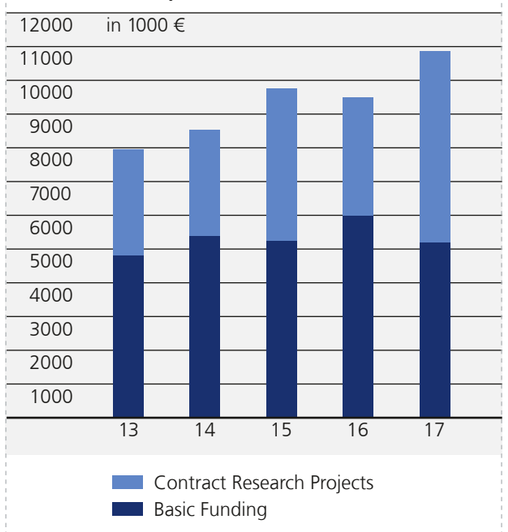
As well as the amounts shown for investment in scientific infrastructure there is also the expenditure for the renovation and extension of laboratory capacity, which is accounted for on the central budget. With these investments, INT could again considerably improve its potential for experimental research in radiation effects. Further plans to expand the experimental facilities are already underway.

Along with basic funding from the Federal Ministry of Defence (BMVg), which enables the implementation of a coordinated research program, INT also receives basic funding from Federal

Budget from 2013 – 2017



Financial Development from 2013 – 2017



Human Resources	2015		2016		2017	
	Manned positions	People	Manned positions	People	Manned positions	People
Scientists	53.9	57	53.0	56	56.3	60
Graduates	23	23	23.8	24	24.0	24
Technicians, Others	13.8	17	14.8	18	14.0	17
Assistants, Trainees	4.3	18	4.6	20	6.6	15
Total	**95.0**	**115**	**96.2**	**118**	**100.9**	**116**

sources. Funding is applied within the Fraunhofer-Gesellschaft in accordance with performance criteria. INT generates the remaining funds necessary for its budget through a large volume of contract research work.

As well as the public sector, project clients in various industries range from SMS companies to DAX-30 groups, and also include associations and international organizations. In the public sector, Fraunhofer INT has provided BMVg – the largest client for INT in Euskirchen – with in-depth consultancy expertise in research and technology planning for more than 40 years.

In addition, research assignments are also carried out for other ministries and public institutions. A considerable share of income comes from EU projects which are jointly conducted with partners from many European nations.

Budget in 1000 €	**2013**	**2014**	**2015**	**2016**	**2017**
Expenses					
Operating Budget	7607.9	8027.6	8643.4	8914.7	9312.3
of which Human Resources	5915.7	6189.4	6660.5	6760.7	6858.3
of which Material Expenses	1692.2	1838.2	1982.9	2154.0	2454.0
Investment Budget	372.0	514.2	1116.2	549.4	1515.5
Total	**7979.9**	**8541.8**	**9759.6**	**9496.1**	**10826.8**
Funding					
Basic Funding	4820.9	5405.8	5233.6	6004.9	5151.9
Contract Research Projects	3159.0	3136.0	4526.0	3459.2	5674.9

ADVISORY BOARD

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The institute is given advice by an advisory board which is composed of personalities from industry, science, politics and administration.

Chairman

Prof. Dr. Horst Geschka; Geschka & Partner Unternehmensberatung Innovarium

Members

- Sir Udo Becker, Vorstand Kreissparkasse Euskirchen
- Sir Kuno Blank, Vorstand der Fraunhofer-Gesellschaft
- Sir Klaus Burmeister; foresightlab
- Sir Dr.-Ing. Karsten Deiseroth; IABG mbH
- Sir Prof. Dr. Horst Geschka; Geschka & Partner Unternehmensberatung Innovarium
- Sir Dr. Wolf Junker, Bundesministerium für Bildung und Forschung (BMBF)
- Madam Dr. Vera Kamp, Plath GmbH
- Sir Erster Direktor BAAINBw Dipl.-Ing. Rainer Krug; Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr
- Madam Cornelia Reimoser, Institutsbetreuerin seitens der Fraunhofer-Gesellschaft
- Sir Dir. Prof. Dr. Winfried Schuhn; Wehrwissenschaftliches Institut für Schutztechnologien – ABC-Schutz (WIS)
- Madam Prof. Dr. Katharina Seuser, Hochschule Bonn-Rhein-Sieg
- Sir MinR. Dipl.-Ing. Norbert Michael Weber; Bundesministerium der Verteidigung (BMVg)
- Sir Dr.-Ing. Thomas Weise; Rheinmetall AG
- Sir Dr. rer. pol. Hans-Ulrich Wiese; ehemals Fraunhofer-Vorstand
- Sir Prof. Dr. Dr. Axel Zweck; VDI Technologiezentrum

1 *Advisory Board Meeting on June 22, 2017*

THE FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 72 institutes and research units. The majority of the more than 25 000 staff are qualified scientists and engineers, who work with an annual research budget of 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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

FRAUNHOFER VVS – GROUP FOR DEFENSE AND SECURITY

Fraunhofer VVS

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The Fraunhofer Group for Defense and Security VVS was founded in 2002 and is chaired by Prof. Dr. Jürgen Beyerer. The total budget of the Fraunhofer Group amounts to approximately 430 million euros per annum, and more than 3700 employees work for the nine VVS institutes.

The group considers its main objectives as follows:

1. Research and development of new technologies and solutions for the protection of people and the security of infrastructures
2. Research for national defense

Being committed to the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry of Defence (BMVg), the Fraunhofer VVS has come to assert itself as the driving force in the entire defense and security sector.

Even on a European level, the Fraunhofer VVS represents one of the key players and facilitates intensive networking with promising collaborative research activities.

Through excellent performance, the Fraunhofer-Gesellschaft significantly contributes to the future strategic orientation of the European security- and defense-research program.

Core competences

The fields of application are assigned to defense research on the one hand, and civil security research on the other hand. The core competences being applied are:

- Defense research 4-D (land, air, water, and cyber)
- security research (protection of people and security of infrastructures, crisis management)
- technology development (microelectronic, materials, components, information and communication technology)
- testing and assessment of operational procedures
- Modeling and simulation.
- Multidimensional security research from a technical, social, economic and political perspective

Portfolio

Security is an issue of growing social importance. Threats posed by terrorism operating internationally, organized economic crime, major accidents or extreme weather events represent a continuing challenge.

In the Fraunhofer Group for Defense and Security VVS, nine Fraunhofer Institutes have joined forces in order to face these challenges. As centers of excellence, they create intelligent and comprehensive solutions both for civil security as well as for defense in order to improve the protection of society against manmade and natural threats.

By pooling expertise and research activities, the Fraunhofer VVS develops cutting edge technology and the accompanying concepts concerning methods, processes and tactics which are essential for facing the whole spectrum of potential and emerging security threats appropriately.

As a result, the Fraunhofer Group is conducting research in the following business segments:

- Protection of critical infrastructures
- Management of crises and disasters
- Cyber security and defense
- Protection and effects
- Reconnaissance and surveillance
- Energetic materials processing and security technology
- Communication and information
- Command, control and operation
- Decision making support for government and economy

Management

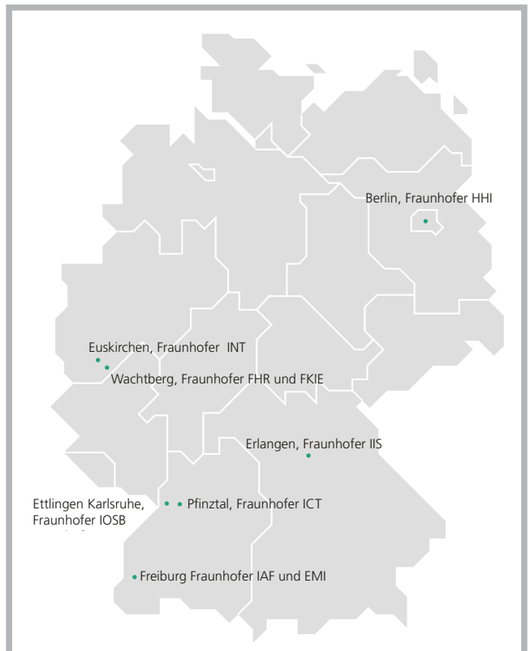
Group Chairman	Prof. Dr.-Ing. Jürgen Beyerer, Fraunhofer IOSB
Group Deputy Chairman	Prof. Dr. Peter Martini, Fraunhofer FKIE
Managing Director	Caroline Schweitzer, Fraunhofer IOSB caroline.schweitzer @iosb.fraunhofer.de

Members

- Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg
- Fraunhofer Institute for Chemical Technology ICT, Pfinztal
- Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Wachtberg
- Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE, Wachtberg
- Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut EMI, Freiburg
- Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen
- Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB, Karlsruhe

Guest Institutes

- Fraunhofer Institute for Integrated Circuits IIS, Erlangen
- Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut HHI, Berlin



1 *Chairman of the Group Prof. Dr.-Ing. Jürgen Beyerer, Fraunhofer IOSB*

FRAUNHOFER GROUP FOR INNOVATION RESEARCH – INNOVATION

With the new Fraunhofer Group for Innovation Research, the Fraunhofer-Gesellschaft aims to strengthen its future role in research, technology and innovation policy dialogue with industry, politics and society. Chairman of the group is Prof. Wilhelm Bauer, executive director of Fraunhofer IAO.

Understanding the complex interdependencies within systems of innovation is critical for business, government and society to succeed. For this reason, it is important to recognize changes as soon as they emerge in any sector, markets or technology. Only if we comprehend these changes can we actively influence the long-term impact on the economy, technology, society, politics and culture.

»Germany must take a leading role both in system-relevant innovations and in innovations that have disruptive potential. It is for precisely this reason that we decided to create a Fraunhofer group dedicated to innovation that focuses specifically on socioeconomic and sociotechnical research,« says Fraunhofer President Prof. Reimund Neugebauer, explaining the rationale behind the new group created on July 1, 2017.

Understanding change, shaping the future

The Fraunhofer Group for Innovation Research provides guidance to stakeholders from industry, politics and society and supports them in determining how to position themselves. To this end, the group analyzes changes in society, markets and technologies and offers a unique support network with sound expertise and a diverse range of knowledge.

Research and support with innovation processes

»By creating the new group, the Fraunhofer-Gesellschaft aims to further consolidate its role in researching and supporting innovation processes, and continue to develop the technological, economic and social factors that determine them,« explains chairman of the group Wilhelm Bauer, who is also executive director of Fraunhofer IAO.

The group offers companies ...

- Knowledge-based guidance on social, economic and technological developments
- Support with their long-term organizational development
- Methodological support in addressing questions of future strategy
- Integration of various stakeholder groups in complex innovation projects

The group offers political stakeholders ...

- Support with the preparation and implementation stages of the decision-making process
- Scientific expertise to identify, understand and assess social and technological change at an early stage, and propose appropriate courses of action
- Research and support with innovation processes

Members and research topics

The group currently comprises five Fraunhofer Institutes that contribute a wide range of different expertise and perspectives to provide a holistic picture of innovation systems:

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

Thanks to the wide range of specialist expertise offered by the member institutes, the group can support its partners in a number of different areas:

- Design and identification of innovation systems
- Socioeconomic aspects of technology development
- Strategic research planning and foresight
- System optimization with regard to human factors, organizational aspects and technology
- Technology and innovation management
- Technology foresight
- Transfer and exploitation of research results

The Fraunhofer Group for Innovation Research is the newest of eight Fraunhofer Groups devoted to specific research areas. It acts as a point of contact, facilitator and service provider for companies, politics and media for all matters relating to a given field of research.

TECHNOLOGICAL ANALYSES AND STRATEGIC PLANNING

Dr. René Bantes

Social, technological and economic development are inextricably linked, since some of the driving forces behind them influence each other. In both the political and private sectors, decision-making for the medium and long term – with lasting and far-reaching consequences – needs the support of appropriate »systemic« analysis and consultation. In order to deliver such, it is not only required to rely on a solid expertise in individual areas of technology, but also to have the ability to analyze and evaluate the overarching importance of these areas with an interdisciplinary approach,taking account of different technological, economical and social dimensions.

The department »Technological Analyses and Strategic Planning (TASP)«, staffed with around 40 scientists from a wide variety of disciplines – mainly natural sciences and technology – relies on its expertise in the global analysis and assessment of technological developments, and in identifying and structuring its clients' technological requirements.

Our aim is to deliver a sound, interest-neutral basis that supports our clients in their strategic and long-term decision-making process. The department's work addresses the concept, introduction and implementation phases of innovation processes, with a pronounced thematic focus on technological questions.

Our service proposition can be structured in three main fields of expertise:

- Technology Push:
  Based on a wide-ranging, systematic and continous technology foresight process, TASP's scientists identify technological inventions and innovations early, comprehensively assess and classify them, and anticipate their possible future development.
- Capability / Market Pull:
  Years of experience in research on national and international security and crisis management, and expertise, especially with participatory approaches in innovation management, add a system-oriented aspect to the technological analysis. With special emphasis on the analysis of (capability) demand this adds a second perspective on possible technology applications.
- Methodological excellence:
  With TASP's continually expanding portfolio of tools and methods for participatory and creative work formats, quantitative IT-backed procedures for data analysis, and innovative visualization techniques, the department has created a methodological basis for a wide range of issues and applications.

Based on these fields of expertise TASP is able to deliver products ranging from the exploration of the general future potential of a technology to the relevance of national and international actors, and of plans and programs in research and technology.

In addition to this, highly-specialized studies are conducted where required, tailor-made to an application area or technology, to deliver specific decision support for the client. Thus we enable the clients to enhance his information base and to make better informed strategic choices for research and technology.

Although the underlying methods are largely generic, there are variances in the formats, conclusions and recommendations derived, depending on specific client requirements. To best serve these requirements, TASP is structured in three usiness Units, each of which addresses different clients and their varying analysis requirements:

- Defense Technology Foresight (WZA)
- Public Technology and Innovation Planning (TIP)
- Corporate Technology Foresight (CTF)

These Business Units and their activities in 2017 are described in detail on the following pages.

The Business Units are supplemented by the group Tools and Methods (TM), which focuses on developing fundamental methods for the scientific work. In addition, work was carried out in specific internal projects, providing a basis for the department's activities in 2018 and the years to come.

BUSINESS UNIT »DEFENSE TECHNOLOGY FORESIGHT«

Hans-Martin Pastuszka

The Business Unit »Defense Technology Foresight (WZA)« covers all the services which TASP, Fraunhofer INT's Technological Analysis and Strategic Planning Department, provides for the Federal Ministry of Defence and its downstream offices. In particular, these include the Federal Office for Bundeswehr Equipment, Information Technology and In-Service Support and its branch centres, as well as the Bundeswehr Office for Defence Planning. It also serves international clients, such as the European Defence Agency (EDA) and NATO.

The technology-oriented futures research of WZA provides its clients with reliable knowledge for their orientation, and decision-making guidance on likely future developments in science and technology and their potential military implications. This includes in particular the early detection of emerging technologies and their specific assessment for defence clients, for example with regard to identifying inherent risks and opportunities for their use in military operations. As well as focusing on technological issues, WZA observes and analyses relevant international research planning processes and strategies, and from the results, derives research and technology planning recommendations for the client, provided for example as »country reports«. WZA thus helps to gain insights into global long term technological developments, ensuring a broad analysis and assessment capability for clients in defence research and technology (R&T).

These services are provided by an interdisciplinary team of scientists and engineers within TASP. This guarantees overall competence in all relevant science and technology fields, supplemented by comprehensive expertise in methodology and processes. The results are made available to the client, in particular through the Business Unit's key product, the quarterly published »Defense Technologies Forecast (Wehrtechnische Vorausschau – WTV)«. The knowledge gained from these activities in defence technology forecasting gives WZA staff members the expertise they need for working in other important inter-departmental projects. For example, this includes the organization and substantive support of INT's »New Technologies« column in the journal »Europäische Sicherheit und Technik (European Security and Technology)«.

In 2017, WZA's prime task was its continued work on the »Defense Technologies Forecast«, which the client makes available to a wide-ranging readership in BMVg, its downstream bodies and in the Bundeswehr (see also the special article in this report following page 21). As in previous years, 11 analyses of selected technological topics and long term system concepts were written and published. Also held were half-yearly workshops that respectively dealt with results and recommendations, all well attended by the client side. A noteworthy fact is that WTV is gradually being used by groups beyond the client side. Beginning a few years ago with the Federal Criminal Police Office (Bundeskriminalamt – BKA), WTV takers now include – with the client's agreement – the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe - BBK), and the Bundesgesellschaft BWI GmbH, the Bundeswehr's central non-military IT service provider, who all receive special versions. In line with a bilateral agreement with BMVg, also the Royal Netherlands Army recently began receiving the WTV.

WTV, as the client's long term technology foresight paper, was also a key starting point for a new activity launched in 2017 under the heading »FuT-Vorausschau (R&T Forecast)«. Following the WTV example, the purpose of this activity is to centrally combine the findings of all Bundeswehr processes of a forecasting nature – both existing and under development – and condense them into an annual »FuT-Zukunftslagebild (Future R&T Situation Picture)« for BMVg. WZA was tasked with developing a concept for such a R&T forecasting coordination process. This was done last year, and based on the WTV model, a possible Future R&T Situation Picture was proposed in prototype form. On this basis, the forecasting process was implemented for the first time in spring 2018, culminating in the first Future R&T Situation Conference, staged on February 27 to 28 at Fraunhofer INT. The conference was carried out on behalf of and chaired by the BMVg R&T Director.

Further projects carried out on selected topics last year included work on the ongoing assignment for brief technology analyses for the Swedish Defence Material Administration (FMV), on the assignment from the Bundeswehr Planning Office for setting up a trend management system (headed by the TASP group Tools and Methods), and on behalf of the »Wehrwissenschaftliches Institut für Werk- und Betriebsstoffe (Bundeswehr Research Institute for Materials, Fuels and Lubricants – WIWeb)« for the desulphurization of vehicle fuels for mobile use.

Among WZA's teaching and committee work, special mention is made of the technical support for two training course modules at the Bundeswehr Staff College (Führungsakademie der Bundeswehr – FüAkBw)«. For the fourth year in succession, WZA contributed to the specialist module »Methods of Analyzing the Future«, with two single presentations on Defence Technology Foresight and the WTV, focussing on Artificial Intelligence and on the method »Disruptive Technology Assessment Game«. A third lecture on »Quantitative Methods of Researching the Future« was presented by the TASP Group »Tools and Methods«, and a first lecture was given in the specialist module »Future Development«, on Defence Technology Future Analysis at INT and on selected current technology topics. Other notable teaching activities were substantive support for the past and the present Institute director in designing and conducting courses on »Methods of Analysing the Future« at the universities of Bonn-Rhein/Sieg and Ravensburg-Weingarten.

The two colleagues appointed to the »Independent Scientific Evaluation Group – ISEG« continued with their contribution to NATO's »Science for Peace and Security - SPS« program. More than 60 research proposals were evaluated during the year, and a common position was developed jointly with other ISEG members.

Finally, WZA was involved in other noteworthy events in 2017, over and beyond the WTV workshops and courses mentioned above. Organized by the Fraunhofer Group for Defense and Security (VVS), a workshop staged in the Bundeswehr Planning Office in January concentrated on future themes of interest to the Bundeswehr. Several WZA colleagues contributed. A highlight for Fraunhofer INT was undoubtedly the workshop on hypersonic missiles, held in the Institute in August on behalf of BAAINBw. At this event, more than 60 participants from all areas of the Bundeswehr, as well as from BMVg-funded research institutes from the German Aerospace Center (DLR) and the Fraunhofer-Gesellschaft, exchanged views on the state of the art and the threat potential. With the intention of upgrading the Bundeswehr's medium and long term capabilities profile, the planners in BMVg also initiated a series of workshops last year, with the aim of defining future Bundeswehr deployment scenarios in a »Future Operating Environment – FOE«.

Again, WZA is especially involved on the technological front. In November, a WTV team presented the threat potential of new technological developments at the Forum on Future Army Development, held at the Army Development Office (Amt für Heeresentwicklung). And last, a December meeting in the context of the trilateral R&T cooperation D-A-CH showed common interest in the possibility of deepening cooperation in technology foresight – this will be looked into further in 2018.

THE DEFENSE TECHNOLOGIES FORECAST 2017

Dr. Ulrik Neupert

At Fraunhofer INT, work for the Business Unit Defense Technology Foresight (WZA) focuses on technology-oriented futures research for the Federal Ministry of Defence (BMVg) and its subordinated offices. This work generates knowledge of likely developments in science and technology, as well as their defense technological and military implications. This serves to provide defense clients with reliable guidance and recommendations for research and technology (R&T) planning. At INT, the central project for these studies is the Defense Technologies Forecast (WTV).

Published quarterly, these long term technology and systems concept analyses are a fixed component of BMVg's R&T planning process – they contribute to the ability to analyze and evaluate new technologies and support the technology-based development of military capabilities.

The WTV addresses single technology topics characterized by high research dynamics, considerable military significance and /or a demand for acute planning action or consultation. Topic selection is based on technology scanning and monitoring conducted at Fraunhofer INT, a process carried out by an interdisciplinary team of scientists and engineers. This is done by analyzing key sources like scientific journals, defense literature and scientific conferences. Once a year, the list of candidate topics for in-depth WTV analysis is drawn up from the technologies identified, on the basis of various criteria for determining relevance for the Bundeswehr. Final selection of the topics covered in 2017 was made jointly with the client.

Written in individual reports of approximately 10 to 15 pages each, the selected technology topics were analyzed with regard to their technological maturity and feasibility, their military applicability, the threat potential and the relevant national and international defense R&T planning landscape. Analysis results were independent action recommendations for the material procurement side (BMVg Equipment Department, BAAINBw and its agencies) and the capability analysis side (BMVg I Planning Department, Bundeswehr Planning Office, Future Development Units of the Military Branches). The Defense Technology Forecast is classified as restricted and is only available for users in the Bundeswehr and BMVg.

The first three quarterly issues of 2017 covered a total of nine technology topics, following the bottom-up approach. The concept was a widespread choice of topics, addressing the largest possible number of readers. Although the focus is on individual technologies, the overall view of analyses published in this form since 2011 shows a broad-based picture of basic and system or capability-related future technologies that are relevant to defense.

Robotics, a significant area for many defense technology fields, was the subject of two articles in 2017. *Human-Robot / Human-Swarm* interfaces are becoming more and more important for human-operated monitoring and controlling of unmanned systems, since the personnel expense for operating individual systems and – increasingly in the future – multi-robot systems or swarms has to be reduced. The article on *Soft Robots* outlined the prospects for developing robots made of soft, yielding and deformable materials. Depending on mission, these materials can change their shape, enable greater passive safety in collisions, or allow soft gripping.

In the field of energy and propulsion technologies, WTV looked at two topics which could hardly be more different. The analysis of *Triboelectric Nanogenerators* deals with an innovative technique for converting mechanical energy from the environment into electrical energy for small users, such as sensors. This article is thus a follow-up on the 2011 article on *Energy Harvesting*. By contrast, the analysis of *Hypersonic Propulsion Systems* described air-breathing propulsion systems for aircraft, space transport systems and guided missiles, which are expected to reach in excess of five times the speed of sound in the future.

Because of the special impact of this technology, on air defense, for example, in the summer of 2017 BAAINBw T1.5 organized

a separate workshop under the title »Hypersonic Missiles«. With both the official and research sides taking part, the workshop was staged at INT.

In optical technologies, WTV considered *All-Optical Circuits* and *Non-Line-of-Sight Imaging*. Reason for the work on All-Optical Circuits is to develop more powerful and energy-efficient data processing systems, by replacing silicon-based circuits with fully light-based technologies in certain areas. *Non-Line-of-Sight Imaging* is a computer-aided method of displaying objects outside the field of view of a camera, based on indirect illumination with short light impulses and the evaluation of the light thus scattered. This could improve situational awareness, especially in the urban area.

A contribution on *Synthetic Biology* shed light on the potential uses, but also on the much-discussed threat aspect of this young science, which aims to create new biological systems with defined properties and functionalities not found in this form in nature. Here, there has been some groundbreaking progress in recent years.

From the cross-cutting area of materials science – where many individual topics have been covered in the past – the field of *Gradient Materials* was examined in the year under review. These show a gradual variation of the chemical composition, of the proportions of individual composite components or of the structural design over volume. New additive manufacturing processes are currently opening up new application prospects.

A cyber warfare-related topic is covered in the article *Cyber Reasoning Systems*. These are automated IT systems – systems without human support – that find security loopholes in software and then eliminate them. Working with potentially higher speeds than IT security experts, they could significantly improve the security of IT systems against cyber attacks in the future.

In the fourth quarter of 2017, as in previous years, the analysis perspective was reversed. In this complementary top-down WTV approach, visionary long term system concepts undergo a broader examination of their technical feasibility in the future. Identifying a topic here results from monitoring technology-driven developments in military capability. Depending on the nature of a topic, the time horizon ranges from the near future to approximately 40 years. The first step in this analysis of system concepts is identifying technologies that are relevant for implementation (enabling technologies). The second step examines the technologies singled out with regard to the state of the art and their maturity level at the assumed time of realization of the overall system. The feasibility of the system concepts under examination is derived from the synopsis of the forecasts on the feasibility of the individual components. In parallel, an impression is developed of a future picture which shows what can be expected to be the most probable manifestation of the system type at the time of examination. Since WTV themes in the fourth quarter are of very different character, the internal logic of technology analysis may be slightly adjusted. The future vision of military systems as based on the analysis of the technological realization prerequisites should serve military planners as a reliable discussion template for fixing long term goals.

The first article in the final issue for the year considered the medium to long term viable vision of the *Digital Battlefield*, with a digital display of all relevant battlefield information and the actors involved. This makes greatly improved situational awareness possible and is the basis for gaining information superiority. Major challenges come from the vulnerability of the underlying information and communication infrastructure, and from the use of artificial intelligence, whose long term technological development and its consequences are currently hardly predictable.

The second contribution for the final quarter looked at the *Resource-Efficient Military Base Camp*. Technology available today gives us concepts for more speedily deployable and flexible camps that can be adapted to different conditions – camps whose greater self-sufficiency in water and energy supplies calls for much less logistical effort. Above all, the will to implement and cooperate with allied nations is needed to create standards to ensure the compatibility of modular components.

To operationalize the results of the WTV analyses, INT hosted two workshops in 2017. They were a platform for discussing presentations and recommendations with the authorities, and for outlining possible further action. This open dialog between technologists, capability demand and management, and material procurement is highly appreciated on all sides. In this way, INT brings its expertise to play in the early stages of defense planning and procurement.

In addition, the meanwhile 80 WTV analyses now available on the Bundeswehr intranet represent an important resource for all Bundeswehr users, such as the future developers of the Armed Forces. The analyses contain scientifically substantiated statements, and their user-friendly presentation enables a realistic outlook on the defense potential of future technologies.

Signed in 2017, the new study agreement secures WTV publication for the next few years. In addition, as of 2018, updates of previously-published WTV analyses will appear regularly. Causes for updated analyses are found in the often highly dynamic developments in a number of technologies. This not only leads to new technological insights, but typically, the number of research players is also increasing, and interesting new military applications are becoming apparent. It follows that such a WTV update may also contain a modified recommendation for national defense technology planning. In this way, the situational picture of future technology relevant to the Armed Forces is constantly kept up to date.

BUSINESS UNIT »TECHNOLOGY AND INNOVATION PLANNING FOR THE PUBLIC SECTOR – TIP«

Dr. Merle Missoweit

TIP, the Business Unit Technology and Innovation Planning for the Public Sector, pools activities for TASP, the Department Technology Analyses and Strategic Planning, for public sector, non-military clients. The clients are the European Commission, the European Parliament, the Federal Ministry of Education and Research (BMBF), and other national and international organizations and actors.

The Business Unit's focus is on decision-making support for research and innovation planning in security research, but increasingly for other applications as well. This primarily means foresight and scenario activities, identifying innovation needs, monitoring the research landscape, assessing technologies, roadmapping, and developing concepts for complex research projects. One of our central skills is the use of participatory methods for integrating the full range of relevant experts and actors. In so doing, the Business Unit's research work achieves a consensus-based, state of the art result.

As in the year before, TIP was increasingly active in innovation management beyond security research. Brought to a successful close was the EU project SONNETS (Societal Needs Analysis and Emerging Technologies in the Public Sector, scheduled term 2016 – 2017), which identified, analyzed and promoted the implementation of emerging technologies to transform the public sector. TIP was in charge of the roadmapping work package, in which the necessary research and implementation activities have been developed. The BMBF project »Horizonte erweitern – Perspektiven ändern« (Widening Horizons – Changing Prospects), running from 2017 to 2020, aims at developing strategies to promote the transfer of scientific research results, innovations and technologies to rural areas. TIP, in cooperation with the business unit CTF, is responsible for identifying and prioritizing technological solutions to needs of rural region as identified in the project.

In the project FRAME (FRAunhofer Microelectronics Innovation Enhancement), which is the founding project for the new Fraun-hofer-Verbund Innovationsforschung (Fraunhofer Group for Innovation Research), TIP leads the module on Foresight and Roadmaps. FRAME supports the development of the Forschungsfabrik Mikroelektronik Deutschland FMD (Research Fab Microelectronics Germany), which has been created as part of a 300 million Euro BMBF project. The aim of the research fab is to strategically develop microelectronics expertise in Germany and push the frontiers of research. Within FRAME, the Foresight and Roadmap module identifies technological and societal developments and discusses their implications for the FMD.

TIP also continued its activities in security research, acquiring two new EU projects. In the first, the Fire & Rescue Innovation Network FIRE-IN, running from 2017 to 2022, TIP supports the development of an international network of fire services and other first responders and their innovation planning (see also page 29). The second project is IN-PREP, an INtegrated next generation PREParedness program for improving the effective inter-organizational response in complex disaster and crisis environments, running 2017 - 2020. Among other duties at IN-PREP, TIP is responsible for assessing needs and preparing a handbook on cross-border cooperation in crisis situations. In national security, TIP has been working since year-end with the German Authority for Technical Relief (Technisches Hilfswerk THW) to conceptualize and then implement a research and innovation planning process for the authority. The »THW Innovation Radar« is intended to give THW strategic readiness for future tasks and operations, and to generate further developments in line with social trends.

In resilience management, new expertise was acquired during the year within the two projects SmartResilience and ResiStand. SmartResilience (duration 2016 - 2019) deals with the resilience of critical infrastructures in smart cities – cities whose infrastructures have already reached a high level of digitization and networking, and which thus may have become more vulnerable. TIP's role is amongst others to analyze related challenges for specific critical infrastructures. The project ResiStand, whose goal is »increasing disaster Resilience by establishing a sustain-

able process to support Standardization of technologies and services«, is running 2016 – 2018. Its tasks are promoting standardization in resilience by proposing new standards, better explaining the potential of standardization, and developing a lasting process for effectively standardizing new resilience solutions. TIP's main role in ResiStand has been to lead the work package on identifying user's standardization needs and requirements. Both projects are important steps towards greater support in the near future for our clients in resilience management and planning.

Parallel to these three main activities, TIP has for some time been putting greater emphasis on the link to social questions regarding the acceptance of technologies and concepts. On-going in this field is, for example, the European Network of Excellence SOURCE – Virtual centre of excellence for research support and coordination on societal security (runtime 2015 – 2019).

TIP's broad expertise is not only clearly visible through its membership of the Protection and Security Advisory Group under Horizon 2020, but also of the interdisciplinary H2020 Group for International Cooperation. The Business Unit also provides expert reviewers for the NATO Science for Peace and Security Program, as well as for the EU research program Horizon 2020. In addition, it represents the Fraunhofer Group for Defense and Security (VVS) at the EARTO Security Working Group. Several TIP staff members are also active as consultants for major research projects.

H2020 PROJECT »IN-PREP« – IMPROVING TRANSBOUNDARY CRISIS MANAGEMENT

Dr. Sonja Grigoleit

Since September 2017, Fraunhofer INT has been carrying out research for the three-year EU Horizon 2020 Project »An **IN**tegrated next generation **PREP**aredness programme for improving effective inter-organisational response capacity in complex environments of disasters and causes of crisis« (IN-PREP). The aim of IN-PREP is to improve the response to disasters such as earthquakes, floods or forest fires, but also to man-made crises like industrial accidents or terrorist attacks.

Both natural and man-made disasters are changing in scale, frequency and ferocity. Many such crises do not stop at national borders. This poses a complex challenge for the European Union, which demands an urgent improvement in the response to transboundary crisis management.

During the three-year term, the project will be developing an overall crisis management system that will address three challenges in the context of transboundary crises:

- Developing a shared response planning system for EU member states
- Improved sharing of relevant information in real time; creating a shared picture of an emerging crisis of the participating states
- Improved coordination of critical and scarce resources and ensuring a timely and efficient crisis response.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The IN-PREP project includes the development of a Mixed Reality *Prepared-ness Platform* (MRPP), providing IT-based modules for response planning and developing scenarios. Command and Control and information systems, situation awareness modules, and decision support mechanisms are being integrated into the platform. In addition, IN-PREP is developing a cross-organisational handbook for transboundary operations. The underlying goal is to improve crisis preparedness by using training programs with realistic disaster scenarios.

Fraunhofer INT is mainly responsible for identifying success and failure factors in transboundary crisis management, and for analyzing legal, political, human and organizational aspects. INT is also leading the development of the handbook of transboundary preparedness and response operations.

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H2020 PROJECT »FIRE-IN« – FIRE AND RESCUE INNOVATION NETWORK

Claudia Berchtold

Coordinated by the Greek »Institute of Communication and Computer Systems« in Athens, the consortium is made up of 20 partners from seven EU countries. The partners include technology providers as well as seven organizations directly involved in civil protection, such as the police, fire and rescue services. Thus, end-users are strongly represented in the consortium and their insight and advice will be used to shape the training modules, handbook and the MRP platform. During the project, several workshops and activities are being staged, also allowing external experts to contribute to and evaluate the IN-PREP system.

The EU-funded project FIRE-IN (Fire and Rescue Innovation Network) kicked off in May 2017. It aims to improve the capability of fire and rescue services at national and European level, and to generate solutions for the capability gaps identified.

In addition, four key activities are focusing on reducing risks and increasing safety for Europe's citizens (see Figure 1):

1. Identifying operational capability gaps and harmonizing cooperation with end-users (lilac)
2. Identifying possible ways of closing these gaps, with constant interaction between research, industry and end-user partners (orange)
3. Defining a research and development (R&D) agenda for fire and rescue services (blue)
4. Developing a concept for the more efficient use of training and demonstration facilities (red).

The project's overarching purpose is to develop a process to promote capability-driven research for fire and rescue services, supported by a broad network of actors from all EU member states. This network will link harmonized cross-domain and cross-border operational requirements in research and development, innovation, pre-commercial procurement and standardization into national and EU capability development programs.

To achieve this, FIRE-IN is setting up and testing a step-by-step approach to a capability-driven research agenda. These steps are being jointly developed and applied by the FIRE-IN partners and their hands-on practice, research and industry networks. They are being tested and adjusted in three iterative cycles during project duration.

1

1 *Concept Core of the FIRE-IN Project*

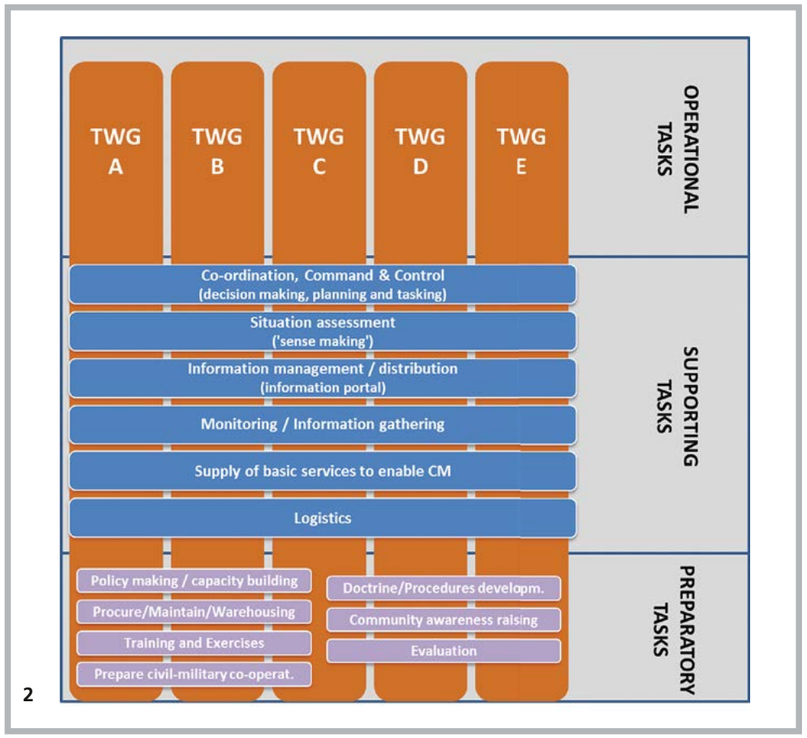
One challenge is the heterogeneity in managing crisis among the fire and rescue services, which have to deal with a wide range of missions. These range from daily emergencies to national disasters in different terrains and under varying conditions. What is missing on top of this is a common taxonomy for the transnational structuring of fire and rescue services and their operations. At the same time, risks are subject to constant change, such as changes in known threats (terrorism or cyber attacks, for example), or the emergence of new threats (nanomaterials, new biological substances).

Nevertheless, the expertise in question can be broken down into five areas that share comparable vocabulary and have similar capabilities and operational approaches (see Figure 2):

The Thematic Working Groups (TWGs) cover the following:

TWG A: Search and Rescue (SAR) and Emergency Medical Response (EMR)
TWG B: Structure fires crisis mitigation, prevention and protection
TWG C: Vegetation fires crisis mitigation
TWG D: Natural Disasters crisis mitigation
TWG E: CBRNE crisis mitigation

FIRE-IN distinguishes between these working groups to simplify collaboration and to accommodate the different deployment practices. All five working groups will operate the planned triple-iterative cycle.



2

2 *FIRE-IN's Thematic Working Groups and cross-domain tasks*

H2020 PROJECT »SMARTRESILIENCE« – SMART RESILIENCE INDICATORS FOR SMART CRITICAL INFRASTRUCTURES

Dr. Gerald Walther, Maike Vollmer, Dr. Thorsten Pusch

In 2016, the two departments NE and TASP received funding from the EU to work on the project SmartResilience. Within this project, they developed indicators that will allow end-users to evaluate the resilience of their smart critical infrastructure. It has been a major concern among policymakers that the current trend towards digitalization and the ensuing increase in interconnectedness between critical infrastructures – for example energy grids, water supply systems, hospitals or the finance sector – could negatively affect their vulnerability. While creating networks of these services will have important benefits for society, it heightens the risk that a disruption of one system due to natural causes – storms or floods – or manmade disasters will cause problems for all systems in the network. In order to mitigate these risks, SmartResilience has explored how the 'smartness', i. e. their connectedness, of systems influences their resilience by analyzing changes in five areas: anticipation, preparation, adaptation, response capability and recovery potential.

It is the overall goal of the project to develop an indicator-based methodology for measuring the resilience of critical infrastructures that can be used by their operators, industry or public bodies to assess how well prepared they are for future hazards.

Several steps have to be taken in order to accomplish this goal: The first is to collect indicators that are currently in use to measure resilience of critical infrastructure. This pool is then enlarged by adding newly-developed indicators. The utility of these indicators is then assessed by applying them to eight case studies. These case studies deal with various aspects of critical infrastructure: energy and water supplies, transportation infrastructures, health and financial services. A final case study will combine several sectors in order to better assess potential interdependencies and cascading effects. All of these case studies will help to determine which indicators are suitable to determine smart critical infrastructure resilience.

The Fraunhofer INT performs several tasks within the project. The business unit TIP was especially involved in the earlier stages of the project, coordinating three tasks in the project.

First, one of the earliest steps consisted of the analysis of the scientific literature of 'resilience' and the subsequent development of an operational definition of the term to be used throughout the project. Second, a review of legal and organizational issues that affect the development and use of indicators had to be conducted. Third, TIP organized Work Package 2, which consisted of an analysis of how smart technologies as well as their interconnectedness affect resilience. Finally, TIP was involved in the early identification and collection of indicators as well as the development of the methodology that is used to evaluate the performance of indicators.

The business unit EME has assessed the resilience of critical infrastructures to the hazards from high power electromagnetic (HPEM) effects. The indicators that are developed as part of this work are evaluated within the eight case studies. A particular focus has been put on the finance sector and associated case studies as it is highly reliant on Information and Communication Technology, which are very prone to HPEM effects.

The project consortium consists of a wide variety of public institutions, research organizations, industrial companies, public authorities and service providers from 12 different EU countries. Coordinator is the Stuttgart based organization EU-VRi (the European Virtual Institute for Integrated Risk Management).

BUSINESS UNIT »CORPORATE TECHNOLOGY FORESIGHT«

Dr. René Bantes

The Business Unit Corporate Technology Foresight (CTF) helps companies to identify future advances in technology, to analyze their importance and to build results into corporate strategic planning. Based on Fraunhofer INT's unique 360° Technology Monitoring – an ongoing process continually updated by an interdisciplinary team of around 40 experienced scientists – the Business Unit offers a broad portfolio of content and methodology skills aimed at supporting strategic decisions.

In an age where technological developments are changing entire industries, CTF helps companies to take a look beyond the corporate horizon and to recognize disruptive technologies at the right time. Usually it would be very costly for companies to develop comparable skills on their own. This means that many technological developments often remain out of sight, even though they can be highly important for long term success. CTF provides a neutral outside-in perspective which helps to develop a sustainable, long term corporate strategy, sets trends, puts technological developments in a company-relevant context, identifies possible future development channels, analyzes their significance and generates recommendations for action.

In the past year, several projects were carried out in this context. Among other things, the starting signal was given in October for the Space flight 2040 project for space management, being run by the German Aerospace Center (DLR) in cooperation with the Fraunhofer Center for International Management and Knowledge Economy (IMW). The project is evaluating risks and opportunities for space flight with the help of scenario analyses. As well as considering new and promising developments in technology, changes in future demand are also under scrutiny – in consequence of the increased commercialization of space travel. Project results should make it possible for space management to identify possible objectives for space travel, and to derive reliable options for action. The project is expected to be wound up in 2018.

In addition, the Fraunhofer Group for Innovation Research (see page 14) is launching its first joint project: FRAME – Fraunhofer Microelectronics Innovation Enhancement – in October. The project concept is to support Research Fab Microelectronics Germany (FMD). With this new concept, FMD intends to underline the Fraunhofer-Gesellschaft's position as innovator and to strengthen the European semiconductor and electronics industry's position globally. Fraunhofer INT's task in the FRAME project is coordinating the work packages for strategy development and technology foresight at FMD.

The highlight of the year was CTF's presence at the Hannover Messe. At the Fraunhofer Gesellschaft's joint stand, CTF mounted the interactive exhibit Augmented Technology Foresight to give a schematic demonstration of its expertise and working methods. With the use of Augmented Reality, the exhibit presents the future of selected technology fields. A look in the »crystal ball« (see image) shows the public disruptive technologies, developments and the influence of related areas. The exhibit generated great interest and triggered many interesting discussions about future research, and it is being staged again at the next Hannover Messe.

In its Trend Newsletter, CTF regularly publishes new insights from research and topics from its work in technology foresight. Subscription to receive the newsletter is possible at: www.int.fraunhofer.de/Trend-NEWS.

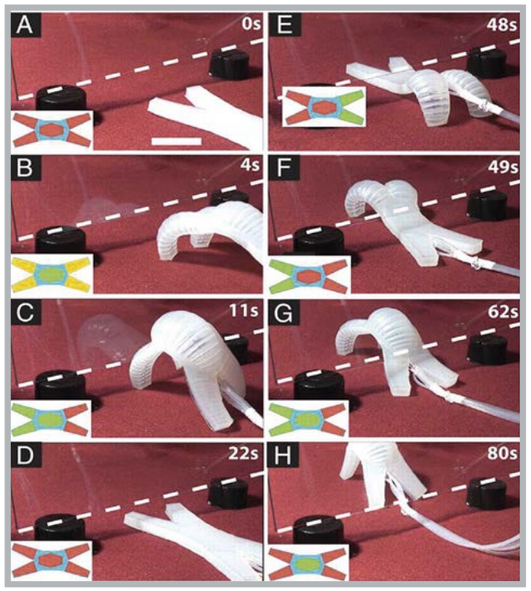
The following pages give some examples of new technologies and research results.

SOFT ROBOTS – THE SOFT MACHINE (R)EVOLUTION

Dr. Diana Freudendahl

A world without robots is hard to imagine today. Even if they are rare in the lives of most people, industrial robots have long been an essential part of our world, in assembling autos or smartphones, for example. They are finding more use in other areas too, such as in medicine and health care, or as service robots in our homes or restaurants. However, they have one major disadvantage when they come into direct contact with people – they have a hard structure, and that can cause injury. This is where soft robots come in – robots made partially or wholly of compliant material, based on biological systems. The long term concept is to revolutionize the co-existence of man and machine.

In future, soft robots could be used for purposes such as search and rescue operations in inaccessible terrain, support in caring for the aged, handling sensitive devices, or in rehabilitation – forming limbs, for example. Soft robots not only have plus points when interacting with people: because of their flexibility, they can be used as diagnosis and service robots in narrow tunnels and pipes, or in space. Ideally, such robots are not just compliant, they can also even carry out an instruction to self-degrade. To this end, they have to be constructed of compounds that decompose relatively easily through physical (e. g. temperature), chemical (e.g. acid), or biological influences (e. g. microorganisms), degrading into physiologically and ecologically harmless products. This would make them ideal for tasks in monitoring the environment, such as detecting heavy metals in water. Especially interesting for industry are hybrid systems for collision-tolerant robots that consist of both soft and rigid elements – systems that facilitate cooperation between workforce and machines.



Research in soft robots is a highly interdisciplinary field that calls for expertise in computer science, materials science, bionics and mechanical engineering. The goal is the utmost flexibility of all technical equipment such as sensors and actuators, control computers, power supply and communications devices. Smart materials such as shape memory alloys or dielectric elastomers are intended for use as artificial muscles, for flexible organic electronics and sensors, as well as for the energy supply.

The first key steps in developing soft robots have been taken, and we can reckon with further developments continuing in the technology. Among the demonstration models that show state-of-the-art design possibilities in soft robots are X-shaped crawler robots, caterpillar-like soft robots, fish and ray-like robots, and hand-like structures and grippers with mostly three to six fingers. A major breakthrough on the mass market is still round the corner, but the economic potential is immense.

TOMORROW'S ENERGY STORES CHANGE COLOR

Stefan Reschke

Electrochromic components and electrical energy storage systems are becoming widespread, the first predominantly in real estate, the second finding both stationary and mobile uses. Electrochromic devices give us electrically controllable features such as intrinsic color changes and privacy effects, for example to electrically adjust transparency or darkness levels in windows. Rechargeable batteries and electrochemical capacitors (also called super capacitors) are growing in importance for storing large energy quantities, for household energy or in vehicles powered solely by electricity for example. Even if these technologies look very different at first sight, they have more in common than might be thought.

Since these components are very similar in functional principle, reaction kinetics, material properties and design principle, research in recent years has increasingly looked at whether and how electrochromatic glazing – as found in modern, energy-efficient office buildings (keyword »Intelligent Windows« or »Smart Privacy Glass«) or other electrochromatic components (as in newer flat screens) - can also be used to store energy. Conversely, research is also looking at whether and where there are practical uses for electrical storage systems that also offer electrically induced color changes, for example in batteries, that make charge levels or the amount of energy remaining visible.

Electrochromatic devices are multilayer constructions. They consist of an active electrochromic electrode, an electrolyte layer, a counter electrode, two flat transparent conductor tracks – each being outside the electrodes – as well as the mechanical support structure made of glass or plastic. This structure can be seen as a rechargeable thin-film battery whose charge level is shown in optical absorption. However, the choice of this »battery's« electrode material is clearly guided by its reversible color change ability. In order to integrate the two aspects of electrochromism and electrical energy storage into one component in the future, electrode material investigation is currently focusing on three material groups: metal oxides, conductive polymers and inorganic non-oxides.

In metal oxides, we distinguish between »cathodic« and »anodic« electrochromics. In the first case, ion deposits lead to color changes; in the second, it is ion emission. Conductive polymers can be tailor-made either for electrochromism or for energy storage. Various polyanilines and polypyrroles show good combination properties. In combination with gold and tungsten trioxide, significant electrochromic energy stores were recently realized for the first time. Currently outstanding in the case of inorganic oxides are the dye Prussian blue and the carbon modification graphene. For both substances, research into electrochromic energy storage is at an early stage.

IONIC LIQUIDS – THE SALT IN THE SOUP

Dr. Kay Suwelack

For some time, research into ionic liquids and liquid salts has been attracting increased attention. Three major application fields stand out: sensor and actuator materials, as a medium for both storing and transporting energy, and as a reaction medium in the production of bio-based platform chemicals. These chemicals are industrially manufactured on a large scale, and they serve as basic materials for many other industrial products.

Ionic liquids, or ILs, are basically highly-concentrated, watery saline solutions or salts in liquid state – Molten Salts, or MSs. They mainly consist of positively or negatively charged ions. Most ILs, which are liquid at low temperatures (below 100 °C), include organic salts. By and large, to reduce melting temperature to below 100 °C for inorganic salts as well, use is made of so-called eutectic mixtures of different inorganic salts.

Compared to conventional fluids, ILs and MSs have several special properties. These include negligible vapor pressure, high thermal and electrochemical stability, high ionic conductivity and significant solvency for organic, inorganic and polymeric materials. Consequently, they are seen as a promising, environmentally friendly and, above all, tailorable alternative to the volatile organic solvents that the EU REACH Regulation wants replaced. Through REACH, the EU has committed European industry to the use of more environmentally friendly, easily manageable and, above all, less harmful substances in production processes. This is why industry is constantly on the lookout for REACH-compliant alternatives such as ionic liquids and molten salts.

So far, the most extensive research work in MS has been in sensor and actuator materials. By altering an external stimulus, such as brightness, humidity, temperature, atmospheric composition (gases), and electric or magnetic field, the properties of these materials can be changed. The changes can be spontaneous, may last for a given period, and are in general reversible. With visible or UV light, for example, the melting point, ionic conductivity or the magnetic moment can be changed.

With the good solubility of gas molecules and the extremely low vapor pressure of MSs, gas measurements are possible.

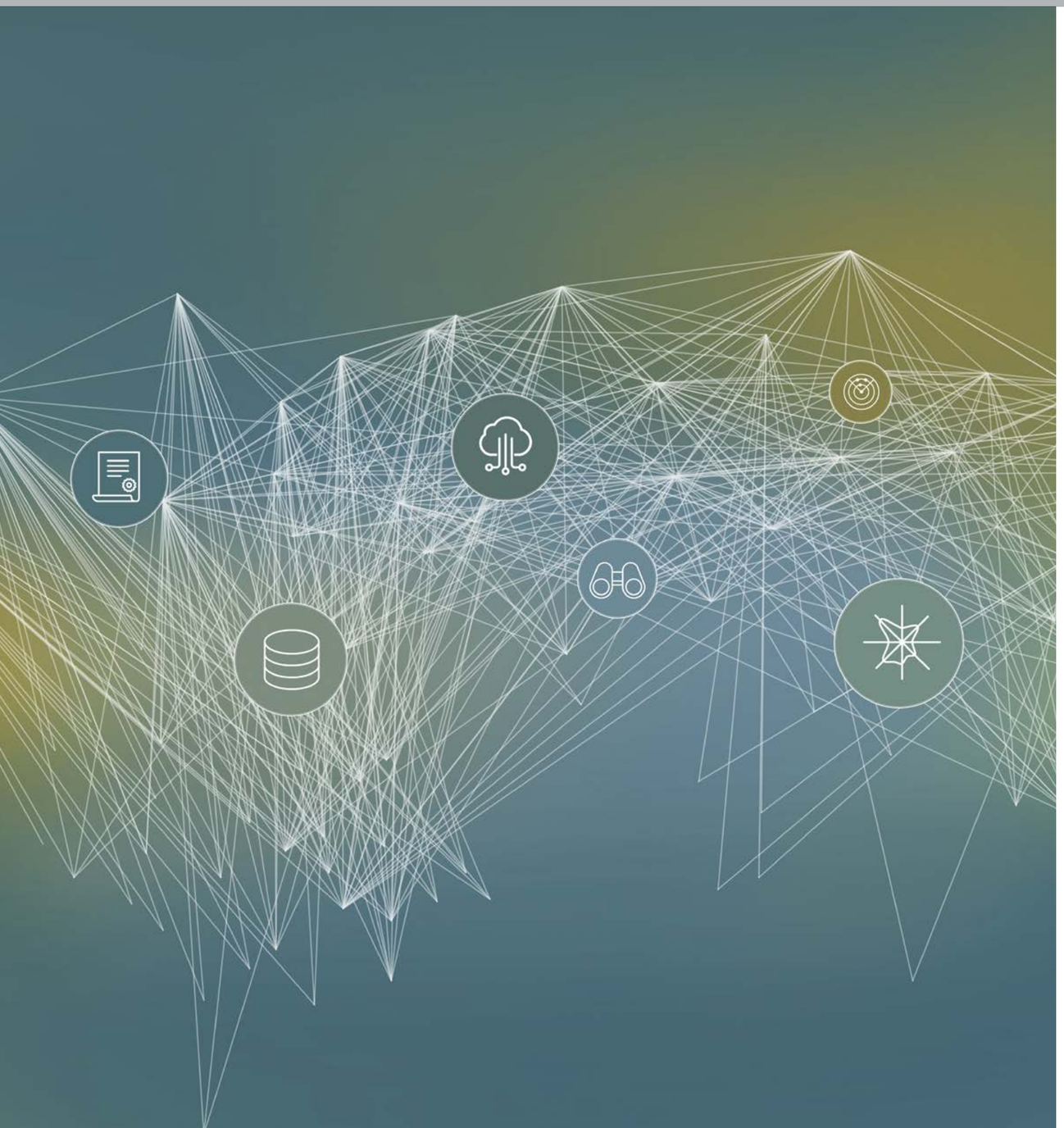
Since MSs hold nanoparticles much better in suspension and for longer, they are also particularly interesting for vibration damping in motor vehicles and machinery.

Moreover, liquid salt mixtures also count as very promising in transferring and storing energy in thermal processes, such as in solar thermal power plants. They are characterized by high transmission efficiency together with low melting point and specific gravity, high specific heat capacity and excellent thermal stability. Energy transfer, for example in a solar thermal power plant, thus runs much more effectively, and the efficiency level increases.

Production processes of bio-based platform chemicals exploit the high boiling point, low volatility and high polarity of ILs and MSs. Compared with conventional volatile organic compounds (VOCs), ILs and MSs are easy to handle and have much better environmental properties, for example, because they can easily be separated from the reaction mixture. By using them, chemical reactions can be carried out at much lower temperatures (< 100 °C). In consequence, concepts like producing key bio-based platform chemicals become very interesting – 5-hydromethylfurfural (5-HMF) for example, for use as a basis in bioplastics chemistry.

TEAM »TOOLS AND METHODS«

Dr. Miloš Jovanović



The Second Year of Methodological Support for Department TASP

The team Tools and Methods (TM) was already set up in the Department Technological Analyses and Strategic Planning (TASP) in 2016. The goal is methodological support for the Department. The range of tools and methods required in TASP is as broad as the tasks of TASP's three business units. From the technological forecast (in the Business Unit Defense Technology Foresight, for example), through innovation research (as in the Business Unit Public Technology and Innovation Planning) to consultation in »Future Technologies and Strategic Orientation« (as in the Business Unit Corporate Technology Foresight), each business unit requires different tools and methods to satisfy the needs of its clients. Again, in 2017, the TM project made valuable contributions, in part in cooperation with the Staff Position »Methods and Training«.

TM support has a three-pronged approach. First, TM staff gives the business units direct and short notice support in their tasks and projects (as in EU projects); second, they undertake long term scanning for new tools and develop tools themselves (worthy of special note is the assistance system KATI, see below). The third is training, workshops and the »Method Forum«, a flexible format in which every INT staff member can present, discuss and try out experience with tools and methods.

The following outlines some of TM's work.

Projects with TM participation

Everyday work for the group includes participation in various business unit projects. This cooperation results from either requests from the business units or suggestions from TM itself. Group members not only support methodologically, but also with specialist expertise wherever applicable.

Methodological support included taking part as Work Package leader in the Horizon 2020 project Smart Resilience (Smart Resilience Indicators for Smart Critical Infrastructures). In Work Package 2 (Challenges and Interdependencies of Smart Critical Infrastructures), new technologies, their challenges and inter-dependencies were examined. As well as content work and project management, TM's contribution was to use knowledge management and modeling, and to help in preparing network analyses.

Using method scanning and adaptation in the field of scenario technology, the group contributed to the NATO project FATE (Futures Assessed alongside Technical Evolutions). This involved examining and comparing scientific approaches that can serve research into alternative futures.

Successfully concluded in 2017 was the project Trend Management System (TMS), which was acquired by the Staff Position and conducted for the Bundeswehr Office for Defence Planning. The Defence Planning Office asked for further software support for its Trend Management. To take account of the Planning Office project requirements, current literature on the subject was reviewed and analyzed, and a software package was written by a subcontractor. After completing the program, initial development work was done on ideas for productively implementing TMS at INT.

For the Business Unit Defense Technology Foresight (WZA), the writing of country reports continued, using methodical source collection and analysis. In 2017, reports were finalized for both the Netherlands and the United Kingdom.

KNOWLEDGE MANAGEMENT

Dr. Silke Römer

TM Developments

In the spring of 2017, the Information Platform New Technologies (IPNT) went into regular operation at INT. Since then, IPNT has been used – especially in WZA – for storing potentially relevant future technologies. The goal is to develop IPNT continuously, to open up new analysis possibilities and to enable constant platform improvement. In addition, the intention is the steady increase of user numbers at INT.

For several years now, the TASP Bibliometric Suite (TABS) has seen continued development and use in INT. Under Tools and Methods, this software for enabling advanced publication analyses (bibliometric analysis) has now been made available to a broader user circle at the Institute.

Also in the second year, the TM group focused attention on the assistance system Knowledge Analytics for Technology & Innovation (KATI), in which IBM Watson software is adapted and further developed to meet the needs of INT. KATI is described in detail in an article below (see page 42).

Ancillary Measures

A permanent task for TM is maintaining internal wikis, which are used for various purposes such as documentation, communication and project management. This includes updating wiki software and maintaining user accounts, but also regularly »tidying up« and restructuring the various areas. The wikis are also an important pillar for knowledge management within the Department. More details on knowledge management can be found in an article below (see page 41).

In 2017, the Method Forum was unfortunately held only once, but it had a central theme: »Scenarios – indispensable or overestimated?« The Forum covered an introduction to the theme (history, possible applications, examples from literature and own project practice), advantages and disadvantages of the scenario technique, and concrete best practices for applying the method.

For the TABS software referred to above, several training courses were offered in a total of four blocks. Business unit staff were provided with fundamental knowledge in bibliometrics, intelligent research and the handling of TABS.

Knowledge management includes suitable concepts and methods for the purposeful, systematic use of the resource knowledge. One of the tasks of the Tools and Methods Group (TM) is to support knowledge management in the department TASP.

TM monitors the status quo and identifies opportunities for improvement. Typically, TM generates suggestions for the application of tools, methods and procedures. No direct practical obligation results, but if required, such issues may be fixed in the organizational units or in individual projects.

One example of use is the handling of data and information that are required over a longer period of time. In this context, knowledge management can help by targeted use of information management, technology and communication.

Information Management

For one thing, some data and information may not be accessible to all who need it. In this case, it is first necessary to check and see if it the effort of data acquisition (and possibly data update and validation) is worthwhile.

In 2017, the need for specific data and information – regarding countries, research institutions and technologies, for example – was revised within the department. At the same time, TM produced an overview of available solutions, both internal and external.

Technology

Data may on the other hand be available, but access and usage imply unwanted obstacles like time-consuming or unnecessarily complicated steps. To improve this, you need an overview regarding what type of access to the content is required.

Data storage for technology monitoring, including related processes, was discussed with the user group in 2017. In the past, dedicated desktop search software had been used to improve data access. On the basis of a needs assessment, steps are being taken to reintroduce such software.

Knowledge Transfer and Communication

Finally, data might already be collected and accessible, but not all potential users know where and how to find it. The same applies to knowledge and experience in methods and tools. Changing this is a permanent task. For its fulfillment, it makes sense to place relevant information via various channels and to appoint contact persons (in this case, the TM Group) who present the information tailored to the individual user's needs.

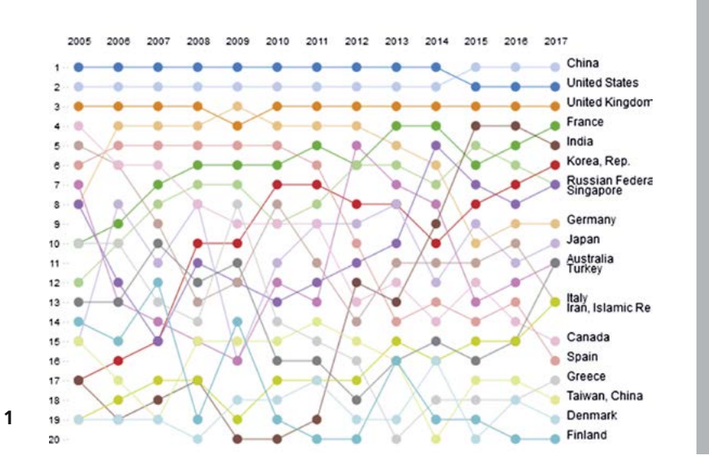
In 2017, the assistance system »Knowledge Analytics for Technology & Information – KATI« was presented in lectures and demonstrations, training courses with respect to TABS, a bibliometrics tool developed in-house was held, and a methodology forum that focused on scenarios took place.

Survey Knowledge and the Exchange of Experience

The TM Group updated and documented its own knowledge of tools and methods, also by communicating with the library and specialized information services, the IT unit and the staff office for »Methods and Training«. To ensure practical relevance, it was important for TM to engage in projects in which tools and methods were developed, applied, adapted or evaluated. Both external and internal networks were helpful for the exchange of experience across departments and institutes.

»KATI« – A NEW EFFICIENT RESEARCH AND ANALYSIS TOOL FOR FRAUNHOFER INT

Dr. Marcus John



1

Two years ago, Fraunhofer INT began development work on KATI, an assistant tool for technology foresight. KATI stands for Knowledge Analytics for Technology & Innovation. With BMVg funding, part of this research project is studying the extent to which cognitive computing can be used in the daily work of the Department Technological Analysis and Strategic Planning (TASP).

The project builds on both the content and methodology expertise of the scientists working in technology foresight and analysis – combining years of experience in data-driven foresight at Fraunhofer INT.

In the year under review, the KATI project made considerable progress and the ground was set for further important work. Most noteworthy is the development of a data model for the graphic database used. Such a database is particularly well-suited for efficiently storing and linking the networked bibliographic data of scientific publications and patents with other data sources (the linked data concept). In a first step, the data model was used to access the Web of Science data that was acquired in the project.

In addition to the bibliographic details of more than 50,000,000 scientific publications, this database also contains their references. In this way, a citation relationship can be used to link publications with each other. This data set and the data model developed from it in effect represent the basic framework that will be used for tapping even more data sources, such as news sites and blogs, as well as patents.

Another focal point of the past year was the development of the user interface and the REST-API (Representational State Transfer – Application Programming Interface) for the entire system. The latter is needed to organize communication and data exchange between the user interface and the system's individual components.

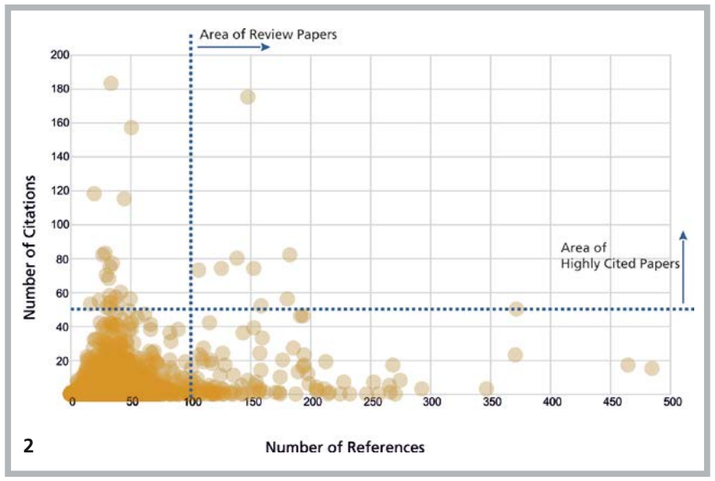
In parallel, a framework for creating and integrating visualizations was developed. In this way, a system was developed in the course of 2017 that combines efficient research capabilities with a whole range of analytical functions. Especially the numerous visualizations, which give KATI certain unique features, were only possible through the REST-API work. A version for daily research and analysis work within the Department has been available since the summer.

Work has thus far concentrated on two application areas that are typical for technology foresight. One is actor analysis, which asks who the leading experts are in a given field, or whether their research focus has changed over time. Figure 1 is an example showing shifts in international publication rankings over time.

The second area is the identification of key publications: such scientific articles that are well-suited for familiarization with a topic and for recognizing current developments. Various metrics are used for this purpose, some of which were specially developed at Fraunhofer INT in order to quantify the Institute's specific requirements for a key publication. Figure 2 shows a simple example, again highlighting the subject of metamaterials. Since interactive visualizations are used in the system, users at Fraunhofer INT can directly access interesting publications via such visuals.

Further development of the system will be following several lines. The first is the continual expansion of the system's database, and as early as last year, work began on exploiting new sites and patents for KATI. In this context, a considerable challenge for the development team is patents, regarding both data structure and quantity.

The second development line will be about supplementing the system with additional analyses and visualizations. One focus will be on enhancing access to topic content with the use of computer linguistics. Machine learning methods could be used for the first time.



2

In addition, during spring 2018, the system will transfer to new, more powerful hardware, to meet the demand for greater computer and storage capacity. Regarding IT and data-based systems for technology foresight, Fraunhofer is entering new scientific territory with this project. First results are nonetheless certainly encouraging.

1 *This illustrates how international rankings have changed over time for publication activity in metamaterials. Among other things, it can be seen that China is now the most active country in this area, a fact that can be observed in many other areas. The diagram also shows that Germany has now been surpassed by a number of countries regarding the number of scientific publications.*

2 *The scatterplot shows the number of references (X-axis) and the number of citations (y-axis) for publications on metamaterials in the years 2015 to 2017. Typical reviews in turn typically contain many references, and are therefore mostly found to the right of the vertical broken line. Potential trend topics or breakthroughs published during this period may have been cited frequently and may therefore be found in the upper left quadrant.*

NUCLEAR AND ELECTROMAGNETIC EFFECTS

Dr. Stefan Metzger

Following the effects of the cuts in BMVg's Research and Technology Budget in 2016, the Department Nuclear Effects (NE) was able to record a very successful 2017. NE processed and completed a large number of projects for private sector clients, as well as for civil and defense clients in the public sector. This is not least due to increased acquisition in 2016. Details are given in the individual contributions from NE's business units. At Departmental level, relocation into the new laboratories in the summer of 2017 was the culmination of almost two and a half years of rebuilding. Again, thanks go to all those who supported NE in the task. The Department now has significantly improved working conditions in state-of-the-art laboratories. The work on implementing an ISO 9001 certified quality management system reached an interim peak in the form of the external certification audit by DNV-GL. Already completed is NE's conversion to the new 2015 form of ISO 9001, which places much more emphasis on sustainability and risk management. This requires that the demands of interested parties be taken into account, and that resultant risks have to be dealt with. Also defined is how the organization's expertise is identified and kept up to date.

The work of NE's Business Units is outlined in detail elsewhere in this report. The following is a personal selection of some of the highlights from the working groups:

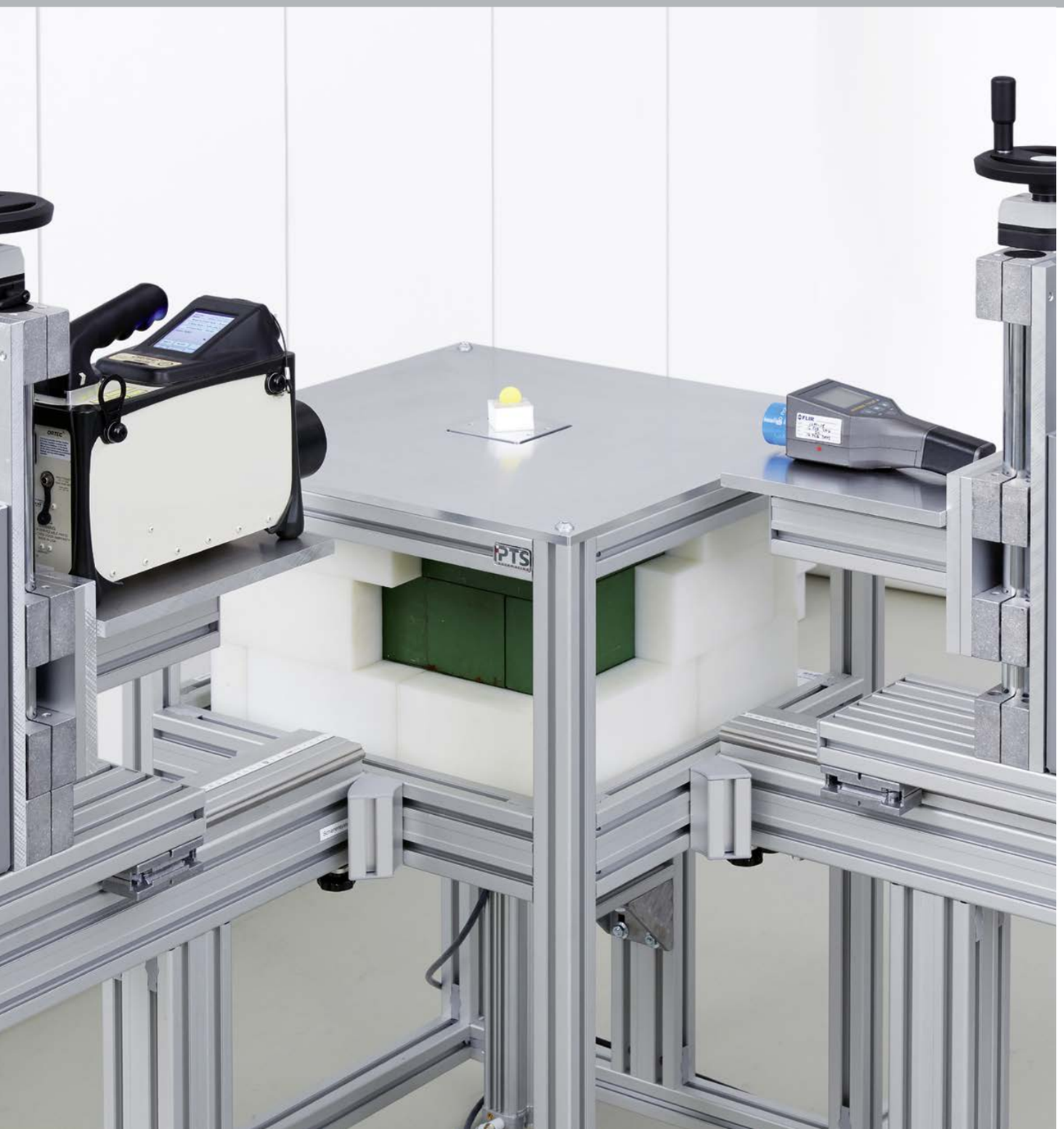
- With central Fraunhofer funding, NE will be able to set up a new standard-compliant anechoic chamber for the Business Unit EME in 2018/19. This will be an ideal complement for the existing HPEM and EMC test methods.
- In 2017, the Business Unit NEO put into operation a picoseconds laser system for simulating single event effects in electronic components. First results were presented at the European Radiation Effects Conference RADECS (see page 58).
- As part of its work portfolio, Business Unit Nuclear Security Policy and Detection Techniques (NSD) was able to demonstrate that modern scintillator materials based on lithium-6 (e. g. GLYC) can be used firstly to replace helium-3, and secondly to efficiently detect both gamma and neutron radiation with just one detector. See page 48.

From September 19 to 21, 2017, the Business Unit NSD staged the symposium »Nuclear and Radiological Threats« for the eighth time. Presentations covered subjects such as the verification of nuclear disarmament, terrorist threats and the Nuclear Test Ban Treaty. For many of the participants, the event was something like a family gathering, as they had already attended previous symposia. NE's second major event in the year was the 6th »Space Challenge« workshop, held from 22 to 23 November. NEO again hosted about 30 external participants from industry, research or the German Aerospace Center (DLR), introducing them to the issue of radiation effects on satellite systems. During the year, NE welcomed Dorothea Wölk as a new member of NEO's staff. She is writing her dissertation on the effects of atmospheric neutrons on electronic components.

Thus, each of the three business units now has a doctoral candidate. In addition, NE regularly offers tasks leading to further scientific qualifications. Examples are two master theses, which were supervised and successfully completed in NEO, as well as a bachelor thesis in NSD. The Department's work was documented in numerous publications and reports. Acting as expert reviewer for renowned journals and participating in or chairing international conferences continue to be important tasks for NE, which helps the Department to keep level with the current state of research in many communities. NE staff also applied their expertise to the work of various standardization bodies such as DIN, IEC or NATO. Details are given elsewhere in this Annual Report.

BUSINESS UNIT »NUCLEAR SECURITY POLICY AND DETECTION TECHNIQUES«

Dr. Theo Köble



The Business Unit Nuclear Security Policy and Detection Techniques (NSD) conducts theoretical and experimental research in the areas of nuclear security policy and nuclear detection methods. Besides fundamental studies, research projects are undertaken for industrial clients and public authorities. In addition, NSD intensifies and expands the national capacity to judge nuclear and radiological weapons and associated asymmetrical threats.

NSD has ultra-modern technical equipment to support its work. For simulating physical processes a Linux cluster with 64 processor cores is available. Besides coupled neutron and gamma transport calculations, NSD also performs coupled neutron and hydrodynamics calculations. For experimental work, the Business Unit operates neutron generators (14 MeV and 2.5 MeV) and isotope laboratories. A large variety of radiation measuring instruments for gamma and neutron sources, especially for use in on-site measurement, is available for testing and comparison.

Regarding nuclear disarmament and possible proliferation, NSD continuously observes political and technological developments, looking especially at the latter from the physical-technical perspective. In particular, nuclear developments in Iran and North Korea were observed, analyzed and evaluated. As part of collaboration work in ESARDA NSD investigated developments in international disarmament agreements and export controls, as well as new safeguard technologies for the IAEA.

NSD also participates in technical preparation work for the Comprehensive Nuclear-Test-Ban-Treaty CTBT, and regularly takes active part in the annual INMM conference in the USA.

NSD also continues its work as partner in several international projects dealing with CBRNE threats (Chemical, Biological, Radiological, Nuclear, Explosives) and countermeasures that address them.

In the EU-Horizon 2020 project C-BORD, the Institute and a variety of European partners are developing improved strategies and equipment for the efficient control of bulk goods carried in containers. For the primary and secondary inspection lines, various inspection systems are being developed, integrated into one overall system and verified in field tests. This takes account of requirements at major sea ports and at smaller and medium-sized container terminals - as at inland ports, for example. NSD is taking part in several work packages, and is itself leading the work package on the detailed assessment of technical solutions and of the whole system.

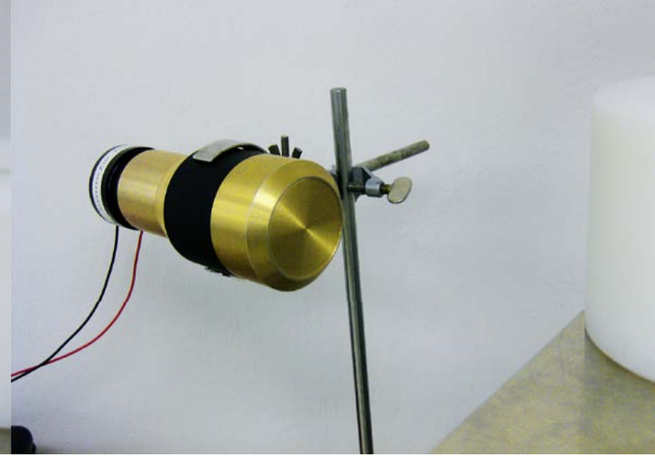
Within the EU DG Home Project ITRAP+10 Phase II, Fraunhofer INT is constructing a reference laboratory for calibrating radiation detectors used for detecting the illegal transport of radioactive and nuclear substances. Together with several European partners, INT is participating in a round robin experiment, in which different measuring instruments are tested in compliance with common standards.

As part of a doctoral thesis, fundamental research is being undertaken on detector systems with innovative materials (see also page 48).

NSD is also involved in work on standards for radiation measurement devices, nationally in DIN/VDE, and internationally in the corresponding IEC body.

ALTERNATIVE MATERIALS FOR DETECTING NEUTRONS

Marie Charlotte Bornhöft



When investigating unknown radioactive materials, detecting neutrons plays an important role. Neutrons are in particular emitted from fissile material, so it is possible to make inferences regarding unknown material and the danger emanating from it. Since neutrons have no electric charge, direct detection is not possible – intermediate steps are necessary. For this purpose, the isotope helium-3 (He-3) is usually used. Moderated, i. e. lower-energy neutrons are captured due to the high cross-section of the gaseous He-3, which in turn emits one proton and one triton per capture. These particles are then detected.

With increasing He-3 demand for neutron detection and a parallel reduction in quantities available on the open market, He-3 prices have risen sharply in recent years. This price increase gave a boost to research into alternative materials for neutron detection. Another isotope which, like He-3, is also suitable for neutron detection is the solid lithium-6 (Li-6). When neutrons react with Li-6, the lithium isotope converts by neutron capture – with the subsequent release of an alpha particle – to tritium (H-3). By a secondary reaction of these particles with the surrounding material, the indirect detection of neutrons is again possible.

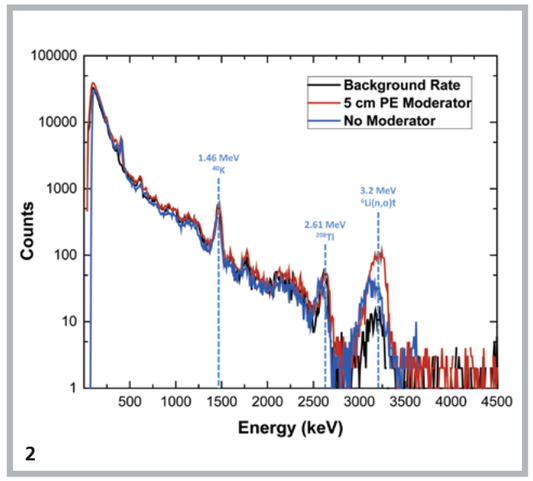
The Business Unit Nuclear Security Policy and Detection Techniques (NSD) investigated two newly-developed detection materials based on Li-6, and compared them with the conventional detection material He-3. Investigated were the scintillation materials CLYC and CLLB. The detectors based on these materials are shown in Figure 1.

These two new scintillation materials have the advantage that they not only detect neutrons, but are also sensitive to gamma radiation. Differentiation of the types of radiation is possible by evaluating the pulse shape of the electrical signal or the energy deposited in the scintillation material.

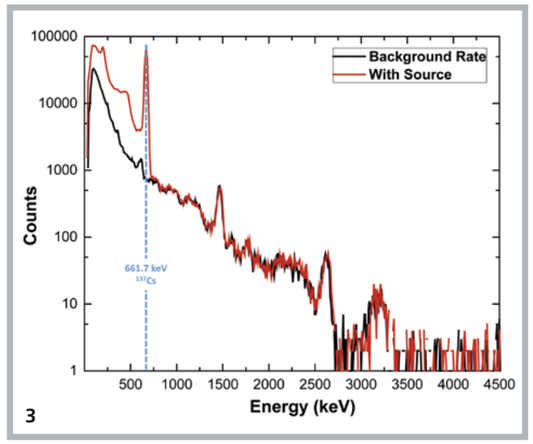
For the CLYC and CLLB detector material tests at Fraunhofer INT, various gamma and neutron sources were used, including the isotopes Cobald-60 (Co-60), Cesium-137 (Cs-137), Californium-252 (Cf-252), and an Americium-Beryllium neutron source. Conventional evaluation electronics were used for the first function tests of the detectors, which involved energy spectrum evaluation in order to determine the radiation type.

Figures 2 and 3 show the measurement data for the neutron source Cf-252 and the gamma source Cs-137. Since the CLYC and CLLB detectors do not have moderation material, additional moderation between the neutron source and the detector shows a significant increase in the measured count rate.

By gamma radiation measurements, it was possible to achieve a 4.4 % resolution of the Cs-137 peak for the CLYC detector. The intrinsic efficiency of this detector was determined to be 15.4 % ± 1.8 %. In comparison with standard material for gamma measurements such as sodium iodide (NaI), this is very good.



The investigation results on Li-6 based detectors at Fraunhofer INT show that materials with this isotope are very well suited for neutron detection, that the gamma detection which is simultaneously possible opens up interesting application possibilities, and that such materials are a real alternative to the conventional detector equipped with He-3.



1 *The photo left shows the CLYC detector with a 2 by 2 inch crystal. The assembled detector contains the crystal, a photomultiplier and electronics. The photo right shows the CLLB detector with a 1 by 1 inch crystal. This also consists of a crystal, photomultiplier and electronics. On the right of each photo is the moderator material containing the neutron source.*

2 *Energy spectrum of a Cf-252 neutron source (blue curve). The reaction of the neutron with the Li-6 detector generates photons with an energy value of 3.2 MeV. Also marked are two gamma peaks from natural environmental radioactivity. Also shown is the comparison between moderated (red curve) and non-moderated (blue curve) neutrons. Note the logarithmic display.*

3 *Energy spectrum of a Cs-137 gamma source. The background is given in black.*

BUSINESS UNIT »ELECTROMAGNETIC EFFECTS AND THREATS«

Dr. Michael Suhrke

With basic funding from the Federal Ministry of Defence (BMVg), the Business Unit EME is tasked with developing the capacity to evaluate electromagnetic effects as a military threat. Work on this task is limited in scope in BMVg itself, so in consultation with BMVg and in cooperation with the defense industry, EME conducts its own theoretical and experimental research, including studies on further developments of measurement technology. Over and above ministry-funded research and BMVg contract research projects, work for clients outside the defense sector (civil security research) and projects for industry are also important.

The Unit's experimental work on electromagnetic threats, especially those from high power microwaves (HPM), includes investigations into the coupling of electromagnetic fields in structures and specific systems, as well as studies on the vulnerability of electronics through high-intensity fields (High Power Electromagnetics, HPEM). The test subjects range from IT equipment and systems based on current technology, and especially on wired and wireless data transmission technology (network technology), to civilian communication technology and components of critical infrastructure. Basic research and experimental work also continues on detection methods for electromagnetic threats, in particular by HPM.

The unit has developed its own TEM waveguide (Transverse Electromagnetic Mode), housed in a shielded hall and serviceable for frequencies up to several Gigahertz. In a wide frequency range, this allows linear coupling measurements for determining transfer functions, as well as studies on electromagnetic compatibility (EMC). Also possible is the investigation of susceptibility with constant and pulsed signals at field strengths up to several kilovolts per meter (kV/m) on objects up to several square meters in size. For measurement tasks outside the Institute, EME relies on its own mobile HPM irradiation facility. With the use of various antennas over a wide frequency range, this facility can also generate field strengths of several kV/m. These systems are supplemented by a reverberation chamber equipped with high power sources for generating even higher field strengths in the Gigahertz range, to reflect the growing number of applications in modern sensor and communications technology at such frequencies. Additionally available are a small anechoic chamber and a wide variety of high frequency and microwave measurement instruments.

Part of the research conducted for BMVg was continued work on a project to develop an HPEM detector, an assignment from the Bundeswehr Research Institute for Protective Technologies (WIS) in Munster. In the project, investigation also continued into the generation dependence of HPEM susceptibility of electronics. In addition, a study analyzed the HPEM susceptibility of sensors. As part of a Technical Agreement on the Development of High Power Microwave Test Methodology and Procedures, a cooperation program on HPEM test methodology continued with FOI in Sweden. In a further project from WIS Munster, a narrow-band Magnetron source with pulse outputs in the megawatt range was procured for free field testing.

Work continued in 2017 with the NATO STO SCI-294 Task Group activity »Demonstration and Research of Effects of RF Directed Energy Weapons on Electronically Controlled Vehicles, Vessels and UAVs«. The Business Unit EME is in particular working here on investigations into HPEM susceptibility of Unmanned Aerial Vehicles (UAVs). Further research in this context was carried out at national level in a project assigned by WIS Munster.

In civil security research, EME is one of 20 partners in the project »Smart Resilience – Indicators for Smart Critical Infrastructures«, launched in 2016 under the European Commission's security research program HORIZON 2020.

EME is also widely active in standardization. This includes the DIN working groups »TEM Waveguide and Reverb Chamber« and »EMC of Semiconductors«, the VG (German defense equipment) standards boards on NEMP and lightning protection, and on electromagnetic compatibility. The Business Unit also provides the national representative on the IEC's Joint Working

Group »Reverberation Chamber«. Further development of HPEM standardization with the goal of a NATO HPEM Protection Guide continues to be a subject for the NATO STO SCI-294 Task Group – as was the case for the forerunner group.

Doctorate work on the subject »HPEM vulnerability of the Smart Grid« was continued in 2017. Results on HPEM vulnerability of intelligent control systems in medium-voltage substations with special focus on coupling paths for electromagnetic interference were presented at the 2017 EMC Europe Conference in Angers, France, in 2017.

A COMPACT HPEM DETECTOR FOR THE PROTECTION OF CRITICAL INFRASTRUCTURES

Christian Adami

Critical infrastructures today consist of complex electronic systems that regulate the exchange of data in communications and the power supply. Intentional Electromagnetic Interference (IEMI) is the process of exposing such electronic systems to electromagnetic field strengths in the microwave frequency range that are beyond the limits of system-specific electromagnetic tolerance (EMC) (see Figure 1). The goal is to trigger temporary or permanent malfunctions in the system. Since electromagnetic interference in the form of IEMI is imperceptible, such attacks can be carried out inconspicuously. The capability to identify temporary or permanent malfunctions caused in systems by IEMI calls for detection technology that shows up high power microwave (HPEM, high power electromagnetics) attacks.

The overall concept of the HPEM detection system, conceptualized and developed as part of a critical infrastructure protection system, essentially consists of five blocks: the four antennas, high frequency processing with such components as logarithmic detectors, analog digital converters (ADCs) and a field programmable gate array (FPGA), the evaluation computer within the detector housing, data transmission and the web interface for controlling. Figure 2 shows the complete system. A major goal in developing this part of the detection project was to allow the forensic analysis of an attack's HPEM signals. For the first time, this saw the use of complete in-house development for the processing electronics, which improved HPEM detector performance and made it more compact at the same time.

With regard to forensics, the detection system was conceived to be able to determine the direction of an HPEM attack and to identify the type, frequency and electric field strength of the HPEM signals. The basic concept of the HPEM detector is signal processing on fast ADCs and an FPGA. At a sampling rate of 50 MHz, the acquired data points have a time interval of 20 ns.

By using HPEM signals in the range of 100 ns and a repetition rate of approx. 1 kHz, a large quantity of data is amassed in a very short time. The hardware developed, as operated on the selected FPGA platform and interpretation mimic, guarantees the processing of such data volumes.

The detection concept provides that the signals detected by the antennas are first transposed via attenuators and limiter diodes to the small signal range. From the four measurement channels, signal components are split off for frequency detection before the input signal envelopes are detected with logarithmic detectors. Their output voltages are used for data recording to derive the trigger, and are digitized via fast ADCs for further processing in the FPGA. From the raw data stream of the FPGA, a built-in microcomputer calculates the input direction and field strength of the detected pulses. The data processed is then transposed to the web interface.

Spiral antennas are used to detect direction, so all linear polarized signals can be detected. Other antenna concepts could not hitherto meet the requirements with regard to flat antenna gain and frequency bandwidth.

1 *Critical infrastructure being threatened with electromagnetic attack from a vehicle*

Forensic knowledge of the signal field strength is highly important. To determine this with the desired accuracy, knowledge of the signal frequency is in turn important, so that the system's frequency response can be compensated for. The detector's frequency detection therefore works reliably in the range up to 5 GHz. Thus the frequency characteristics of components and antennas can be calculated for assessing physical measurement parameters. In the function group for frequency detection, the signals are processed, inter alia with a limiting amplifier. In order to cover the desired frequency range, the signal is split into two paths, and the respective frequency is scaled down by a quadruple or eight-fold prescaler.

The actual frequency value is determined via a counter circuit for the digitized signal. Frequency detection properties give the detector a frequency range from 500 MHz to 5 GHz, which allows the reliable determination of field strength and frequency. Outside this range, HPEM events can be detected as such as long as the trigger threshold is exceeded. This however does not give more detailed information about field strength.

The concept developed by Fraunhofer INT includes controlling the HPEM detection system via a web interface. The system can thus be accessed at any time via any network, regardless of where the detection and processing hardware is positioned. A microcomputer from Raspberry Pi is used to operate the web server for the graphical user interface (GUI), in addition to raw data processing.

The GUI divided into one tab for the standard user with no specific background knowledge, and a second tab for the expert. During normal operation, the standard user should quickly receive information about unusual occurrences. The information presented on the strength and direction of the incoming measurement signals should allow the best-informed decision on measures to be taken.

As far as possible, physical quantities are avoided, and accessibility for a wide range of users should be ensured through clear-cut abstractions. The expert mode is intended for the expert user who needs further information for forensic classification of the events measured.

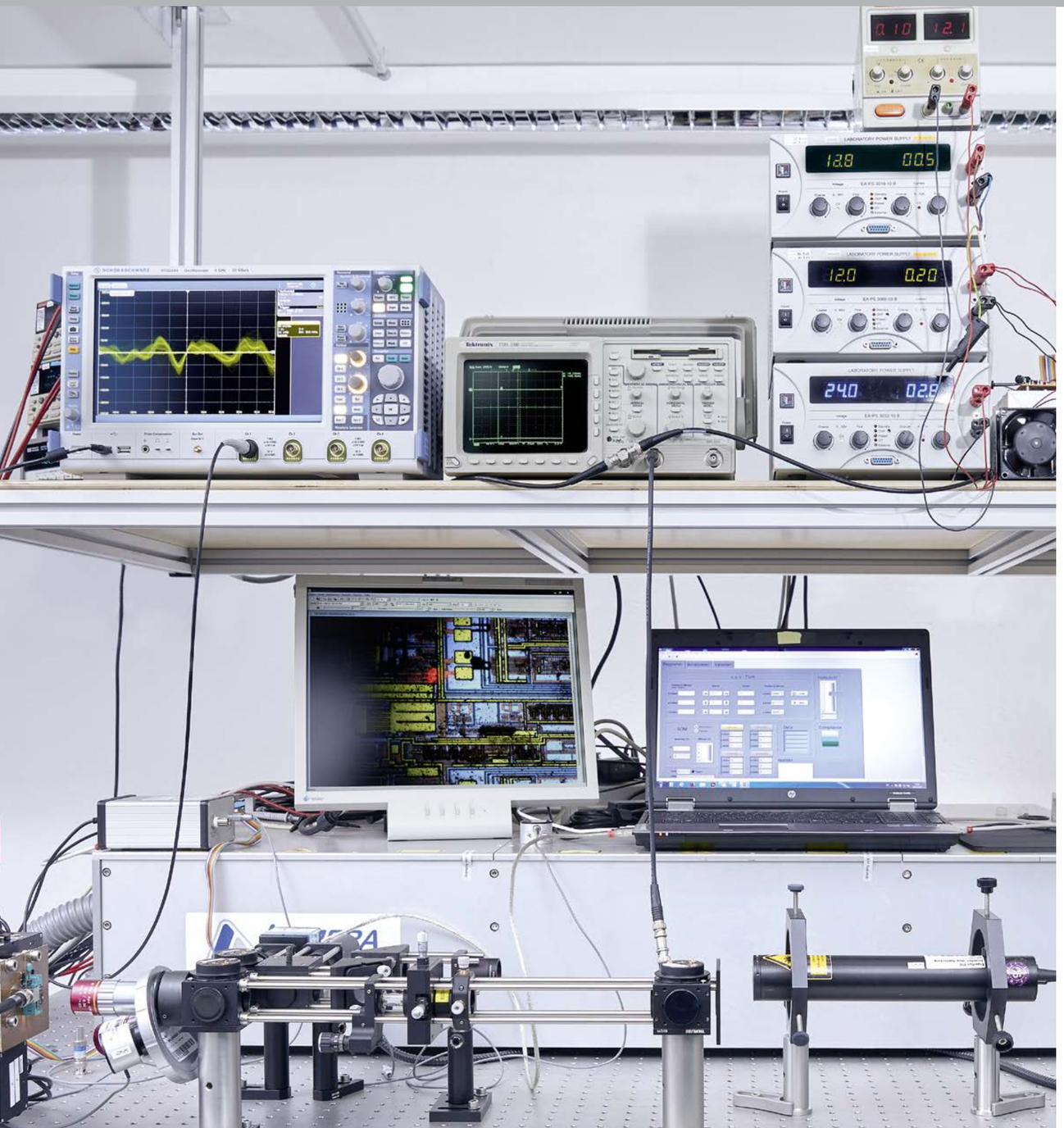
The described hardware in conjunction with the control and processing software was combined in a functional model to form a complete working system. Functional tests and measurements of the screen attenuation of housing verified essential parameters of the HPEM detection system.

2 *The complete HPEM Detector system*

3 *HPEM Detector Controlling and Processing Software*

BUSINESS UNIT »NUCLEAR EFFECTS IN ELECTRONICS AND OPTICS«

Dr. Jochen Kuhnhenn



Fraunhofer INT's Business Unit Nuclear Effects in Electronics and Optics (NEO) is specialized in the effects of ionizing radiation on electronic, optoelectronic and optical components and systems. NEO conducts radiation tests in accordance with recognized standards and advises companies in radiation qualification and hardening, for example for satellites or accelerators. Lessons learned are also used in the development of radiation sensors. Radiation tests are mainly carried out in INT's own facilities, although external facilities are also used. Unique in Europe, INT's radiation apparatus makes it possible to recreate in the laboratory all radiation types and the effects they induce, for example on satellites. In addition, NEO has the latest available technology for measuring even the smallest changes in parameter characteristics.

Work in the field of Single Event Effects (SEE) continued in 2017. On completion of several projects for aerospace suppliers, in which the sensitivity of electronic systems to atmospheric neutrons was examined, this field was intensified by the start of a PhD thesis. In order to develop efficient and reliable test methods, the examination of various effects on international neutron sources is planned.

In cooperation with the European Space Agency ESA and the European Organization for Nuclear Research CERN, a first SEE campaign was conducted in 2017 on the Super Proton Synchrotron (SPS). A further SEE campaign was held in Jyväskylä, for the first time under the sole responsibility of INT.

Finally, INT concluded the construction on site of a laser test system for investigating single event effects, and the results were presented at a number of conferences. For the first time, a large number of these demanding tests can now be conducted in Germany, without the need for costly travel to international accelerators. The implemented system also makes it possible to validate measuring set-ups and to localize particularly sensitive areas on the integrated circuits.

There were also special projects on the accumulated impact of radiation effects. A 14-month irradiation was carried out for ESA, which identified dose rate dependence on components at high dose values. This is necessary to prove the relevance of highly accelerated ground tests for later impact on a long term satellite mission.

For the JUICE mission, which will be examining Jupiter's moons, irradiation tests were carried out on glass fibers. The main challenge was the combination of the very high dose values required and extremely low temperatures. Only the systems of Fraunhofer INT make it possible to realize these conditions over a period of weeks. Successful completion of these tests after several weeks of preparation made it possible to qualify the glass fibers for the mission.

With the support of the Fraunhofer Space Alliance – with NEO also taking part – several joint events were conducted by participating institutes. As part of the Space Alliance, NEO was again present at the Space Tech Expo in Bremen, for example.

To promote the next generation of scientists, NEO is active in their training. In cooperation with the RheinAhrCampus of Coblence University, two Masters theses were successfully completed in NEO.

To cater for new possibilities for the irradiation facilities, at the beginning of 2017 the X-ray flash system was dismantled and disposed of after 50 years of use. The demand for tests with this system had been steadily decreasing for years. The space thus made available widens test possibilities significantly, for example for irradiation with low dose rates.

SINGLE EVENT TESTS ON DIGITAL ISOLATORS WITH SHORT LASER PULSES

Dr. Michael Steffens

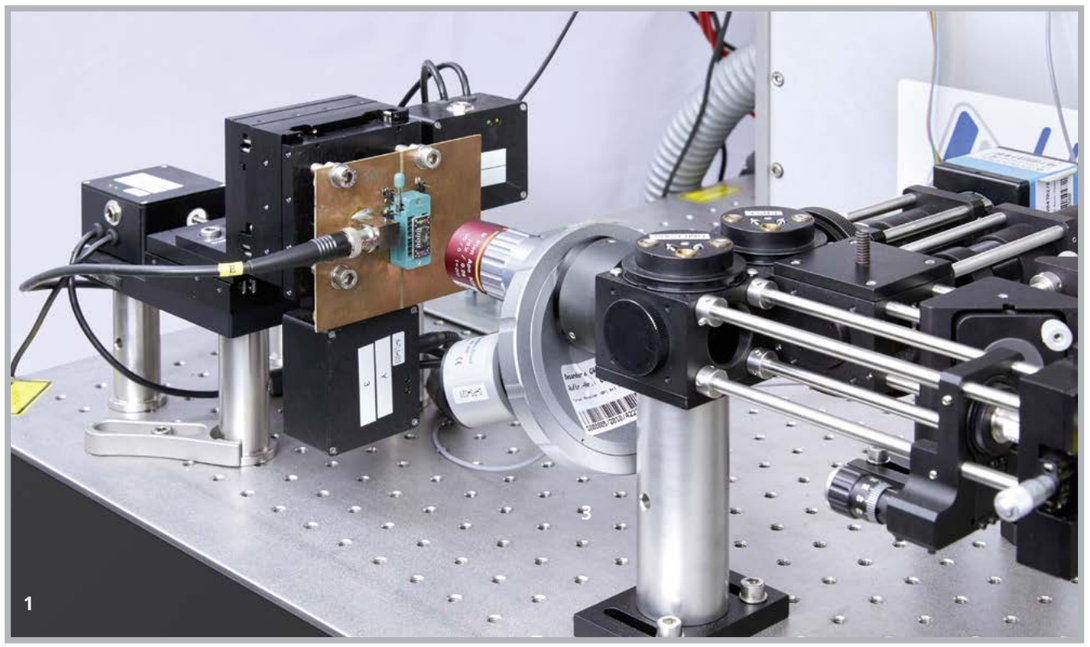
Digital isolators are potential alternatives to optocouplers for applications where communication between galvanically isolated systems or circuits is required, while providing simultaneous higher performance and lower power consumption.

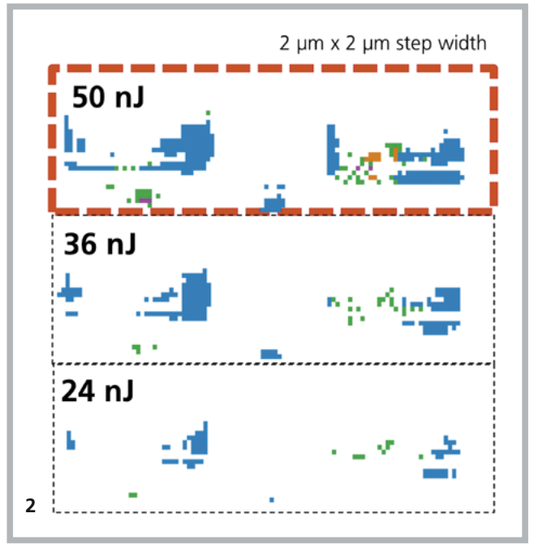
In previous total dose and heavy ion tests (as also referred to in INT's 2016 Annual Report), some commercially available examples of this technology were examined by the Business Unit NEO on behalf of ESA and in cooperation with Seibersdorf Laboratories. A test object was examined in the heavy ion test up to a linear energy transfer (LET) of 60 MeV cm^2/mg without the occurrence of latch-ups, but with two characteristic families of transients.

These are brief volatile signals that may otherwise be misinterpreted by other circuit components, which then lead indirectly to operational errors. What occurred in the tests was an »analogue« transient that was superimposed on the digital output signal, and a »digital« transient that changed the logic state of the output until the next switching operation.

To establish whether these very different transients are generated in different areas of the component, and to see how these areas are distributed, Fraunhofer INT carried out additional spatially resolved tests using a 1064 nm picosecond laser system, as well transient mapping via one of the data channels of the component. The laser system structure (see Fig. 1) and the infrastructure required for fully automatic measurement were developed and assembled by NEO.

1 *Laser-SEE assembly at Fraunhofer INT*



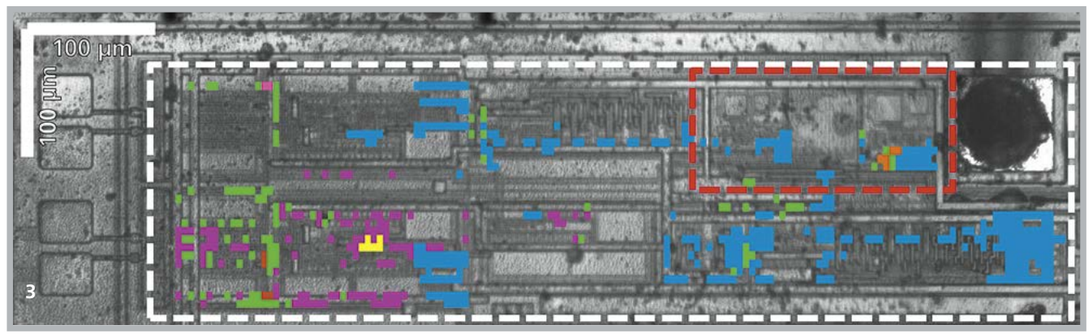


In Figure 2, the white dotted section roughly outlines one of the data channels of the Digital Isolator 14850 (step width in x and y direction 5 µm). Figure 3 shows the red outlined area in finer resolution, as dependent on laser intensity (step width 2 µm).

Shown was not only the spatial distribution of the various known transients and rare additional transient types (marked in green, purple, orange and yellow), but extensive areas were also identified which under laser bombardment cause a latch-up on the component (blue). A possible explanation for the occurrence of latch-ups, which were not observed in previous heavy ion tests according to ESCC 25100 heavy ion tests, may be the known higher penetration depth of the 1064 beam in silicon, compared with the shorter range of the heavy ions used at the time.

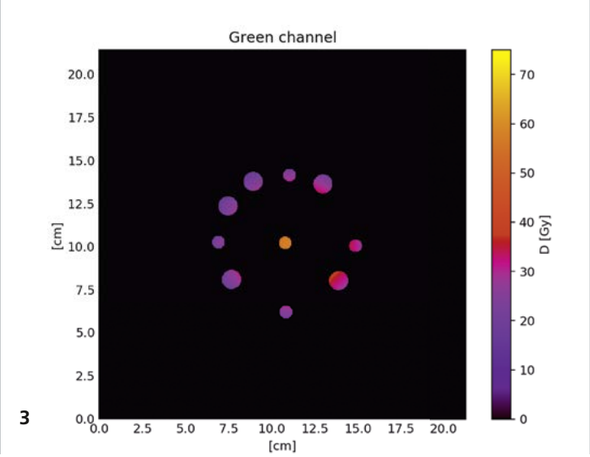
2 *Higher resolution detail of Figure 2, at different laser intensities*

3 *Illustration of a data channel of the component MAX14850, with the occurring effects outlined. The area outlined in red is shown in finer resolution in Figure 3*



THE USE OF RADIOCHROMIC FILMS IN PROTON IRRADIATION

Dr. Max Baum

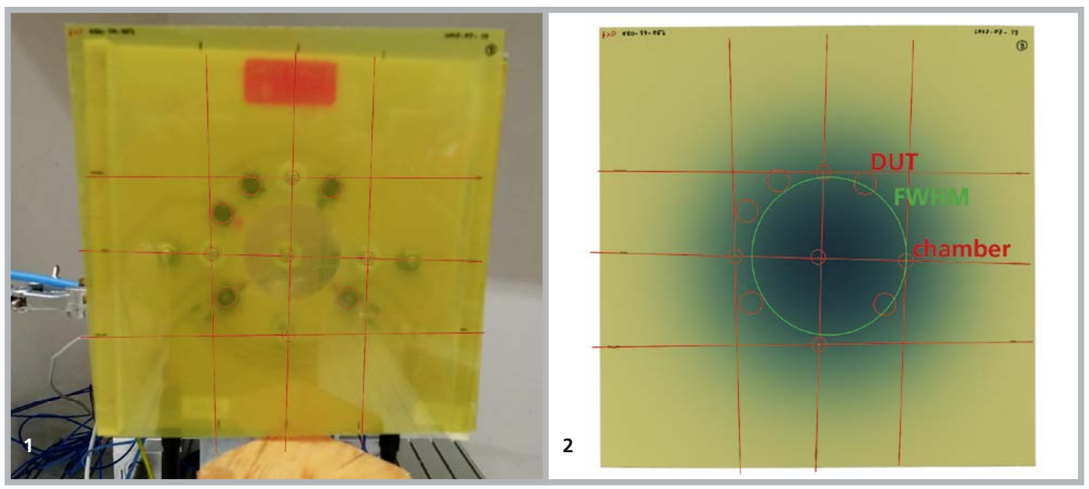


3

In cooperation with the research center Forschungszentrum Jülich (FZJ), the Business Unit Nuclear Effects in Electronics and Optics (NEO) has worked on the proton irradiation of electronic, optoelectronic and optical components, and material samples for more than 20 years. Jülich operates the cyclotron JULIC with 39 MeV, as well as a synchrotron with high energy protons (up to 2.5 GeV). Good dosimetry and knowledge of the beam profile are important for these irradiations. The questions are: How many particles come from the beam, and how are the particles distributed over the beam or the components under examination?

Fluence deviation (particle number per area) between two irradiated components can be as much as 35 percent if their respective distance to the center of the beam differs by only one centimeter. Although the question of beam intensity sounds obvious, this is not easy to determine.

While gamma dosimetry is well established and one can acquire commercial dosimetry systems based on national standards, protons do not yet have a standard source for calibrating a dosimetry system. At low particle energies, the beam current can be measured with a Faraday cup, as installed on the Jülich cyclotron. However, this gives no information about how the particles are distributed over the entire surface. In a series of experiments over the last two years, NEO has identified two dosimetry systems that are suitable for use with proton beams of different energies. In particular, they must have a cross-sectional area which is significantly smaller than the beam diameter.



1 2

1 *Unirradiated film in front of a circuit board with components and integrated ionization chambers. The red guidelines are added for evaluation.*

2 *Irradiated film. The red and green guidelines are added for evaluation.*

On one hand, we use ionization chambers calibrated for Co-60 gamma radiation. Their display value can be converted for protons of different energies. On the other hand, use is made of a Single Event Upset Monitor (SEU), which is based on non-destructive bit flips in an SRAM memory. Previous SEU monitor calibration occurred on various accelerators with protons up to approx. 250 MeV. Both systems provide dose levels, but they do not provide a detailed picture of the complete beam profile as they only measure at individual locations on the beam.

To obtain a picture of the entire beam, radiochromic films are used. When exposed to radiation, a chemical reaction in these films results in film discoloration. Their sensitivity curve is non-linear, as the underlying chemical reaction is limited in its discoloration. The films require a reference system for calibration, and what comes into question for this are the two systems referred to above. The films were extensively studied in cooperation with FZJ. For protons at 39 MeV, calibration curves were recorded for three types of film.

For irradiation, the films have been in routine use since 2016. Thanks to the films it is possible to measure the section of the beam that falls on the device under test (DUT), and this has led to a considerable improvement in dosimetry.

3 *Evaluated film. Shown are only the positions of the components and ionization chambers. It can be seen that the components did not receive exactly the same dose.*

SCIENTIFIC-TECHNICAL SUPPORT

Peter Clemens, Giesela Fuss

The Department Nuclear and Electromagnetic Effects (NE) has an extensive scientific-technical infrastructure that supports the experimental work in its three Business Units. Belonging to the section Scientific-Technical Support (Wissenschaftlich Technische Infrastruktur – WTI) is a precision engineering laboratory which makes special mechanical parts for experimental apparatus, and an electronics laboratory which produces special electronics for experiment work and carries out servicing and repairs.

When the electronics laboratory was relocated to the new laboratory area in the summer, laboratory furniture and work desks were completely renewed, bringing them up to the latest technical standard.

CCD Circuit Board Plotter and Circuit Board Production in the Electronics Laboratory

After relocation, the circuit board plotter procured last year went into operation. It is used for the rapid automated production of printed circuit boards for prototypes and small batches. Components for internally developed electronic circuits are then soldered onto the PCBs.

Data originating from a circuit development program (layout program) are converted and sent to the plotter's controls. Using a milling cutter in a high-speed spindle, insulation channels are milled into the board's copper layer. This creates individual conductor paths and connection pads for the components. In a second operation, holes required for feed-throughs and plugs can be produced. In the third step, the edge of the board can be fully cut through except for a few tabs. The board can then be broken off.

Insulation milling is particularly suitable for the production of high-frequency boards, as these call for the use of large ground planes and thus a lot of copper remains.

Insulation milling is uneconomical for conventional circuit board production (only conductor paths, little copper surface). The processing time is long and production is too expensive due to the limited service life of the cutters. For the conventional production of layout templates for exposure, a high-quality photo printer was procured and tested. Thus a sufficient degree of blackening can be achieved on normal copy films again.

The cutting plotter has the possibility of directly exposing the photo layer with a laser. For rational usage, however, it would be necessary to provide a second production process for photo-negative coated circuit boards. Where an order calls for larger quantities and the smallest structures, production work is contracted out.

Construction of a Probe Cube in the Engineering Laboratory

A probe cube was produced for a project of the working group Electromagnetic Effects and Threats EME. The cube is made of solid brass plates, the side panels being bolted and soldered, while the top and base were fastened with screws. Field probes were mounted in the recesses on the side panels. The holes in the base house the sockets for passing signals to the exterior. The illustration below shows the base view. The inside of the cube is electromagnetically shielded.

Probes and cubes form the reception antenna for the direction-dependent detection of high-power microwaves.

The Secretariat supports Department NE:

- with organizational support for projects,
- when reporting on experimental research,
- in radiation protection,
- through cooperation in preparing and conducting workshops,
- in drafting questionnaires (also online).

DEPARTMENT BUSINESS ADMINISTRATION AND CENTRAL SERVICES

Prof. Dr. Harald Wirtz

Business Administration and Central Services is the Institute Department responsible for all commercial and administrative tasks, as well as for providing the central infrastructure.

The Department subdivides into Finance, Human Resources and Law (FPR), and Central Infrastructure (ZI). These services are rounded off by the independent Library and Specialized Information Services, as well as Marketing and PR.

The group **Finance, Human Resources and Law** is responsible for book-keeping, accounting, controlling, human resources and travel management. **Accounting** in the Institute is conducted in accordance with German commercial and tax law. The area also handles the purchase of all consumer items and investment goods, in compliance with purchase guidelines and the official German terms for awarding service and construction contracts (VOL/VOB). The Department also manages the INT cash office, handling all cash and non-cash payments.

Controlling covers all monetary processes within Fraunhofer INT. This includes the continuous supervision and control of the Institute's entire budget, as well as administrative support for projects within the departments. Since Institute sponsors continuously conduct both internal and external audits, the Department also deals with all audit inquiries.

Human Resources supports Institute management in personnel planning, and processes all personnel tasks such as job advertising, hiring, job evaluations and resultant income-group classification, as well as contract extenuation. Travel management assists staff in every aspect of official travel, covering planning and preparation, transport and hotel bookings, and travel expense accounting in accordance with Federal Law.

Central Infrastructure is responsible for Facility Management / Internal Services and Central IT Services. Facility Management continues to play an important role in coordinating the various construction projects on the premises. Central IT Services covers the Institute's entire IT infrastructure, providing first level support for the users. Central IT Services are also intensively involved in preparing and implementing the project on IT-based support systems for the early detection of emerging technologies and the project »Rahs«. It advises and supports the Department TASP in procurement questions and manages the requisite IT components.

Marketing and Public Relations does all the necessary communications and marketing work for results produced by INT's individual business units. The sector also coordinated all the activities for the Open Day, staged by the Institute on its Euskirchen premises in celebration of its 40th anniversary (see also the special report on page 71). In addition, Angela Haberlach gained a Bachelor's Degree on the subject »Erfolgsfaktoren einer Social-Media-Marketing-Strategie für Forschungsinstitute im Science-to-Business Bereich (Success Factors of a Social Media Marketing Strategy for Research Institutes in the Science-to-Business Field)«.

Predominant tasks of the **Library and Specialized Information Service** are procuring and managing the media that the Institute requires, and supporting the scientists in research and accessing information. Depending on project needs, further specialized databases and other information sources are licensed and made available. To meet new requirements from public sponsors, the library service also assists project teams with their publication work. In addition, the library trains media and information specialists in information and documentation work.

SPACE ALLIANCE 2017

Thomas Loosen

For the Fraunhofer Space Alliance, 2017 was again a very eventful, but also a very successful year. The Alliance entered its fourth year of existence in February, and this called for the election of a new speaker. The choice again fell on Prof. Michael Lauster, which Fraunhofer INT regards as a vote of confidence in the Professor and his staff. »We hope to continue the successful work of the Alliance in the next three years. The Alliance's success is owed to the trust and openness that brought together previously isolated Alliance research projects in the form of joint appearances and projects.« says Prof. Lauster.

While Fraunhofer's standing as a space player was enhanced at home, the Alliance's presence in the international arena continued to grow in 2017. The American market was carefully sounded out at the Space Tech Expo USA in Pasadena, California, while the appearance at the Paris Airshow focused on the French and European space sectors. The Alliance was also present at the Space Tech Expo Europe, which – as in 2015 – the institutes concerned consider to be an interesting specialist fair that generates many highly-qualified contacts.

The small satellite ERNST remains a flagship project for the Space Alliance. Under the overall leadership of Fraunhofer EMI, the project assesses the military use of small satellites. Fraunhofer's own satellite – as with ERNST – is a total novelty being taken from first blueprint to finished satellite in orbit. This was registered with great interest at the events listed above. The satellite is scheduled for launching in 2020. In addition to EMI, IOSB is contributing an infrared camera, and INT is developing a radiation sensor and radiation assessment technology specifically for the project. An important aspect for the ERNST project is the use of commercially available components in satellite construction. This is a major factor with regard to the growing »New Space« trend in Europe, where private actors are playing an important role with some COTS (commercial off the shelf) components.

On the whole it is true to say that both at home and abroad, Fraunhofer is enjoying even greater regard as a space player, especially as a provider of solutions for technical problems in space. This was not so before the Alliance kicked off in 2014. An important goal for the future is to look for space-relevant technologies and expertise among institutes hitherto not involved with the Alliance, so enabling two-way technology transfers. For this role, the Fraunhofer Space Alliance is well positioned as a relay station within the Fraunhofer Gesellschaft and its extremely broad technology portfolio.

CHAIR AT RWTH AACHEN UNIVERSITY

Christian Hemmers

The Institute for Technology Analysis and Foresight in Security Research at the RWTH University in Aachen again continued its course content and methodology work in the year under review. The purpose of the Chair is to provide university students with quantitative and qualitative methods for researching the future, particularly in the context of application-oriented teaching and learning concepts. Regarding future research from the perspectives of suitability and optimization, this includes both underpinning epistemological methods and examining the methods spectrum.

The Chair focuses on the analysis of forecasting processes in technology, as well as on the adaptation, development and improvement of appropriate procedures and methods. Findings from continuously generated research provide the support for scientific decision-making in technology as it evolves in the course of time.

In the Summer Semester 2017, student participation for the lecture course »Methods of Future research (MdZF)« numbered 82, while for the Winter Semester 2017/2018 the number was 248. This again was a considerable increase in student numbers for the period under review. In addition to the theoretical content, students have the opportunity to develop their communication and presentation skills in practical exercises. Participants view the course as a useful and appealing addition to the predominantly technology and economics oriented curriculum in engineering studies.

For the second year in succession, the incumbent Chair, Prof. Dr. Dr. Michael Lauster, cooperated with Prof. Dr. Dr. Axel Zweck (Sociology Chair at RWTH University Aachen) to conduct the interdisciplinary seminar »(Inter)Disciplinary Future – Tomorrow's Technologies from the Social and Engineering Science Views«. The basic concept is for students of engineering to collaborate with sociology students over technology assessment. The course goal is the analysis of the perspectives of each science field and to open up a student's awareness of the science field he or she is not studying. Working in small, cross-discipline groups, the students concentrate on a particular topic and learn the most important methods and instruments of technology assessment. The final event of the 2017 course was held at Fraunhofer INT in July.

The Institute is again offering its seminar on knowledge and science theory for advanced students; and more seminars, in engineering ethics for example, are in the pipeline for coming semesters.

Another success was the lecture series »Methods of Researching the Future«, established at the Ravensburg-Weingarten University. The lectures, conducted by Prof. Lauster, give students of the Technology Management Faculty an application-based insight into the methodological principles of researching the future. The series takes place in block form once a year in Weingarten, and finds positive student response.

Prof. Lauster is also supervising a dissertation on the subject of technology acceptance, which has the objective of developing an indicator toolkit for measuring a potential user's likely acceptance of technology. In addition, various master, bachelor and project papers are offered at the chair, which are supervised, among others, in cooperation with Fraunhofer INT.

STAFF POSITION METHODS AND TRAINING

Dr. Birgit Weimert

Together with specialist and procedural expertise, methodological skills are a major building block of competent technology analysis and forecasting. Among the core tasks of the Staff Position are the developing and maintaining of a comprehensive overview of the method landscape, the constant updating of method and processing knowledge, and our own research work in this area.

Working closely with the group »Tools and Methods«, the Staff Position »Methods and Training" is also concerned with the sustained development of methodological competence in Fraunhofer INT, as well as with promoting method development and evaluation. This is done in part by joint orientation in the »Method Forum«, where new tools and methods, but also INT staff projects, are presented. It is rounded off by consultation and / or participation in selected projects.

Work in the past year concentrated on identifying and analyzing the latest methodological and procedural approaches, and evaluating their usefulness for the INT.

In addition, the Staff Position again supported INT management with strategic acquisitions. This involved contact with Fraunhofer INT's clients and partners, as well as cooperation with other Fraunhofer institutes and the Head Office, for example in preparing the position paper »Blockchain and Smart Contracts« for the Fraunhofer-Gesellschaft.

Furthermore, the project »Trend Management Systems« was completed for the Bundeswehr's Planning Office. In collaboration with a partner, a tool was developed which professionalizes the foresight process in many ways.

For a number of years, Dr. Birgit Weimert has been on the board of the future research network »Netzwerk für Zukunftsforschung«, and is also an editor and designated co-publisher of the future research journal »Zeitschrift für Zukunftsforschung«. In addition, she is actively involved in developing standards and quality criteria for future research in German-speaking countries. This resulted in 2017 in the publication of a pocket guide that provides a systematic, condensed overview of criteria that can be used to determine the quality of future research processes and their outcomes, as well as of research and practice.

BUILDING PROJECTS

Sabrina Müller

Construction work at Fraunhofer INT in 2017 was quieter than in previous years. Already in December 2016, the Institute premises seen from the outside no longer looked like a major building site. Inside, too, by the start of 2017 most of the new rooms had been furnished and were in use. This was mainly thanks to the hard work of our Facility Management, good coordination and exact planning.

Even so, in early 2018 there was still the task of equipping and moving into the newly-finished laboratory tract. At the beginning of the year, the electronics and chemistry laboratories, the NANU preparation room, the ESD, EME, NSD and NEO rooms were handed over for use. Laboratory regulations vary depending on the room concerned. Approval procedures for the NSD measuring room were only finalized in December, so the laboratory was only completed in 2018.

During 2017, Facility Management also renovated a number of offices, most of which were already in use following moves and new allocations. Facility Management and Central IT (ZIT) also made available a bright, new and well-equipped room, for use by the growing group of under and post graduate students. The room, home to the library prior to the Master Plan, was handed over for use in early December. This frees up the former room in the old building, which can also be converted into an office in 2018.

The new canteen in the heart of the Institute, approved and made available at the beginning of 2017, has become very popular. The staff lunches here every day. During the breaks in the summer months, good use was made of the outdoor area with terrace and fountain.

Having completed the new construction program, the Institute reached the limits of the premises. In consequence, the adjacent lot to the south was acquired by the Institute for Federal Real Estate (Bundesanstalt für Immobilienaufgaben BImA). Piece by piece, this property is being developed and made ready for use. A final decision on the exact use has yet to be taken.

A major task for 2018 is the extension of the NEMP absorber facility. Test boring was carried out at the end of December, as a step toward a soil survey for this project.

OPEN DAY

Angela Haberlach, Sabrina Müller

The Fraunhofer Institute for Technological Trend Analysis INT staged another Open Day in 2017, for the first time since 2007. The occasion was the 40th anniversary of the Institute in its Euskirchen home, INT's base since moving from its original location in Stohl, near Kiel. On Saturday, July 8, 2017, visitors were given the opportunity of a look behind INT's scenes, under the motto »hands-on research«. They were offered an overall, varied view of the Institute's many fields of work.

Normally closed, the laboratories and experiment facilities of the Department Nuclear and Electromagnetic Effects (NE) were opened, providing exclusive insights into the scientists' work in the world of radiation effects. A special attraction was the presentation of experiments set up especially for the visitors. The visitors were even able to gain hands-on experience with some of the experiments.

Technological Analyses and Strategic Planning (TASP), INT's second specialist department, was equally important. A department that chiefly calls for desk work and seems rather unspectacular to onlookers, TASP was graphically presented by the business units concerned, including a talk by the Department Head, Dr. René Bantes. With his presentation on autonomous driving, Jürgen Kohlhoff gave an example of future research. To make research work as efficient as possible, the TM group supports the department by continually developing and renewing appropriate tools and methods. An example for this was the presentation of the project »Knowledge Analytics for Technology & Innovation (KATI)«.

Whether railroad, car, smartphone or satellite – in the Department Nuclear and Electromagnetic Effects (NE) every technology enthusiast found a stand to catch his attention. As examples, the Business Unit Nuclear Security Policy and Detection Techniques (NSD) presented the function of portal monitors, using a miniature locomotive and the DeGen measurement vehicle.

For the Business Unit Electromagnetic Effects and Threats (EME), the talk by Dr. Thorsten Pusch showed how smartphones can be tested for interference susceptibility. Using the unit's own TEM waveguide – also on view for the visitors – smartphones are exposed to selective electromagnetic radiation in INT's shielded hall, and the resultant effects are measured in parallel.

The Business Unit Nuclear Effects in Electronics and Optics (NEO) also concerns itself with radiation and technology. Among other items, the Institute presented its own cryostat, a device that can cool down small volumes close to absolute zero (approx. – 273 °C), which is relevant for satellite missions in the depths of space. In addition, Dr. Stefan Höffgen spoke on the effects of cosmic radiation on daily life, for example on computers, cars or planes.

Visitors could also take a closer look at INT's two workshops. In the electronics workshop, they were able to try their hand at soldering tiny components, using a microscope and tweezers on a soldering facility. In the mechanical workshop, there was a demonstration of the extensive equipment required for setting up experimental apparatus.

INT's administration also presented itself: in the library, visitors were able to practise state-of-the-art scientific researching, accessing various INT databases. Central IT Services showed the ultramodern, powerful computer infrastructures that were

acquired and put into operation in line with the KATI Project. And Human Resources presented the Institute's various training and professional areas.

The echo from the large number of visitors was very positive. Many were not really aware of the kind of research INT undertakes, even though they had been living nearby for years. On the other hand, there were many visitors who came to the

Institute with surprisingly well-grounded knowledge; and the staff had some interesting discussions with them. In retrospect, all concerned judged the Open Day to be a great success. This was owed to the very great efforts that the staff in all departments put into preparing and staging the day. In the next few years there will certainly be another Open Day, at a time that is still to be determined.

SHORTLY NOTED

Gina Frederick, Sabrina Müller

Girls' Day

In 2017, Fraunhofer INT again made an active contribution to the nationwide Girls' Day event. This gave 12 schoolgirls from the region a chance to spend a day in the Institute. After Prof. Dr. Dr. Michael Lauster, Director of Fraunhofer INT, had introduced the Institute, the visitors were split up into small groups and

shown various types of experiment. Using a spectrometer, the girls were able to identify different light sources. They carried out an experiment on environmental radioactivity, and under expert guidance, soldered together a flashing star that they could take home with them at the end of the day.

After lunch, they had the opportunity for more detailed discussions with three women researchers. The girls put detailed questions about training, daily work routine and even private life, before returning to their classmates the following day.

INT will be taking part in Girls' Day in 2018 as well.
For further information on this nationwide event, go to: www.girls-day.de.

School Competition

A whole week as a researcher – just before summer vacation, Fraunhofer INT made that possible for school pupils as part of the competition »Go-Ing & Go-Job«, staged by the zdi-Zentrum (Center for the Future through Innovation). Via the center's program ANTalive, pupils get hands-on experience in the world of applied sciences and technology. Under the motto »Technology Consulting for Decision Makers«, and supervised by Senior Scientist Jürgen Kohlhoff, the six participants developed a study on the theme »Personal Robot«. The pupils took on the role

of assistant to a management board member of a company planning to put money into a start-up venture. The goal was to launch a personal robot onto the market in the near future.

Work was divided into the areas technological feasibility, legal framework, social acceptance and cost, and this was followed up by the corresponding research. The result was an 8-page study and a poster presentation that the pupils staged in the Sparkasse Bank at Düren on July 10. In total, more than 40 scholars from 15 secondary schools in the region of Aachen, Düren and Euskirchen took part in the 2017 program.

In the yearly »Go-Ing & Go-Job« contest for school pupils, participants work for a week in small, mixed teams in selected companies, where they deal with real projects and tasks and develop possible solutions. It gives them a platform for demonstrating their creativity and logical thinking. The competition serves to generate more interest for »MINT Careers« (jobs in math, information technology, science and technology).

»Herausforderung Weltraum«

In November 2017, Fraunhofer INT hosted the 6th »Herausforderung Weltraum« workshop, which focused on »Requirements for Space Components regarding their Radiation Resistance«. The workshop, staged by the Business Unit Nuclear Effects in Electronics and Optics (NEO), primarily addressed research

institutions, universities and small and medium sized enterprises (SMEs) working in aerospace.

The program included various presentations by scientists from INT and by two external experts from the Airbus Group. The 19 participants were also introduced to the Institute's experiment facilities. This included a demonstration of optical measuring possibilities and of INT's own cryostat, used for low-temperature radiation tests. In addition, a picoseconds laser was used to simulate single event effects, and single event upsets were simulated on a neutron generator.

The aim of the workshops is to support the participants in preparing and implementing space projects. The event also helps to make contact and exchange experience.

Best Poster Award for Dr. Merle Missoweit

Dr. Merle Missoweit, Head of the Business Unit Public Technology and Innovation Planning (TIP), and Piotr Tofilo (Main Fire Service School, Warsaw), were joint winners of the Poster Award at the 21st Fire Related Research and Developments Conference (RE17). Their poster presentation introduced the Horizon 2020

Project FIRE-IN (Fire and Rescue Innovation Network), which was launched in 2017. Taking part in the project are 16 partners from 8 European countries. The target over the next five years is to define requirements of the fire and rescue services, and to identify appropriate solutions and research areas.

The conference was held on November 9 at the HQ of the United Kingdom's third largest fire and rescue body, the West Midlands Fire Service, in Birmingham. The conference brings together representatives from rescue services, the fire industry, research bodies, universities, international organizations and private players, providing them with a platform for getting to grips with the latest developments in research and practice regarding fire.

APPENDIX

University Courses, Lectures and Exercises

Baum, M.: Lecture »Beiträge des Fraunhofer INT zum Aufbau des LHC am CERN«, Master's course Technology and Innovation Communications, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin, 7/6/2017

Chmel, S.: Lecture and exercise »Physics«, Bachelor's course Forensic Sciences (2nd semester), University of Applied Sciences Bonn-Rhein-Sieg, summer term 2017

Chmel, S.: Lecture and exercise »Measuring Techniques«, Bachelor's course Forensic Sciences (3rd semester), University of Applied Sciences Bonn-Rhein-Sieg, winter term 2017/2018

John, M.: »Leben und Arbeiten mit dem Cochlea Implantat – Funktionsweise, Chancen, Risiken und Erfahrungen im Hinblick auf die medizinische Rehabilitation«, Module as part of the Advanced Course of Rehabilitation Medicine of the Academy of Social Medicine, Berlin, 1/23/2017

John, M.: »Das Cochlea Implantat: Funktionsweise, Entwicklung, Chancen, Risiken und Erfahrungen im Hinblick auf die logopädische Praxis«, IB-Medical Academy, School for Logopaedia, Berlin, 2/24/2017 and 2/27/2017

John, M.: Lecture »Die Technisierung des Menschen – über Cochlea Implantate, Cyborgs und Human Enhancement«, Bachelor's course Technical Journalism / PR, Bonn-Rhein-Sieg University of Applied Sciences, Sankt Augustin, 6/7/2017

John, M.: »Die Technisierung des Menschen – über Cochlea Implantate, Cyborgs und Human Enhancement«, Master's course Technology and Innovation Communications, University of Applied Sciences Bonn-Rhein-Sieg«, Sankt Augustin, 7/13/2017

Jovanovic, M.: »Bibliometrische Analysen als Unterstützung der journalistischen Recherche«, Discussion Forum Technology and Society, University of applied sciences Bonn-Rhein-Sieg, Sankt Augustin, 4/12/2017

Jovanovic, M.: »Bibliometrische Analysen als Unterstützung der journalistischen Recherche«, Discusummer termion Forum Technology and Society, University of applied sciences, Bonn-Rhein-Sieg, Sankt Augustin, 5/11/2017

Jovanovic, M.: »Als Infowissler an einem Fraunhofer Institut«, Lecture during the student workshop for information scientific research, Heinrich-Heine-University Düsseldorf, Düsseldorf, 11/17/2017

Kohlhoff, J.: Lecture and exercise »Elektromobilität«, Module »Technology and Society«, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin, 4/19/2017 and 5/3/2017

Kohlhoff, J.: Lecture »Elektromobilität»in the Master's Course Technology and Innovation Communications, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin, 5/4/2017

Kohlhoff, J.: Presentation »Mensch/Maschine – Verschwimmen die Grenzen?« in the Master's Course »Technologiemanagement«, Ravensburg-Weingarten University of Applied Sciences, Weingarten, 5/17/2017

Kohlhoff, J., Reschke, S.: Exercise »Methoden der Zukunftsforschung« in the Master's Course »Technologiemanagement«, Ravensburg-Weingarten University of Applied Sciences, Weingarten, 5/17-19/2017

Lauster, M.: »Methoden der Zukunftsforschung I«, RWTH Aachen University, Aachen, winter term 2016/2017 and winter term 2017/2018

Lauster, M.: »Methoden der Zukunftsforschung II«, RWTH Aachen University, Aachen, summer term 2017

Lauster, M.: »Erkenntnis- und Wissenschaftstheorie für Ingenieure«, RWTH Aachen University, Aachen, winter term 2016/2017

Lauster, M: »Gut oder Böse? – Technische Autonomie im Diskurs«, TREE-Forschungskonferenz, University of applied sciences Bonn-Rhein-Sieg, Sankt Augustin, 6/9/2017

Lauster, M.: Joint Seminar Engineers / Sociologists on Technology Assessment, RWTH Aachen University, Aachen, summer term 2017

Lauster, M.: Lecture »Methoden der Zukunftsforschung«, Ravensburg-Weingarten University of Applied Sciences, Weingarten, summer term 2017

Wiemken, U.: Lecture/Seminar Bachelor's course »Technical Journalism«, Module »Technology and Society«, University of Applied Science Bonn-Rhein Sieg, Sankt Augustin, summer term 2017

Wiemken, U.: Lecture/Seminar Master's course »Technology and Innovation Communication«, Module »Technology, Politics and Society«, University of Applied Science Bonn-Rhein Sieg, Sankt Augustin, summer term 2017

Wirtz, H.: Lecture »Change- und Innovationsmanagement« in the Bachelor's course Business Administration (8th semester), Hochschule Fresenius, Köln, winter term 2016/2017, summer term 2017, winter term 2017/2018

Wirtz, H.: Lecture »Qualitäts-, Change- und Innovationsmanagement« in the Bachelor's course Betriebswirtschaftslehre (2nd semester), Hochschule Fresenius, Köln, winter term 2016/2017, summer term 2017, winter term 2017/2018

Wirtz, H.: Lecture »Investition und Finanzierung« in the Bachelor's Course Betriebswirtschaftslehre (3rd semester), Hochschule Fresenius, Köln, winter term 2016/2017, summer term 2017, winter term 2017/2018

International Corporation

Baum, M., Höffgen, S., Kuhnhenn, J., Kündgen, T., Lennartz, W., Metzger, S., Paschkowski, E., Schmitz, S., Steffens, M., Weinand, U., Wolf, R., Wölk, D.: CERN, Geneva, Switzerland

Baum, M., Höffgen, S., Kuhnhenn, J., Weinand, U.: KIC Project HOBAN, France

Baum, M., Höffgen, S., Kuhnhenn, J., Kündgen, T., Lennartz, W., Metzger, S., Paschkowski, E., Schmitz, S., Steffens, M., Weinand, U., Wolf, R., Wölk, D.: ESA-ESTEC, Noordwijk, Netherlands

Berchthold, C., Grigoleit, S., Müller, L., Sendrowski, P., Vollmer, M.: In Horizon 2020 project IN-PREP (An Integrated next generation PREParedness programme for improving effective inter-organisational response capacity in complex environments of disasters and causes of crisis), 19 project partners

Berky, W., Bornhöft, S., Chmel, S., Friedrich, H., Lieder, E.: In H2020 project C-BORD (Effective Container Inspection at BORDer Control Points), 18 project partners

Friedrich, H., Glabian, J., Köble, T., Ossowski, S., Risse, M.: In DG Home project ITRAP+10-phase-2 (Illicit Trafficking Radiation Assessment Program + 10 phase II Round Robin Tests), 5 project partners

Grigoleit, S., Freudendahl, D.M.: In EU-FP7 project SOURCE (Virtual centre of excellence for research support and coordination on societal security), 13 project partners

Grigoleit, S., Müller, L., Sendrowski, P., Blab, R.: In Horizon 2020 project SONNETS (Societal Needs analysis and emerging Technologies in the public Sector), 4 project partners

Heuer, C., Pastuszka, H.-M., Brandt, H., Huppertz, G., Langner, R., Neupert, U., Offenberg, D., Römer, S., Ruhlig, K., Walter, G., European Defence Agency (EDA), »Overarching Strategic Research Agenda (OSRA)« (15.ESI.OP.162), in cooperation with Totalförsvarets Forskningsinstitut (FOI, Sweden), TNO (Netherlands) and Ingeniería de Sistemas para la Defensa de España (Isdefe, Spain), 2015–2017

Köble, T., Schumann, O.: ESARDA VTM Working Group

Kuhnhenn, J., Metzger, S., Steffens, M.: Seibersdorf Laboratories, Seibersdorf, Austria

Missoweit, M.: Submission of the Horizon 2020 proposal EMPOWER, led by Johanniter Unfallhilfe e.V.

Neupert, U., Langner, R., Nätzker, W., Ruhlig, K., Huppertz, G., Offenberg, D.: FMV (Försvarets Materielverk)-projects Teknisk Prognos 2016/2017 and Teknisk Prognos 2017

Pastuszka, H.-M., Grüne, M.: European Defence Agency (EDA), »Technology Watch Follow-on: technology mapping and foresight (TWFO)« (15.ESI.OP.201), in cooperation with Ingeniería de Sistemas para la Defensa de España (Isdefe, Spain), 2016–2017

Pusch, T., Jöster, M., Suhrke, M.: EU H2020-Project Smart-Resilience (Smart Resilience Indicators for Smart Critical Infrastructures), 20 project partners

Suhrke, M., Jöster, M, Adami, Ch.: participation in the NATO STO SCI-294 Task Group Demonstration and Research of Effects of RF Directed Energy Weapons on Electronically Controlled Vehicles, Vessels, and UAVs, 9 nations

International Reviews

Höffgen, S.: Journal of Instrumentation

Höffgen, S., Kuhnhenn, J., Metzger, S.: RADECS 2017 Conference

Jöster, M.: IEEE Transactions on Electromagnetic Compatibility

Kuhnhenn, J.: Journal of Nuclear Materials

Kuhnhenn, J.: Journal of Lightwave Technology

Kuhnhenn, J.: Transactions of Nuclear Science

Kuhnhenn, J.: Sensors (ISSN 1424-8220, CODEN: SENSC9)

Kuhnhenn, J.: Journal of Selected Topics in Quantum Electronics

Lubkowski, G.: Progress in Electromagnetics Research (PIER)

Metzger, S.: IEEE Transactions on Nuclear Science

Suhrke, M.: IEEE Transactions on Electromagnetic Compatibility

Thorleuchter, D.: Advances in Engineering: an International Journal

Thorleuchter, D.: Decision Support Systems

Thorleuchter, D.: Electronic Commerce Research and Applications

Thorleuchter, D.: Expert Systems with Applications

Thorleuchter, D.: Information

Thorleuchter, D.: Information Fusion

Thorleuchter, D.: International Journal of Information Science

Thorleuchter, D.: Journal of Experimental & Theoretical Artificial Intelligence

Thorleuchter, D.: Sustainability

Collaboration in Committees

Chmel, S.: Head of work group »Antrags- und Projektmanagement« of the Fraunhofer EU-Network

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

Grüne, M.: EDA Technology-Watch Workshops, European Defence Agency (EDA), Brussels

Hecht-Veenhuis, S.: Berufsbildungsausschuss NRW, sub-committee »Geprüfter Fachwirt / Geprüfte Fachwirtin für Medien- und Informationsdienste in NRW«

Kuhnhenn, J.: Awards Committee at RADECS 2017 in Geneva, Switzerland

Lauster, M.: Sprecher Fraunhofer Allianz Space

Lauster, M.: Forschungsvorstand Deutsche Gesellschaft für Wehrtechnik DWT e.V.

Metzger, S.: RADECS Steering Committee

Metzger, S.: Chairing of the Radiation Effects Data Workshops (REDW) at the RADECS 2017 in Geneva, Switzerland

Missoweit, M.: Horizon 2020 Secure Societies Protection and Security Advisory Group

Missoweit, M.: Horizon 2020 Advisory Group on International Cooperation

Missoweit, M.: EARTO Security and Defence Research Group

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

Neupert, U.: Developer Network A 16+, Joint Support Service

Römer, S.: NATO-STO Research & Technology Group SAS-123 »Futures Assessed alongside socio-Technical Evolutions (FATE)«

Thorleuchter, D.: Member of the PhD reading and exam committee of Ghent University, Belgium

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

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

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

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

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

Thorleuchter, D.: Program Committee of the International Conference on Intelligent Systems and Computer Vision 2017, 04/17-19/2017, Fez, Morocco

Weimert, B.: Board Member of the »Netzwerk Zukunftsforschung e.V.«

Weimert, B.: Scientific Editor of the »Zeitschrift für Zukunftsforschung«

Participation in Norming Processes

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

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

Adami, Ch.: NATO HPM Standardization (NATO STO SCI-294 Task Group)

Jöster, M.: DKE / AK 767.13.5, »EMV von Halbleitern«, DKE Deutsche Kommission Elektrotechnik, Elektronik Informationstechnik im DIN und VDE

Köble, T.: DIN und VDE DKE/GK851 »Aktivitätsmessgeräte für den Strahlenschutz«

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

Kuhnhenn, J.: IEC SC86A/WG1, Revision of IEC 60793-1-54

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

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

Lectures and Presentations

Adami, Ch.:
Lab tests of UAVs – setup, diagnostics and first results, NATO STO SCI-294 TG, 5th Meeting, London, 10/17-19/2017

Bantes, R.:
»Capacity Crunch, wird aus dem World-Wide-Web ein World-Wide-Wait?«, AFCEA Event »Internet der Dinge für Systeme der Bundeswehr – Vernetzung und Souveränität«, Bonn, 10/10/2017

Bantes, R.:
»Technologische Zukünfte, Was kommt auf uns zu?«, »European Innovators«, Hannover, 11/16/2017

Baum, M.:
»Dosis- und Struktureffekte in Siliziumhalbleitern«, Workshop Herausforderung Weltraum, Euskirchen, 11/22/2017

Grigoleit, S.:
»Roadmap development«, SONNETS final event, 23rd ICE/IEEE ITMC Conference in Madeira, Portugal, 6/28/2017

Grüne, M.:
»Defence Technology Foresight for the German MoD«, 5th Workshop on Technology Watch, European Defence Agency (EDA), Brussels, 11/29/2017

Höffgen, S.:
»Application of the FAIR Facility to Space Radiation Research«, lecture ESOC (Final Presentation), Darmstadt, 4/28/2017

Höffgen, S.:
»Wirkung kosmischer Strahlung auf das tägliche Leben: Computer, Autos, Flugzeuge«, Open Day Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 7/8/2017

Höffgen, S.:
»Single-Event Effects«, Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 11/22/2017

Höffgen, S.:
»Strahlungseffekte in Verbindungshalbleitern«, Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 11/23/2017

Jöster, M.:
»High Power Electromagnetics für Counter-UAS«, Round Table Defence and security research 2017, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 4/11/2017

Köble, T.:
»Study of Neutron Detection Technologies Using 6Li as a Replacement of 3He«, 58th Annual Meeting INMM, Indian Wells, USA, 7/19/2017

Köble, T.:
»CLYC scintillators: a possible enhancement for handheld OSI detectors«, CTBT Science and Technology Conference, Vienna, Austria, 6/26/2017

Kuhnhenn, J.:
»Radiation Effects Testing for Space Missions«, RADHARD-Symposium 2017, Seibersdorf laboratories, Seibersdorf, Austria, 5/16/2017

Kuhnhenn, J.:
»New Radiation Testing Aspects at Fraunhofer INT«, Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hanover, 9/27/2017

Kuhnhenn, J.:
»Strahlungseffekte in Materialien«, Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 11/23/2017

Lanzrath, M.:
»HPEM Vulnerability of Smart Grid Substations – Coupling paths into typical SCADA devices«, EMC Europe 2017, Angers, France, 9/4-9/2017

Lauster, M.:
»Fraunhofer Kompakt«, Planungsamt der Bundeswehr, Berlin, 1/18-19/2017

Lauster, M.:
»Industrie 4.0 und Sicherheit – drei Anwendungsbereiche der Raumfahrt der Zukunft«, Workshop DLR: Zukunftsbild Mobilität, Bonn, 2/17/2017

Lauster, M.:
NATO, Visit of SCI-294 Task Group, Meeting, Euskirchen, 3/7-9/2017

Lauster, M.:
Presentation of the Fraunhofer Space Alliance – »Applied Research for Europe's Space Industry«, visit of ESA Director General Johann-Dietrich Wörner, Headquarter of the Fraunhofer-Gesellschaft, Munich, 3/14/2017

Lauster, M.:
»Raumfahrt bewegt – Ein Beitrag zu den Zukünften der Mobilität«, BMWi, 3/27/2017

Lauster, M.:
»AIR – Combining Emerging Technologies for an International Center of Excellence«, Terceira/Azoren, Portugal, 4/20/2017

Lauster, M.:
»Future Operating Environment – einige Überlegungen zu technologischen Aspekten«, BAKS FOE Berlin, 5/9/2017

Lauster, M.:
»Bringing New Space and Old Europe together: When Technologies Merge«, SpaceTech Expo, Pasadena, USA, 5/23-25/2017

Lauster, M.:
»Technische Autonomie im Diskurs, Begriffsklärung und Stand der Dinge«, TREE-Forschungskonferenz, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin, 6/9/2017

Lauster, M.:
»Vorstellung der Allianz Space«, ASI Battiston, 6/27/2017

Lauster, M.:
»Unmanned Vehicles«, DWT-Forum Bad Godesberg, 7/5/2017

Lauster, M.:
»Vorträge im Rahmen des Tags der Offenen Tür«, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 7/8/2017

Lauster, M.:
»Was ist Zukunftsforschung und was vermag sie zu leisten? Und vor allem: Wie kann man damit den Herausforderungen von Industrie 4.0 begegnen?«, Symposium Ravensburg, 10/17/2017

Lauster, M.:
»Fraunhofer-Allianz Space – Angewandte Forschung für Europas Raumfahrt«, BDLI, Berlin, 11/16/2017

Lauster, M.:
ESTEC, Nordwijk (NL), 11/29/2017

Lauster, M.:
»Fraunhofer-Gesellschaft und Institutsvorstellung«, Museumsgästehaus Mottenburg, LVR-Industriemuseum Euskirchen-Kuchenheim, 11/30/2017

Melin, G., Lablonde, L., Robin, T., Kuhnhenn, J., Weinand, U., Morana, A., Girard, S., Marin, E., Perisse, J., Genot, J., Grelin, J., Hutter, L., Mace, J., Boukenter, A., Ouerdane, Y.:
»Radiation hardened temperature measurement chain based on femtosecond laser written FBGs in a specific optical fiber«, Workshop on Specialty Optical Fiber and Their Applications, Limassol, Cyprus, 10/27/2017

Metzger, S.:
»Ist das Risiko durch den Einsatz von COTS im New Space tragbar?«, Presentation at the meeting of the space programme planning committee of the German Space Agency (Programmkommission Raumfahrt des DLR) on the subject of commercialization of space, Bonn, 5/5/2017

Metzger, S.:
»Untersuchung von Strahlungseffekten am Fraunhofer INT«, Lecture at the Helmholtz-Institut für Strahlen- und Kernphysik der University of Bonn, 7/25/2017

Metzger, S.:
»Fraunhofer Onboard Radiation Sensors (FORS)«, Presentation at the Space Environment Monitoring Workshop (SPACEMON) 2017 at the ESA-ESTEC in Noordwijk, Netherlands, 12/13-15/2017

Missoweit, M.:
Panelist at Tensions of Europe Conference, Athens, Greece, 9/8-9/2017

Missoweit, M.:
Poster Prasentation at Annual Conference on Fire Related Research and Developments (RE17), Birmingham, United Kingdom, 11/9/2017

Neupert, U., Pastuszka, H-M., Grüne, M., Huppertz, G., Ruhlig, K.:
»Wehrtechnische Zukunftsanalyse«, Lecture at the Führungsakademie der Bundeswehr, Hamburg, 11/28/2017

Neupert, U., Römer, S.:
»Disruptive Technology Assessment Gaming (DTAG) – ein militärisches Table-top-Game zur Technologiebewertung«, Lecture at the Führungsakademie der Bundeswehr, Hamburg, 11/29/2017

Neupert, U., Heuer, C., Huppertz, G.:
»Wehrtechnische Vorausschau (WTV) – Bedrohungspotenziale aus technischer Sicht«, Forum Zukunftsentwicklung Heer, Amt für Heeresentwicklung, Cologne, 11/8-9/2017

Neupert, U., Heuer, C., Diana Freudendahl:
»Nicht-invasives Performance Enhancement – Sachstände, aktuelle Entwicklungen«, 1. Workshop »Human Performance Enhancement«, Joint Support Service, Bonn, 12/14/2017

Pastuszka, H.-M., Neupert, U.:
»Wehrtechnische Zukunftsanalyse – WZA«, Lecture at the Führungsakademie der Bundeswehr, Hamburg, 2/7/2017

Pastuszka, H.-M., Heuer, C., Ekström, Th., Kindvall, G., Gonzalez, G.M.M., Jacobs, L.M.R.A.:
»OSRA (Overarching Strategic Research Agenda and CapTech SRAs Harmonization) presentation at R&T PoC meeting«, European Defence Agency (EDA), Brussels, Belgium, 4/4/2017

Pastuszka, H.-M.:
»Wehrtechnische Zukunftsanalyse für die Bundeswehr«, Working Group Space & Defence, NBank, Hannover, 11/16/2017

Pastuszka, H.-M.:
»Wehrtechnische Vorausschau für die Bundeswehr«, D-A-CH R&T Director's Meeting, DLR, Cologne, 12/14/2017

Schmitz, S.:
»Mapping of SEE-sensitive regions and locating of additional failure modes relevant for RHA in Digital Isolators«, RADLAS, Montpellier, France, 10/9/2017

Schumann, O.:
»Comparative Testing of the MCA-527 and MCA-166 Mini Multi Channel Analyzers«, ESARDA 39th Annual Meeting Proceedings, Düsseldorf, 5/16/2017

Steffens, M.:
»Survey of total ionising dose tolerance of power bipolar transistors and Silicon Carbide devices for JUICE – Status of ongoing activities«, ESA/CNES Final Presentation Days: Radiation Effects on EEE components, ESA-ESTEC, Noordwijk, Netherlands, 3/9/2017

Steffens, M.:
»Strahlung im Weltraum«, Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 11/22/2017

Steffens, M.:
»Strahlungsabschirmung«, Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 11/22/2017

Suhrke, M.:
»Hochleistungsmikrowellen gegen Bedrohungen durch Drohnen«, Meeting of the Advisory Board, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen, 6/22/2017

Publications

Bantes, René:
Capacity Crunch. Wird aus dem »World Wide Web« das »World Wide Wait»?: Vortrag gehalten auf der 109. AFCEA Fachveranstaltung »Internet der Dinge für Systeme der Bundeswehr – Vernetzung und Souveränität«, 2017, Bonn (Fachveranstaltung »Internet der Dinge für Systeme der Bundeswehr – Vernetzung und Souveränität« <109, 2017, Bonn>), 2017
URN urn:nbn:de:0011-n-4768398

Bantes, René:
Technologische Zukünfte – Was kommt auf uns zu?: Vortrag gehalten beim 2. EUROPEAN INNOVATORS Jahresnetzwerktreffen, 2017, Hannover (EUROPEAN INNOVATORS (Jahresnetzwerktreffen) <2, 2017, Hannover>), 2017
URN urn:nbn:de:0011-n-4768932

Baum, Max; Felden, Olaf; Weinand, Udo; Höffgen, Stefan; Kuhnhenn, Jochen; Metzger, Stefan:
Proton dosimetry at the accelerator COSY for radiation effect testing: Poster presented at European Conference on RADiation Effects on Components and Systems, RADECS 2017, Geneva, Switzerland, 2-6 October 2017 (European Conference on RADiation Effects on Components and Systems (RADECS) <2017, Geneva>), 2017
URN urn:nbn:de:0011-n-4811310

Berky, Wolfram; Glabian, Jeannette; Köble, Theo; Lehmacher, Thomas; Risse, Monika:
Highly efficient on-site detection of neutron sources with the INT measurement car DeGeN
In: IEEE sensors letters, (2017), Online First, 4 pp.
DOI 10.1109/LSENS.2017.2786477

Berky, Wolfram; Bornhöft, Charlotte; Friedrich, Hermann; Köble, Theo; Risse, Monika; Rosenstock, Wolfgang; Schumann, Olaf:
Study of neutron detection technologies using ^{6}Li as a replacement of ^{3}He: Paper presented at INMM 2017, 58th Annual Meeting Institute of Nuclear Materials Management, July 2017, Indian Wells (Institute of Nuclear Materials Management (INMM Annual Meeting) <58, 2017, Indian Wells/Calif.>), 2017
URN urn:nbn:de:0011-n-4743439

Blanc, Jeremy; Ricci, Daniel; Kuhnhenn, Jochen; Weinand, Udo; Schumann, Olaf:
Irradiation of radiation-tolerant single-mode optical fibers at cryogenic temperature
In: Journal of Lightwave Technology, Vol.35 (2017), No.10, pp.1929-1935, DOI 10.1109/JLT.2017.2676840

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Workshop »Neue Technologien im Bereich Radar«, Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Wachtberg

9/19-21/2017
8. Symposium Nukleare und radiologische Waffen – Technologische Urteilsfähigkeit und nukleare Sicherheit in Deutschland, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen

10/2-6/2017
Exhibition booth RADECS 2017

10/24-26/2017
Exhibition booth SpaceTechExpo 2017

11/22-23/2017
6. Workshop Herausforderung Weltraum, Fraunhofer Institute for Technological Trend Analysis INT, Euskirchen

Press Releases

Strahlungswirkung und Zukunftsforschung – 550 Besucher hinter den Kulissen des Euskirchener Fraunhofer-Instituts, 7/16/2017

ISO 9001 QM certification expanded to entire Nuclear Effects department, 10/9/2017

Using »Cognitive Computing« for Scientific Research, 11/3/2017

INT's First Test Series using Picosecond Lasers for Mapping Single of Event Effects (SEEs), 11/7/2017

EU project will improve crisis management response across EU member states and beyond, 11/15/2017

Institute Course

Müller, L. (Fraunhofer INT):
Sozialwissenschaftliche Begleitforschung in der Technikentwicklung, Euskirchen, 1/11/2017

Winnink, J. (CWTS, Leiden, NL):
Early stage identification of potential breakthroughs in science, Euskirchen, 2/8/2017

Weinand, U. (Fraunhofer INT):
Smart Security Glass – Entwicklung eines optischen Detektor Systems für Glasbruch, Euskirchen, 2/15/2017

Klüfers, P. (Universität der Bundeswehr München):
Politische Krisen- und Konfliktvorhersagen: Interpretation quantitativer Risikomodelle, Euskirchen, 3/15/2017

Dietz, A. (Fraunhofer IST):
Moderne Beschichtungsverfahren in der Raumfahrt, Euskirchen, 3/22/2017

Bleckmann, M. (Wehrwissenschaftliches Institut für Werk- und Betriebsstoffe WIWeB):
Additive Fertigung in der Bundeswehr, Euskirchen, 3/29/2017

Grüne, M. (Fraunhofer INT):
EDA Technology Foresight – Implementierung einer Vorausschau-Methodik und erste Erkenntnisse, Euskirchen, 5/3/2017

Kretschmer, T.(Fraunhofer INT):
Klimawandel und Sicherheitspolitik, Euskirchen, 5/31/2017

Gerndt, R. (Airbus Defense & Space):
LISA Technology Package – a gravitational wave observatory precursor mission, Euskirchen, 6/7/2017

Spiecker, C. (Fachhochschule Potsdam):
Die (bildliche) Konstruktion der Zukunft im Science Fiction Film, Euskirchen, 6/14/2017

Streefkerk, J. W. (TNO, Soesterberg, NL):
The TNO Innovation Radar, Euskirchen, 6/21/2017

Reschke, S. (Fraunhofer INT):
Anticipation – ein bibliometrischer Blick auf einen facettenreichen Begriff, Euskirchen, 6/28/2017

Berchtold, C. (Fraunhofer INT):
Verwundbarkeitsabschätzung und Resilienz im Kontext von Naturgefahren – Risikomanagement-Ansätze und Ihre Implementierung, Euskirchen, 8/30/2017

John, M. (Fraunhofer INT):
Suchst du noch oder liest du schon? Wie bringt man einem Computer Zukunftsforschung bei?, Euskirchen, 9/13/2017

Pusch, T. (Fraunhofer INT):
Elektromagnetische Verträglichkeit am Limit: Störbarkeit von Smartphones durch Hochleistungsmikrowellen, Euskirchen, 9/13/2017

Sendrowski, P. (Fraunhofer INT):
Kurze Vorstellung und Einführung in die kritische Sicherheitsforschung, Euskirchen, 10/4/2017

Pastuszka, H.-M. (Fraunhofer INT):
Geschäftsfeld Wehrtechnische Zukunftsanalyse (WZA) – Aktuelle Projekte, Euskirchen, 10/11/2017

Ben Bekhti, N. (Fraunhofer FHR):
Aus den galaktischen Tiefen hin zum Weltraumschrott – Unglaubliche Weiten, doch rund um die Erde wird es eng, Euskirchen, 10/18/2017

Kohlhoff, J. (Fraunhofer INT):
Autonomes Fahren und Elektromobilität – Überblick und Trends, Euskirchen, 11/8/2017

Musacchio, F. (Fraunhofer INT):
Die Polarlichter Ganymeds, Euskirchen, 11/15/2017

Sonsalla, R. (DFKI GmbH Bremen):
A Robotic Mars Mission in the Desert of Utah, Euskirchen, 11/29/2017

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- Düsseldorf (100 km)

By rail

Nearest Inter-City Main Stations:
Bonn Hauptbahnhof and Cologne Hauptbahnhof.
From there regular rail connections to Euskirchen.
From Euskirchen Station with Bus No 875 in direction »Großbüllesheim-Wüschheim«; or Bus No 806 in direction »Heimerzheim Fronhof« to »Appelsgarten«

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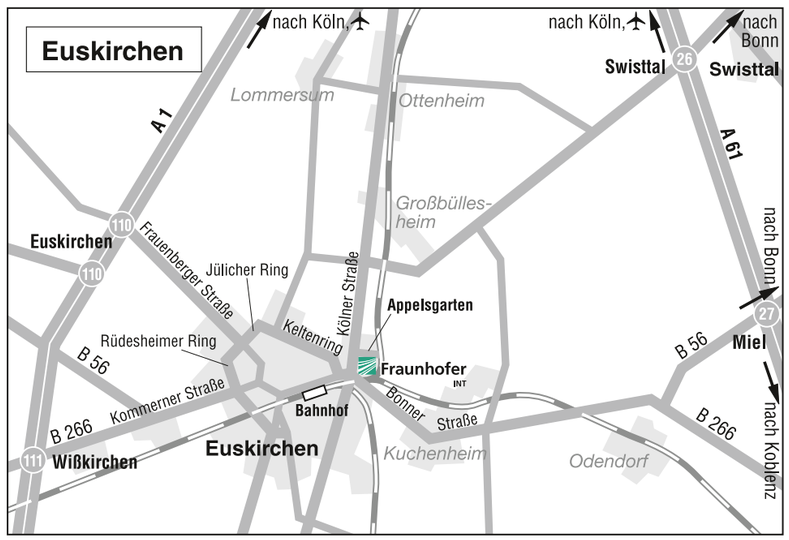

PUBLISHING DETAILS

Editor

Angela Haberlach (responsible), Thomas Loosen,
Gina Frederick, Sabrina Müller

Design, Realisation, Production

Konzeptbüro Horst Schneider, Erftstadt

Picture Credits

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Printing

Fraunhofer-Verlag,
Fraunhofer-Informationszentrum Raum und Bau IRB

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